Hochschule für Angewandte Wissenschaften Hamburg
Hamburg University of Applied Sciences

Bachelor Thesis

Department of Automotive and Aeronautical Engineering

Human Factors Analysis on Creating an Inclusive Aircraft Lavatory Environment for Blind and Visually Impaired People

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29 February 2012

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Definition of Bachelor Thesis

Name: Kimberly Dippel

Topic: **Human Factors Analysis on Creating an Inclusive Aircraft Lavatory Environment for Blind and Visually Impaired People**

Background

Blind and visually impaired people face different kinds of limitations and difficulties in their daily lives, especially when they need to interact with public environments, which they may not be familiar with. Nowadays, the design and technologies inside the aircraft lavatory do not fit the needs of blind and visually impaired people. This situation has to be improved in order to provide convenience and overcome existing barriers.
In this Bachelor Thesis problems and aspects on the usage of the aircraft lavatory by blind and visually impaired people and their support by cabin crew are going to be analyzed, in order to develop a design guideline which offers advice and guidance on how to create an inclusive aircraft lavatory environment for the blind and visually impaired. The application of this design guideline shall then be demonstrated by an exemplary design outline of an aircraft lavatory.

Tasks

The tasks are as follows:

- Analysis on the implementation of regulations
- Analysis on existing problems inside the aircraft lavatory
- Development of requirements
- Development of a design guideline
- Application of the design guideline on the aircraft lavatory

This Bachelor Thesis will be accomplished in cooperation with:

Bertrandt Ingenieurbüro GmbH, Blohmstraße 10, 21079 Hamburg

Abstract

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Abstract

Despite blindness or visual impairment, people cannot or do not want to give up on traveling by plane. Since an airplane is not an everyday living space, it is particularly difficult for the blind and visually impaired to orientate themselves inside the aircraft cabin and the aircraft lavatory. Nowadays, the design and technologies inside the aircraft lavatory do not fit the needs of blind and visually impaired people. In order to make traveling by plane as pleasant as possible for blind and visually impaired people, they need to get best possible support by the cabin crew and through appropriate cabin design.

The focus of this thesis is the derivation of requirements for an inclusive aircraft lavatory based on the needs of blind and visually impaired people as well as the application of these requirements on the development of a design concept of an aircraft lavatory.

Declaration

I hereby declare that this Bachelor Thesis has been completed by myself independently without outside help and only the defined sources and study aids were used. Sections that reflect the thoughts or works of others are made known through the definition of sources.

City, Date

Signature

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List of Terms and Abbreviations

Afr	WHO African Region
AMD	Age-related Macular Degeneration
Amr	WHO Region of the Americas
App	Application
ASN	Aircraft Safety Network
BLND	Blind or visually impaired passenger
BSVH	Blinden- und Sehbehindertenverein Hamburg e.V. (Association of Blind and Visually Impaired People in Hamburg)
D	Design aspects [Requirements]
DBSV	Deutscher Blinden- und Sehbehinderten Verband e.V. (German Association of Blind and Visually Impaired People)
DEAF	Deaf or hearing impaired passenger
DPNA	Disabled passenger with intellectual or developmental disability needing assistance
Emr	WHO Eastern Mediterranean Region
Eur	WHO European Region
Fully Sighted Person	A person who has no visual impairment
G	General aspects [Requirements]
HILA	High Integrated Flexible Lavatory
Human Factors	Human Factors is a multidisciplinary study that deals with psychology, anthropometry, safety, engineering and industrial design aspects between the user and the system the user is in.
IC	InterCity: A long-distance train.
ICE	InterCityExpress: A highspeed long-distance train.
IFE	In-Flight Entertainment
Inclusive Environment	An environment in which the different needs of all user groups are recognized. It is safe, predictable and convenient to be used by all user groups including PRMs.

L	Lavatory
L	Liveware [SHEL(L) Model]
lux	A unit of illuminance, measuring the brightness of an area which is illuminated by light.
Mock-Up	A usually full-sized scale model of a structure, used for demonstration, testing or training purposes.
MRO	Maintenance, Repair and Overhaul
NABC	Needs, Approach, Benefits, Competition
OEM	Original Equipment Manufacturer
PRM	Person with Reduced Mobility
QR Code	Quick Response Code
Requirement	Required performance or characteristic of an object or system. The requirements in this Bachelor Thesis are distinguished through the terms “shall” and “should”. Shall: The word describes that the requirement is mandatory. If the requirement is not met, the corresponding solution is not acceptable without formal agreement. Should: The word describes that the requirement is a recommendation or advice. These are expected to be followed unless good reasons are stated for not doing so.
RFID	Radio-Frequency Identification
Sear	WHO South-East Asia Region
WCHC	Wheel Chair Category Cabin: Passenger who is completely immobile and can move about only with the help of a wheelchair.
WCHR	Wheel Chair Category Runner: Passenger can walk short distances and walk up / down stairs.
WCHS	Wheel Chair Category Stepper: Passenger can walk short distances, but cannot walk up / down stairs.
WHO	World Health Organisation
Wpr	WHO Western Pacific Region

1 Introduction

1.1 Motivation

The major goals of the current development in the aviation industry are to increase passenger comfort in all classes and save kerosene by the use of lightweight materials. Great importance is set on satisfying all wishes of the passengers. However, this current development mostly takes place independent of the needs and wishes of passengers with and without disability or impairment.

Independence and self-determination are key aspects that are linked to quality of life. Inside an aircraft, it is important to present information to all user groups in the most effective and efficient form. Blind and visually impaired people face different kinds of limitations and difficulties in their daily lives, especially when they need to interact with public environments, which they may not be familiar with. Despite blindness or visual impairment, people cannot or do not want to give up on traveling by plane. Since an airplane is not an everyday living space, it is particularly difficult for the blind and visually impaired to orientate themselves inside the aircraft cabin and the aircraft lavatory. In order to make traveling by plane as pleasant as possible for blind and visually impaired people, they need to get best possible support by the cabin crew and through appropriate cabin design.

Nowadays, the design and technologies inside the aircraft lavatory do not fit the needs of blind and visually impaired people. This situation has to be improved in order to provide convenience and overcome existing barriers. An inclusive aircraft lavatory for blind and visually impaired people will not only help them but might also help other user groups interacting with this environment.

1.2 Objectives

The objective of this Bachelor Thesis is to develop a design concept for an inclusive aircraft lavatory environment for blind and visually impaired people. In this inclusive lavatory environment blind and visually impaired people shall be able to move freely and use the lavatory equipment without needing the help of a fully sighted person. To achieve this, it is fundamental to analyze the current status regarding the accessibility of aircraft lavatories for blind and visually impaired people. Problems and aspects on the usage of the aircraft lavatory by blind and visually impaired people and their support by cabin crew are going to be analyzed.[1]

The focus of this thesis will be the derivation of requirements for an inclusive aircraft lavatory for blind and visually impaired people as well as the application of these requirements on the development of a design concept for an aircraft lavatory.

The scope of this Bachelor Thesis will be dealing with the following aspects:

- Description of the causes and effects of blindness and visual impairment
- Description of the aircraft lavatory and its usage
- Analysis of the current situation for blind and visually impaired people inside aircraft lavatories
- Derivation of requirements for an inclusive aircraft lavatory environment for blind and visually impaired people
- Development of a design concept for an inclusive aircraft lavatory environment for blind and visually impaired people
- Presentation of further suggestions for supporting blind and visually impaired people inside the aircraft cabin

[1] To improve legibility of this thesis, references to either female or male persons are only given in the masculine form.

1.3 Structure of Work

This Bachelor Thesis is structured in 9 chapters and 2 appendices as follows:

Chapter 1: Introduction

Chapter 2: Defines the terms blindness and visual impairment and gives an overview on the distribution, causes and effects of blindness and visual impairment.

Chapter 3: Gives an overview of the aircraft lavatory environment and its usage.

Chapter 4: Analyzes the current situation for blind and visually impaired people inside aircraft lavatories. It gives a detailed overview on different aspects and problems concerning location and identification of the aircraft lavatory, orientation inside the lavatory, identification and usage of the lavatory equipment and location and identification of the passenger seat.

Chapter 5: Presents requirements needed for designing an inclusive aircraft lavatory environment for blind and visually impaired people.

Chapter 6: Gives a detailed overview of the developed design concept for an inclusive aircraft lavatory environment for blind and visually impaired people.

Chapter 7: Gives further suggestions for supporting blind and visually impaired people inside the aircraft cabin.

Chapter 8: Summarizes the contents of this Bachelor Thesis.

Chapter 9: Describes issues that have not been covered in this Bachelor Thesis and need to be addressed in further studies.

Appendix A: Questionnaires and group discussion guidelines used for surveying.
Appendix A1: Questionnaire used for surveying blind and visually impaired people.
Appendix A2: English translation of the questionnaire in Appendix A1.
Appendix A3: Group discussion guideline used for surveying blind and visually impaired people.
Appendix A4: Questionnaire used for surveying cabin crew.
Appendix A5: Group discussion guideline used for surveying cabin crew.

Appendix B: List of useful publications.

2 Blindness and Visual Impairment

2.1 Definitions and Classification

Blind and visually impaired people belong to the group of persons with reduced mobility (PRMs). The European Regulation (EC) No 1107/2006, a legal framework concerning the rights of PRMs when traveling by air, uses following definition:
"'Disabled person' or 'person with reduced mobility' means any person whose mobility when using transport is reduced due to any physical disability (sensory or locomotor, permanent or temporary), intellectual disability or impairment, or any other cause of disability, or age, and whose situation needs appropriate attention and the adaptation to his or her particular needs of the service made available to all passengers." [1]

People who are visually impaired do not see well enough to perform everyday tasks, even with the aid of glasses, contact lenses, medicine or surgery. The ability of a person to see is usually classified according to the extent of their overall vision, known as their *field of vision*, and how well they are able to see fine detail, known as *visual acuity*. [13] In order to determine which people are counted as visually impaired and which people are counted as blind, the terms *visual impairment* and *blindness* need to be defined further. As can be derived from the definitions noted below, there is no common definition for the term blindness and therefore there are very different estimations on how many people in the world are actually blind.

In the Aid of the Blind program of the United States Congress a person is considered as blind if the remaining vision in the better eye after best correction is equal or less than 1% or a corresponding visual field loss is less than 20 degrees. [2] [3]

In the German Social Security Code (SGB), blind and visually impaired people are defined as follows: [4]

- A person is **visually impaired**, if the visual acuity of his better seeing eye is less than 30% even with best possible correction.
- A person is **severely visually impaired**, if the visual acuity of his better seeing eye is less than 5% even with best possible correction.
- A person is **blind**, if the visual acuity of his better seeing eye is less than 2% even with best possible correction.

Figure 1 illustrates the varying eyesights: A person with only 5% residual vision can see an object at a distance of 5m instead of 100m like a fully sighted person would see it. 5% residual vision can also mean that a person only sees 5% of the normal visual field, thus as if he would see through a keyhole (tunnel vision). [4]

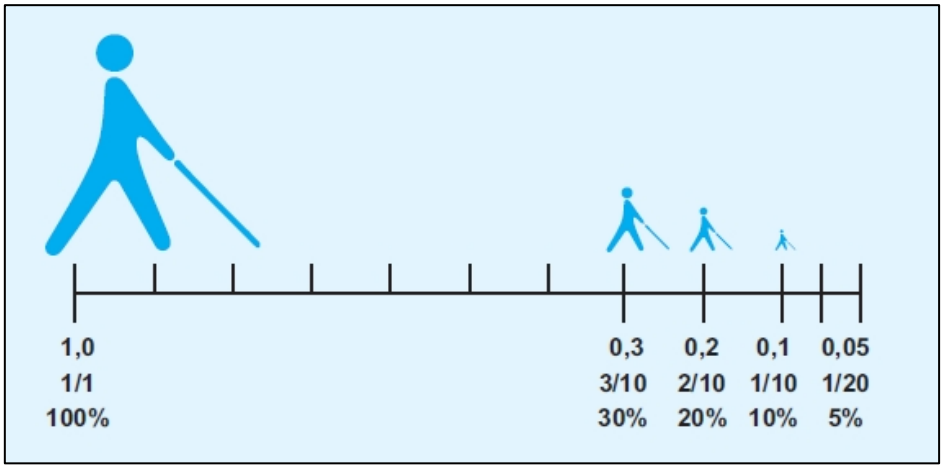

Figure 1: Illustration of varying eyesights [5]

According to the International Classification of Diseases of the World Health Organization, there are four levels of visual function:

- normal vision,
- moderate visual impairment,
- severe visual impairment,
- blindness.

The term *low vision* includes moderate visual impairment and severe visual impairment. Low vision and blindness represent all visual impairment. [6] Low vision is defined as visual acuity between 5% and 30%, or a corresponding visual field loss to less than 20 degrees in the better eye with best possible correction. Blindness is defined as visual acuity of less than 5%, or a corresponding visual field loss to less than 10 degrees in the better eye with best possible correction. [7]

2.2 Facts and Figures

There is no statistically determined data on the actual number of blind and visually impaired people in the world. According to the Fact Sheet No 282 of October 2011 of the World Health Organization (WHO), it has been estimated that currently 285 million people in the world are visually impaired, of whom 39 million are blind and 246 million have low vision. 121 million are visually impaired because of uncorrected refractive errors (see Chapter 2.3). [6] However, the Fact Sheet of 2011 does not provide a precise breakdown of the estimated numbers. Thus, the paper "Global data on visual impairment in the year 2002" of the WHO will be used in this thesis, as it provides very detailed information on the causes and distribution of blindness and visual impairment in the world. According to this paper, there were an estimated 161 million visually impaired people in 2002, which corresponds to 2,57% of the world population. About 37 million were blind (0,57%) and 124 million had low vision (2%) and another 153 million were visually impaired due to uncorrected refractive errors. [7]

The burden of visual impairment is not distributed uniformly throughout the world. The largest shares carry the least developed regions in Africa and Asia (Figure 2). In Europe and the United States of America about 0,2% of the population is blind. However, about 1% of the population in developing countries is blind. About 90% of the world's visually impaired live in developing countries. Figure 3 and Figure 4 show the global estimation of blind and visually impaired people in the world. [7]

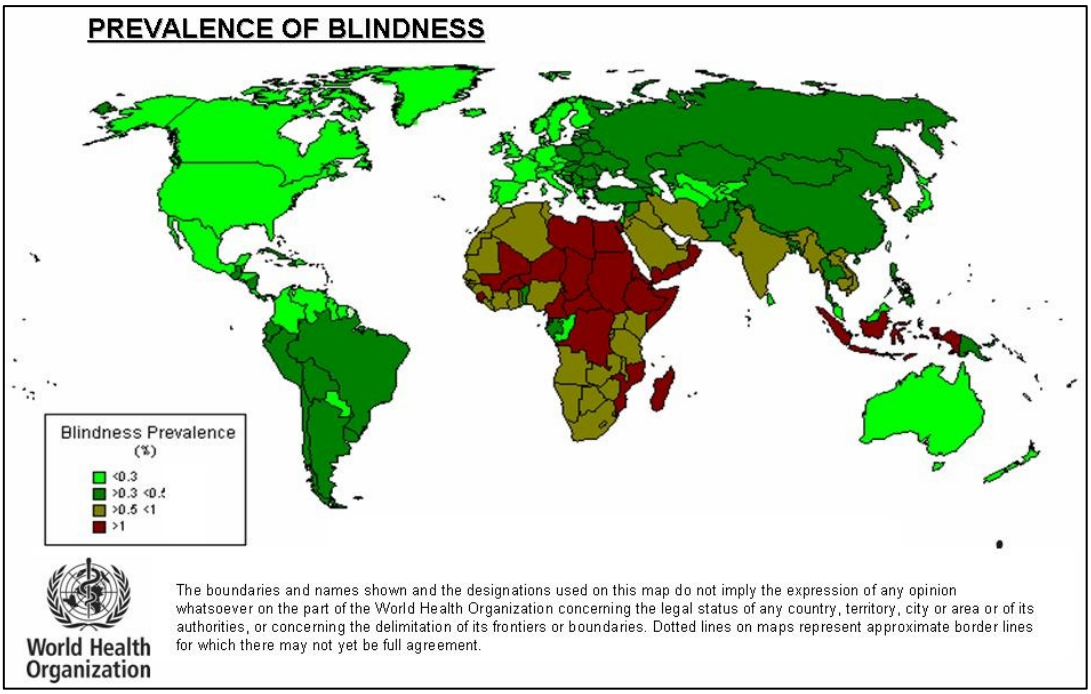

Figure 2: Prevalence of blindness, WHO [8]

	Afr	Amr	Emr	Eur	Sear	Wpr
Population	672.238	852.551	502.823	877.886	1590.832	1717.536
No. of blind People	6.782	2.419	4.026	2.732	11.587	9.312
No. with low vision	19.996	13.116	12.444	12.789	33.496	32.481
No. with visual impairment	**26.778**	**15.535**	**16.469**	**15.521**	**45.083**	**41.793**

Afr, WHO African Region; Amr, WHO Region of the Americas; Emr, WHO Eastern Mediterranean Region; Eur, WHO European Region; Sear, WHO South-East Asia Region; Wpr, WHO Western Pacific Region.

Figure 3: Global estimate of visual impairment (in millions), WHO 2002 [7]

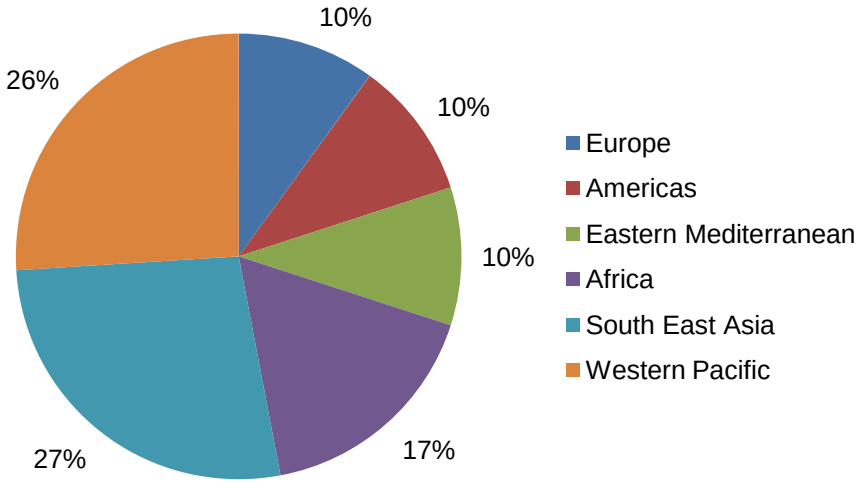

Figure 4: Global estimate of visual impairment (in percent), WHO 2002 [7]

There is also a distribution imbalance across age groups (Figure 5). Although childhood blindness is a significant problem, its magnitude is relatively small when compared to the extent of blindness in the age group of adults over 50 years of age. About 82% of all blind people in the world are adults 50 years of age and older. [7] Due to an increasingly ageing population, many countries (especially in Europe) will likely see a rise in cases of age-related visual impairment.

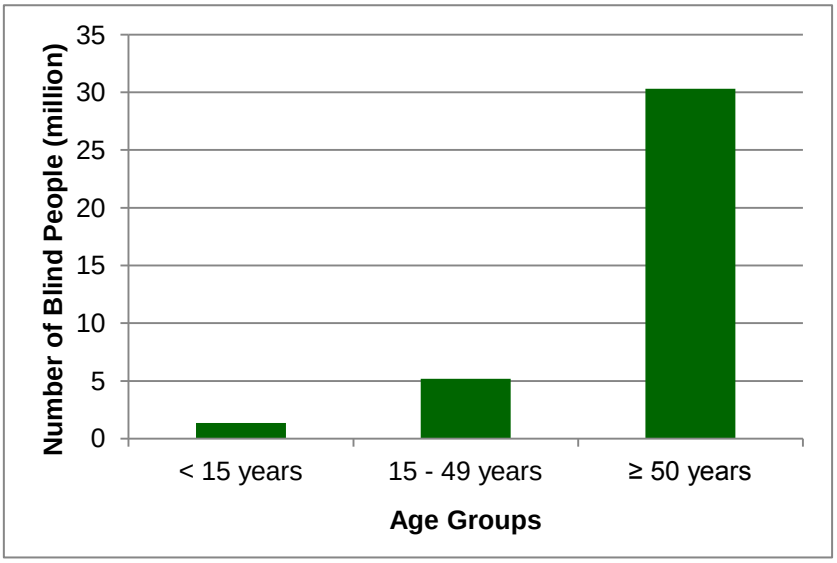

Figure 5: Global extent of blindness, by age (in millions), WHO 2002 [7]

Visual impairment is also unequally distributed with regard to gender: the estimated prevalence ratios indicate that females have a higher risk of having visual impairment than males. [7]

In Germany, blind and visually impaired people are not counted. The WHO assumes that in 2002 there were about 1,2 million blind and visually impaired people in Germany, of whom about 200.000 were blind.[7] About 28.000 people in Germany go blind each year. [4]

Figure 6 shows the number of persons with reduced mobility who were assisted by FraCareServices, which provides assistance to PRMs at Frankfurt/Main Airport. About 540.000 PRMs are assisted every year by FraCareServices. [9]

	JUL	AUG	SEP	OKT
WCHR	32.648	32.731	37.396	35.720
WCHS	8.211	8.616	9.419	9.226
WCHC	2.468	2.553	2.590	2.267
DEAF	548	556	562	402
BLND	467	584	610	503
DPNA	4	30	9	23

Figure 6: Number of PRMs assisted by FraCareServices between July and October 2008 [9]

During the timeframe from July to October 2008, about 1% of the assisted persons with reduced mobility at Frankfurt/Main Airport were either blind or visually impaired. Most of the assisted persons were wheelchair users.[9] But since not all blind and visually impaired people claim such services e.g. because they are very experienced in traveling by plane or they are accompanied by an assisting person, the given numbers in Figure 6 only have limited significance.

2.3 Structure and Function of the Eye

The five human senses are touch, taste, smell, sight, and hearing. Around 80% of the information when moving around and identifying features is gathered through the visual system. [10] The eye is a very complex organ and it is important to understand how the eye interacts and processes light, color and contrast. It is outside of the scope of this thesis to describe all of its components in detail, however, there are several features about the eye that are important to consider (Figure 7).

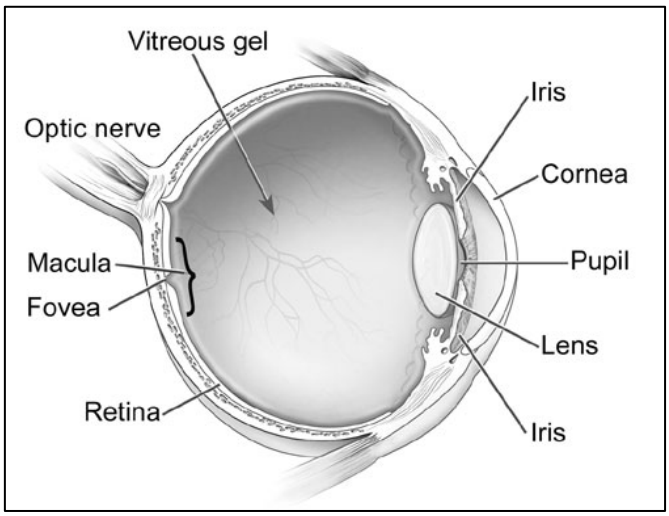

Figure 7: A cross-section through the human eye [11]

How we see depends upon the transfer of light. Light passes through the cornea and the lens, which help focus the light rays onto the back of the eye (retina). The pupil regulates the amount of incoming light by changing its width. The cells in the retina absorb the light and are then converted into electrical impulses which are transferred along the optic nerve into the brain where they are processed accordingly and the image is created. [12]

The macula is a small area at which the light rays are concentrated. The remaining 98% of the retina form the visual field, where movements and objects in the middle and outer periphery of the visual field are perceived. [12]

The retina is composed of four kinds of photoreceptor cells. The rod photoreceptor cells are able to operate well under low lighting conditions and are evenly distributed across the retina. There are also three types of cone photoreceptor cells: the short-, medium-, and long-wavelength cones with the peak sensitivities in the blue, yellow and green spectrum. The cells are clustered within the fovea and operate when the pigments absorb light. [13]

A sharp and clear image on the retina of the eye is essential for good vision. Very often, however, the lens is not able to focus the light correctly onto the retina. Therefore, the eye needs some additional help to focus clearly. Such visual impairment, which can be corrected with e.g. eyeglasses or contact lenses, is called *refractive error* (near-sightedness, far-sightedness or astigmatism[2]). [6] If normal vision cannot be fully restored anymore, the consequences are partial vision loss or even blindness. [12]

What a visually impaired person can see largely depends on which region of the eye is no longer fully functional. Depending on the cause of visual impairment, different regions of the eye can be affected. The most common cause of visual impairment are eye diseases.

[2] Astigmatism is usually caused by an irregularly shaped cornea. In an eye with astigmatism, light fails to focus clearly on the retina. Thus, a sharp and clear image cannot be produced.

2.4 Types and Causes of Visual Impairment

There are a lot of causes for visual impairment and blindness. According to WHO estimates, the most common causes are cataract, glaucoma, age-related macular degeneration, corneal opacities and diabetic retinopathy (see Figure 8). [7]

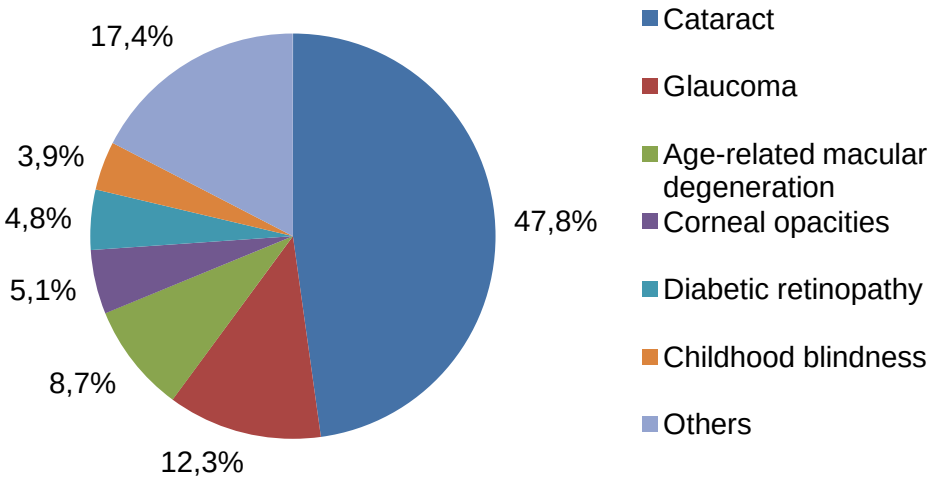

Figure 8: Global causes of blindness (in percent), WHO 2002 [7]

In developed countries, such as in WHO-Region Eur-A (Denmark, Finnland, Iceland, Ireland, Italy, Netherlands, United Kingdom), the major cause of visual impairment is related to ageing. Due to the growing number of elderly people and the rise of life expectancy, age-related macular degeneration is increasing in significance as a cause of visual impairment (see Figure 9). [7]

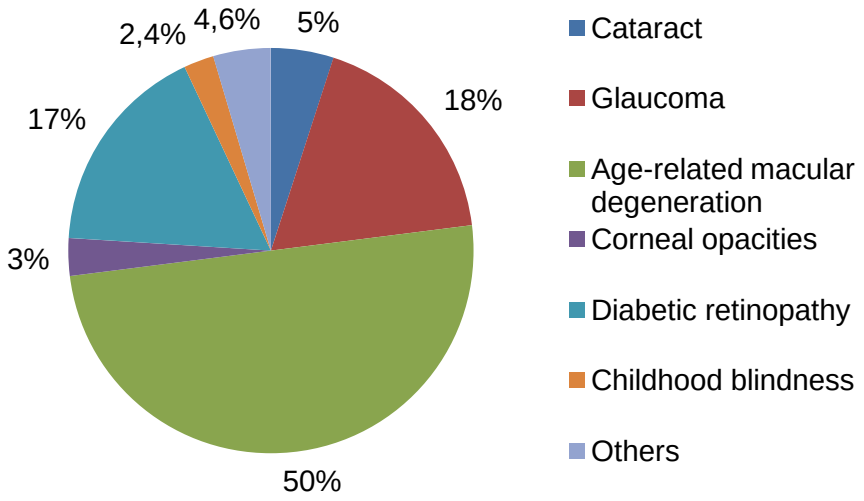

Figure 9: Causes of blindness in WHO Region Eur-A (in percent), WHO 2002 [7]

The various visual impairments affect the eye sight in varying degrees. A brief summary of some of the more common visual impairments will be given as examples to show how they may affect the vision.

The following picture shows a scene as someone without visual impairment would see it. A person without visual impairment is often referred to as a *fully sighted person*.

Figure 10: Perception without any visual impairment [14]

The following pictures illustrate how the scene in the picture above (Figure 10) may appear to someone with visual impairment.

2.4.1 Cataract

Cataract is the clouding of the lens of the eye. This obstructs the passage of light and leads to deterioration of the vision and a general visual field loss (Figure 11). The most common cause is the natural ageing process of the lens, comparable to the wrinkling of skin or the graying of hair. But there can also be other causes, e.g. injuries, inflammation or metabolic diseases such as diabetes. Although cataracts may be removed surgically, surgical equipment and services are inadequate in many developing countries and therefore cataract remains the leading cause of visual impairment in the world. [5] In Germany the cataract surgery is one of the most performed surgical procedures with about 600.000 surgeries every year. [15]

Figure 11: Perception with Cataract [14]

2.4.2 Glaucoma

Figure 12: Perception with Glaucoma [14]

The main characteristic of glaucoma is a dangerous buildup of internal eye pressure, which places pressure on blood vessels. The blood supply is cut, resulting in the damage of the eye's optic nerve. If glaucoma is untreated, it might affect the peripheral vision and the person only sees with the macular region (so called *tunnel vision*, see Figure 12). Progressive eye damage could then lead to blindness. There are approximately 1 million people in Germany who suffer from this eye disease. [5]

2.4.3 (Age-related) Macular Degeneration

Macular degeneration is a disease of the macula (point of sharpest vision), which results to the loss of vision in the center of the visual field (Figure 13). Early signs of vision loss include shadowy areas or distorted vision. It is the leading cause of vision loss and blindness of those aged over 50 years (age-related macular degeneration, AMD). [5] AMD is the most common eye disease in developed countries such as Germany, where about 3 million people suffer from macular degeneration. [16] Due to the rising number of elderly people, vision loss because of AMD is a growing problem.

Figure 13: Perception with AMD [14]

2.4.4 Diabetic Retinopathy

Figure 14: Perception with Diabetic Retinopathy [14]

Diabetic retinopathy is caused due to a high blood sugar level, which leads to changes in the blood vessels. This also affects the small blood vessels in the retina of the eye. One of its characteristics is bleeding in the eye caused by damaged blood vessels and therefore the retina is no longer sufficiently supplied with blood. In some cases, scar tissue may be scattered in the eye causing vision to be patched and blurred (Figure 14). In Germany, about 1 million people with diabetes suffer from diabetic retinopathy. [5]

2.4.5 Retinitis Pigmentosa

Retinitis pigmentosa is associated with an impairment of the peripheral visual field. The loss of the visual field is due to the dysfunction of retinal cells. This usually involves a progressive, gradual and irregular degeneration of the rods, which are located in the periphery of the retina. Only a small central residual vision remains, which is also known as *tunnel vision*. It is often accompanied by a loss of visual acuity and eventually blindness. The person only sees objects that are directly in the line of sight (Figure 15). In Germany, there are about 30.000 to 40.000 people who suffer from retinitis pigmentosa. [5]

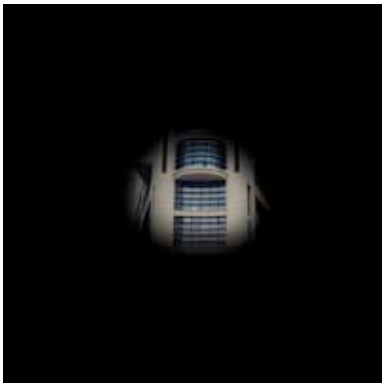

Figure 15: Perception with Retinitis Pigmentosa [14]

2.4.6 Color Blindness

Color vision deficiency, commonly called as *color blindness*, can be part of the different eye diseases described above. People who are color blind have difficulties in distinguishing colors. The term color blindness is misleading: people who cannot see all colors can still see things (other than color) as clearly as people who are not color blind. It is important to take color blind people into account when designing public facilities. [17]

Color blindness is caused when the eye's sensitive cells, known as cones, are faulty or missing (see Chapter 2.3: Structure and Function of the Eye). It can be inherited, which usually affects both eyes equally, or can be acquired as a result of e.g. ageing or injuries. As color blindness is mostly inherited, it affects more males than females. In Europe, about 8% of males and only about 0,4% of females are affected by color vision deficiency. [18]

There are several types or degrees of color blindness. If the function of one type of the cone cells is lost, the person can still recognize fairly good variety of hues using the remaining two cone cell types. But a certain range of colors becomes harder to distinguish. The most common form is a red-green color deficiency, in which a person may be unable to distinguish between red and green, especially when the colors are similar in tone (Figure 16). [17]

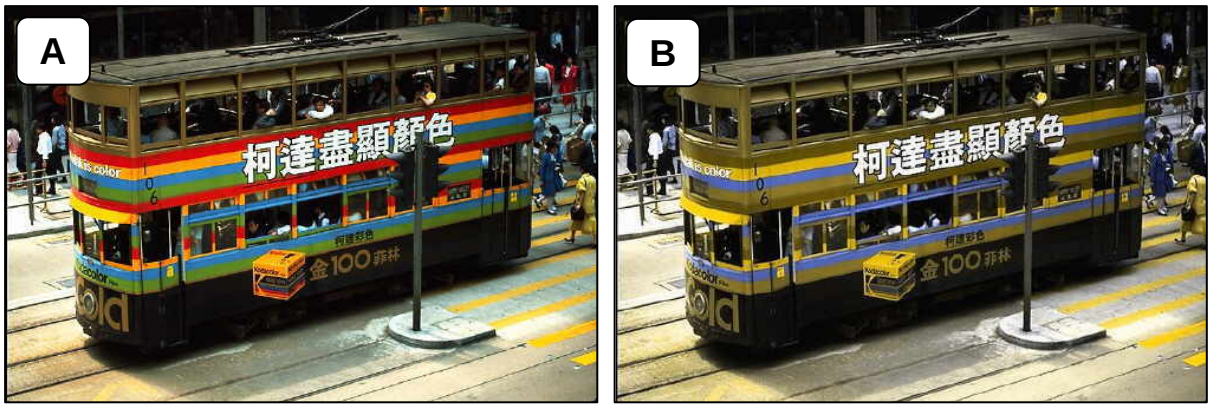

Figure 16: Perception with red-green color deficiency (Figure B) [19]

A rare form of color blindness is a blue-yellow color deficiency in which a person may be unable to distinguish between blue and yellow. [17]

If more than one type of cone cells is faulty or missing, the person loses color vision. Affected persons can no longer see colors but merely different shades of gray. They often have limited visual acuity and their eyes are often very sensitive to glare (Figure 17). This form is rarer than blue-yellow color deficiency. [17]

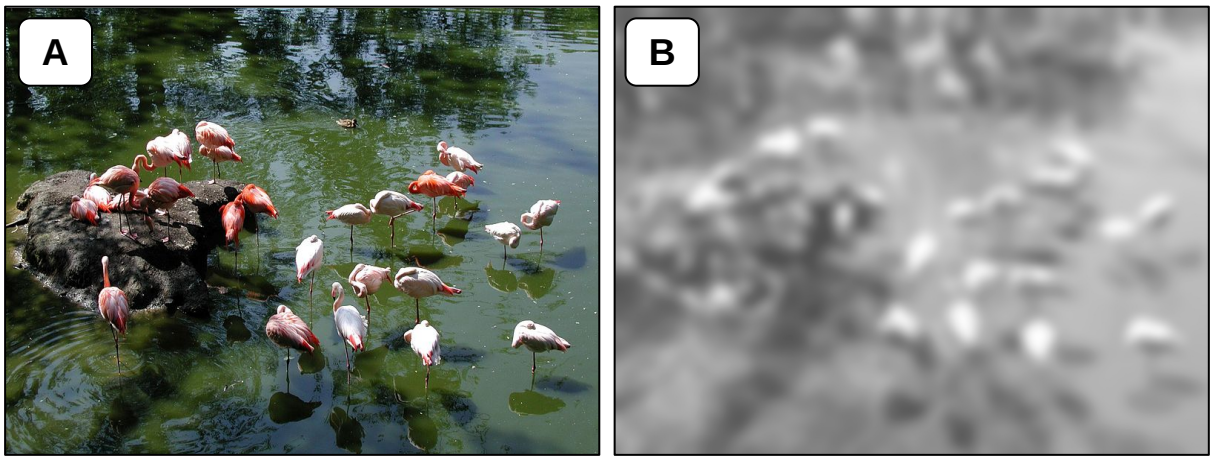

Figure 17: Perception with total color blindness (Figure B) [20]

2.5 Mobility Aids for Blind and Visually Impaired People

Due to their lack of vision, blind and visually impaired people have a better trained tactile and aural sense than normal sighted people. Many blind people feel their surroundings with their hands or tools. Moreover, their aural sense is very sensitive, which is very helpful to compensate the loss of vision. Those who move around independently will do so either solely by using their residual sight or by using a mobility aid. [21]

Many different aids have been invented for the blind and visually impaired: beginning with embossed printing, also known as Braille, to tools of everyday life. White canes and guide dogs give the blind and visually impaired more security when moving around. All these aids are very helpful indeed, but they cannot replace the visual sense. [21]

Braille has been developed in 1825 by the blind Frenchman Louis Braille. The font, which is composed of dots, is embossed into a material such as paper and can be read by touching the surface with one's fingertips (Figure 18). Each Braille character is made up of six dot positions, with which letters are displayed. Since learning takes several years, not every blind person is able to read Braille. Especially persons who turned blind in a late age are mostly not able to read Braille, other than persons, who turned blind in an early age and therefore had the chance to learn Braille at school. [21]

Figure 18: Embossed printing (Braille) [22]

Blind and visually impaired people use the white cane as an aid for orientation (Figure 19). This is used to scan the ground in front of the person by sweeping the cane from one side to the other. The cane warns from obstacles such as stairs or walls and at the same time it serves as a signal for other people to be extra vigilant. Walking with the cane must be learned and trained, which takes about 150 hours. [21]

To make public places more accessible to blind and visually impaired people in everyday life, tactile paving is found on many footpaths and train stations (Figure 19). Tactile paving has a pattern with domes or bars that are detectable by the white cane or underfoot. It is used to guide but also to alert blind and visually impaired people of hazards or dangers such as big gaps or rail tracks. [23]

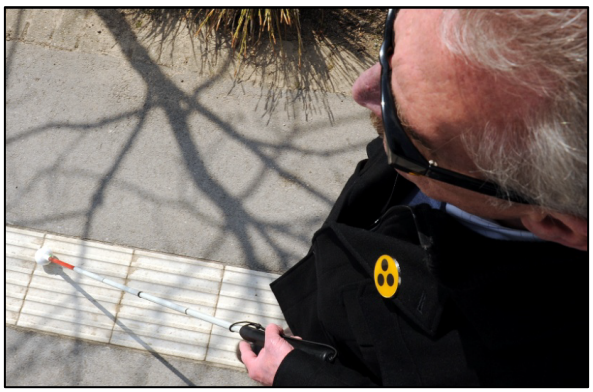

Figure 19: Blind person with a white cane [24]

Alternatively, a visually impaired person may have a guide dog to assist them with their mobility (Figure 20). Guide dogs are trained for about 8 months in a guide dog school. They have to be good-natured, friendly, self-confident and eager to learn in order to be suitable for the activities of a guide dog. A well-trained guide dog can protect its holder from dangers and give him guidance. To cope with a guide dog, the holder needs to be trained as well to perceive the signals of the dog, which are passed onto the holder over the lead harness. [21]

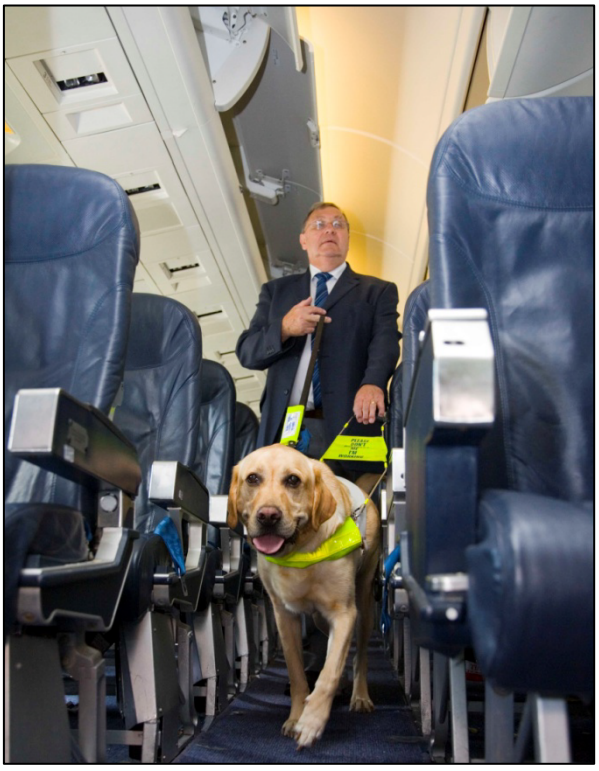

Figure 20: Blind person with a guide dog [25]

3 The Aircraft Lavatory and Its Usage

In order to understand the different aspects blind and visually impaired people need to deal with inside the aircraft cabin and especially the aircraft lavatory, the aircraft lavatory environment and its usage need to be defined. Moreover, it is important to underline the (critical) interfaces between the blind and visually impaired passenger and the lavatory environment. The following sub-chapters give an overview on these issues.

3.1 The Lavatory Environment

Aircraft lavatories have fixed locations and are mostly installed near exits. The lavatories in short- or medium-range aircraft (e.g. A320, B737) are located in the front (door 1) or in the rear of the cabin (door 4). Figure 21 shows possible locations of the lavatories (L) inside a Lufthansa A320.

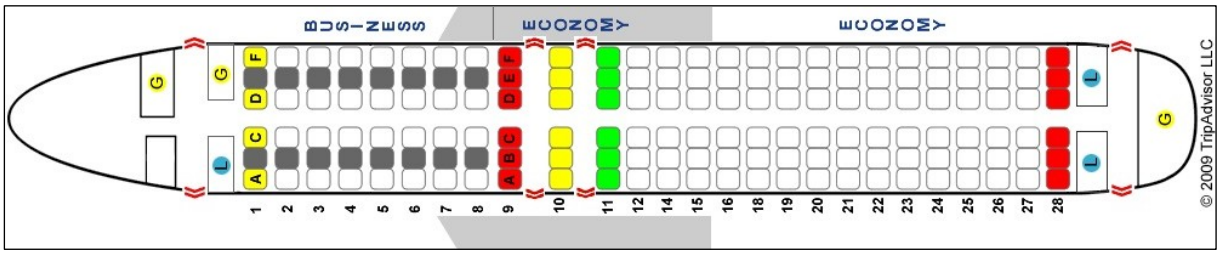

Figure 21: Aircraft overview of a Lufthansa A320-200 [26]

The lavatories in long-range aircraft (e.g. A340, B747) are mostly located in the front and in the rear of the cabin, as well in the area in front and behind the wing of the aircraft (door 2, door 3). Figure 22 shows possible locations of the lavatories inside a Lufthansa A340.

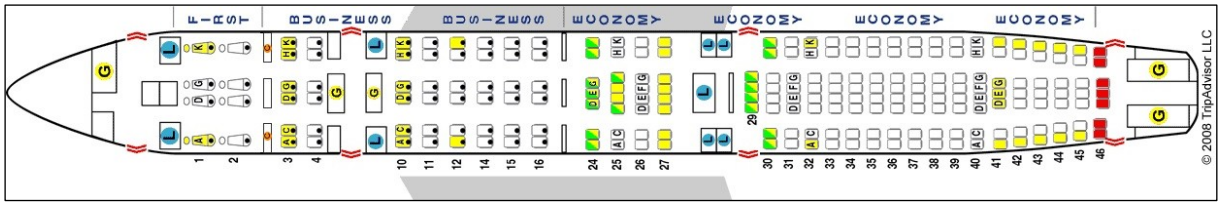

Figure 22: Aircraft overview of a Lufthansa A340-300 [26]

As there is very small space for monuments inside the cabin, lavatories are adapted to the form of the cabin section where they are installed. Hence, there can be different lavatories built inside an aircraft. Lavatory design varies from aircraft to aircraft and airline to airline. Most aircraft have standard size lavatories, which have the dimensions of about 38” x 41” (width x depth) and are not wheelchair accessible (Figure 23). [27]

Figure 23: A380 Main deck lavatory [28]

The main components of an aircraft lavatory are the lavatory housing with a door, a toilet bowl with a flush button, wash basin with water faucet, soap and paper towel dispensers, waste bin, a mirror and a nursing table. The original equipment manufacturer (OEM) offers various options to the airline company on how the aircraft lavatory can be customized through the selection of different items and associated technical solutions, such as a touchless water faucet. Figure 24 shows a basic configuration of an A380 lavatory. [27]

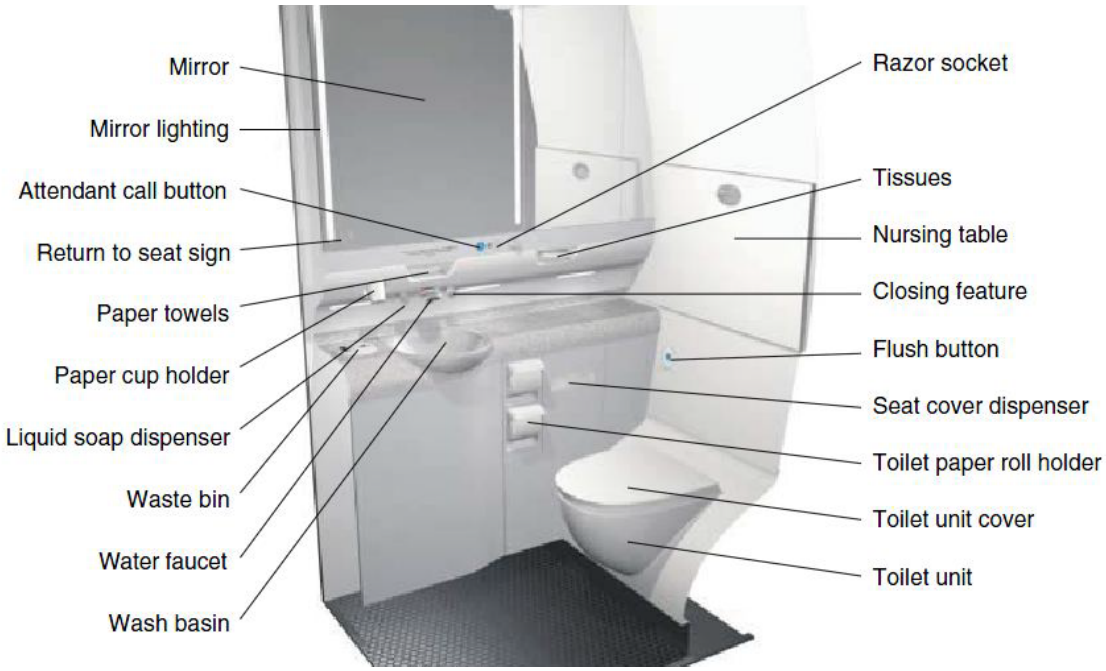

Figure 24: A380 Main deck lavatory equipment overview [27]

Wheelchair accessible lavatories (PRM lavatories) have an increased size (width ≈ 56”) and are specially designed for PRMs (Figure 25). The units offer specific PRM features, such as a lever-type door handle and additional handrails, and the wide door allows access for wheelchair bound passengers with a personal escort. [27] However, only long-range aircraft need to be equipped with at least one PRM lavatory. [1] Further regulations concerning the aircraft lavatory and other aspects regarding blind and visually impaired people are found in Chapter 4.1: Applicable PRM Regulations.

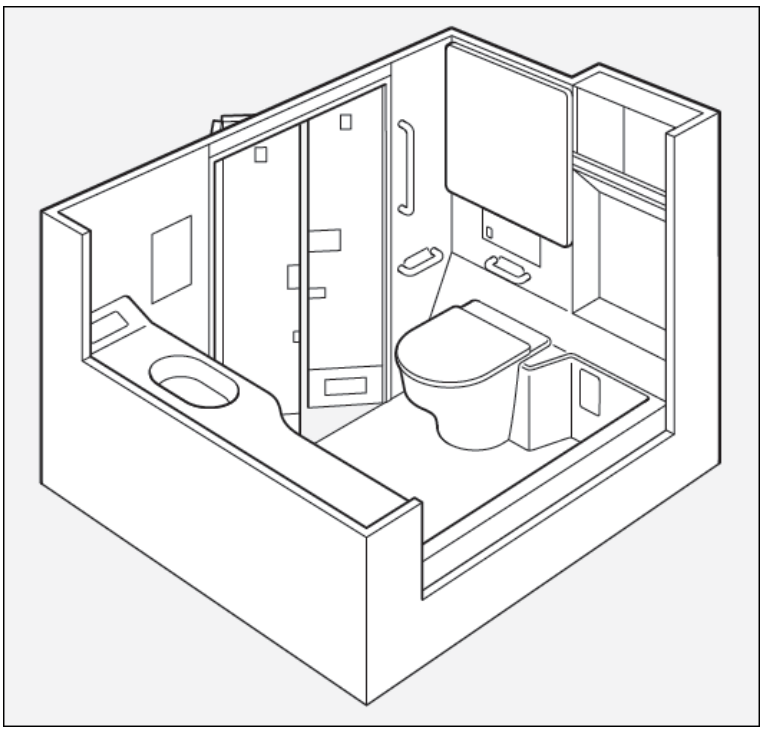

Figure 25: Schematic of an A380 PRM lavatory [29]

3.2 The SHEL(L) Model

The SHEL(L) Model is particularly useful in examining Human Factors issues in systems such as the aircraft lavatory. It is helpful to underline the (critical) interfaces between the blind and visually impaired passenger and the lavatory environment. The Software, Hardware, Environment and Liveware Model is a theoretical framework, which is often used to describe the focus of Human Factors. It explains the interrelations and interdependencies of different system components on the one hand and the human component on the other hand under the influence of environmental conditions.[30] According to the model, the different components are defined as follows:

S – Software (practices, procedures, etc.)

H – Hardware (technical systems and equipment)

E – Environment (external influences and factors)

L – Liveware (the human: passenger and cabin crew)

Figure 26: The SHEL(L) Model [31]

Concerning the topic of this Bachelor Thesis, the blind or visually impaired passenger (BLND) is the focus of interest (*Liveware*) in this SHEL(L) model. If the BLND needs to go to the lavatory, he might probably get in touch with an assisting person or with the cabin crew (*Liveware*). Yet, this interface should not be necessary as the BLND (or passenger in general) wants to move independently and freely inside the cabin. The area in front of the lavatory, the lavatory itself and the environmental influences, such as temperature and light, constitute the *Environment*. The interior of the lavatory, e.g. toilet seat, flush button, soap dispenser or faucet, forms the *Hardware*. Instructions and regulations, which are written or illustrated on placards and signs, form the *Software*.

There can be critical interfaces between the different components, which can be:

- L – S Regulations and instructions are not comprehendible
- L – H The flush button cannot be detected or reached
- L – E The lavatory has a glaring light source
- L – L Cabin crew is not trained concerning how to interact with BLND

The focus of interest in this thesis will be the critical interfaces Liveware – Liveware, the interaction between BLND and cabin crew, and Liveware – Hardware, the interaction between the BLND and the lavatory hardware.

3.3 Sequences of Action

There are several difficulties for BLNDs to use an aircraft lavatory. To give an impression on the areas of interest for the design and configuration of a lavatory, the detailed process of lavatory utilization is outlined in the following.

In order to get to the lavatory, the BLND needs to leave his seat first. He has to find his way alongside the aisle to the lavatory door and identify if the lavatory is vacant, occupied or out of order. If the lavatory is vacant, the BLND can then open the door, get inside the lavatory and close and lock the door from the inside. The BLND has to orientate himself inside the lavatory, as he has to find out how the lavatory is structured and designed in order to operate the different elements. When locating the toilet unit, he needs to open the toilet unit cover to take a seat. Afterwards the BLND needs to locate and operate the flush button and wash his hands by using the water faucet and the soap dispenser. To dry his hands, he has to get some paper towels from the paper towel dispenser. The wet paper towels are then disposed in the waste bin. Eventually the BLND also wants to groom himself, wash his face, brush his teeth or shave inside the lavatory. In some lavatories it is also possible to take a shower during flight. If the BLND is done inside the lavatory, he has to unlock and open the door and find his way back to his seat. If problems occur inside the lavatory or if the BLND is in need of help, the BLND should know where the attendant call button is located and how it is operated.

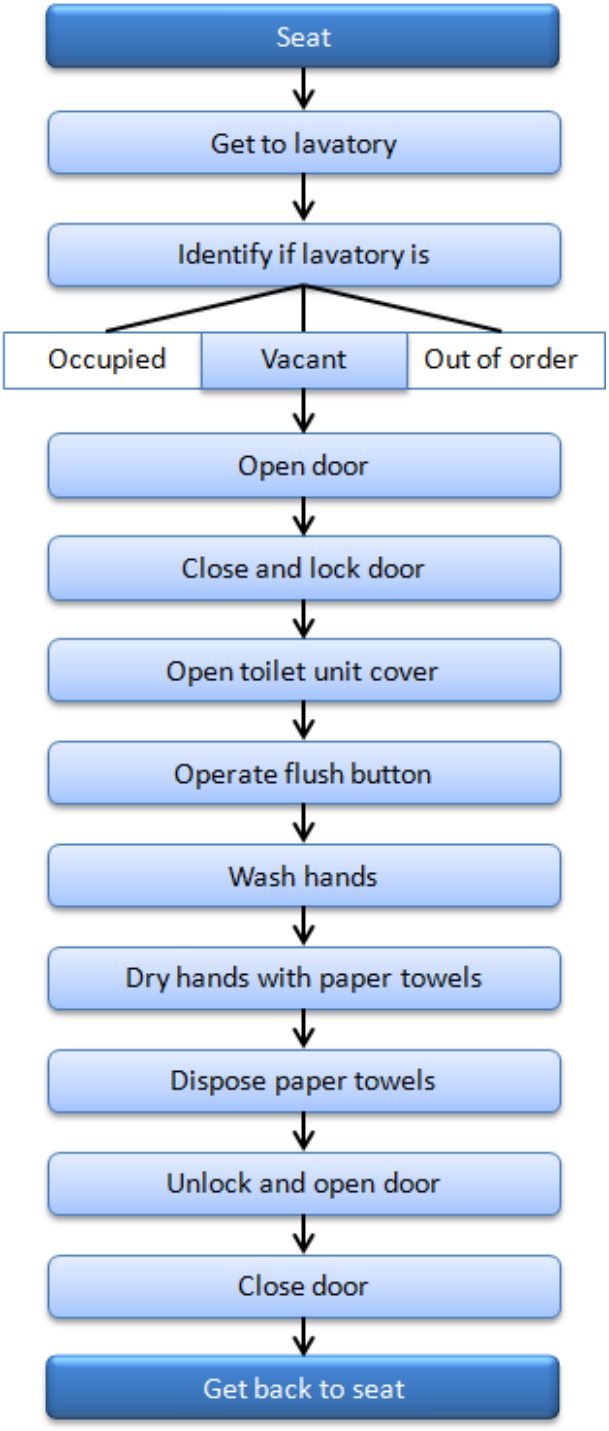

Figure 27: Sequences of action [Source: Author]

4 Status Quo of Current Lavatory Design and Usage

In order to describe the current status regarding the accessibility of aircraft lavatories for blind and visually impaired people, it is fundamental to analyze their experiences inside the aircraft lavatory. Furthermore, it is important to identify what regulations regarding blind and visually impaired people the airlines need to comply with.

4.1 Applicable PRM Regulations

Persons with reduced mobility have the same rights to free movement as any other, non-disabled person. This is applicable to traveling by plane as to every other situation in life. It is the responsibility of everyone in an organization to ensure they meet the needs of their customers.

In the following, the rights of access to air travel and passenger rights are presented. In the European Union (EU), the rights of persons with reduced mobility when traveling by air are implemented in the “Regulation (EC) No 1107/2006 of the European Parliament and the Council”. Concerning flights to and from the United States, the rights of persons with reduced mobility are defined in the “Air Carrier Access Act, 14 CFR Part 382, Nondiscrimination on the Basis of Disability in Air Travel” of the U.S. Department of Transportation. Both are regulations that prohibit discrimination in airline service on the basis of disability or reduced mobility. There are minimum requirements laid down in these regulations. They clearly explain responsibilities of the traveler, airlines and airport operators and are designed to minimize special problems that persons with reduced mobility face when traveling by plane. [32] [1] Regulations regarding PRMs in general and blind and visually impaired people in particular are listed below.

Crew Training

Airlines, which operate aircraft with more than 19 passengers, shall provide training on PRMs to all its personnel. This training shall be appropriate to the duties of each employee (14 CFR §382.61) and shall be designed to help the employee understand the special needs of these travelers.

Assistance by the Crew

Airlines shall provide required assistance to a PRM in moving to and from the lavatory, which does not include lifting or carrying the PRM (14 CFR §382.39; EC 1107/2006 Annex II).

Accompanying Persons

In order to meet applicable safety requirements, airlines may require that a person with reduced mobility is accompanied by another person who is capable of providing assistance to that person (EC 1107/2006 Article 4).

Carriage of Guide Dogs

Airlines shall permit the carriage of a guide dog in the cabin. The guide dog shall then be permitted to sit where the PRM sits, unless the guide dog obstructs the aisle or other areas which must remain unobstructed in an emergency evacuation (14 CFR §382.55; EC 1107/2006 Annex II).

Mobility Aids and Assistive Devices

PRMs shall be permitted to bring on board white canes and other assistive devices (14 CFR §382.41).

Passenger Seats

In aircraft with 30 or more seats at least half of all aisle seats shall be provided with movable armrests (14 CFR §382.21). It shall be ensured that PRMs can obtain seating in rows with movable armrests. Carriers shall comply to Federal Aviation Authority (FAA) safety rules, including those concerning exit seats (14 CFR §382.38). A person must not be seated in an exit row, if this person lacks sufficient mobility (14 CFR §121.585).

Access to the Lavatories

On board an aircraft with more than one aisle (e.g. A380) at least one accessible lavatory shall be included. The lavatory shall be spacious enough to allow a passenger using an on-board wheelchair to enter and maneuver inside the lavatory. It shall also provide door locks, accessible call buttons, grab bars, lever faucets and other controls and dispensers (14 CFR §382.21).

In accordance to the Air Carrier Access Act, aircraft delivered after April 1992 need to be accessible. Aircraft delivered before April 1992 must meet the accessibility requirements, if its interior is been refurbished. [32]

As one can see, there are a number of accessibility issues that are not implemented in the regulations, such as accessible lavatories in narrow body / single aisle aircraft. Important key aspects on design, comfort and convenience have not been considered. Furthermore, the requirements on aircraft lavatories do not cover the needs of all persons with reduced mobility, such as blind and visually impaired people.

4.2 Survey of Blind and Visually Impaired People and Cabin Crew

To make an aircraft lavatory as accessible as possible, it has to be figured out where blind and visually impaired people need support and also where cabin crew need support in assisting the BLNDs. It has to be identified how the BLNDs interact with other elements, such as the system environment, user interfaces and other individuals, e.g. the cabin crew (see Chapter 3.2: The SHEL[L] Model). Existing systems need to be evaluated in order to identify design errors and problems and also to put out efficient aspects that may be used in the new designs. The starting point for designing future systems is a description of the current or likewise systems. The evaluation of existing systems requires that specific data regarding usability and task performance are collected and analyzed accordingly. To obtain information on how BLNDs can be supported in the aircraft cabin, and especially in the lavatory, BLNDs as well as cabin crew have been questioned.

Materials

To gather as much information as possible on the current status, questionnaires have been distributed and group discussions have been conducted as data collection methods for the analysis on the usage of the lavatory by blind and visually impaired people.

Questionnaires are particularly useful for discovering people's opinions and attitudes on a specific subject and large amounts of information can be collected quickly. When data cannot be directly availed from an observational study then the most effective way to gather information is usually to employ a questionnaire. [33] The (electronic) questionnaires need to be designed properly, especially for the blind and visually impaired people. BLNDs cannot properly read the questionnaire if it is made out of e.g. tables, figures and checkboxes. The questionnaire needs to be barrier-free, which means that it has to have a simple layout and structure where e.g. the questions are written down one by one, so that the BLNDs are able to read it properly on their Braille terminal display (Figure 28).

Figure 28: Braille terminal display [34]

Large amounts of specific information on a particular subject can be provided through interview methods. Especially group discussions encourage people to express and discuss their opinions which can provide an efficient means of bringing out a consensus opinion. In order to gain a lot of information, the group discussion needs to be structured but also needs some flexibility. Thus, the focus of the group discussion can be directed and information on new or unexpected issues can be uncovered and explored. [33]

The questionnaires and group discussion guidelines used for gathering data for this thesis are subdivided to obtain information on general aspects, aspects on getting to the lavatory, usage of the lavatory and getting back to the seat. As described before, the focus of interest are the interrelations between the BLND, the cabin crew and the lavatory hardware. Information has been collected on numerous issues such as the design in general, usability, user perceptions and experiences, satisfaction, errors and user opinions and attitudes. The group discussion guidelines and questionnaires are provided in Appendix A.

Procedure

For the data collection, the questionnaires have been distributed among blind and visually impaired people, who are members of the German Association of Blind and Visually Impaired People (DBSV), and among a group of former Lufthansa cabin crew, consisting of seven flight attendants, who have worked as cabin crew for an average of five years. 22 questionnaires have been completed and sent back by the blind and visually impaired.

After the questionnaires have been distributed, group discussions have been conducted, as further questions have emerged through the completed questionnaires. Therefore, the same group of Lufthansa cabin crew has been questioned to look deeper into particular issues. In order to gain further information by blind and visually impaired people, the working group “Environment and Transportation” of the Association of Blind and Visually Impaired People in Hamburg (BSVH) has been questioned in a group discussion.

Information on different aspects and problems that blind and visually impaired people are dealing with inside the aircraft cabin have been obtained through the aid of these surveys. In the following sub-chapter, the present conditions inside the aircraft cabin and aircraft lavatory are mainly presented with the aid of the results of these surveys but also with information provided by different airlines on their websites. Moreover, requirements for an inclusive aircraft lavatory environment will be derived from the results of these surveys (see Chapter 5: Derivation of Requirements for an Inclusive Aircraft Lavatory Environment).

4.3 Present Conditions inside the Aircraft Cabin and Lavatory

Nowadays most aircraft lavatories are not accessible neither for wheelchair occupants nor for blind and visually impaired people. Accessible PRM lavatories are only found on twin aisle, long-range aircraft and are mostly only designed for the needs of wheelchair occupants (see Chapter 3.1: The Lavatory Environment). Airbus is currently developing a wheelchair accessible lavatory for short-range aircraft (e.g. A320), which is called the Space-Flex Lavatory. [35] However, much more has to be done for PRMs in general and in particular for blind and visually impaired people concerning accessible cabin and lavatory design.

Information on the provided service and cabin features can be found on the webpage of the respective airlines. PRMs can obtain information regarding accessibility of the particular aircraft in advance before taking a flight. When PRMs book their ticket, they need to inform the airline at least 48 hours before departure regarding their special needs for assistance. Thus, the airline can make all reasonable efforts to provide the service required. [36]

Several airlines have already been dealing with the needs of blind and visually impaired people. For example, some airlines such as Air France or Alitalia have safety briefing cards and a cabin layout in large print text overlaid with Braille characters (Figure 29). In the latest aircraft of Air France, some useful information, e.g. seat numbers and instructions inside the lavatory, are written in Braille. [37] Anyhow, the blind and visually impaired that have been surveyed are not satisfied with the current situation inside the aircraft cabin, as these information are not provided by all airlines and also not in all aircraft. The experiences of the surveyed BLNDs as well as of the surveyed cabin crew will be presented in the following.

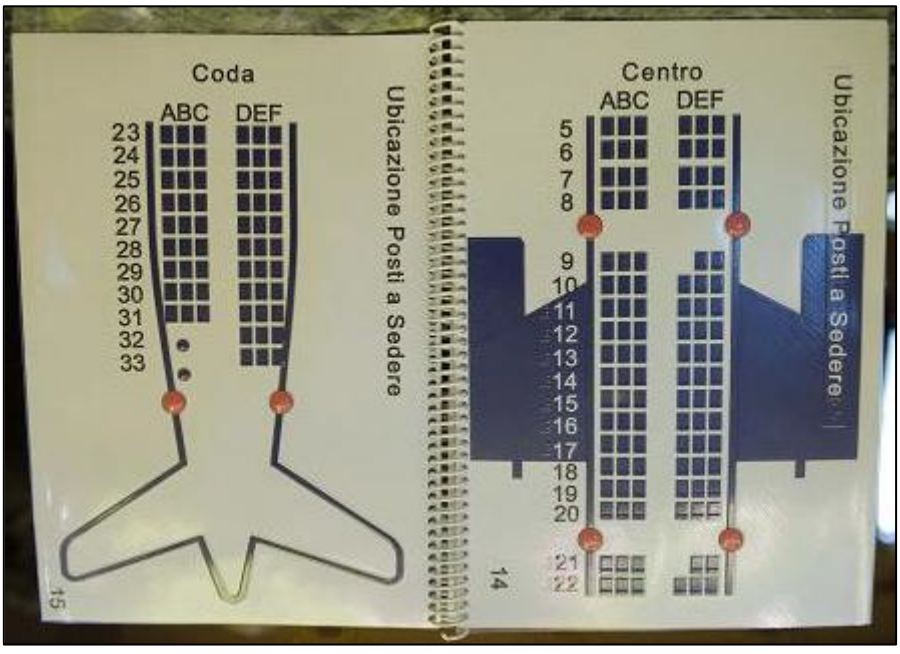

Figure 29: Tactile cabin layout provided by Alitalia [38]

4.3.1 General Operational Aspects

Most surveyed BLNDs travel either with an assisting person or with their guide dog. There are certainly also BLNDs, who fly on their own. A minority of them are frequent flyers, who feel comfortable and are familiar inside the aircraft cabin. However, most surveyed BLNDs, who fly on their own, need assistance by the cabin crew. [39] [40]

The cabin crews are trained to give good service to the passengers. BLNDs and PRMs in general mostly board the aircraft first, as they need special assistance to get to their seat. Upon boarding, the cabin crew will help the BLND to get seated and give him information about the immediate surroundings: where the seat of the BLND is located within the aircraft, where to find the emergency exits and lavatories, where the attendant call button is placed, where the oxygen masks are located and how they are used. In practice, however, a majority of the surveyed BLNDs assume that most airlines only give a personal safety briefing to the BLNDs upon request, as it consumes plenty of time. But it also mostly depends on the personal initiative of the flight attendant. It has to be considered that flight attendants are not specially trained to be personal caretakers and therefore only know little about the needs of blind and visually impaired people. [39] [40]

4.3.2 The Cabin Environment

PRMs have specially assigned seats inside the aircraft. The location of these seats depends on the airline. At Lufthansa, for example, the PRMs are seated between two emergency exits on a window seat. According to the surveyed cabin crew, this is needed to ensure a smooth and fast evacuation to all passengers. Thus, the impaired passengers also have a longer way to get to the toilet. On the other hand, PRMs flying with Emirates are seated in aisle or bulkhead seats (Figure 30). This has the advantage that the PRM can get to the lavatory much easier and faster. Furthermore, it is more convenient for the cabin crew when assisting and helping the PRM. [40]

Blind and visually impaired people need help by other passengers or the cabin crew in order to find their seat. All surveyed BLNDs have stated that they cannot perceive the seat number signs, as the lettering is too small. Further, none of the surveyed BLNDs have ever been inside an aircraft where tactile Braille characters are used on the signs. Some of them count the seat rows from their seat to the lavatory beforehand to find their way back, which can also be a hassle if the seat is located far from the lavatory. Because of this hassle, most surveyed BLNDs ask the cabin crew for help when they want to go to the lavatory. However,

the attendant call button at the passenger seat is not always located at the same position and does not have a tactile labeling, which makes it a challenge for BLNDs to identify it. [39]

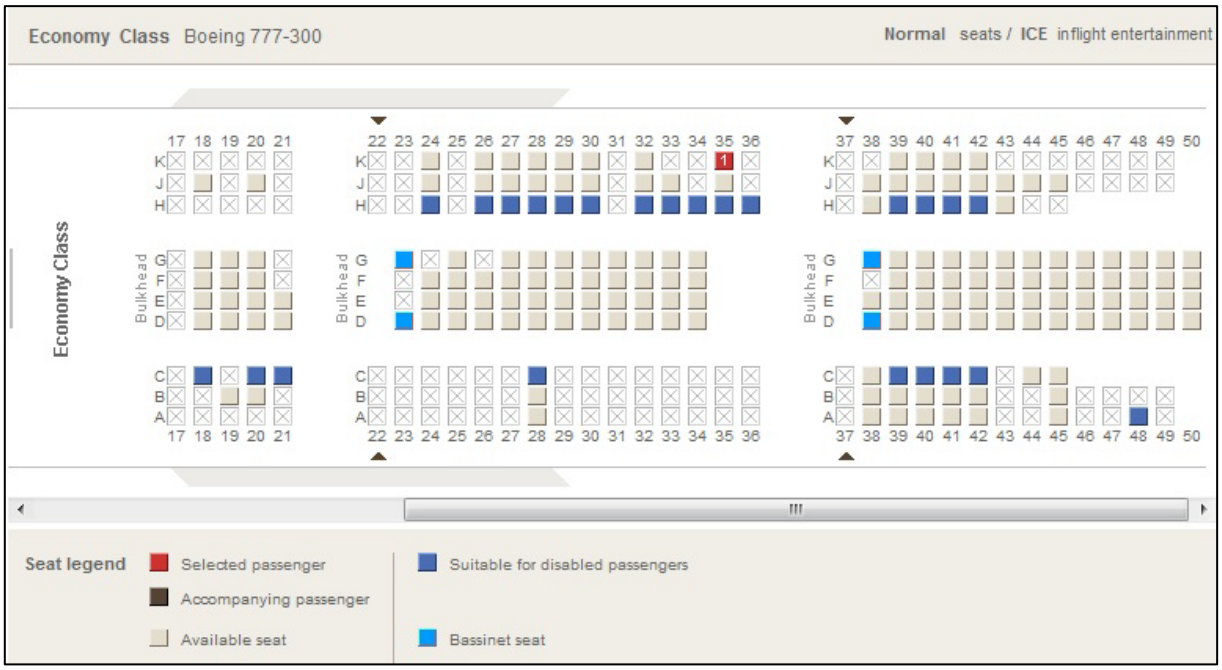

Figure 30: Cabin overview indicating suitable seats for disabled passengers (Emirates) [41]

4.3.3 The Lavatory Environment

Most BLNDs that have been surveyed need to be assisted when going to the lavatory. First, the BLND calls the cabin crew by pushing the attendant call button. Afterwards, the flight attendant accompanies him to the lavatory. The flight attendant shows the BLND the relevant parts inside the lavatory (see Chapter 3.3: Sequences of Action) and describes him how they are operated. The flight attendant then closes and locks the lavatory door from the outside. In case the BLND is in need of help, the flight attendant waits in front of the lavatory until the BLND is finished to get back to his seat. The surveyed flight attendants confirm that this whole procedure is very time consuming for them and they are not able to perform their work while they are assisting the BLND. [40]

BLNDs, who do not ask the cabin crew for help, need to find the way to the lavatory on their own. The BLND slowly walks along the aisle until he gets to the lavatory. He often has to ask other passengers where the lavatory is, as it is very difficult for the BLND to locate it. He usually tries to push the door open in order to identify if the lavatory is vacant or occupied. But without any help, he is not able to identify if the lavatory is out of order. Moreover, the vacant / occupied sign is hardly identifiable for the BLND. Opening, closing and locking the door is no problem, as long as the BLND is familiar with the mechanisms. [39]

User Interfaces

Inside, the BLND first needs to orientate himself to locate the different components of the lavatory, as the different elements do not have a fixed location inside all lavatories. The BLND has to verify the positions of the different parts by touching them, which is not very pleasant due to hygienic reasons. It is hard for the surveyed BLNDs to distinguish the flush button, as it almost has the same tactile surface characteristics as the wall. Since Braille or tactile labeling is not used inside the lavatories of most airlines, the surveyed BLNDs cannot distinguish between the different buttons, especially the attendant call button and the flush button. It happens occasionally that BLNDs accidentally operate the attendant call button instead of the flush button. Other surveyed BLNDs however, do not even know that there is an attendant call button inside the lavatory. The newest and most modern technologies, such as the touchless opening of the waste bin, are not of an advantage for BLNDs. It is difficult enough for them to find the opening of the waste bin when they do not know that the waste bin is opened with a downward flap mechanism. Trial and error is a process which they need to do to find out how the mechanisms work. [39]

Return to Seat Sign

The illuminated return to seat sign and the cabin chime are hard to identify for the surveyed BLNDs. Non-frequent-flyers do not necessarily know how to interpret the cabin chimes. [39]

Lavatory Lighting

Some of the surveyed visually impaired people find the lighting inside the lavatory slightly diffuse and dark, others however feel comfortable with the lighting. If the lighting is too dark, they have problems perceiving information through their eyes, which means that they need to use their tactile sense even more. [39]

Color Scheme of the Lavatory

The lavatory is painted in low-contrast gray color shades, which makes it especially for visually impaired people difficult to identify the different lavatory components. [39]

Guide Dog

Surveyed BLNDs with a guide dog find it inconvenient to get to the lavatory with their dog, as there is not much space to move inside the cabin. They usually leave the guide dog at their seat and ask the cabin crew for help in order to get to the lavatory. [39] [40]

The visit to the lavatory consumes a lot of time, not only for the BLNDs but also for the cabin crew. Due to inconveniences caused by these identified problems, some of the surveyed BLNDs avoid going to the lavatory even on long-range flights. [39] [40]

4.4 In Comparison: Present Conditions inside the Train Cabin

Lavatories are also found in long-distance trains such as the IC or ICE in Germany. Surveyed blind and visually impaired people recommended designing the aircraft cabin and lavatory environment similar to the redesigned cabin of the ICE 2. The redesigned cabin of the ICE 2, the second series of the high-speed train, has got many features inside the cabin for BLNDs. Due to the upcoming extensive modernization of all ICE-Trains, a standardized cabin design with a high comfort level for all PRMs will be realized. [42]

At every door inside the redesigned ICE 2, a tactile train overview is provided to give better guidance inside the train. There is a high-contrast and tactile guidance system with attention fields on the floor leading through the train, which give better orientation to the blind and visually impaired. All seats are provided with seat numbers in Braille and embossed lettering, which are installed on the side of the headrest of each aisle seat. Furthermore, handles on the side of each aisle seat provide more safety to all passengers when moving inside the cabin. [43]

Figure 31: Tactile train overview [44]

Figure 32: Tactile seat numbers with Braille [43]

Figure 33: Attention field indicating the entrance of the first class cabin [44]

Inside the lavatory of the redesigned ICE 2, illustrations and pictograms are used on placards for better comprehensibility. For blind and visually impaired people, Braille and embossed elements have been added to the placards. The red emergency button (attendant call button) has a high contrasting color and is signposted with a green SOS placard. Due to hygienic reasons, disinfectant dispensers are provided in the vicinity of the wash basin inside every lavatory of the redesigned ICE 2. [42]

Figure 34: Lavatory of the redesigned ICE 2 [44]

Figure 35: Tactile placard on the ICE lavatory door [Source: Author]

Figure 36: Usage of tactile pictograms and Braille on placards inside ICE lavatories [Source: Author]

4.5 Workshops for Blind and Visually Impaired People

In order to familiarize BLNDs and other PRMs with the aircraft cabin environment, they either need best support by the cabin crew or they can attend a workshop, as offered by the Aircraft Safety Network.

The Aircraft Safety Network (ASN), with its headquarters at Vienna Airport, offers safety training courses for flight attendants and for passengers as well. The goal of ASN is to give passengers a better understanding of various safety issues, which can occur during a flight. “Accessible Air Travel” is a workshop in which the ASN cooperates with the Austrian Association for Blind and Visually Impaired People. It gives BLNDs the opportunity in getting more familiar with the aircraft by showing and letting them touch the different parts inside the cabin, including the lavatory. Thus, the BLNDs have a better orientation inside the cabin, which helps them on future flights. They also learn how to behave during an emergency evacuation, how to put a life jacket on (Figure 37) and how to use the evacuation slides. [45]

Figure 37: Workshop of the Aircraft Safety Network [45]

However, the aircraft cabin and lavatory environment should be as accessible as possible for blind and visually impaired people without needing them to attend such workshops. Accessible facilities need to be provided for BLNDs, which will help them move around independently inside the aircraft cabin.

5 Derivation of Requirements for an Inclusive Aircraft Lavatory Environment

5.1 The NABC Value Assessment Method

The NABC value assessment method stands for **N**eeds, **A**pproach, **B**enefits and **C**ompetition, which helps structure thoughts and facts. It is an easy tool to analyze and develop value propositions for projects by defining the four parameters Needs, Approach, Benefits and Competition, which try to answer following questions: [46]

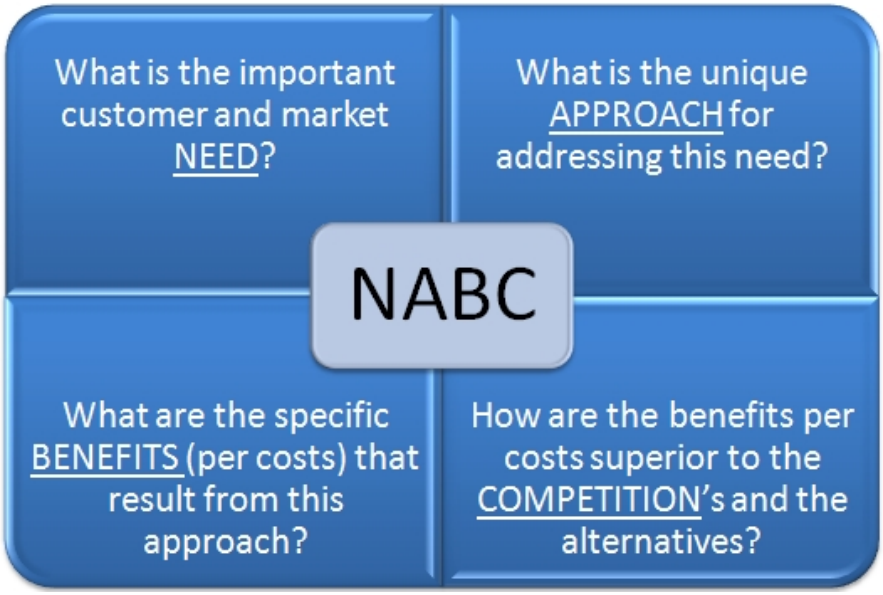

Figure 38: The NABC value assessment method [46]

In the context of this thesis, the aim is to show what needs to be done to ensure that blind and visually impaired people can move around freely and that they can do so easily and without much effort. First of all, the general needs of blind and visually impaired people need to be specified so as to define the approaches for these needs. The aim of this thesis is not to make and enforce legal requirements, thus the most important part of the NABC method is to identify the benefits, which the airlines gain by providing an inclusive aircraft lavatory environment for blind and visually impaired people. By identifying these benefits, airlines could find it easier to provide such an inclusive lavatory environment. Moreover, when defining requirements, it is necessary to ensure feasibility for the airlines.

For an inclusive aircraft lavatory environment for blind and visually impaired people, the four NABC parameters for this thesis are defined as follows:

Needs

- Equal treatment of all passengers
- Accessible aircraft lavatories for blind and visually impaired people
- Possibility for the BLNDs to get to the lavatory on their own
- Possibility for the BLNDs to get back to their seat on their own
- Decrease workload of cabin crew

Approach

- Provide a guidance system leading to the lavatory
- Provide an aircraft lavatory with an intuitive and familiar design
- Provide supporting aids for the blind and visually impaired people

Benefits

- Increasing satisfaction of (blind and visually impaired) passengers
- Airlines gain more (blind and visually impaired) passengers, who formerly avoided traveling by plane due to arising problems and inconveniences
- Workload of cabin crew is decreased due to the independency of the BLNDs

Competition

- Airlines providing inclusive lavatories give additional convenience to all passengers, particularly to blind and visually impaired people. Thus, blind and visually impaired people might only want to travel with such airline in order to take advantage of this service / cabin feature.

5.2 Design Requirements

In order to design an aircraft lavatory, which is accessible for blind and visually impaired people, requirements need to be derived based on the needs of the BLNDs, which have been identified through surveying BLNDs and cabin crew members (see Chapter 4.3: Present Conditions inside the Aircraft Cabin and Lavatory).

In the following, the requirements needed for designing an inclusive aircraft lavatory environment for blind and visually impaired people are presented and are subdivided into general (G) and design (D) aspects. The design aspects are subdivided into two parts: cabin environment and lavatory environment. The requirements are mostly derived through the surveys but some are also self-developed. The applied terms **shall** and **should** are explained in the List of Terms and Abbreviations.

The requirements stated here only relate to the particular needs of blind and visually impaired people. The aircraft lavatory **must** comply with other requirements of relevant regulations as well.

5.2.1 General Aspects

The general aspects primarily relate to the overall appearance, design and features of the redesigned aircraft lavatory. Moreover, the feasibility for airlines is taken into account.

Requirement-No.:	**G-01**
Requirement Statement:	The operation of the different lavatory elements shall be intuitive, self-explanatory or easy to explain.
Rationale:	Due to user friendliness.
Source:	Surveyed blind and visually impaired people & cabin crew

Requirement-No.:	**G-02**
Requirement Statement:	Regulations and recommendations regarding safety, security, health and comfort shall be considered in the lavatory design.
Rationale:	In order to fulfill the ergonomic needs of flight attendants and passengers.
Source:	Surveyed blind and visually impaired people

Requirement-No.:	**G-03**
Requirement Statement:	The lavatory should have an aesthetic design for all user groups.
Rationale:	The lavatory should have a design, which is accepted by all user groups and not only by the blind and visually impaired people.
Source:	Self-developed

Requirement-No.:	**G-04**
Requirement Statement:	The lavatory shall provide electrical system interfaces for electronic supporting devices.
Rationale:	To ensure the possibility of making use of electronic supporting devices for blind and visually impaired people (see Chapter 7).
Source:	Self-developed

Requirement-No.:	**G-05**
Requirement Statement:	The lettering used on placards and signs shall be readable for blind and visually impaired people.
Rationale:	To enable perception of information contents for blind and visually impaired people.
Source:	Surveyed blind and visually impaired people

Requirement-No.:	**G-06**
Requirement Statement:	Pictograms and symbols should be used on placards and signs.
Rationale:	Pictograms and symbols are larger than its equivalent text and are clear in their meaning.
Source:	Surveyed blind and visually impaired people

Requirement-No.:	**G-07**
Requirement Statement:	Implementation effort for new design aspects should be as low as possible.
Rationale:	Ensures feasibility for the airlines.
Source:	Self-developed

5.2.2 Design Aspects

The design aspects relate to the needs of blind and visually impaired people concerning the location and identification of the lavatory, the orientation inside the lavatory, the identification and usage of the lavatory equipment and the location and identification of the passenger seat.

Cabin Environment

Requirement-No.:	**D-01-01**
Requirement Statement:	A distinctive way-guidance system for blind and visually impaired people shall be available leading along the aisle.
Rationale:	To ensure independent orientation for blind and visually impaired people.
Source:	Surveyed blind and visually impaired people

Requirement-No.:	**D-01-02**
Requirement Statement:	The location of the lavatory shall be easy to identify without the usage of the visual sense.
Rationale:	To ensure independent orientation for blind and visually impaired people.
Source:	Surveyed blind and visually impaired people

Requirement-No.:	**D-01-03**
Requirement Statement:	The availability of the lavatory shall be easy to identify without the usage of the visual sense.
Rationale:	To ensure that blind and visually impaired people are able to identify the lavatory status.
Source:	Surveyed blind and visually impaired people

Requirement-No.:	**D-01-04**
Requirement Statement:	The lavatory door shall be easy to operate.
Rationale:	To ensure easy and independent operation of the lavatory for blind and visually impaired people.
Source:	Surveyed blind and visually impaired people

Lavatory Environment

Requirement-No.:	**D-02-01**
Requirement Statement:	Lavatory elements shall be easy to identify without the usage of the visual sense.
Rationale:	To ensure independent orientation for blind and visually impaired people.
Source:	Surveyed blind and visually impaired people

Requirement-No.:	**D-02-02**
Requirement Statement:	User interfaces and controls shall be easy to identify for blind and visually impaired people by high contrast and tactility.
Rationale:	To ensure easy and independent operation of the lavatory for blind and visually impaired people.
Source:	Surveyed blind and visually impaired people

Requirement-No.:	**D-02-03**
Requirement Statement:	There shall be no sharp edges inside the lavatory.
Rationale:	To avoid injuries.
Source:	Surveyed blind and visually impaired people

Requirement-No.:	**D-02-04**
Requirement Statement:	Glare from light sources and surfaces shall be avoided inside the lavatory.
Rationale:	To ensure easy orientation for visually impaired people.
Source:	Surveyed blind and visually impaired people

Requirement-No.:	**D-02-05**
Requirement Statement:	All buttons shall be distinguishable from each other, especially the attendant call button and the flush button.
Rationale:	To ensure easy and independent operation of the lavatory for blind and visually impaired people.
Source:	Surveyed blind and visually impaired people & cabin crew

Requirement-No.:	**D-02-06**
Requirement Statement:	The attendant call button shall be easily identifiable as a call button.
Rationale:	To ensure that the attendant call button is easy to identify in an emergency situation.
Source:	Surveyed blind and visually impaired people & cabin crew

Requirement-No.:	**D-02-07**
Requirement Statement:	Visual and audible confirmation shall be given inside the lavatory when the attendant call button has been actuated.
Rationale:	To ensure easy and independent operation of the lavatory for blind and visually impaired people.
Source:	Surveyed blind and visually impaired people & cabin crew

Requirement-No.:	**D-02-08**
Requirement Statement:	The information given in the cabin shall also be given inside the lavatory by visual and / or audible systems.
Rationale:	To ensure that blind and visually impaired people are informed if there is e.g. a return to seat or fasten seatbelt request.
Source:	Surveyed blind and visually impaired people

Requirement-No.:	**D-02-09**
Requirement Statement:	The water faucet shall be easy to control for blind and visually impaired people.
Rationale:	To ensure easy and independent operation of the lavatory for blind and visually impaired people.
Source:	Surveyed blind and visually impaired people

Requirement-No.:	**D-02-10**
Requirement Statement:	Hand disinfection should be possible inside the lavatory.
Rationale:	Due to hygienic reasons.
Source:	Surveyed blind and visually impaired people

Requirement-No.:	**D-02-11**
Requirement Statement:	Hygiene shall be easily ensured by the lavatory design.
Rationale:	Due to hygienic reasons.
Source:	Self-developed

6 Design Concept for an Inclusive Lavatory Environment

One of the most important areas inside the aircraft cabin is the lavatory. Nobody, including BLNDs, wants to be in the need of help by other persons inside the lavatory. In order to achieve this, it is necessary to ensure that lavatories are also accessible for BLNDs. In this design concept for an inclusive aircraft lavatory environment for blind and visually impaired people, the requirements that have been defined beforehand (Chapter 5) will be taken into account. This design concept will describe how a standard aircraft lavatory, as described and illustrated in Chapter 3.1: The Lavatory Environment, can be improved to make it inclusive for blind and visually impaired people. An important objective when improving conditions needs to be that the new designed environment is also acceptable to fully sighted people.

Various design recommendations on the usage of e.g. color and contrast, written information and tactile lettering have been developed by different institutes and also by the German Association for Blind and Visually Impaired People. These recommendations will be taken into account in this design concept. For a list of these publications and other relevant information see Appendix B.

6.1 Design Philosophy

The results of the survey have shown that aircraft lavatories have poor color, contrast and tactile characteristics, which are very important for blind and visually impaired people when identifying objects. In addition, the survey has also shown that blind and visually impaired people have individual problems, e.g. most visually impaired people find it too dark inside the lavatory, but others however find the lighting acceptable. It is impossible to use color, contrast and lighting to satisfy the needs of all people with different visual acuity. This chapter presents how color, contrast and lighting should generally be used inside the aircraft lavatory and how they will be implemented in this design concept. Further, a design philosophy for all placards and signs inside the lavatory, as well as in the cabin, will be presented. The lavatory shall have a uniform design language. The design shall be functional but also have an aesthetic appearance for fully sighted people (Requirement G-03).

6.1.1 Color & Contrast

When designing an inclusive environment for visually impaired people, it is important to use color and tone contrast to highlight features such as door handles or buttons and give visual clues on the identification of edges and boundaries (Requirements D-02-02). Most visually

impaired people have a blurred visual perception and some are even not able to perceive some or all colors (see Chapter 2.4: Types and Causes of Visual Impairment). However, they are able to perceive light and dark tones that are high in contrast.

Color also influences, intentionally or unintentionally, the mood of the persons perceiving it. Hence, it is fundamental which colors are used in the lavatory design. [13] In this design concept, the high contrasting colors black and white will be used, which give the lavatory a high quality design, which is also acceptable by fully sighted people (Requirement G-03). This color combination has already been applied on the design of HILA, the High Integrated Flexible Lavatory, a PRM Lavatory which has been developed by DASELL Cabin Interior, Airbus and iDS Hamburg. [47]

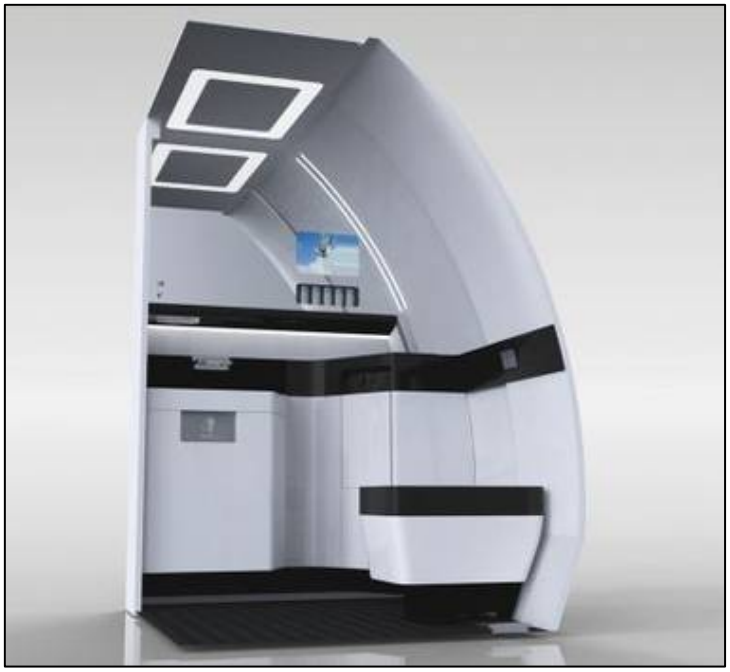

Figure 39: PRM lavatory HILA [47]

White color denotes cleanliness and purity, while black is used to highlight different surfaces or components inside the lavatory. Red, blue and green stand out from the colors black and white and therefore will be used for important user interfaces (Requirement D-02-02), which will be described further in Chapter 6.3: Lavatory Equipment. People around the world associate the colors differently. The relevant associations with the colors red, blue and green in this design concept are generally defined in western cultures as follows: [13] [48]

Red: A signal color, which can immediately focus attention on a particular element.
Blue: The color of the sky and the ocean and is seen as cooling, calming and relaxing.
Green: A color associated with harmony and nature and is used as a color of safety.

6.1.2 Lighting

Light is essential for perceiving colors. It provides adequate color and contrast to surfaces inside the lavatory. However, large amounts of light cause contrast to reduce and glare to increase. This glare will disable vision and thus visually impaired people have problems when light is reflected from shiny surfaces (Figure 40). Additionally, colored lighting should be avoided as this reduces contrast. [13]

Figure 40: Glare caused by the shiny surface of the sign [13]

Further, lighting should be directed and controlled to prevent shadows. Bright light sources can cause glare and generate strong and hard-edged shadows. This can lead to difficulties for all users inside the aircraft lavatory and especially for those with visual impairment. [13]

As described before, most visually impaired people are satisfied with the lighting inside the lavatory. Anyhow, it would be of a benefit for them if the lighting was a little brighter. According to “The Colour, Light and Contrast Manual” for designing inclusive built environments, it is recommended that bathrooms should have an illuminance of 200 to 300 lux. Larger illuminance shall be avoided as this may cause glare (Requirement D-02-04). [13]

6.1.3 Placards and Signs

All user interfaces need to be labeled with readable placards or signs for blind and visually impaired people in order to ensure that instructions and regulations that are given on placards and signs are followed (Requirement G-05). All passengers, including BLNDs, need to know that e.g. smoking is not allowed inside the lavatory and that tap water is no drinking water.

The survey has shown that the placards and signs installed nowadays inside the aircraft cabin are not readable for blind and visually impaired people. The fonts used on the placards and signs are too small and not tactile. Further, the font is gray on light gray or white background, which has not enough contrast for visually impaired people.

According to the BSVH, sans serif fonts such as Arial should be used on placards. Not more than two fonts and unnecessarily many different font sizes should be used, as the eyes would need to adapt too often to these differences. In addition, all characters should have a sufficient boldness and the letter spacing should not be too small, otherwise the letters would be perceived as ambiguous and blurry. The exact font size, letter spacing and boldness needs to be identified in further studies, as there is no detailed guidance on the design of aircraft lavatory placards for BLNDs. To assure the readability of placards and signs for visually impaired people, lettering should be high in contrast to its background. There are different color combinations that are rich in contrast which can be applied on placards and signs. The BSVH recommends black letters on white background or black letters on yellow background and blue letters on white or yellow background (Figure 41). White text on black background is also easy to read for visually impaired people. In this design concept, the information shall be given in black lettering on white background, as these colors are commonly used and therefore also acceptable to fully sighted people. Additionally, the placards and signs shall have a black frame for better recognizability. [49]

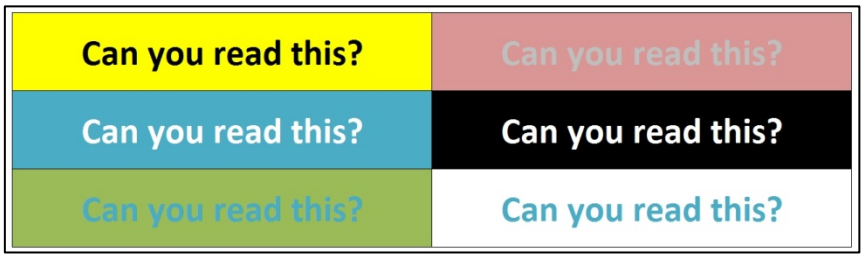

Figure 41: Readability of written text with different color contrasts [Source: Author]

The information given on placards and signs shall additionally be given in either Braille or tactile profile letters. Engraved letters are not suitable, as they are more difficult to recognize than profile letters. However, not every BLND is able to read Braille, thus the placards and signs should have tactile profile letters, as BLNDs are more proficient in reading these than Braille. This is due to the fact that it takes years to learn Braille, but only hours of practice to learn to identify tactile profile letters. [39] According to the BSVH, the tactile profile letters should be preferably designed in prism shape (like an upside-down V) as illustrated in Figure 42. Further, the black frame of the placard or sign shall also be tactile and thus it shall also have a prism shaped profile. Prism shaped letters are nowadays already used in e.g. train stations on handrail signs, which give way-finding information to BLNDs (Figure 43). [50]

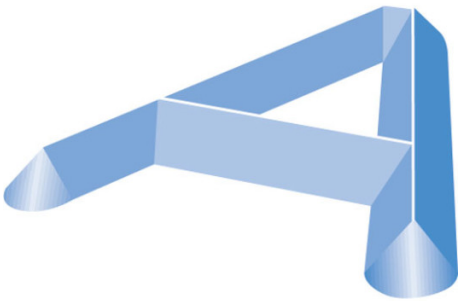

Figure 42: Tactile, prism shaped letter [51]

Figure 43: Braille and tactile profile letters in prism shape on a handrail sign [52]

These two features – high-contrast and tactile lettering – which are needed on placards and signs for blind and visually impaired people shall be combined in this design concept. The tactile profile letters can be read by visually impaired and fully sighted people, as the letters are colored black and their background white. Placards and signs should be visible or even eye-catching, however, they should not destroy the aesthetic design of the lavatory. Figure 44 illustrates how a placard with these characteristics may look like.

Figure 44: Modified placard (example) [Source: Author]

Nonetheless, it is also desired to replace as much written text on placards and signs by its equivalent pictogram as possible in order to increase comprehensibility (Requirement G-06). This shall be adapted to placards and signs where it is possible and useful to do so. Internationally used standards shall be taken into account when designing pictograms to avoid misunderstanding of their messages. The pictogram on the placard or sign shall also be embossed so it is identifiable by BLNDs by touching its surface. Pictograms will benefit all passengers, including blind and visually impaired people and those with learning disabilities.

It is outside of the scope of this thesis to identify which placards and signs should contain pictograms and which plain text. This topic shall be covered in future studies.

To meet the above design requirements for placards and signs, the currently used placards and signs do not need to be newly dimensioned. Only the mentioned colors and tactile characteristics need to be applied onto the new placards and signs. Since the placards and signs without tactile characteristics have already been certified for aviation, the new placards and signs do not need a new certification, as there are no changes e.g. in the material. There are also no changes in the integration of the new placards and signs, since they have the same dimensions and are located at the same position inside the aircraft. Thus, the new placards and signs will not have any effects on the cabin operation.

6.2 Way-Guidance System

As the floor is where most people look to gather information when moving around, way-guidance information provided on the floor could assist blind and visually impaired people. In order to get to the toilet independently of the help of assisting persons or cabin crew, blind and visually impaired people need support through a high-contrast and tactile way-guidance system (Requirement D-01-01).

A guidance system along the aisle to the lavatory and e.g. to the emergency exits can be implemented in the aircraft similar to the guidance system in train stations. A tactile way-guidance system consisting of a single line containing bars that are detectable by the white cane can be installed along the centre of the aisle. Anyhow, this solution can be very unaesthetic in connection with the overall design composition of the cabin. Cabin crew could also have problems moving the catering trolleys on ribbed surfaces. Further, it could not be so easy for BLNDs to use their cane along the aisle, as there can be many obstacles such as hand baggage lying on the floor or people standing in the way. As the aisle is not very wide for BLNDs to sweep their cane back and forth, it can happen that they will move their cane against the seats along the aisle. Hence, a guidance system along the entire length of the aisle is not necessary, as the BLNDs are guided through the aisle itself.

Figure 45: Lightstrip leading along the aisle [54]

A possibility of installing a guidance system inside the cabin is to modify the existing light strips (Figure 45). In this design concept, the light strips, which are installed on the floor along the aisle, shall be high in contrast to its surroundings. This means that lightstrips shall be white, if the carpet has a dark color. Through the high-contrast lightstrip, a visual clue is given to visually impaired people. In order to lead the BLND to the lavatory, a broad ribbed and high-contrast way-guidance strip (Figure 46) shall be installed beside the lightstrips in the vicinity of the lavatories. A BLND who anyhow uses a white cane inside the cabin can slide his cane along the aisle and is then lead by the ribbed way-guidance strip to the lavatory.

In the economy class, the ribbed strip shall be installed about 4 seat rows before the lavatory. Thereby, the strip leads the BLND to the lavatory. However, the ribbed surface of the light strips should not be too distinctive to avoid obstacles and potential hazards inside the cabin. Furthermore, the carpet surface and the strip surface shall have the same level in order to avoid tripping hazards. So that BLNDs are able to perceive the strip with their white cane, the strip itself as well as the ribs shall have a sufficient width. Guidance on how to dimension such way-guidance strips in public places is given by the DBSV.[53] However, the exact dimensions of way-guidance strips that are implemented in aircraft cabins need to be identified in further studies.

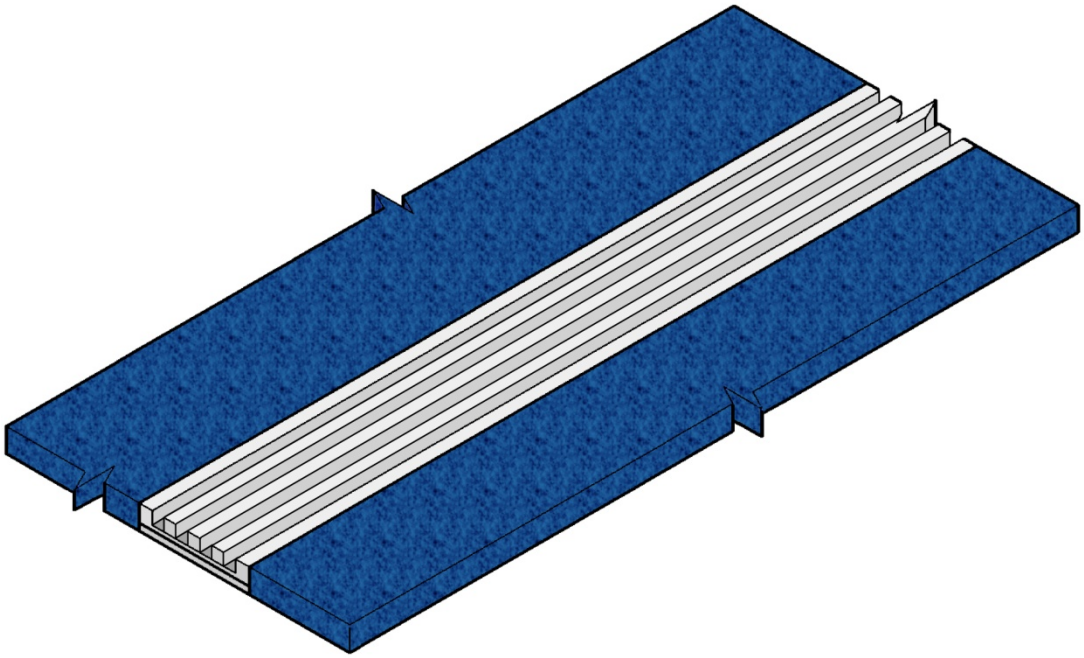

Figure 46: High-contrast and tactile way-guidance strip [Source: Author]

For BLNDs who are not using a white cane inside the aircraft, a tactile and high contrast sign shall be added onto the bottom side of the overhead compartment. In the economy class, the sign shall be installed about 4 seat rows before the lavatory and shall contain the message “Lavatory Ahead” and an arrow, indicating the direction where the lavatory is located. Thus, BLNDs may slide their hand along the bottom side of the overhead compartment and easily locate the lavatory on their own.

Figure 47: "Lavatory Ahead" sign [Source: Author]

In order to identify and recognize the lavatory, a high-contrast and tactile feature shall be installed outside the lavatory (Requirement D-01-02). The BSVH has recommended that the door shall have a broad black frame whilst the rest of the outside lavatory is kept in white or another light color.[39] By this means, visually impaired people are able to identify the entrance of the lavatory. Additionally, a tactile lavatory pictogram shall be added onto the door. For blind and visually impaired people using their white cane as a mobility aid, there shall be a tactile feature, which shall be implemented into the existing kickstrip at the bottom of the outside of the lavatory. The part of the kickstrip installed at the bottom of the lavatory door shall have a vertically ribbed structure. This can then be perceived through moving the cane along the kickstrip surface of the lavatory door. Figure 48 illustrates how the outside of a lavatory may look like when implementing the above stated features.

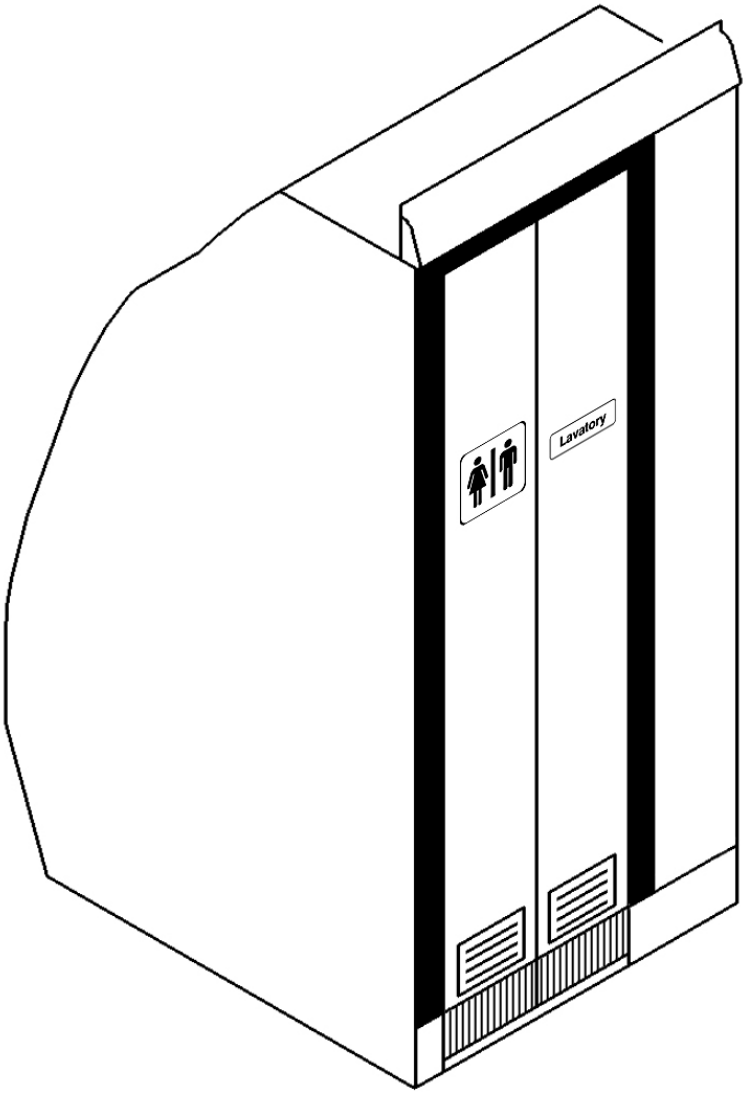

Figure 48: Modified outside lavatory door identification features [Source: Author]

High-contrast attention fields installed on the floor as implemented inside the ICE 2 (see Chapter 4.4, Figure 33: Attention field indicating the entrance of the first class cabin) are very effective, but may not be very aesthetic when implemented inside the aircraft cabin. Attention fields consisting of domes as implemented in e.g. train stations or footpaths can be an obstacle or a hazard for the passengers. And as described before, cabin crew could find it difficult to move the catering trolleys on surfaces with ribs or domes.

When going back to the seat, blind and visually impaired people want to find their seat independently of any help. They would find it advantageous if the seat number signs were installed on the side of the headrest of each aisle seat, similar to the redesigned ICE 2. However, this would be very pricey for the airlines to realize, as this would mean to add numerous new signs and develop a new attachment for the headrest mounted signs. In addition, other passengers would probably not feel comfortable anymore, if BLNDs accidentally touch their head when seeking for the seat number sign. Hence, the seat number placards and signs, which are nowadays attached on the overhead bins (Figure 49), should be modified as every other placard or sign as described above (Chapter 6.1: Design Philosophy). The placards shall have big and tactile profile lettering which are high in contrast. Thus, BLNDs can slide their hand along the overhead bins and find their seat on their own. To indicate the beginning and the end of the seat rows, a vertical tactile strip shall be added at the beginning and at the end of the overhead bins. This gives the BLNDs the information that the seat rows end at that point due to e.g. an emergency exit, which is located ahead. Unfortunately, smaller BLNDs would probably not be able to reach the seat number placards / signs on the overhead bins.

Figure 49: Seat number sign on the bottom of the overhead bin [55]

6.3 Lavatory Equipment

In this chapter, the major problems identified through the survey will be determined and it will be analyzed how they may be modified for this design concept. As described before, blind and visually impaired people feel their surroundings with their hands or their tools. In order to identify buttons and other user interfaces, they should be distinguishable from their surroundings by high-contrast and tactile characteristics.

A standard aircraft lavatory, as described and illustrated in Chapter 3.1: The Lavatory Environment, will be modified and improved in this design concept in order to make it accessible for blind and visually impaired people. Thus, the location, dimensions and materials of the different lavatory elements will not be changed, as long as it is not indicated in the text.

Lavatory Door

When getting to the lavatory, BLNDs first need to identify if the lavatory is vacant, occupied or out of order (Requirement D-01-03). In the first instance, the vacant / occupied sign shall be designed larger and have tactile lettering in prism shape to make it easier for BLNDs to scan the sign with their fingers (Figure 50). For faster tactile identification of the availability of the lavatory, the letters of the occupied sign shall fill in the whole sign, while the letters of the vacant sign shall only fill about 2/3 of the sign. Thus, the letter spacing of the two signs is different, which gives a good identifiable tactile characteristic to the sign. Moreover, the sign shall be clearly identifiable and specifiable by people with red-green color deficiency. Therefore the green color of the vacant sign shall have a different hue than the red color of the occupied sign. In this design concept, the green color shall have a light hue and the red shall have a dark hue. Due to the light green color of the vacant sign, the lettering of the sign shall have a high-contrast color, which is black. Figure 51 illustrates how a person with red-green color deficiency would perceive the modified vacant / occupied sign.

To make it easy for BLNDs to scan the sign with their fingers, it shall have an outer dimension of about 3 cm x 14 cm (height x width). Additionally, the sign shall have an aluminum frame, which will be used as an attachment for the additional “out of order” sign.

Figure 50: Modified vacant / occupied sign [Source: Author]

Figure 51: Perception of the modified vacant / occupied sign with red-green color deficiency [Source: Author]

Nowadays, the availability sign outside the lavatory door only indicates if the lavatory is vacant or occupied. Thus, this sign needs to be modified by adding the additional information “out of order”. In order to achieve this, either a new locking system needs to be designed and developed, which can be very costly, or an inexpensive additional sign, which can be manually attached by the flight attendant on top of the vacant / occupied sign, may be designed (Figure 52). This attachable sign shall have a slide-mechanism, which can be easily attached by sliding it on to the aluminum frame of the vacant / occupied sign.

Figure 52: Additional "out of order" sign [Source: Author]

There are currently three standard opening mechanisms for lavatory doors. Single blade lavatory doors are equipped either with a turning knob or a lever type door handle. These two opening mechanisms ease lavatory door opening for PRMs and are therefore preferred by the blind and visually impaired people that have been surveyed. [39]

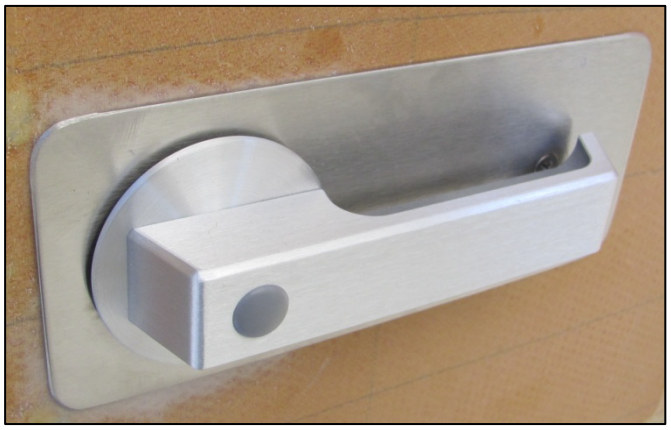

Figure 53: Lever type door handle [Source: Author]

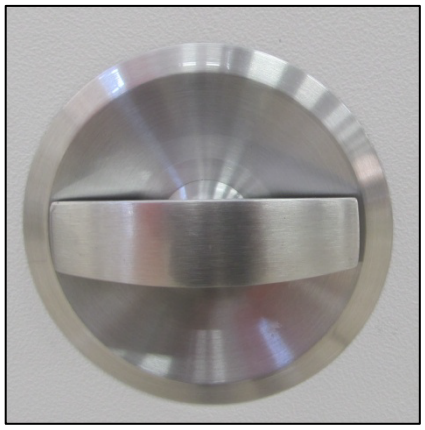

Figure 54: Turning knob [Source: Author]

The inward opening bi-folding doors are equipped with a push plate, which needs to be pushed inwards to open the door. Since this door opening mechanism is standard in most aircraft and easy to operate (Requirement D-01-04), this shall be used in this design concept. The surveyed BLNDs would find it helpful if there was a signage directly on the push plate. Therefore, the lettering “Push” shall be embossed in black tactile letters onto the push plate.

Further, the push plate in metal finishing shall have a black tactile frame for better identification as a user interface. The tactile characteristics should not have a prism shape in order to avoid inconveniences when pushing the door open (Figure 55).

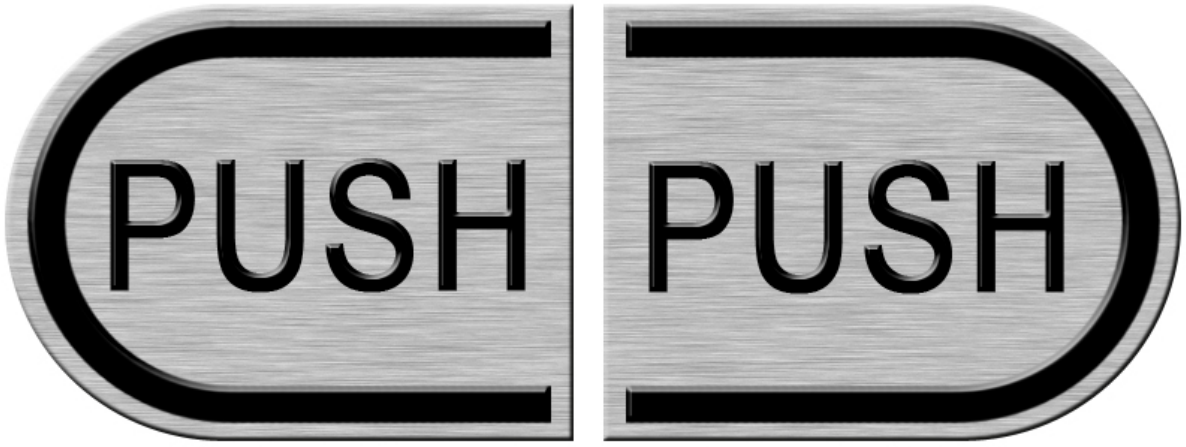

Figure 55: Modified push plate [Source: Author]

If the blind or visually impaired passenger has entered the lavatory, he must be able to close and lock the door on his own. Since the locking mechanism is different in each aircraft lavatory and located at different positions, locking the door is not very easy for BLNDs. Therefore there shall be a high-contrast and tactile placard on the inside of each lavatory door, which contains a description of the locking mechanism, as it is for example pictorially shown in Figure 56. However, it is also important that the locking mechanism has not more than two locking positions, as this would confuse the BLND. Two locking positions for locking and unlocking the door are unambiguous and clear for the user.

Figure 56: Pictorial description of the lavatory door locking mechanism [37]

Toilet Unit Cover

To make it easier for visually impaired people to identify if the toilet unit cover is opened or closed, it shall be colored black. Thereby, a visual clue is given to visually impaired people. Through this visual clue, they do not accidentally touch the unhygienic toilet seat when they are trying to identify if the toilet unit cover is opened or closed. They instantly see if the toilet unit cover is opened or closed (Figure 57).

Figure 57: Modified toilet unit cover [Source: Author]

Flush Button

The flush button is one of the major problems identified through the survey. It is hard for BLNDs to identify it and distinguish it from the attendant call button, as it only has poor labeling and no tactile characteristic at all. The flush button, which is currently installed inside most aircraft lavatories (see Figure 58) shall be modified to be distinguishable from other buttons especially from the attendant call button (Requirement D-02-05). The button shall be kept in the color blue (color of the ocean) and shall have a tactile profile marking around it. The button itself shall also have a different surface characteristic than its sleek surroundings and shall therefore be slightly rough. Additionally, the flush button shall have a slightly cambered profile, which is a characteristic of pushbuttons. The words “FLUSH” and “PUSH” shall be added above / below the button in blue prism shaped lettering, which makes the flush button for BLNDs easier to identify. Due to the additional lettering, the modified flush button unit needs to be approximately 1,5-times longer than the current flush button unit.

Figure 58: Flush button inside an A380 [Source: Author]

Figure 59: Modified flush button [Source: Author]

Attendant Call Button

Nowadays, most attendant call buttons are colored orange, on which a human figure is illustrated (Figure 60). It is very small and inconspicuous and does not have any tactile characteristic for BLNDs to identify it.

The attendant call button shall not only be distinguishable from the flush button but shall also be easily identifiable as an emergency call button (Requirements D-02-05 & D-02-06). Thus, the attendant call button needs to stand out from all other lavatory elements and shall therefore be colored in the signal color red. Further, the attendant call button needs to have an unambiguous geometric shape to prevent misusage of the call button as the flush button. The equilateral triangle is internationally used for warning signs. The button of the hazard warning light inside a car for example, has an equilateral triangle shape. This shape shall also be used for the attendant call button. In this design concept, the attendant call button is a red button with an equilateral triangle shape with rounded corners (Requirement D-02-03). The edges of the triangle of the modified attendant call button shall have a sufficient size and shall have a length of at least 3 cm.

Figure 60: Attendant call button inside an A320 lavatory [Source: Author]

Figure 61: Modified attendant call button [Source: Author]

The attendant call button is a safety related button for passengers but also a service or assistance call button. Due to the new “emergency” design of the attendant call button, fully sighted people may not want to push the button anymore, if they are in need of service, e.g. because of an empty soap dispenser. Therefore, it should also have a labeling through an additional placard, containing the lettering “Assistance”. Like all other placards, it shall have tactile prism shaped lettering. In order to stand out, the lettering on this placard shall be green (color of safety) instead of black. An “SOS” labeling, as implemented inside the ICE, would not be of an advantage, as fully sighted people may not want to push the button, if they are not in an emergency situation but in need of service.

Figure 62: Attendant call button placard [Source: Author]

The attendant call button shall be located inside the lavatory in the reach of the standing and seated passenger. Therefore, it shall be located under the mirror on the side that is closer to the toilet unit (Figure 63). At this location, the attendant call button is reachable but also secure from being accidentally actuated.

Figure 63: Location of the modified attendant call button and placard inside an A320 lavatory [Source: Author]

If the attendant call button has been actuated, additionally to the haptic confirmation a moderate acoustic signal will be activated inside the lavatory (Requirement D-02-07). By this means, the information is given to the BLND that cabin crew will soon be at the lavatory to assist or help him. When the flight attendant has reached the lavatory, the acoustic signal can be deactivated by the attendant by pushing the attendant call button once again.

Return to Seat Sign

The surveyed BLNDs have stated that the return to seat sign inside the aircraft lavatory is not sufficiently identifiable for them. Hence, additionally to the return to seat sign and the cabin chime, there shall always be an automatic pre-recorded announcement when there is a return to seat request (Requirement D-02-08).

Figure 64: Return to seat sign [Source: Author]

User interfaces for washing one's hands

Identifying the wash basin, water faucet and soap dispenser is not problematic for BLNDs. However, the water faucet should have a common mechanism, such as a push or lever type design. The BSVH stated in the group discussion that touchless sensor technology should be avoided in the design of user interfaces, as the BLNDs seek for tactile elements inside the lavatory, which is hardly given through touchless sensor technology. Hence, in this design concept, the water faucet shall have a push design, which is standard in most aircraft lavatories (Requirement D-02-09). However, it could also be possible to implement sensor technology inside aircraft lavatories if the sensors have tactile characteristics, which help blind and visually impaired people to identify the function of the sensor.

BLNDs do not have difficulties locating the paper towel dispenser. For visually impaired people though, a black border along the paper towel dispenser opening could help them identify it better and shall therefore be incorporated in this design concept.

When disposing the used paper towels, the surveyed BLNDs have difficulties identifying and operating the downward waste bin flap. They usually look for a forward waste bin opening somewhere underneath the wash basin. For this reason, the waste bin could be modified by placing the waste bin flap from above to the front of the lavatory cabinet. New developed lavatories shall therefore have the waste bin flap at the front of the lavatory cabinet, similar to how it has already been implemented in the lavatory in Figure 65.

Figure 65: Lavatory module inside a Boeing 737 of All Nippon Airways [56]

However, modifying all waste bin flaps means to modify all lavatory cabinets, which would be very pricey for the airlines to realize. Instead of modifying the waste bin, the waste bin flap shall be high in contrast to its surroundings and have the lettering “Waste Bin” and the instruction “Push Downwards” in tactile and high-contrast letters. However, tactile characteristics on horizontal surfaces are not very hygienic due to the possibility of germ formation caused by the (small amounts of) stagnant water. To ensure hygiene (Requirement D-02-11), the waste bin flap shall have a cambered surface, which makes the water flow down the flap. In order to allow the water to drain off, a small space of about 2 mm between the waste bin flap and the countertop surface shall be provided. Thus, the water can automatically flow into the waste bin.

To prevent misusage of storage compartments as waste bins, which are placed underneath the wash basin, these compartments shall all have a tactile and high-contrast placard indicating the message “No Waste”.

When touching lavatory elements, blind and visually impaired people mostly do not know what exactly they are touching. Due to the unhygienic environment of the aircraft lavatory, a disinfectant dispenser shall be provided (Requirement D-02-10). The disinfectant dispenser shall be positioned in the vicinity of the wash basin and shall be labeled with a high-contrast and tactile placard.

6.4 Lavatory Design Overview

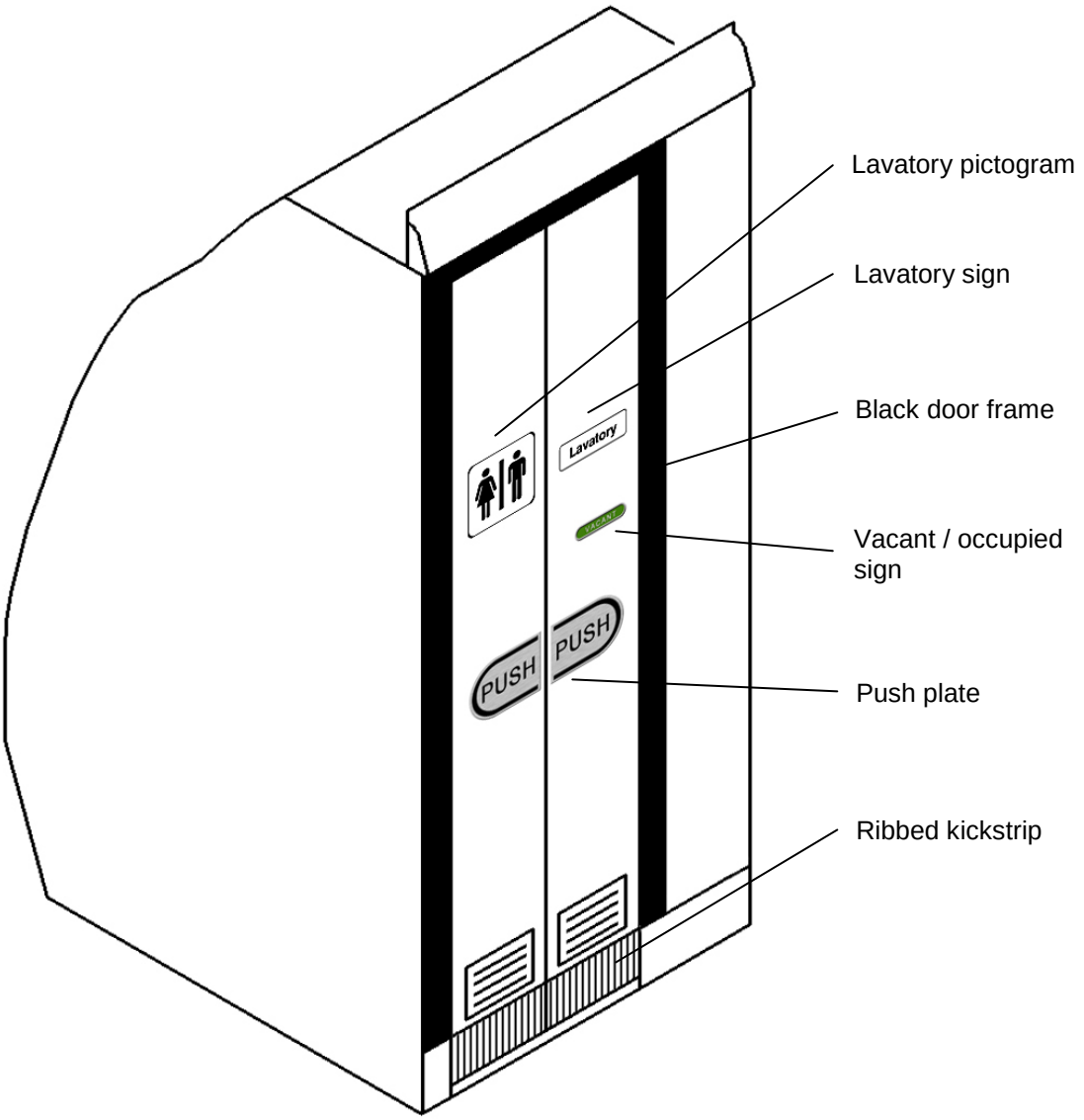

Figure 66: Overview of the outside of the modified lavatory [Source: Author]

As shown in Figure 66, the lavatory door has been modified in this design concept as follows:

- A black door frame has been added for better identification of the lavatory door for visually impaired people.
- A ribbed structure has been added to the kickstrip at the bottom of the lavatory door for better identification of the lavatory door for BLNDs using a white cane.
- A tactile lavatory pictogram has been added additionally to the “Lavatory” sign to aid blind and visually impaired people to identify the lavatory.
- The vacant / occupied sign has an increased size and tactile lettering to aid BLNDs to identify the availability of the lavatory. Further, an out of order sign is provided.
- The push plate has the lettering “PUSH” in high-contrast and tactile letters to give BLNDs an instruction on how to open the lavatory door.

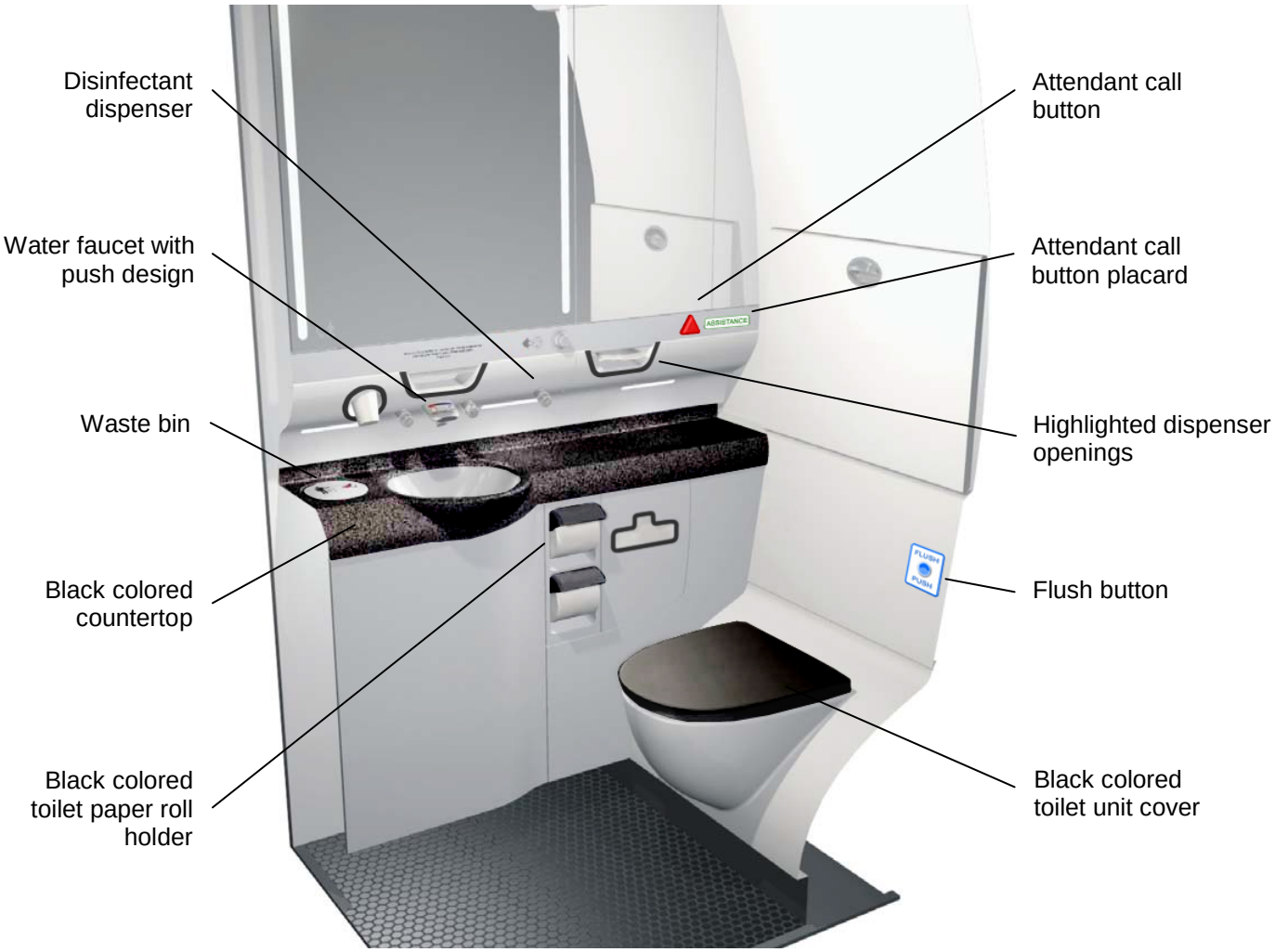

Figure 67: Overview of the inside of the modified lavatory [Source: Author]

As shown in Figure 67, the inside of the lavatory has been modified in this design concept as follows:

- The high-contrasting colors black and white have been used to give visual clues to visually impaired people.
- The high-contrast and tactile lettering “FLUSH” and “PUSH” have been added to the flush button. Further, the flush button has a cambered surface for better identification as a push button. The flush button is located at the right side behind the lavatory, which is standard in most toilets.
- A new designed attendant call button and a respective placard have replaced the present attendant call button. These stand out from all other lavatory elements. The attendant call button is reachable from the standing and sitting position.
- The waste bin flap has been modified with high-contrast and tactile characteristics.
- A disinfectant dispenser has been added due to hygienic reasons.
- Additionally, all placards and signs have been modified with tactile characteristics (not shown in the figure).

Perception with Visual Impairment

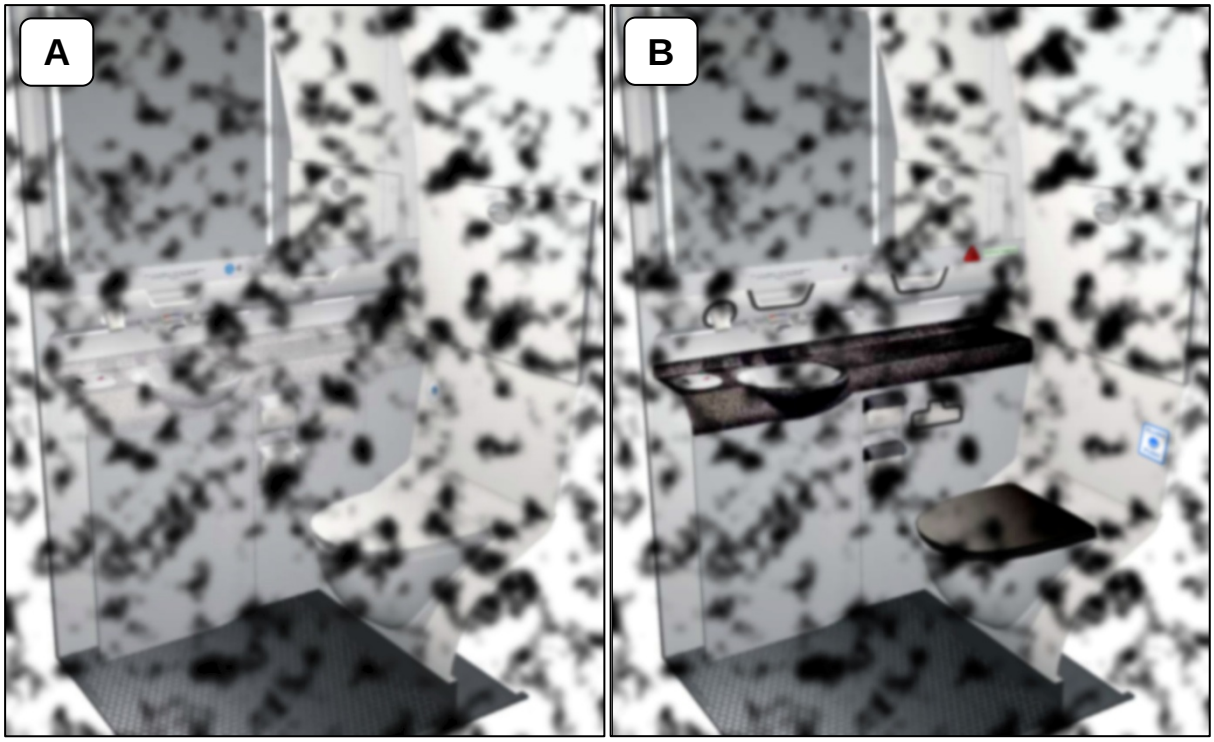

Figure 68: Visual perception with diabetic retinopathy.
(A) Current lavatory design, (B) Modified lavatory design [Source: Author]

Figure 68 illustrates very well the effects of color and contrast. It shows how a person with diabetic retinopathy perceives the lavatory environment. In Figure A, the BLND can only hardly identify the lavatory elements, as everything is colored similarly. The lavatory elements seem to merge into one another. In Figure B however, the BLND can perceive all important user interfaces. He immediately sees if the toilet unit cover is opened or closed, the toilet paper holders are easy to identify and in an emergency situation he is also able to find the attendant call button more easily.

The above figure also shows very well that an inclusive aircraft lavatory environment for blind and visually impaired people may also give an impression of having a very high quality and very elegant interior design. Thus, the lavatory environment is not only functional for blind and visually impaired people, but it also has an aesthetic appearance for fully sighted people.

7 Further Suggestions for Supporting Blind and Visually Impaired People

Additionally to the modifications of the different lavatory parts, as described in the Design Concept, there are several possibilities for supporting blind and visually impaired people. These means, which are going to be described in this chapter, can help to ensure that BLNDs are able to walk independently from their seat to the lavatory and back, as well as to use the lavatory without the help of a fully sighted person. There are some deficiencies that need to be solved in the future through different aids, technical means or just simple operational training. Some technical means that will be described in this chapter are nowadays not yet realized inside the aircraft due to a pricey implementation, but they could give support to blind and visually impaired people in the future in newly developed aircraft and aircraft lavatories.

Operational Aspects

Even with all the modifications described in the previous chapter, blind and visually impaired people will always need (more or less) support by cabin crew. To make traveling by plane for BLNDs as pleasant as possible, flight attendants should know how to deal with the disability issues of persons with reduced mobility and BLNDs in particular. In order to reduce uncertainties, flight attendants must attend a disability-specific training. To provide a good training on a practical basis, it is necessary that BLNDs take part in this training. This makes it possible for BLNDs to explain specific wishes, fears, expectations and problems to the flight attendants. Such operational training on a practical basis is of great significance to clear existing quality deficits, reduce inhibitions and enhance communication skills of cabin crew.

Inside the aircraft, flight attendants need to explain to the BLND all safety relevant issues, for example where to find the attendant call button at their seat, where their seat is located inside the aircraft cabin and where the emergency exits and the nearest lavatories are located. Further, flight attendants need to explain the layout of the lavatory and how the lavatory equipment is operated. Nevertheless, as already mentioned before, this is very time consuming for the cabin crew. A tactile information brochure with all relevant information would be a great support for the cabin crew.

Tactile Information Brochure

Even if a lavatory has the best inclusive design, BLNDs would not be able to find particular lavatory equipment, if they do not know what and where to seek for. BLNDs would locate

controls and other user interfaces easier, if the elements have a standardized position inside all aircraft lavatories. However, this is not given nowadays, as lavatories are adapted to the form of the cabin section where they are installed. For this reason, a brochure with an explanation and figures describing the layout of the lavatory would help BLNDs when orientating themselves inside the lavatory. Further, the brochure should contain operating instructions of the different lavatory parts, such as the locking mechanism or the waste bin flap. Apart from a lavatory description, it could also contain the safety instructions in written text. A tactile aircraft overview with the locations of the lavatories and emergency exits should also be added. This brochure with large, high-contrast and tactile lettering and figures should be handed to the BLNDs upon boarding the aircraft.

Audio Description

Another possibility for making it easier for BLNDs to orientate themselves inside the aircraft cabin is to provide an audio description of the cabin and the lavatories through an MP3-Player or, if available, through the in-flight entertainment (IFE) system. The audio description should be at least given in English, the local language of the airline, as well as the languages of the country of departure and the country of arrival.

Audio description can also be provided inside the lavatory itself, which automatically describes the lavatory to the BLND upon entering it. This feature should only be activated by cabin crew when a BLND is entering the lavatory, as this feature is not needed for all passengers. Apart from that, the audio description inside the lavatory could disturb other passengers outside the lavatory.

Automatic Mechanisms

Automatic mechanisms, such as automatic flushing of the toilet after the toilet unit cover has been closed, are also a possibility to support BLNDs inside the aircraft lavatory. However, a flush button should always be provided, as the toilet would not be flushed automatically if the toilet unit cover has not been closed.

Voice Control

By means of the human voice, it could be possible for the BLND to control the lavatory equipment without needing to touch it, which is very hygienic and convenient. To provide voice control inside the lavatory, a voice recognition device is needed, which converts the spoken words into an electronic command. However, it is important that the implemented voice control system must be able to identify spoken words regardless of accent or dialectal influences. An advantage of voice control is that it is possible to program the voice

recognition device to understand more languages than just English. Thus, BLNDs who cannot speak English are also able to use the voice control feature of the lavatory. The voice control system shall at least understand English, the native language of the airline, as well as the languages of the country of departure and the country of arrival.

When implementing voice control inside the lavatory, it is necessary to ensure that it will not be misused by other passengers standing outside the lavatory. The voice recognition device shall only allow commands by passengers inside the lavatory and shall therefore filter the voice commands from outside the lavatory and other ambient noises. Further, this feature should also only be activated by cabin crew when a BLND is entering the lavatory.

Radio-Frequency Identification (RFID)

Radio-Frequency Identification makes automatic identification, localization of objects and data transfer possible through a wireless radio system. An RFID system consists of a transponder, which is located on or within an object that contains an identifying code, and a code reader, which is needed to readout the identifying code. [57] Such code reader can be installed at the lavatory door. With the aid of e.g. a bracelet containing an identifying code (Figure 69), which can be given to all BLNDs upon boarding, the code reader at the lavatory door identifies that a BLND is entering the lavatory and automatically activates the audio description and / or voice control feature. Thereby, the cabin crew does not need to activate these features manually.

Figure 69: Blind Guide Bracelet [58]

Another possibility to implement RFID inside the lavatory is to equip lavatory equipment, such as the flush button and placards, with an RFID transponder. The bracelet should therefore contain a code reader and an audio output device. When the BLND moves his hand in the vicinity of lavatory equipment with an RFID code, the bracelet identifies the equipment and gives an audio description of it. By this means, BLNDs can easily identify the

lavatory equipment without needing to touch it. The bracelet should also have an on/off switch in order to be able to turn it off, if it is not in use.

Moreover, this bracelet can also be used as a navigation aid for the BLND by e.g. vibrating upon reaching the vicinity of the lavatory. It could also be possible to enter the seat number information into the bracelet, which will then also vibrate upon reaching the vicinity of the respective seat. Therefore, at least one RFID chip needs to be installed in each seat row.

For BLNDs it would further be of an advantage, if there is an attendant call button implemented in the bracelet. Thus, the BLND can always call for help or assistance no matter where in the cabin he is situated at that moment.

Nowadays, RFID is e.g. used in companies for time recording purposes. The employee holds his chip card or token (RFID transponder) onto the time recording terminal (code reader) when he is at work, making a break or leaving work.

Quick Response Code (QR Code)

The Quick Response Code is a two-dimensional code, which consists of a square matrix out of black and white dots and elements (Figure 70). The information encoded in this two-dimensional code can be decoded with e.g. a smartphone and a respective QR Code encoder application (app). One can hold the camera of the smartphone on to the QR Code and the app decodes and displays the QR Code information on the smartphone display. The advantage of QR Codes in comparison to standard barcodes is that they are still readable if a part of the code is contaminated or destroyed. Further, QR Codes can even be scanned if the camera is not positioned properly onto it. [59]

Figure 70: QR Code example [60]

QR Codes can be implemented inside the aircraft lavatory e.g. on placards and signs. Therefore, the information indicated on the placard or sign is additionally made available as a QR Code. This QR Code can be added onto the placard or sign, as illustrated in Figure 71.

The QR Code can be decoded with the help of a scanning device, which will be handed out to blind and visually impaired people upon boarding. With the aid of such QR Code and scanning device, BLNDs do not need to touch and scan the placard or sign with their hands in order to obtain the information. Apart from this, if visually impaired people cannot perceive the information on the placards e.g. due to blurriness, they simply scan the QR Code.

Figure 71: QR Code implemented on a lavatory placard [Source: Author]

VOIM – Smartphone for the Visually Impaired

A scanning device for QR Codes can e.g. be VOIM, a smartphone for blind and visually impaired people (Figure 72). VOIM means “seeing” in Korean and is a cell phone and a device especially designed for BLNDs and features route navigation, word recognition and object identification (Figure 73). It consists of a silicon panel for displaying information in Braille, a camera for gathering information, a Bluetooth earpiece for transmitting the gathered information into audio information, and a strap for wearing the device around the neck. [61] [62]

Figure 72: VOIM [61]

Figure 73: Functions of VOIM [61]

This device can be used inside the aircraft cabin to get to the lavatory, identify obstacles ahead and identify lavatory equipment. Further, the written information on placards and signs can be scanned, which will then be converted in to audio information, which the BLND can listen to. For example, if the BLND has to identify an object, he can place the device near the target and information will exposed to the silicon panel in Braille and / or transformed into sound, which can be heard through the earpiece. In conclusion, VOIM increases the level of independency and safety for BLNDs when using this device inside the aircraft cabin. [61] [62]

8 Summary

This Bachelor Thesis deals with the development of a design concept for an inclusive aircraft lavatory environment for blind and visually impaired passengers.

In 2002, about 37 million people around the world were blind, 124 had low vision and another 153 million were visually impaired due to uncorrected refractive errors. [7] Due to their lack of vision, blind and visually impaired people have a better trained tactile and aural sense than fully sighted people. These people need to be supported inside the aircraft cabin through different aids, such as color contrast, tactile characteristics and acoustic information.

In order to understand the different aspects BLNDs need to deal with concerning the aircraft lavatory usage, the aircraft lavatory environment and its usage have been defined. Moreover, critical interfaces between the blind and visually impaired passenger and the lavatory environment were identified. To describe the current status inside aircraft lavatories, regulations regarding BLNDs when traveling by air have been presented. Further, BLNDs as well as cabin crew have been surveyed. The focus of interest of the survey was especially the interaction between the BLND and cabin crew and the interaction between the BLND and the lavatory hardware. The experiences of the surveyed BLNDs and cabin crew have been analyzed and major critical issues regarding operational aspects, the cabin environment and the lavatory environment have been identified.

Due to the special assistance needed by BLNDs, cabin crew spend much time giving them personal briefings concerning e.g. emergency procedures, the immediate surroundings of their seat and the functionality of the lavatory. This personal assistance is very time consuming for the cabin crew. However, BLNDs want to move independently and freely inside the cabin without needing special assistance. Major aspects which need improvement that have been stated by the surveyed BLNDs are the location and identification of the lavatory monument and the location and identification of the lavatory equipment due to insufficient use of color contrast and tactile characteristics. Because of this, BLNDs cannot distinguish between the different user interfaces inside the lavatory. Hence, it is not unusual that BLNDs operate e.g. the attendant call button instead of the flush button.

From the results of the survey, requirements for an inclusive aircraft lavatory environment for blind and visually impaired people have been derived. These requirements were then taken into account in the design concept. The design concept describes how a standard aircraft lavatory can be improved to make it inclusive for blind and visually impaired people. Anyhow,

when improving conditions for blind and visually impaired people, the new design environment shall give no disadvantages to fully sighted people. In the design concept, various recommendations on the usage of e.g. color and contrast, written information and tactile lettering that have been developed by different institutes have been considered.

First, a design philosophy has been developed. It describes how color, contrast and lighting are used in the design concept of an inclusive lavatory for BLNDs. Further, the design philosophy describes how the general design of placards and signs is composed. During the development of the design concept, the special design functionality for BLNDs, the aesthetic appearance for all user groups and the feasibility for airlines have been taken into account. Additionally to the design concept of an inclusive lavatory for BLNDs, further suggestions for supporting BLNDs on operational and technical aspects have been given.

9 Outlook

The design concept for an inclusive aircraft lavatory environment for blind and visually impaired people, which has been developed in this Bachelor Thesis, shall serve as a guide in the modification of aircraft lavatories and also in the development of designs for future aircraft lavatories. To continue to pursue this topic, following issues, which have not been covered in this Bachelor Thesis, need to be addressed in further studies:

Construction of a lavatory mock-up based on the developed design concept

In order to test the developed design concept, a full-sized lavatory mock-up needs to be built first. The mock-up must contain the design aspects that have been stated in the design concept. Thus, the mock-up does not need to be fully functional. A usability test with blind and visually impaired people shall then be conducted in the mock-up.

Usability test with blind and visually impaired people as well as fully sighted people

To test the developed design concept, blind and visually impaired people should take part in usability tests inside the lavatory mock-up. In this usability test it shall be observed how the BLNDs interact with the lavatory environment and the different lavatory user interfaces. The advantages of such observational study are that it provides objective information and a very good insight into the actual activities performed in the system. Further, BLNDs shall also give feedback through an interview or a questionnaire on e.g. their experiences, satisfaction and what errors occurred during the usability test. Furthermore, fully sighted people should also take part in usability test in order to identify how the new developed design environment is accepted by them.

Examination on the feasibility concerning technical, design and economical aspects

The developed design concept needs to be examined on different feasibility aspects. Remarks regarding concerns of e.g. designers, MRO providers and airlines need to be collected and taken into account to improve the feasibility of the design concept. Further, it should be analyzed how much money airlines need to invest into the modification of one aircraft lavatory as well as the modification of all aircraft lavatories in their fleet.

Investigation on further, alternative design options

Aspects concerning the exact design of placard information, such as font size, letter spacing and boldness, as well as the exact dimensions of way-guidance strips inside the aircraft cabin, need to be identified in further studies. Moreover, it has to be identified which placards and signs should contain pictograms and which plain text. Alternative design options should

be investigated additionally to the developed design concept, as there are many technical and design possibilities to support blind and visual impaired people. Some technical possibilities have already been mentioned in Chapter 7. These suggestions should be examined on how they may be implemented in newly developed aircraft cabins.

Implementation of the design concept in the design of new (PRM) lavatories

When developing new lavatories, the design concept should not only be implemented in standard lavatories, but also in PRM lavatories. PRM lavatories should be accessible for all PRMs and not only for wheelchair occupants. To make the PRM lavatory accessible for blind and visually impaired people, the design concept developed in this Bachelor Thesis should be applied as widely and as well as possible. Hence, it has to be examined how exactly PRM lavatories can be made accessible for blind and visually impaired people.

When designing inclusive aircraft cabins and lavatories for all PRMs, the OEMs and airlines need to cooperate more with disability organizations, such as the German Association of Blind and Visually Impaired People, as well as cabin crew. PRMs and cabin crew know best where they need support and where there are actual deficiencies in the aircraft cabin design.

Infrastructures worldwide are not necessarily designed for persons with reduced mobility, including blind and visually impaired people. This is also due to the fact that companies etc. do not see the necessity in making their infrastructures accessible and inclusive for all user groups. They need to see the economic relevance of this user group. If they do not see this, they do not take any steps on designing inclusive environments. In order to give persons with reduced mobility the same possibilities of free movement as any other, non-disabled person, inside aircraft cabins, regulations regarding inclusive design need to be enacted.

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Appendix A

Questionnaires and group discussion guidelines used for surveying blind and visually impaired people and cabin crew

Appendix A1: Questionnaire used for surveying blind and visually impaired people.

Appendix A2: English translation of the questionnaire in Appendix A1.

Appendix A3: Group discussion guideline used for surveying blind and visually impaired people.

Appendix A4: Questionnaire used for surveying cabin crew.

Appendix A5: Group discussion guideline used for surveying cabin crew.

BLINDEN- UND SEHBEHINDERTENGERECHTE FLUGZEUGTOILETTE

Sehr geehrte Damen und Herren,

ich studiere im 7.Semester Flugzeugbau mit dem Schwerpunkt Kabine und Kabinensysteme an der Hochschule für Angewandte Wissenschaften Hamburg und schreibe zurzeit meine Abschlussarbeit zum Thema **"Blinden- und sehbehindertengerechte Flugzeugtoilette"**.

Das Ziel meiner Abschlussarbeit ist es aufzuzeigen, inwieweit die Flugzeugtoilette geändert werden sollte, damit auch blinde und sehbehinderte Menschen die Flugzeugtoilette problemlos nutzen können. Um dieses Thema praxisnah bearbeiten zu können, bin ich auf Ihre Hilfe angewiesen. Ich würde mich sehr freuen, wenn Sie mich durch die Beantwortung des Fragebogens unterstützen würden. Einige Fragen beziehen sich speziell auf blinde Menschen, andere Fragen nur auf sehbehinderte Menschen. Wenn Fragen nicht auf Sie zutreffen, lassen Sie diese einfach aus.

Bitte senden Sie den ausgefüllten Fragebogen an
kimberly.dippel@haw-hamburg.de

Vielen Dank für Ihre Unterstützung!

Mit freundlichen Grüßen,
Kimberly Dippel

FRAGEBOGEN

1) Wie alt sind Sie?

2) Wie viel Prozent Sehleistung haben Sie?

3) Seit wann sind Sie blind bzw. sehbehindert?

4) Haben Sie noch weitere Beeinträchtigungen?

5) Wie oft sind Sie schon geflogen?

6a) Sind Sie Kurzstrecke geflogen (bis ca. 2 Stunden Flugzeit)?

6b) Sind Sie Mittelstrecke geflogen (bis ca. 6 Stunden Flugzeit)?

6c) Sind Sie Langstrecke geflogen (ab ca. 6 Stunden Flugzeit)?

7) Wie oft sind Sie allein (ohne sehende Begleitung) geflogen?

8) Haben Sie einen Blindenführhund? Wenn ja, reisen Sie mit Ihrem Hund?

9) Informieren Sie üblicherweise die Fluggesellschaft über Ihre Beeinträchtigung?

10) Haben Sie sich bzw. wurden Sie über die behindertengerechte Ausstattung des Flugzeugs informiert?

11) Wie schätzen Sie den Umgang des Kabinenpersonals mit Ihnen insgesamt ein?

12) Erklärt Ihnen jemand vorher wo Sie was in der Toilette finden?

13) Wie sind Sie bisher mit folgenden Aspekten der Toilette zurechtgekommen? Bitte erläutern Sie Ihre Antworten.

a) Weg bis zur Toilette

b) Erkennen der Tür als Toilettentür

c) Erkennen ob die Toilette besetzt ist oder nicht

d) Öffnen der Tür von außen

e) Schließen der Tür von innen

f) Toilettenschüssel finden

g) Toilettendeckel öffnen / schließen

h) Toilettenpapier finden

i) Spülung finden & betätigen

j) Waschbecken finden

k) Wasserhahn betätigen, Warm- / Kaltwasser regulieren

l) Seifenspender finden / betätigen

m) Handtuch / Papiertücher finden

n) Mülleimer finden & benutzen

o) Tür von innen öffnen

p) Tür von außen schließen

q) Der Weg zurück zum Sitzplatz

14) Finden Sie den Serviceknopf auf der Toilette (um den Flugbegleiter zu rufen) ohne Probleme?

15) Wie merken Sie, wenn Sie in der Toilette sind, dass Sie zurück zu Ihrem Sitzplatz müssen (z.B. auf Grund von Turbulenzen)?

16) Wenn Sie einen Blindenführhund haben, gehen Sie mit diesem auf die Toilette? Tauchen hierbei irgendwelche Probleme auf?

17) Gibt es genügend Hilfsmittel (wie z.B. Griffleisten) in der Toilette?

18) Wie empfinden Sie die Beleuchtung in der Toilette?

19) Wie empfinden Sie die farbliche Gestaltung der Toilette?

20) Wie empfinden Sie die Oberflächenbeschaffenheit der einzelnen Teile in der Toilette?

21) Können Sie die einzelnen Schilder in der Toilette erkennen? Helfen Ihnen die Schilder?

22) Was müsste man ändern / verbessern, damit Sie allein den Weg zur Flugzeugtoilette finden sowie allein gut in der Flugzeugtoilette zurechtkommen?

23) Waren Sie schon mal in einer Flugzeugkabine, in der Blindenschrift zu finden war? Wenn ja, mit welcher Fluggesellschaft sind Sie geflogen? Was fanden Sie in der Kabine gut?

24) Bevorzugen Sie eine Fluggesellschaft z.B. auf Grund der behindertengerechten Kabine oder des guten Services? Wenn ja, um welche Fluggesellschaft handelt es sich und was sind die Gründe?

INCLUSIVE AIRCRAFT LAVATORY ENVIRONMENT FOR BLIND AND VISUALLY IMPAIRED PEOPLE

Dear Sir or Madam,

I am an Aeronautical Engineering student at the Hamburg University of Applied Sciences and I am currently writing on my thesis with the topic "**Inclusive Aircraft Lavatory Environment for Blind and Visually Impaired People**".

The aim of my thesis is to identify in which ways the aircraft lavatory needs to be designed and modified in order to make the aircraft lavatory as accessible as possible for blind and visually impaired people.
In order to analyze this topic on a practical basis, I am in need of your help. I would be very pleased, if you could help me by answering this questionnaire. Some questions only apply to blind people, other questions only to visually impaired people. If questions do not apply to you, then simply leave them out.

Please send the completed questionnaire back to
kimberly.dippel@haw-hamburg.de

Thank you for your support!

Sincerely,
Kimberly Dippel

QUESTIONNAIRE

1) Please specify your age:

2) Please specify your visual acuity in percent:

3) Since when are you blind / visually impaired?

4) Do you have any other impairments?

5) How often have you flown already?

6a) Have you ever been on short haul flights (flight time of up to 2 hours)?

6b) Have you ever been on medium haul flights (flight time of up to 6 hours)?

6c) Have you ever been on long haul flights (flight time of over 6 hours)?

7) How often have you flown on your own (without a fully sighted person)?

8) Do you have a guide dog? If yes, do you travel with your dog?

9) Do you generally inform the airline about your impairment?

10) Did you inform yourself / have you been informed about accessible facilities inside the aircraft?

11) How satisfied are you with the service and handling by the cabin crew?

12) Does somebody explain to you how the lavatory is built up?

13) How do you cope with following aspects concerning the lavatory? Please explain your answers.

a) The way to the lavatory

b) Identifying the door as a lavatory door

c) Identifying if the lavatory is vacant or occupied

d) Opening the door from the outside

e) Closing the door from the inside

f) Locating the toilet bowl

g) Opening / closing the toilet unit cover

h) Locating the toilet paper

i) Locating and operating the toilet flush button

j) Locating the wash basin

k) Operating the faucet, regulating warm- / coldwater

l) Locating / operating the soap dispenser

m) Locating hand- / paper towels

n) Locating / operating the waste bin

o) Opening the door from the inside

p) Closing the door from the outside

q) The way back to the seat

14) Are you able to locate the attendant call button inside the lavatory without any problems?

15) How do you realize inside the lavatory that you need to get back to your seat (e.g. due to turbulences)?

16) If you have a guide dog, does he accompany you to the lavatory? What kind of problems show up?

17) Are there enough supporting aids (e.g. handrails) inside the lavatory?

18) What do you think about the lighting inside the lavatory?

19) What do you think about the color scheme of the inside of the lavatory?

20) What do you think about the surface characteristics of the different components inside the lavatory?

21) Can you perceive the different placards and signs inside the lavatory? Do they help you?

22) What needs to be improved / changed in order to make you find the way to the lavatory on your own and make you able to get along inside the lavatory by yourself?

23) Have you ever been inside an aircraft cabin, in which Braille characters have been implemented? If yes, which airline was it? Which parts of the cabin did you find good?

24) Do you prefer an airline e.g. due to accessible facilities inside the cabin or good service? If yes, which airline is it and what are the reasons?

BLND GROUP DISCUSSION GUIDELINE (BSVH)

Inclusive Aircraft Lavatory Environment for Blind and Visually Impaired People

1) GENERAL INFORMATION

(1-1) What means of transportation do blind and visually impaired people prefer? What are the reasons?

2) QUESTIONS ON THE AIRCRAFT LAVATORY

(2-1) What problems do you have concerning the usage of the aircraft lavatory (getting to the lavatory, inside the lavatory, getting back to the seat)?

(2-2) What needs to be improved regarding the service provided by the airlines?

(2-3) Do you avoid using aircraft lavatories? If yes, what are the reasons?

(2-4) How do you orientate yourself inside the aircraft lavatory?

(2-5) What needs to be improved / changed concerning the usage of the lavatory?

(2-6) How do the different parts of the lavatory need to be designed?	
Door	
Flush Button	
Attendant Call Button	
Wash Basin	
Faucet	
Waste Bin	
Paper Towel Dispenser	
Placards and Signs	
Lighting	
Others	

CABIN CREW QUESTIONNAIRE

Inclusive Aircraft Lavatory Environment for Blind and Visually Impaired People

1) GENERAL INFORMATION

(1-1) Please mark your gender:	
☐ Female	☐ Male

(1-2) Please specify your age:

(1-3) Which airline are / were you working for?

(1-4) What is your professional level as cabin crew?			
☐ Cabin Crew	☐ Purser/Cabin Manager	☐ Cabin Crew Instructor	☐ Others
If you have marked others, please specify your professional level below:			

(1-5) Please specify your work experience as cabin crew below:
____ years

(1-6) Please specify which aircraft types you have flown with as cabin crew:

(1-7) Do you get any disability-specific training?		
☐ Yes	☐ No	
If yes, how often do you get such training?		
☐ Once a year	☐ Once every 2 years	☐ Others: _____

2) QUESTIONS ON BLIND AND VISUALLY IMPAIRED PEOPLE

(2-1) How often did you experience blind and visually impaired people during your work as cabin crew? Please specify for short-, medium- and long range flights.				
	never	rarely	sometimes	often
short range	☐	☐	☐	☐
medium range	☐	☐	☐	☐
long range	☐	☐	☐	☐

(2-2) How many percent of the PRMs (Persons with Reduced Mobility) were blind or visually impaired? *(Please estimate)*

short range: approximately _____ %

medium range: approximately _____ %

long range: approximately _____ %

(2-3) How often do blind and visually impaired people travel with an assisting person?				
☐ never	☐ rarely	☐ sometimes	☐ often	☐ always

(2-4) Do the blind and visually impaired travel with their guide dog?				
☐ never	☐ rarely	☐ sometimes	☐ often	☐ always
Do they bring their guide dog into the lavatory?				
☐ Yes		☐ No		
Where is the dog usually seated inside the aircraft? *(Please describe below)*				
What problems did you observe concerning the guide dog (inside the lavatory; with other passengers; etc.)? *(Please describe below)*				

(2-5) Is there a certain area in the cabin, where blind and visually impaired people (or PRMs in general) are seated?	
☐ Yes	☐ No
If yes, where are they usually seated? *(Please describe below)*	

(2-6) Do blind and visually impaired people usually ask for help if they want to go to the lavatory?			
☐ Yes		☐ No	
If yes, how often do they ask for help?			
☐ rarely	☐ sometimes	☐ often	☐ always

(2-7) What do you do to support blind and visually impaired people to use the lavatory (getting to the lavatory, inside the lavatory, getting back to the seat)? *(Please describe below)*

(2-8) Are there any airline regulations (obligations / prohibitions) concerning the support of blind and visually impaired people (or PRMs in general)? *(Please describe below)*	
Obligations	**Prohibitions**

(2-9) What are the typical problems / difficulties for you as cabin crew when assisting the blind and visually impaired (getting to the lavatory, inside the lavatory, getting back to the seat)?*(Please describe below)*

(2-10) What problems do blind and visually impaired people have (getting to the lavatory, inside the lavatory, getting back to the seat)? What problems did you observe? *(Please describe below)*

(2-11) What has been done for the blind and visually impaired concerning lavatory design? *(Please describe below)*

(2-12) Are there certain parts in the lavatory which often get broken in connection with the usage by blind and visually impaired people? *(Please describe below)*

(2-13) Please describe the differences between different aircraft types (B737, A320, etc.) in terms of support (concerning cabin design) for blind and visually impaired people.

3) FURTHER REMARKS

(3-1) What do you think should be changed in the cabin, especially in the lavatory to support blind and visually impaired people? What can be done to support you as cabin crew in order to give better support to them? *(Please describe below)*

Please save the completed questionnaire and send it back to:
kimberly.dippel@haw-hamburg.de

Thank you for your support!

CABIN CREW GROUP DISCUSSION GUIDELINE

Inclusive Aircraft Lavatory Environment for Blind and Visually Impaired People

1) GENERAL INFORMATION

(1-1) How often do you get disability specific training?

(1-2) What kind of training did you get concerning persons with reduced mobility (PRMs) in general and concerning blind and visually impaired people in particular?	
Persons with Reduced Mobility	**Blind and Visually Impaired People**

2) QUESTIONS ON BLIND AND VISUALLY IMPAIRED PEOPLE

(2-1) How often did you experience PRMs (in general) and blind and visually impaired people during your work as cabin crew?

(2-2) Where are PRMs generally seated?

(2-3) Do you describe to the blind and visually impaired people the different parts of the cabin, e.g. where to find the lavatories or the attendant call button at their seat?

(2-4) What kind of supporting aids are inside PRM lavatories? Has there something been done for blind and visually impaired people?

(2-5) Are there any supporting aids inside the cabin (e.g. aircraft layout in Braille)?

(2-6) What do you do to support blind and visually impaired people to use the lavatory (getting to the lavatory, inside the lavatory, getting back to the seat)?		
Getting to the lavatory	**Inside the lavatory**	**Getting back to the seat**

(2-7) Are there any airline regulations (obligations / prohibitions) concerning the support of blind and visually impaired people (or PRMs in general)?	
Obligations	**Prohibitions**

(2-8) What are the typical problems / difficulties for you as cabin crew when assisting the blind and visually impaired (getting to the lavatory, inside the lavatory, getting back to the seat)?

(2-9) What problems do blind and visually impaired people have (getting to the lavatory, inside the lavatory, getting back to the seat)? What problems did you observe?

(2-10) Are there certain parts in the lavatory which often get broken in connection with the usage by blind and visually impaired people? Do parts get broken in general?

3) FURTHER REMARKS

(3-1) What do you think should be changed in the cabin, especially in the lavatory to support blind and visually impaired people? What can be done to support you as cabin crew in order to give better support to them?

Appendix B

Useful Publications

Access to Air Travel for Disabled Persons and Persons with Reduced Mobility – Code of Practice

Department for Transport (DfT)

www.dft.gov.uk

The code sets out recommendations to ensure people with reduced mobility enjoy a consistent and seamless level of service. The code covers the whole journey, from accessing information at the booking stage through to arriving at the final destination.

Access to air travel – Guidance for disabled and less mobile passengers

Disabled Persons Transport Advisory Committee (DPTAC)

http://dptac.independent.gov.uk

The guide follows a step by step journey from planning the flight to getting to the destination. It explains why airports and airlines need information about disabled and less mobile passengers.

Access Handbook Template – A Tool to Help Manage the Accessibility of the Built Environment

National Disability Authority (Ireland)

http://www.nda.ie/cntmgmtnew.nsf/0/1E4453E67C647DCB80257088005E9F3A

The handbook lists and explains the features and facilities of a building, which must be maintained and / or improved in order to ensure access for everyone.

Access to Air Travel for Persons with Reduced Mobility and Disabled Persons – Guide of practice

Direction De L'Aviation Civile – Grand-Duché De Luxembourg

The purpose of the guide is to improve the accessibility of air travel for persons with reduced mobility and disabled persons. The guide sets out minimum standards, which the aviation industry should provide but encourages those involved to provide higher level of service and facilities.

Carriage by Air of Special Categories of Passengers – Final Report

European Aviation Safety Agency, TÜV Rheinland Kraftfahrt GmbH

The report gives an overview of existing regulations, rights and guidance material regarding persons with reduced mobility traveling by air.

Royal National Institute of Blind People (RNIB)

www.rnib.org.uk

The institute offers information, support and advice to blind and visually impaired people. It also gives advice on e.g. designing accessible information.

Accessibility Specification for Toilets on Aircraft

Disbled Persons Transport Advisory Committee (DPTAC)

http://www.dptac.independent.gov.uk/pubs/aviation/toiletspec/index.htm

The specification aims to ensure all disabled persons and persons with reduced mobility are able to gain access to toilet facilities, move within the toilet and fully use the toilet facilities on aircraft.

The Colour, Light and Contrast Manual - Designing and Managing Inclusive Built Environments

Keith Bright and Geoffrey Cook

Wiley-Blackwell

www.wiley.com/go/brightandcook

The book offers guidance on how color, light and contrast can be incorporated within buildings to enhance their usability.

ILIS – Integratives Leit- und Informationssystem

http://www.ilis-leitsysteme.de/

Offers possibilities on implementing high-contrast and tactile way-guidance and signage systems. In German.

Deutscher Blinden- und Sehbehindertenverband e.V.

Gemeinsamer Fachausschuss für Umwelt und Verkehr (GFUV)

http://www.dbsv.org/dbsv/unsere-struktur/uebergreifende-fachausschuesse/gfuv/

Offers guidance and DIN codes on general design aspects, way-guidance systems, tactile lettering, written information, etc. In German.