TECHNISCHE UNIVERSITÄT WIEN

Diploma Thesis

Universal Design in Metro Stations
-
A Case Study in Copenhagen and Vienna

submitted in satisfaction of the requirements for the degree of
Diplom-Ingenieurin
of the TU Vienna, Faculty of Architecture and Planning
by

Yasmin Haase, BSc
Matr. Nr.: 01427022

Supervision:
Ao.Univ.Prof. Univ.Prof. Mag. Dr. Günter Emberger
and
DI Helmut Lemmerer
E230-01 Research Unit of Transport Planning and Traffic Engineering

Vienna
August 18, 2023

Abstract

Background

Universal Design in public transport is indispensable for the independence of individuals and allows people to participate in society. Therefore, barrier-free metro stations are an essential part of public transport in Copenhagen and Vienna. By looking at Frederiksberg station in Copenhagen, which is situated within a fully automated metro network, and Längenfeldgasse station in Vienna, which is not fully automated yet, the approaches towards inclusive built environments are analyzed.

Methods

The research was conducted through two methods. First, an evaluation tool was applied in one station of each city, providing insights on positive and improvable criteria for different user groups concerning the accessibility of the station surrounding. Secondly, through go-along interviews, remarks by mobility-restricted people were gathered to obtain information beyond the applied catalog.

Results

Despite many existing standards within this field, both stations reveal deficiencies for all examined user groups concerning accessibility. Among others, Frederiksberg station in Copenhagen lacks ideal infrastructure for wheelchair users and people with hearing difficulties. Furthermore, Längenfeldgasse station in Vienna shows potential for improvement, especially for vision and hard-of-hearing people. Additionally, evaluation tool outcomes were confirmed through the go-alongs, and further details concerning specific needs were revealed.

Conclusion

Recommendations for improvements concerning both stations stem from existing standards, interviews with persons of the target groups, and a comparison to the respective other metro station. Different user groups have contradictory requirements for a metro station area; therefore, designing a metro station requires a sensitive approach.

Kurzfassung

Hintergrund

Universelles Design trägt zu individueller Unabhängigkeit bei und ermöglicht eine Teilhabe an der Gesellschaft. Daher sind barrierefreie U-Bahn-Stationen sind ein essenzieller Bestandteil des öffentlichen Verkehrs in Kopenhagen und Wien. Anhand der Station Frederiksberg in Kopenhagen, welche sich innerhalb eines vollautomatisierten Systems befindet, und der Station Längenfeldgasse, welche sich noch nicht in einem vollautomatisierten System befindet, wird die Inklusivität der gebauten Umwelt analysiert.

Methodik

Die Forschung wurde mit Hilfe zweier Methoden durchgeführt. Es wird ein Bewertungskatalog in jeweils einer Station der beiden Städte angewandt, welcher Einblicke über positive und verbesserungswürdige Kriterien unterschiedlicher Nutzer:innengruppen betreffend der Barrierefreiheit innerhalb der U-Bahn-Station gibt. Weiters werden durch begleitende Interviews Kommentare von mobilitätseingeschränkten Personen zusammengetragen, um über den Bewertungskatalog hinaus detaillierte Informationen zu bekommen.

Ergebnisse

Trotz vorhandener Normen im Bereich des barrierefreien Gestaltens öffentlicher Räume, weisen beide Stationen Defizite für alle untersuchten Personengruppen auf. Innerhalb der Station Frederiksberg in Kopenhagen ist insbesondere ein Mangel an geeigneter Infrastruktur für Personen im Rollstuhl und Personen mit eingeschränktem Hörvermögen evident. In der Station Längenfeldgasse in Wien ist vor allem ein Optimierungspotential für seh- und hörbeeinträchtigte Personen zu verzeichnen. Weiters wurden die Ergebnisse des Bewertungskatalogs durch begleitende Interviews bestätigt und darüber hinaus detailierte Informationen über individuelle Bedürfnisse aufgezeigt.

Fazit

Die Empfehlungen beider Stationen resultieren aus existierenden Normen, Kommentaren teilnehmender Personen und der jeweils anderen untersuchten U-Bahn-Station. Die Notwendigkeit einer sensiblen Herangehensweise der Planung wird deutlich, durch sich widersprechende Anforderungen der nutzenden Gruppen.

Acknowledgments

This thesis was possible because of many others. Therefore, **special thanks go to**

Prof. Emberger and **DI Lemmerer**, for your interest in this work from the beginning, the subject-specific feedback, and the support throughout this work.

Cecilie, for supporting my interest in this topic and for the unique possibility of collaborating with you and the Copenhagen Metro.

all interviewees who participated in this study and **experts** who shared valuable insights into the lived practice of planning Universal Design.

my colleagues and, in particular, **friends** with whom and from whom I was able to learn. Many thanks to **Eric** for motivating study sessions and innumerable pomodoros.

my family, especially my parents, who supported every step and decision I made during my studies. I am lucky to be part of such a curious, motivating, and understanding surrounding. And thank you, **Toby**, for introducing me to Danish culture, language, and food.

Table of Contents

List of abbreviations

DOT	Din Offentlige Transport
DS	Danish Standard
e.g.	exempli gratia
EX	Elevator number X
EN	European Standard
FS	Frederiksberg station
FSV	Österreichische Forschungsgesellschaft Straße, Schiene, Verkehr
Ibid.	Ibidem
ISO	International Organization for Standardization
LS	Längenfeldgasse station
MofA	Mobility for All
M1/M2/M3	Metro Line M1/M2/M3 in Copenhagen
OECD	Organisation for Economic Co-operation and Development
OIB	Österreichisches Institut für Bautechnik
PRM	Persons with reduced mobility
RIS	Rechtsinformationssystem des Bundes
SBi	Danish Building Research Institute
TSI PRM	Technical Specification for Interoperability - Persons with Reduced Mobility
TWSI	Tactile walking surface indicator
UN	United Nations
UNHCR	The United Nations Refugee Agency
U4/U6	Metro Line U4/U6 in Vienna
VDV	Verband Deutscher Verkehrsunternehmen
WHO	World Health Organization
WKO	Wirtschaftskammer Österreich

1. Introduction

"Accessibility is indispensable for 10%, necessary for 40%, and comfortable for 100% of the population."
(WKO 2022, own translation)

The Sustainable Development Goal 11, "Sustainable cities and communities," includes target 11.2, which claims safe, affordable, accessible, and sustainable transport systems for all by 2030 (United Nations 2022a). The European Commission states in the strategy for the rights of persons with disabilities, that accessibility is "an enabler of rights, autonomy, and equality" (European Union 2021, p. 6). Accessible public transport provides independent access to work sites, health facilities, educational programs, and social and recreational interaction and, therefore, is necessary for being fully socially integrated (Steinfeld, Maisel and Steinfeld 2018). Furthermore, it is crucial for influencing active aging (WHO 2007). A checklist from WHO for age-friendly transportation includes transport stops and stations and states their importance of location, seatings, weatherproof stops, cleanliness, safety, lighting, and more (Ibid.). The population aged 60 years and over will increase worldwide (WHO 2022); thus, recognizing the factors mentioned in this checklist will gain importance. However, not only older or disabled people are relevant user groups. Universal Design focuses equally importantly on accessibility for children, parents with a pram, people traveling with heavy luggage or a bicycle, and many more. All these groups can be considered mobility-restricted and have different requirements for the built environment. The existing legal framework tries to ensure the regulation of designing public transport stations on international and national levels. Relevant laws and standards concerning Universal Design for Denmark and Austria are evaluated as part of this thesis. Even though a legal framework exists, compliance with applicable laws and standards can be improved. As Clarkson and Coleman (2015, p. 245) state, "[...] there is much yet to be done before we can honestly say that we live in an inclusive world".

1.1 Research aims and questions

This research aims to evaluate the inclusivity of two metro stations of different metro systems. One station is located in Copenhagen, where fully automated trains are running. The other station is in Vienna, where the first automated metro line is planned to be introduced in 2026. Furthermore, this project intends to gain international insights into Universal Design implementations of already existing metro stations. Finally, through the evaluation of the built environment, recommendations should be derived for improvements of these specific stations and stations not constructed yet, leading to the following research question, including two subquestions:

How can Universal Design be improved within the metro system of Copenhagen and Vienna?

- How do Frederiksberg station in Copenhagen and Längenfeldgasse station in Vienna meet the need of mobility-impaired people?
- What could be implemented to improve the inclusivity of these stations and those not yet built?

1.2 Thesis structure

This thesis is structured into six parts. The introduction provides an overview of the research aim, and question, thesis structure, and limitations. Following, the theoretical framework provides insights into Universal Design, the needs of different mobility-restricted groups of people, a general overview of the chosen metro systems, statistics, and the existing legal framework. The methods and methodology section introduces the reader to the applied MofA (Mobility for All) evaluation tool and go-alongs. The evaluation tool consists of multiple tables resulting in quantitative evaluation and photo documentation of the considered stations. The go-alongs are semi-structured interviews with participants while moving through a metro station in Copenhagen and Vienna. The fourth section comprises the results of the applied methods in both cities. The MofA evaluation tool provides quantitative data and a picture catalog, whereas the go-alongs result in qualitative data. Diagrams represent the walked path, including the location of positive and negative remarks of participants towards the built environment. The discussion represents the fifth part, including recommendations for the respective metro stations and future stations, including references to existing standards. Finally, the conclusion and perspective summarize this research project and provide an outlook for future research projects in this field.

1.3 Limitations and delimitations

The study focuses mainly on the metro companies' responsibilities, particularly metro station buildings; it must be addressed that other evaluation criteria from the MofA evaluation tool were not considered. The evaluation of the continuity in the trip chain outside a metro station is not covered. However, it is an essential component of "door-to-door" (Aarhaug and Elvebakk 2015) accessibility for mobility-restricted people. This thesis covers one station in each city; thus, generalizing the results for all excluded stations is impossible. Furthermore, the sample of participants was not entirely randomized. In Copenhagen, participants were recruited through MSc Arch. B. Christensen, an employee and contact person of Copenhagen Metro. In Vienna, different accessibility associations were asked to forward the request to affected people. In both cases, dedicated people responded, and people uncomfortable with the go-along process might have been excluded. Additionally, the MofA evaluation catalog does not cover all essential criteria for persons with reduced mobility (PRM); some categories are based on subjective answers. Complete data on mobility-impaired persons are not available due to a lack of exhaustive data regarding PRM in the broad sense. Furthermore, language barriers and the lack of English translations of some Danish handbooks and guides meant that these could not

be considered in detail.

2. Theoretical framework

The following will outline the theoretical framework of this study, including definitions, a chapter on Universal Design, PRM and their needs and challenges using public transport, and statistics in Denmark and Austria. Furthermore, the metro network in Copenhagen and Vienna will be described in detail as the legal framework concerning accessibility in public transport on international and national levels. The conclusion of this chapter will summarize the main points stated.

2.1 Definitions

The terms impairment, disability and Universal Design are central to this thesis and will be explained in more detail.

2.1.1 Impairment

Clarkson et al. state in the book "Inclusive Design" (2003a) impairment can result from congenital diseases, health conditions, the aging process, or traumatic events. Whether an impairment leads to a disability depends significantly on social and environmental factors, such as the design of environments, products, systems, and services.

2.1.2 Disability

Disability can be seen as a discrepancy between individuals and their social and physical environment (Clarkson et al. 2003a). According to WHO (2023), the environment has a major impact on the experience and extent of disability, as inaccessible environments create barriers to fully participating in society.

2.1.3 Universal Design

Multiple terms are used interchangeably as Inclusive Design, Universal Design, and Design for All (Eikhaug 2010). Whereas the term Inclusive Design was defined by the UK government in 2000 (Ibid.), Universal Design originated in the USA and was promoted by architect Ron Mace starting in 1985 (Clarkson et al. 2003b). Design for All is closely related to Inclusive Design, and this term is used in Europe and Scandinavia (Eikhaug 2010). Bendixen and Benktzon (2015) state that the term Design for All, and accessibility is used in countries such as Denmark, Sweden, and Finland, even though accessibility is less and less used. According to the European Committee for Standardization (CEN), Design for All and Universal Design include a similar philosophy of inclusive design (Dansk Standard 2021a). Furthermore, article two in the Convention on the Rights of Persons with Disabilities explains Universal Design as the "design of products, environments, programs, and services to be usable by all people, to the greatest extent possible, without adaptation or specialized design" (United Nations 2008, para.

5). Bröcker (2011) mentions it is to be expected that the EU will focus on the term Universal Design in the future. United Nations uses the term Universal Design as well; thus, it is included in the title of this thesis. Throughout this project, terms such as Universal Design, Inclusive Design, and Design for All will be used synonymously, as designing for the greatest number of people seems to be a common interest.

2.2 Universal Design in detail

Ron Mace wanted the debate on accessibility to shift to an approach of designing for people of all ages and abilities rather than having special products for disabled or older people. Thus seven principles of Universal Design were established by the Center of Universal Design around 1997:

"1 Equitable use
2 Flexibility in use
3 Simple and intuitive to use
4 Perceptible information
5 Tolerance for error
6 Low physical effort
7 Size and space for approach and use"
(Clarkson et al. 2003b, p.13)

The user pyramid in Figure 1 visualizes an inclusive design approach to include more than non-disabled users and users with minor disabilities, as this is the lowest part of the pyramid (Benktzon 1993). The middle part covers people with different difficulties as reduced strength or mobility, and older people with more severe age-related impairments. The top of the pyramid represents people who depend on others for numerous daily activities. Inclusive Design tries to include higher levels of the pyramid and, therefore, is a bottom-up approach according to Persad (2011).

.

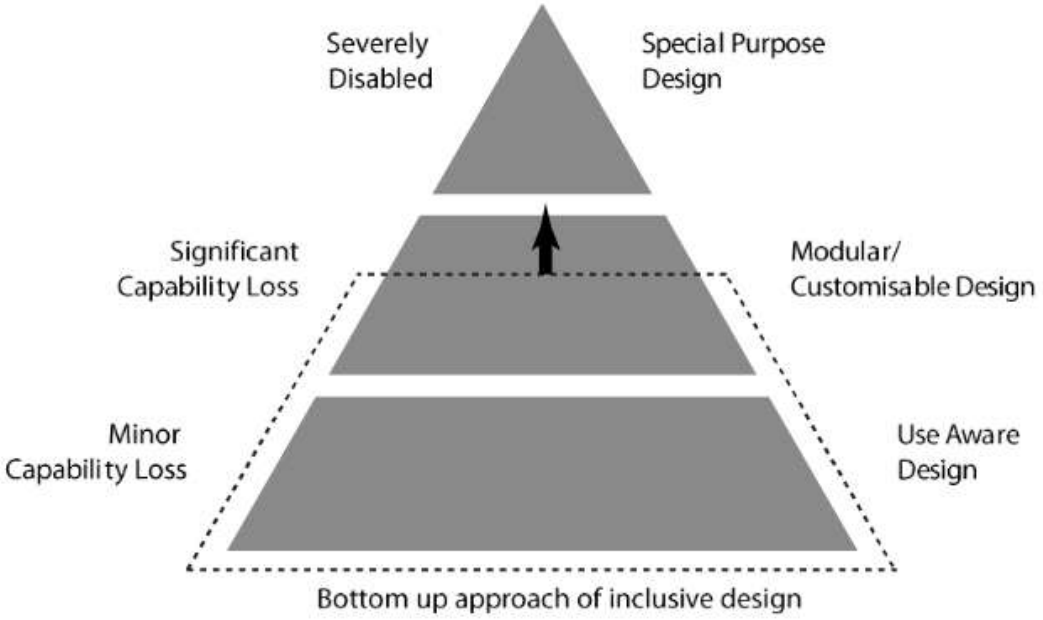


Figure 1: Inclusive design pyramid (Persad 2011, p. 27)

2.2.1 The benefit of Universal Design

As European Standard 17210 (Austrian Standards International 2021) mentions, planning inclusively contributes to health and wellbeing. Furthermore, considering the demographic change and the aging society, accessible environments have become more important. Additionally, accessibility provides economic and social benefits since previously excluded groups can participate in society and increase their independence. Finally, integrating Universal Design helps promote sustainability as adaptations of the built environment at a later stage can be avoided.

Inclusive mobility systems

Fian and Hauger (2020) elaborated a conceptual framework for designing and organizing an inclusive mobility system to provide accessible mobility systems in the future. They state that current mobility infrastructure in Austria and other OECD countries is not user-friendly for all vulnerable groups, and potential for improvement exists. As a result of their paper, eight key inclusive components were determined. One is the "i Environment", which consists of requirements for a barrier-free transport station, including the built environment, guidance systems, passenger information, and navigation systems. This thesis contributes to their defined "i Environment" component of an inclusive mobility system.

2.2.2 Multiple-senses principle

Wayfinding and information should be perceivable through different senses according to the principle of multiple senses (Dansk Standard 2021b). Design decisions should consider various sensory impairments (Austrian Standards International 2023). The international standard suggests providing visual, audible, tactile, and simple language formats. At least

visual information should be offered to people with hearing impairments instead of audible communication, and audible plus tactile information should be accessible for visually impaired people. Depending on the noise level and the options for positioning and detection of tactile information, it has to be decided whether audible, tactile information, or both are necessary to supplement visual communication (Dansk Standard 2021b).

2.3 PRM and their needs using public transport

The group of mobility-restricted people is heterogeneous and should include PRM in a narrow and broad sense. Their individual requirements for (autonomous) public transport reveal the necessity of complex solutions.

2.3.1 Mobility-restricted people

People who are restricted in mobility can be divided into two categories (VDV and VDV-Förderkreis 2012). The category of mobility-restricted people in a narrow sense includes people with physical disabilities, for example, wheelchair users, visually impaired people as partially sighted or blind people, hard-of-hearing people, people with speech impairments, developmental disabilities, and mentally ill people. The category of mobility-restricted in a broad sense can be distinguished between travel-related and age-related groups. Travel-related types include people traveling with baggage, prams, pushchairs, bicycles, shopping trollies, or luggage carts. Furthermore, it contains people traveling with dogs, expectant mothers, overweight people, people unfamiliar with the surroundings or persons with temporary impairments, people with allergies, and passengers who do not speak the local language. Age-related mobility-restricted groups are older adults or children.

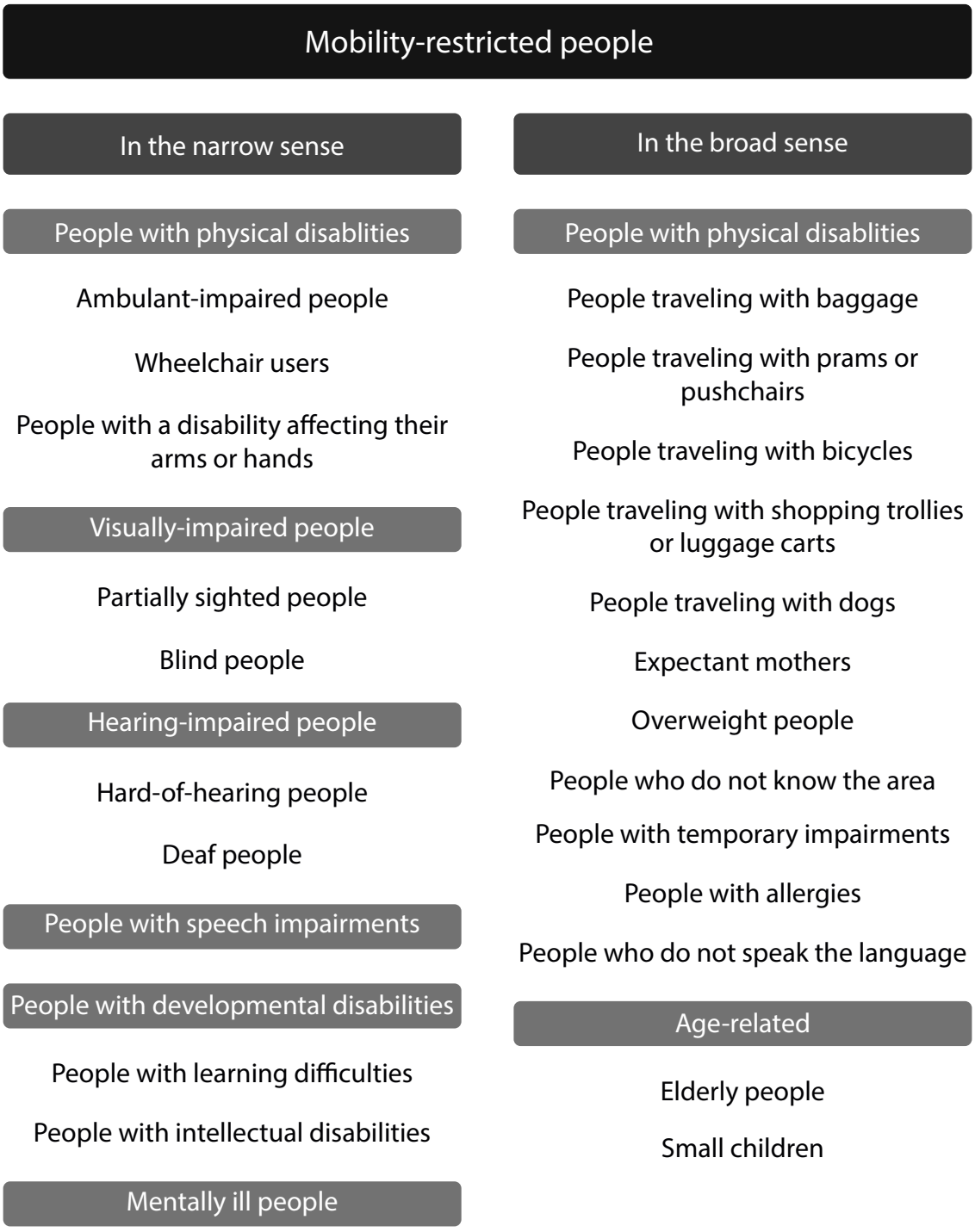


Figure 2: Mobility-restricted people (based on VDV and VDV-Förderkreis 2012, p. 29)

2.3.2 PRM and their challenges using public transport

People with restricted mobility encounter different difficulties in everyday life when using public transport. To better understand specific user groups and their needs, this chapter includes general requirements and focuses mainly on infrastructural requirements.

Elderly people

According to United Nations, persons over 60 are defined as older; however, it might depend on

other aspects such as physical appearance or age-related health conditions (UNHCR 2020). The OECD (2022) refers to over 65-year-olds as the elderly population; therefore, there seems to be no standard definition of older people. Life expectancy is rising worldwide, and the proportion of older people in every country is increasing (WHO 2022). Persons aged 65 years and above are part of the fastest-growing age group globally (United Nations 2022b). Older people are not a homogenous group as their health conditions, travel needs, and favored mode of transport might differ (Cirella et al. 2019). However, the risk of disability rises with age (United Nations 2022c). Age-related impairments such as reduced mobility, visual, hearing, or cognitive impairment can occur simultaneously (WHO 2022). Therefore elderly passengers can have difficulties climbing stairs or walking long distances, standing for a long time, standing stable, or dealing with new technologies (VDV and VDV-Förderkreis 2012). Shrestha et al. (2017) mention not only the conditions in a public transport vehicle but everything attached to the entire trip, from the start to the end, is essential to older passengers. They care about service quality, personal security, frequency, reliability, affordability, etc. Particularly relevant to this paper by reference to a bus stop, they identify that preferably real-time information, audible information, a visible and well-lit location, a clean and weatherproof station, and seatings should be available.

Passengers with prams or heavy luggage

People with prams, pushchairs, or heavy luggage might depend on assistance when entering or exiting a public transport vehicle, experience a lack of space even if there is a designated space for them, and might face a shortage of seats for companions (VDV and VDV-Förderkreis 2012).

Children and adults of small stature

The radius of action increases for children aged eight to ten years, and accessibility to public transport becomes more important to them (FSV 2015). Austrian guidelines from FSV (Ibid.) state the importance of having sufficient staff in public transport vehicles and that a positive experience at a young age can impact transportation choices later in life. Furthermore, children's requirements for public transport are similar to the ones of adults; concerning public transport stops, children prefer seating options, adequate lighting, spacious covered areas, and covered parking for bicycles and scooters. It must be stated that children have different requirements than adults, due to their unpredictable behavior.

Difficulties of smaller passengers, can be faced when reaching controls, ticket validators, communication equipment, and handles (VDV and VDV-Förderkreis 2012).

Visually impaired or blind people

According to the international standard (Dansk Standard 2021b, p.7), visual impairment is defined as a "permanent reduction of visual perception ranging from partial sight to blindness depending on the residual functional sight." Furthermore, this standard states, "In relation to accessibility requirements, "partially sighted persons" means persons, who primarily use their (residual) sight, and "persons who are blind" means persons who primarily rely on audible and tactile input, although they can also have a certain amount of visual perception." There are

different ways for visually impaired people to navigate through space. By using other senses, such as touch, sound, olfaction, and kinesthetic senses, they can orient themselves in case visual information is not accessible (Goldschmidt 2018). Additionally, cognitive maps of the environment provide mental images making independent travel possible. Goldschmidt (Ibid.) states that the most used assistive devices are the white cane and the guide dog. The white cane is moved from one side to the other, detecting obstacles within a 90 cm range, and it can provide the user with haptic and auditory information. Different techniques can be applied, depending on the built environment and the familiarity of it. For example, smaller objects might be missed, which reveals their limitations. A guide dog requires a mobility training course. The dog is trained to avoid all obstacles and can be a support for traveling through open areas even though it is not suitable for all blind people since the travel speed is faster compared to traveling with a cane. Related to public transport, blind people might have trouble finding the stop, the pavement edge, an entrance door, ticket machines, or other amenities with control elements (VDV and VDV-Förderkreis 2012). Furthermore, visual information such as timetables, network maps, or exit stops can be hard to recognize. Choosing the right line and destination can pose a problem at central stops. Passengers with reduced vision might be at risk because they miss visual warnings or encounter obstacles. Partially sighted people might face the same difficulties, depending on the severity of the impairment.

Hard-of-hearing or deaf people

Deaf and hard-of-hearing passengers, depending on the severity of their impairment, are at risk of missing information exclusively provided acoustically. These can be warnings, noises from a moving vehicle, or similar indications (VDV and VDV-Förderkreis 2012). According to Fürst and Vogelauer (2012), joint problems encountered at stations and the surrounding area for this user group include incomprehensible announcements at stations and the lack of induction technology at larger stations. Additionally, they identified elevators and the lack of specially trained staff as issues.

Wheelchair users, passengers using walkers, or ambulant-impaired people

People who use walkers or ambulant-impaired people often have similar difficulties as wheelchair users when using public transport, depending on the severity of their impairment (VDV and VDV-Förderkreis 2012). Additionally, for people with walkers, using handholds can pose a problem. All these user groups face issues such as accessing a stop and the platform, getting in and out of a vehicle, positioning inside the vehicle, and reaching operating elements. The importance of functional elevators becomes evident in a quotation from Raul Krauthausen, one of the founders of Sozialheld*innen (Social Heroes), an organization dedicated to improving accessibility (Sozialhelden e.V. 2021). He states, “For me as a wheelchair user, not knowing whether an elevator is working or not is a big obstacle since I am dependent on it [...] As a result, I often have detours of 30 minutes or more” (Sozialhelden e.V. 2016, own translation).

Passengers without full use of their hands

People without full use of their hands face problems such as pushing buttons, validators, ticket machines, or handholds (VDV and VDV-Förderkreis 2012).

Passengers with impaired concentration and orientation

People with difficulties with concentration and orientation frequently encounter problems when reading timetables or network maps, processing static and dynamic information as well as orientation aids and warning signs (VDV and VDV-Förderkreis 2012).

Autonomous mobility systems

The research project CATAPULT was funded by Urban Europe and was a collaboration between different European countries (CATAPULT 2023). It aims to investigate inclusive urban autonomous mobility solutions and identify certain needs for mobility-restricted groups such as children, older passengers, or people with different impairments (Rieß et al. 2021). Senior citizens emphasized the importance of the availability of a contact person, safety in case of emergency, and an emergency button for connecting a human, not a chatbot. Furthermore, there was a split opinion about video surveillance. Some explicitly wished for it, and others expressed concerns. Additionally, it was stated that a clear visual guidance system is indispensable. Children highlighted the importance of readability, visibility, and understandability. They wished for more benches, trash cans, trees, and playful elements at bus stops. Furthermore, they expressed a desire for colorful and unusual design and safety features.

2.4 Statistics

This subchapter intends to provide an overview of available data concerning PRM, older adults, children, and metro users in Denmark and Austria, as well as city-specific data, depending on availability.

2.4.1 Statistics in Denmark

Available statistics for Denmark and Copenhagen were mainly gathered through a Danish report called “Mennesker med handicap,” Statistics Denmark, and personal communication with a contact person at Metro Copenhagen.

Mobility-restricted people

According to Dansk Handicap Forbund (2022), it is not easy to quantify the number of people with disabilities in Denmark, but 10-15% of the population is assumed to be affected. The report “Mennesker med handicap” (VIVE et al. 2021) gives an overview of people living in Denmark who categorize themselves as handicapped and is based on the international classification of disability of WHO. In this report, participants were asked to answer whether they suffer from a long-term physical health problem and, if they do, whether the most severe health problem is a minor or a major health problem. Additionally, they were asked if they had a mental disorder; if this was the case, they had to specify whether it was minor or major. The

data includes people aged between 16 and 64 years and is based on the population on June 30, 2020. Results might be influenced by the Covid19 pandemic. People can have a physical and a mental disorder at the same time but not a minor and a major disability of the same kind. Results show that around 69% of the population do not, and 31% consider themselves disabled in 2020. In the first quarter of 2020, 69% of Denmark's population is equivalent to 4 017 706, and 31% is equivalent to 1 805 057 people (Statistics Denmark 2023a). According to VIVE et al. (2021), 15.8% state having a minor physical handicap, 8.6% state having a major physical handicap, 7.4% affirm having a minor mental disorder, and 3.3% answered having a major mental disorder. The share of people with disabilities increases with age. The report includes a chapter on transport. Figure 3 shows that people with a handicap have more difficulties than people without a handicap using public transport in Denmark. People were asked whether they could use public transport such as bus and train in case of high passenger volume. Around a third of people suffering from a major physical handicap do not use or can not use buses or trains under these circumstances. In addition, a share of 30.5% of people with a major mental disorder do not use or can not use a bus or train in case of high passenger volume.

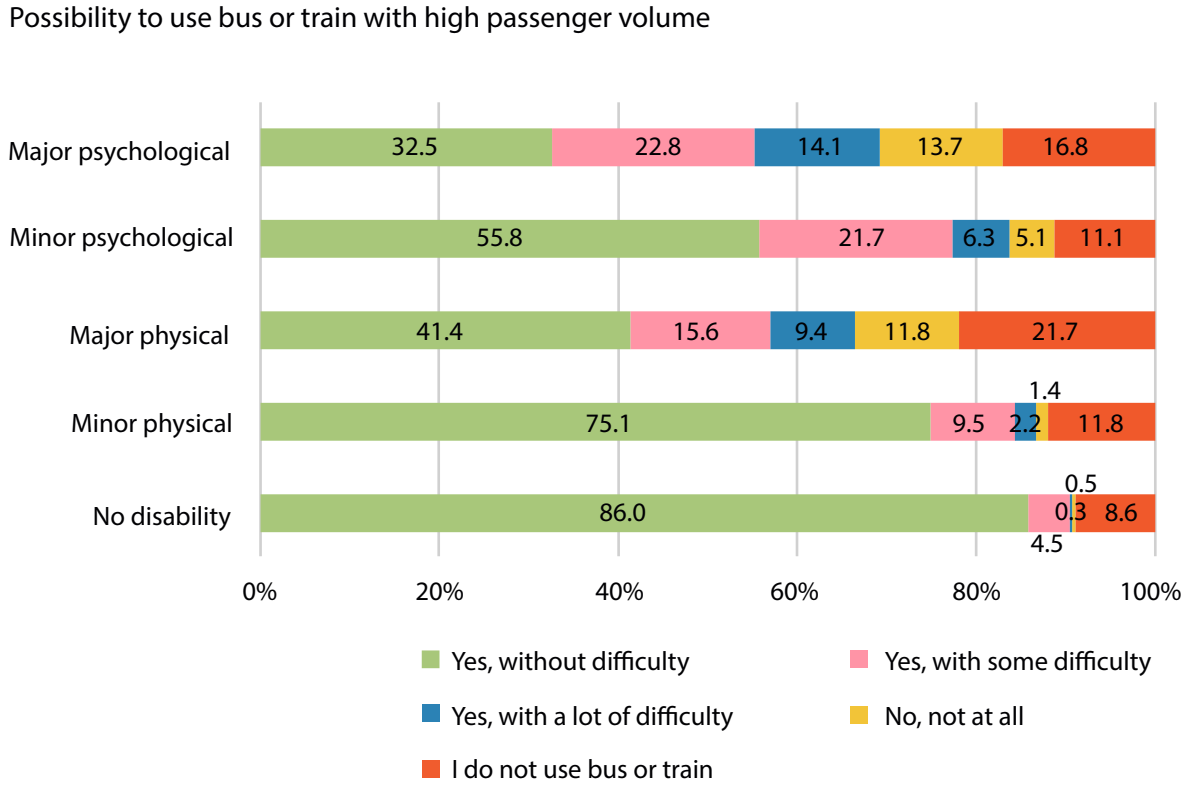


Figure 3: Statistics on the use of public transport in high passenger volumes and the severity of people's disabilities in Denmark (VIVE et al. 2021, p. 119, own translation)

Elderly

As OECD (2015) states, "Denmark is facing the challenge of population ageing" even though the aging process is slower compared to other OECD countries. Table 1 shows the share of

people aged 65 years and above based on population numbers published on December 7, 2022 in Province Byen København, which includes the municipalities Copenhagen, Frederiksberg, Dragør, and Tårnby. This province was chosen to make the population numbers from 2022 comparable to projections. Years 2030, 2040, and 2045 are calculations of projections based on a data set from May 24, 2022. An increase of 4.4% in people aged 65 years and older is expected between 2022 and 2045. No numbers for projections for further years are available.

Table 1: Statistics elderly Copenhagen (Calculations based on Statistics Denmark 2022a, 2022b)

Province Byen Copenhagen	65 years or older
2022	12.2%
2030	13.3%
2040	15.8%
2045	16.6%

Children

In this thesis, children are expected to travel alone starting at the age of 6 years. RVS 03.04.13, a guideline on child-friendly mobility, covers children up to 14 years of age (FSV 2015). Therefore, data were collected for children aged between 6 and 14. In Copenhagen and Frederiksberg, the total number of children between 6 and 14 years was 58.845 in the first quarter of 2023, representing around 7.8% of the total number of people living in this area (calculations based on Statistics Denmark 2023b).

Copenhagen Metro

A data set including total passenger numbers and people with a handicap in the whole Copenhagen Metro system was provided by Copenhagen Metro employee Agertoug (personal communication, June 7, 2022). It refers to numbers in 2019; numbers from the following years were not considered since the covid pandemic might have influenced passenger numbers. In 2019 an average share of 0.2% of people using the metro in Copenhagen traveled with the travel card “Rejsekort classic” of the customer type handicap. This ticket type can be requested by people having an official confirmation of their disability or their carer (Rejsekort & Rejseplan A/S 2023).

2.4.2 Statistics in Austria

Available statistics for Austria and Vienna were gathered through a report by the Austrian Ministry of Social Affairs, Statistik Austria, and personal communication with people from “Wiener Linien” and “Fonds Soziales Wien” concerning metro data.

Mobility-restricted people

In 2015 the percentage of persons aged 15 and older in Austria suffering from permanent mobility impairment was 14.1%, representing 1,03 million people (Austrian Ministry of Social Affairs 2016). Furthermore, other permanent disabilities are mentioned, such as visual impairment affecting 216,000 people (3%), hearing impairment affecting 157,000 people (2.1%), nervous or psychological issues affecting 270,000 people (3.7%), learning disability and mental issues affecting 60,000 people (0.8%) and language problems affecting 26,000 people (0.4%) (Ibid.). According to a report by the Austrian Ministry of Social Affairs conducted from October 2018 to September 2019, 7.9% of 15 to 29-year-olds, 9.1% of 30 to 44-year-olds, and 16.7% of 45 to 59-year-olds in Austria suffered from visual difficulties (Austrian Ministry of Social Affairs 2020). The most severely impacted group of people with sight problems starts from 75-year-olds, with 28.6%. Younger people are barely affected by hearing difficulties, whereas every tenth person of 60 to 74-year-olds is. Starting from 75 years, more than a fourth has hearing problems, especially in louder surroundings 60.1% of 74 years or older suffer from hearing difficulties. The report shows mobility issues increase with age, 45.1% of 75 years or older have difficulties walking half a kilometer without assistive devices on an even surface, and 49.0% of the respective group have problems when climbing stairs

.

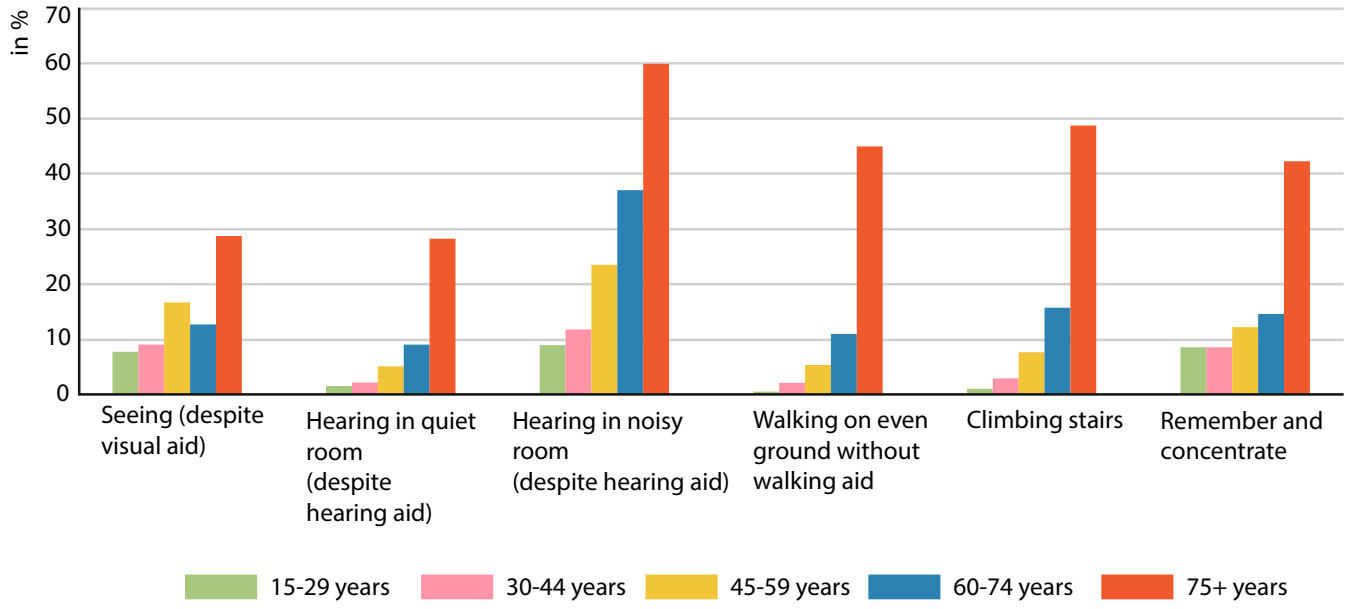


Figure 4: Statistics of different impairments by age in Austria (based on Austrian Ministry of Social Affairs 2020, p.36, own translation)

Furthermore, data were collected on people with disabilities and their attitudes towards public transport. For example, in 2015, 11.9% of disabled people always and 14.4% sometimes considered themselves disadvantaged when using public transport (Austrian Ministry of Social Affairs 2016).

Elderly

2015 a micro-census was conducted in Austria, and it stated that due to demographic change, the number of disabled seniors would increase (Austrian Ministry of Social Affairs 2016). A population forecast made by Statistik Austria shows predictions for Austria and Vienna for the years 2030, 2040, 2060, 2080, and 2100 (Statistik Austria 2022a). In both cases, the average age and the group of people aged 65 years or older will increase. As Table 2 shows, this group of people is predicted to increase by 8.5% from 16.6% in 2022 to 25.1% in 2100 in Vienna.

Table 2: Statistics Elderly Vienna (Statistik Austria 2022a)

Vienna	65 years or older
2022	16.6%
2030	18.5%
2040	20.6%
2060	23.2%
2080	24.6%
2100	25.1%

Children

The total number of children between 6 and 14 years was 163,035 in Vienna in the first quarter of 2022, representing around 8.4% of the total number of people living in this area (calculations based on Statistik Austria 2023).

Viennese Metro

According to information from Izsak, an employee of Wiener Linien, no data concerning people with disabilities using the metro in Vienna is available (personal communication, March 15, 2023). Lindner and Berger from "Fonds Soziales Wien" (personal communication, December 6, 2022) state that in 2019 2,890 customers got a reduced annual ticket for public transport in Vienna due to blindness and deafness. These are numbers concerning affected people, not their carers. "Fonds Soziales Wien" only provides reduced yearly tickets for the mentioned groups; therefore, this does not allow any conclusions to be drawn about the total number of metro users with reduced mobility.

2.5 Two metro systems

Since the case studies were conducted within two metro systems, the following sections will generally describe them.

2.5.1 Metro system in Copenhagen

The metro system in Copenhagen was opened in 2002; 50% of the Copenhagen Metro belongs to the City of Copenhagen, 40.7% to the Danish Government, and 8.3% to the City of Frederiksberg (Metroselskabet I/S 2022a). It is part of DOT (Din Offentlige Transport), a collaboration

between public transport companies to ensure a well-functioning public transport system on Sjælland, Lolland, Falster, and Møn (DOT 2022a). The metro trains are fully automated; they run every two minutes during rush hours, and since 2009 they have operated 24 hours a day (Metroselskabet I/S 2022b). Trains are 39 m long and 2,65 m wide, the operating speed is 40 km/h on average, and the train has a capacity of 306 passengers (Metroselskabet I/S 2022c). All metro stations have a similar design, characterized by simplicity and strict lines; daylight is brought into underground stations through glass pyramids (Metroselskabet I/S 2022d). Jensen and Morelli (2011, p. 41) describe the working and design of the Copenhagen metro as "functionally and aesthetically a hallmark of cool and smooth modernism" and state, "clean and smooth platforms rid of any signs of ornament." Moreover, they mention difficulties with the discrete signage, as it is "in danger of "drowning in the semiotic sea" of urban signscape" (Ibid.). Using other metro system examples such as Paris or London, they criticize the Copenhagen Metro for not creating an "urban space" due to the lack of different activities or programs than passenger circulation. Although the lack of creating an "urban space" is addressed, it has to be stated that Copenhagen Metro already integrates art during construction work on the construction site hoardings (Metroselskabet I/S 2019) and will continue to do so in future stations of the metro line M4 (Metroselskabet I/S 2023).

Concerning accessibility, an accessibility panel exists (personal communication MSc Arch. B. Christensen, 2022). Bringing assistive devices and guide dogs is free of charge; under certain circumstances, travel companions can accompany people at a reduced price, and some disabled are eligible for tickets with travel discounts (DOT 2022b). Special ticket prices for children and seniors are offered (DOT 2023). Furthermore, there are elevators from street level to the platform at each station, same level boarding into trains is provided, and certain areas inside the metro vehicle are reserved for people with prams, wheelchairs, and large luggage. Metro stewards offer assistance if someone needs extra time when boarding a metro vehicle, and the control room can be contacted using a yellow call point. A ticket is mandatory for scooters and bicycles; during rush hours, transporting them in the metro is not permitted (DOT 2022c). Figure 5 displays a network map of the metro system in Copenhagen, including future stations represented in grey.

Figure 5: Metro network Copenhagen (based on Metroselskabet I/S 2022e)

2.5.2 Metro system in Vienna

Wiener Linien builds the network for public transport in Vienna and operates metros, busses, and trams (Wiener Linien 2022a). The first metro lines started in 1978 (Wiener Linien 2022b). As of 2026, there will be the first fully automated line of the Viennese metro (Stadt Wien 2023a). Four types of vehicles currently operate in the metro system, e.g., the type "V" with a length of around 111 m and width of 2,85 m wide, has a capacity of 882 passengers (Prillinger 2017). On average, metro trains travel 32,47 km/h (Wiener Linien 2022c). Since 2010 night metros have been established (Wiener Linien 2022d), currently night metros run on Friday and Saturday nights and before holidays. Figure 6 displays a Viennese metro system network map, valid until May 31, 2021. Artists are allowed to hold live concerts at various locations within the subway system (Wiener Linien 2022f), and artistic works were integrated into the design of some stations (Wiener Linien 2022g).

According to Wiener Linien, accessibility is an important topic. Particular focus is on people with reduced mobility and vision or hearing impairments; therefore, all metro stations are accessible (Wiener Linien 2022h). A barrier-free website and a navigation system called "POPTIS" for blind and visually impaired passengers are provided (Wiener Linien 2022i). Wiener Linien communicates with organizations for the disabled already in the planning phase to integrate ideas

for meeting their needs from the start (Stadt Wien 2022a). Metro trains type "V" have a folding ramp at the first and last door to reduce complications when boarding a vehicle; in exceptional cases, such as a defect, major events, or due to certain weather conditions, the folding ramps can be deactivated (Wiener Linien 2022j). In the last two cases it is possible to inform people through the application "WienMobil". Under certain circumstances, travel companions travel for free, and guide dogs can always accompany the owner free of charge (Wiener Linien 2022i). Bicycles can be transported in the metro for free, although it is not allowed to bring them during rush hours (Wiener Linien 2022k). A test phase for a virtual Avatar named "Iris" started in September 2022 for translating disruptions to sign language (Wiener Linien 2022l). Animated videos of the avatar will be integrated into the application "WienMobil" in the future. Stickers on elevators indicate priority user groups such as parents with a pram, people in a wheelchair, older people, or others in need of an elevator (Wiener Linien 2022m). In case of disruption of elevators, it is announced on the webpage of Wiener Linien or in their application. Depending on the impairment, there is financial support for tickets, and elderly and young adults pay less for their tickets (Stadt Wien 2022b).

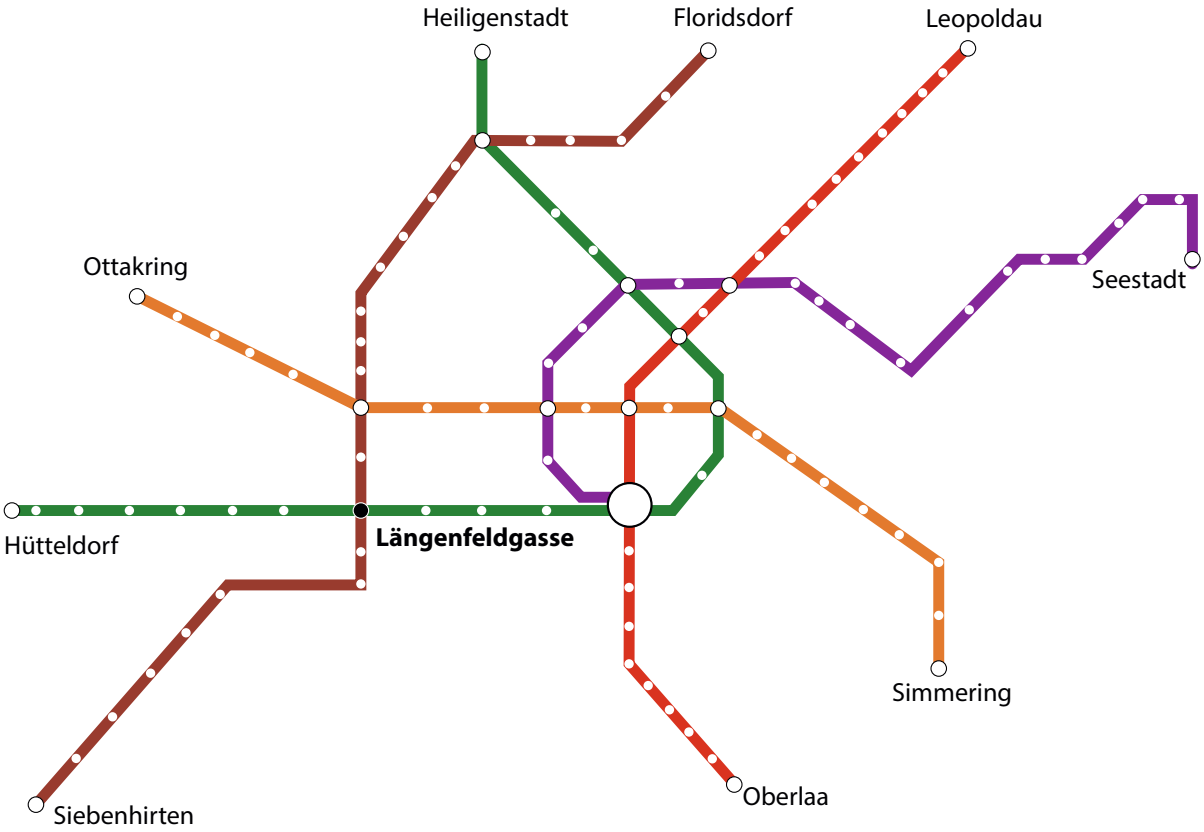


Figure 6: Metro network Vienna (based on Wiener Linien 2022e)

2.6 Legal framework

The following sections will elaborate on the international and national legal framework concerning accessibility for metros in Denmark and Austria, including UNCRPD (United Nations Convention on the Rights of Persons with Disabilities), different regulations, and standards.

2.6.1 International legal framework

UNCRPD

On March 30, 2007, the UNCRPD, which promotes and protects the rights of persons with disabilities, was open for signatures (United Nations 2023a). Austria ratified it in September 2008, and Denmark did in July 2009 (United Nations 2023b). Additionally, an Optional Protocol allows people to complain to the United Nations Committee in case of violation against disabled people's rights (United Nations 2023c). Austria ratified this protocol in September 2008, whereas Denmark did in September 2014 (Ibid.). Article one of the CRPD specifies persons with disabilities as those "who have long-term physical, mental, intellectual or sensory impairments which in interaction with various barriers may hinder their full and effective participation in society on an equal basis with others" (United Nations 2023d). Article nine of the CRPD is specifically about accessibility and states, "to enable persons with disabilities to live independently and participate fully in all aspects of life, States Parties shall take appropriate measures to ensure to persons with disabilities access, on an equal basis with others, to the physical environment, to transportation, to information and communications, including information and communications technologies and systems, and to other facilities and services open or provided to the public, both in urban and in rural areas" (United Nations 2022d).

European regulation

An essential European regulation is the European Commission Regulation No 1300/2014 of November 18, 2014, on the technical specifications for interoperability relating to the accessibility of the Union's rail system for persons with disabilities and persons with reduced mobility (TSI PRM). It is a binding legislative act for Austria and Denmark that applies to the trans-European conventional and high-speed rail system network (The European Commission 2014).

European standards

At the time of research, different drafts for European standards were relevant to railway applications and the design for PRM use; Table 3 summarizes them. These European standard drafts (prEN) include the following phrase "This document is not specifically intended for Urban Rail, however these standards or clauses from these standards can be adopted by Urban Rail projects should they choose to do so". Therefore, they can be applied in metro systems in the future. If accessed through Austrian Standards, draft prEN16584-1:2022 is called "ÖNORM EN 16584-1:2022"; if accessed through Danish Standards, this draft can be found by the name

"DS/EN 16584-1". For readability and clarity, the acronyms were omitted.

Table 3: European standard drafts for railway applications and design for PRM use

prEN Number	EN Name
prEN 16584-1: 2022	Railway applications – Design for PRM use – General requirements; Part 1: Contrast
prEN 16584-2: 2022	Railway applications – Design for PRM use – General requirements; Part 2: Information
prEN 16584-3: 2022	Railway applications – Design for PRM use – General requirements; Part 2: Optical and friction characteristics
prEN 16585-1: 2022	Railway applications – Design for PRM use – Equipment and components on board rolling stock; Part 1: Toilets
prEN 16585-2: 2022	Railway applications – Design for PRM use – Equipment and components on board rolling stock; Part 2: Elements for sitting, standing and moving
prEN 16585-3: 2022	Railway applications – Design for PRM use – Equipment and components on board rolling stock; Part 3: Clearways and internal doors
prEN 16586-1: 2022	Railway applications - Design for PRM use – Accessibility of persons with reduced mobility to rolling stock; Part 1: Step for access and egress
prEN 16586-2: 2022	Railway applications - Design for PRM use – Accessibility of persons with reduced mobility to rolling stock; Part 2: Boarding aids
prEN 16587: 2022	Railway applications – Design for PRM use – Requirements on obstacle-free routes for infrastructure

Table 4 displays selected further international standards (ISO), European Standards (EN), and Technical Specifications (TS), which emphasize accessibility and Universal Design. The publication dates are according to Austrian Standards. All of the standards are accessible through Danish Standards, although publishing dates might differ.

Table 4: Further international and European standards relevant to this thesis

ISO/EN/TS Number	ISO/EN/TS Name
ISO 17049: 2013	Accessible design - Application of braille on signage, equipment, and appliances
ISO 21542: 2021	Building construction - Accessibility and usability of the built environment
ISO 23599: 2019	Assistive products for blind and vision-impaired persons - Tactile walking surface indicators

ISO 24504: 2014	Ergonomics - Accessible design - Sound pressure levels of spoken announcements for products and public address systems
ISO 4190-5: 2006	Lift (Elevator) installation - Part 5: Control devices, signals, and additional fittings
ISO/TR 11548-1: 2001	Communication aids for blind persons - Identifiers, names and assignation to coded character sets for 8-dot Braille characters - Part 1: General guidelines for Braille identifiers and shift marks
ISO/TR 11548-2: 2001	Communication aids for blind persons - Identifiers, names, and assignation to coded character sets for 8-dot Braille characters - Part 2: Latin alphabet based character sets
EN 81-70: 2022	Safety rules for the construction and installation of lifts - Particular applications for passenger and goods passenger lift - Part 70: Accessibility to lifts for persons including persons with disabilities
EN 115-1: 2017	Safety of escalators and moving walks - Part 1: Construction and installation
EN 17210: 2021	Accessibility and usability of the built environment - Functional requirements
CEN/TS 15209: 2021	Tactile paving surface indicators produced from concrete, clay and stone

2.6.2 Legal framework in Denmark

The legal framework for disabled people in Denmark includes the disability discrimination act, building regulations, multiple standards, handbooks, and guidelines.

Disability discrimination act

Since 2018 there has been an "Act on Prohibition of Discrimination on Grounds of Disability" (Lov om forbud mod forskelsbehandling på grund af handicap) in Denmark. Still, this act includes paragraph 3, stating there is no obligation to ensure reasonable accommodation or accessibility (Social-, Bolig- og Ældreministeriet 2018).

Building regulations

The currently valid Danish building regulation is from 2018 and includes regulations regarding the access and equipment of public buildings and information on stairs, handrails, requirements for toilets, and more (Bolig- og Planstyrelsen 2018). In addition, it refers to DS Handbook 186, which provides recommendations for fulfilling these requirements. The guideline for user concepts in BR18 defines a user as someone without or with minor or major disabilities.

Further standards and recommendations

Besides the international and European standards, country-specific technical recommendations, handbooks, and guidelines exist. Selected ones with relevance to this thesis are shown in Table 5. Handbooks and SBi-Guides are only available in Danish. The translation of the titles is based on the translations made by Danish Standards or the researcher.

Table 5: Additional Danish standards, handbooks, and guides relevant to this thesis

DS/SBI Number	DS/SBI Name
DS/CEN/TR 17621: 2021	Accessibility and usability of the built environment - Technical performance criteria and specifications
DS-Handbook 105: 2012	Outdoor areas for all - How to plan a barrier-free outdoor area
DS-Handbook 105.2: 2015	Outdoor areas for all - Planning and Design - Guidelines for providing access for disabled persons
DS-Handbook 186: 2017	Guide - Accessibility in BR18 - Compared to DS/ISO 21542:2012
SBi-Guide 250: 2017	Accessible construction in general - Introductory questions
SBi-Guide 272: 2020	Guide on building regulations 2018

2.6.3 Legal framework in Austria

At the federal level in Austria, there is different legislation, such as the federal constitution, the federal disability equality act, and several guidelines and standards. The following paragraphs will discuss them in detail. At the state level, the building regulations for Vienna are relevant to the Viennese metro.

Austrian federal constitution

In 1997 article 7, paragraph 1, the Austrian federal constitution was amended, stating that no citizen may be disadvantaged because of a disability.

"All citizens are equal before the law. Privileges of birth, sex, status, class, and creed are excluded. No one may be disadvantaged because of their disability. The Republic (Federal Government, Federal States, and municipalities) is committed to ensuring equal treatment of disabled and non-disabled persons in all areas of daily life."
(RIS 2022 article 7 paragraph 1, own translation)

Federal disability equality act (FDEA)

On July 6, 2005, several existing laws were amended, the constitution was adapted, and the federal disability equality act was passed, which can be seen as a best practice example within the EU (Österreichischer Behindertenrat 2023).
Paragraph 1 in the FDEA states:

"This federal law aims to eliminate or prevent discrimination against persons with disabilities and thus to ensure the equal participation of persons with disabilities in society and to enable them to lead a self-determined life."
(Austrian Ministry for Finance 2006 paragraph 1, own translation)

Furthermore, paragraph 5 defines when to consider a facility accessible:

> *"Buildings and other facilities, means of transport, technical items, information processing systems and other designed areas of life are barrier-free if they can be used by people with disabilities in an intended manner, without particular effort, and assistance."*
> *(Austrian Ministry for Finance 2006 paragraph 5, own translation)*

Further standards

In addition to the international and European standards, further country-specific standards are relevant to this thesis; Table 6 shows selected ones.

Table 6: Additional Austrian standards relevant to this thesis

ÖNORM Number	ÖNORM Name
ÖNORM A 3011-3: 1982	Graphic symbols for public information; symbols 53 to 76
ÖNORM A 3012: 2021	Visual guiding system for public information
ÖNORM B 5330-1: 2012	Internal doors - Part 1: General dimensions
ÖNORM B 5371: 2021	Stairs, guard-rails and parapets in buildings and landscapes - Planning and implementation principles
ÖNORM B 1600: 2023	Accessible building construction - Design principles
ÖNORM V 2102: 2018	Tactile walking surface indicators (TWSI) - Technical aids for blind and partially sighted persons
ÖNORM V 2104: 2012	Technical aids for visually impaired, blind and mobility impaired persons - Safety devices for construction and dangerous sites
ÖNORM V 2105: 2011	Technical aids for visually impaired and blind persons - Tactile inscriptions and information systems

OIB guideline

OIB guidelines are implemented for consistent building regulations in Austria. Six of them exist in accordance with Regulation No 305/2011 of the European Parliament and the Council of March 9, 2011 (Österreichisches Institut für Bautechnik 2023). Especially OIB guideline 4, "Safety in use and accessibility", is relevant to this thesis since it includes emergency exits, protection against slippery accidents, and others.

Guidelines for planning, construction, and maintenance of roads (RVS)

The guideline "Barrier-Free Roads to Meet Everyday Requirements" by the Austrian Research Association for Roads, Railways and Transport was published on September 1, 2010. It ensures pedestrian traffic's safety, easiness, and fluency, has to be applied in planning phases, construction, and reconstruction projects, and focuses on mobility and sensory disabled people

(Austrian Research Association for Roads, Railways and Transport 2010). Furthermore, the guideline refers to different ÖNORMs and emphasizes considering the TSI PRM.

Building regulations

The building regulations in Vienna have considered barrier-free building since 1991 (Stadt Wien 2023b). Multiple requirements for barrier-free buildings are mentioned in this document (RIS 2023). Paragraph 115 summarizes the most important ones and defines types of facilities where safe use has to be possible for all. It includes public buildings and is therefore relevant to public transport stations.

2.7 Staging mobilities framework

According to Jensen (2013), the Staging Mobilities framework suggests seeing mobilities as staged from above and below. This book describes "Staging Mobilities" as a process of creating lived mobility practices, including their material preconditions.

> *"Mobilities do not 'just happen' or simply 'take place'. Mobilities are carefully and meticulously designed, planned, and 'staged' (from above). However, they are equally importantly acted out, performed, and lived as people are 'staging themselves' (from below)."*
> *(Jensen 2013 p.4)*

This citation leads to Figure 7, inspired by a diagram in Jensen's book. This thesis can be situated at the interface of "staging from above" and "staging from below". Both metro companies are in charge of designing and regulating the physical environment of metro stations based on a legal framework; this can be defined as "staging from above". Passengers without, with minor or major disabilities, are the ones acting out according to these rules and environmental circumstances; therefore, they are "staging from below". The research about the inclusivity of metro stations is placed between those two sides; it includes the research of legislation, the physical space, and, equally importantly, the lived perception of passengers.

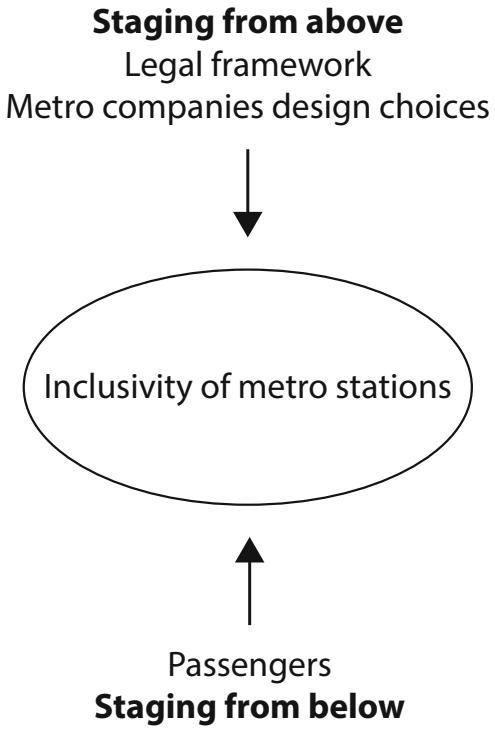


Figure 7: Thesis in relation to staging mobilities framework

2.8 Conclusion theoretical framework

In conclusion, the theoretical framework reveals the importance of Universal Design in public transport stations. This design approach attempts to include the needs of as many people as possible in planning. People not considered mobility-restricted in the narrow sense can still be part of this group in the broad sense, such as people traveling with prams, people not familiar with their surroundings, and others. Multiple benefits result from inclusive mobility systems, which make the experience of using public transportation for 100% of users more comfortable. Due to a demographic shift, the necessity for Universal Design in metro stations will increase. In addition, chapter "2.4 Statistics" reveals a lack of data concerning mobility-impaired people in the broad sense. Different laws, regulations, and standards for accessibility are given on an international and national basis. Due to the UNCRPD definition of people with disabilities as people having long-term impairments, it would be recommended to extend the definition and additionally include people with temporary impairments and mobility-restricted groups of people in the broad sense. According to European standard drafts for railway applications and design for PRM use, these might soon apply to metro systems in the EU. Several other standards already regulate metro station buildings. However, standards are recommendations rather than binding legal acts. Although two different metro systems are elaborated on in more detail in this thesis, it is impossible to compare them directly. The networks vary in size, operation, stations, vehicles, and design. Whereas the Copenhagen Metro seemingly focuses on functionality and aesthetics, the Viennese Metro offers other functions besides transportation and additional

information for disabled people. Despite all these differences, "Looking at parallel industries can show [...] how other sectors have responded" (Eikhaug 2010, p. 44). Therefore, researching different metro systems and their stations should bring international insights into designing inclusively and reveal gaps in this field. Furthermore, a crucial part of this project is to be at the interface of staging the inclusivity of metro stations from above and below.

3. Methodology and methods

This chapter will frame the applied methods, such as the "Mobility for All" (MofA) evaluation tool and go-alongs, and explain the methodology in detail.

3.1 MofA evaluation tool

The MofA evaluation tool results from a research program called "ways2go" in 2008, supported by BMK (Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation, and Technology) and FFG (Austrian Research Promotion Agency) (2008). It intends to improve the accessibility of squares, entrance areas, and public transport buildings. Ing. Krpata from Wiener Linien was the project coordinator; further project partners were experts from the Austrian Federal Railways, the Technical University of Vienna, and associations representing disabled groups. The results of this research program are still used in a seminar at the Technical University of Vienna to educate students in evaluating the barrier-free design of public transport stations.

Since the evaluation tool was available in German, the researcher translated it into English. However, some words could not be translated directly; therefore, the best possible paraphrase was chosen. Further adaptations are elaborated in "MofA tool adaptations, critiques, and recommendations". For the appropriate application of the tool, one interview was conducted with DI Pipp from the Austrian Federal Railways on May 23, 2022. Another interview was conducted with DI Meysner from Wiener Linien on August 26, 2022.

Application of the MofA evaluation tool

The MofA evaluation tool consists of three steps and was used by Wiener Linien to evaluate metro station buildings. The focus of the project is the area of the metro company's responsibility; therefore, the station building itself, including the entrance building, passages, and platforms, is evaluated in this thesis. Other catalogs or inspection criteria from the research program "ways2go" had to be excluded. The three application steps will be explained using the example of a public transport building. First, there is the application of an inspection criteria catalog for different user groups as mobility, vision, and hearing impaired, at the station. Each of these three user groups consists of two subgroups. The group of mobility impaired includes the walking impaired and people in a wheelchair. The group of visually impaired consists of visually impaired and blind people, and the group of hearing-impaired comprises hard-of-hearing and deaf people. For all these subgroups, three tables exist depending on the station's area: one is

related to the entrance building, one is related to passages and access to platforms, and the third is related to platforms. Some user groups comprise a fourth table with general criteria for all areas. Criteria irrelevant to an area are greyed out. Ratings from category "1", representing the best possible category, to "4", the lowest rating, are possible.

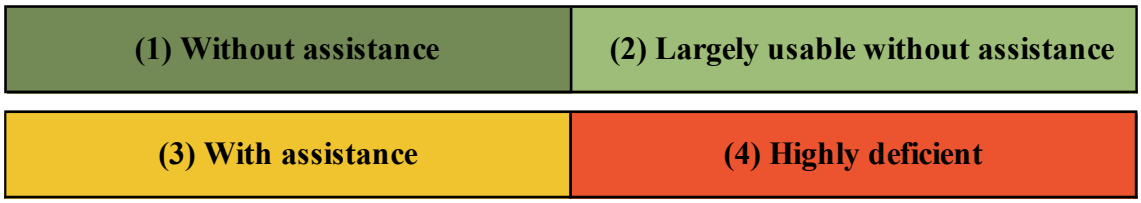


Figure 8: Rating for inspection criteria (based on BMK and FFG 2008)

The second step consists of an evaluation catalog that summarizes the ratings of each group and area. It focuses on the functionality of a barrier-free trip chain; therefore, a low rating of 4 in one user group area leads to a rating of "4" in all other areas since no barrier-free trip chain is provided. Although a "4" might suggest otherwise, it has to be stated that it does not necessarily mean the respective group cannot use the station, but it does reveal high deficiencies. The lowest rating is to be considered in the evaluation catalog for stations with several entrance buildings, passages, and platforms. The highest rating per column and per line is 12, the maximum achievable overall points is 72.

Grade	Evaluation
1	Accessible without assistance (Prerequisite: mobility training, local knowledge)
2	Only minor changes required for independent use
3	Use possible with reasonable assistance from others
4	Use not possible or not reasonable even with assistance

Total sums for station	
01 to 18	Barrier-free trip chain for all considered groups
19 to 36	Largely barrier-free trip chain for all considered groups - individual people require assistance
37 to 54	Trip chain interrupted by minor obstacles - but solvable with reasonable assistance
55 to 72	Insurmountable obstacles - not possible or reasonable even with assistance

Subtotals for individual disabled groups	
01 to 03	Barrier-free trip chain for considered group
04 to 06	Largely barrier-free trip chain for considered group - individual people require assistance
07 to 09	Trip chain interrupted by minor obstacles - but solvable with reasonable assistance
10 to 12	Insurmountable obstacles - not possible or reasonable even with assistance

Figure 9: Evaluation scale - Evaluation catalog (based on BMK and FFG 2008)

The catalog of measures represents the third step. It shows optimization potential by location and level, is linked to a picture in the appendix, and summarizes the current and potential ratings for the future if adaptions are implemented. Elevators are part of all areas, but to avoid repetition in the catalog of measures, they are only mentioned in the entrance building area.

Table 7: Level explanation - Catalog of measures

Level	Explanation
L0	Ground level
L-1	Passage/Access platform level
L-2	Platform level

The evaluation of the station building in both cities is based on the same catalogs and inspection criteria.

MofA tool adaptations, critiques, and recommendations

Some of the inspection criteria and rating categories were adapted to reduce the margin of misinterpretation and to support better readability and coherence of the tool. For example, the classification for the inspection criteria "Accessibility to the building and the vehicle" for blind people and visually impaired was unified. The classification for the inspection criteria "Loudspeaker" for visually impaired people was unified with the one in the table for hard-of-hearing people since the direct translation would involve a "new sound system," which does not necessarily contribute to the intelligibility of the loudspeaker. Directly translated, the rating of "4" would be "Impossible," which is incorrect since participants might still be able to navigate through a station if the multiple sense principle was used. Furthermore, some inspection criteria state it is "Always possible with assistance"; therefore, the wording for rating "4" in the inspection criteria catalog was changed to "Highly deficient." The original classification of the inspection criteria "Monitors" for the hard-of-hearing included the phrase "Min. 40-inch or equivalent display - same character size (40-inch display)". This phrase implies that monitors of 40 inches always have the same character size, which was considered inaccurate.

The character size of fonts would be considered more important than the size of a monitor. Therefore, the category of monitors was excluded from the inspection criteria tables to shift the focus to the category "Visual guidance system," which includes the character size of fonts. Furthermore, some inspection criteria were greyed out to emphasize that specific categories are not relevant to the respective area of the station. Finally, the layout of the tables was adapted for better readability and unification of all tables.

It has to be criticized that the inspection criteria catalogs have some subjective categories; therefore, it can depend on the person who applies it and their experience and knowledge about international or national standards and barrier-free design. Furthermore, the inspection criteria catalog consists of four classifications; sometimes, the first and second are the same. In some inspection criteria tables, the classifications were challenging to differentiate. For example, the options for inspection criteria "Illumination" can not be measured. There are no options to measure whether "Optimal illumination," "Good illumination," "Poor illumination," or "Not adequately illuminated" is appropriate, and the boundaries are blurring between the answer possibilities. Further remarks concerning the completeness of the tool have to be mentioned. It does not include accessible toilets, voice announcements in elevators or on platforms in English, seating at the station, or exit signages including a street or square name. Due to the lack of elevator details, tables were created for each elevator of the two stations.

It would be recommended to restructure the MofA evaluation tool of Wiener Linien and restrict it to only three classifications as Austrian Federal Railways does; some of the uncertainties could thus be avoided. Furthermore, specifying some classifications as the inspection criteria "Glass portals" could help people using this tool and not knowing particular standards in detail. Finally, to avoid future misinterpretation of this tool, an attempt was made to connect the currently valid international and national standards for Denmark and Vienna with the inspection criteria of the MofA evaluation tool in "4.1 Results MofA criteria and related standards".

3.2 Go-along

According to Kusenbach (2018), the go-along is an ethnographic research method where the researcher accompanies study participants during a realistic spatial-social activity. She states it is a qualitative method including a small number of participants and is used to get in-depth insights and non-numerical outcomes. Kusenbach differentiates between trails and tours. Whereas trails are bound to movements that happen within an authentic context of the participant's life and take up to multiple hours or days, a tour is more organized and is thus more controlled by the researcher. Tours are usually shorter and might cover a smaller area than trails. Several research projects used the method of go-along. For example, Wästerfors (2021) explored inaccessibility in urban and digital settings with participants through go-along.

In this thesis, people with different disabilities were accompanied through a metro station in Copenhagen and Vienna. The focus was on people with vision, hearing, or walking impairment, as the MofA catalog indicates. In Copenhagen, the participants were contacted through MSc Arch.

B. Christensen, who is in contact with people within the accessibility panel of the Copenhagen Metro. A text for recruiting participants was prepared by the researcher and forwarded by her. In Vienna, different organizations, such as the Austrian Council for disabled people and "Inclusion24" were contacted by the researcher. The researcher was in direct contact with the participants in Vienna. In both cities, they got detailed information beforehand, including a time slot, the meeting point, general questions and possible topics concerning the built environment, and a proposed route suggested by the researcher to prepare them for their go-along.

At the research day participants were handed a consent form to permit sound and video recording and for the data to be used for research publications and presentations. An example of the consent form in English can be found in the appendix. Before the walking interview, participants in both cities were asked to answer the following questions:

- What is your gender?
- How old are you?
- Would you consider yourself hard-of-hearing, deaf, visually impaired, blind, walking impaired, in need of a wheelchair, or none of the above?
- Do you pass Frederiksberg metro station daily, weekly, monthly, or less than monthly?
- Do you have a specific routine for entering and exiting the station? If so, how would you describe this routine?
- Do you have a specific routine for navigating the station? If so, how would you describe this routine?

Since Vienna has no doors at the platform edge yet but will have integrated doors on platforms of the automated metro line U5, there was one additional question prepared for the participants in Vienna:

- Do you think glass doors along the platform edge could positively or negatively impact your disability?

The walking interview was a semi-structured interview led by the researcher, and everything was sound recorded with a dictaphone. The Copenhagen Metro provided an additional employee to help conduct the research at Frederiksberg station. Therefore Thomsen was in charge of filming in case participants agreed to be filmed. In Vienna, only the researcher conducted the interviews. The video recordings were made to help reconstruct the path traveled and to locate participants' statements. The accompanied people were encouraged to talk about positive and negative perceptions of the built environment as they experience it while moving through the station.

3.3 Methodology

In a previous project called "Wayfinding at the Metro Station Frederiksberg in Copenhagen" (Bischler et al. 2022), the researcher, as part of a team, revealed the research gap of mobility-restricted people finding their way through Frederiksberg station. Therefore, this study focuses on Frederiksberg station in Copenhagen. A similar station in Vienna, Längenfeldgasse, was selected in consultation with DI Meysner from Wiener Linien. One requirement was to find a station where several metro lines meet, and people have to change platforms to get to different directions. The other necessity was a station not connected to a regional train station. Due to construction work on the Viennese metro system, some stations were closed and could not be considered. The MofA evaluation tool was applied before conducting the go-alongs. After accompanying participants through the stations, the MofA evaluation tool was reevaluated, considering comments collected during the interview with participants.

4. Results

This chapter presents the empirical outcomes; it includes results of standards in relation to the MofA evaluation tool, the MofA evaluation tool, elevator details, and go-along remarks of participants regarding Frederiksberg and Längenfeldgasse station.

4.1 Results MofA criteria and related standards

Table 8 provides an overview of inspection criteria and user groups according to the MofA evaluation catalog and related existing international and national standards at the time of writing. However, it is not intended to be exhaustive. Standards from this thesis's chapter "2.6 Legal framework" were assigned thematically. A blank field might imply no legal framework, but existing standards cannot be excluded. Multiple inspection criteria are mentioned in several standards; if this is the case, they are stated in the respective column. Danish handbooks and guides only available in Danish such as DS håndbog 105, DS håndbog 105.2, DS håndbog 186, SBi-Guide 250, and SBi-Guide 272 could not be considered in more detail in this table due to the lack of an English translation. The following tables contain the abbreviations VI for visually impaired, B for blind, HI for hearing impaired, D for deaf, WI for walking impaired and WU for wheelchair users.

Table 8: MofA criteria and related standards

Inspection criteria according to MofA	User group according to MofA	International Standards	Danish Standards	Austrian Standards
Accessibility to the buildings and the vehicle	B VI	ISO 21542: 2021 EN 17210: 2021	DS 17621: 2021	

Audio induction loop	HI	ISO 21542: 2021 ISO 4190-5: 2006 EN 17210: 2021	DS 17621: 2021	ÖNORM B 1600: 2023
Clear width of doors and entrances	WI WU	ISO 21542: 2021 EN 17210:2021	DS 17621: 2021	ÖNORM B 5330-1: 2012 ÖNORM B1600: 2023
Clear width of paths	WI WU	ISO 21542: 2021 EN 17210:2021	DS 17621: 2021	ÖNORM B1600: 2023 ÖNORM V 2104: 2012
Elevators	B VI WI WU	ISO 17049:2013 ISO 21542:2021 ISO 23599: 2019 ISO 4190-5: 2006 ISO/TR 11548-1: 2001 ISO/TR 11548-2: 2001 EN 81-70: 2021 EN 17210: 2021	DS 17621: 2021	ÖNORM B 1600: 2023 ÖNORM V 2102: 2018
Escalators during maintenance	B	ISO 21542: 2021 EN 115-1: 2017		ÖNORM V 2104: 2012
Floor conditions	B VI WI WU	ISO 21542: 2021 EN 17210: 2021	DS 17621: 2021	ÖNORM B 1600: 2023
Glass portals	VI	ISO 21542: 2021 EN 17210: 2021 EN 81-70: 2021	DS 17621: 2021	ÖNORM B 1600: 2023 ÖNORM V 2104: 2012
Handrails for stairs and ramps	B VI WI WU	ISO 17049: 2013 ISO 21542: 2021 EN 17210: 2021	DS 17621: 2021	ÖNORM B 1600: 2023 ÖNORM B 5372: 2021 ÖNORM V2102: 2018 ÖNORM V 2105: 2011
Illumination	VI HI D	ISO 21542:2021 ISO 23599: 2019 EN 17210:2021 CEN/TS 15209: 2021	DS 17621: 2021	ÖNORM A 3012: 2021 ÖNORM B 1600: 2023 ÖNORM V 2102: 2018
Loudspeaker	B VI HI	ISO 21542: 2021 ISO 24504: 2014		ÖNORM B 1600: 2023 ÖNORM V 2102: 2018

Monitors	VI HI D	ISO 21542: 2021 EN 17210: 2021	DS 17621: 2021	ÖNORM A 3012: 2021 ÖNORM B 1600: 2023
Operating elements	WI WU	ISO 17049: 2013 EN 17210: 2021 ISO 21542: 2021 ISO 4190-5: 2006 EN 81-70: 2022 EN 17210: 2021	DS 17621: 2021	ÖNORM A 3012: 2021 ÖNORM B 1600: 2023 ÖNORM V 2102: 2018
Orientation, findability of areas	B VI	ISO 21542: 2021 EN 17210: 2021		ÖNORM V 2102: 2018
Safety line along the platform edge	VI		DS 17621: 2021	ÖNORM V2102: 2018
Sign language competence at the helpdesk	D			
Stairs and ramps including clear width, individual steps and fall-back level staircase	VI WI WU	ISO 21542: 2021 EN 17210:2021	DS 17621: 2021	ÖNORM B 5371: 2021 ÖNORM B1600: 2023
Tactile guidance system including tactile safety line along the platform edge	B VI	ISO 21542: 2021 ISO 23599: 2019 EN 17210: 2021 CEN/TS 15209: 2021	DS 17621: 2021	ÖNORM B 1600: 2023 ÖNORM V 2102: 2018 ÖNORM V 2104: 2012 ÖNORM V 2105: 2011
Visual guidance system	VI HI D	ISO 21542: 2021 ISO 23599: 2019 EN 17210:2021	DS 17621: 2021	ÖNORM A 3011-3: 1982 ÖNORM A 3012: 2021 ÖNORM B 1600: 2023

4.2 Results MofA evaluation tool

The MofA evaluation tool was applied at Frederiksberg station in Copenhagen and Längenfeldgasse station in Vienna. The following chapters contain information on different user groups' positive and improvable inspection criteria and the respective tables.

4.2.1 MofA evaluation catalog at Frederiksberg station in Copenhagen

The selected station in Copenhagen is Frederiksberg station, where three lines intersect. Line

M1 and M2 depart at the same platform, referred to as platform M1/M2, within this thesis. Line M3 departs from the other platform, which is referred to as platform M3. The station was built during two different construction periods. The older part of the station consists of platform M1/M2 and the part of the intermediate level leading to “Frederiksberg Centret”; it was opened in 2003. The newer part of the station consists of platform M3 and the intermediate level above; it was opened in 2019. There are five ways to enter Frederiksberg station. Three include stairs, two others include escalators, and one has an additional moving walkway next to the staircase. Figure 10 gives an overview of the definition of areas for the MofA evaluation tool. The entrance buildings at Frederiksberg station are considered “simple entrance buildings” since the stairs and escalators lead directly from the street level to the underground station. The two concourse levels, including stairs and escalators, are considered passages and access to platforms. Due to their relevance in multiple areas, elevators are not assigned to one area. Platform M3 is exclusively accessible through escalators; during an emergency, an additinal emergency staircase would be available (personal communication MSc Arch. B. Christensen, 2022). The vertical connection from the intermediate level to platform M1/M2 and between each other includes a staircase and escalators.

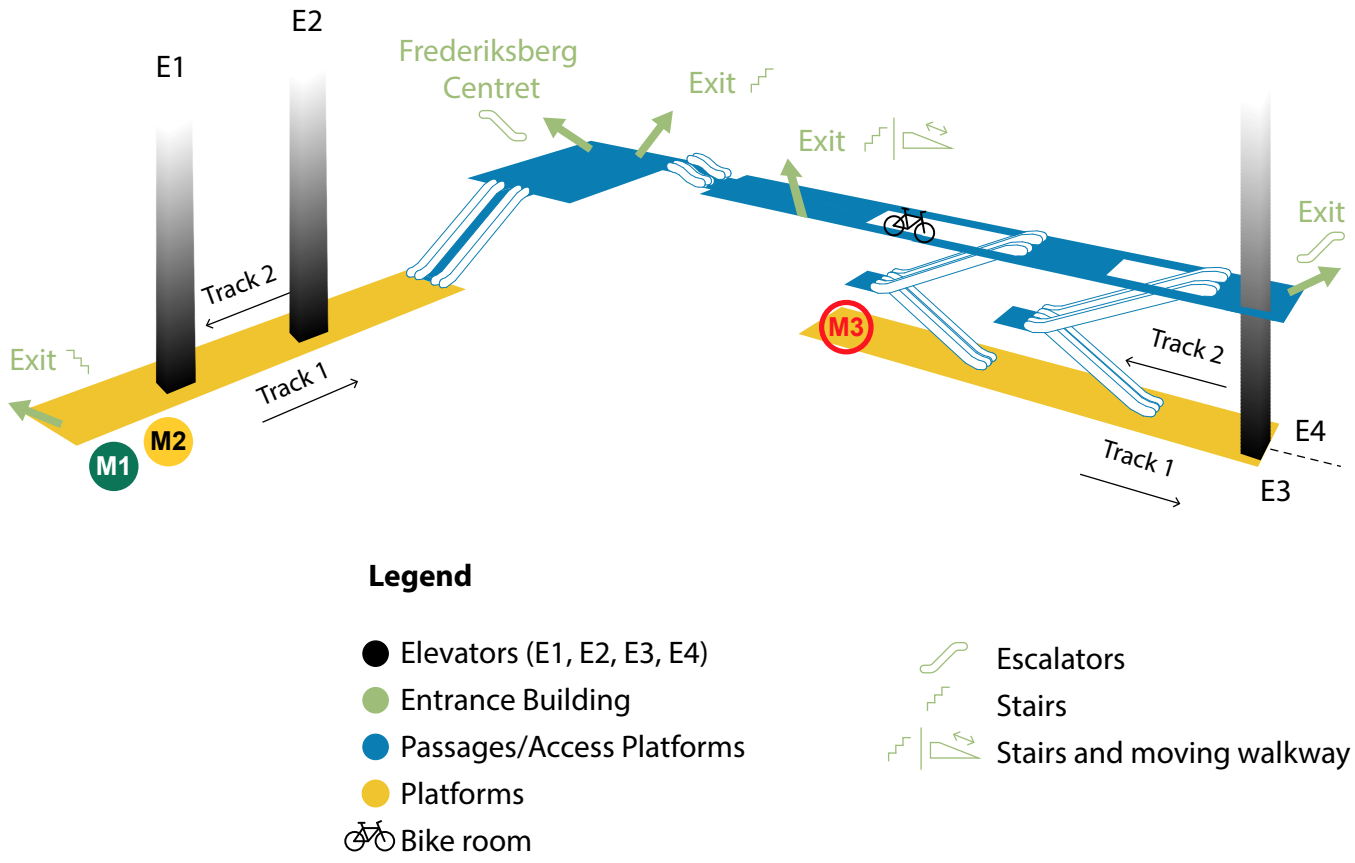


Figure 10: Frederiksberg station layout (adapted from Bischler et al. 2022)

Frederiksberg station was evaluated on May 10, 2022. The results will be outlined in this

chapter, and classifications above "1" will be explained in detail, except categories "1" and "2" are the same. Details are not specified if the same issue applies to different areas or other groups of people in the MofA evaluation catalog to avoid repetition. Moreover, comments were added for participants' remarks if a go-along comment changed the researcher's initial classification.

Positive criteria for walking impaired and wheelchair users

The clear width of paths in all station areas is above 200 cm, the clear width of doors and entrances is above 85 cm, and since there are no staircases with up to 3 steps, the category of individual steps is classified as "1". Due to different standards for ramps and moving walks, the existing moving walkway is not considered a ramp and categories related to ramps are greyed out. According to Agertoug (personal communication, May 31, 2022), an employee of Copenhagen Metro, the ramp does not exceed 1 cm elevation per 20 cm in length; thus, it is 5% inclined and according to standards. In addition, two elevators per platform for more than ten persons each are available, and the floor conditions are considered slip-resistant with grip. Although the staircases on the passage level are rated "1", no statement can be made regarding staircases in emergency exits.

Improvable criteria for walking impaired people

Due to the staircase leading to Solbjerg Plads, which has three different flights of stairs and more than 36 steps, classification "3" is justified. The handrails available on stairs are single handrails at a height between 85 cm and 95 cm. Some of the operating elements inside elevators are above 110 cm, which is classified as "3". Ramps and all related categories are not relevant at the passage and platform level since they are considered part of the entrance building. Information about the criteria rating in different station areas for walking impaired people can be found in Table 9, Table 10, and Table 11.

Improvable criteria for wheelchair users

Individual steps in the entrance building area are irrelevant to the classification since none exist. The steps from one intermediate level to the other make it impossible for people in a wheelchair to change to the other platform underground; this is considered "Highly deficient." Information about the rating of criteria in different areas of the station for wheelchair users can be found in Table 12, Table 13, and Table 14.

Table 9: Inspection criteria walking impaired people - Entrance area FS (based on BMK and FFG 2008)

Inspection criteria for walking impaired people - Area: Entrance building (FS)				
Walking impaired people	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Clear width of paths in general	> 200 cm	180 -200 cm	120 -180 cm	< 120 cm
Clear width of stairs and ramps	> 180 cm	160 - 180 cm	120 - 160 cm	< 120 cm
Clear width of doors and entrances	> 85 cm	min. 85 cm	min. 85 cm	below 85 cm
Fall-back level staircase if neither elevator nor ramp is available	Flight of stairs with max. 16 steps; max. 36 steps in total < 16 cm height/ depth min. 30 cm.	Flight of stairs with max. 18 steps; max. 36 steps in total < 16 cm height/ depth min. 30 cm.	Flight of stairs with max. 18 steps; max. 72 steps in total < 16 cm height/ depth min. 30 cm.	more than 72 steps in total
Individual steps on the pavement	No individual steps	Up to 3 individual steps with handrail on both sides; Step height < 16 cm / depth min. 30 cm	Up to 3 individual steps with handrail on one side; Step height > 16 cm / depth min. 30 cm	Up to 3 individual steps without handrail; Step height > 16 cm / depth > 30 cm
Ramps	Up to 6%, from 10 m lenght intermediate landing with 120 cm (150 cm in case of directional change), wheel deflector at least 10 cm high, up to 2 m height difference	Up to 6%, from 10 m lenght intermediate landing with 120 cm (150 cm in case of directional change), without wheel deflector, up to 2,5 m height difference	above 6% up to 10%, optionally with intermediate landing, up to 3 m height difference	over 10% longitudinal gradient always, even with existing intermediate landings
Handrails (stairs/ramps)	Double handrail (75 and 90/100 cm height), easy to grip, on both sides of the path, handrail extension min. 40 cm	Single handrail (between 80 cm and 95 cm high), easy to grip, on both sides of the path, handrail extension min. 40 cm	Single handrail (between 80 cm and 95 cm high), on one side of the pathway	No handrail
Elevator: number of elevators, cabin size	2 elevators per platform > 10 persons	1 elevator per platform, min. 10 persons (= 2 m²)	Between 5 and 9 persons (4 persons = 1 m²)	Neither elevator nor ramp
Operating elements	between 80 cm and 100 cm	between 80 cm and 110 cm	above 110 cm	Above 120 cm height or below 70 cm height
Floor conditions	Slip-resistant, with grip	Slip-resistant	Partly slip-resistant	Not slip-resistant

Table 10: Inspection criteria walking impaired people - Passages FS (based on BMK and FFG 2008)

Inspection criteria for walking impaired people - Area: Passages / Access platform (FS)				
Walking impaired people	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Clear width of paths in general	> 200 cm	180 -200 cm	120 -180 cm	< 120 cm
Clear width of stairs and ramps	> 180 cm	160 - 180 cm	120 - 160 cm	< 120 cm
Clear width of doors and entrances	> 85 cm	min. 85 cm	min. 85 cm	below 85 cm
Fall-back level staircase if neither elevator nor ramp is available	Flight of stairs with max. 16 steps; max. 36 steps in total < 16 cm height/ depth min. 30 cm.	Flight of stairs with max. 18 steps; max. 36 steps in total < 16 cm height/ depth min. 30 cm.	Flight of stairs with max. 18 steps; max. 72 steps in total < 16 cm height/ depth min. 30 cm.	more than 72 steps in total
Individual steps on the pavement	No individual steps	Up to 3 individual steps with handrail on both sides; Step height < 16 cm / depth min. 30 cm	Up to 3 individual steps with handrail on one side; Step height > 16 cm / depth min. 30 cm	Up to 3 individual steps without handrail; Step height > 16 cm / depth > 30 cm
Ramps	Up to 6%, from 10 m lenght intermediate landing with 120 cm (150 cm in case of directional change), wheel deflector at least 10 cm high, up to 2 m height difference	Up to 6%, from 10 m lenght intermediate landing with 120 cm (150 cm in case of directional change), without wheel deflector, up to 2,5 m height difference	above 6% up to 10%, optionally with intermediate landing, up to 3 m height difference	over 10% longitudinal gradient always, even with existing intermediate landings
Handrails (stairs/ramps)	Double handrail (75 and 90/100 cm height), easy to grip, on both sides of the path, handrail extension min. 40 cm	Single handrail (between 80 cm and 95 cm high), easy to grip, on both sides of the path, handrail extension min. 40 cm	Single handrail (between 80 cm and 95 cm high), on one side of the pathway	No handrail
Elevator: number of elevators, cabin size	2 elevators per platform > 10 persons	1 elevator per platform, min. 10 persons (= 2 m²)	Between 5 and 9 persons (4 persons = 1 m²)	Neither elevator nor ramp
Operating elements	between 80 cm and 100 cm	between 80 cm and 110 cm	above 110 cm	Above 120 cm height or below 70 cm height
Floor conditions	Slip-resistant, with grip	Slip-resistant	Partly slip-resistant	Not slip-resistant

Table 11: Inspection criteria walking impaired people - Platforms FS (based on BMK and FFG 2008)

Inspection criteria for walking impaired people - Area: Platforms (FS)				
Walking impaired people	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Clear width of paths in general	> 200 cm	180 -200 cm	120 -180 cm	< 120 cm
Clear width of stairs and ramps	> 180 cm	160 - 180 cm	120 - 160 cm	< 120 cm
Clear width of doors and entrances	> 85 cm	min. 85 cm	min. 85 cm	below 85 cm
Fall-back level staircase if neither elevator nor ramp is available	Flight of stairs with max. 16 steps; max. 36 steps in total < 16 cm height/ depth min. 30 cm.	Flight of stairs with max. 18 steps; max. 36 steps in total < 16 cm height/ depth min. 30 cm.	Flight of stairs with max. 18 steps; max. 72 steps in total < 16 cm height/ depth min. 30 cm.	more than 72 steps in total
Individual steps on the pavement	No individual steps	Up to 3 individual steps with handrail on both sides; Step height < 16 cm / depth min. 30 cm	Up to 3 individual steps with handrail on one side; Step height > 16 cm / depth min. 30 cm	Up to 3 individual steps without handrail; Step height > 16 cm / depth > 30 cm
Ramps	Up to 6%, from 10 m lenght intermediate landing with 120 cm (150 cm in case of directional change), wheel deflector at least 10 cm high, up to 2 m height difference	Up to 6%, from 10 m lenght intermediate landing with 120 cm (150 cm in case of directional change), without wheel deflector, up to 2,5 m height difference	above 6% up to 10%, optionally with intermediate landing, up to 3 m height difference	over 10% longitudinal gradient always, even with existing intermediate landings
Handrails (stairs/ramps)	Double handrail (75 and 90/100 cm height), easy to grip, on both sides of the path, handrail extension min. 40 cm	Single handrail (between 80 cm and 95 cm high), easy to grip, on both sides of the path, handrail extension min. 40 cm	Single handrail (between 80 cm and 95 cm high), on one side of the pathway	No handrail
Elevator: number of elevators, cabin size	2 elevators per platform > 10 persons	1 elevator per platform, min. 10 persons (= 2 m²)	Between 5 and 9 persons (4 persons = 1 m²)	Neither elevator nor ramp
Operating elements	between 80 cm and 100 cm	between 80 cm and 110 cm	above 110 cm	Above 120 cm height or below 70 cm height
Floor conditions	Slip-resistant, with grip	Slip-resistant	Partly slip-resistant	Not slip-resistant

Table 12: Inspection criteria wheelchair users - Entrance area FS (based on BMK and FFG 2008)

Inspection criteria for wheelchair users - Area: Entrance building

Wheelchair users	(1) Without assistance	(2) Largely usable without assistance	(3) With assistance	(4) Highly deficient
Clear width of paths in general	> 200 cm	180 - 200 cm	120 -180 cm	< 120 cm
Clear width of ramps	> 180 cm	160 - 180 cm	120 - 160 cm	< 120 cm
Clear width of doors and entrances	> 85 cm	min. 85 cm	min. 85 cm	below 85 cm
Single steps	Single step up to 3 cm outdoors, max. 2 cm indoors	3 - 5 cm height of single step	3 - 5 cm height of single step	Single step above 5 cm or several steps
Ramps	Up to 6%, from 10 m lenght intermediate landing with 120 cm (150 cm in case of directional change), wheel deflector at least 10 cm high, up to 2 m height difference	Up to 6%, from 10 m lenght intermediate landing with 120 cm (150 cm in case of directional change), without wheel deflector, up to 2,5 m height difference	above 6% up to 10%, optionally with intermediate landing, up to 3 m height difference	over 10% longitudinal gradient always, even with existing intermediate landings
Elevators: number of elevators, cabin size	2 elevators per platform > 10 persons	1 elevator per platform, min. 10 persons (= 2 m²)	Between 5 and 9 persons (4 persons = 1 m²)	Neither elevator nor ramp
Operating elements	Between 80 cm and 100 cm	Between 80 cm and 110 cm	Above 110 cm	Above 120 cm height
Handrails (ramps)	Double handrail (75 cm and 90/100 cm height), easy to grip, on both sides of the path, handrail extension min. 40 cm	Single handrail (between 80 cm and 95 cm high), easy to grip, on both sides of the path	Single handrail (between 80 cm and 95 cm high), on one side of the pathway	No handrail
Floor conditions	Slip-resistant, with grip	Slip-resistant	Partly slip-resistant	Not slip-resistant

Table 13: Inspection criteria wheelchair users - Passages FS (based on BMK and FFG 2008)

Inspection criteria for wheelchair users - Area: Passages / Access platform				
Wheelchair users	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Clear width of paths in general	> 200 cm	180 - 200 cm	120 -180 cm	< 120 cm
Clear width of ramps	> 180 cm	160 - 180 cm	120 - 160 cm	< 120 cm
Clear width of doors and entrances	> 85 cm	min. 85 cm	min. 85 cm	below 85 cm
Single steps	Single step up to 3 cm outdoors, max. 2 cm indoors	3 - 5 cm height of single step	3 - 5 cm height of single step	Single step above 5 cm or several steps
Ramps	Up to 6%, from 10 m lenght intermediate landing with 120 cm (150 cm in case of directional change), wheel deflector at least 10 cm high, up to 2 m height difference	Up to 6%, from 10 m lenght intermediate landing with 120 cm (150 cm in case of directional change), without wheel deflector, up to 2,5 m height difference	above 6% up to 10%, optionally with intermediate landing, up to 3 m height difference	over 10% longitudinal gradient always, even with existing intermediate landings
Elevators: number of elevators, cabin size	2 elevators per platform > 10 persons	1 elevator per platform, min. 10 persons (= 2 m²)	Between 5 and 9 persons (4 persons = 1 m²)	Neither elevator nor ramp
Operating elements	Between 80 cm and 100 cm	Between 80 cm and 110 cm	Above 110 cm	Above 120 cm height
Handrails (ramps)	Double handrail (75 cm and 90/100 cm height), easy to grip, on both sides of the path, handrail extension min. 40 cm	Single handrail (between 80 cm and 95 cm high), easy to grip, on both sides of the path	Single handrail (between 80 cm and 95 cm high), on one side of the pathway	No handrail
Floor conditions	Slip-resistant, with grip	Slip-resistant	Partly slip-resistant	Not slip-resistant

Table 14: Inspection criteria wheelchair users - Platforms FS (based on BMK and FFG 2008)

Inspection criteria for wheelchair users - Area: Platforms				
Wheelchair users	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) with assistance**	**(4) Highly deficient**
Clear width of paths in general	> 200 cm	180 - 200 cm	120 -180 cm	< 120 cm
Clear width of ramps	> 180 cm	160 - 180 cm	120 - 160 cm	< 120 cm
Clear width of doors and entrances	> 85 cm	min. 85 cm	min. 85 cm	below 85 cm
Single steps	Single step up to 3 cm outdoors, max. 2 cm indoors	3 - 5 cm height of single step	3 - 5 cm height of single step	Single step above 5 cm or several steps
Ramps	Up to 6%, from 10 m lenght intermediate landing with 120 cm (150 cm in case of directional change), wheel deflector at least 10 cm high, up to 2 m height difference	Up to 6%, from 10 m lenght intermediate landing with 120 cm (150 cm in case of directional change), without wheel deflector, up to 2,5 m height difference	above 6% up to 10%, optionally with intermediate landing, up to 3 m height difference	over 10% longitudinal gradient always, even with existing intermediate landings
Elevators: number of elevators, cabin size	2 elevators per platform > 10 persons	1 elevator per platform, min. 10 persons (= 2 m²)	Between 5 and 9 persons (4 persons = 1 m²)	Neither elevator nor ramp
Operating elements	Between 80 cm and 100 cm	Between 80 cm and 110 cm	Above 110 cm	Above 120 cm height
Handrails (ramps)	Double handrail (75 cm and 90/100 cm height), easy to grip, on both sides of the path, handrail extension min. 40 cm	Single handrail (between 80 cm and 95 cm high), easy to grip, on both sides of the path	Single handrail (between 80 cm and 95 cm high), on one side of the pathway	No handrail
Floor conditions	Slip-resistant, with grip	Slip-resistant	Partly slip-resistant	Not slip-resistant

Positive criteria for visually impaired and blind people

Floor conditions and the accessibility to the buildings and the vehicle got the best possible rating. Upon request, Agertoug (personal communication, May 31, 2022) defined in writing that the floor of the station is made of granite and either they are "jet burned" or made in "flamed granite" to be slip-resistant. The tactile guidance system in the entrance area is rated "1" since walls, ramps, escalators, and stairs are considered sufficient for wayfinding in this area. The visual guidance system provides a clear design, good contrast, and pictograms. The character size is expected to be bigger than 10 cm, although this could not be verified through measurements. All staircases have handrails on both sides in all areas; therefore, a rating of "1" for blind people is given. Loudspeakers on the platform level are subjectively well understandable even at full operating noise level.

Improvable criteria for visually impaired people

Four general criteria for all areas for visually impaired people exist. "Orientation, findability of the station" was classified as "3" since the entrance from Solbjerg Plads is inconspicuous. Due to complaints from a participant about the lighting at the entrance to Sylows Allé at night, the category "Illumination at the station area" was classified as "3". Since the research was conducted during the day, this could not be verified by the researcher. The area of the entrance building reveals multiple deficiencies. Stair treads are not marked without gaps, and the contrast is low; therefore, it is considered classification "3". Handrails for stairs are classified as "2" in this area since they have some contrast and are continuous without edges. Elevators are considered class "3" due to irregularities of floor announcements and a lack of contrast for buttons. A differentiated rating for all four elevators can be found in Table 43 and Table 44. Escalators neither have a proper marking of stair treads nor a contrast distinction between tread and riser is provided; this puts the inspection criteria "Escalators" in classification "3". Glass portals are classified "3" due to a lack of marking. A loudspeaker is not considered relevant at the entrance area, nor is a safety line along the platform edge since there is no platform. The tactile guidance system is considered classification "3" at the passage level. Due to the different construction periods of this station, diverse tactile guidance systems lead the way. The older TWSIs lack contrast and are not palpable enough. Additionally, a connection between old and new tactile guidance system is missing. Due to a handrail with edges a Like the entrance building area, neither a loudspeaker nor a safety line along the platform edge is considered relevant since there is no platform. In the area of platforms, stairs, handrails, and escalators are not available, and a safety line along the platform edge is not necessary due to glass doors on the platform edge. Therefore, these inspection criteria were greyed out in the applied tables. Information about the rating of criteria in different areas of the station for visually impaired people can be found in Table 15, Table 16, and Table 17.

Improvable criteria for blind people

Blind people might need help finding one of the stations entrances and therefore the findability of areas is considered classification “3”. Escalators during maintenance at the entrance or passage level are considered classification “3” since a blind participant stated that escalators are not always marked when out of order. Further information about the ratings for blind people can be found in Table 18, Table 19, and Table 20.

Table 15: Inspection criteria visually impaired people - Entrance area FS (based on BMK and FFG 2008)

Inspection criteria for visually impaired people - General criteria for all areas (FS)				
Visually impaired people	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Floor conditions	Sufficient roughness of the surface	Sufficient roughness of the surface	Uneven floor, unmarked individual steps	Unpaved station area, slippery flooring, risk of tripping, risk of black ice
Illumination at the station area (SA)	Stop signage illuminated + SA brightly illuminated	Stop signage not illuminated but SA well illuminated (min. 10 lux)	Stop signage not illuminated and SA insufficiently illuminated (min. 1 Lux)	Stop signage not perceptible, SA unlit (below 1 Lux)
Orientation, findability of the station	Station visually very easy to find	Station visually easy to find	Station not easy to find, no contrasts with the station environment	Obstructed view - station impossible to find
Accessibility to the buildings and the vehicle	Free entrance and exit, clear width and height of the pathway must be kept free	Free entrance and exit, clear width and height of the pathway must be kept free	Bulky obstacles in the entry area (sporadic)	Bulky obstacles throughout the area (as bollards, hydrant, post box, etc.)
Inspection criteria for vision impaired people - Area: Entrance building				
Visual guidance system	Wayfinding system with character size ≥ 10 cm, good contrast, pictograms, clear design	Wayfinding system with character size 7.5 - 10 cm, good contrast	Wayfinding system with character size below 7.5 cm	No guidance, always possible with assistance
Tactile guidance system	TWSI with at least 50% colour contrast. Palpable, no gaps, continous. Further guidance	TWSI with at least 30% colour contrast. Palpable, contious, further guidance (gaps in some areas - potential for optimisation)	TWSI without sufficient colour contrast. Not palpable. Always possible with assistance	
Loudspeaker	Subjectively well understandable sound even at full operating noise level	Good sound system	Poor sound system	No loudspeaker
Stairs	Stair treads marked with high contrast without gaps	Stair treads marked with high contrast without gaps	Gaps or other deficiencies in the marking of stair treads	No marking
Handrails for stairs	Handrail with min. 50% colour contrast. Continuous without edges.	Handrail with min. 30% colour contrast. Continuous without edges.	Handrails without sufficient colour contrast. Always possible with assistance	No handrails
Elevators	Voice announcements with floor announcement. Contrasting tactile operating elements. Including emergency call	Voice announcements with floor announcement. Tactile operating elements. Lack of contrast. Including emergency calls	Without voice announcements. No tactile operating elements and no contrast. Including emergency call	Always possible with assistance
Escalators	Good marking of stair treads	No marking of stair treads but colour contrast between tread and riser	Always possible with assistance	
Safety line along the platform edge	Colour contrast at least 50%. Continuous without gaps	Colour contrast at least 30%. Continuous without gaps	Without sufficient colour contrast	Always possible with assistance
Glass portals	Glass portal with sufficiently high and contrasting plinth or glass marking	Glass portal with sufficiently high and contrasting plinth or glass marking	Always possible with assistance	

Table 16: Inspection criteria visually impaired people - Passages FS (based on BMK and FFG 2008)

Inspection criteria for visually impaired people - Area: Passages / Access platform (FS)				
Visually impaired people	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Visual guidance system	Wayfinding system with character size ≥ 10 cm, good contrast, pictograms, clear design	Wayfinding system with character size 7.5 - 10 cm, good contrast	Wayfinding system with character size below 7.5 cm	No guidance, always possible with assistance
Tactile guidance system	TWSI with at least 50% colour contrast. Palpable, no gaps, continous. Further guidance	TWSI with at least 30% colour contrast. Palpable, continous, further guidance (gaps in some areas - potential for optimisation)	TWSI without sufficient colour contrast. Not palpable. Always possible with assistance	
Loudspeaker	Subjectively well understandable sound even at full operating noise level	Good sound system	Poor sound system	No loudspeaker
Stairs	Stair treads marked with high contrast without gaps	Stair treads marked with high contrast without gaps	Gaps or other deficiencies in the marking of stair treads	No marking
Handrails for stairs	Handrail with min. 50% colour contrast. Continuous without edges.	Handrail with min. 30% colour contrast. Continuous without edges.	Handrails without sufficient colour contrast. Always possible with assistance	No handrails
Elevators	Voice announcements with floor announcement. Contrasting tactile operating elements. Including emergency call	Voice announcements with floor announcement. Tactile operating elements. Lack of contrast. Including emergency calls	Without voice announcements. No tactile operating elements and no contrast. Including emergency call	Always possible with assistance
Escalators	Good marking of stair treads	No marking of stair treads but colour contrast between tread and riser	Always possible with assistance	
Safety line along the platform edge	Colour contrast at least 50%. Continuous without gaps	Colour contrast at least 30%. Continuous without gaps	Without sufficient colour contrast	Always possible with assistance
Glass portals	Glass portal with sufficiently high and contrasting plinth or glass marking	Glass portal with sufficiently high and contrasting plinth or glass marking	Always possible with assistance	

Table 17: Inspection criteria visually imapaired people - Platforms FS (based on BMK and FFG 2008)

Inspection criteria for visually impaired people - Area: Platforms (FS)				
Visually impaired people	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Visual guidance system	Wayfinding system with character size ≥ 10 cm, good contrast, pictograms, clear design	Wayfinding system with character size 7.5 - 10 cm, good contrast	Wayfinding system with character size below 7.5 cm	No guidance, always possible with assistance
Tactile guidance system	TWSI with at least 50% colour contrast. Palpable, no gaps, continous. Further guidance	TWSI with at least 30% colour contrast. Palpable, contious, further guidance (gaps in some areas - potential for optimisation)	TWSI without sufficient colour contrast. Not palpable. Always possible with assistance	
Loudspeaker	Subjectively well understandable sound even at full operating noise level	Good sound system	Poor sound system	No loudspeaker
Stairs	Stair treads marked with high contrast without gaps	Stair treads marked with high contrast without gaps	Gaps or other deficiencies in the marking of stair treads	No marking
Handrails for stairs	Handrail with min. 50% colour contrast. Continuous without edges.	Handrail with min. 30% colour contrast. Continuous without edges.	Handrails without sufficient colour contrast. Always possible with assistance	No handrails
Elevators	Voice announcements with floor announcement. Contrasting tactile operating elements. Including emergency call	Voice announcements with floor announcement. Tactile operating elements. Lack of contrast. Including emergency calls	Without voice announcements. No tactile operating elements and no contrast. Including emergency call	Always possible with assistance
Escalators	Good marking of stair treads	No marking of stair treads but colour contrast between tread and riser	Always possible with assistance	
Safety line along the platform edge	Colour contrast at least 50%. Continuous without gaps	Colour contrast at least 30%. Continuous without gaps	Without sufficient colour contrast	Always possible with assistance
Glass portals	Glass portal with sufficiently high and contrasting plinth or glass marking	Glass portal with sufficiently high and contrasting plinth or glass marking	Always possible with assistance	

Table 18: Inspection criteria blind people - Entrance area FS (based on BMK and FFG 2008)

Inspection criteria for blind people - General criteria for all areas (FS)				
Blinde people	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Floor conditions	Sufficient roughness of the surface	Sufficient roughness of the surface	Uneven floor, unmarked individual steps	Unpaved station area, slippery flooring, risk of tripping, risk of black ice
Orientation, findability of areas	TWSI line to the entry area or further guidance	TWSI line to the entry area or further guidance	Always possible with assistance	
Accessibility to the buildings and the vehicle	Free entrance and exit, clear width and height of the pathway must be kept free	Free entrance and exit, clear width and height of the pathway must be kept free	Bulky obstacles in the entry area (sporadic)	Bulky obstacles throughout the area
Inspection criteria for blind people - Area: Entrance building				
Tactile guidance system *)	TWSI well palpable, continuous. No gaps, further guidance	TWSI well palpable, partial gaps. Potential for optimisation in some areas	TWSI not palpable. Alwas possible with assistance	
***) at simple entrance buildings**	With TWSI	Even without TWSI if continuing guidance is sufficient		
Loudspeaker	Subjectively well understandable sound system even at full operating noise level	Good sound system	Poor sound system	No sound system
Handrails for stairs	Handrails on both sides. Continuous without edges	Handrails on both sides. Continuous without edges	Handrails one sided	No handrails
Tactile handrail information (THI) - see comment in footnote 1				
Elevators	Voice announcements with floor announcement. Contrasting tactile operating elements. Including emergency call	Voice announcements with floor announcement. Tactile operating elements. Lack of contrast. Including emergency calls	Without voice announcements. No tactile operating elements and no contrast. Including emergency call	Always possible with assistance
Escalators during maintenance	Protection against the risk of falling	Protection against the risk of falling	Always possible with assistance	
Tactile safety line along the platform edge	Continuous without gaps (Manhole covers bridge gaps)	Continuous without gaps (Manhole covers bridge gaps)	No tactile safety line. Always possible with assistance	
Footnote: The following categories are no evaluation criteria				
THI in the traffic flow for escalators or staircases in areas with "rush hour"	Inappropriate - barrier to the traffic flow		Always possible with assistance	
THI in calmer areas (in front of elevators)	Appropriate for verifying location if the traffic flow is not impeded		Always possible with assistance	

Table 19: Inspection criteria blind people - Passages FS (based on BMK and FFG 2008)

Inspection criteria for blind people - Area: Passages / Access platform (FS)				
Blinde people	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Tactile guidance system	TWSI well palpable, continuous. No gaps, further guidance	TWSI well palpable, partial gaps. Potential for optimisation in some areas	TWSI not palpable. Alwas possible with assistance	
Loudspeaker	Subjectively well understandable sound system even at full operating noise level	Good sound system	Poor sound system	No sound system
Handrails for stairs	Handrails on both sides. Continuous without edges	Handrails on both sides. Continuous without edges	Handrails one sided	No handrails
Tactile handrail information (THI) - see comment in footnote 1				
Elevators	Voice announcements with floor announcement. Contrasting tactile operating elements. Including emergency call	Voice announcements with floor announcement. Tactile operating elements. Lack of contrast. Including emergency calls	Without voice announcements. No tactile operating elements and no contrast. Including emergency call	Always possible with assistance
Escalators during maintenance	Protection against the risk of falling	Protection against the risk of falling	Always possible with assistance	
Tactile safety line along the platform edge	Continuous without gaps (Manhole covers bridge gaps)	Continuous without gaps (Manhole covers bridge gaps)	No tactile safety line. Always possible with assistance	
Footnote: The following categories are no evaluation criteria				
THI in the traffic flow for escalators or staircases in areas with "rush hour"	Inappropriate - barrier to the traffic flow		Always possible with assistance	
THI in calmer areas (in front of elevators)	Appropriate for verifying location if the traffic flow is not impeded		Always possible with assistance	

Table 20: Inspection criteria blind people - Platforms FS (based on BMK and FFG 2008)

Inspection criteria for blind people - Area: Platforms (FS)				
Blind people	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Tactile guidance system *)	TWSI well palpable, continuous. No gaps, further guidance	TWSI well palpable, partial gaps. Potential for optimisation in some areas	TWSI not palpable. Alwas possible with assistance	
Loudspeaker	Subjectively well understandable sound system even at full operating noise level	Good sound system	Poor sound system	No sound system
Handrails for stairs	Handrails on both sides. Continuous without edges	Handrails on both sides. Continuous without edges	Handrails one sided	No handrails
Tactile handrail information (THI) - see comment in footnote 1				
Elevators	Voice announcements with floor announcement. Contrasting tactile operating elements. Including emergency call	Voice announcements with floor announcement. Tactile operating elements. Lack of contrast. Including emergency calls	Without voice announcements. No tactile operating elements and no contrast. Including emergency call	Always possible with assistance
Escalators during maintenance	Protection against the risk of falling	Protection against the risk of falling	Always possible with assistance	
Tactile safety line along the platform edge	Continuous without gaps (Manhole covers bridge gaps)	Continuous without gaps (Manhole covers bridge gaps)	No tactile safety line. Always possible with assistance	
Footnote: The following categories are no evaluation criteria				
THI in the traffic flow for escalators or staircases in areas with "rush hour"	Inappropriate - barrier to the traffic flow		Always possible with assistance	
THI in calmer areas (in front of elevators)	Appropriate for verifying location if the traffic flow is not impeded		Always possible with assistance	

Positive criteria for hard-of-hearing and deaf people

Illumination in the passage and platform area is considered optimal; multiple participants reassured this statement during the go-alongs.

Improvable criteria for hard-of-hearing people

Due to the lack of a helpdesk, no audio induction loop at a helpdesk is available. Consequently, the classification of the inspection criteria "Audio induction loop at the helpdesk" is "4" at all levels. The participant with hearing impairment could not understand the announcement on the platforms. Therefore it is classified as "3". Information about the rating of criteria in different areas of the station for hard-of-hearing people can be found in Table 21, Table 22, and Table 23.

Improvable criteria for deaf people

Due to the lack of a helpdesk, no person with sign language competencies at a helpdesk is available. Thus the classification of the inspection criteria "Sign language competence at the helpdesk" is "4" in all areas. Information about the rating of criteria in different areas of the station for deaf people can be found in Table 21, Table 22, and Table 23.

Table 21: Inspection criteria hard-of-hearing and deaf people - Entrance area FS (based on BMK and FFG 2008)

Inspection criteria for hearing impaired people - Area: Entrance building (FS)				
Hearing impaired people	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Visual guidance system	Wayfinding system with character size ≥ 10 cm, good contrast, pictograms, clear design	Wayfinding system with character size 7.5 - 10 cm, good contrast	Wayfinding system with character size below 7.5 cm	No guidance, always possible with assistance
Audio induction loop at the helpdesk	Available, direct voice contact possible	Available, voice contact only possible through a glass pane	Not available, voice contact possible through a glass pane	Always possible with assistance
Loudspeaker	Subjectively well understandable sound system even at full operating noise level	Good sound system	Poor sound system	No sound system
Illumination	Optimal illumination	Good illumination	Poor illumination	Not adequately illuminated

Deaf people	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Visual guidance system	Wayfinding system with character size ≥ 10 cm, good contrast, pictograms, clear design	Wayfinding system with character size 7.5 - 10 cm, good contrast	Wayfinding system with character size below 7.5 cm	Always possible with assistance, no guidance
Sign language competence at the helpdesk	Available	Available on request	Not available	Not available
Illumination	Optimal illumination	Good illumination	Poor illumination	Not adequately illuminated

Table 22: Inspection criteria hard-of-hearing and deaf people - Passages FS (based on BMK and FFG 2008)

Inspection criteria for hearing impaired people - Area: Passages / Access platform (FS)				
Hearing impaired people	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Visual guidance system	Wayfinding system with character size ≥ 10 cm, good contrast, pictograms, clear design	Wayfinding system with character size 7.5 - 10 cm, good contrast	Wayfinding system with character size below 7.5 cm	No guidance, always possible with assistance
Audio induction loop at the helpdesk	Available, direct voice contact possible	Available, voice contact only possible through a glass pane	Not available, voice contact possible through a glass pane	Always possible with assistance
Loudspeaker	Subjectively well understandable sound even at full operating noise level	Good sound system	Poor sound system	No loudspeaker
Illumination	Optimal illumination	Good illumination	Poor illumination	Not adequately illuminated

Deaf people	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Visual guidance system	Wayfinding system with character size ≥ 10 cm, good contrast, pictograms, clear design	Wayfinding system with character size 7.5 - 10 cm, good contrast	Wayfinding system with character size below 7.5 cm	Always possible with assistance, no guidance
Sign language competence at the helpdesk	Available	Available on request	Not available	Not available
Illumination	Optimal illumination	Good illumination	Poor illumination	Not adequately illuminated

Table 23: Inspection criteria hard-of-hearing and deaf people - Platforms FS (based on BMK and FFG 2008)

Inspection criteria for hearing impaired people - Area: Platforms (FS)

Hearing impaired people	(1) Without assistance	(2) Largely usable without assistance	(3) With assistance	(4) Highly deficient
Visual guidance system	Wayfinding system with character size ≥ 10 cm, good contrast, pictograms, clear design	Wayfinding system with character size 7.5 - 10 cm, good contrast	Wayfinding system with character size below 7.5 cm	No guidance, always possible with assistance
Audio induction loop at the helpdesk	Available, direct voice contact possible	Available, voice contact only possible through a glass pane	Not available, voice contact possible through a glass pane	Always possible with assistance
Loudspeaker	Subjectively well understandable sound even at full operating noise level	Good sound system	Poor sound system	No loudspeaker
Illumination	Optimal illumination	Good illumination	Poor illumination	Not adequately illuminated
Deaf people	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Visual guidance system	Wayfinding system with character size ≥ 10 cm, good contrast, pictograms, clear design	Wayfinding system with character size 7.5 - 10 cm, good contrast	Wayfinding system with character size below 7.5 cm	Always possible with assistance, no guidance
Sign language competence at the helpdesk	Available	Available on request	Not available	Not available
Illumination	Optimal illumination	Good illumination	Poor illumination	Not adequately illuminated

Evaluation catalog

Frederiksberg station shows high deficiencies, especially for wheelchair users, hard-of-hearing, and deaf people. At least one or more inspection criteria make it hard or even impossible for these groups of people to navigate through the station, resulting in a poor rating for a barrier-free trip chain. Improving some of the deficiencies (e.g., elevators) could lead to a better rating for different affected groups of people and various parts of the station simultaneously. Overall, Frederiksberg station gets a rating of 63 out of 72, which illustrates a high potential for improvements.

Table 24: Evaluation catalog - Frederiksberg station (based on BMK and FFG 2008)

Station Frederiksberg Barrier-free travel chain					Construction year 2003 + 2019
		Entrance Building	**Passage(s) / Access Platform**	**Platform(s)**	**SUM**
Mobility	**Walking impaired**	3	3	3	9
	Wheelchair users	4	4	4	12
Vision	**Vision impaired**	3	3	3	9
	Blind	3	3	3	9
Hearing	**Hearing impaired**	4	4	4	12
	Deaf	4	4	4	12
	SUM	21	21	21	63

Catalog of measures

The catalog of measures for Frederiksberg station shows a good perspective for future ratings if adaptions inside the station are implemented. All locations reveal potential improvement, especially the entrance and passage areas. The platform area shows optimization potential for TWSIs, glass portals, and loudspeakers. Three optimization potentials are currently rated “4”, most of them are rated “3”. The photo documentation of the station is based on pictures taken on March 5, March 27, July 6, and July 8, 2022. It can be found in “Photo documentation - Frederiksberg station” on page 149.

Table 25: Catalog of measures - Frederiksberg station (based on BMK and FFG 2008)

Copenhagen Metro - Catalog of measures			Frederiksberg station		
Location	**Level**	**Optimization potential**	**Figure**	**Evaluation**	**Perspective**
Entrance Building					
	L0	Audio induction loop at a helpdesk, direct voice contact possible	-	4	1
	L0	Sign language competence at a helpdesk	-	4	1
Entrance Solbjergs Plads	L0	Visibility of entrance - Red Metro "M"	Figure 120	3	1
Entrance Sylows Allé	L0	Visibility of entrance	Figure 122	3	1
Entrance Sylows Allé	L0	Lighting	Figure 122	3	1
Entrance Solbjergvej	L0	TWSIs	Figure 121	3	1
Escalators	L0 to L-1	Escalator marking	Figure 130	3	1
		Escalator during maintenance	Figure 131	3	1
Moving walkway	L0 to L-1	Moving walkway marking	Figure 121	3	1
Stairs	L0 to L-1	Stair markings	Figure 147	3	1
		Handrail contrast	Figure 126	2	1
		Double handrail	Figure 126	2	1
Entrance moving walkway	L0 to L-1	Glass door municipality	Figure 125	3	1
Elevators	L0 to L-2	Voice announcement, tactile operating elements	Figure 143	3	1
Passages / Access platform					
Escalators	L-1 to L-2	Escalator marking	Figure 130	3	1
		Escalators during maintenance	Figure 131	3	1
Concourse level	L-1	Stair markings	Figure 147	3	1
		Glass doors to bike room	Figure 124	3	1
		Several steps on concourse level	Figure 133	4	1
		TWSI in front of escalators	Figure 136	3	1
		TWSI connecting escalators	Figure 133	3	1
		TWSI gap between 2003 station part and 2019 station part	Figure 134	3	1
		TWSI distance to screens and objects	Figure 135	3	1
		TWSI gap (moving walkway entrance)	Figure 121	3	1
		Door frame (moving walkway entrance)	Figure 129	3	1
		TWSI single line metal	Figure 135	3	1
Stairs	L-1 to L-2	Double handrail	Figure 126	2	1
Platforms					
Platform M3	L-2	TWSI guiding to elevators along the platform	Figure 140	3	1
		Loudspeaker announcement (from side and deeper voice level)	-	3	1
		Glass portals	Figure 146	3	1
Platform M1/M2	L-2	TWSI single line metal	Figure 141	3	1
		TWSI connecting escalators	-	3	1
		TWSI along platform	Figure 141	3	1
		Glass portals	Figure 146	3	1
		Loudspeaker announcement (from side and deeper voice level)	-	3	1

4.2.2 MofA evaluation catalog at Längenfeldgasse station in Vienna

The selected station in Vienna is Längenfeldgasse station, where lines U4 and U6 cross. This station's exact location in Vienna's metro network is marked with a black dot in Figure 6. Both platforms are at the same level, and each line has one track per platform. The station was opened in 1987 during the second construction phase of the Viennese metro (Stadt Wien 2022c). There are two roofed entrance buildings and three ways to enter Längenfeldgasse station; the western entrance leads to Storchensteg, and the two eastern entrances lead to Längenfeldgasse. Figure 11 gives an overview of the different areas for the MofA evaluation tool. In this station, stairs and escalators are defined as access to the platform. Due to their relevance in several areas, elevators are not clearly assigned to one area. One entrance building provides access to platforms with an elevator. Both platforms have numerous pillars. The entrance building on the east side includes a bakery and a restaurant.

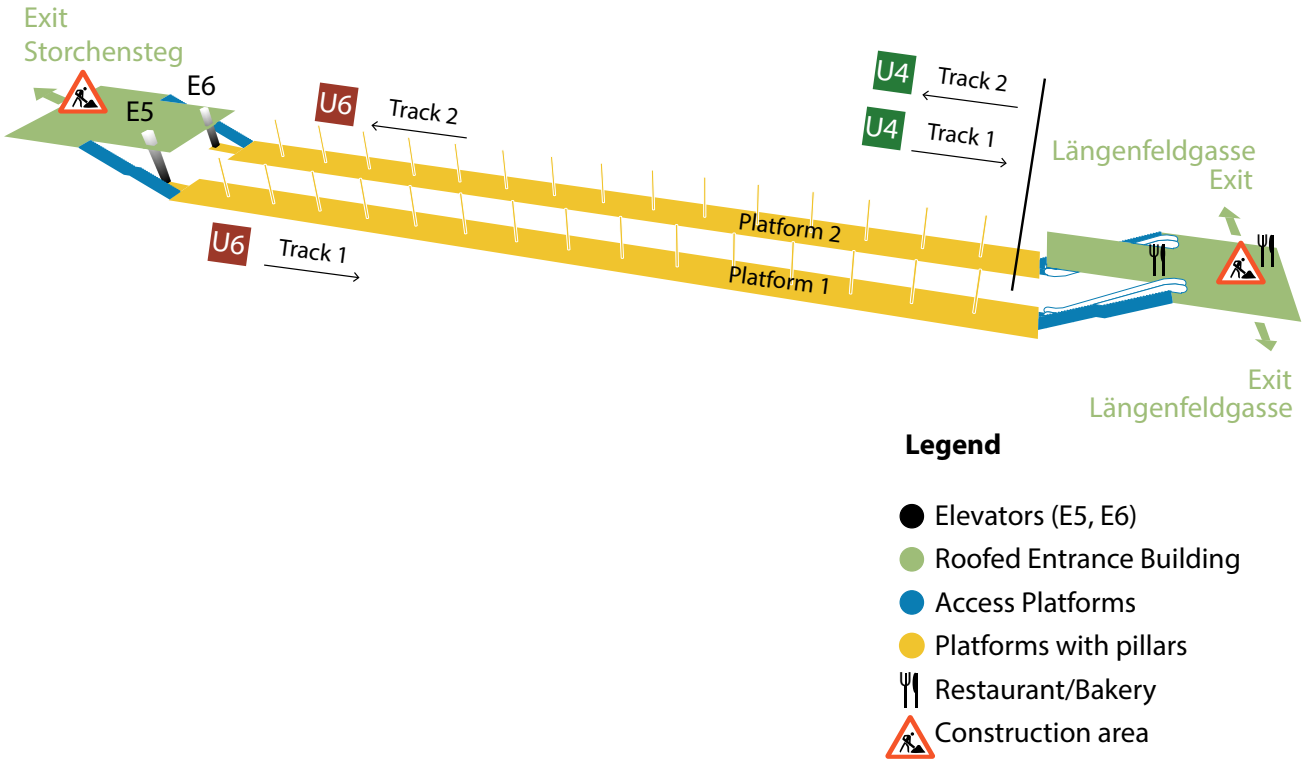


Figure 11: Längenfeldgasse station layout

Längenfeldgasse station was evaluated on March 5, 2023. The results focus on the same details as the ones at Frederiksberg station in chapter "4.2.1 MofA evaluation catalog at Frederiksberg station in Copenhagen". At the time of research, there were construction sites in both entrance buildings, which influenced the ratings of some categories.

Positive criteria for walking impaired and wheelchair users

The clear width of paths is generally more than 200 cm in all station areas. The clear width of doors and entrances is considered above 85 cm. Elevator doors are 80 cm wide but explicitly excluded from this category since ÖNORM B 1600 (Austrian Standards International 2023) proposes 80 cm wide doors for elevators in existing buildings. No single steps are at Längenfeldgasse station. On stairs, double handrails at the height of 65 cm and 83.5 cm, although they do not correlate with the suggested height in category "1", it is the most accurate classification. The floor conditions were considered slip-resistant, and with a grip, this was confirmed by participants. Although a wheelchair user simultaneously mentioned that on the platform level, the ground felt uneven and as if it was sloping to the side.

Improvable criteria for walking impaired people

Categories related to stairs and ramps are irrelevant to the entrance area or platforms; therefore, they are not considered in these areas. Due to only one elevator per platform for up to 10 persons, the category "Elevators" is classified as "2". Some functional elements are above 110 cm, leading to classification "3". At the passage area, the fall-back level of a staircase results in a "3". Even though the flight of stairs has 21 steps, it is the most accurate category of all four. There are 42 steps in total from the platform to the ground floor, and according to a floorplan for level "N0" provided by Wiener Linien, the steps have a height below 16 cm and a depth of at least 30 cm. Due to the lack of paths, doors and entrances, ramps, and individual steps at the passage level, no classification was elaborated. The same principle applies to the platform level and the category of doors or entrances. Information about the rating of criteria in different areas of the station for walking impaired people can be found in Table 26, Table 27, and Table 28.

Improvable criteria for wheelchair users

For wheelchair users, elevators are the most relevant improvable category in all areas of this station. The same rating applies here as it does for walking impaired people. Detailed information concerning the two elevators can be found in Table 45. Individual steps are not given anywhere at Längenfeldgasse station. Information about the rating of criteria in different areas of the station for wheelchair users can be found in Table 29, Table 30, and Table 31.

Table 26: Inspection criteria walking impaired - Entrance area LS (based on BMK and FFG 2008)

Inspection criteria for walking impaired people - Area: Entrance building (LS)				
Walking impaired people	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Clear width of paths in general	> 200 cm	180 -200 cm	120 -180 cm	< 120 cm
Clear width of stairs and ramps	> 180 cm	160 - 180 cm	120 - 160 cm	< 120 cm
Clear width of doors and entrances	> 85 cm	min. 85 cm	min. 85 cm	below 85 cm
Fall-back level staircase if neither elevator nor ramp is available	Flight of stairs with max. 16 steps; max. 36 steps in total < 16 cm height/ depth min. 30 cm.	Flight of stairs with max. 18 steps; max. 36 steps in total < 16 cm height/ depth min. 30 cm.	Flight of stairs with max. 18 steps; max. 72 steps in total < 16 cm height/ depth min. 30 cm.	more than 72 steps in total
Individual steps on the pavement	No individual steps	Up to 3 individual steps with handrail on both sides; Step height < 16 cm / depth min. 30 cm	Up to 3 individual steps with handrail on one side; Step height > 16 cm / depth min. 30 cm	Up to 3 individual steps without handrail; Step height > 16 cm / depth > 30 cm
Ramps	Up to 6%, from 10 m lenght intermediate landing with 120 cm (150 cm in case of directional change), wheel deflector at least 10 cm high, up to 2 m height difference	Up to 6%, from 10 m lenght intermediate landing with 120 cm (150 cm in case of directional change), without wheel deflector, up to 2,5 m height difference	above 6% up to 10%, optionally with intermediate landing, up to 3 m height difference	over 10% longitudinal gradient always, even with existing intermediate landings
Handrails (stairs/ramps)	Double handrail (75 and 90/100 cm height), easy to grip, on both sides of the path, handrail extension min. 40 cm	Single handrail (between 80 cm and 95 cm high), easy to grip, on both sides of the path, handrail extension min. 40 cm	Single handrail (between 80 cm and 95 cm high), on one side of the pathway	No handrail
Elevator: number of elevators, cabin size	2 elevators per platform > 10 persons	1 elevator per platform, min. 10 persons (= 2 m²)	Between 5 and 9 persons (4 persons = 1 m²)	Neither elevator nor ramp
Operating elements	between 80 cm and 100 cm	between 80 cm and 110 cm	above 110 cm	Above 120 cm height or below 70 cm height
Floor conditions	Slip-resistant, with grip	Slip-resistant	Partly slip-resistant	Not slip-resistant

Table 27: Inspection criteria walking impaired - Passages LS (based on BMK and FFG 2008)

Inspection criteria for walking impaired people - Area: Access platform (LS)				
Walking impaired people	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Clear width of paths in general	> 200 cm	180 -200 cm	120 -180 cm	< 120 cm
Clear width of stairs and ramps	> 180 cm	160 - 180 cm	120 - 160 cm	< 120 cm
Clear width of doors and entrances	> 85 cm	min. 85 cm	min. 85 cm	below 85 cm
Fall-back level staircase if neither elevator nor ramp is available	Flight of stairs with max. 16 steps; max. 36 steps in total < 16 cm height/ depth min. 30 cm.	Flight of stairs with max. 18 steps; max. 36 steps in total < 16 cm height/ depth min. 30 cm.	Flight of stairs with max. 18 steps; max. 72 steps in total < 16 cm height/ depth min. 30 cm.	more than 72 steps in total
Individual steps on the pavement	No individual steps	Up to 3 individual steps with handrail on both sides; Step height < 16 cm / depth min. 30 cm	Up to 3 individual steps with handrail on one side; Step height > 16 cm / depth min. 30 cm	Up to 3 individual steps without handrail; Step height > 16 cm / depth > 30 cm
Ramps	Up to 6%, from 10 m lenght intermediate landing with 120 cm (150 cm in case of directional change), wheel deflector at least 10 cm high, up to 2 m height difference	Up to 6%, from 10 m lenght intermediate landing with 120 cm (150 cm in case of directional change), without wheel deflector, up to 2,5 m height difference	above 6% up to 10%, optionally with intermediate landing, up to 3 m height difference	over 10% longitudinal gradient always, even with existing intermediate landings
Handrails (stairs/ramps)	Double handrail (75 and 90/100 cm height), easy to grip, on both sides of the path, handrail extension min. 40 cm	Single handrail (between 80 cm and 95 cm high), easy to grip, on both sides of the path, handrail extension min. 40 cm	Single handrail (between 80 cm and 95 cm high), on one side of the pathway	No handrail
Elevator: number of elevators, cabin size	2 elevators per platform > 10 persons	1 elevator per platform, min. 10 persons (= 2 m²)	Between 5 and 9 persons (4 persons = 1 m²)	Neither elevator nor ramp
Operating elements	between 80 cm and 100 cm	between 80 cm and 110 cm	above 110 cm	Above 120 cm height or below 70 cm height
Floor conditions	Slip-resistant, with grip	Slip-resistant	Partly slip-resistant	Not slip-resistant

Table 28: Inspection criteria walking impaired - Platforms LS (based on BMK and FFG 2008)

Inspection criteria for walking impaired people - Area: Platforms (LS)				
Walking impaired people	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Clear width of paths in general	> 200 cm	180 -200 cm	120 -180 cm	< 120 cm
Clear width of stairs and ramps	> 180 cm	160 - 180 cm	120 - 160 cm	< 120 cm
Clear width of doors and entrances	> 85 cm	min. 85 cm	min. 85 cm	below 85 cm
Fall-back level staircase if neither elevator nor ramp is available	Flight of stairs with max. 16 steps; max. 36 steps in total < 16 cm height/ depth min. 30 cm.	Flight of stairs with max. 18 steps; max. 36 steps in total < 16 cm height/ depth min. 30 cm.	Flight of stairs with max. 18 steps; max. 72 steps in total < 16 cm height/ depth min. 30 cm.	more than 72 steps in total
Individual steps on the pavement	No individual steps	Up to 3 individual steps with handrail on both sides; Step height < 16 cm / depth min. 30 cm	Up to 3 individual steps with handrail on one side; Step height > 16 cm / depth min. 30 cm	Up to 3 individual steps without handrail; Step height > 16 cm / depth > 30 cm
Ramps	Up to 6%, from 10 m lenght intermediate landing with 120 cm (150 cm in case of directional change), wheel deflector at least 10 cm high, up to 2 m height difference	Up to 6%, from 10 m lenght intermediate landing with 120 cm (150 cm in case of directional change), without wheel deflector, up to 2,5 m height difference	above 6% up to 10%, optionally with intermediate landing, up to 3 m height difference	over 10% longitudinal gradient always, even with existing intermediate landings
Handrails (stairs/ramps)	Double handrail (75 and 90/100 cm height), easy to grip, on both sides of the path, handrail extension min. 40 cm	Single handrail (between 80 cm and 95 cm high), easy to grip, on both sides of the path, handrail extension min. 40 cm	Single handrail (between 80 cm and 95 cm high), on one side of the pathway	No handrail
Elevator: number of elevators, cabin size	2 elevators per platform > 10 persons	1 elevator per platform, min. 10 persons (= 2 m²)	Between 5 and 9 persons (4 persons = 1 m²)	Neither elevator nor ramp
Operating elements	between 80 cm and 100 cm	between 80 cm and 110 cm	above 110 cm	Above 120 cm height or below 70 cm height
Floor conditions	Slip-resistant, with grip	Slip-resistant	Partly slip-resistant	Not slip-resistant

Table 29: Inspection criteria wheelchair users - Entrance area LS (based on BMK and FFG 2008)

Inspection criteria for wheelchair users - Area: Entrance building (LS)				
Wheelchair users	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Clear width of paths in general	> 200 cm	180 - 200 cm	120 -180 cm	< 120 cm
Clear width of ramps	> 180 cm	160 - 180 cm	120 - 160 cm	< 120 cm
Clear width of doors and entrances	> 85 cm	min. 85 cm	min. 85 cm	below 85 cm
Single steps	Single step up to 3 cm outdoors, max. 2 cm indoors	3 - 5 cm height of single step	3 - 5 cm height of step	Single step above 5 cm or several steps
Ramps	Up to 6%, from 10 m lenght intermediate landing with 120 cm (150 cm in case of directional change), wheel deflector at least 10 cm high, up to 2 m height difference	Up to 6%, from 10 m lenght intermediate landing with 120 cm (150 cm in case of directional change), without wheel deflector, up to 2,5 m height difference	above 6% up to 10%, optionally with intermediate landing, up to 3 m height difference	over 10% longitudinal gradient always, even with existing intermediate landings
Elevators: number of elevators, cabin size	2 elevators per platform > 10 persons	1 elevator per platform, min. 10 persons (= 2 m²)	Between 5 and 9 persons (4 persons = 1 m²)	Neither elevator nor ramp
Operating elements	Between 80 cm and 100 cm	Between 80 cm and 110 cm	Above 110 cm	Above 120 cm height
Handrails (ramps)	Double handrail (75 cm and 90/100 cm height), easy to grip, on both sides of the path, handrail extension min. 40 cm	Single handrail (between 80 cm and 95 cm high), easy to grip, on both sides of the path	Single handrail (between 80 cm and 95 cm high), on one side of the pathway	No handrail
Floor conditions	Slip-resistant, with grip	Slip-resistant	Partly slip-resistant	Not slip-resistant

Table 30: Inspection criteria wheelchair users - Passages LS (based on BMK and FFG 2008)

Inspection criteria for wheelchair users - Area: Access platform (LS)				
Wheelchair users	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Clear width of paths in general	> 200 cm	180 - 200 cm	120 -180 cm	< 120 cm
Clear width of ramps	> 180 cm	160 - 180 cm	120 - 160 cm	< 120 cm
Clear width of doors and entrances	> 85 cm	min. 85 cm	min. 85 cm	below 85 cm
Single steps	Single step up to 3 cm outdoors, max. 2 cm indoors	3 - 5 cm height of single step	3 - 5 cm height of single step	Single step above 5 cm or several steps
Ramps	Up to 6%, from 10 m lenght intermediate landing with 120 cm (150 cm in case of directional change), wheel deflector at least 10 cm high, up to 2 m height difference	Up to 6%, from 10 m lenght intermediate landing with 120 cm (150 cm in case of directional change), without wheel deflector, up to 2,5 m height difference	above 6% up to 10%, optionally with intermediate landing, up to 3 m height difference	over 10% longitudinal gradient always, even with existing intermediate landings
Elevators: number of elevators, cabin size	2 elevators per platform > 10 persons	1 elevator per platform, min. 10 persons (= 2 m²)	Between 5 and 9 persons (4 persons = 1 m²)	Neither elevator nor ramp
Operating elements	Between 80 cm and 100 cm	Between 80 cm and 110 cm	Above 110 cm	Above 120 cm height
Handrails (ramps)	Double handrail (75 cm and 90/100 cm height), easy to grip, on both sides of the path, handrail extension min. 40 cm	Single handrail (between 80 cm and 95 cm high), easy to grip, on both sides of the path	Single handrail (between 80 cm and 95 cm high), on one side of the pathway	No handrail
Floor conditions	Slip-resistant, with grip	Slip-resistant	Partly slip-resistant	Not slip-resistant

Table 31: Inspection criteria wheelchair users - Platforms LS (based on BMK and FFG 2008)

Inspection criteria for wheelchair users - Area: Platforms (LS)				
Wheelchair users	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) with assistance**	**(4) Highly deficient**
Clear width of paths in general	> 200 cm	180 - 200 cm	120 -180 cm	< 120 cm
Clear width of ramps	> 180 cm	160 - 180 cm	120 - 160 cm	< 120 cm
Clear width of doors and entrances	> 85 cm	min. 85 cm	min. 85 cm	below 85 cm
Single steps	Single step up to 3 cm outdoors, max. 2 cm indoors	3 - 5 cm height of single step	3 - 5 cm height of single step	Single step above 5 cm or several steps
Ramps	Up to 6%, from 10 m lenght intermediate landing with 120 cm (150 cm in case of directional change), wheel deflector at least 10 cm high, up to 2 m height difference	Up to 6%, from 10 m lenght intermediate landing with 120 cm (150 cm in case of directional change), without wheel deflector, up to 2,5 m height difference	above 6% up to 10%, optionally with intermediate landing, up to 3 m height difference	over 10% longitudinal gradient always, even with existing intermediate landings
Elevators: number of elevators, cabin size	2 elevators per platform > 10 persons	1 elevator per platform, min. 10 persons (= 2 m²)	Between 5 and 9 persons (4 persons = 1 m²)	Neither elevator nor ramp
Operating elements	Between 80 cm and 100 cm	Between 80 cm and 110 cm	Above 110 cm	Above 120 cm height
Handrails (ramps)	Double handrail (75 cm and 90/100 cm height), easy to grip, on both sides of the path, handrail extension min. 40 cm	Single handrail (between 80 cm and 95 cm high), easy to grip, on both sides of the path	Single handrail (between 80 cm and 95 cm high), on one side of the pathway	No handrail
Floor conditions	Slip-resistant, with grip	Slip-resistant	Partly slip-resistant	Not slip-resistant

Positive criteria for visually impaired and blind people

The tactile waking surface indicators are classified as "1" on the passage and platform levels. Although a blind participant stated he needs to go slow due to the structured tiles next to the TWSIs, it is well palpable at a slow pace and continuous without gaps in these areas. The tactile guidance on the passage and platform level has at least 50% color contrast, is without gaps, and includes further guidance. The color contrast of the safety line along the platform edge is considered at least 50% and continuous without gaps. Therefore, the best possible rating is applied. The illumination at the station is classified as "1", and both entrances have the typical blue metro cube of Wiener Linien, making every station entrance easy to find. The visual guidance system is assumed to include a character size of over 10 cm. However, it could not be measured in situ. Furthermore, the visual guidance consists of a good contrast, pictograms, and a clear design in all areas. A yellow marking on escalators justified a rating of "1", as does the marking of stairs without gaps.

Improvable criteria for visually impaired people

Due to construction works in the entrance area, the category of accessibility to the building is considered "3". The construction work was part of a renewal for TWSIs. Therefore, partial gaps lead to a rating of "2". Loudspeakers and a safety line along the platform edge are only considered relevant for platforms. Since no loudspeakers are available, the rating is "4". Glass portals are irrelevant for the passage area and were greyed out. Handrails could be more contrasting in the passage area; therefore, a rating of "2" is given. Neither glass portals are present on the platforms nor are escalators. Elevator "E6" did not have any voice announcements at the time of research, which resulted in a classification of "3" for all elevators. Information about the criteria rating in different station areas for visually impaired people can be found in Table 32, Table 33, and Table 34.

Improvable criteria for blind people

"Orientation and findability" as general criterion is considered classification "3" for blind people. The TWSIs of the west entrance building have partial gaps, and no TWSIs are leading to the east entrance building. Escalators are only available in the passage area; therefore, escalators during maintenance are irrelevant for the entrance building and platform areas. A blind participant in Längenfeldgasse station mentioned during the go-along being very careful when approaching escalators and focusing on the moving handrail when using them. A motionless handrail on an escalator indicates that an escalator is out of service. Due to this experience the category of escalators during maintenance results in a classification of "3". Information about the rating of criteria in different areas of the station for blind people can be found in Table 35, Table 36 and, Table 37.

Table 32: Inspection criteria visually impaired People - Entrance area LS (based on BMK and FFG 2008)

Inspection criteria for visually impaired people - General criteria for all areas (LS)				
Visually impaired people	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Floor conditions	Sufficient roughness of the surface	Sufficient roughness of the surface	Uneven floor, unmarked individual steps	Unpaved station area, slippery flooring, risk of tripping, risk of black ice
Illumination at the station area (SA)	Stop signage illuminated + SA brightly illuminated	Stop signage not illuminated but SA well illuminated (min. 10 lux)	Stop signage not illuminated and SA insufficiently illuminated (min. 1 Lux)	Stop signage not perceptible, SA unlit (below 1 Lux)
Orientation, findability of the station	Station visually very easy to find	Station visually easy to find	Station not easy to find, no contrasts with the station environment	Obstructed view - station impossible to find
Accessibility to the buildings and the vehicle	Free entrance and exit, clear width and height of the pathway must be kept free	Free entrance and exit, clear width and height of the pathway must be kept free	Bulky obstacles in the entry area (sporadic)	Bulky obstacles throughout the area (as bollards, hydrant, post box, etc.)
Inspection criteria for vision impaired people - Area: Entrance building				
Visual guidance system	Wayfinding system with character size ≥ 10 cm, good contrast, pictograms, clear design	Wayfinding system with character size 7.5 - 10 cm, good contrast	Wayfinding system with character size below 7.5 cm	No guidance, always possible with assistance
Tactile guidance system	TWSI with at least 50% colour contrast. Palpable, no gaps, continous. Further guidance	TWSI with at least 30% colour contrast. Palpable, contious, further guidance (gaps in some areas - potential for optimisation)	TWSI without sufficient colour contrast. Not palpable. Always possible with assistance	
Loudspeaker	Subjectively well understandable sound even at full operating noise level	Good sound system	Poor sound system	No loudspeaker
Stairs	Stair treads marked with high contrast without gaps	Stair treads marked with high contrast without gaps	Gaps or other deficiencies in the marking of stair treads	No marking
Handrails for stairs	Handrail with min. 50% colour contrast. Continuous without edges.	Handrail with min. 30% colour contrast. Continuous without edges.	Handrails without sufficient colour contrast. Always possible with assistance	No handrails
Elevators	Voice announcements with floor announcement. Contrasting tactile operating elements. Including emergency call	Voice announcements with floor announcement. Tactile operating elements. Lack of contrast. Including emergency calls	Without voice announcements. No tactile operating elements and no contrast. Including emergency call	Always possible with assistance
Escalators	Good marking of stair treads	No marking of stair treads but colour contrast between tread and riser	Always possible with assistance	
Safety line along the platform edge	Colour contrast at least 50%. Continuous without gaps	Colour contrast at least 30%. Continuous without gaps	Without sufficient colour contrast	Always possible with assistance
Glass portals	Glass portal with sufficiently high and contrasting plinth or glass marking	Glass portal with sufficiently high and contrasting plinth or glass marking	Always possible with assistance	

Table 33: Inspection criteria visually impaired people - Passages LS (based on BMK and FFG 2008)

Inspection criteria for visually impaired people - Area: Access platform (LS)				
Visually impaired people	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Visual guidance system	Wayfinding system with character size ≥ 10 cm, good contrast, pictograms, clear design	Wayfinding system with character size 7.5 - 10 cm, good contrast	Wayfinding system with character size below 7.5 cm	No guidance, always possible with assistance
Tactile guidance system	TWSI with at least 50% colour contrast. Palpable, no gaps, continous. Further guidance	TWSI with at least 30% colour contrast. Palpable, continous, further guidance (gaps in some areas - potential for optimisation)	TWSI without sufficient colour contrast. Not palpable. Always possible with assistance	
Loudspeaker	Subjectively well understandable sound even at full operating noise level	Good sound system	Poor sound system	No loudspeaker
Stairs	Stair treads marked with high contrast without gaps	Stair treads marked with high contrast without gaps	Gaps or other deficiencies in the marking of stair treads	No marking
Handrails for stairs	Handrail with min. 50% colour contrast. Continuous without edges.	Handrail with min. 30% colour contrast. Continuous without edges.	Handrails without sufficient colour contrast. Always possible with assistance	No handrails
Elevators	Voice announcements with floor announcement. Contrasting tactile operating elements. Including emergency call	Voice announcements with floor announcement. Tactile operating elements. Lack of contrast. Including emergency calls	Without voice announcements. No tactile operating elements and no contrast. Including emergency call	Always possible with assistance
Escalators	Good marking of stair treads	No marking of stair treads but colour contrast between tread and riser	Always possible with assistance	
Safety line along the platform edge	Colour contrast at least 50%. Continuous without gaps	Colour contrast at least 30%. Continuous without gaps	Without sufficient colour contrast	Always possible with assistance
Glass portals	Glass portal with sufficiently high and contrasting plinth or glass marking	Glass portal with sufficiently high and contrasting plinth or glass marking	Always possible with assistance	

Table 34: Inspection criteria visually impaired people - Platforms LS (based on BMK and FFG 2008)

Inspection criteria for visually impaired people - Area: Platforms (LS)				
Visually impaired people	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Visual guidance system	Wayfinding system with character size ≥ 10 cm, good contrast, pictograms, clear design	Wayfinding system with character size 7.5 - 10 cm, good contrast	Wayfinding system with character size below 7.5 cm	No guidance, always possible with assistance
Tactile guidance system	TWSI with at least 50% colour contrast. Palpable, no gaps, continous. Further guidance	TWSI with at least 30% colour contrast. Palpable, contious, further guidance (gaps in some areas - potential for optimisation)	TWSI without sufficient colour contrast. Not palpable. Always possible with assistance	
Loudspeaker	Subjectively well understandable sound even at full operating noise level	Good sound system	Poor sound system	No loudspeaker
Stairs	Stair treads marked with high contrast without gaps	Stair treads marked with high contrast without gaps	Gaps or other deficiencies in the marking of stair treads	No marking
Handrails for stairs	Handrail with min. 50% colour contrast. Continuous without edges.	Handrail with min. 30% colour contrast. Continuous without edges.	Handrails without sufficient colour contrast. Always possible with assistance	No handrails
Elevators	Voice announcements with floor announcement. Contrasting tactile operating elements. Including emergency call	Voice announcements with floor announcement. Tactile operating elements. Lack of contrast. Including emergency calls	Without voice announcements. No tactile operating elements and no contrast. Including emergency call	Always possible with assistance
Escalators	Good marking of stair treads	No marking of stair treads but colour contrast between tread and riser	Always possible with assistance	
Safety line along the platform edge	Colour contrast at least 50%. Continuous without gaps	Colour contrast at least 30%. Continuous without gaps	Without sufficient colour contrast	Always possible with assistance
Glass portals	Glass portal with sufficiently high and contrasting plinth or glass marking	Glass portal with sufficiently high and contrasting plinth or glass marking	Always possible with assistance	

Table 35: Inspection criteria blind people - Entrance area LS (based on BMK and FFG 2008)

Inspection criteria for blind people - General criteria for all areas (LS)				
Blind people	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Floor conditions	Sufficient roughness of the surface	Sufficient roughness of the surface	Uneven floor, unmarked individual steps	Unpaved station area, slippery flooring, risk of tripping, risk of black ice
Orientation, findability of areas	TWSI line to the entry area or further guidance	TWSI line to the entry area or further guidance	Always possible with assistance	
Accessibility to the buildings and the vehicle	Free entrance and exit, clear width and height of the pathway must be kept free	Free entrance and exit, clear width and height of the pathway must be kept free	Bulky obstacles in the entry area (sporadic)	Bulky obstacles throughout the area
Inspection criteria for blind people - Area: Entrance building				
Tactile guidance system *)	TWSI well palpable, continuous. No gaps, further guidance	TWSI well palpable, partial gaps. Potential for optimisation in some areas	TWSI not palpable. Alwas possible with assistance	
***) at simple entrance buildings**	With TWSI	Even without TWSI if continuing guidance is sufficient		
Loudspeaker	Subjectively well understandable sound system even at full operating noise level	Good sound system	Poor sound system	No sound system
Handrails for stairs	Handrails on both sides. Continuous without edges	Handrails on both sides. Continuous without edges	Handrails one sided	No handrails
Tactile handrail information (THI) - see comment in footnote 1				
Elevators	Voice announcements with floor announcement. Contrasting tactile operating elements. Including emergency call	Voice announcements with floor announcement. Tactile operating elements. Lack of contrast. Including emergency calls	Without voice announcements. No tactile operating elements and no contrast. Including emergency call	Always possible with assistance
Escalators during maintenance	Protection against the risk of falling	Protection against the risk of falling	Always possible with assistance	
Tactile safety line along the platform edge	Continuous without gaps (Manhole covers bridge gaps)	Continuous without gaps (Manhole covers bridge gaps)	No tactile safety line. Always possible with assistance	
Footnote: The following categories are no evaluation criteria				
THI in the traffic flow for escalators or staircases in areas with "rush hour"	Inappropriate - barrier to the traffic flow		Always possible with assistance	
THI in calmer areas (in front of elevators)	Appropriate for verifying location if the traffic flow is not impeded		Always possible with assistance	

Table 36: Inspection criteria blind people - Passages LS (based on BMK and FFG 2008)

Inspection criteria for blind people - Area: Access platform (LS)				
Blinde people	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Tactile guidance system	TWSI well palpable, continuous. No gaps, further guidance	TWSI well palpable, partial gaps. Potential for optimisation in some areas	TWSI not palpable. Alwas possible with assistance	
Loudspeaker	Subjectively well understandable sound system even at full operating noise level	Good sound system	Poor sound system	No sound system
Handrails for stairs	Handrails on both sides. Continuous without edges	Handrails on both sides. Continuous without edges	Handrails one sided	No handrails
Tactile handrail information (THI) - see comment in footnote 1				
Elevators	Voice announcements with floor announcement. Contrasting tactile operating elements. Including emergency call	Voice announcements with floor announcement. Tactile operating elements. Lack of contrast. Including emergency calls	Without voice announcements. No tactile operating elements and no contrast. Including emergency call	Always possible with assistance
Escalators during maintenance	Protection against the risk of falling	Protection against the risk of falling	Always possible with assistance	
Tactile safety line along the platform edge	Continuous without gaps (Manhole covers bridge gaps)	Continuous without gaps (Manhole covers bridge gaps)	No tactile safety line. Always possible with assistance	
Footnote: The following categories are no evaluation criteria				
THI in the traffic flow for escalators or staircases in areas with "rush hour"	Inappropriate - barrier to the traffic flow		Always possible with assistance	
THI in calmer areas (in front of elevators)			Always possible with assistance	

Table 37: Inspection criteria blind people - Platforms LS (based on BMK and FFG 2008)

Inspection criteria for blind people - Area: Platforms (LS)				
Blinde people	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Tactile guidance system *)	TWSI well palpable, continuous. No gaps, further guidance	TWSI well palpable, partial gaps. Potential for optimisation in some areas	TWSI not palpable. Alwas possible with assistance	
Loudspeaker	Subjectively well understandable sound system even at full operating noise level	Good sound system	Poor sound system	No sound system
Handrails for stairs	Handrails on both sides. Continuous without edges	Handrails on both sides. Continuous without edges	Handrails one sided	No handrails
Tactile handrail information (THI) - see comment in footnote 1				
Elevators	Voice announcements with floor announcement. Contrasting tactile operating elements. Including emergency call	Voice announcements with floor announcement. Tactile operating elements. Lack of contrast. Including emergency calls	Without voice announcements. No tactile operating elements and no contrast. Including emergency call	Always possible with assistance
Escalators during maintenance	Protection against the risk of falling	Protection against the risk of falling	Always possible with assistance	
Tactile safety line along the platform edge	Continuous without gaps (Manhole covers bridge gaps)	Continuous without gaps (Manhole covers bridge gaps)	No tactile safety line. Always possible with assistance	
Footnote 1: The following categories are no evaluation criteria				
THI in the traffic flow for escalators or staircases in areas with "rush hour"	Inappropriate - barrier to the traffic flow		Always possible with assistance	
THI in calmer areas (in front of elevators)	Appropriate for verifying location if the traffic flow is not impeded		Always possible with assistance	

Positive criteria for hard-of-hearing and deaf people

For hard-of-hearing and deaf people, the best-rated criteria are the visual guidance system and the illumination at the station.

Improvable criteria for hard-of-hearing people

Since there is no helpdesk at the station, an audio induction loop at a helpdesk cannot be provided. This results in a rating of "4". Information about the criteria rating in different areas of the station for hard-of-hearing people can be found in Table 38, Table 39, and Table 40.

Improvable criteria for deaf people

Due to the lack of a helpdesk, staff who knows sign language is not available. This results in a rating of "4" in all areas. Information about the criteria rating in different station areas for deaf people can be found in Table 38, Table 39, and Table 40.

Table 38: Inspection criteria hard-of-hearing and deaf people - Entrance area LS (based on BMK and FFG 2008)

Inspection criteria for hearing impaired people - Area: Entrance building (LS)				
Hearing impaired people	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Visual guidance system	Wayfinding system with character size ≥ 10 cm, good contrast, pictograms, clear design	Wayfinding system with character size 7.5 - 10 cm, good contrast	Wayfinding system with character size below 7.5 cm	No guidance, always possible with assistance
Audio induction loop at the helpdesk	Available, direct voice contact possible	Available, voice contact only possible through a glass pane	Not available, voice contact possible through a glass pane	Always possible with assistance
Loudspeaker	Subjectively well understandable sound system even at full operating noise level	Good sound system	Poor sound system	No sound system
Illumination	Optimal illumination	Good illumination	Poor illumination	Not adequately illuminated
Deaf people	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Visual guidance system	Wayfinding system with character size ≥ 10 cm, good contrast, pictograms, clear design	Wayfinding system with character size 7.5 - 10 cm, good contrast	Wayfinding system with character size below 7.5 cm	Always possible with assistance, no guidance
Sign language competence at the helpdesk	Available	Available on request	Not available	Not available
Illumination	Optimal illumination	Good illumination	Poor illumination	Not adequately illuminated

Table 39: Inspection criteria hard-of-hearing and deaf people - Passages LS (based on BMK and FFG 2008)

Inspection criteria for hearing impaired people - Area: Access platform (LS)				
Hearing impaired people	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Visual guidance system	Wayfinding system with character size ≥ 10 cm, good contrast, pictograms, clear design	Wayfinding system with character size 7.5 - 10 cm, good contrast	Wayfinding system with character size below 7.5 cm	No guidance, always possible with assistance
Audio induction loop at the helpdesk	Available, direct voice contact possible	Available, voice contact only possible through a glass pane	Not available, voice contact possible through a glass pane	Always possible with assistance
Loudspeaker	Subjectively well understandable sound even at full operating noise level	Good sound system	Poor sound system	No sound system
Illumination	Optimal illumination	Good illumination	Poor illumination	Not adequately illuminated
Deaf people	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Visual guidance system	Wayfinding system with character size ≥ 10 cm, good contrast, pictograms, clear design	Wayfinding system with character size 7.5 - 10 cm, good contrast	Wayfinding system with character size below 7.5 cm	Always possible with assistance, no guidance
Sign language competence at the helpdesk	Available	Available on request	Not available	Not available
Illumination	Optimal illumination	Good illumination	Poor illumination	Not adequately illuminated

Table 40: Inspection criteria hard-of-hearing and deaf people - Platforms LS (based on BMK and FFG 2008)

Inspection criteria for hearing impaired people - Area: Platforms (LS)				
Hearing impaired people	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Visual guidance system	Wayfinding system with character size ≥ 10 cm, good contrast, pictograms, clear design	Wayfinding system with character size 7.5 - 10 cm, good contrast	Wayfinding system with character size below 7.5 cm	No guidance, always possible with assistance
Audio induction loop at the helpdesk	Available, direct voice contact possible	Available, voice contact only possible through a glass pane	Not available, voice contact possible through a glass pane	Always possible with assistance
Loudspeaker	Subjectively well understandable sound even at full operating noise level	Good sound system	Poor sound system	No sound system
Illumination	Optimal illumination	Good illumination	Poor illumination	Not adequately illuminated
Deaf people	**(1) Without assistance**	**(2) Largely usable without assistance**	**(3) With assistance**	**(4) Highly deficient**
Visual guidance system	Wayfinding system with character size ≥ 10 cm, good contrast, pictograms, clear design	Wayfinding system with character size 7.5 - 10 cm, good contrast	Wayfinding system with character size below 7.5 cm	Always possible with assistance, no guidance
Sign language competence at the helpdesk	Available	Available on request	Not available	Not available
Illumination	Optimal illumination	Good illumination	Poor illumination	Not adequately illuminated

Evaluation catalog

The evaluation catalog shows a rating of 66. Inside the Viennese station, most deficiencies were revealed for vision and hearing impaired people. However, the rating for the mobility-impaired group of people could also be improved. Some ratings of "4" for visually impaired, blind, hard-of-hearing, and deaf people lead to subtotals of "12" per group. A missing help desk and temporary construction work at the station lead to these outcomes. Due to only one elevator per platform and an insufficient height of operating elements, mobility-impaired people face issues in this station.

Table 41: Evaluation Catalog - Längenfeldgasse Station (based on BMK and FFG 2008)

Station Längenfeldgasse Barrier-free travel chain					Construction year 1987
		Entrance Building	**Passage(s) / Access Platform**	**Platform(s)**	**SUM**
Mobility	**Walking impaired**	3	3	3	9
	Wheelchair users	3	3	3	9
Vision	**Vision impaired**	4	4	4	12
	Blind	4	4	4	12
Hearing	**Hearing impaired**	4	4	4	12
	Deaf	4	4	4	12
	SUM	22	22	22	66

Catalog of measures

The catalog of measures for Längenfeldgasse station shows a good perspective for future ratings if adaptions inside the station are implemented. Fewer changes than in Frederiksberg station would be necessary to provide a barrier-free trip chain for all user groups in all station areas according to the MofA evaluation tool. Due to construction work in the entrance buildings, temporary limitations of the tactile guidance system were given. This deficiency of the station will be eliminated by the end of April 2023 (personal communication DI Meysner, March 15, 2023). Other deficiencies of TWSIs are part of the optimization potential. Furthermore, changes concerning voice announcements, operating elements, and the number of elevators could improve the rating. A photo documentation of the station based on pictures taken March 5, April 23 and June 2, 2023 can be found in "Photo documentation - Längenfeldgasse station" on page 158.

Table 42: Catalog of measures - Frederiksberg station (based on BMK and FFG 2008)

Wiener Linien - Catalog of measures			Längenfeldgasse station		
Location	**Level**	**Optimization potential**	**Figure**	**Evaluation**	**Perspective**
Entrance Building					
	L0	Audio induction loop at a helpdesk, direct voice contact possible	-	4	1
	L0	Sign language competence at a helpdesk	-	4	1
Entrance building Storchensteg	L0	TWSI gaps to entrance building	Figure 155 Figure 156	3	1
Entrance building Längenfeldgasse	L0	TWSI to entrance building	Figure 155	3	1
Both entrance buildings inside	L0	TWSI gaps and bulky obstacles	Figure 158	3	1
Elevators	L0 to L-2	Voice announcements, operating elements, number of elevators	-	3	1
Passages / Access platform					
Escalators	L-1	Escalators during maintenance	-	3	1
Stairs	L-1	Handrail contrast	Figure 164	2	1
Platforms					
Platform 1 and 2	L-2	Loudspeaker	-	4	1

4.3 Elevator details at Frederiksberg station

Figure 10 shows the labeling of all four elevators at Frederiksberg station. E1 and E2 are the elevators leading to platform M1/M2, and E3 and E4 are the elevators leading to platform M3. All four elevators at Frederiksberg station are different from each other, although the ones on platform M3 are rather similar. Those two are located in the newer part of the station and are better equipped regarding readability, visibility, and palpability. E4 seemed to have English floor announcements regularly, whereas E3 seemed to have some irregularities. Both elevators have constant audible Danish information, and the operating elements are at an angle for better usability. The elevators in the older part of the station have audible Danish information but neither English announcements nor English floor announcements; the numbers inside the elevators are recessed; on the outside, the buttons do not contrast with the surrounding surface. Measurements for the controls were taken from the center of a button. Emergency calls are available in all four elevators. More detailed information can be found in Table 43 and Table 44.

Table 43: Detailed information about elevators E1 and E2

Criteria	E1	E2
Announcement English	Unavailable	Unavailable
Floor announcement English	Unavailable	Unavailable
Announcement Danish	Available	Available
Floor announcement Danish	Available only when going up	Available
Operating elements inside	Braille unavailable Numbers are recessed	Braille available Numbers are recessed
Operating elements outside	Braille unavailable No additional information, plain button recessed	Braille unavailable No additional information, plain button recessed
Operating elements contrast inside	Numbers clear Emergency clear Buttons light up white when pressed	Numbers not clear, Emergency lacks contrast Buttons light up red when pressed
Operating elements contrast outside	Unavailable	Unavailable
Height operating elements inside	100 cm - 110 cm	100,5 cm - 104,5 cm
Height operating elements outside	105 cm	110 cm
Emergency call	Available	Available

Table 44: Detailed information about elevators E3 and E4

Criteria	E3	E4
Announcement English	Available	Available
Floor announcement English	Not always available	Available
Announcement Danish	Available	Available
Floor announcement Danish	Not always available	Available
Operating elements inside	Inclined controls Braille available Numbers are raised	Inclined controls Braille available Numbers are raised
Operating elements outside	Arrow raised Button flat	Arrow raised Button flat
Operating elements contrast inside	Numbers clear Emergency yellow contrast Buttons light up white when pressed	Numbers clear Emergency yellow contrast Buttons light up white when pressed
Operating elements contrast outside	Arrow with contrast Button without contrast	Arrow with contrast Button without contrast
Height operating elements inside	106 cm - 115 cm	106 cm - 115 cm
Height operating elements outside	102 cm	102 cm
Emergency call	Available	Available

4.4 Elevator details at Längenfeldgasse station

Figure 11 shows the location of the two elevators at Längenfeldgasse station. One elevator per platform was available. E5 had announcements in German; E6 neither had English nor German announcements at the time of research. Braille is unavailable on any operating elements; however, numbers and arrows are raised for palpability. The height of operating elements ranged from approximately 82.5 cm to 110.5 cm. Measurements were taken from the center of a button. Emergency calls were available in E5 and E6.

Table 45: Detailed information about elevators E5 and E6

Criteria	E5	E6
Announcement English	Not available	Not available
Floor announcement English	Not available	Not available

Announcement German	Available	Not available
Floor announcement German	Available	Not available
Operating elements inside (braille, numbers palpable)	Braille not available Arrows are raised	Braille not available Arrows are raised
Operating elements outside	Braille not available Arrows are raised	Braille not available Arrows are raised
Operating elements contrast inside	Arrows bright on dark ground	Arrows bright on dark ground
Operating elements contrast outside	Arrows bright on dark ground	Arrows bright on dark ground
Height operating elements inside	82,5 cm - 110,5 cm	82,5 cm - 110,5 cm
Height operating elements outside	85 cm	85 cm
Emergency call	Available	Available

4.5 Results go-along

At Frederiksberg station, the go-alongs were conducted in English in July 2022; at Längenfeldgasse station, they were conducted in March 2023 in german language and then translated into English by the researcher. The paths of the participants and the duration varied in the end since each participant had different needs and preferences for entering, exiting, and moving through the station. The results are as individual as each person and their degree of disability but provide a detailed overview of their specific needs. Some people shared insights without being asked, and some waited for questions to be asked. Only comments related to the built environment of Frederiksberg station and Längenfeldgasse station could be considered in this analysis not to exceed the extent of this work.

4.5.1 Go-alongs at Frederiksberg station in Copenhagen

Changes were made inside the station in Frederiksberg station after the MofA tool was applied on May 10, 2022. Due to this fact, not all comments by participants were photo-documented. Between May and July 2022 floor markings on the concourse level were removed, and advertisements were attached at the glass portals on platform M1/M2.

Participant 1

The first participant at Frederiksberg station was female, 75 years old, and the walk lasted one hour and 26 minutes. During the July 6, 2022 interview, she stated that she was waiting for a hearing aid and an eye operation since she had a problem recognizing contrast. Sometimes she uses a walking stick, but not at the time of research. She uses Frederiksberg station more than once a day and therefore knows the station very well. The elevators are more accessible for her

to use than the escalators. The talk with her was a lot about lighting and the feeling of safety.

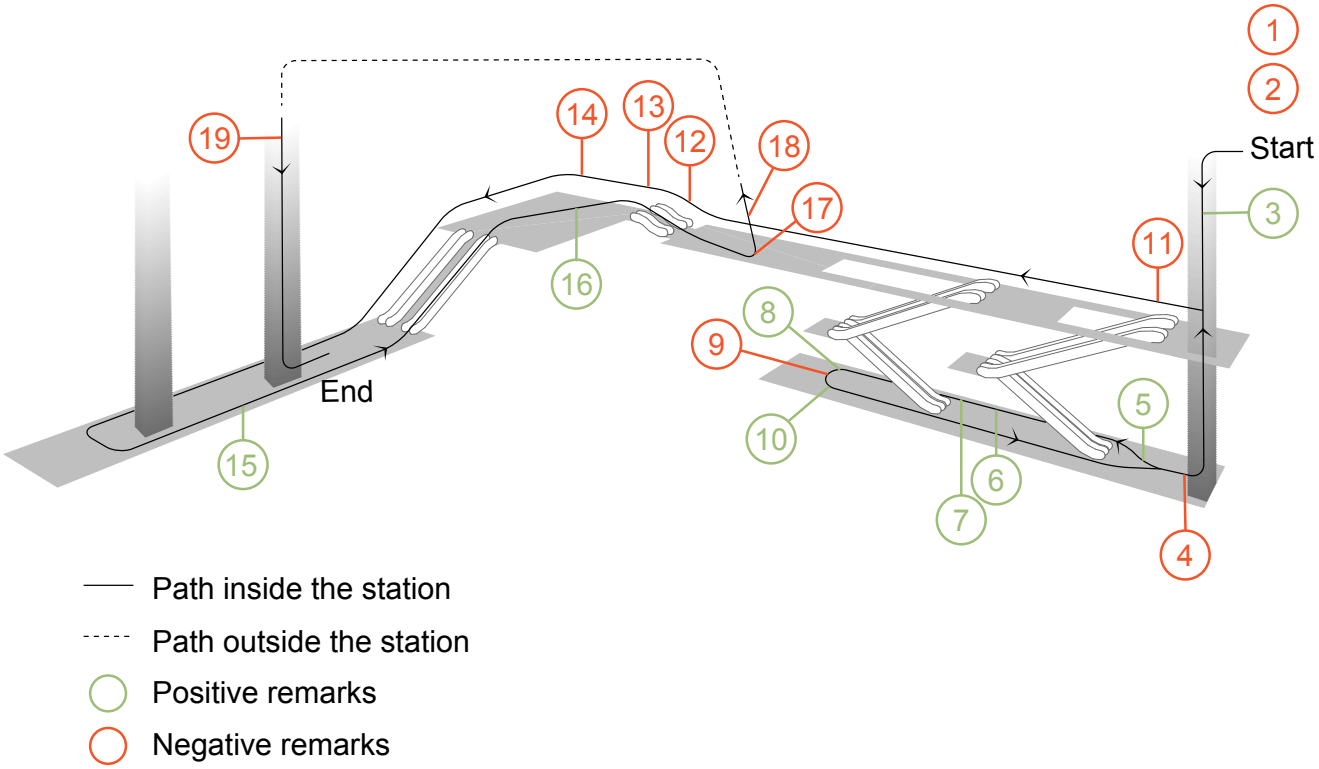


Figure 12: Participant 1 - Go-along at FS (adapted from Bischler et al. 2022)

1 This entrance is too dark during the night.

Figure 13: Entrance Sylows Allé on the outside

2 Her sight problems became evident when standing in front of escalators. „I would prefer if there was a yellow line. For me, it [the escalators] is just grey, grey, grey.“

3 The buttons were visible enough inside the elevator.

Figure 14: Operating elements inside E3 and E4

4 A map of the metro system beside the elevators would be desirable.

Figure 15: Elevators on platform M3

5 The loudspeaker inside the station was good enough for her to understand.

6 Tactile walking surface indicators were easy to step on.

Figure 16: TWSI on platform M3

7 The monitors were well-readable.

Figure 17: Exemplary monitor on platform M1/M2

8 Glass portals on platforms were recognizable as such.

Figure 18: Glass portals on platform M3

9 More leaning options would be desirable.

Figure 19: Leaning options on platform M3

10 The map on the wall was well-readable, although it could be more modern and digitalized.

Figure 20: Map on platform M3

11 She would prefer to have the temporary floor markings back.

Figure 21: Temporary floor markings on passage level

12 Better marking of stairs would be desirable.

Figure 22: Stair marking on passage level

13 At this point, it was hard to orient. The next map would need to be closer.

14 Defined exit names would be desirable.

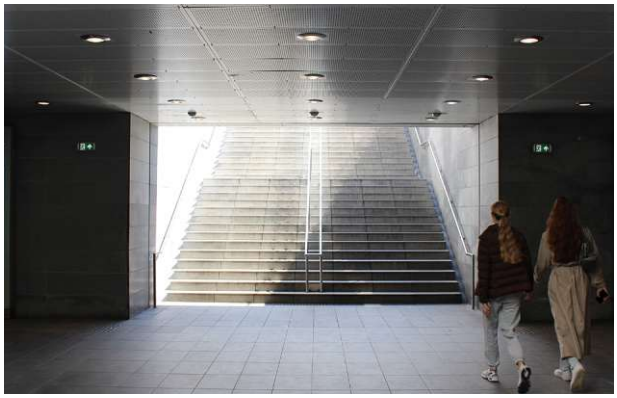


Figure 23: Example undefined exit

15 She would appreciate having staff at the station in extraordinary situations.

16 The surface of the floor was generally rough enough.

17 This entrance seemed unsafe to her. Therefore, she would never use it.

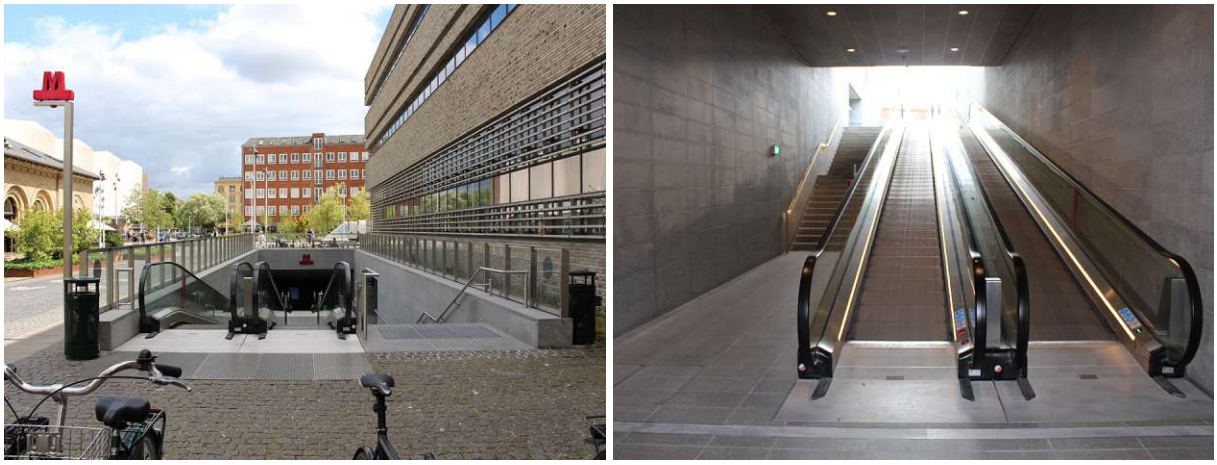


Figure 24: Entrance Solbjergvej

18 The moving walkway felt more comfortable than escalators, but lacked proper marking.

19 Another color for the buttons outside the elevator would be desirable.

Figure 25: Exemplary operating element outside E1 on platform M1/M2

Participant 2

Participant two was male, 73 years old, and the walk lasted 28 minutes on July 7, 2022. He had vision impairment; the sharpness in his left eye was non-existent. Nevertheless, he relied on his remaining eyesight and did not use braille. The participant passes Frederiksberg once a year. He appreciates using the metro and adds that there are no times he would avoid using it. The researcher had to accompany him to the correct meeting place since it was hard to find without help. Usually, he uses the stairs, but they are difficult for him.

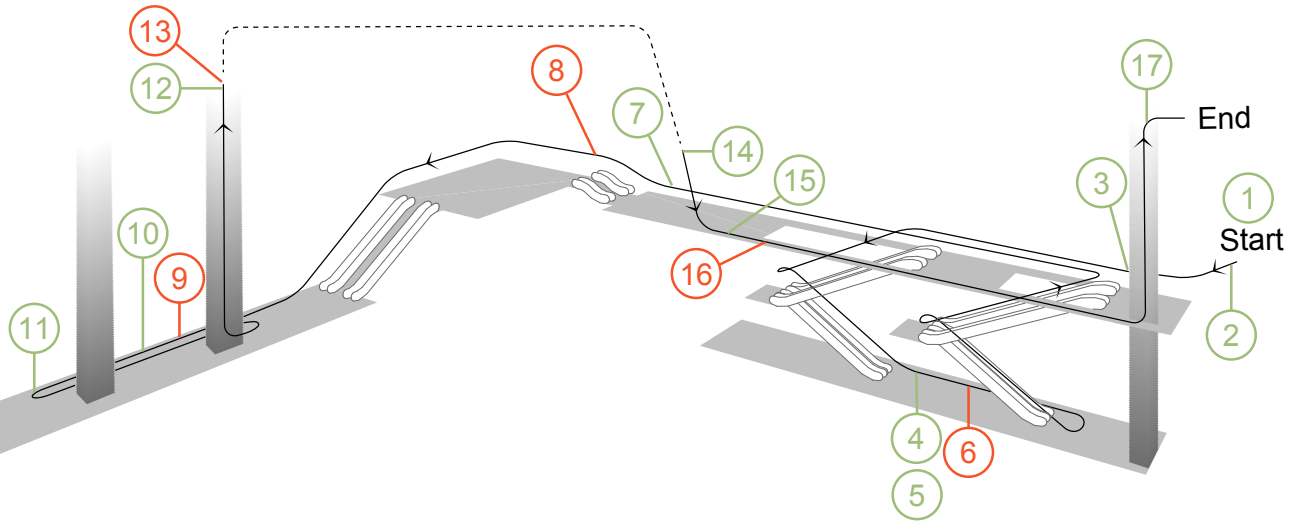


Figure 26: Participant 2 - Go-along at FS (adapted from Bischler et al. 2022)

1 The illumination was good at that time and day; it was not so bright outside. "The change in lights is often a problem, from outside to inside [...] on a clear day with lots of sunshine, it might be a problem."

Figure 27: Entrance Sylows Allé on the outside

2 The escalators were fine, as was the height of the handrails.

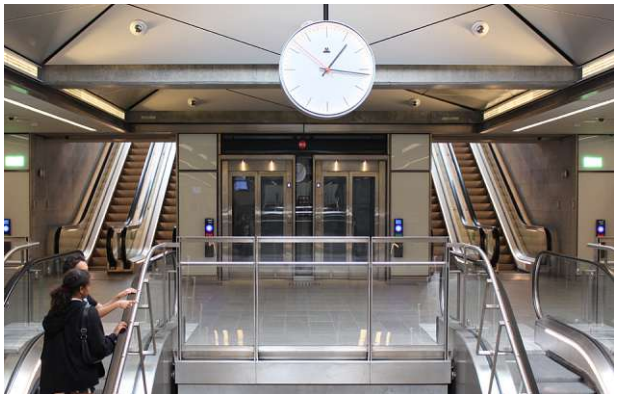


Figure 28: Entrance Sylows Allé from the inside

3 The overview map is considered easy to read.

Figure 29: Map on passage level

4 The lighting at this location was good.

5 Monitors were used for orientation.

Figure 30: Exemplary monitor on platform M1/M2

6 Platform numbers were never recognized before, neither on the wall nor the floor.

Figure 31: Platform number on platform M3

7 The monitor was big enough and easy to read (Figure 30).

8 "Stairs are a problem." Due to the lack of recognition of stair markings, the escalator was taken instead.

Figure 32: Stair marking on passage level

9 The flags showing platform numbers were not used.

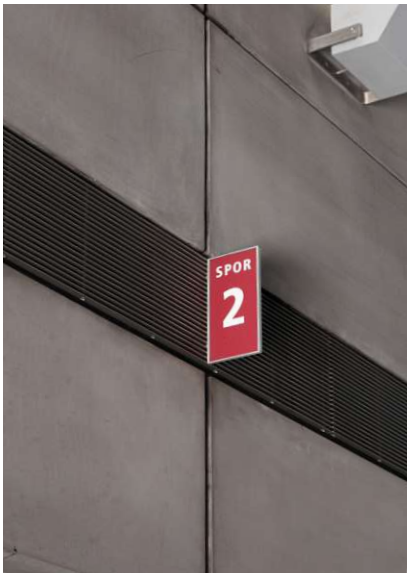


Figure 33: Platform number on platform M1/M2

10 White markings on the floor showed him where to stand; they indicated where the door would open.

Figure 34: Floor markings on platform M3

11 The contrast of handrails at the stairs was good. He knew the handrails were there; thus, he focused on the stairs.

12 The button on the outside of the elevator was perceivable.

Figure 35: Exemplary operating element outside E1 on platform M1/M2

13 Bigger numbers inside the elevator would be desirable. The participant had to bend down to read the numbers.

Figure 36: Operating elements inside E2

14 He could use the moving walkway since the dark and light colors have good contrast to make the starting visible.

Figure 37: Moving walkway entry

15 The surface of the floor was generally rough enough.

16 The glass door would need to be marked differently. It depends significantly on the lighting behind the door if it is perceiveable as a glass door.

Figure 38: Door marking on passage level

17 The arrow on the outside of the elevator was clear. It was easier to see the operating elements inside this elevator than the one before. The participant was fast when pressing buttons and mentioned that the palpable numbers helped with orientation. The loudspeaker was considered loud and clear.

Figure 39: Operating elements inside and outside E3 and E4

Participant 3

The third participant was a 23-year-old male, and the walk with him lasted about 32 minutes on July 7, 2022. He was double-sided hearing impaired and suffered from roughly 80% hearing loss but had normal hearing in the bass area. He did have a hearing aid which helped him understand high voices better. However, he could not hear audio induction loops inside the station. The participant relied a lot on his eyes compared to his ears; proper visual guidance helped him to orient himself. He had never used Frederiksberg station before, and in general, there were no times he would avoid using the metro.

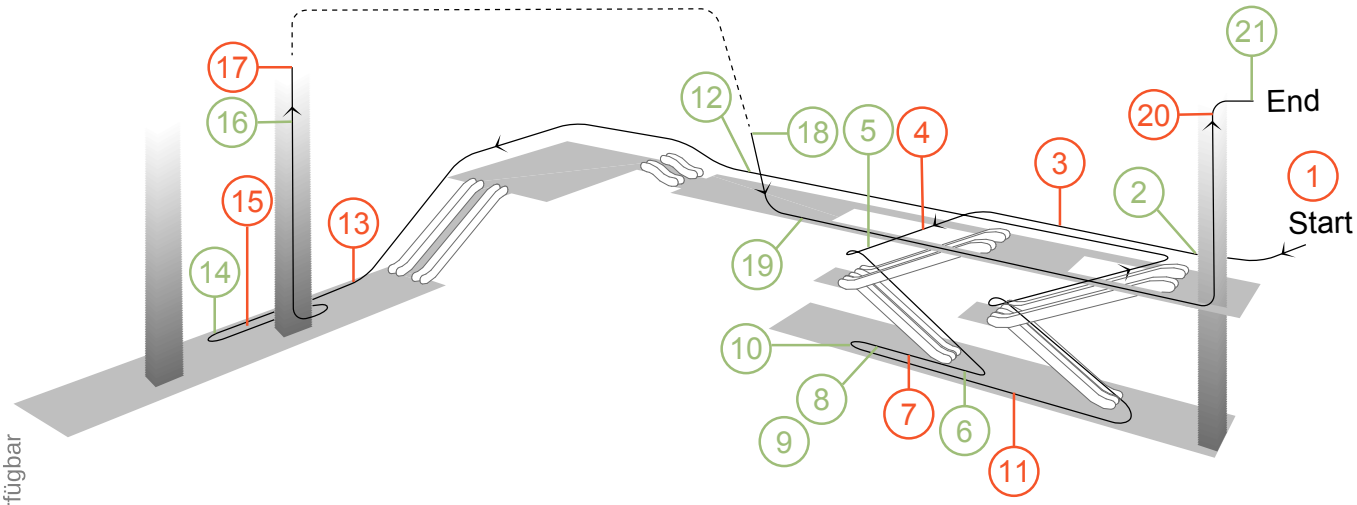


Figure 40: Participant 3 - Go-Along at FS (adapted from Bischler et al. 2022)

1 It was difficult to find this entrance.

Figure 41: Entrance Sylows Allé on the outside

2 The overview map was good.

Figure 42: Map on passage level

3 "I can hear the ventilation, that is a bit annoying."

4 The escalators were considered too narrow.

Figure 43: Escalators on passage level

5 The height of the handrails on the escalators was considered good.

6 The participant would often use monitors for orientation.

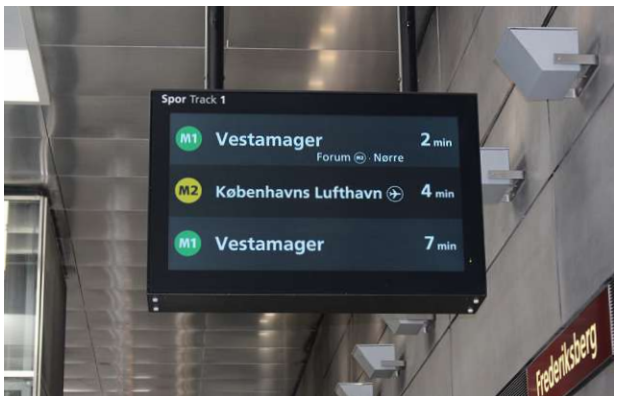


Figure 44: Exemplary monitor on platform M1/M2

7 Platform numbers were not used. "This is the first time I see them."

Figure 45: Platform number on platform M3

8 He used the floor markings to know where to stand.

Figure 46: Floor markings on platform M3

9 He would sometimes lean on the handrails in case the backpack is heavy.

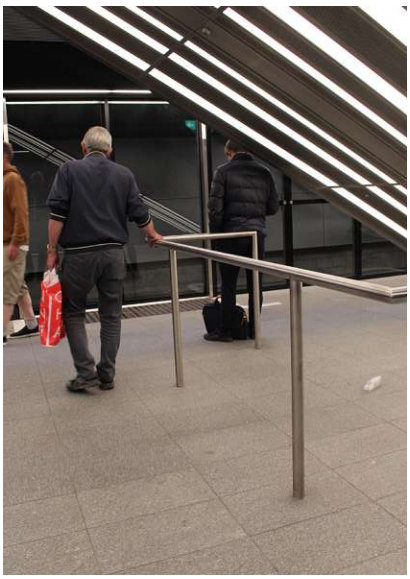


Figure 47: Handrails on platform M3

10 Leaning options on the platform would be used by the participant.

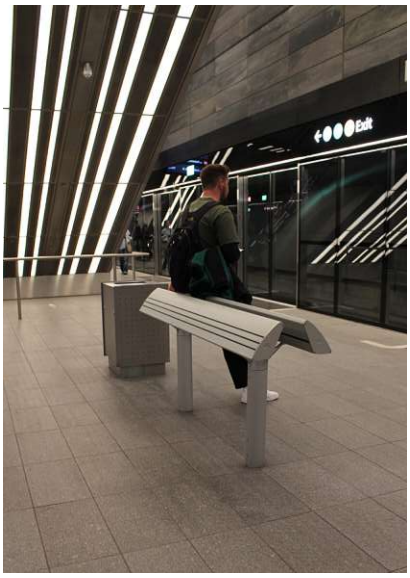


Figure 48: Leaning option on platform M3

11 "The speakers are often quite bad. For me it is just mumbling [...] that might be because we are in a box here, so we echo."

12 The monitor was well-readable.

Figure 49: Monitor on passage level

13 Platform numbers were not used.

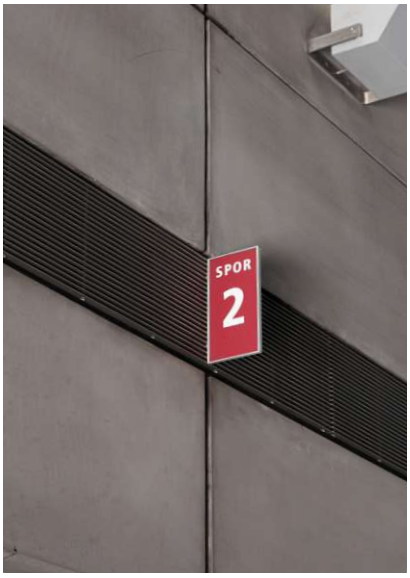


Figure 50: Platform number on platform M1/M2

14 He was able to hear the noise of the closing doors.

15 Loudspeakers were not understandable.

16 The buttons were easy to use inside the elevator.

Figure 51: Operating elements inside E2 on platform M1/M2

17 It was not possible to understand the voice announcement in the elevator.

18 It was possible to use the moving walkway without any problem.

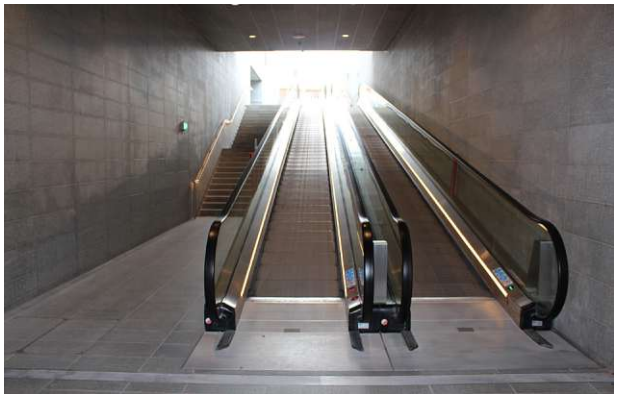


Figure 52: Moving walkway

19 The surface of the floor was generally rough enough.

20 The loudspeakers were better, but he still relies on his eyesight because the voice announcement was not clear enough to understand.

21 In case of unexpected interruptions, he would appreciate having staff at the metro station he can ask for help.

Participant 4

Participant four was a 60-year-old female, and the go-along with her lasted 28 minutes on July 7, 2022. She was walking impaired and used an electric wheelchair. She uses the metro weekly and depends on the functionality of the elevators. The participant emphasized only using the metro when it is essential. When arriving on the platform level, she always takes the first door of the metro.

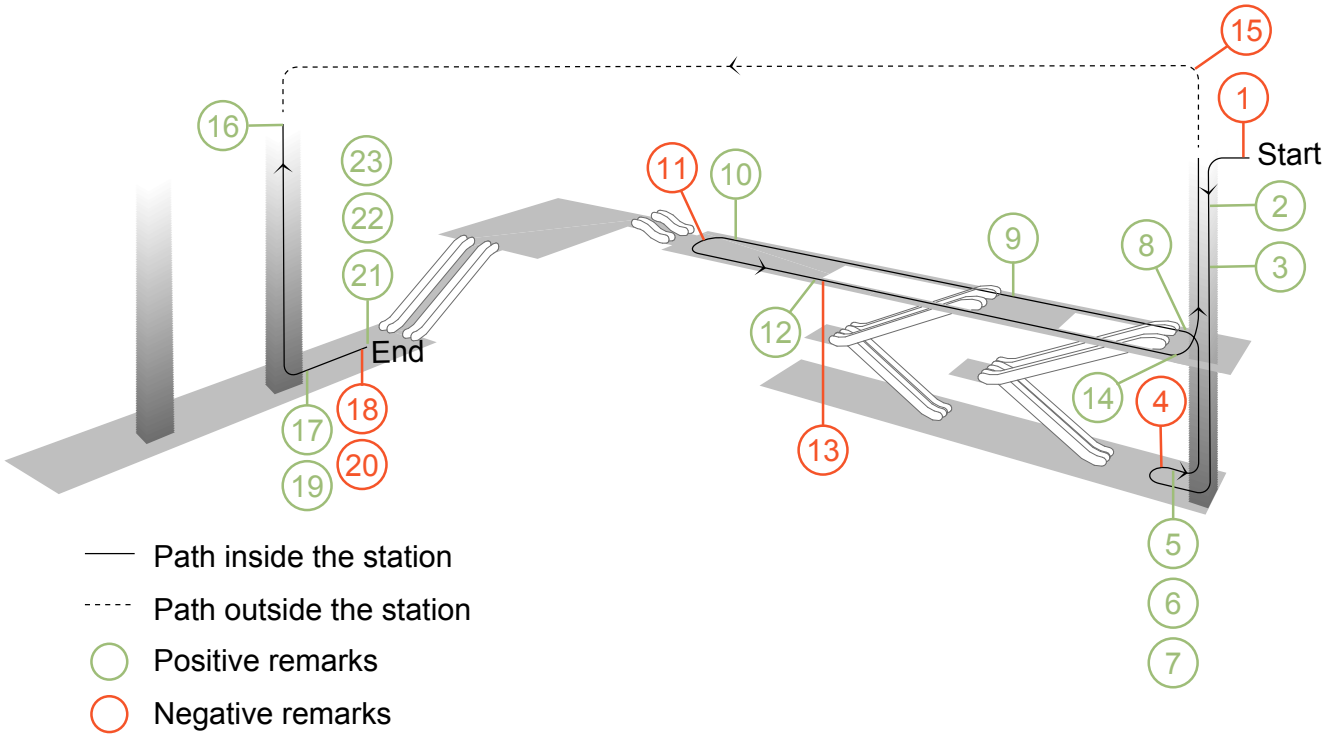


Figure 53: Participant 4 - Go-along at FS (adapted from Bischler et al. 2022)

1 "If I want to contact Metroselskabet, I can't here. I have to go to the train level because there is no point where I can press the yellow button here."

Figure 54: Yellow button on platform M3

2 Buttons on the outside and the inside of the elevator were stated as good to reach.

Figure 55: Operating elements inside and outside E3 and E4

3 Loudspeakers were described as "good" inside the elevators.

4 Platform numbers were not used for orientation.

Figure 56: Platform number on platform M3

5 The monitors were good in terms of readability.

Figure 57: Exemplary monitor on platform M1/M2

6 Glass doors on the platform were considered marked well enough.

Figure 58: Glass doors on platform M3

7 The illumination was good and evoked a feeling of safety.

8 Overview maps were good in terms of readability and design.

Figure 59: Map on passage level

9 Tactile walking surface indicators would not pose a problem for a manual or electric wheelchair.

Figure 60: TWSIs on passage level

10 The monitor was well-readable.

Figure 61: Monitor on passage level

11 "I do not understand why there is no elevator, lift or ramp. When I come in the wheelchair in the winter [...] and when it is raining, this is a problem!"

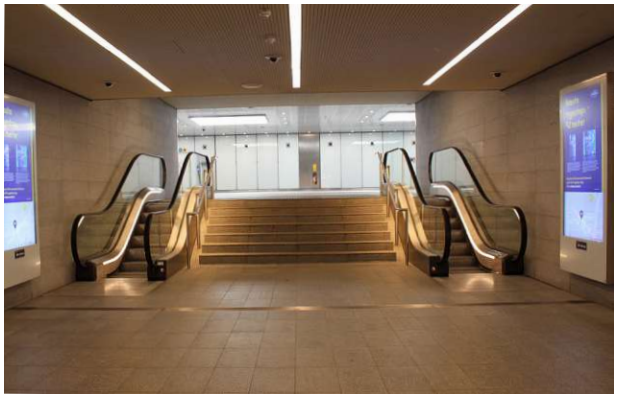


Figure 62: Missing ramp or elevator on passage level

12 The participant would only use the moving walkway if the elevators do not work.

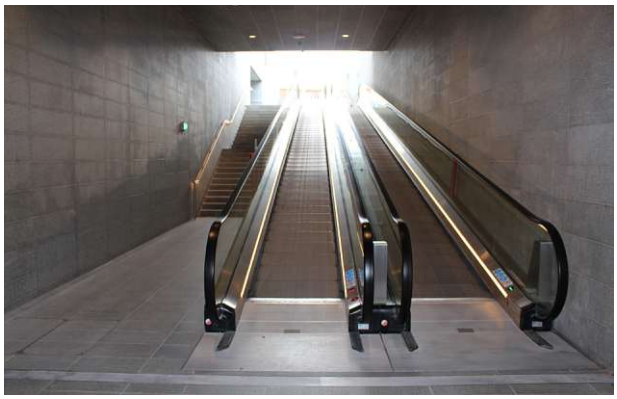


Figure 63: Moving walkway

13 "I cannot see that there is a bicycle."

Figure 64: Door marking on passage level

14 Check-in poles had a proper height.

Figure 65: Check-in pole on passage level

15 When changing platforms, locating the entrance at Sylows Allé would be challenging.

Figure 66: Entrance Sylows Allé on the outside

16 The buttons inside and outside the elevator were comfortable to reach.

Figure 67: Operating elements inside E2 on platform M1/M2

17 Tactile walking surface indicators were easy to pass.

Figure 68: TWSIs on platform M1/M2

18 The gap between the floor and the train would be too big for wheelchairs with small wheels.

19 Concerning staff at the metro station, the participant said, “It could help if I knew they were here, but then I have to be certain.”

20 Platform numbers were not used for orientation.

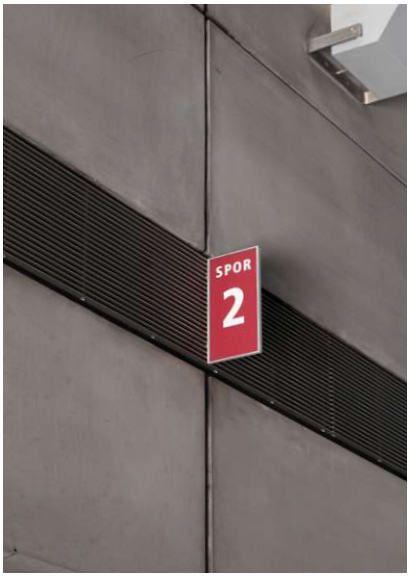


Figure 69: Platform number on platform M1/M2

21 The illumination was good and evoked a feeling of safety.

22 Loudspeakers were clear and understandable.

23 The surface of the floor was generally rough enough.

Participant 5

The fifth participant was a 46-year-old male; the go-along lasted approximately one hour and

23 minutes on July 7, 2022. He stated he is blind or visually impaired, depending on the light. In bright surroundings, he was blind and could not use his eyes for orientation. However, he could use his peripheral vision in dark environments to navigate. During the go-along, he used his extra dark sunglasses beneath another pair of sunglasses; except for the light from above, nothing is perceivable. Additionally, he was asked to keep his eyes closed most of the time while walking through the station; sometimes, he was asked to give feedback about the surroundings or contrast using the vision he had. He often relies on hearing and creates a visual mesh inside his head while walking. The participant used his feet to feel things, called himself a high-contrast user, and usually does not walk very far on the platform level when coming down the escalators. He passes Frederiksberg station every month and uses this station primarily for changing lines. He usually follows the wall unless the light allows him to see. He can not see colors; therefore, grey tactile walking surface indicators made of metal on the grey stone were not perceivable. According to him, having the contrast of black on grey background is better than having white on grey background. He stated it would be best to have a black line with a white outline or vice versa to increase contrast.

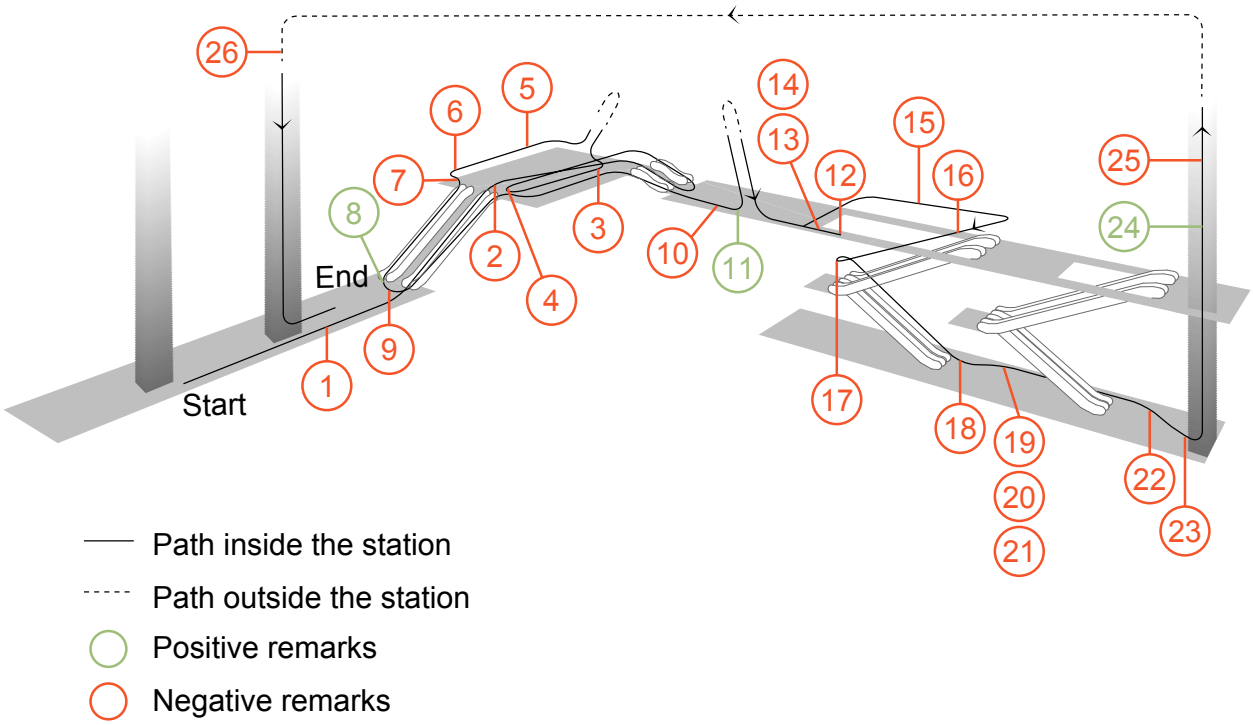


Figure 70: Participant 5 - Go-along at FS (adapted from Bischler et al. 2022)

(1) The problem when using the glass portals on the platform as orientation was that there were people in the way.

Figure 71: Exemplary glass portals as orientation along platform M3

2 The participant could not immediately find the TWSIs since they were not placed straight across the escalator. “The rule is you should not put it [the cane] more out than a little beside your body because if I put it out too much, I hit people.”

Figure 72: Connection TWSIs and escalator on passage level

3 No indicator that led to the right was available. The participant only assumed there was an escalator based on the sound.

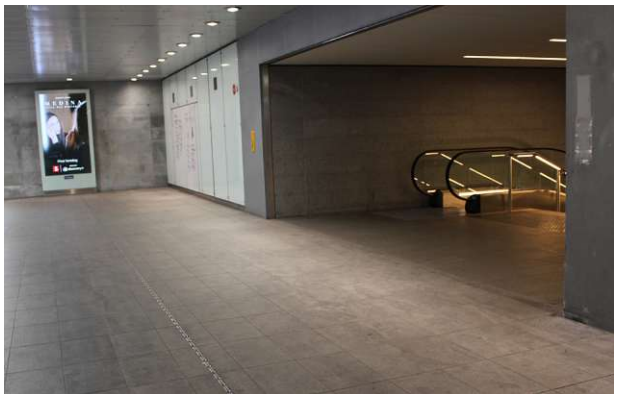


Figure 73: TWSIs missing connection between older and newer parts of the station

4 It would be desirable that the tactile walking surface indicators of both escalators are connected.

5 Metal TWSIs were thin and hard to find. People using them might think it is just an irritation on the floor.

Figure 74: TWSIs in the older part of the station

6 The screen was very close to TWSIs, the participant would prefer one meter distance.

Figure 75: Distance TWSIs and screen

7 The trash can was too close to TWSIs.

Figure 76: Distance TWSIs and trash can

8 The sound was a good indicator when the cane hit the ribbed metal surface in front of the escalators.

Figure 77: Exemplary ribbed metal surface in front of escalators

9 No TWSI connection between the escalators was available.

10 Following the walls led outside again.

11 The moving walkway could be used without any difficulties.

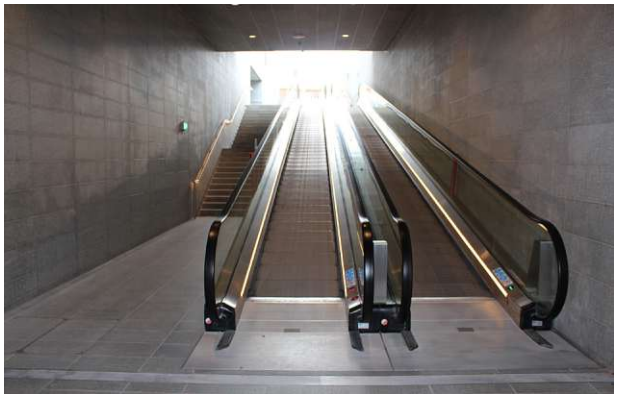


Figure 78: Moving walkway

12 "If people get down here, they could get lost."

13 The participant's cane got trapped behind the doors.

Figure 79: Open door posing an obstacle

14 The frame of the door seemed to be a TWSI; it irritated the participant.

Figure 80: Door frame on the ground

15 The handrail was uncomfortable to use.

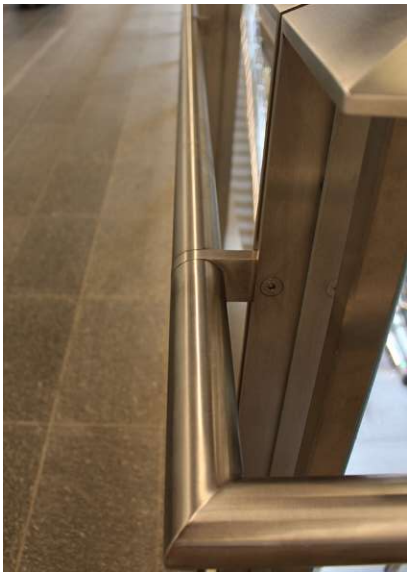


Figure 81: Handrail on passage level

16 The participant's experience was that escalators were not always adequately marked if they were out of order.

17 It needed to be clarified to the participant where to go. Following the walls led to the check-in poles, which were obstacles and caused confusion.

Figure 82: Intermediate level of escalators led to platform M3

18 The loudspeaker on the platform announced the platform but did not indicate a direction.

19 The participant could not see the platform number on the wall with or without glasses. He would only notice the platform number on the floor if he knew it was there.

Figure 83: Platform number on platform M3

20 With opened eyes and one of the two darkening sunglasses, the contrast between the floor and the black floor marking was visible. The white floor marking was rather hard to see.

Figure 84: Floor marking contrasts on platform M3

21 The lights at the entrance doors were blinding.

Figure 85: Lighting next to entrance doors on platform M3

22 There were no TWSIs available leading to the elevators.

23 Finding the button on the outside of the elevator took some time.

Figure 86: Operating elements outside the elevators on platform M3

24 The buttons inside the elevators were raised, which was considered good.

Figure 87: Operating elements inside E3 and E4

25 The bell could be more clear to feel (Figure 87).

26 The buttons on the outside of the elevator were hard to find. The recessed numbers inside the elevator were hard to read and smaller than inside the first elevator. The voice announcement "Døren åbnes" was considered "useless" by the participant.

Figure 88: Exemplary operating element outside E1 and operating elements inside E2 on platform M1/M2

4.5.2 Go-alongs at Längenfeldgasse station in Vienna

Participant 6

The sixth participant was a man with no remaining eyesight. The walk duration with the 68-year-old participant was one hour and 5 minutes on March 6, 2023. He used the station monthly, primarily to change the platform and seldom to get outside the station. The tactile walking surface indicators were essential for his orientation since he used a white cane. He stated that he would use the metro at any time of the day. The only exceptions are major events or construction works in certain stations. Concerning the future metro station of U5, including glass doors at the platform edge, the participant stated this would be appreciated, and glass doors would create a sense of security for him.

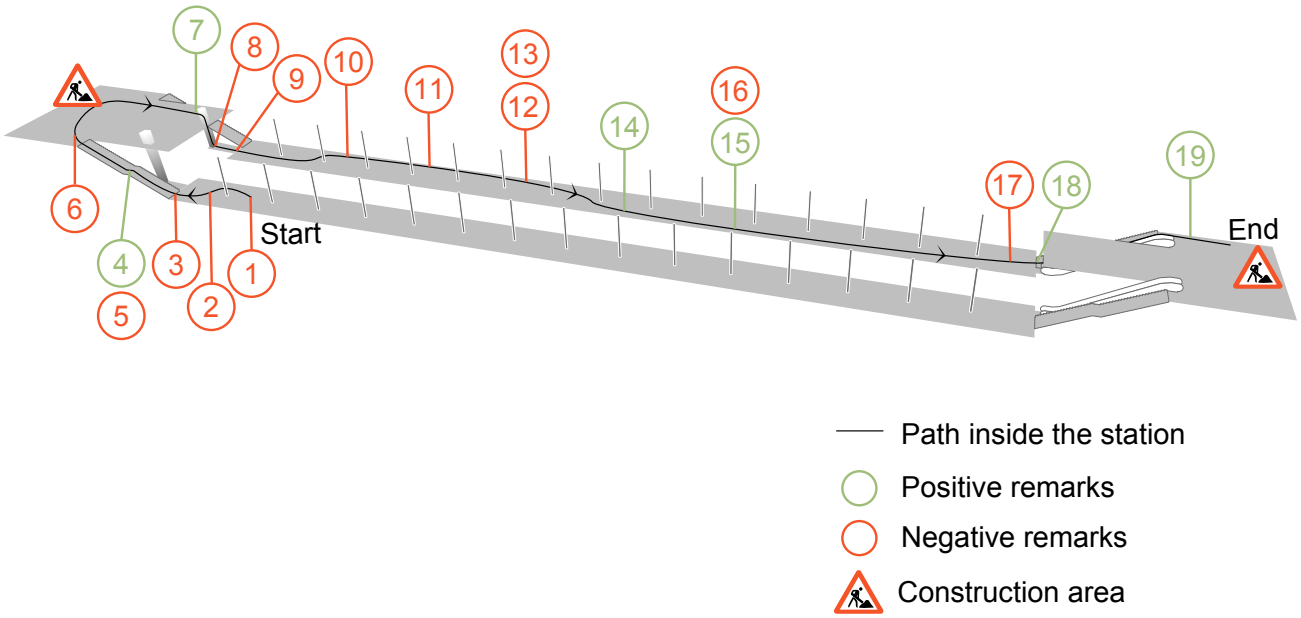


Figure 89: Participant 6 - Go-along at Längenfeldgasse station

1 The station was very loud, which made it hard to differentiate between trains arriving at the track next to oneself or another track in the station.

2 The TWSIs were palpable but only recognizable when slowly walking since structured tiles were on the floor next to them.

Figure 90: Structured tiles next to TWSIs

3 The TWSIs should guide to the right handrail of a staircase.

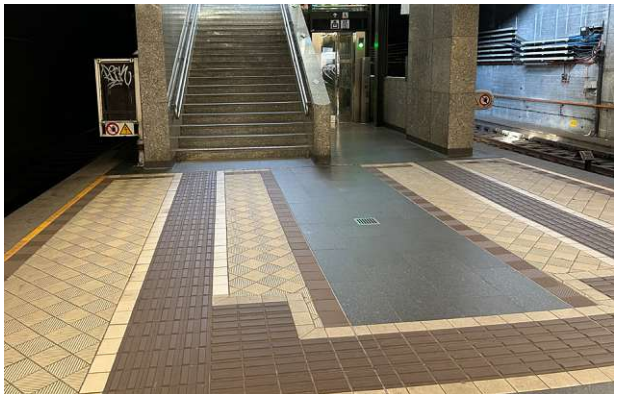


Figure 91: TWSIs led to the left handrail from platform level

4 The upper handrail was suitable to use.

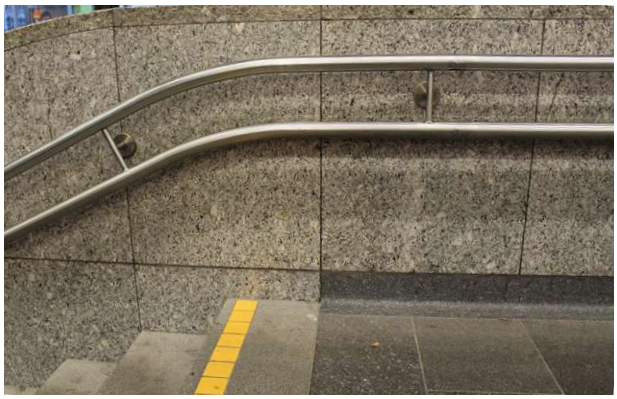


Figure 92: Double handrail for stairs

5 The lower handrail was not ideal; there was a danger of hurting the hand (Figure 92).

6 Due to construction work, people relying on the TWSIs would be led into an open door exclusively for construction workers.

7 The pillar with an integrated button to call the elevator was good to use.

Figure 93: Operating buttons of the elevator on a separate pillar

8 An elevator stating the side and direction of the trains arriving at this platform would be desirable.

9 According to standards, TWSIs should not be further away from the wall than 40 cm.

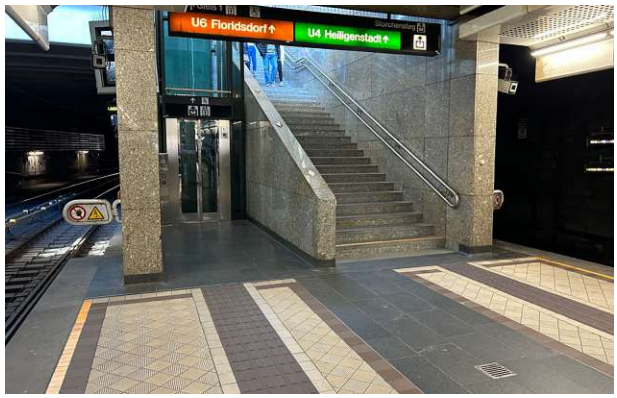


Figure 94: Criticized distance from the middle wall toTWSIs

10 Systems where track and platform are separated through a glass wall, would be preferred to find the doors of vehicles.

11 Floor markings at the U6 tracks to mark door entrances were not palpable with a white cane.

Figure 95: Floor markings U6 on platform 2

12 Seatings could pose a problem when parallel to the tactile guidance system. If people stretch their feet from the benches, they are close to TWSIs.

Figure 96: Seatings parallel to the TWSIs

13 The lower edge of the seating was 30 cm apart from the floor (Figure 96).

14 At the time of research, the surface of the floors was never slippery and always rough enough.

15 Handrails of escalators were used for orientation. “If it moves away from the body, it is usable.”

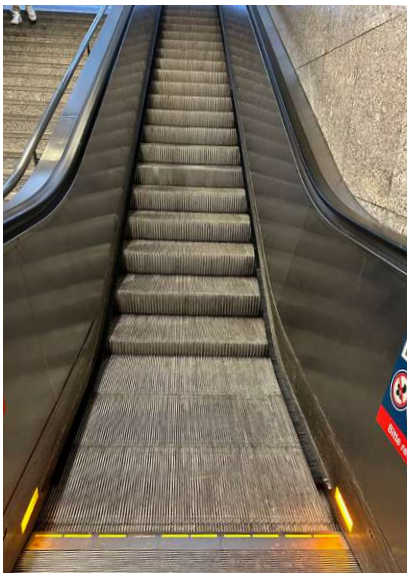


Figure 97: Escalators at Längenfeldgasse station

16 In general, much attention has to be paid when using escalators. If the handrail is not moving, it signals that an escalator is out of order (Figure 97).

17 There was no sound from the escalator due to the loud noise in the station, even when standing close to it.

18 A good connection from TWSIs to escalators was available.

Figure 98: Connection between TWSIs and escalator

19 This kind of metal frame was good to use.

Figure 99: Metal frames inside the entrance building

Participant 7

The seventh participant was a 50-year-old woman, and the walk lasted 55 minutes on March 8, 2023. She was vision and hearing impaired and mainly used her remaining eyesight. She had a hearing aid that would make audio induction loops perceivable and used a white cane but did not rely on the tactile guidance system. The cane is primarily used in crowded places, such as main roads or public transport stations like a metro station, to avoid obstacles in front of her. Längenfeldgasse station is used approximately monthly. She usually tries to place herself at the platform where she would want to get out of the metro system to avoid obstacles and walks along the platform. The participant does not take the metro during rush hours if possible. Concerning the future metro station of U5, including glass doors at the platform edge, especially the marking of those, will be crucial to her.

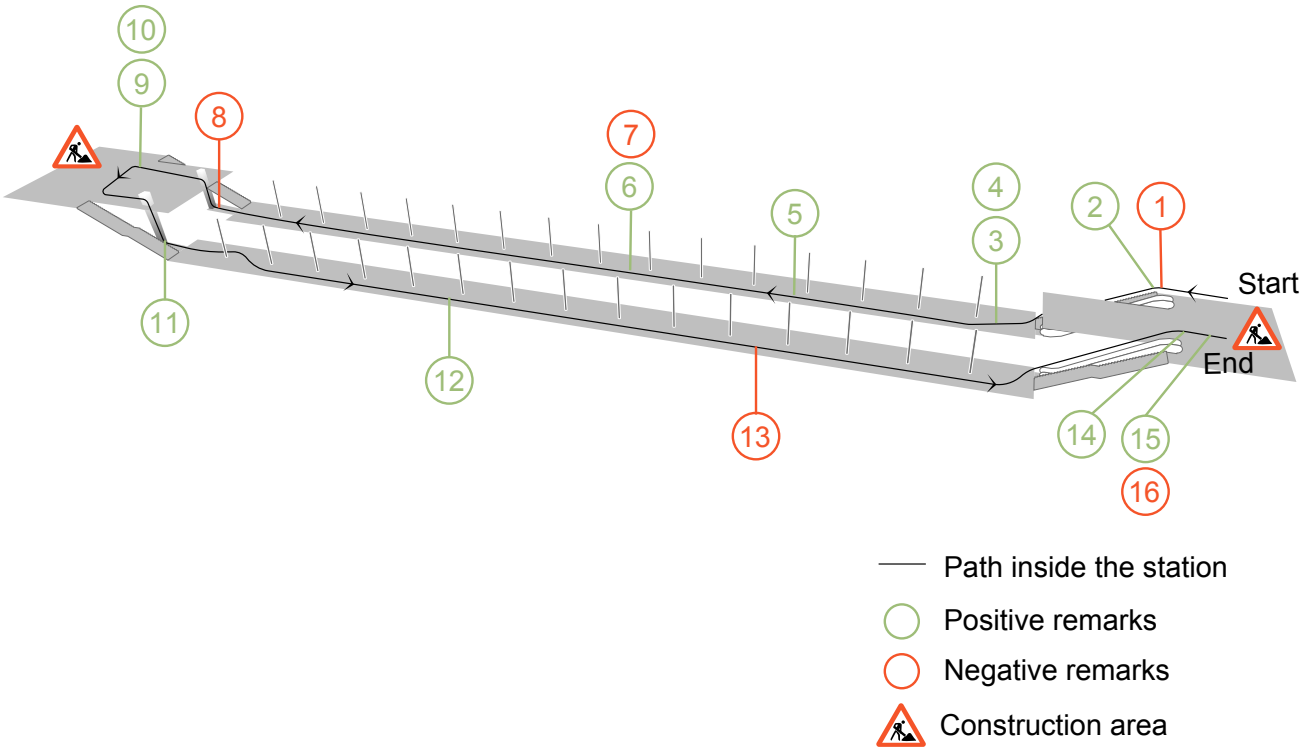


Figure 100: Participant 7 - Go-along at Längenfeldgasse station

1 The lower handrail was not ideal since there was a danger of hurting the hand.

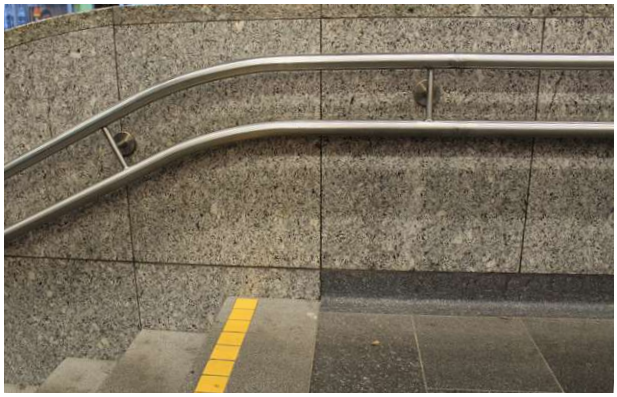


Figure 101: Double handrail for stairs

2 The yellow markings on the stairs helped with navigation.

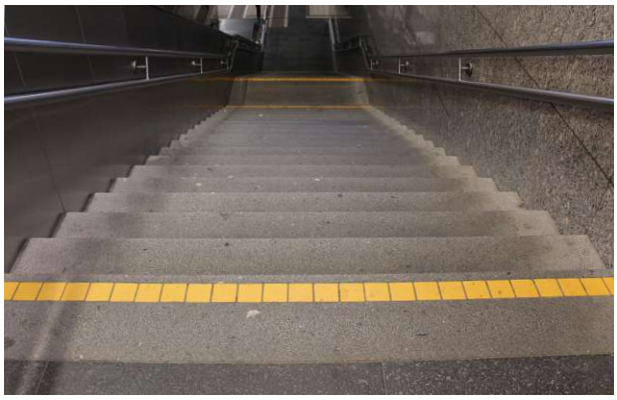


Figure 102: Yellow marking of stairs

3 The floor markings at the entrances of U6 were appreciated.

Figure 103: Floor markings U6 on platform 2

4 The visual guidance system was readable.

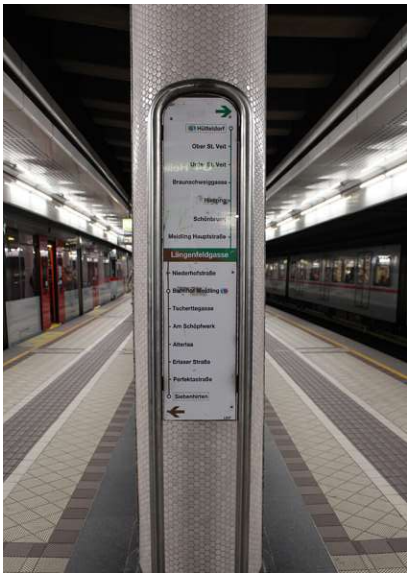


Figure 104: Visual guidance system on platform level

5 The trash cans were no obstacles.

Figure 105: Trash cans on platform level

6 The monitors were well-readable.

Figure 106: Exemplary monitor on platform level

7 Loudspeakers from the vehicles were perceivable but not understood due to the noise inside the station.

8 Inclined operating elements at the elevator were palpable but could be better.

Figure 107: Operating elements inside E5

9 Construction work was sufficiently marked.

Figure 108: Construction work in the entrance area

10 At the time of research, the floors were sufficiently rough.

11 The loudspeaker announcement inside the elevator was understandable and an additional screen helped with orientation .

12 The pillars were no obstacles since they were always placed in the middle of the platform.

Figure 109: Exemplary picture of a platform including pillars

13 More space on the platform would be preferable, especially during rush hours it can be very crowded.

14 The marking of escalators was recognizable.

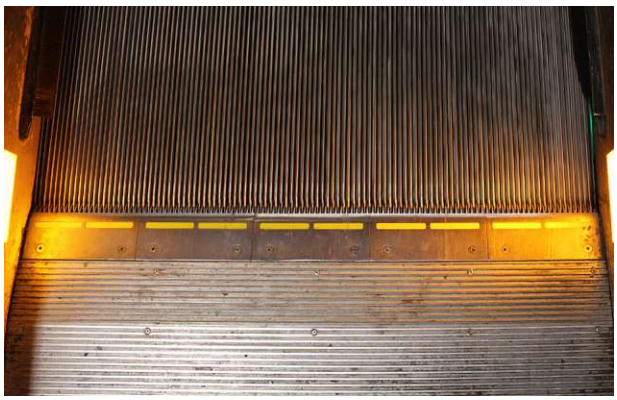


Figure 110: Escalators with marking

15 The illumination of the station was suitable.

16 The width of the stairs was considered narrow during rush hours.

Participant 8

Participant 8 was a 21-year-old male; the walk through the station lasted for 22 minutes on March 27, 2023. He was walking impaired and used an electric wheelchair. At the time of research, it was his second time at Längenfeldgasse station. He depended on the functionality of elevators and exceptionally gets on the train through the first or last door since they include a ramp. The participant avoids the metro during the night due to unpleasant passengers. He is optimistic about the future metro station of U5, including glass doors at the platform edge, and would appreciate those on other lines too.

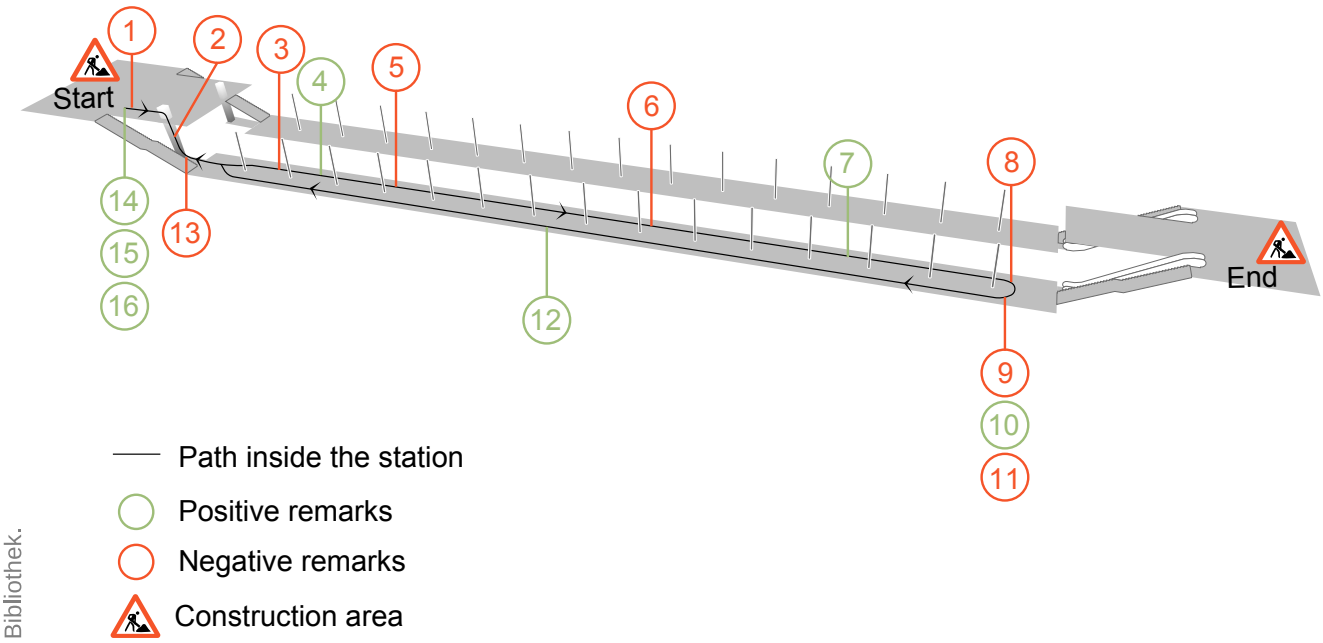


Figure 111: Participant 8 - Go-along at Längenfeldgasse station

1 The marking of the station could be better.

Figure 112: Exemplary entrance building with the typical metro cube

2 The buttons inside the elevator could be lowered for better reachability.

Figure 113: Operating elements inside E5

3 The paths could be wider. Floor markings that suggest where people should stand would be desired.

Figure 114: Exemplary picture of the platform width

4 TWSIs did not represent an obstacle (Figure 114).

5 Navigating the station could be challenging when people get off a train, and others sit on the benches simultaneously.

6 The ground was uneven and sloped to the side. The wheels of the wheelchair were not even.

7 In crowded situations, the TWSIs were used for orientation (Figure 114).

8 An additional elevator would be desirable, to reach both entrance buildings with an elevator.

Figure 115: Exemplary exit without elevator at Längenfeldgasse station

9 The visual guidance system could be mounted on the pillars on a lower level since wheelchair users have a different field of vision.

10 The signage on the walls opposite the platform was at a good height.

Figure 116: Signage on the wall opposite the platform

11 The signage on the walls opposite the platform should be lit.

12 The floor markings on the platform for tracks of U6 were appreciated, and they should also be on other platforms.

Figure 117: Floor markings U6 on platform 2

13 The button for calling the elevator was hard to reach since it was in the corner.

14 The monitors on the platform level were used. They were well-readable, and an underscore marks barrier-free vehicles.

Figure 118: Exemplary monitor on platform level

15 The surface of the floor was sufficiently rough at the time of research.

16 The illumination was good in this station. Nevertheless, lights could be integrated into the floor to help with orientation.

5. Discussion and recommendations

Multiple laws and standards exist for creating barrier-free public transport stations. Standards are regularly amended, and at the same time, metro stations are planned for the future, making it difficult for metro companies to stay at the current state of the art with an entire metro network. Despite these discrepancies, the results of the inspection criteria tables of the MofA evaluation tool and the go-alongs with participants show how two metro stations meet the need of mobility-impaired people at the time of research. At Frederiksberg station, enhanced inclusivity between the older part and the newer part of the station can be recognized. Contrasts were increased, the tactile guidance system was made more palpable, and elevators, including their functional elements, were improved. Additionally, the availability of loudspeakers at the platforms and an audio induction loop inside the station was favorable. Längenfeldgasse station includes many Universal Design relevant implementations as well. The marking of step nosings, escalators, and the constant availability of contrasting operating elements in elevators are some positive features compared to Frederiksberg station. Furthermore, construction work concerning the TWSIs in Vienna might lead paths better and safer in the future for blind and visually impaired people. Both stations illustrate that it is a constantly changing process to keep metro stations updated to improve accessibility.

Accompanying passengers sensitized and helped sharpen the eye for Universal Design choices. By including individuals directly impacted, current knowledge of standards is transferred, and essential points can be highlighted by them. In case of contradictory standards, participants can be consulted and share their insights. Furthermore, including affected people helps get more

insights into the subjective categories of the MofA evaluation tool.

According to EN 17210, "At least one accessible route to metro facilities, platforms and rolling stock shall be provided" (Austrian Standards International 2021, p. 269). Even though this is valid for both metro stations, it would be recommended to make all routes accessible if the costs do not exceed the benefit. In some cases, it currently requires mobility-impaired people to study their routes beforehand, which restricts flexibility. It would be beneficial to have various accessible entrances to metro stations regardless of someone's disability. Therefore, some of the following recommendations are based on the assumption that not only one but multiple entries should be accessible. Furthermore, parts of a metro station can be at the intersection of public or private ground. Some recommendations indicate the necessity of a profound connection to the municipality or private parties since responsibilities overlap, especially in the entrance area. Although a contact person was temporarily available on the platforms at Frederiksberg station, the constant presence of staff at stations, especially around autonomous subways, would be recommended. The stated point would also be applicable for the future line U5 in Vienna. Additionally, designing metro stations by following the multiple-senses principle is essential, which was particularly important for a double-impaired person with hearing and vision difficulties.

5.1 General recommendations according to MofA tool

Having a helpdesk at both stations, including an audio induction loop and staff knowing sign language, would improve the trip chain for people with hearing-related impairments. Moreover, ISO 21542 recommends having "guards that are detectable by vision and by touch" for escalators and moving walks under maintenance (Dansk Standard 2021b, p. 72). At both stations, participants mentioned situations where escalators were not adequately marked when out of order. Additionally, the visual contrast of handrails could be increased in Frederiksberg and Längenfeldgasse station. However, it has to be mentioned no determination of the luminance reflectance factor (LRV) was made.

5.2 MofA tool recommendations - Frederiksberg station

The visibility of the entrance leading to Solbjerg Plads could be more visible with the typical red metro signage on the ground floor. At the time of research, this entrance seemed inconspicuous. Improving the lights during the night at the entrance of Sylows Allé and improving the visibility of the entrance would be recommended, as the European standard 17210 suggests adequate lighting depending on the activity in certain spaces (Dansk Standard 2021c). People tied to the elevators and wanting to change platforms might have issues finding it or feel unsafe. Marking escalators with a contrasting color before the first and last step can encourage, for example, visually impaired and older people to use them. European standard 17210 (Dansk Standard 2021c) recommends visual contrast in safety situations such as step nosing. Furthermore,

attention has to be paid outdoors since weather and variations in lighting can impact the visual contrast. Properly marking the nosing of a moving walkway is part of a safety situation; therefore, the nosing should be marked similarly. Figure 162 shows a contrasting yellow marking of escalators in Längenfeldgasse station as a reference. Visual stair warnings could be improved by implementing a visual contrast line without gaps on the first and last steps, as DS/CEN/TR 17621 (Dansk Standard 2021a) suggests. A visually impaired participant mentioned the wish for implementation during a go-along. Figure 162 shows the marking of stairs in Längenfeldgasse station as a reference. Concerning handrails, DS/CEN/TR 17621 (Dansk Standard 2021a) recommends a double handrail with two different heights, one at a height between 85 cm and 100 cm and another one at a height between 60 cm and 75 cm. ISO 21542 also includes these heights and adds that especially children, people of small stature, and wheelchair users (on ramps) would benefit from a lower handrail (Dansk Standard 2021b). Additionally, the profile of handrails should be without sharp edges (Dansk Standard 2021a); the handrail in Figure 128 at the passage level in Frederiksberg should be adjusted accordingly. DS/CEN/TR 17621 (Dansk Standard 2021a) suggests consistent visual indicators on glazing with a height of 7.5 cm between 90 cm to 100 cm and 150 cm to 160 cm above the surface. Additionally, it is recommended to have one at a height between 10 cm to 30 cm. ÖNORM B 1600 includes that a marking of glass doors can be exempt if a plinth area of 30 cm height, including a certain contrast difference, is existent (Austrian Standards International 2023). Due to the subtle aesthetics and architectural choices inside Frederiksberg station, marking a plinth would be recommended to make glass doors to the bike rooms and the ones on the platform level visible. ISO 21542 states that all floor levels should be accessible by lifts, ramps or have level access (Dansk Standard 2021b). At Frederiksberg station, the two concourse levels are not accessible for wheelchair users. However, they could be made accessible by implementing a ramp, moving walk or lifting platform. With this intervention, people dependent on a wheelchair could cross the station underground. It should be noted that there is limited space in this station, which may be the reason for the lack of implementation of these options. Concerning TWSI guidance systems, DS/ISO 21542 states that continuous tactile information should be provided (Dansk Standard 2021b). This is not the case at Frederiksberg station. To improve the continuity of the system, TWSIs should lead from the older part to the newer part of the station. A gap is apparent at the concourse level and the lack of a TWSI connection between the escalators was mentioned by a blind participant. A TWSI line could connect them to help blind and visually impaired people finding their way to the respective other platform. TWSIs directly in front of escalators would help people with a cane to find them faster and easier, Figure 136 shows displaced TWSIs close to escalators. Figure 121 shows one out of the five entrances, including a moving walkway; TWSIs leading to this entrance are missing. Furthermore, a tactile guidance system leading along the platform, next to the glass doors, would be recommended. ÖNORM V 2102 mentions a minimum distance of 60 cm between the TWSIs and the platform edge (Austrian Standards International 2018). This line along the platform could lead directly to escalators or elevators to

guide the way of visually impaired and blind people. ISO 23599 suggests leading TWSIs directly to the elevator control panel (Dansk Standard 2019). An existing implementation of this can be seen at Längenfeldgasse station in Figure 159. Figure 129 depicts a door frame on the concourse level, which was mistakenly identified as TWSI by a participant. Such misunderstanding can be avoided if the TWSIs within a station are designed uniformly following existing standards. Different guiding patterns of TWSIs can be implemented; the most common are parallel flat-topped elongated bars (Dansk Standard 2019). TWSIs of Frederiksberg station's older part should be adapted to ISO 23599. Figure 135 illustrates TWSIs close to obstacles as trash cans or screens mounted on the wall, these should be further apart. According to ÖNORM V 2102, the distance between obstacles and the outer edge of the tactile guidance system should be 40 cm to 50 cm (Austrian Standards International 2018). Due to the complaint of a participant with hearing impairment not being able to understand the loudspeaker announcement, it would be recommended to reassure standards conformity of loudspeaker announcements on platforms. A suggestion would be loudspeaker announcements from the entering vehicle's side and a deeper voice level. However, it was not possible to measure the speech transmission index. According to the MofA evaluation tool, there are several ways to improve the elevators at Frederiksberg station. In E1, floor announcements should be made available when going down as well as contrasting tactile operating elements outside the elevator. E2 lacks contrast of functional elements inside and outside the elevator; tactile operating elements are unavailable outside the elevator. According to ISO 21542, a visual contrast to the face plate would be desirable (Dansk Standard 2021b). Implementing this would improve readability. E3 does not always announce the floor; this should be changed. The emergency button inside elevators E3 and E4 is up to a height of 115 cm. According to MofA criteria, a height of operating elements between 80 cm and 100 cm would be ideal.

5.3 MofA tool recommendations - Längenfeldgasse station

According to ISO 21542, tactile guidance should be provided to lead visually impaired persons to the main entrance of a building (Dansk Standard 2021b). The west entry at Längenfeldgasse station does have TWSIs, but they do have gaps. The eastern entrance does not have any TWSIs. Reworking the ones with gaps and providing some at the east entrance would improve the findability of the station's main entrances. The entrance buildings were undergoing temporary construction work, which has adversely affected the accessibility for individuals who are visually impaired or blind. Therefore, construction work should be completed as soon as possible. Furthermore, the MofA catalog of measures reveals that well-understandable loudspeakers, even at full operating noise level, should be provided. ÖNORM V 2102 refers to the necessity of additional operational measures alongside the TWSIs to efficiently identify the proper vehicle at a station with multiple lines (Austrian Standards International 2018). This could be realized by a driver or automatic speaker stating the line and final stop. Concerning elevators, Längenfeldgasse station provides only one for each platform. In the case of maintenance, this

might cause problems for people needing a functional elevator. A second elevator for each platform would be desired. However, it has to be stated that the space in this station is scarce, which may be the reason causing this deficiency. Controls inside the elevator are slightly above 110 cm; lowering them to a maximum height of 110 cm could improve the situation for wheelchair users. Participant eight, using a wheelchair, confirmed lower buttons for better reachability. Moreover, providing voice announcements in E6 would improve orientation for visually impaired and blind passengers.

5.4 Additional measures in general

Although the MofA evaluation tool revealed significant issues, additional measures could be taken for better inclusivity by following existing standards, and learning from the respective other metro station or affected people. In general, a simple station layout is to be aimed for. Furthermore, it would be recommended for metro companies to get detailed statistics concerning mobility-restricted people. This might raise awareness of the number of people needing Universal Design which could shift priorities from aesthetics to functionality. Additionally, implementing speakers inside elevators announcing both stations' sides, lines, and destinations could make wayfinding easier for all user groups.

5.5 Additional measures for Frederiksberg station

According to EN 17210, "seating options shall be provided on platforms" (Dansk Standard 2021c, p. 265). Hence, providing seating options besides the leaning options at platform M3 at Frederiksberg station could be beneficial. Adding more color-coded paths and overview maps to the station could make navigation easier. Placing an additional map on platform M3 near the elevators would be recommended, in order to have one map on each side of the platform. Another overview map could be considered on the passage level leading to platform M1/M2, coming from platform M3. Moreover, placing the station name at a lower height across the tracks, additionally to the ones provided above the glass portals, could help individuals at lower heights and those seated in a metro vehicle. An example of implementation would be Figure 165 in Längenfeldgasse station. In emergencies, using escalators to reach the ground floor is not recommended. Signages at Frederiksberg station encourage people to use them as emergency exits. As a result, hazardous situations could arise due to the dimensions of 40 cm depth and 20 cm height of an escalator step. Although the escalator width of 80 cm complies with standards, it would be preferable to have wider ones, particularly in places where escalators are the sole means of vertical circulation, such as platform M3. In Vienna, for example, escalators are 100 cm wide, and an additional staircase is provided. Moreover, a participant who was hard-of-hearing mentioned them being too narrow in Frederiksberg station. Another recommendation would be to define all exits, including a name of a street or place it leads to. Furthermore, a yellow button on the ground floor was desired by a participant; the availability only on platform M3 was criticized. Another improvement would be to upgrade floor markings on platform M3

by integrating a black outline around the white marking next to the doors. Due to the lack of contrast, the white marking on the gray ground is not visible to all. Multiple participants did not perceive platform numbers on the wall and floor. Therefore, placing them prominently next to the monitors could attract more attention. Concerning elevators, some improvements are not covered by the MofA evaluation tool. Bigger numbers in E2 would improve readability, and the bell for emergency calls in E3 and E4 could be more palpable. Especially the visually impaired and blind participants recognized these deficiencies. Furthermore, the blind participant stated that there are blinding lights on platform M3 next to the glass portals. No direct light would be recommended since floor markings navigate people to stand there.

5.6 Additional measures for Längenfeldgasse station

Due to construction work on TWSIs inside the two entrance buildings of Längenfeldgasse station, it would be advisable for Wiener Linien to contact organizations for visually impaired and blind people in such a case. Participant six, who runs a newsletter for around 300 blind people, stated during the go-along that he did not know about the construction work; if he had known, he could have informed some people who might have been severely affected by it. Although two handrails at different heights are available at the staircases, the lower handrail is not constructed as ISO 21542 states (Dansk Standard 2021b). The lower handrail profile should be built without the risk of potential finger injuries, like the upper handrail. Furthermore, ISO 21542 (Ibid.) suggests avoiding highly contrasting floor patterns since they can cause disorientation and influence the recognition of safety elements. If the floor at Längenfeldgasse station would only consist of two instead of multiple color patterns, safety elements could be better readable. Participant six mentioned it is only possible to walk slowly when relying on the TWSIs in this station due to the structured tiles close to the TWISs. Wider unstructured tiles between those two elements could improve navigation for people using the TWSIs. Furthermore, seatings at Längenfeldgasse station are parallel to TWISs which can pose an obstacle when people sitting there stretch their legs. Placing elements to sit or lean perpendicular to TWSIs could avoid conflicts. Additionally, TWSIs leading to the right handrail of a staircase and glass panels separating the platform from the track would be desirable for blind and visually impaired passengers. Furthermore, floor markings in combination with glass panels along the platform edge could be implemented at the tracks of U4 to highlight the entrance of vehicles. An example would be platform M3 in Frederiksberg station (Figure 140). Currently cantilever elements are 30 cm from the floor, which is according to ÖNORM B 1600 (Austrian Standards International 2023). Although this is the case, participant number six mentioned the 30 cm to be obsolete; focusing on a maximum height of 20 cm would be essential. Due to a different angle of their white cane, smaller people would still be at risk of running into objects with a maximum height of 30 cm. Moreover, lighting up the signage across the platforms would make them better readable to all user groups. European standard 17210 (Austrian Standards International 2021) suggests a low noise level in rooms, which should be implemented since

the four tracks generate a high noise level. Two participants acknowledged the noise during the go-along. Hearing enhancement systems could be provided in accordance with ISO 21542 (Dansk Standard 2021b), which emphasizes the provision in public transport areas. Concerning elevators, braille could be implemented, as well as English floor announcements and more raised operating elements. According to a participant using a wheelchair, the platform path should be wider. Participant seven stated the same about the staircase in the entrance building Längenfeldgasse during rush hours. Although both widths are according to standards, more space could make navigation through the station easier. Additionally, Frederiksberg station's clean and straight design could be a positive example of visual guidance without distraction from the surrounding.

5.7 Conflict of interests and standards

Several conflicts of standards and participants' interests were identified. In Frederiksberg station, participant one stated that a different marking of operating elements outside of E2 would be desirable, and participant two mentioned this button to be well perceivable. Although both of them have a visual impairment, their perception is contrary. Participant five in Copenhagen, who was blind, mentioned being sensitive to bright and direct lights. Participant eight in Vienna, a wheelchair user, stated that lights integrated into the floor could help navigate the station easier. Assuming these remarks were made in one station, respecting both interests would be impossible due to different built environment requests. These examples emphasize the necessity to know everyone's needs and carefully weigh who might benefit and who might be adversely affected by a change.

Furthermore, ÖNORM B 1600 states that cantilever elements should have underrun protection at a maximum height of 30 cm for blind people (Austrian Standards International 2023). Participant number six disagreed with the 30 cm and emphasized a maximum height of 20 cm. Moreover, some standards are not consistent with others. DS/CEN/TR 17621 (Dansk Standard 2021a) suggests the lower handrail at a staircase to be at a height between 60 cm and 75 cm and the higher handrail to be at a height between 85 cm and 100 cm, whereas ÖNORM B 1600 (Austrian Standards International 2023) suggests the lower handrail to have a height of 75 cm and the higher handrail to be at a height of more than 90 cm. These two standards also differ regarding visual indicators and their height on glazing. Whereas DS/CEN/TR 17621 (Dansk Standard 2021a), recommends uninterrupted visual indicators of at least 7.5 cm height, ÖNORM B 1600 (Austrian Standards International 2023) has different variants depending on the contrast rate and can vary from 6 cm to 10 cm height. These are just some of the discrepancies between interests and standards; to describe all of them in detail would exceed the scope of this thesis.

6. Conclusion and perspective

In conclusion, looking at two different metro systems for improving Universal Design in metro stations has proven to be enriching. Although the MofA evaluation tool does not cover all

relevant categories, it is recommended for evaluating different metro station buildings and their accessibility. However, additional knowledge of the legal framework and specific standards is required when using this tool. According to the MofA evaluation tool, Frederiksberg station in Copenhagen revealed high deficiencies for wheelchair users, hard-of-hearing, and deaf people. Due to two different construction periods of the station, Universal Design is differently implemented causing difficulties in wayfinding. In Längenfeldgasse station, high deficiencies were identified for visually impaired, blind, hard-of-hearing, and deaf people. The research was carried out during a phase of construction work on TWSIs inside the entrance buildings of the station, which significantly affected the results.

Even though the Copenhagen Metro and Wiener Linien have different approaches to Universal Design, some are similar due to design decisions based on the same existing legal framework. Analysing two stations of different metro systems in-situ provided insights beyond standards and regulations. In-depth knowledge was gained through the conduction of go-alongs with affected people, which enabled a better understanding of their needs and helped identify obstacles. Detailed recommendations concerning implementations for different mobility-restricted groups in both stations were elaborated, based on the MofA evaluation tool, existing standards, participants' remarks, and findings of the respective other station. Furthermore, conflicts of interest and differences between Austrian and Danish standards were identified. This study focused exclusively on metro station buildings; thus, future research could delve into the inclusivity of public spaces and other modes of transport to ensure door-to-door accessibility.

List of figures

List of tables

List of references

Aarhaug, J. and B. Elvebakk (2015). "The Impact of Universally Accessible Public Transport–a before and after Study". In: *Transport Policy* 44, pp. 143–150. ISSN: 0967070X. DOI: 10.1016/j.tranpol.2015.08.003. (Accessed on 03/07/2022).

Austrian Ministry for Finance (2006). *Bundes-Behindertengleichstellungsgesetz.* URL: https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=20004228 (accessed on 01/07/2023).

Austrian Ministry of Social Affairs (2016) *Bericht der Bundesregierung über die Lage der Menschen mit Behinderungen in Österreich 2016.*

– (2020). *Österreichische Gesundheitsbefragung 2019*.

Austrian Research Association for Roads, Railways and Transport (2010). *Barrier-Free Roads to Meet Everyday Requirements.*

Austrian Standards International (2018). *ÖNORM V 2102: Tactile Walking Surface Indicators (TWSI) - Technical Aids for Blind and Partially Sighted People.*

– (2021). *ÖVE/ÖNORM EN 17210: Accessibility and Usability of the Built Environment - Functional Requirements.*

– (2023). *ÖNORM B 1600: Accessible Building Construction - Design Principles.*

Bendixen, K. and M. Benktzon (2015). "Design for All in Scandinavia – A Strong Concept". In: *Applied Ergonomics.* Special Issue: Inclusive Design 46, pp. 248–257. ISSN: 0003-6870. DOI: 10.1016/j.apergo.2013.03.004.

Benktzon, M. (1993). "Designing for Our Future Selves: The Swedish Experience". In: *Applied Ergonomics* 24.1, pp. 19–27. ISSN: 00036870. DOI: 10.1016/0003-6870(93)90155-3.

Bischler, F., A. L. Brusius, Y. Haase, and L. B. Maczó (2022). *Wayfinding at the Metro Station Frederiksberg in Copenhagen.* Aalborg University: AAU.

Bolig- og Planstyrelsen (2018). *Bygningsreglementet*. URL: https://bygningsreglementet.dk/# (accessed on 01/13/2023).

Bröcker Katja (2011). *Barrierefreier Zugang in Öffentlichen Gebäuden Und Öffentlichen Verkehrsmitteln*. Master thesis. Technical University Vienna.

BMK and FFG (2008). *Ways2go 1st Call.*

CATAPULT (2023). *Policies for Inclusive Urban Autonomous Mobility Solutions.* URL: https://catapultproject.eu/ (accessed on 07/30/2023)

Cirella, G., M. Bąk, A. Kozlak, B. Pawłowska, and P. Borkowski (2019). "Transport Innovations for Elderly People". In: *Research in Transportation Business & Management* 30. ISSN: 22105395. DOI: 10.1016/j.rtbm.2019.100381.

Clarkson, J., S. Keates, R. Coleman, and C. Lebbon, eds. (2003a). *Inclusive Design - Glossary of Terms.* London: Springer London. ISBN: 978-1-85233-700-1. DOI: 10.1007/

978-1-4471-0001-0.

– eds. (2003b). *Inclusive Design - Introduction: From Margins to Mainstream.* London: Springer London. ISBN: 978-1-85233-700-1. DOI: 10.1007/978-1-4471-0001-0.

Dansk Handicap Forbund (2022). *Tal på handicap i Danmark.* URL: https:// danskhandicapforbund. dk/da/presse/fakta-om-handicap/tal-pa-handicap-i-danmark/ (accessed on 12/04/2022).

Dansk Standard (2019). *DS/ISO 23599: Assistive Products for Blind and Vision-Impaired Persons - Tactile Walking Surface Indicators.*

– (2021a). *DS/CEN/TR 17621: Accessibility and Usability of the Built Environment - Technical Performance Criteria and Specifications.*

– (2021b). *DS/ISO 21542: Building Construction - Accessibility and Usability of the Built Environment.*

– (2021c). *DS/EN 17210: Accessibility and Usability of the Built Environment - Functional Requirements.*

DOT (2022a). *About DOT.* URL: https://dinoffentligetransport.dk/en/about-dot/ (accessed on 11/27/2022).

– (2022b). *Disability access conditions.* URL: https://dinoffentligetransport.dk/en/customer-service/rules-and-guidelines/disability-access-conditions/ (accessed on 11/29/2022).

– (2022c). *Bicycles, animals and baggage* . URL: https://dinoffentligetransport.dk/en/ customer-service/rules-and-guidelines /bicycles-animals-and-baggage/ (accessed on 12/01/2022).

– (2023). *Single tickets.* URL: https://dinoffentligetransport.dk/en/tickets/single-tickets/ (accessed on 04/07/2023).

Eikhaug, O., ed. (2010). *Innovating with People: The Business of Inclusive Design.* Oslo: Norwegian Design Council. ISBN: 978-82-991852-2-6.

European Union. (2021). *Union of Equality: Strategy for the Rights of Persons with Disabilities 2021-2030.* LU: Publications Office. URL: https://data.europa.eu/ doi/10.2767/31633 (accessed on 03/15/2022).

Fian, T. and G. Hauger (2020). "Composing a Conceptual Framework for an Inclusive Mobility System". In: *IOP Conference Series: Materials Science and Engineering* 960.3. ISSN: 1757-8981, 1757-899X. DOI: 10.1088/1757-899X/960/3/032089.

FSV (2015). *Child-friendly Moblity - RVS 03.04.13.* Österreichische Forschungsgesellschaft Straße, Schiene, Verkehr.

Fürst, E. W. M. and C. Vogelauer (2012). "Mobility of the Sight and Hearing Impaired: Barriers and Solutions Identified". In: *Qualitative Market Research* 15.4, pp. 369–384. ISSN: 13522752. DOI: 10.1108/13522751211257060.

Goldschmidt, M. (2018). "Orientation and Mobility Training to People with Visual Impairments". In: *Mobility of Visually Impaired People.* Ed. by Edwige Pissaloux and Ramiro Velázquez. Cham: Springer International Publishing. ISBN: 978-3-319-54444-1.

DOI: 10.1007/978-3-319-54446-5.go

Jensen, O. B. (2013). *Staging Mobilities.* International Library of Sociology. New York: Routledge. ISBN: 978-0-415-69373-8.

Jensen, O. B. and N. Morelli (2011). "Critical Points of Contact: Exploring Networked Relations in Urban Mobility and Service Design". In: *Landinspektoeren* 46.1, pp. 36–49. ISSN: 1903-5454.

John Clarkson, P. and R. Coleman (2015). "History of Inclusive Design in the UK". In: *Applied Ergonomics* 46, pp. 235–247. ISSN: 00036870. DOI: 10.1016/j. apergo.2013.03.002.

Keates, S., P. J. Clarkson, L.-A. Harrison, and P. Robinson (2000). "Towards a Practical Inclusive Design Approach". In: *Proceedings on the 2000 Conference on Universal Usability* - CUU '00. Proceedings on the 2000 Conference. Arlington, Virginia, United States: ACM Press, pp. 45–52. ISBN: 978-1-58113-314-1. DOI: 10.1145/355460.355471.

Kusenbach, M. (2018). *The SAGE Handbook of Qualitative Data Collection.* 1 Oliver's Yard, 55 City Road, London EC1Y 1SP: SAGE Publications Ltd. ISBN: 978-1-4739-5213-3. DOI: 10.4135/9781526416070.

Metroselskabet I/S (2019). *Cool Construction - Temporary Urban Art*.

– (2022a). *About the Metro.* URL: https://intl.m.dk/about-the-metro/ (accessed on 11/27/2022).

– (2022b). *20 år med Metroen.* URL: https://m.dk/om-metroen/20-%25C3%25A5r-med-metroen/ (accessed on 11/27/2022).

– (2022c). *Togsystemet.* URL: https://m.dk/om-metroen/metroens-koncept/togsystemet/ (accessed on 11/27/2022).

– (2022d). *Arkitekturen.* URL: https://m.dk/om-metroen/metroens-koncept/arkitekturen/ (accessed on 11/27/2022).

– (2022e). *The Copenhagen Metro.* URL: https://intl.m.dk/ (accessed on 11/27/2022).

– (2023). *M4 to Sydhavn.* URL: https://intl.m.dk/we-are-constructing-new- lines/m4-to-sydhavn/ (accessed on 04/07/2023).

OECD (2015). *Working Better with Age in Denmark - Assessment and Key Recommendations.*

– (2022). *Elderly Population - OECD Data*. URL: http://data.oecd.org/pop/elderly-population.htm (accessed on 10/29/2022).

Österreichischer Behindertenrat (2023). *Gesetze*. URL: https://www.behindertenrat. at/recht-und-soziales/gesetze/ (accessed on 01/07/2023).

Österreichisches Institut für Bautechnik (2023). *OIB-Richtlinien*. URL: https://www.oib.or.at/de/oib-richtlinien (accessed on 01/08/2023).

Persad, U. (2011). *Exploring a Capability-Demand Interaction Model for Inclusive Design Evaluation.* PhD thesis. University of Cambridge.

Prillinger, H. (2017). *The Vienna Metro: Technical Specifications.* The Vienna Metro. URL: https://homepage.univie.ac.at/horst.prillinger/ubahn/english/technical_ specs.html (accessed on 11/29/2022).

Rejsekort & Rejseplan A/S (2023). *Hvem skal rejse?* URL: https://www.rejsekort.dk/ da/hjaelp/hvem-skal-rejse (accessed on 01/02/2023).

Rieß, J., L. Zeisel, K. Raunig, and C. Cadiano Flores (2021). *CATAPULT D.2.2 Catalogue of Needs and Requirements, Report on Statistical Data Analysis Results.* URL: https://catapultproject.eu/wp-content/uploads/2023/03/D2.2-Catalogue-of-needs-and-requirements-report-on-statistical-data-analysis-results_final.pdf.

RIS (2022). *Rechtsinformationssystem Des Bundes - Bundes-Verfassungsgesetz*. URL: https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=bundesnormen&Gesetzesnummer=10000138 (accessed on 03/17/2022).

– (2023). Rechtsinformationssystem Des Bundes - Bauordnung Für Wien. URL: https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=LrW&Gesetzesnummer=20000006 (accessed on 05/01/2023).

Shrestha, B. P., A. Millonig, N. B. Hounsell, and M. McDonald (2017). "Review of Public Transport Needs of Older People in European Context". In: *Journal of Population Ageing* 10.4, pp. 343–361. ISSN: 1874-7884, 1874-7876. DOI: 10.1007/s12062-016-9168-9.

Social-, Bolig- og Ældreministeriet (2018). *Lov Nr 688 Af 08/06/2018 - Lov Om Forbud Mod Forskelsbehandling På Grund Af Handicap.* URL: https://www.retsinformation.dk/eli/lta/2018/688 (accessed on 01/12/2023).

Sozialhelden e.V. (2016). *Sozialhelden gewinnen Deutschen Mobilitätspreis für Aufzugstörungsmelder*. url: https://sozialhelden.de/blog/sozialhelden-gewinnen-deutschen-mobilitaetspreis/ (accessed on 11/09/2022).

– (2021). *Über uns*. URL: https://sozialhelden.de/wir/ (accessed on 11/09/2022).

Stadt Wien (2022a). *Barrierefrei Stationen und Fahrzeuge.* Linienkreuz U2xU5. URL: https://u2u5.wien.gv.at/mobilitaet-in-wien/ (accessed on 11/27/2022).

– (2022b). *Thema "Fahrtbegünstigungen" - Sozialinfo Wien.* URL: https://www.wien.gv.at/sozialinfo/content/de/10/SearchResults.do?keyword=Fahrtbeg%C3%BCnstigungen (accessed on 12/01/2022).

– (2022c). *U-Bahn*. URL: https://www.geschichtewiki.wien.gv.at/U-Bahn (accessed on 04/19/2023).

– (2023a). Erweiterung der U-Bahn-Linie U5, Route und Ausbauschritte. URL: https://www.wien.gv.at/stadtentwicklung/projekte/verkehrsplanung/u-bahn/u2u5/linie-u5.html (accessed on 04/05/2023).

– (2023b). *Barrierefreies Bauen.* URL: https://www.wien.gv.at/menschen/barrierefreiestadt/bauen.html (accessed on 01/13/2023).

Statistics Denmark (2022a). *Population at the First Day of the Month by Region, Sex and Age - StatBank Denmark - Data and Statistics*. URL: https://www.statbank.dk/statbank5a/SelectVarVal/Define.asp?MainTable=FOLK1AM&PLanguage=1&PXSId=0&wsid=cftree (accessed on 12/31/2022).

– (2022b). *Population Projections 2022 by Region/Province, Age and Sex - StatBank*

Denmark - Data and Statistics. URL: https://www.statbank.dk/statbank5a/ SelectVarVal/Define.asp?MainTable=FRLD122&PLanguage=1&PXSId=0&wsid=cftree (accessed on 12/31/2022).

– (2023a). *Population at the First Day of the Quarter by Region, Sex, Age and Time - StatBank Denmark.* URL: https://www.statbank.dk/statbank5a/selectvarval/saveselections.asp (accessed on 06/09/2023).

– (2023b). *Population at the First Day of the Quarter by Region, Sex, Age and Marital Status - StatBank Denmark.* URL: https://www.statbank.dk/statbank5a/Selectout/pivot.asp (accessed on 05/01/2023).

Statistik Austria (2022a). *Demographisches Jahrbuch.*

– (2023). *STATcube - Bevölkerung Zu Quartalsbeginn Ab 2002*. URL: https://statcube.at/statistik.at/ext/statcube/jsf/tableView/tableView.xhtml (accessed on 05/01/2023).

Steinfeld, A., J. Maisel, and E. Steinfeld (2018). *Accessible Public Transportation: Designing Service for Riders with Disabilities*. 1 Edition. New York: Routledge. 1 p. ISBN: 978-1-4822-3410-7.

The European Commission (2014). *Commission Regulation No 1300/2014 Technical Specifications for Interoperability Relating to Accessibility of the Union's Rail System for Persons with Disabilities and Persons with Reduced Mobility.*

UNHCR (2020). *Emergency Handbook - Older Persons.*

United Nations (2008). *Convention on the Rights of Persons with Disabilities Article 2 Definitions | United Nations Enable*. URL: https://www.un.org/development/desa/disabilities/convention-on-the-rights-of-persons-with-disabilities/article-2-definitions.html (accessed on 10/09/2022).

– (2022a). *Goal 11 | Department of Economic and Social Affairs*. URL: https://sdgs.un. org/goals/goal11 (accessed on 03/11/2022).

– (2022b). *Shifting Demographics*. URL: https://www.un.org/en/un75/shifting-demographics (accessed on 10/29/2022).

– (2022c). *Ageing and Disability*. URL: https://www.un.org/development/desa/ disabilities/disability-and-ageing.html (accessed on 10/28/2022).

– (2022d). *Convention on the Rights of Persons with Disabilities Article 9 – Accessibility*. URL: https://www.un.org/development/desa/disabilities/convention-on-the-rights-of-persons-with-disabilities/article-9-accessibility.html (accessed on 04/26/2022).

– (2023a). *Convention on the Rights of Persons with Disabilities (CRPD)*. URL: https://www.un.org/development/desa/disabilities/convention-on-the-rights-of-persons-with-disabilities.html (accessed on 01/04/2023).

– (2023b). *United Nations Treaty Collection*. URL: https://treaties.un. org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=IV-15&chapter=4&clang= _en (accessed on 01/04/2023).

– (2023c). *United Nations Treaty Collection*. URL: https://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=IV-15-a&chapter=4&clang=_en#2 (accessed on

06/18/2023).
– (2023d). *Convention on the Rights of Persons with Disabilities Article 1 – Purpose*. URL: https://www.un.org/development/desa/disabilities/ convention-on-the-rights-of-persons-with-disabilities/article-1-purpose.html (accessed on 04/08/2023).
VDV and VDV-Förderkreis (2012). *Barrierefreier ÖPNV in Deutschland*. 2., vollst. überarb. und erw. Ausg. Meerbusch Düsseldorf: Alba Fachverl. ISBN: 978-3-87094-694-4.
VIVE, Anna Amilon, Stine Vernstrøm Østergaard, and Rikke Fuglsang Olsen (2021). *Mennesker med handicap: hverdagsliv og levevilkår 2020.* VIVE - Det Nationale Forsknings- og Analysecenter for Velfærd. ISBN: 978-87-7119-977-2
Wästerfors, D. (2021). "Required to Be Creative. Everyday Ways for Dealing with Inaccessibility". In: *Disability & Society* 36.2, pp. 265–285. ISSN: 0968-7599, 1360-0508. DOI:10.1080/09687599.2020.1720610.
WHO (2007). *Global Age-Friendly Cities: A Guide*. ISSN: 978-92-9021-685-8. URL: https://apps.who.int/iris/handle/10665/119892.
– (2022). *Ageing and Health*. URL: https://www.who.int/news-room/fact-sheets/detail/ageing-and-health (accessed on 10/29/2022).
– (2023). *Disability*. URL: https://www.who.int/health-topics/disability (accessed on 02/19/2023).
Wiener Linien (2022a). *Das Unternehmen*. URL: http://www.wienerlinien.at/%C3%BCber-uns (accessed on 11/18/2022).
– (2022b). *Zeitreise: Die Geschichte der Öffi-Pläne.* Wiener Linien Unternehmensblog. URL: https://blog.wienerlinien.at/zeitreise-die-welt-der-oeffi-plaene/ (accessed on 11/18/2022).
– (2022c). *40 Facts zu 40 Jahre Wiener U-Bahn*. Wiener Linien Unternehmens-blog. URL: https://blog.wienerlinien.at/40-facts-zu-40-jahre-wiener-u-bahn/ (accessed on 11/29/2022).
– (2022d). *Mit der U-Bahn durch die Nacht.* Wiener Linien Unternehmensblog. URL: https://blog.wienerlinien.at/erfolgreich-durch-die-nacht/ (accessed on 11/29/2022).
– (2022e). *Fahrpläne, Netzpläne*. URL: http://www.wienerlinien.at/fahrpl%C3%A4ne (accessed on 04/10/2023).
– (2022f). *U-Bahn-Stars*. URL: http://www.wienerlinien.at/u-bahn-stars (accessed on 11/18/2022).
– (2022g). *Kunst bei den Wiener Linien.* URL: http://www.wienerlinien.at/kunst-in-der-ubahn (accessed on 11/18/2022).
– (2022h). *Barrierefreiheit bei den Wiener Linien.* URL: http://www.wienerlinien.at/barrierefreiheit (accessed on 11/27/2022).
– (2022i). Brochure: *Barrierefrei - Selbstbestimmt Durch Die Stadt.*
– (2022j). Automatische Klapprampen in der U-Bahn. URL: http://www.wienerlinien.at/de/barrierefreiheit/automatische-klapprampen (accessed on 11/27/2022).
– (2022k). *Ihr Fahrrad in der U-Bahn.* www.wienerlinien.at.URL: https://www.wienerlinien.at/eportal3/ep/https%3A%2F%2Fwww.wienerlinien.

at%2Feportal3%2Fep%2FprogramView.do%3FpageTypeId%3D66526%26channelId%3D-55059%26programId%3D82186 (accessed on 12/01/2022).

– (2022l). *Weltneuheit: Testbetrieb unseres Gebärden-Avatars Iris startet.* URL: http://www.wienerlinien.at/news/weltneuheit-testbetrieb-unseres-geb%C3%A4rdenavatars-iris-startet (accessed on 11/27/2022).

– (2022m). *Stressfrei unterwegs mit dem Kinderwagen*. Wiener Linien Unternehmensblog. URL: https://blog.wienerlinien.at/unterwegs-mit-dem-kinderwagen/ (accessed on 11/27/2022).

WKO (2022). *FAQ's Barrierefreiheit*. URL: https://www.wko.at/service/unternehmensfuehrung-finanzierung-foerderungen/FAQ-s-Barrierefreiheit.html (accessed on 03/29/2022).

Appendix

Consent form - English

Inclusive Design within the Metro System of Vienna and Copenhagen

Copenhagen July 2022

Information about your participation

- Before the go-along there will be an introduction including general questions about your person.
- Afterwards we will ask you to walk a certain route through Frederiksberg station, during this process you will be accompanied by an interviewer.
- We would ask you to share positive and negative experiences concerning the built environment while walking through the station.
- This go-along interview will be filmed and/or sound recorded in order to document the conversation.
- With your consent, data collected during your participation will be used for scientific purposes and publication as part of a master thesis (video recordings, sound recordings and background info). The data will be stored until the master thesis is finished (expected September 2022). After that the data will be deleted. All will be carried out according to GDPR rules and guidelines.
- You can withdraw your participation in the study or have certain identifying data withheld from research publications at any time without further explanation by contacting Yasmin Haase (exxxxxxx@student.tuwien.ac.at).

Consent Form

Research study by Research Unit of Transport Planning and Traffic Engineering, Technical University of Vienna

I hereby agree to voluntarily participate in the research being undertaken. I have been informed that the consent to participate can be revoked at anytime or that I can have certain identifying data withheld from research publications by contacting Yasmin Haase.

I give permission to do video recordings with a video camera while I walk through Frederiksberg station… ☐ **Yes** ☐ **No**

I give permission to do sound recordings with a dictaphone while I walk through Frederiksberg station… ☐ **Yes** ☐ **No**

… and for such data to be re-produced and used for research publications and presentations.
☐ **Yes** ☐ **No**

Signature: _____ Participant ID: _____

Date: _____ / _____ / _____

Photo documentation - Frederiksberg station

Figure 119: Entrance 1

Figure 120: Entrance 2

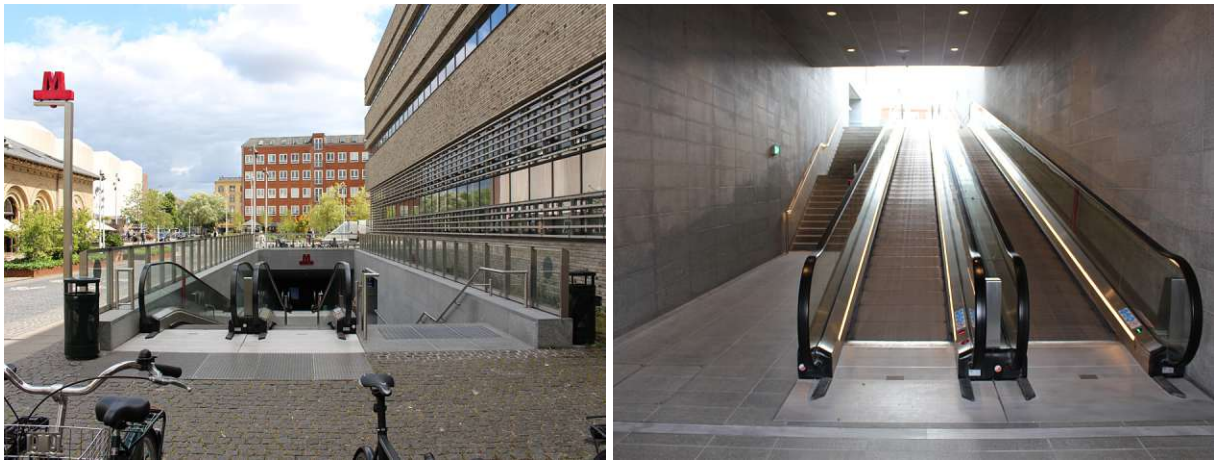


Figure 121: Entrance 3

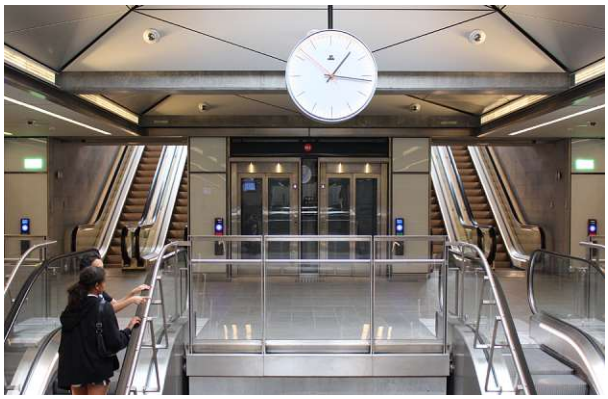



Figure 122: Entrance 4

Figure 123: Entrance 5


Figure 124: Glass door on passage level

Figure 125: Glass door on entrance level

Figure 126: Handrail on entrance level

Figure 127: Handrail on passage level

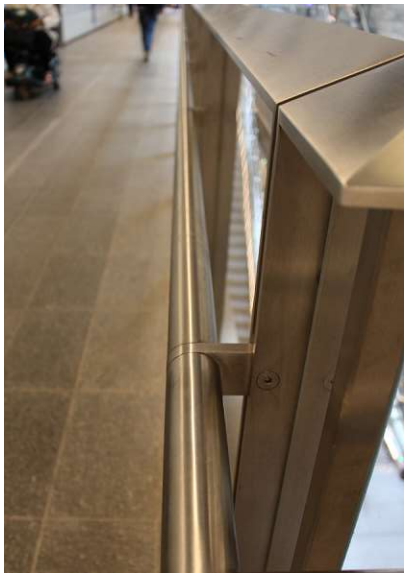


Figure 128: Handrail detail on passage level

Figure 129: Door frame on passage level

Figure 130: Escalator detail

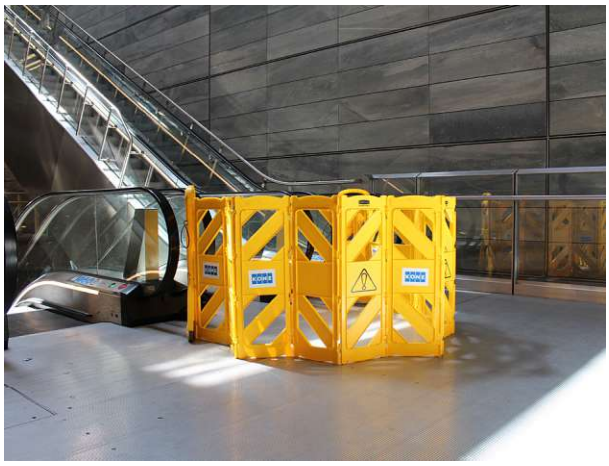


Figure 131: Escalator during maintenance

Figure 132: Escalator as emergency exit

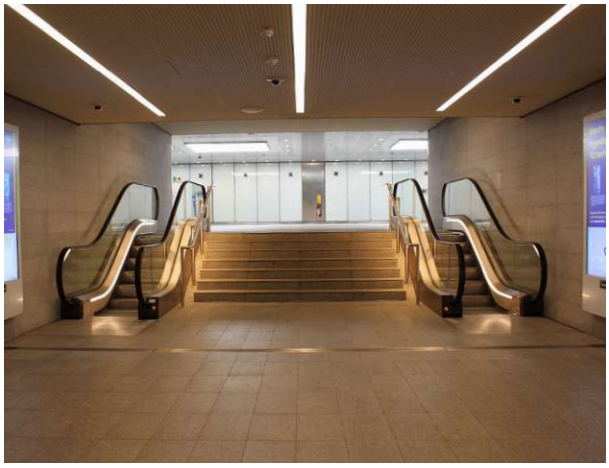


Figure 133: Passage levels

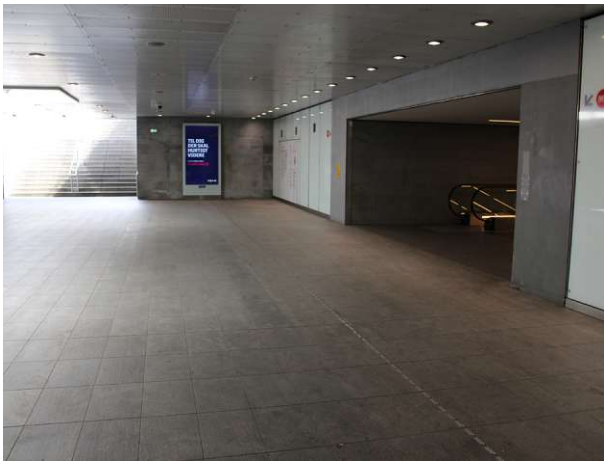


Figure 134: Missing TWSI connection old part and new part of the station

Figure 135: Distance TWSIs to obstacles

Figure 136: TWSIs and escalator connection

Figure 137: Temporary visual guidance floor

Figure 138: Visual guidance wall and escalator

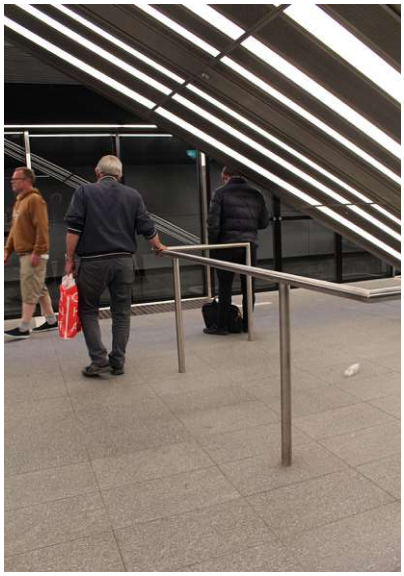


Figure 139: Leaning options on platform M3

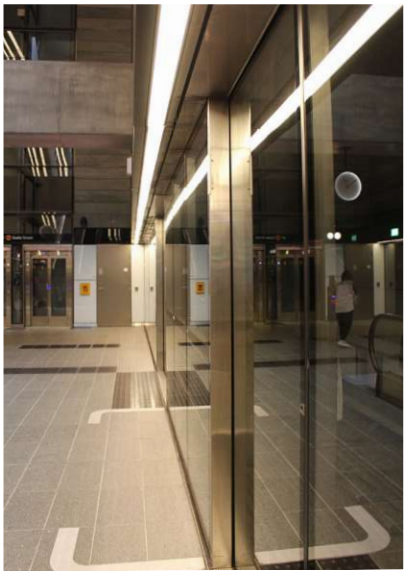


Figure 140: Doors to vehicle on platform M3

Figure 141: Platform M1/M2

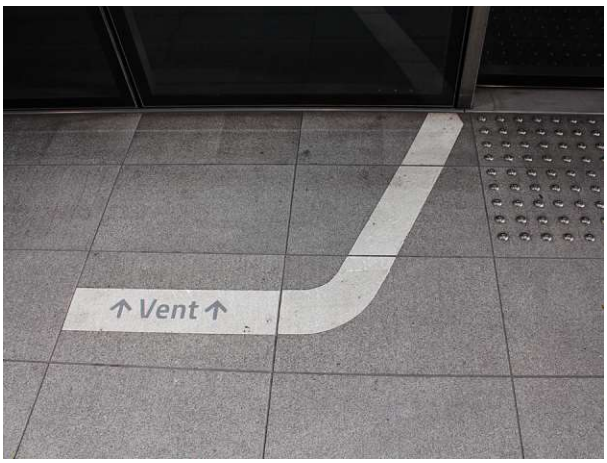


Figure 142: Floor markings platform M1/M2

Figure 143: Operating elements E2 inside and E1 outside

Figure 144: Operating elements elevator platform M3 outside

Figure 145: Elevators and operating elements inside on platform M3

Figure 146: Comparison doors to vehicle platform M1/M2 and M3

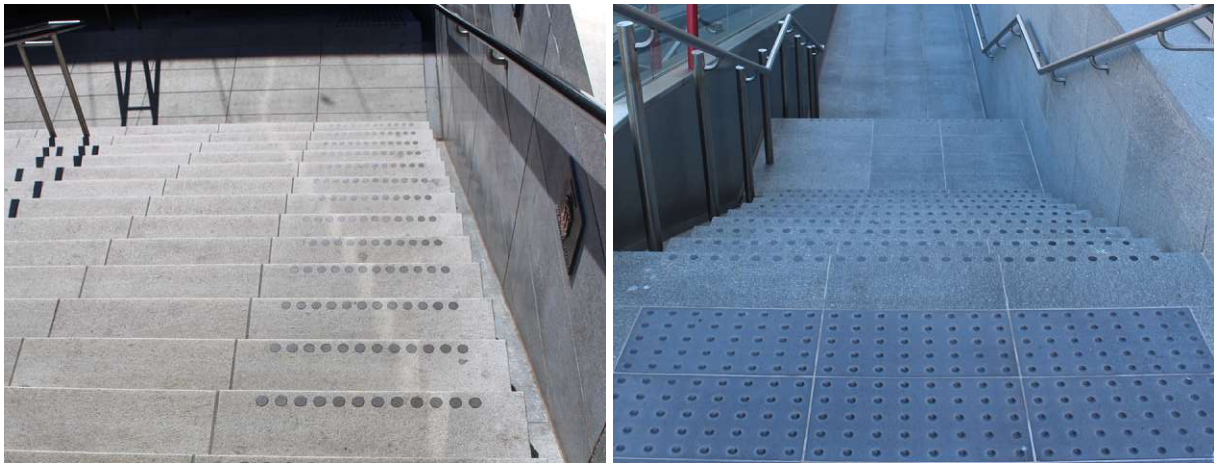


Figure 147: Comparison stair markings old and new part of the station

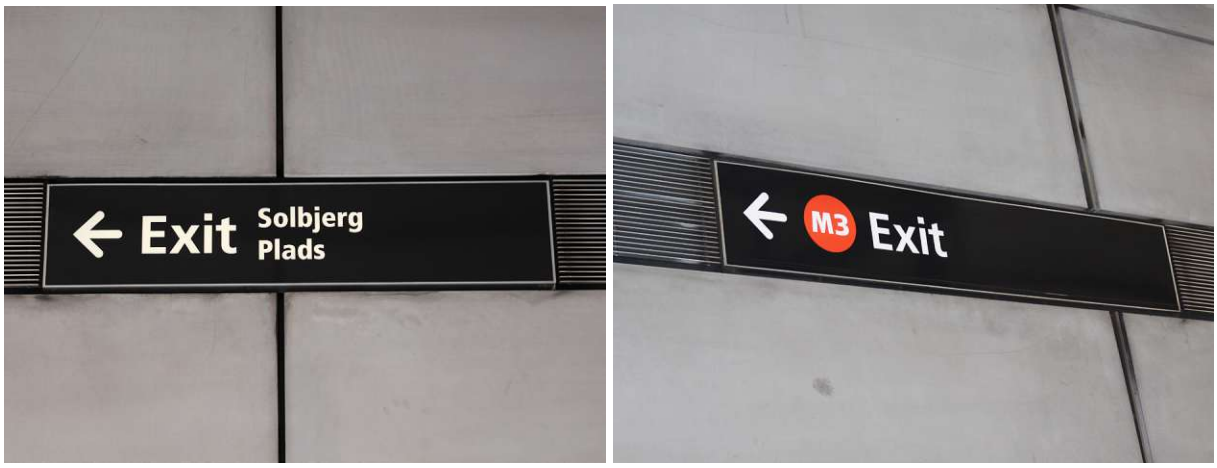


Figure 148: Exit signage with and without details

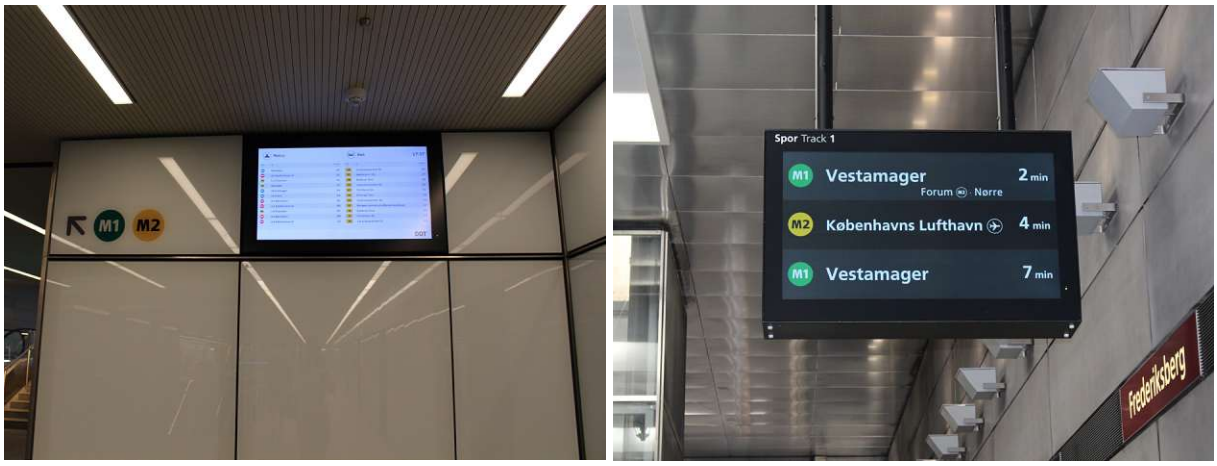


Figure 149: Monitor on passage level and platform M1/M2

Figure 150: Ticket vending machines in higher and lower height

Figure 151: Check-in pole

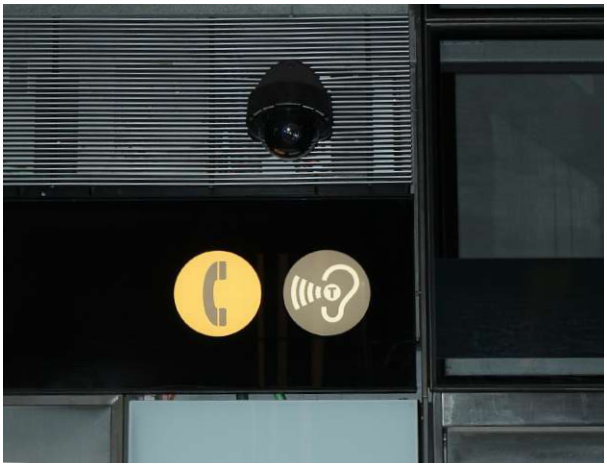


Figure 152: Audion induction loop

Figure 153: Platform numbers at platform M1/M2 and platform M3

Photo documentation - Längenfeldgasse station

Figure 154: Entrance building (1) Längenfeldgasse and (2) Storchensteg

Figure 155: Entrance building 2 TWSIs outside

Figure 156: Entrance building 1 restaurant

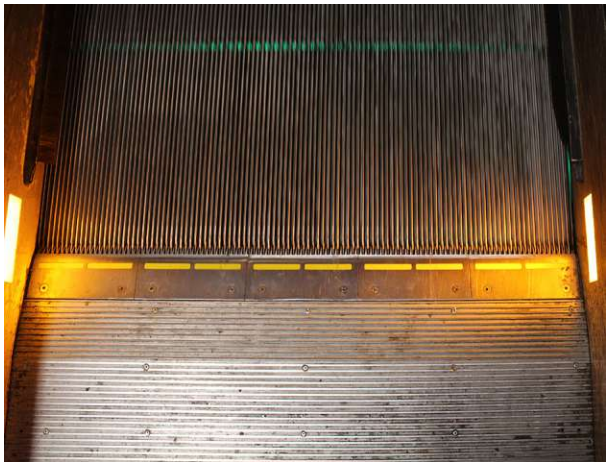
Figure 157: Entrance building 2 detail inside

Figure 158: Entrance building 2 detail construction work

Figure 159: Entrance building 2 elevator E6 outside and E5 inside

Figure 160: Platforms overview

Figure 161: Connection platform to entrance building 1



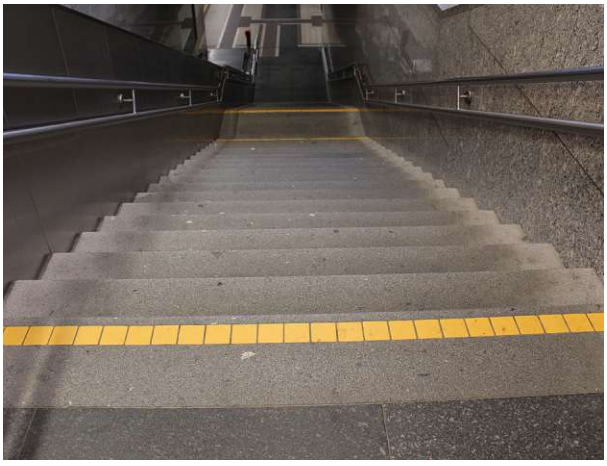


Figure 162: Marking of escalator and stairs

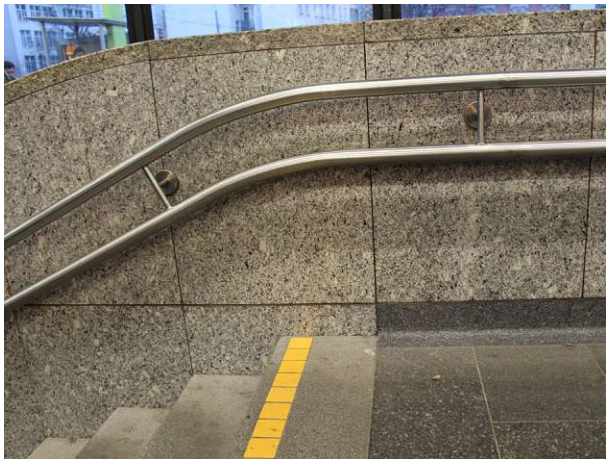


Figure 163: Handrail detail

Figure 164: Visual guidance above tracks

Figure 165: Visual guidance across platform

Figure 166: Monitor track 2 - U4

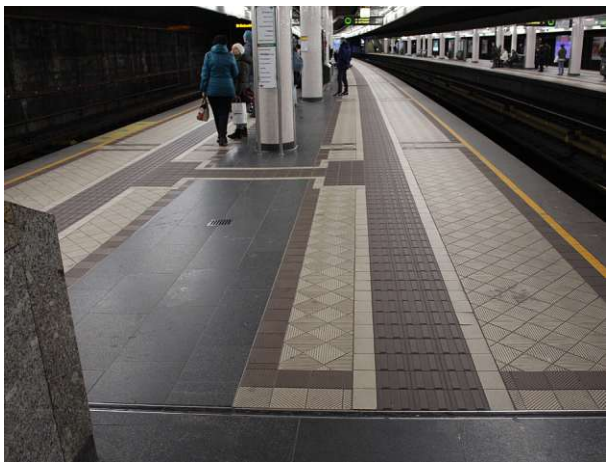


Figure 167: Connection elevator and TWSIs

Figure 168: TWSI detail

Figure 169: Comparison entrance vehicle U4 and vehicle U6

Figure 170: Ticket vending machines

Figure 171: Seatings

Figure 172: Trash cans on platform level

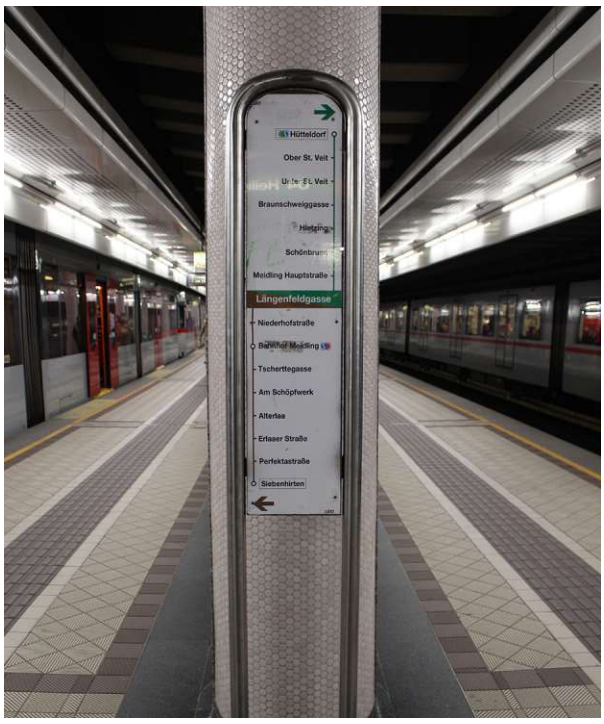


Figure 173: Visual guidance on platform level