Diploma Thesis

Passenger requirements and behaviour in metro systems

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Vienna, May 2025 ____________________ Markus Haferl, BSc

Dedication

I would like to dedicate this thesis to all those who have supported and guided me throughout my degree programme.

First and foremost, I am deeply grateful to my supervisor **Bernhard Rüger**, for his continuous support during my master's thesis and for involving me in the *NEXUS* project, though I gained invaluable insights into international project management.

Special thanks go to my second supervisor **Takeru Shibayama**, which guidance was instrumental in implementing the survey, which is a crucial part of this thesis. I am also thankful for every meeting we had, where I learned how to better organize tasks and approach complex challenges.

Moreover, I want to thank all my colleagues at the *Research Unit of Track-Bound Transportation Systems* for their constant support and for creating an environment where I truly enjoyed working.

This thesis is also dedicated to my parents, whose encouragement throughout my entire studies made it possible for me to fully focus on my education. I am especially thankful for my father, whose profound knowledge of civil engineering was a reliable source of inspiration and support.

Last but not least, I want to thank my fellow students and friends at university. Together me mastered every tough exam and supported each other through countless long days of studying – an experience I will always treasure.

Abstract

This thesis explores passenger requirements and behaviour on key aspects of metro travel, with focus on future-oriented developments such as metro automation, platform distribution control, positioning of (real-time) information screens on the platform and preferred seating and sitting positions in the vehicle. Combining quantitative and qualitative methods, the study aims to understand both the requirement of passengers and their actual behaviour in the public transport.

A structured survey (n=899) was conducted among passengers researching acceptance of automatic metros, influence of real-time information systems on the travel habits, sense of security on the platforms and the positioning behaviour inside the carriage. Additionally, qualitative insights were gathered through expert interviews with professionals from transport operators and research institutions in German-speaking countries. The analysis included descriptive and inferential statistics, such as ANOVA and Chi-Squared tests, as well as thematic interpretation of open responses and interview data.

The findings indicate a strong demand for clear and situationally relevant information, particularly in unfamiliar or disrupted travel context. Passengers expressed a desire for communication that goes beyond standard announcements, favouring context sensitive updates that support real-time decision-making, such as crowding levels and delays. Platform distributions and crowding were identified as key factors influencing perceived safety and comfort. Respondents emphasized the importance of even passenger flow across the platform and within trains, noting that crowded entrance areas and unclear boarding procedures can lead to discomfort, longer dwell times and safety concerns. While automation is generally accepted, it is often met with scepticism when they lack clear information about the safety systems and operational procedures of automated metros. Preferences and expectations vary significantly across demographic groups, highlighting the importance of inclusive communication and design strategies.

This thesis concludes with recommendations for user-centred transport planning and points several areas for future research, including behavioural studies and international comparison. Ultimately, the results underline the value of integrating passenger feedback in the ongoing evolution of metro systems.

Table of content

List of Illustration

Index of tables

1. Introduction

1.1. General background and context

In the future the capacity of metros will reach its limits. The contributing factors include urbanisation, efforts to promote public transport for environmental and policy-related reasons, and a shortage of qualified metro drivers. (Currie and Muir, 2017) In order to maintain the capacity and quality of metro operation, passenger distribution has to be optimized, the change-over time has to be reduced, and safety measures have to be increased. The behaviour of passengers and their requirements must be prioritized first, to achieve high quality and efficiency in the metro system. In order to get more acknowledge about the needs and the behaviour of passengers in the metro systems, this thesis researched what specific features passengers want and need to make public transport more efficient.

This thesis accompanies the international project NEXUS. This project is co-funded by the European Union and is one of Europe’s Rail projects and a subsidiary project of HORIZON. Together with 13 partners from seven countries NEXUS is advancing the transformation of Europe's metro systems by integrating adaptability, automation and AI-powered optimization through three interconnected workspaces to improve efficiency, sustainability and stakeholder engagement.

1.2. Problem statement

Studies had shown that the needs and behaviour of passengers have a significant influence of passenger times and the utilisation of various areas in the vehicle and the platform. (Luca *et al.*, 2024) Inadequately planned metro concepts can lead to capacity bottlenecks. The utilisation of the metro system depends on the interaction between platform and carriages designs. Entrances and exits that are always positioned next to the same metro wagons on a metro line led to a poor distribution of passengers. Advanced real-time information systems can depict the utilizations of each carriage to lead passengers to area that are not that crowded and utilized.

First of all, a better designed and organised metro system, will improve the passenger flow and decrease the dwell time. Therefore, the headways between trains can be reduced and crowding and the density of passengers in the metro system can be reduced. The decease of the utilization will have an impact on the comfort of passengers, because too close physical contact causes discomfort and stress for the person.

In the process of digitalization, the degree of automation of the metros is being increased. The main advantages of automatic metro systems are shorter intervals, extended operation hours and an improved real-time information. Also, the bottlenecks of qualified metro drivers can be prevented. The consciousness and acceptance of passengers of this automatic driver-less systems have to be investigated. There can be an additional service staff on board which improved the safety of passengers enormously. Furthermore, the safety on the platforms can be ensured, because automatic systems require platform screen doors. A definition and a more precises explanation of platform screen door can be found in the chapter 2.2.1. These construction systems offer an additional barrier between the platform and the track.

1.3. Research objectives and questions

The thesis aims to make metro systems, especially automatic metro systems, more efficient and user-friendly by gaining a deeper understanding of passenger behaviour and their requirements. A key focus is on increasing awareness and acceptance of build trust and encourage usage. Additionally, optimizing passenger distribution on platforms and within vehicles will help to reduce crowding and to maximize the capacity. Enhanced security measures and improved information systems will help to create a safer and more comfortable travel experience. By understanding where passengers prefer to sit or stand, designers can improve the trains' interior to make it more comfortable and easier to move around it.

Research question: What requirements and behaviour do passengers have of the metro systems to improve the efficiency, capacity, the comfort, and safety with particular focus on awareness of automatic metros, passenger distribution, improved information systems and a better vehicle interior design?

1.4. Methodology overview

In order to accomplish the research question of requirements and behaviour of passengers in metro systems a quantitative and a qualitative methodology was elected. For the quantitative methodology a survey was chosen as an instrument. This survey contains 19 questions and was spread in two different cities in Europe and on diverse social media platforms and newsletters. The survey is divided into four core topics, which are acceptance and benefits of automatic metro systems, distribution on the platform, information systems on preferred metro layouts.

In order to get more insights of the behaviour of passengers, five expert interviews were conducted.

Elisabeth Oberzaucher, a behavioural biologist at the University of Vienna, provided insights into human movement, spatial behaviour and group dynamics. Her expertise helped contextualise survey results regarding behaviour on the platform and in the vehicle. The interview focused on interior design, platform distribution and automatic metro systems.

Markus Geist from SBB contributed knowledge based on numerous passengers' survey conducted in Switzerland. The interview focused on vehicle interior and passenger information systems, supporting the practical perspective of passenger expectations.

Julian Fordon shared his experience with the "IdeenZug" concept of Deutsche Bahn, which includes innovative seating options and integrated information displays. The discussion focused on customer experience, interior solutions, and guidance systems. His input helped illustrate how experimental train design can address evolving passenger needs.

Tobias Fiebag combined academic and practical experience in train interior design, particularly regarding the suburban train in Munich of Deutsche Bahn. The interview centred on interior layouts and information systems, with a special focus on the alignment between theoretical planning and practical implementation.

Sarah Fessl, who is works in Costumer experience at ÖBB, provided insights into customer-oriented interior design, including family and relaxation zones in trains. Also, information systems inside and outside the vehicle were discussed to improve the distribution of passengers.

1.5. Thesis structure overview

This master's thesis is divided into six chapters.

Chapter 2 provides an overview of current research on passenger requirements and behaviour, focusing on automatic metro systems, platform screen doors, passenger distribution, carriage design and their impact on dwell time.

Chapter 3 describes the methodology, including a passenger survey conducted in two European cities and numerous online channels and expert interviews to better understand passenger behaviour.

Chapter 4 presents the results of the survey and expert interviews. The results of the survey are divided into four sub-chapters.

Chapters 5 and 6 discuss the results, highlight practical implications and limitations, and make suggestions for future research, particularly in the areas of metro automation and real-time information systems.

2. Theoretical fundamentals

2.1. Metro automation

2.1.1. Definition and level of automation:

Automation refers to the process of using technology to perform tasks without direct human intervention. An automatic metro is a metro system that operates with little or no human intervention. These systems include an automatic train operation that controls train acceleration, braking and speed, door closure and operation in the event of disruptions. The system can also be controlled external and prevent different aspects of safety. There is a range of systems with different grades of automation. These grades of automation can be classified into five levels (GoA 0 to GoA 4) based on how developed the degree of automation is. (Marinov and Shinde, 2023)

Grad of Automation 0 is a basic, on-sight train operation, in which a train driver manually operated a tram on the street.

Grad of Automation 1 is a system where the driver controls starting and stopping of the ride, is responsible for the door closure and is responding in case of emergencies.

Grad of Automation 2 is a semi-automatic train operation, where starting and stopping is automated, but the driver still operates the doors, can control the train if it is needed and handles emergencies. This system is the most used level of automation today.

Grad of Automation 3 is also an automated system, where starting and stopping are automated. In this system a train attendant operates the doors and could drive the train in case of emergencies. This metro has a driver cabin.

Grad of Automation 4 this system is fully automated and monitored remotely. There is no on-train staff to handles emergencies and the doors closure is controlled from an operating centre. (Alstom, 2025)

Table 1: Grade of automation of metros (Alstom, n.d.); (Marinov & Shinde, 2023)

Grade of automa-tion	Type of train operation	Setting train in motion	Driving+ stopping	Door closure	Operating in event of disruptions	Examples
GoA 0	No automation	Driver	Driver	Driver	Driver	Tramway
GoA 1	Automatic train protection with driver	Driver	Driver	Driver	Driver	Vienna; Berlin (U6, U7); Rom (Line B, C)
GoA 2	Automatic train protection and automatic train operation with drivers	Driver / Automatic	Automatic	Driver	Driver	Paris –Line 4; London Victoria line; Madrid Line 10; Berlin U5; Vienna U2
GoA 3	Driverless train operation	Automatic	Automatic	Automatic / Attendant	Attendant	Barcelona Line 9; London Docklands Light Railway
GoA 4	Unattended train operation	Automatic	Automatic	Automatic	Automatic	Paris Line 1,14; Copenhagen; Milano (M5)

2.1.2. Benefits

Within the next 5 year it is expected that fully automated metro systems will become the most common mode of metro operation. The first implementation has been made 35 years ago and now over 1000 km of metro are operated automatically around the world every day. In order to better illustrate this figure, one quarter of the world's metros have at least one fully automated line and 7 % of the total metro infrastructure is operated automatically. The benefits of automatic metro systems are not only advantages from the perspective of a metro operator. A conversion of the existing system into automated metros particularly benefits passengers and the society as a whole. (UITP, 2019)

The fundamental advantages of metro automation for passengers can be divided into 5 core topics:

Mobility: The automatic system can increase capacity by reducing train headways through more efficient driving, optimizing speed curves, and maintaining consistent dwell times. These improvements increase the capacity up to a 30%. The safety measures of the platform screen doors, minimize the operational disruptions and ensure a higher service availability. Due to higher personnel costs at night, full metro automation can make off-peak operations, especially during the night, more affordable and lead to shorter intervals. Furthermore, passengers benefit from shorter waiting times and a better service consistency, leading to more satisfaction and a higher comfort to use the metro. (UITP, 2019)

Safety: Full metro automation requires an additional equipment of platform screen doors, which have an implemented intrusion detection system. These facilities prevent accidents on the platforms and decrease suicide attempts. The system has been in use for 35 years and ensures a higher safety record with zero fatalities and removes risks like signals passed at danger and over-speeding. In case of an incident automated systems allow faster responses, such as remote train rescues and system redundancy, which ensures a more robust and resilient metro network. In addition, a smoother train ride the speed curves can be optimized, which minimize passenger injuries inside the train. (UITP, 2019)

Affordability: Although the infrastructure costs of automatic metro systems are higher, long-term economic benefits include reduced material and labour costs, as well as lower operating expenses. Additionally, there are increased revenues due to fewer disruptions and more ticket validations, energy savings from more economical driving, and improved operational efficiency. (UITP, 2019)

Ecology: In comparison to conservative metro systems, automatic metro systems can reduce energy consumption up to 30%. The main reasons are more environmentally friendly driving pattern and maximizing the impact of regenerative braking. Due to an optimized information system and automated coupling the train length can be adapted to move just as many wagons as needed. (UITP, 2019)

Humanity: Since metro drivers are not required anymore to operate the automatic metro systems, there is more personnel capacity for face-to-face customer assistance. The staff will be in the train with the passengers to have faster interventions with small asset failures, improve the cleanliness in the vehicles and acts as additional security staff. The passengers will feel safer and more comfortable during their ride. Staff on the train can also help passengers to feel safer during the adaptation phase of the automatic metro if the metro is controlled automatically (UITP, 2019)

Another factor that is crucial for the implementation of automatic metro systems, is the labour shortage, which especially in Europe is a big problem to secure the capacity in the metro system. Due to a large number of retirements, an increase in train running times and a declining interest in the profession as a metro driver, it's a difficulty to hire and retain skilled metro drivers. Automation ensures a denser timetable, reducing dependency on human operators. (Public Transport and Shared Mobility EGUM Subgroup, 2022)

In order to show the improvements of automatic metro systems a simulation was conducted including moving block signalling. The capacity of the Tyne and Wear Metro in the United Kingdom could be extended from 20 to 30 trains per hour. Low adhesion conditions such as wet or slippery tracks reduce capacity improvements just to 23 trains per hour. A more consistent driving profile reduces travel times by up to 8% but slightly increase the energy consumption. This can be attributed to frequent acceleration and deceleration because of shorter dwell time and a higher average speed. An optimized passenger flow management must be developed to minimize change-over time. Solutions such as real-time crowd monitoring platform screen doors and optimized train door layout help to manage boarding efficiency, avoiding to much acceleration and unnecessary delays.(Powell *et al.*, 2016)

2.1.3. Acceptance

An implementation of a new system requires the acceptance of passengers. Through to missing knowledge about safety and the operation of automatic metro systems, person may feel insecure in a vehicle, that is not controlled by a human. A survey published in Sydney, Australia in 2016 by Fraszczyk and Mulley (2017) aimed to gather insights on how people felt about the planned changes of the metro system. At this time Australia didn't have an automated metro system, but one was scheduled to be introduced in 2019.

The results of the survey are divided by train users in Sydney and non-users. The significant difference was that less people that use a metro system had required a driver in the train to feel safe. On one hand, 43 % of metro users answered, “very important” when they were asked to “How would you rate the importance of a driver on a train?” In the other hand non-users voted 71 % “very important” to the same question. The most important benefits to the respondents were “reduced ticket pricing”, “extended running periods” and “increased train frequency”. After elaborating the survey information campaigns were recommended to educate passengers about safety, reliability and benefits such as increased frequency and lower fares. Also the driver’s cab retained in the new vehicles to change the system step-by-step. (Fraszczyk and Mulley, 2017) The survey has been carried out almost 10 years ago. The technological progress and the acceptance of automated systems increased. In the following survey similar questions had been asked to passenger in European cities to know more about their awareness of their current system and their acceptance of an implementation of a driverless metro.

2.1.3.1. Retraining of metro drivers

Also, the acceptance of metro drivers has to be considered. Automatic metro systems will replace these drivers’ jobs. To keep these high-qualified employees within the company, a concept has to be developed to retrain them. As metro drivers have much experience with incidents in the metro operation, they have knowledge that is really important in case of failures and accidents in the system. Current metro drivers can diagnose malfunctions in signalling, braking or power systems and take manual control during accidents and failures. Also, during the implementation they could provide their knowledge to identify anomalies in train behaviour or systems performance. The safety of passengers could be rise enormously if metro staff could be present in the vehicle during the ride to ensure passenger safety evacuation or emergency situations and to have a quicker communication with the control centre. (Song *et al.*, 2024)

2.2. Platform screen doors

2.2.1. Definition, benefits, and drawbacks

Platform screen doors are sliding barrier doors installed at the edges of stations platforms between the moving trains and the waiting passengers on the platform.

They consist of fixed panels and motorized sliding doors that open and close in synchronization with the train doors. The Platform Screen Door system includes several key components. Fixed panels are continuous barriers between the track and the platform. The sliding doors operate with motorized mechanisms to open and close the doors at the same time as the vehicle doors. Various safety mechanisms ensure that obstructions are detected, and the door movements are safely executed. More detail about this detection is explained in the section 2.2.2.1. (JICA Study Team, 2025)

This installation is classified into two types. The first type consists of full-height elements that extend from the station floor to the ceiling. An example can be seen in Figure 1. The second type is full-train-height, that reaches the height of the train but does not extend to the ceiling. Both types are integrated into metro systems to synchronize with train door operations, preventing unauthorized access to the tracks while improving the passenger flows. (Abdurrahman, Jack and Schmid, 2018)

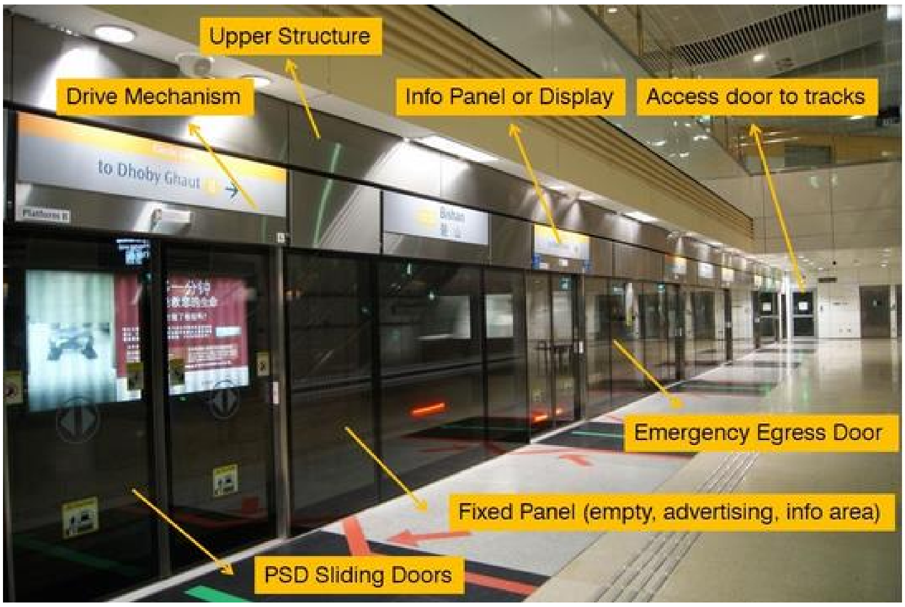

Figure 1: Platform screen door with features (Railsystem, 2025)

The main benefits of platform screen doors are suicide prevention, optimisation of station energy consumption and safety. In addition, the quality of stay for passengers can be improved due to platform noise mitigation and air quality improvement. One the other side platform screen doors have also negative impacts on the system, such as extended dwell times, an increased risk of mantrap and can have a negative influence on the emergency evacuation periods. (Abdurrahman, Jack and Schmid, 2018)

2.2.2. Safety prevention of platform screen doors

The most common and serious health problem in railway settings is suicide. Approximately 85% of all deaths in the rail bound systems are caused by suicide attempts. Suicidal behaviours are not the only cause of unauthorized trespassing into the track area. Other motives are taking a short cut, thrill seeking, vandalism, theft and urinating. The most researched measure to prevent passengers from the rails is the use of platform screen doors. (Fredin-Knutzén *et al.*, 2024)

Installed PSD reduce the service disruption due to passenger accidents associated with intrusion on the track. Data from Hong Kong of the year 2000 has shown, that after the retrofitting of PSD the lost operational time due to passenger intrusion could be decreased to 0.75 minutes a day and the lost operational time due to objects falling on tracks could be decreased to 0.075 minutes a day. Suicides were prevented in many cases. (Law and Yip, 2011)

A study in Seoul, South Korea also found that Platform Screen Doors reduced the number of suicides at 89%. Half-height PSDs, which do not extend to the ceiling of the platform, were not as effective as full-height ones, which eliminated metro suicides completely by blocking access to the track area. (Chung *et al.*, 2016)

The additional safety benefit and separation between platform and the track has also a positive impact on the operation and availability of train service. (Law and Yip, 2011)

2.2.2.1. Foreign Object detection between PDSs and metro doors

For the detection of foreign objects between Platform Screen Doors and metro train doors, computer vision techniques with deep learning are used. By using traditional detection methods, such as laser sensors and infrared light curtains, hundreds of incidents were reported yearly in which foreign objects get trapped between doors using. Liu et al. (2019) investigated deep learning-based foreign object detection systems in a study in China. This system has an accuracy of 98,4%. The dataset includes 164 images, which are categorized into seven classes (e.g., bag, bottle, plastic bag, umbrella, person) and 984 image augmented techniques, such as flipping, cropping and brightness adjustments were applied. The implementation of deep learning-based object detection reduces the need for manual monitoring and improving both safety and operational efficiency in metro stations. (Liu *et al.*, 2019)

2.2.3. Platform screen door and dwell time:

The influence of platform screen doors on the dwell time has positive as well as negative effects, that must be weighed against each other. Generally, platform doors have a net negative impact on dwell times, taking between 4 and 15 seconds of extra time per station stop. The reasons are larger doors, that have to be opened and closed, slower passenger movements due to the additional distance between platforms and trains and a slower breaking process of the vehicle. The main time factor is that after closing both sets of doors it has to be ensured that no one is trapped in the gap between these two sets of doors. PSD have also benefits on the metro operation, because of safety aspects and less interruptions. (Barron *et al.*, 2018)

The door closing process of platform screen doors depends on static and dynamic components. The static component is the time, it takes from a complete stop of the train to a complete opening of the doors. As well as the time taken from the door closure initiation to the complete closure. The dynamic part refers to the time taken for the actual boarding and alighting process. (Abdurrahman, Jack and Schmid, 2018)

Experimental results from the Pedestrian Accessibility Movement Environmental Laboratory (PAMELA) showed that PSD slightly reduced boarding and alighting time by about 1.4 seconds. One factor was the different behaviour of passenger, which queued beside doors rather than blocking the platform for alighting passengers. Also due to smaller vertical gaps between the platform and the vehicle, the passenger change-over time can be decreased. (Seriani, 2016)

2.2.3.1. Media function:

Platform screen doors bring an additional surface for passenger information screens. These screens can be fitted above the doors. Above all real-time information such as train arrival times, malfunctions of the vehicle doors and the capacity utilization of separate carriages can be displayed. (Abdurrahman, Jack and Schmid, 2018)

2.2.3.2. Influence on the accessibility:

The gap closer function facilitates the access for mobility-challenged passengers and can reduce the risk of tripping. This function helps bridging the horizontal gap between the platform edge and the train. The gap closer makes a bridge between the platform and the vehicle. It slides back into the doorframe while the doors are closing, so they don't have an impact on the train movement. (Abdurrahman, Jack and Schmid, 2018)

In conclusion it can be stated that the dwell time of metro systems with platform screen door tends to increase. However, improvements, such as a better distribution on platforms through real-time information systems and a more organised alighting process, facilitated by queuing systems and floor markings can help minimize the negative effects on the dwell time.

2.3. Passenger distribution on platforms

In order to maintain and even expand the systems' capacities, it has to be identified which factors do have an influence on the distribution of passengers on platforms to decrease the dwell time and to reduce the headway between trains. The influence of the passengers' choice of carriage at boarding at the metro platform has to be considered, to optimize the system. This has a huge impact on the operation of trains but also improve the comfort level of passengers in the carriage. An important role is played by the number of platform screen doors, the number of platform stairway entrances and the layout design of the vehicles. Also, the position of entrances in metro stations influences the capacity utilization of the vehicle. (Ding *et al.*, 2021) Through to new information systems the distribution on the platform can be influenced by communicating the passenger which sequence and wagon of the train is less utilized. Following the influence of the infrastructure and information systems will be examined in more detail.

2.3.1. Influence of infrastructure – Station entrances and exits locations

A crucial factor on the distribution of passengers is the position of station entrances and exits. Regular metro users may take into consideration the position of the platform exit at their destination station. They may know which wagons are usually more crowded than others, so that they place themselves where they expect less crowded wagons to stop and to have the possibility to sit. When there is no time to walk along the platform, because the metro will arrive shortly or the platform is too crowded to move, they will board at the door close to the platform entrance. Not frequent users stay near the station entrance to avoid additional walking on the platform.

A study analysed the influence of the access points on the distribution of passengers with a multinomial probability distribution in Toronto, Canada in 2012. The highest concentration of passengers was at the door next to the station entrance. The distribution of alighting passengers is more even, but still concentrated on the doors near the station exits. The modelling confirmed that passengers naturally spread out in a way that required the least physical effort, especially in routes to entrances and exits. The problem can be reduced with multiple strategically placed entrances and exits. Ground signage and digital information can motivate passengers to head for less-used carriages. (Krstanoski, 2014)

An additional study was conducted by Eigner (2014). He investigated the distribution of passengers on different platforms with differently positioned entrances and exits in metro stations in Vienna. The essential finding was, that the position of entrances and exits on a metro platform have a crucial impact on the distribution of the people on the platform. The uneven distribution continues to affect the distribution in the vehicle and the distribution on the alighting of the passengers. The direction of access from infrastructure facilities such as stairs and escalators influence the flow of people. The position of these access facilities determines the flow of people, because the direction in which the people are distributed is determined by these. Entrances and exits that are central on the platform divides the passenger flow in two directions, whereby exits and entrances on the side of the platform just generates only one direction in the passenger flow. The direction of entrances and exits also plays a role in the last-minute door-rushing, because people tend to use the closest door on the platform. If a platform has only one entrance, all passengers tend to gather near the same train door. When many people try to hold the door open to avoid missing the train, this delays the train's departure — which increases the waiting time at the platform. The uneven distribution on the platform impacts other people that want to pass by. Especially at platforms with entrances and exits at the end of the platform, passengers are prevented to pass by, which increase the uneven distribution even more. At a waiting time of more than three minutes passengers, who use the metro frequently, place themselves on the position of the platform, where they have the closest way to the exit at their final destination. In case the exits of the most crowded destinations are positioned at the same metro doors, the distribution is becoming worse. It is suggested that more entrances and exits have to be build and direct transfer options must be established in terms of infrastructure in order to have a balanced distribution on the platform. (Eigner, 2014)

2.3.2. Information systems on platforms

2.3.2.1. Digital real-time information systems

Real-time passenger information systems can help to influence passenger distribution along the platform and within train carriages to decrease congestion. The main features of these systems are real-time arrival and departure updates, occupancy levels to guide passengers towards less crowded sections. Also, multimodal transport connections, including transfer options between different services can be displayed and accessibility will be expanded.

The passenger information systems can be classified into station-based, onboard and mobile systems. Station-based systems are usually large digital displays on platforms that show arrival times, route maps and service changes. For impaired people also audio announcements can be conducted. Onboard systems should inform passengers about upcoming stops, real-time route progress and transfer options. Mobile systems can provide live updates on schedules, seat availability and alternative routes (Monzert, 2020).

2.3.2.2. Influence of real-time information systems on the behaviour of passengers

In 2016, the University of Queensland in Australia analysed the influence of personnel information systems (PIS) on platform distribution. This study was accompanied by a survey and a simulation. 77% of respondents found the introduction of information systems that indicating the occupancy rate of individual carriages helpful, and 87% indicated that they would use these systems to access under-utilised areas. The preference of the individual information systems was listed after according to the order: Platform display, mobile phone and audio announcement.

Three scenarios were tested in the simulation. In scenario 1, passengers boarded at the closest vehicle door. In Scenario 2, specific doors were designed to improve the boarding and alighting flow. In Scenario 3, a platform information system was installed to show the utilisation of the individual carriages. Scenario 3 had the best result, as it best distributed the passengers on the platform. Without the information systems, passengers chose the closest door. Scenario 2, which had specific separate doors for boarding and alighting, had the highest dwell time. (Ahn *et al.*, 2016).

In 2021, Yu et al. conducted a study in China to investigate how monetary incentives could influence passenger distribution on metro platforms. Passengers were offered a partial refund of their fare if they moved to a less crowded area of the platform. On a real-time information screen, they could see which parts of the metro are less utilized and the screen depict them, how much percentage of their ticket price they can get back. A real-time information screen showed which areas of the platform were less crowded, along with the percentage of the fare passengers could get back if they moved to those areas. Special card readers were installed that automatically credited the refund to passengers' metro cards when they boarded from the designated zones. The study tested different scenarios to examine the relationship between fare refunds and passenger behaviour. The metro operator can adjust the refund amount to influence how many people move to the less crowded areas. Therefore, it's important that the fare reduction is not too high to motivate just a certain percentage of passengers to move to this place and not the majority.

The results showed that female, elder and weekend travellers are more sensitive to the discount. Most passengers over 40 years were willing to move at a discount of 10%, while passengers aged under 30 need a discount of up to 40% to motivate them to move. Most female passengers were willing to move at a discount of 30% of their ticket price. The passengers' income does not have a significant impact on the passenger's willingness to move. It can be said that time stress is the main limiting factor on the willingness to move around the platform. The numerical values of discounts separated by age, weekday / weekend and gender are listed in the Table 2.

Table 2: Requested discount for moving to a less crowded area (Yu et al., 2021)

Critical discount value		Age <30 (%)	30 ≤ age ≥40 (%)	Age ≥40 (%)
Weekday	Male	40	24	8
	Female	28	13	0
Weekend	Male	18	3	0
	Female	7	0	0

Due to data policy there have been some limitations in this study. On the metro cards passengers' location and characteristics couldn't be recorded. With the development of electronic tickets on the smartphone, the personal characteristics can be recorded in APPs like Alipay and WeChat. Due to European Data restrictions this study and conduction is not possible in Europe, but it shows that passengers would move to another position on the platform if the utilization would be displayed and which society group is more willing to move. (Yu *et al.*, 2021)

2.3.2.3. Manual passenger information systems

Floor markings: A promising approach to improve boarding efficiency is the strategic use of floor markings. These markings provide passengers with clear visual guidance by designating specific areas for waiting and boarding. It helps to reduce congestion and streamline in the process. These markings signal what is expected from each individual boarder and help shape the behaviour of waiting passengers into a social norm. Floor markings make also clear, if a person follows or breaks the rule. If trains do not stop at the exact same position on the platform, because the level of automatization is not advanced, the floor markings can also be displayed with light stripes that project, where boarders have to wait to not have any interruptions with alighting passengers. (Kodapanakkal *et al.*, 2024).

The floor markings must be clearly recognisable for all passengers. The angle of the boundary lines plays a less important role. In general, it should be clearly indicated in the exit area that it is not permitted to enter this area before the person alighting. This can be indicated by a red stop sign. In the waiting area, symbols of feet are very well understood by passengers. In general, passengers should be able to form a queue. (E. Oberzaucher, personal communication, February 7, 2025)

Posters showing the doors to be favoured: An effective system that is less cost-intensive is the postering of graphics that depict were passengers have to board the carriage to have the minimal distance to their exit station. This system motivates especially not frequent users to change their position at the platform. Through to a heterogeneous positioning of exit escalators and stair on different stations the distribution of passengers should be better balanced. The Figure 2, taken in Tokyo by Takeru Shibayama in 2024 shows a signage system on the platform that clearly indicates where each train carriage will stop. This helps passengers understand the poster's message and distribute themselves more evenly along the platform.

Figure 2: Manual passenger information system in Tokyo (Shibayama, personal communication, 2024)

2.4. Behaviour of passengers inside the train

The choice of seating areas is above all influenced by psychological safety. People tend to choose a position, where they have an overview of their environment and a sufficiently large physical distance to each other.

2.4.1. Psychological aspects

2.4.1.1. Four zones of interpersonal distance

The American psychologist Grandville Hall initiated the study of personal space and how humans use it in social interactions. In 1969 Hall delineated four zones of interpersonal distance that characterize the Western culture. They can be divided as following: intimate (up to 18-inch, 45 cm), personal (18-48 inch, 45 - 120 cm), social (48 inches to 12 feet, 120 cm-360 cm) and public (greater than 12 feet, 360 cm). These zones depend on the cultural background and the individual feelings. The intimate zone is used for close personal relationships, such as partners, family and close friends. In public spaces this distance is usually only tolerated in special circumstances (e.g., crowded metro trains). The personal distance is typical for conversations with friends. This distance provides a comfortable space for interaction without feeling intrusive. The social distance is used for formal and business interaction and is common in workplaces and customer interactions. For public speaking and larger group communication the public distance is recommended. In public transport, people often have to adjust their personal space, which can lead to discomfort or stress. (Hall, 1969)

2.4.1.2. Cultural differences on preferred interpersonal distance

It also has to be considered that the culture of people has a big impact on the interpersonal distance preferences. A study from Sorokowska, Sorokowski and Hilpert (2017) were conducted in 42 different countries to get more acknowledge how the space preferences can be characterized by countries. The climate in a country has an impact on the preferred distances. Hotter climate affects emotional intensity, which is likely related to intense and closer interpersonal contacts. For example, people from Mediterranean societies prefer closer interaction distances than northern countries. Also, the wealth of a region impacts the preferred distances. The poorer a region is, the bigger are the interpersonal distances. This can be attributed to higher inequality, criminality and less social trust in a country.

The study shows that woman prefer greater distances to other people they don't know. Also, older people prefer greater personal and intimate distances compared to younger people. More collectivistic societies generally prefer closer interpersonal distances, while individualistic societies maintain greater distances. The conclusion of this study is that the layout of platforms and vehicles should be adapted to the city, where they are going to drive. Demographic research such as age distribution, climate conditions and the Human Development Index should be considered. (Sorokowska, Sorokowski and Hilpert, 2017)

2.4.2. Preferences for sitting

Riding comfort, seat availability and perceptions of crowding levels are regarded to have significant behavioural impacts. Globally a continuous growth of the population is expected in cities, which puts the capacity of metros at its limits. Additionally, increasing income levels will be assigned to a higher expectation in the quality and comfort features of public transport trips. Users usually prefer standing to sitting, especially for long trips.

In Singapore, a number of commuters were found to be taking the metro in the opposite direction so that they could board a metro in their destination at that platform. Therefore, an investigation has been conducted to determine which additional time driving passengers would take on them to have a seat at their ride. The longer the whole trip of the passengers was the more rather they travelled backward first. The proportion of passengers choosing to travel backward increases with trip distance and passengers are more likely to prefer longer sittings trips over shorter standing trips. The highest proportion of backward travel occurs during the morning peak hours between 6 am and 9 am. (Tirachini *et al.*, 2016)

2.4.2.1. Standing Multiplier

To consider the four zones of interpersonal distance theory of Hall (1969), the density in the vehicle has a crucial role on the comfort of passengers. A standing multiplier factor has been established, to summarise this in figures. This factor represents how much more uncomfortable standing is compared to sitting. Under normal crowding conditions the standing multiplier is between 1.18 and 1.24. The factor rises very sharply to 1.55 when the density of standing passengers is more than three passengers per square meter. This factor now points out that standing is 18-55% more unpleasant than sitting for passengers. The standing multiplier factor in Singapore is lower than in Great Britain (1.4-1.6) and lower than in France (1.1). This variations may be explained by cultural and economic reasons and vehicle design. (Tirachini *et al.*, 2016)

2.4.3. Carriage design features:

2.4.3.1. Sitting preferences in metros

Efficient and passenger-friendly train carriage design is crucial for improving comfort, capacity and overall travel experience. Passenger requirements are often overlooked in the design process. Therefore, a survey, which was conducted among Melbourne, has been conducted to metro train users, asking them about their interior preferences. The majority of frequent metro users was in favour of the idea of having three doors per carriage per side. Although lengthwise sitting offers more aisle space, people preferred the crosswise seats, because it offers more available seats per vehicle. The most popular seating layout was the 2+2 layout. An example of this layout can be seen in Figure 3. Due to the sufficient available seats and the ease of movement in the aisle. (Yang *et al.*, 2022)

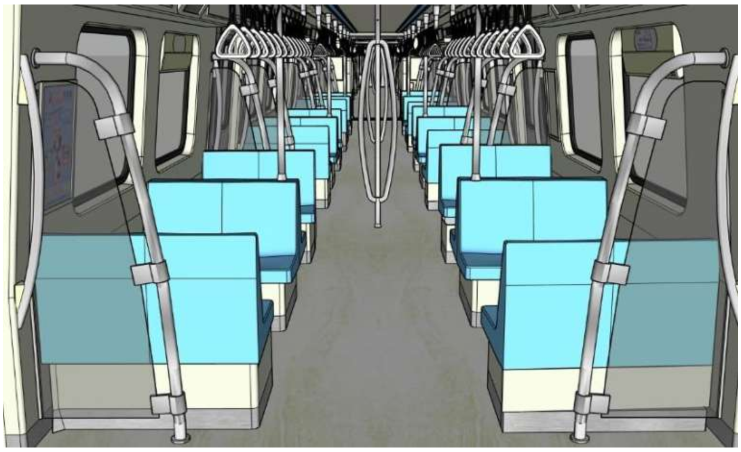

Figure 3: 2+2 seating layout in metros (Da Un Yun, personal communication, 2025)

The study by Wardman and Murphy (2015) provides insights into how passengers perceive different seating arrangements, and the discomfort associated with standing. Passengers do not value all seating layouts equally. The most preferred seating layouts in the metro are 2+2 configurations, especially for passengers traveling in groups. In contrast, 3+3 seating is less desirable in crowded conditions, as middle seats increase direct contact with strangers. Longitudinal seating and flip seats are the least preferred due to their discomfort and lack of privacy. Additionally, seat orientation plays a role, with a slight preference for seats facing the direction of travel.

However, some passengers are willing to stand rather than sit in an undesirable seat. The choice of the seats mainly depends on how crowded the train is. When the train is empty, passengers choose window seats, which provide more privacy and avoid aisle disturbance in 2+2 seating layouts. In crowded situations, aisle seats become more attractive as they allow easier movement and reduce the feeling of being "trapped". In longitudinal layout designs, passengers prefer seats that allows as few other passengers, as possible to sit next to them for example, seats at the end of the row. Especially sitting between two strangers is one of the most disliked scenarios. Often passengers rather stand than taking this middle seat. (Wardman and Murphy, 2015)

Passenger flow is significantly affected by the seat configuration. Layouts that narrow the aisle and passageways can slow down the boarding and alighting process. The reduction of seats near doors creates more space for standing passengers and also motivates them to move further inside the carriage. For crowded metro environments strategically placed handrails and vertical poles provide safety and stability for standing passengers. A practical solution is to use foldable seats, which can adapt to passenger demand, offering seating when space allows and folding away to free up standing room during crowded time. (Thoreau, Holloway and Bansal, no date)

2.4.3.2. Handhold preferences:

The survey in Melbourne also investigated the preferences of handholds, as an interior design element. Especially in crowded situations, where people have to stand during their ride, these elements can influence the distribution of passengers. In order of cultural and customs parameters there are different shapes, sizes and materials used in different cities. The study revealed that vertical poles are the most favoured hand hold type, while flexible handrails are the least preferred. The preference of vertical handrail is influenced with travel time, waiting time and station familiarity, while the rankings on rigid handrails, grab bars and grab rails are more associated with gender. In the most metro vehicles, the vertical poles are positioned near the train doors, which otherwise can influence the passenger flow. This study recommends this handrail elements should also be placed in other areas of the carriage. A majority of 66% of the responders believed that handholds could be better positioned to promote smoother passenger flows. (Yang *et al.*, 2022)

2.4.3.3. Seating preferences in metros with crosswise seating

An investigation conducted by Martin Kubanik has been carried out to get more knowledge, why people choose the position they actually do. The psychological factor and unconscious decisions play a major role in this decision. The examination showed up the activity's passengers did while their ride. Mainly people looked to themselves to a random part of the vehicle or had a social interaction with passengers, which they knew before. Passengers avoided eye contact with other passengers or having calls while the ride. The investigations were conducted in Vienna and Graz with metros and tramways. Metro vehicles in Vienna are primarily equipped with crosswise seating layouts. Each section consists of four 2+2 seats, including one window and one aisle seat, with two seats facing each other. When the neighbouring seat was unoccupied, up to 70% of passengers chose to sit by the window, showing a clear preference for window seats. This percentage decreased about 10% if the vehicle was more crowded. Additionally, seats facing in the direction of travel were preferred to seats facing against the direction of travel. The position of the standing position was mainly influenced by the design of the vehicle. In metros where the seating area was more or less separated to the entrance area, more than 75% of the passengers stayed in the entrance area. This can have a significant impact on the dwell time and change-over times, because the doors are blocked by people in this case. Metro layouts with a less separated flow between seating and entrance areas, tend to offer better distribution throughout the vehicle. (Kubanik, 2017)

2.5. Dwell time and passenger change-over time

Public transport systems worldwide are facing increasing demand due to urbanization and policies promoting sustainable mobility. However, metro systems often struggle with capacity constraints, leading to congestion and operational inefficiencies. One key factor effecting metro performance is dwell time. This is the time a train remains at a station for passengers to board and alight. (Karekla and Tyler, 2012)

There are four main components that have an impact on the boarding and alighting of passengers and the dwell time. It can be categorized into environmental conditions (e.g. the weather), information provided to pedestrians (e.g. maps, on-board displays, on-train announcements), infrastructure (platform, seating options, entrance area) and interaction with other passengers (e.g. crowding, safety). The factor that can't be influenced by metro operators are the environmental conditions. In Chapter 2.3.2, the influence of information services, particularly real-time information displays, is analysed. These systems influences the distribution of passengers and decrease crowding to reduce the time of the boarding and alighting process. (Seriani *et al.*, 2019)

A customized layout of the vehicles can reduce change-over times in the boarding and alighting process. This reduction of dwell times in the station leads to shorter travel times, improve the stability of the timetable and decrease the headway time between trains. The door-closing process, in particular, needs careful analysis. Disruptions, such as delays in door-closing, can significantly affect the overall change-over time. Platform screen doors are an additional factor that have to be examined in the door-closing process. Since there is an additional door passengers have to pass when they enter the metro, the interaction between these doors in case of disruption plays a crucial role in the passenger check-in process. Also, the accessibility of people with impairments must be considered to ensure that public transport is inclusive for all. With adapted measures the boarding and alighting process for people with impairments can be improved. In the following sections, the impact of vehicle and platform layout—along with the human factors involved will be analysed.

2.5.1. Influence of the vehicle and platform design on the dwell time

The factors of the vehicle that can be optimized are door widths, layout design and entrance areas. The width of the doors influences the boarding and alighting process. Wider doors make parallel or offset boarding possible The design of entrance areas near the doors plays a key role in overall metro layout, as large gatherings in these spaces can create bottlenecks. (Zmaritsch, 2017)

To help reduce dwell time, a study by Karekla and Tyler (2012) explored platform - side improvements. They found that reducing the height difference between platform and train improved passenger flow by up to 10%. Based on these findings, they also recommend raising the platform at the boarding positions. In addition, widening the platform helps to have more space on the platform and to better distribute the passenger flow. A widening of rain doors from 1500 mm to 1800 mm can result in a 29% faster boarding and alighting process. A combination of a step height reduction and a widening of doors can reduce the dwell time by up to 37%. (Karekla and Tyler, 2012)

2.5.1.1. Influence of platform screen doors on the dwell time

A significant factor affecting dwell time is that some passengers attempt to board the train at the last moment, just as the doors are about to close. This behaviour can extend dwell time by 1 to 13 seconds, particularly when passengers hold the doors open. If the door-closing process is interrupted, it leads to even further delays, which can result in a total delay of up to 25 seconds. Especially during the peak hours door holding and last-minute rushing is more present, this characterizes a serious issue during peak hours, where the headway time between trains is low. (Kuipers *et al.*, 2021)

Also, the formation of passengers during the boarding process has a big influence on the dwell time. There is an interaction between queue patterns on the station platform and the flow of lanes formed during the boarding and alighting process. These queueing behaviours are influenced by factors such as platform screen doors, which indicate where the train doors will be. This encourages a more organized queuing. Passengers tend to form queues rather parallel to the platform edge than vertical to it. Therefore, platform screen doors bring an additional safety aspect for boarding passengers. (Kuipers *et al.*, 2021)

2.5.2. Influence of the human behaviour on the dwell time

The most important factor that influences the change-over time is the interaction between passengers. When crowd density exceeds two passengers per square meter, walking speed decreases significantly, and the effects of crowding become noticeable. The influence is not just because of physical characteristics of the environment that people can't move that fast. It is also a psychological phenomenon, for the reason that people act different in a crowd.

These psychological aspects of crowds, have many impacts. The phenomenon that people behave differently in groups than they would on their own, is a complex behaviour pattern. Feelings play an important role such as being dense, disorderly, confining, chaotic, disturbing, cluttered and unpleasant. Also, environmental condition such as a noisy, hot or smelly surrounding influence the behaviour of passengers. Crowding can cause stress if there is a lack of available seats, a tight squeeze, a little distance between people and the fear of sexual harassment. In these situations, passengers' comfort and the willingness to use these means of transportation at that time of day decrease. (Delac, 2014)

2.5.2.1. Boarding and alighting process

Entering the train people need 40% more time than exiting the vehicle. Investigations have found out that the boarding time was 12 % longer than the alighting time on average. The main reasons for the time difference are crossing the gap between the platform and the vehicle and people first looked around the vehicle before choosing a seat. Speed of passengers depends on many design variables such as heigh and distance between the trains and the platform, width and number of doors per vehicle. The interaction between the passengers in the door area is really complex and depends on many factors therefore an exact measurement of the door width can't be listed. The number of doors per carriage influences the dwell time, but it is closely linked to the vehicle's interior layout, such as the positioning of seats and standing areas.

In order to analyse passenger behaviour at metro stations, this report refers to the study *Exploring the Effect of Boarding and Alighting Ratio on Passenger Behaviour at Metro Stations* by Laboratory Experiments by Seriani et al. (2019). The study was conducted by University College London and investigated how the ratio between boarding and alighting passengers influences passenger movement, boarding and alighting time, and platform crowding.

Passengers generally allow others to exit the train before attempting to board. This behaviour does not change in either crowded or non-crowded scenarios. Furthermore, in highly crowded conditions, passengers boarding the train tend to form narrow lanes due to space constraints, whereas in less crowded situations, wider or even multiple lanes are possible, allowing for a smoother flow. The ratio between boarding and alighting passengers plays a crucial role in the change-over process. The studies showed that the first passengers were faster than those who followed, as they had more space available. If there were more boarders than alighting passengers, only one narrow flow lane was formed for passengers. Boarding was influenced significantly by how crowded the train was. When the density inside the train exceeded four passengers per square meter, boarding flow at the doors decreased.

These passengers are blocking the door area, causing congestion, which results in delays for those trying to board the train.

The behaviour among the passengers plays a crucial role in the boarding process. People tend to act like the passengers they are around with. Treating others with respect is important to most people. However, if a few people who do not enable respectful interaction with others during the entry and exit process, their actions influence the group behaviour and significantly hinder the entry process. The ratio between boarding and aligning passengers affects the queuing behaviour. When there are more boarding passengers, queues form directly in front of the doors that delays the boarding process. When alighting dominates, queues shift to the sides, which allows a smoother passenger flow. The infrastructure can influence the human behaviour. A combination of platform screen doors with additional floor markings, that allocate where people should queue for boarding the train, has a huge impact on the dwell time. The effect of platform markings can be strengthened when a keep out zone is added, which helps to organise the formation of alighting lanes. Wider doors and more spacious entrance areas are factors that can be adjusted on the vehicle. (Kuipers et al., 2021)

The efficiency of passenger flow is mainly influenced by factors such as crowd density, the sequency of passenger movements and the ratio between boarding and alighting. The studies pointed out that earlier door closing policies can be used when train density is high. This change can reduce dwell time by 26%. Also, modifications to train and platform layouts can improve the passenger flow. Effective measures are wider doors and a structured queuing, which can be achieved by floor markings, signage and guidance systems. Platform screen doors can also have a positive impact on the queuing process. People can position themselves closer to the platform edge and the door closing policies can be adapted better. (Seriani et al., 2019)

3. Methodology

3.1. Introduction

T The research questions of this work are separated in two parts, requirements and behaviour of passengers in metro systems. The research questions of this work are separated in two parts. These are the requirements and the actual behaviour of passengers in metro systems In fact, each one of them need different methodologies, these topics are considered separately to be able to examine them in the best possible way. For the requirements part a questionnaire was conducted in Sofia, Genoa and on several social media platforms. To gain more insights into passenger behaviour, expert interviews were conducted with experts in the fields of human behaviour, interior design and customer experience. Both methodologies are combined to compare differences between the two methods and to get important findings.

3.2. Research design

The main objectives are the investigation of the passenger requirements and behaviour in their desired metro system. The requirement and the behaviour part will be separated in the research, though they need different methodologies. A conducted survey will provide a better prospective in the needs of passengers. The subjective view of passengers and their real behaviour are often really different to each other. In addition, expert interviews were conducted to have more data about how people act in metro systems. Especially, their perception of which sitting and standing areas they prefer in the vehicle deviates strongly from their actual behaviour.

3.3. Quantitative Method: Survey

3.3.1. Research objective of the survey

The survey conducted in this study is essential as it provides firsthand data that directly supports the part “passenger requirements” in the research objective. By gathering responses from passengers in metro systems, the survey ensures a comprehensive understanding of the needs and requirements of passengers, which wouldn’t be possible to literature research. The questionnaire should also give to the passenger the opportunity to have a vote in the design of their public transport system.

The main objective of the survey is to gain more insight into how passengers feel about automatic metro systems, what information systems could support the distribution of passengers on the platform, to know more about their needs in the vehicle layout and about their experience with incidents in the metro operation.

The research questions can be defined as: What requirements and behaviour do passengers have of the metro systems to improve the efficiency, capacity, the comfort, and safety with particular focus on awareness of automatic metros, passenger distribution, improved information systems and a better vehicle interior design?

3.3.2. Survey instrument and structure

The structure of the survey was defined in five parts. It was separated in the four main objectives that were examined in this survey, along with a section on demographic questions. At the first page of the survey, passengers were referred to the Data Protection Regulation with the attached Data Protection Information. This document was elaborated with the data protection officer of the Technical University of Vienna. Passengers were aware of the Data protection with the phrase: "We adhere to strict data protection regulations, including General Data Protection Regulation, ensuring your information is handled responsibly. By participating in this survey, you acknowledge that you have read and agree to the data protection information: Data Protection Information". In addition, the questionnaire declared that a response would help improve the metro system, the capacity, safety and the comfort in the vehicles and stations, and the survey consists of 19 questions, which takes about 10 minutes to answer.

1. Demographic analysis
2. Acceptance and desired benefits of automatic metro systems
3. Distribution on platforms and required information systems
4. Safety incidents and the quantitative estimate
5. Preferences of common areas in the carriage

The first part inquires about demographic questions, to collect information in order to better assess whether the survey reached a representative sample of the general population. Especially the questions about impairments, the frequency of weekly trips, and whether the respondents' home has access to a metro system are important to link them with other questions. The questions of this chapter were single choice questions, except the question about impairments.

The second section asks passengers about their consciousness of driver-less metro systems, and which benefits they expect of these systems. As further research has shown that passengers tend to trust human drivers more than a computer-controlled system. The survey that has been carried out in Sydney by Fraszczyk and Mulley (2017). The aim of the study is to compare passenger awareness and acceptance of driverless metro systems after nearly a decade.

Question 6 was split in two versions, due to the survey was spread online and was advertised with flyers and posters in the metro stations and vehicles. This question is a single choice question and asks people if they actually know how the metro system is controlled. Therefore, it has to be traced, where the respondents come from, to check if their response match with the actual operation system.

Q6. (Platform version) How do you think this metro is operated?
Q6 (Online version) How do you think the metro that you last used is operated?

Questions 7 and 8 were separated from Question Number 6 with a page break. With the quotes "In the future, technological advancements may lead to more automation in metro systems." and "Automation of the metro can bring several benefits to you", passengers were stated that the metro system will be changed in the future. Question 7 gave passengers, who responded "No" the option to explain their concerns in a text field.

Q7. Would you take this metro if it becomes fully automatic without a driver?

Question 8 was implemented as a Likert scale with the answer options completely disagree, partially disagree, neutral / I don't have any opinion, partially agree and completely agree. Benefits like "More frequent schedule", "Improved platform safety", "Service staff on board" and "Less disruptions" were listed and every benefit required an answer. Also, an additional question "Do you expect any other benefit?" to give respondents the possibility to add their thoughts.

Q8. Do you think that automated metro systems have a positive impact on the listed aspects?

The third section should list up, what benefits real-time information systems can have on the distribution on the platform and the comfort during their ride. In the ninth question, passengers should indicate where they normally wait on the platforms. With these answers platform concepts and layouts can be modified in the future. This question is a single-choice question.

Q9: You have reached the (underground) metro platform. The next train departs in 5 minutes. Where do you wait on the platform?

Question 10 and 11 were conducted also as a single-choice question and should create awareness for passengers that in the future information systems can depict the utilization of carriages on monitors at the platform. So, passengers can choose a carriage that offers them an available seat. The cities Genoa and Sofia do not currently have these systems at the moment. It was expected that a majority of passengers didn't know about the existence of these systems before.

For the answer possibilities beside the options are "Yes, in any case", "No", passengers had the option "Yes, but only if I have to wait up to 2/5 minutes longer" for question 10 and "Yes, but only if I take the train for at least 3 / 5 stations." Observations pointed out that a high percentage of passengers are choosing to seat even for one station. This numbers separate the station stops where people would still be standing.

Q10: The display on the platform shows that the next train will be full, but the next one will have more space available. You are not in a rush. Would you wait?

Q11: The display shows that if you move three carriages down the platform, there will be seats available. When you look around, not so many passengers are waiting in that part of the platform. Would you move there?

In fact, to know where the specific information is needed question 12 shows a picture of a platform with five numbers of different displays. This question was elaborated as a Likert scale. These displays are positioned on the platform screen door, overhead displays across the tracks, a display on the sidewall, floor markings, and a mobile phone. Other possible answers include, "outside the platform", "in the train" and "I don't need". All graphics of the survey were designed by Da Un Yun, who is working in the department for transportation science in Vienna. Different kind of information (e.g., Alternative routes if there are disruptions, Nearest wagon to the exit at my stop, Crowded or less crowded wagons, planned disruptions or service changes) can be allocated to the desired location and display.

Q12: Where do you want to get the following types of information?

In order to give respondents, the opportunity to share their opinions about what additional information is also needed, question 13 is an open question, for which no response is required.

Q13. Do you wish any other type of information when travelling by metro?

The fourth section contains just one question, and the question type is a Likert scale. For each line any allocation is required. Incidents, such as “I was too close to the edge of the platform when the train arrived” and “I didn’t feel safe, because there were too many people on the platform” can be assigned to the frequency people experiences this incident.

Q14. Have you ever experienced yourself any of the following situations on the metro platform?

The fifth and last section investigates the desired carriage layout passengers would like to see in the future. Question 15 is a multiple-choice question and Question 16 to 19 are single-choice questions. Questions 15 enquires about the situations, when passengers prefer to stand instead of choosing an available seat. Question 16 to 19 are very similar to each other and depict four pictures of different carriages layouts. Passengers can choose their preferred seat or standing position, they would choose. The differences between the graphics are lengthwise and crosswise seating designs. The available seats are marked with numbers, and the standing positions are characterized by people, that were drawn as a silhouette.

Q15. In which of the following situations would you accept standing while taking the train?

Q16.–Q19. Now you are entering into the train, and the situation is like the picture below. You are travelling for 5 stations (about 10 minutes).

Which is your preferred seat? / Which is your preferred standing position?

3.3.2.1. Pretest:

The questionnaire was tested with a minority of people to assess their response time and the understanding of the questions. The average response time was about ten minutes, which was the maximum time to consider getting as many responses as possible. Through the team members of the project “NEXUS” and a separate meeting with the Advisory Board Members, which should accompany the project with their knowledge, much qualitative feedback was given to correct and avoid misunderstanding in the survey. The Advisory Board Members were European Passengers Federation, EU-Rail, Metro operators from the cities Barcelona, Madrid, Paris, Copenhagen, Turin, Milan and Prague.

3.3.3. Survey Implementation and Outreach Strategy

The survey was conducted in the framework of the NEXUS-Project. It was agreed that the survey would be distributed in the cities of the metro operators involved in the project, Sofia and Genoa. During the project, the Advisory Board committee gave feedback on the “Passenger requirements in future metro systems” survey, and the metro operations from Prague and Barcelona also made themselves available to promote the survey.

The distribution was made in two ways. The first was a direct promotion on platforms and vehicles via Posters and Flyers. The design for these materials were made by Maria Méndez, who works in the company “ERTICO” in Belgium. Her company is also involved in the project, which was responsible for marketing, among other things. An example of the promotional image can be seen in Figure 4. The second one was via social media, Newsletter and Webpages. Therefore, also a template design was created to advertise the survey. Both ways were separated in two different surveys, due to question 6 was minimal different.

For the survey, the online-survey-tool SurveyMonkey was chosen. The main advantage of this survey platform was the multi-linguistic feature, where many different questions can be categorized in one survey. In fact, to be able to separate all questions from different countries and stations, various collection links and QR-Codes were allocated. These weblinks can link people to their first language and can also be divided in the data evaluation process.

The target group of the survey were first of all passengers of metro systems in Europe, especially in Bulgaria and Italy. The whole society is aimed to be represented in the survey. In fact, since the survey requires 10 minutes, it was expected that only people who are better informed would respond more frequently. Due to limited personnel capacity, there were not enough resources to ask elderly people on the platform who don't have a mobile phone or don't know how to scan a QR-code. The results are expected to show that this age group will be less represented.

Figure 4: Image for promoting the survey (Maria Méndez, personal communication, 2025)

3.3.4. Data collection process

The start date for the survey was not the same in the participating cities and institutions. Due to additional corrections there was a delay of the planned investigation period. In the following table and sections every city and institution are listed separately. The start and end dates of the survey, the way in which the survey was distributed (social media, E-mail, flyers, etc.), the number of responses, and other incidents that occurred during the survey are described in more detail. There were three different SurveyMonkey versions of the survey. One online version, where the survey was promoted through social media, newsletters and two local version, which were advertised on the platforms with posters, flyers, and screens in Genoa and Sofia.

Table 3: Responses and survey period by passenger survey collectors

Organisation	Online	Local	Start	End	Platform of the promotion
Metro Sofia	133	5	24.2	20.4	Website, Facebook, Local
AMT (Genoa)	20	53	24.3	20.4	LinkedIn, Newsletter, Local
VTU (Sofia)	77	(–)	24.2	20.4	Website
Metro Barcelona TMB	381	(–)	2.4	20.4	E-Mail distribution
European Passenger Federation	103	(–)	31.3	20.4	LinkedIn, Newsletter, Workshop
UITP + General	99	(–)	24.2	20.4	Newsletter, LinkedIn
TU Wien	28	(–)	15.3	20.4	LinkedIn, Facebook, X

3.3.4.1. Metro Sofia (Sofia)

The distribution channel of Metro Sofia collected in total 138 responses between February 24th and April 20th. For the online distribution the official website and Facebook were used. The questionnaire was also promoted on the platform screens as can be seen in Figure 5. The running time on the displays was 30 seconds. The poor response of 5 answers is due to the poor visibility, as the displays were positioned upside down.

Figure 5: Distribution of the survey on the platform in Sofia (Todor Todorov, personal communication, 2025)

3.3.4.2. AMT (Genoa)

The survey was promoted online and locally. For online distribution, LinkedIn and a newsletter were utilized. Locally, the survey was advertised through posters placed on platforms and inside carriages (refer to Figure 6) in Genoa. The data collection period spanned from March 24th to April 20th. In total 73 responses were collected from AMT.

Figure 6: Distribution of the survey inside the train in Genoa (Lorenzo Mantero, personal communication, 2025)

3.3.4.3. VTU (Sofia)

Todor Kableshkov University of Transport in Sofia collected 77 responses on their official website between February 24th and April 20th.

3.3.4.4. TMB (Barcelona)

The metro operator from Barcelona TMB shared the link of the survey by e-mail with the customers that are registered on their databases (around 43.000 users). In total 381 responses were collected between April 2nd and April 20th.

3.3.4.5. UITP & General link

UITP distributed the survey with their own collector and the general link collector. The promotion was done with LinkedIn, internal communication, target mailing and newsletter on various channels all over the world. In total 99 responses were collected between February 24th and April 20th.

3.3.4.6. European Passenger Federation

The survey was distributed via LinkedIn and also in a workshop among stakeholders of the European Passenger Federation. 103 responses were collected between March 31st and April 20th.

3.3.4.7. TU Wien

The Institute of Transportation Science at the Technical University of Vienna distributed the survey via Facebook, X, and LinkedIn on their channels. 28 responses were collected between March 15th and April 20th.

3.3.5. Data Analysis

The statistical analysis of the survey data was conducted using R (version 4.4.3), which is a programming language specifically designed for statistical analysis and graphics. The analysis followed a structure that included data preparation, hypothesis testing, and the application of various statistical models. The aim was to evaluate the research hypotheses and answer the research questions deduced from the theoretical framework. The goal of the analysis was to identify relevant response patterns, detect statistically significant group differences and support the answering of the research questions derived from the theoretical framework. The analysis process consisted of three main steps: data preparation, descriptive graphical analysis and statistical testing.

3.3.5.1. Data preparation:

Before the data was evaluated, all responses of the survey were collected within a SPSS file. The three versions of the questionnaire, Online-version, Genoa-local-version and Sofia-local-version were separated to split the data first. Demographic variables such as age and gender were also reviewed and compared to officially EU statistics to assess the sample's representativeness. After this step, all three datasets were merged into a single working dataset. Open-ended responses were translated and thematically summarized, while multiple-choice questions were converted into binary indicators to allow for statistical analysis.

3.3.5.2. Descriptive Analysis and Visualization

Descriptive statistics were calculated to provide an overview of the data and to visualize the results of each question. The examination of the survey was visualized using bar charts, while stacked bar charts were used to display the distribution of responses to Likert-scale items. Several variables were further broken down by demographic subgroups (e.g. age, metro use frequency) to identify patterns in acceptance and passenger distributions. Only response categories with a share above

2-5% were labelled in the plots to maintain readability. All visualisations were generated using the R packages “ggplot2”, “likert” and “dplyr”.

3.3.5.3. Statistical testing

To test for significant relationships among variables, the following statistical tests were applied:

- **Chi-Squared tests** were used to examine associations among categorical variables such waiting position on the platform, willingness to move to a less crowded position on the platform, preferred seating options, and metro use frequency.

- **One-way ANOVA** was used to test for differences in means across groups (e.g., acceptance of automatic metros and age, or gender)

All statistical tests were conducted at a significance level of $p = 0.05$. When statistically significant results were found, F-values, p-values and mean differences were reported and interpreted accordingly.

3.4. Qualitative method: Expert interviews:

To gain a better understanding of behaviour patterns, expert interviews were conducted to gather knowledge in social behaviour and human movement patterns, customer experience, information systems and special vehicle interior solutions. These interviews were intended to complement the survey, which primarily focused on passenger requirements by providing deeper insights into behavioural components of public transport users. As a method, expert interviews, allow for a more nuanced understanding that cannot be obtained through literature review alone.

Interview questions include following key topics:

- vehicle interiors preferences
- information systems
- metro automation
- interaction platform and vehicle (platform doors)

Table 4: Overview of expert interviews

Experts	Institution	Specialization
Elisabeth Oberzaucher	University of Vienna	Behaviour biologist
Markus Geist	SBB	Head of Fleet Projects Infrastructure
Julian Fordon	Deutsche Bahn	Ideen Zug specialized vehicle interior
Sarah Fessl	ÖBB-Holding	Customer experience
Tobias Fiebag	Deutsche Bahn	Vice railway operations manager

3.4.1. Expert interview with Elisabeth Oberzaucher

In order to get better understandings in the behaviour and group dynamics expert a interview with Elisabeth Oberzaucher was conducted on the 7 February 2025. Elisabeth Oberzaucher is an Austrian behavioural biologist, and researcher specializing in human behaviour, urban planning, and evolutionary biology. She is a scientist at the University of Vienna, and her work focuses on the interaction between humans and their environment, including spatial behaviour, gender differences and evolutionary psychology. Her studies explore how people navigate public spaces, how they choose seats on buses and trains, and how evolutionary psychology influences behaviour in confined spaces.

Through her work, she contributes to the improvement of public transportation systems by providing insights into human movement patterns, and social behaviour. The interview guide was structured in advance to support the main topics of the survey with additional expert knowledge. Before the interview exact questions were listed up and were sent to Elisabeth Oberzaucher for preparing herself. The interview questions were divided in the following topics: metro interior, platform distribution, and automatic metros. The interview was conducted online via Zoom and lasted 55 minutes.

3.4.2. Expert interview with Markus Geist (SBB)

To get more information and insights of the passengers' requirements within vehicle, an interview with Markus Geist was conducted on 28 February 2025. He works in the management of fleet project infrastructure in the company SBB, which is the train operator in Switzerland. Based on Markus Geist's experience with customer needs and experiences in train vehicles, his knowledge complements the passengers' survey and the theoretical foundation on this work. Many surveys asking passengers about their preferences were conducted by him and his team.

The research questions were sent in advance to him one week before and covered the key topics "vehicle interior, information systems, automatic operation, and platform screen doors. Since SBB has not yet implemented automation vehicle operation projects, just the first two key topics were asked. The questions and responses are listed up in chapter 4.3.2. The interview was conducted online via Microsoft Teams and lasted 30 minutes.

3.4.3. Expert interview with Julian Fordon (Deutsche Bahn)

An interview with Julian Fordon, who works as a senior manager in the department for marketing strategy and communications at Deutsche Bahn was held on the 20 March 2025. He was responsible for the implementation of *IdeenZug (engl. Idea train).* The train design is a completely new concept with integrated information displays, adjustable seats, and creative standing options. The research questions were sent to him one month in advance and focused particularly on special solutions in the new train concept, such as the development and mechanism of the special interior, customer experience, light-dependent guidance systems and multiplex seats. The interview was conducted online via Microsoft Teams and lasted 56 minutes.

3.4.4. Expert interview with Tobias Fiebag (Deutsche Bahn)

Tobias Fiebag wrote his diploma thesis at the University of Applied Science in St. Pölten about the interior design of the suburban railway in Munich. At the moment he is working at Deutsche Bahn in exactly this area. His specialised knowledge from his diploma thesis and the practical experience based on it, make him a strong candidate for the interview. The questions were sent to him in advance and cover key topics, such as interior design and information systems in vehicles. Especially the comparison of his theoretical knowledge and the practical evaluation of it are really interesting. The interview was conducted online via Microsoft Teams and lasted 47 minutes.

3.4.5. Expert interview with Sarah Fessl (ÖBB)

Sarah Fessl, who works as a product manager on customer experience with focus on train interior and design, was responsible for the implementation of family and relaxation zones in the Railjet in Austria. The expert interview was conducted on the 13 March 2025 and covered the key topic interior design and information systems. Besides that, she was asked if the Austrian train operator ÖBB was considering the implementation of driverless trains and platform screen doors. The interview was conducted online via Microsoft Teams and lasted 63 minutes.

3.5. Reliability, validity and limitations

The quantitative and qualitative methodologies in this work complement each other very well. The questionnaire is used as a quantitative methodology to get more information about passengers' requirements into the metro network. The subjective perception of passengers often differs from their actual behaviour. For this reason, the expert interviews and the literature research about human behaviour in transport systems questions critically the responses of the survey. The results of all methodologies are compared in Chapter 4 in order to be able to draw valuable conclusions. Despite the efforts to ensure reliability and validity, there are several limitations that need to be considered. The questionnaire was carried out on the platform with flyers and posters and on the internet. Especially on the platform people had to scan a QR-Code to take part into the survey. For this reason, elderly passengers, who don't know how to scan a QR code, couldn't take part in the survey. Due to a lack of personnel resources, it was not possible to assist passengers individually.

3.6. Ethical considerations

Respondents of the survey were informed that the project members adhere to strict data protection regulations, including the General Data Protection Regulation, to ensure that the information is handled responsibly. Participants were made aware that they acknowledged that they read and agreed to the attached data protection information. The General Data Protection Regulation was elaborated with the data protection officer of TU Wien.

4. Results

4.1. Overview of findings

Metro Automation: a large majority of respondents expressed acceptance of fully automated metro systems. Among those who were reluctant to use automatic metros, the main concerns included potential technological failure, the risk of hacking, inadequate systems response in emergency situations, and the absence of qualified staff to manage evacuations. The most frequently expected benefits of automatic metros were “extended operation hours”, “improved real time information” and “more frequent schedule.”

Passenger Distribution: the results indicate that passengers’ platform behaviour is influenced more by travel related attitudes and habits than by demographic factors A clear pattern emerged showing that those who are familiar with the metro system are more willing to adapt their behaviour such as waiting for the second next metro or moving three carriages further on the platform in order to avoid crowding. This suggests that targeted information systems can effectively influence passenger distribution and crowding management of the platform.

Information systems and platform safety: the analysis highlights key patterns in how passengers experience safety and access information on metro platforms, showing clear differences depending on age and gender. Female respondents reported feeling unsafe due to crowding more frequently, while older male passengers struggled more often to find necessary travel information. Preferences for the placement of platform information vary significantly by age, which younger passengers tending to prefer more dynamic displays, while older passengers favour clearly visible.

Choice of positioning in the vehicle: results show that seating and standing preferences are mainly influenced by age and gender. The main reason why passengers choose to stand was to give their seat to someone in greater need. Gender differences are particularly noticeable in crosswise seating layouts, where woman tend to prefer aisle seats. In the lengthwise seating layout, the seat located closest to the door, was the most preferred option, particularly among travellers below 31 years, highlighting a strong preference for easy access and efficient boarding and exit.

4.2. Results of the survey

4.2.1. Introduction

The following chapter presents the results of the passengers' survey, which was conducted between 24 February 2025 and 20 April 2025. The survey was conducted among 899 participants and analyses the aspects of automatic metros, platform distribution, information systems and preferred position on board. The data was collected using SurveyMonkey. The survey was translated into Bulgarian, Catalan, Czech, English, German, and Italian, and all versions were implemented in the survey using SurveyMonkey multilingual tool. The survey was analysed using *R* for the statistical evaluation.

4.2.2. Sample Description

The members of the NEXUS team supported the passengers' survey. On the one hand the survey was distributed on the platform in Genoa and Sofia using posters and display screens. On the other hand, the survey was distributed online (e.g. newsletter, social media). The collectors and the specific number of responses are listed in section 3.3.4. There is a total of 899 completed responses on the survey. The data was collected between 24 February 2025 and 20 April 2025. Of these, 55.9 % were male, 41.8 % were female, 0.6 % were non-binary and 1.7 % didn't prefer to answer this question as can be seen in Figure 7.

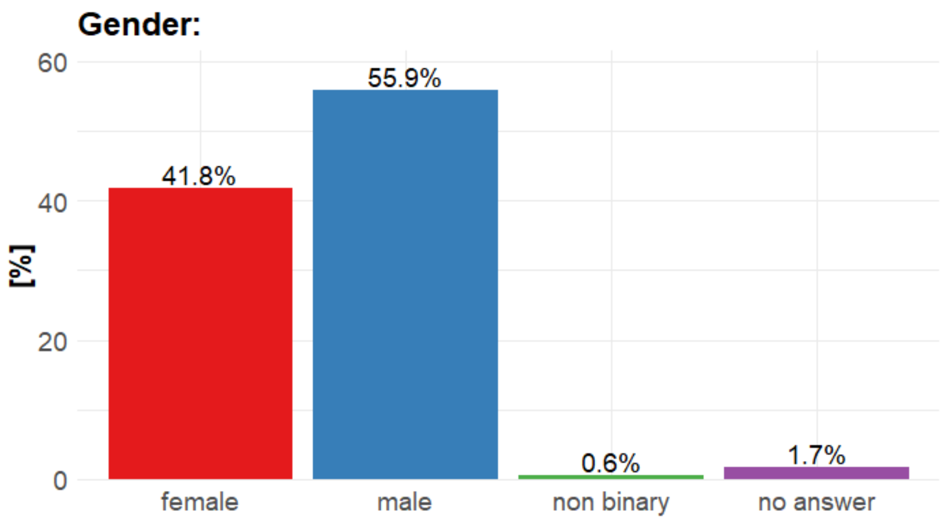

Figure 7: Survey – Gender distribution

Figure 8 provides an overview of the respondents' age distribution. Specifically, 20.8 % of the respondents are between 18-30 years old, 18.2 % are between 31-40 years old, 18.8 % are between 41-50 years old and 19.5 % are between 51-60 years old. In comparison with the statistics from Eurostat (2025) 10.7 % of all people who live in the EU are between 15-24 years old, 32.1 % are between 25-50 years old, 21.0 % are between 50-64 years old, and 21.6 % are above 65 years old. This shows that the younger part of the population is more represented in this survey than the older part of the population. (*Eurostat*, 2025)

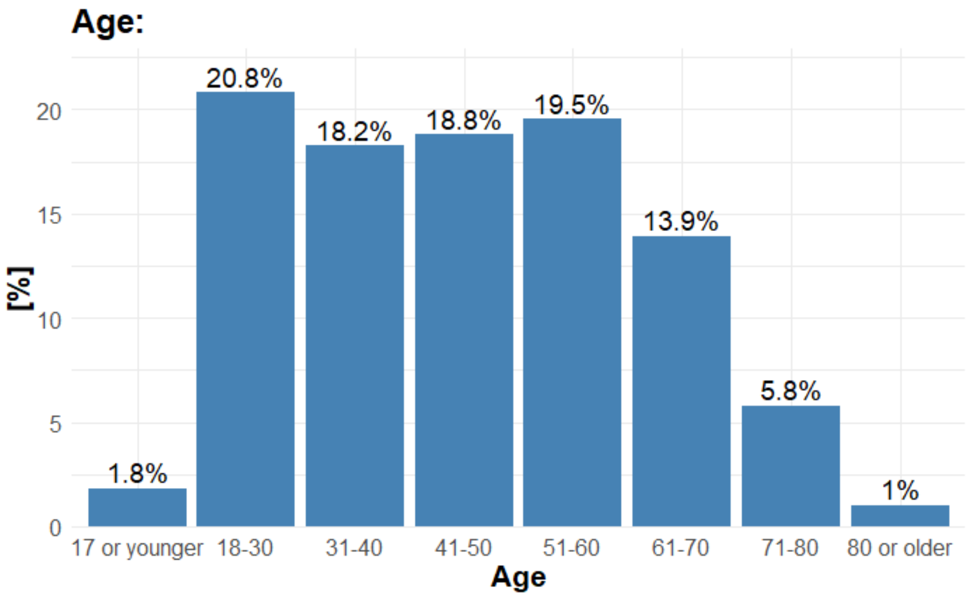

Figure 8: Survey - Age distribution

As illustrated in Figure 9, respondents were asked "Do you have any long-term mobility impairment? ". 90.6 % stated that they don't have any impairment, 3.8 % responded that they have a restriction in movement and 1.5 % of the respondents have a visual impairment. The remaining percentage is allocated to visual and auditive impairments, psychological and intellectual disabilities, as well as other types of limitations. EU statistics indicate that at least a percentage of 18-26 % of the population have any kind of impairments. (Grammenos, 2024)

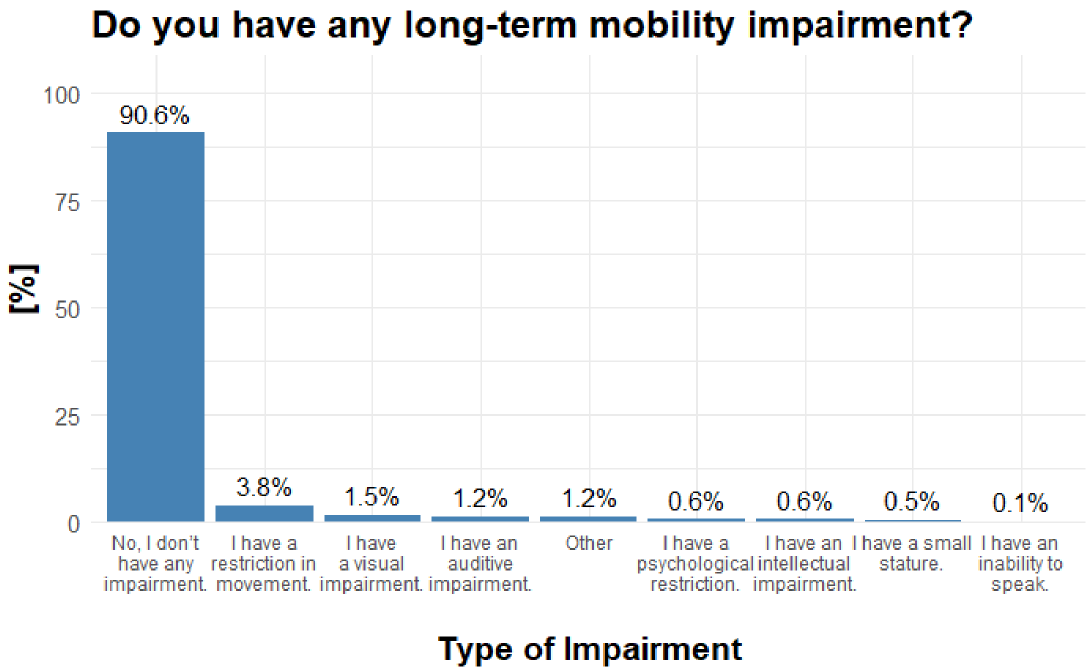

Figure 9: Survey – Impairment distribution

The majority of the people that responded the survey use the metro regularly. 70.6 % of all respondents are living in or close to a place with a metro. Figure 10 demonstrates that 15.9 % of the respondents rarely or never use the metro, 23.9 % use the metro at least a few times a month and 60.3 % are using metro several times a week.

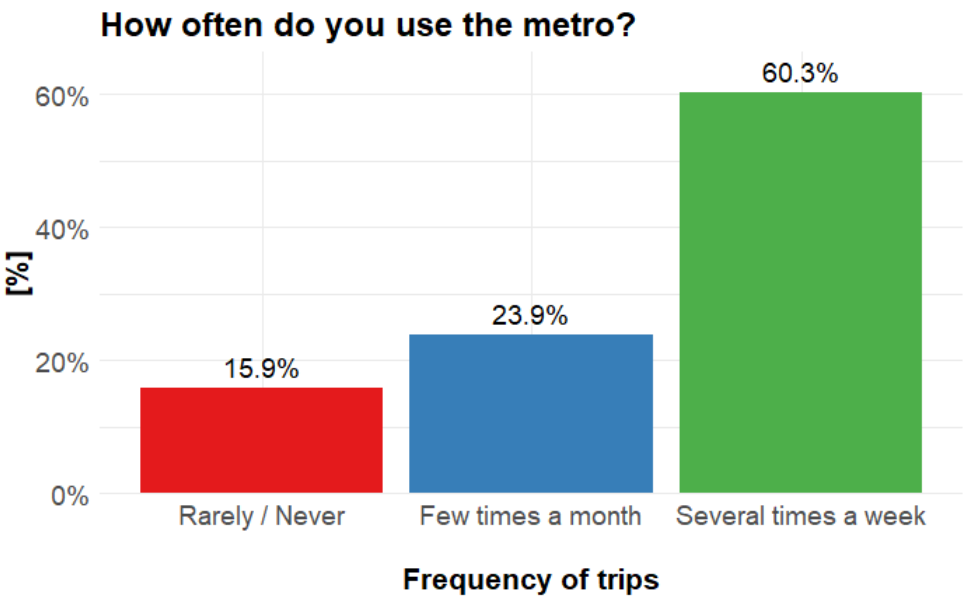

Figure 10: Survey – Metro use frequency

4.2.3. Metro Automation - Analysis and findings

In order to implement an automatic driverless metro system in an existing metro network, the passengers' survey examined the level of public acceptance of such systems. Respondents who didn't support the idea of a driverless metro were asked to describe their concerns. In addition, passengers were asked about their expectations regarding the potential benefits of automatic metros.

A clear majority of respondents would take a fully automatic metro without a driver. Surprisingly, based on the data presented in Figure 11, 86.9 % of the respondents expressed acceptance of a driverless metro, while only 13.1 % reported concerns. People that responded "No" to this question had the possibility to describe their concerns in an open-end comment field. The main reasons for rejecting a driverless metro were that many respondents were worried that technology could fail, be hacked, or respond inadequately during emergencies. They wanted qualified staff on board to guide evacuations, especially for disabled individuals requiring assistance. Additionally, a competent persons' oversight was seen as necessary for maintaining direct control of the vehicle. There was also concern that automatic systems might not reopen the door if a person is stuck during the boarding process, and that they are not as patient as human drivers. Also, some passengers didn't trust the technology because they didn't think it was fully developed at the moment.

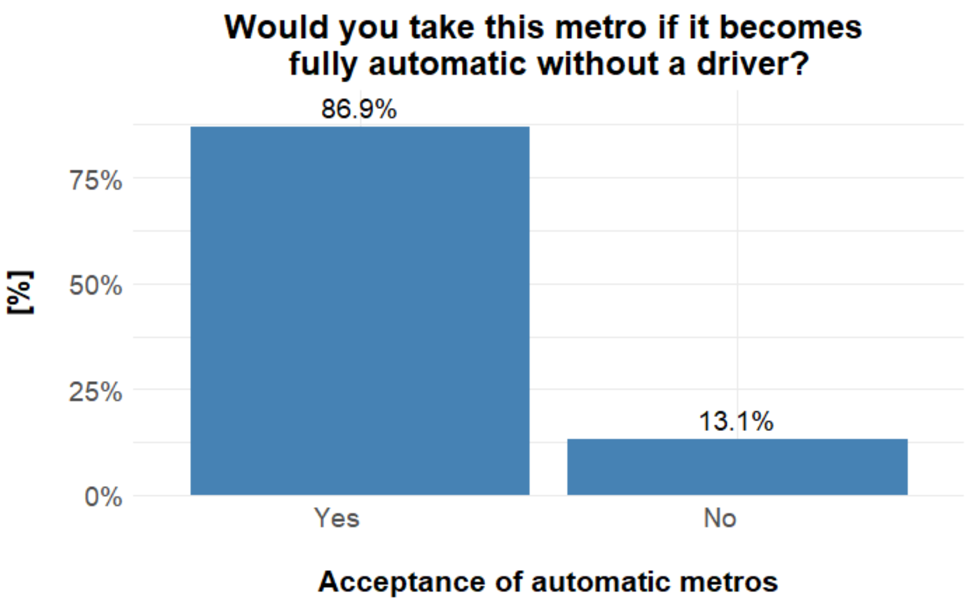

Figure 11: Survey – Acceptance of automatic metros

To statistically examine the relationship between the acceptance of automatic metros and demographic variables such as gender, age, and frequency of metro use, an analysis of variance (ANOVA) was conducted. Each demographic variable was tested for its association with automatic metro acceptance to assess whether the differences between groups were statistically significant. The analyses were performed using R.

As shown in Table 5, a statistically relationship was found between the acceptance of automatic metros and gender. The p-value = 0.000304 is below the conventional threshold of 0.05, indicating that the effect is statistically significant. The corresponding F-value of 13.14 is a meaningful difference in average acceptance levels between male and female respondents. The observed mean difference of -0.1966 indicates that, on average female respondents selected “No” in response to the acceptance 0.1966 points more often than the overall sample mean.

Table 5: Results of ANOVA tests on the Acceptance of Automatic Metro Systems by Gender, Age and Frequency of Metro Use.

Dependent Variable	Df	F-value	P-value	Mean Diff (No-Yes)	95%-CI (Lower)	95%-CI (Upper)
Gender	1	13.14	0.000304	-0.1966	-0.303	-0.090
Age	1	0.326	0.568	-0.0878	-0.340	0.214
Metro Use	1	0.007	0.934	-0.0115	-0.282	0.260

As shown in Figure 12, female respondents are generally less accepting automatic metros compared to male respondents. The responses of females and males are divided into three age groups. 18.5 % of females below 31 years do not accept automatic metros, while the acceptance rate for other female age groups is remaining almost the same. For males it reveals a trend of increasing acceptance with increasing age. 11.1 % of male respondents below 31 years were not accepting automatic metros, while just 5.8 % of male respondents above 60 years were not accepting them.

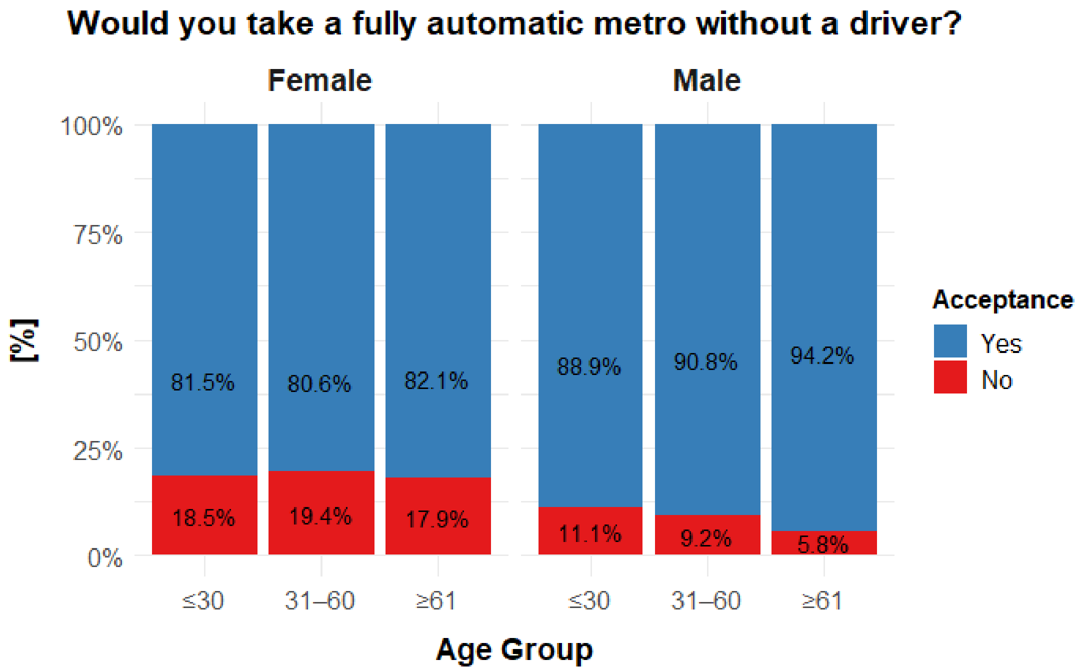

Figure 12: Survey – Acceptance of automatic metros by age and gender

The most expected benefits for automatic metro systems are "Extended operation hours", "improved real-time information", and "more frequent schedule". An overview of the responses can be found in Figure 13. Compared to the previous question, where respondents could explain why they would not take an automatic metro, a higher percentage now indicate neutrality or no opinion about onboard service staff, although some still feel human assistance is essential during emergencies or the boarding process. Respondents also suggested additional potential benefits in open-ended responses, including a more accurate timetable, fewer disruptions caused by staff shortage, illnesses and strikes. Enhanced safety was also mentioned, with respondents citing improved station security, a reduction in human error, and better system oversight. Furthermore, respondents noted that human resources currently allocated to train operation could be reallocated to other areas of the metro system, for example, in safety checks for passengers.

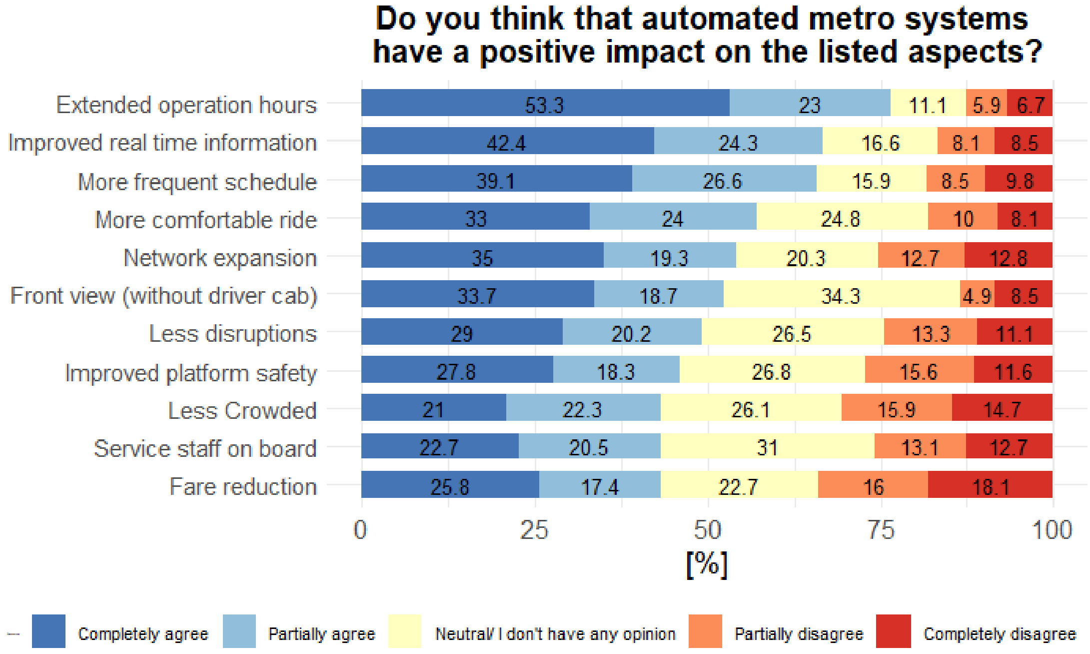

Figure 13: Survey – Expected benefits of automatic metros

In order to examine what benefits passengers expect who accept metros and those who don't accept them, their responses were divided into these two categories. Acceptors of driverless metros mainly expect "Extended operation hours", "More frequent schedule" and "Improved real time information". Notably, benefits such as "Less Crowded" and "Service staff on board" were perceived as less relevant.

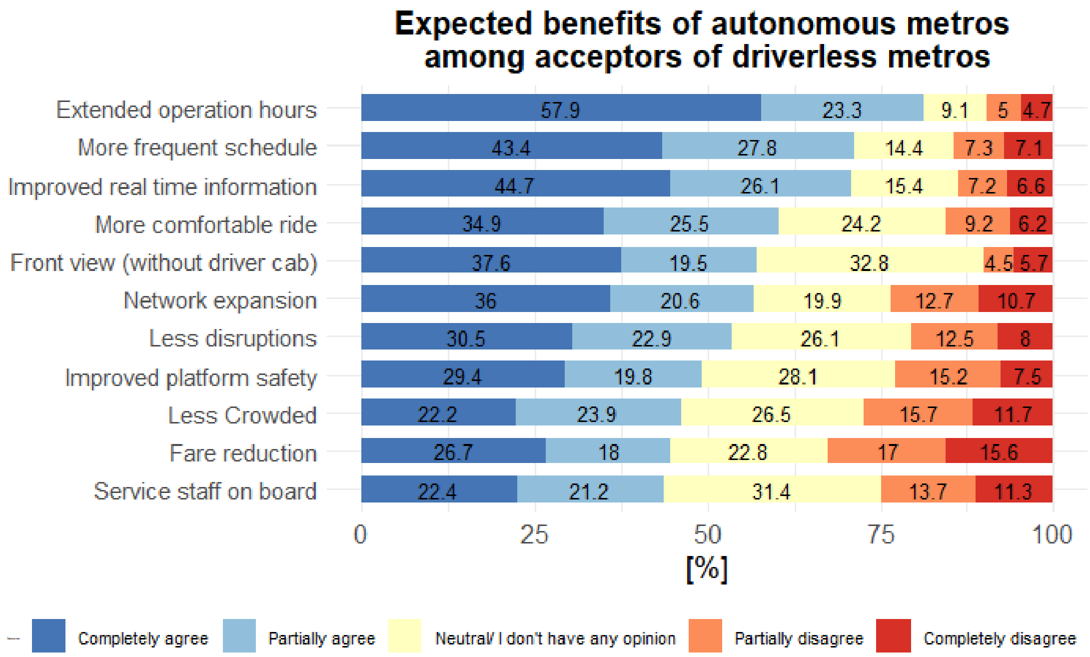

Figure 14: Survey – Expected benefits among acceptors of driverless metros

Non-acceptors showed lower agreement to the listed benefits. Their main expectations are “Extended operation hours”, “Improved real time information” and “Network expansion”. Surprisingly, just 39.8 % of the non-acceptors agreed completely or partially with “Service staff on board” despite the lack of human presence being one of the most frequently cited reasons, why people said they don’t accept an automatic metro. Interestingly, just a small percentage of the respondents agreed with benefits such as “Improved platform safety” and “Less disruption”. The most disagreed benefits among non-acceptors were “Less crowded” and “Improved platform safety”.

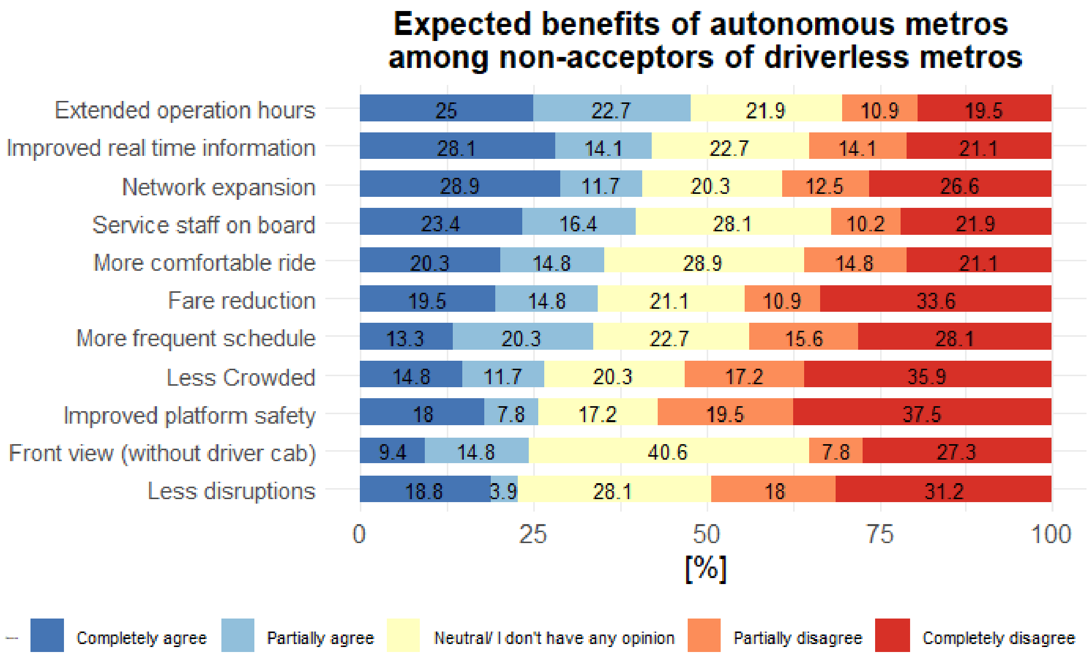

Figure 15:Survey – Expected benefits among non-acceptors of driverless metros

4.2.4. Passenger Distribution - Analysis and findings

The survey examined passengers’ preferred waiting positions on the platform aiming to understand behavioural patterns in relation to platform distribution. In particular, it explored whether real-time information systems showing crowding levels could serve as effective motivators for influencing passenger behaviour. Specifically, respondents were asked whether such systems would encourage them to move to a less crowded area of the platform or to wait for the second next metro to have the possibility to sit during their ride.

Figure 16 shows where passengers are waiting on the platform. 44.4% of respondents are waiting at the nearest train door to exit at their destination station. Surprisingly, 29.8% of all respondents are waiting on a bench on the platform. Only a small percentage of the respondents chose to wait near the platform entrance. Passengers who selected “Other” at this question prefer areas that are less crowded, where they expect a carriage with wheelchair access, or they choose their position unconsciously.

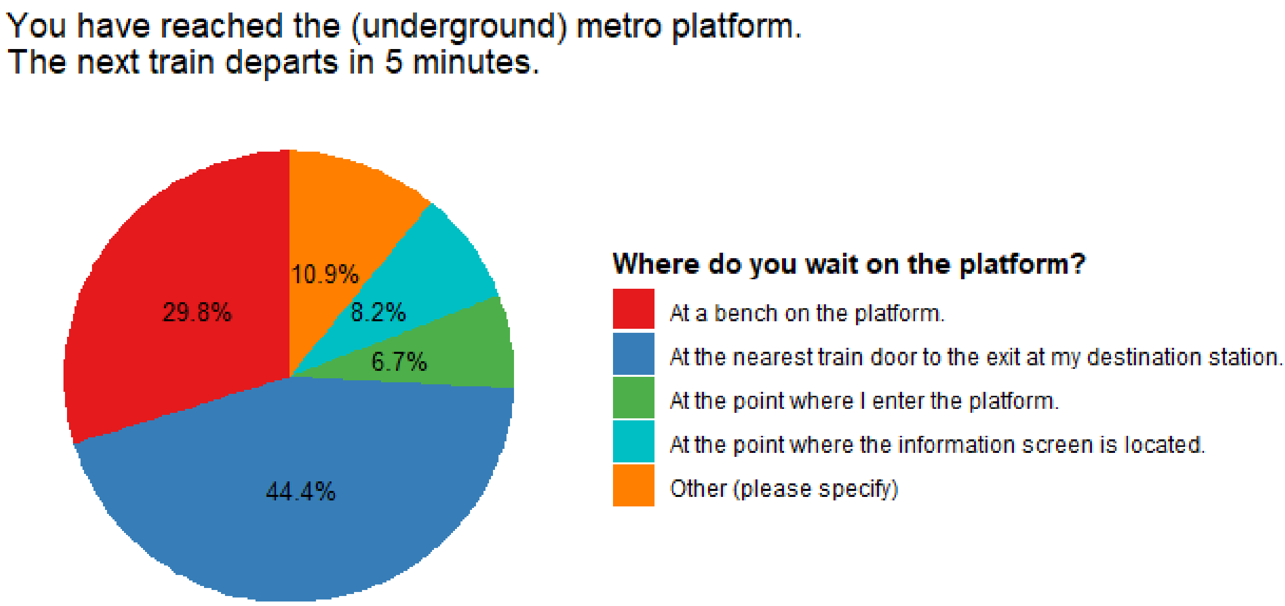

Figure 16: Survey – Preferred waiting position on the platform

A Chi-Squared test was conducted to assess whether there is a statistically significant relationship between the indicated waiting position and demographic variables and survey item related to metro automation and information systems. The variable “Impairment” was not included in the analysis, most likely due to a low number of impaired respondents, which would prevent reliable statistical testing.

Table 6 illustrates that gender and age of the respondents are not statistically significant for the waiting position. Metro use frequency (p=0.000010), the acceptance of automated metros (p=0.005060), along with the willingness to wait for a second next metro (p=0.001650) and moving to a less crowded carriage (p=0.003460) have a significant relationship to the waiting position on the platform. In order to visualise the correlation between these variables, a bar chart was created to depict the relationship between the waiting position on the platform and both metro use frequency and willingness to move to a less crowded carriage. The variable “Impairment” was not included in the analysis, most likely due to a low number of impaired respondents, which would prevent reliable statistical testing.

Table 6: Results of Chi-Squared tests regarding waiting position on the platform

Variable	Chi-Squared	p-value	Significant
Gender	12.497	0.388396	No
Age	35.603	0.152508	No
Metro use	76.007	0.000010	Yes
Acceptance automation	14.953	0.005060	Yes
Waiting for second next metro	31.938	0.001650	Yes
Moving on the platform	29.496	0.003460	Yes

Figure 17 illustrates the relationship between passengers' frequency of metro use and their preferred waiting position. The findings support the assumption that passengers who are familiar with the metro systems choose the nearest train door to the exit of their destination station twice as often as people who rarely or never use the metro. 20.3% of passengers who are not familiar with the metro system are positioning themselves next to the information system on the platform. A trend indicating that the more passengers use the metro, the less frequently they choose to sit on the bench.

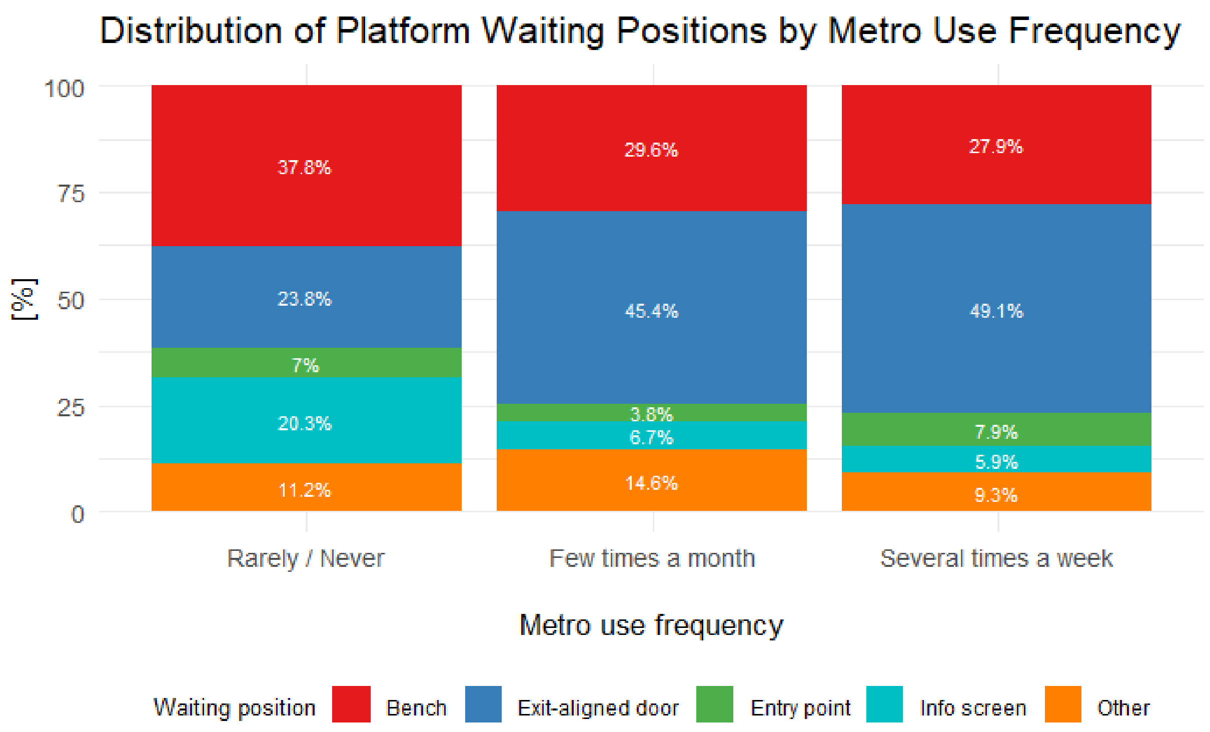

Figure 17: Survey – Platform waiting position by metro use frequency

The following bar chart in Figure 18 shows which groups of passengers are willing to move to a less crowded carriage in relation to their preferred waiting position. It highlights that passengers who wait near the platform entrance are less likely to move three carriages farther to access a less crowded area with available seats. Additionally, passengers who wait near the train door closest to the exit at their destination station depend rather their decision on the stops they will travel, compared to those who prefer to wait next to the information screen or a bench.

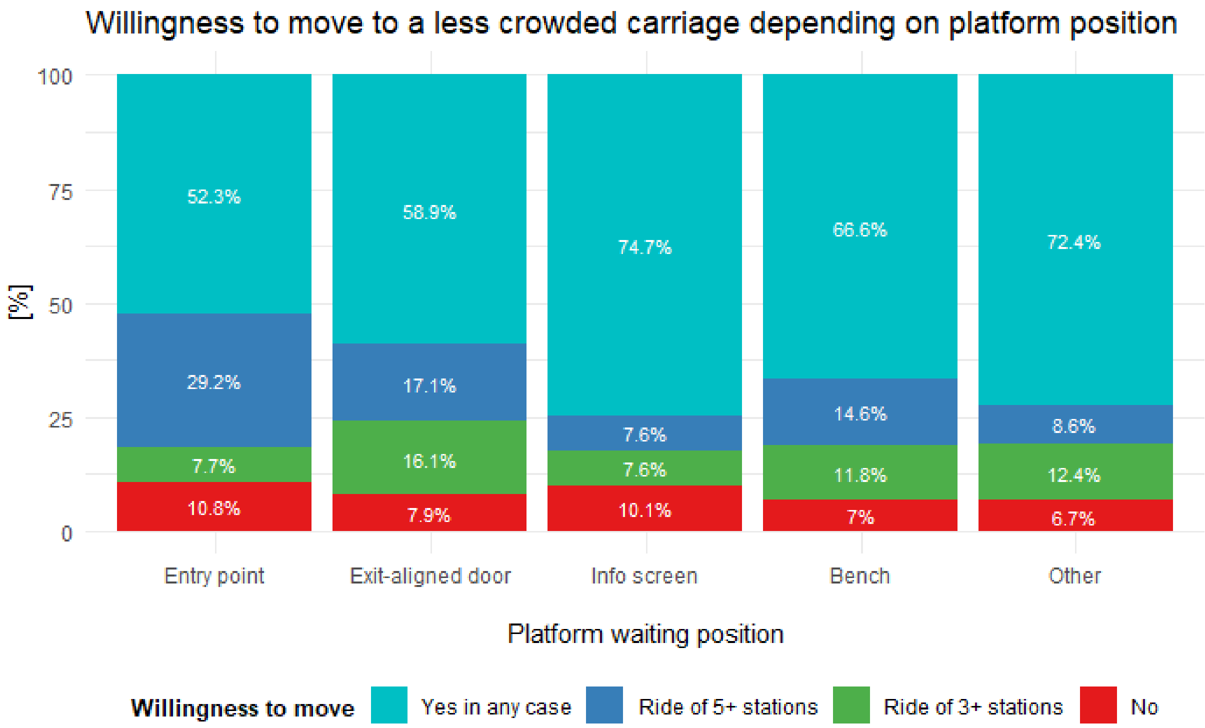

Figure 18: Survey – Preferred waiting position on the platform by willingness to move to a less crowded carriage

The pie chart in Figure 19 shows the percentage of respondents that would wait for a second next metro to avoid crowding in the vehicle. 26.6 % of all respondents would wait more than 5 minutes to have more space available during their ride. For 37.0 % of the respondents the limit would be 5 minutes to wait for a second next metro. 28.9 % indicated that the limit for waiting for a second next metro was 2 minutes for them. Only 7.5 % of all respondents would not wait for a second next metro in order to avoid crowding.

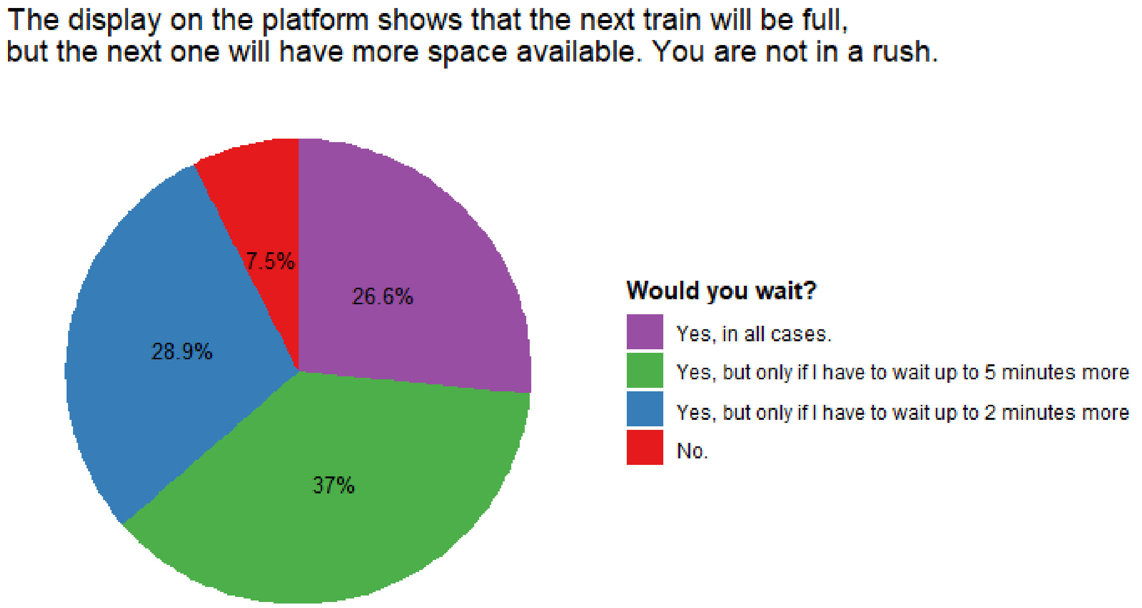

Figure 19: Survey – Willingness to wait for the second next metro

Table 7 summarizes the results of the Chi-Squared test examining the relationship between various factors and the willingness to wait for the second next metro. The analysis revealed statistically significant associations with four variables: Gender (p = 0.0169), Acceptance of automatic metros (p =0.0077), the waiting position on the platform (p =0.0016), and the willingness to move to a less crowded carriage (p =<0.0001). These findings indicate that passengers who are generally willing to wait for the second next metro are also more likely to move to a less crowded carriage. In contrast, no significant associations were found for frequency of metro use, indicating that the habit of driving do not substantially influence this aspect of passenger behaviour. The variable “Impairment” was not included in the analysis, most likely due to a low number of impaired respondents, which would prevent reliable statistical testing.

Table 7: Results of the Chi-Squared tests regarding willingness to wait for the second next metro

Variable	Chi-Squared	p-value	Significant
Gender	20.381	0.0169	Yes
Age	29.638	0.0973	No
Metro use	13.441	0.5705	No
Acceptance automation	11.879	0.0077	Yes
Waiting position	31.938	0.0016	Yes
Moving on the platform	43.124	<0.0001	Yes

Figure 20 shows that a majority of 63.5% would move three carriages, which is about 60 meters, down the platform in order to have an available seat during their ride in any cases. Only 7.9% would not move to a less crowded area, and 28.7% base their decision on the numbered stops they have to make on the metro.

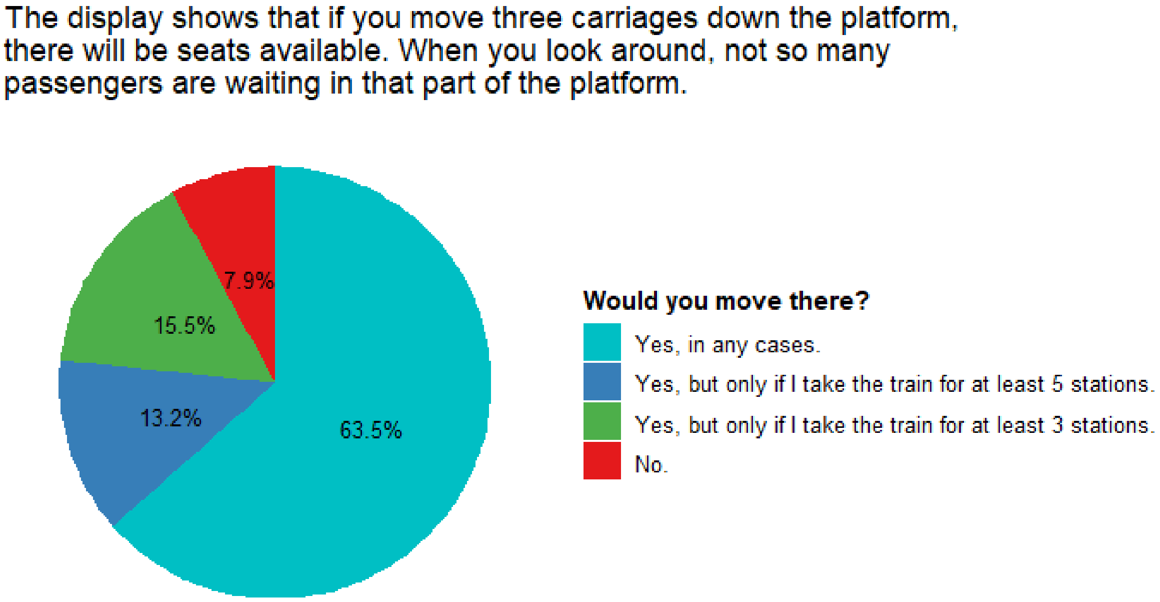

Figure 20: Survey – Willingness to more three carriages down the platform to get a seat during the metro ride.

Table 8 presents the results of the Chi-Squared test assessing the relationship between several factors and the willingness to move three carriages down the platform to find an available seat in the vehicle. The results indicate significant associations with three variables: acceptance of automatic metros ($p = 0.046$), preferred waiting position on the platform ($p = 0.003$) and willingness to wait for the second next metro ($p = 0.00001$). This suggest that passengers who position themselves strategically on the platform and those who are willing to wait longer for a less crowded metro are also more inclines to move farther along the platform for an available seat.

Table 8: Results of the Chi-Squared tests regarding willingness to move three carriages down the platform for an available seat.

Variable	Chi-Squared	p-value	Significant
Gender	15.033	0.095859	No
Age	17.158	0.698753	No
Metro use	23.607	0.071079	No
Acceptance automation	7.979	0.046470	Yes
Waiting position on the platform	29.496	0.003670	Yes
Waiting for the second next metro	43.124	0.000010	Yes

4.2.5. Information systems and platform safety - Analysis and findings

To understand passengers' preferences for information on the platform, they were asked to rate eleven different information categories to their desired position. Passengers could provide additional suggestions in an open-end comment field. Additionally, respondents were asked if they have ever experienced a risky or uncomfortable situation on the platform. In the questionnaire, passengers rated how frequently they had experienced the following situations.

- I was too close to the edge of the platform when the train arrived.
- My stroller, scooter, or other items started rolling toward the tracks.
- I accidentally dropped something on the metro track.
- I did not feel safe because there were too many people on the platform.
- I did not find necessary information for my travel on the platform.

Less than 5 % of all respondents reported experiencing "My stroller, scooter, or other items started rolling toward the tracks" and "I accidentally dropped something on the metro track.". To investigate a possible relationship between the two most commonly reported situations "I did not feel safe due to crowding on the platform, "I could not find necessary information for my ride" a Chi-Squared test was conducted to examine associations with demographic variables and survey items. A statistically significant association was found between feeling unsafe due to platform crowding and gender ($p = <0.001$) and metro use frequency ($p = <0.001$), as well as between the inability to find necessary information and the respondents' age ($p = 0.006$).

Furthermore, respondents could list their additional situations where they didn't feel safe on the platform. The most frequent mentioned situations were unpleasant individuals, who create a sense of insecurity, a poor separation of pedestrian flow on the platform and information on the platform didn't match the information on the train and was badly located. Woman in particular emphasized the need for clearly visible cameras on the metro platform to enhance their sense of security.

Table 9: Results of the Chi-Squared tests regarding experiences on the platform

Situation:	**I did not feel safe due to crowding on the platform**			**I could not find necessary information for my ride**		
Variable	Chi-Squared	p-value	Significant	Chi-Squared	p-value	Significant
Gender	55.872	<0.001-	Yes	12.624	0.397	No
Age	27.821	0.474	No	50.121	0.006	Yes
Metro use	61.281	<0.001	Yes	23.943	0.245	No
Acceptance automation	27.609	<0.001	Yes	7.436	0.114	No
Waiting position	26.846	0.043	Yes	20.244	0.209	No

Figure 21 shows that between 9% and 18% of respondents report standing too close to the edge of the platform at least once a year. Among males, the likelihood of feeling unsafe due to platform edge proximity decreases with age. In contrast, female respondents report a consistent level of discomfort across all age groups. Associations shown in the Chi-Squared test in Table 9 indicates that females feel more insecure in all three age groups. 61% of all females up to 30 years reported that they did not feel safe due to crowding at the platform at least once a year. This percentage keeps constant with age. 44 % of males between 31 and 60 years indicate that they don't feel safe at the platform because of too many people. For males there is a rising trend with increasing age. The trend is exactly the opposite when looking for information. Females under 30 years report more difficulty finding the information they need for their metro ride, than at the age of 61 or older 51 % of males cannot find their required information at least once a year and 42 % of females above 61 years indicate that they can't find the information they need.

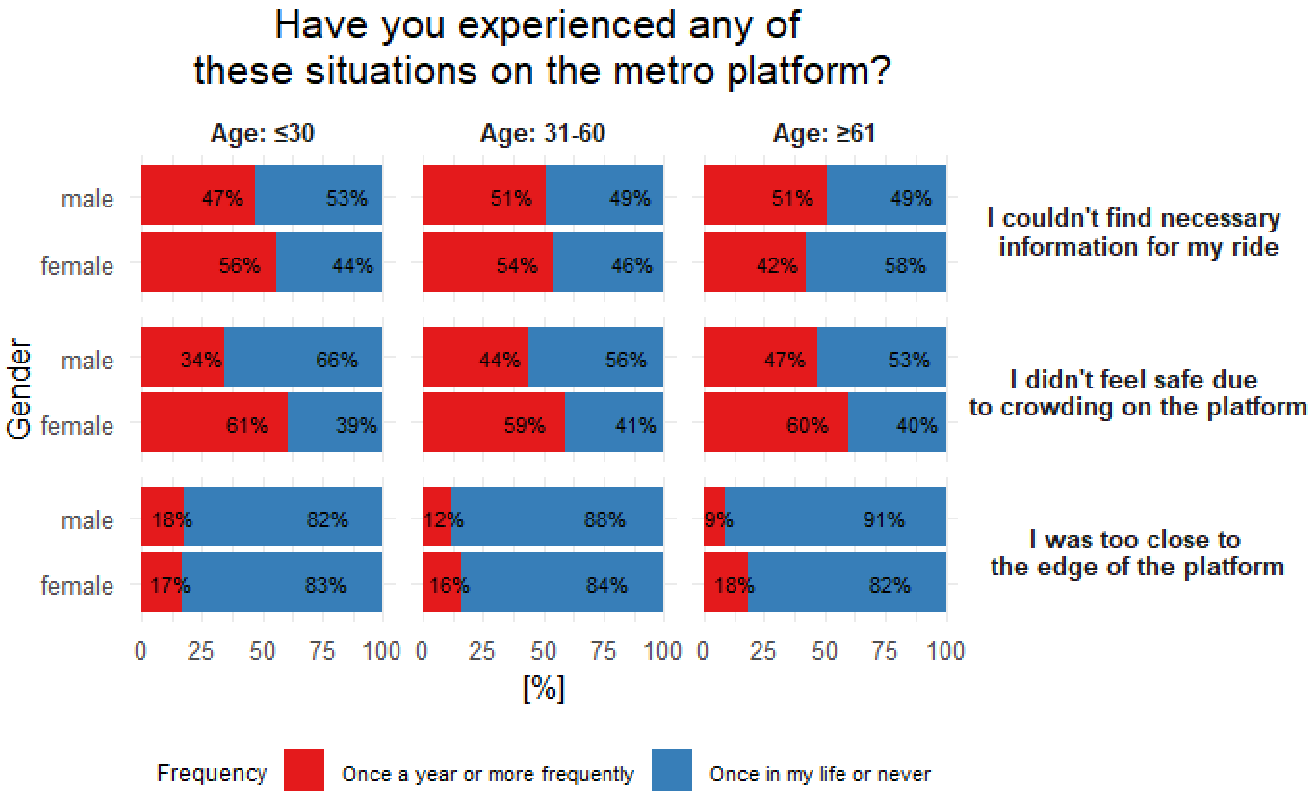

Figure 21: Survey – Experience of listed incidents by age group and gender

To get more insight into where passengers require certain information at the platform, respondents were requested to allocate eleven individual information to their desired position on the platform. Figure 22 was attached to the questionnaire to illustrate the possible locations where information could be displayed.

- Display 1 – Screen on the platform screen door
- Display 2 – Screen above the platform, perpendicular to the track
- Display 3 – Information screen mounted on the sidewall of the platform
- Display 4 – Floor markings with LEDs
- Display 5 – Mobile Phone

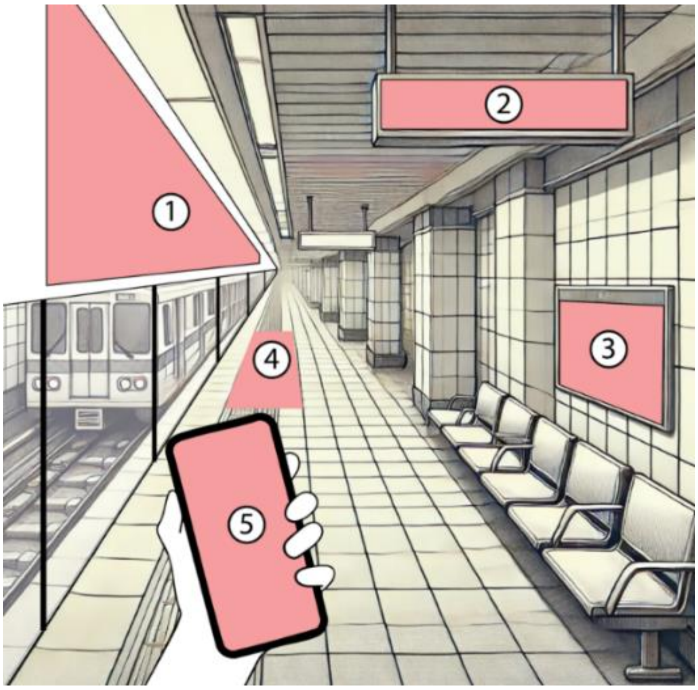

Figure 22 Survey - Options of display where the listed information is preferred. (Da Un Yun, personal communication, 2025)

In addition to the display options, respondents could also select “Outside the platform”, “In the train” and “I don’t need the information” were possible options to answer. This was a multiple-choice question and therefore the percentage of the result is more than 100%, because the percentage was calculated by the number of respondents.

Since Table 9 shows a statistically significant relationship between experiencing not being able to find the necessary information at the platform and the age, the results were divided by age groups. The information “Alternative routes if there are disruptions” was frequently assigned to multiple displays. Passengers up to 30 years preferred their mobile phone for displaying this information, while people older than 60 years required this information either on the display above the platform (display 2) or outside the platform. To get information about the closest stations to tourist spots in all age groups the most popular display was the information screen on the sidewall of the platform (display 3). In addition, train arrival times were most commonly associated with display 2.

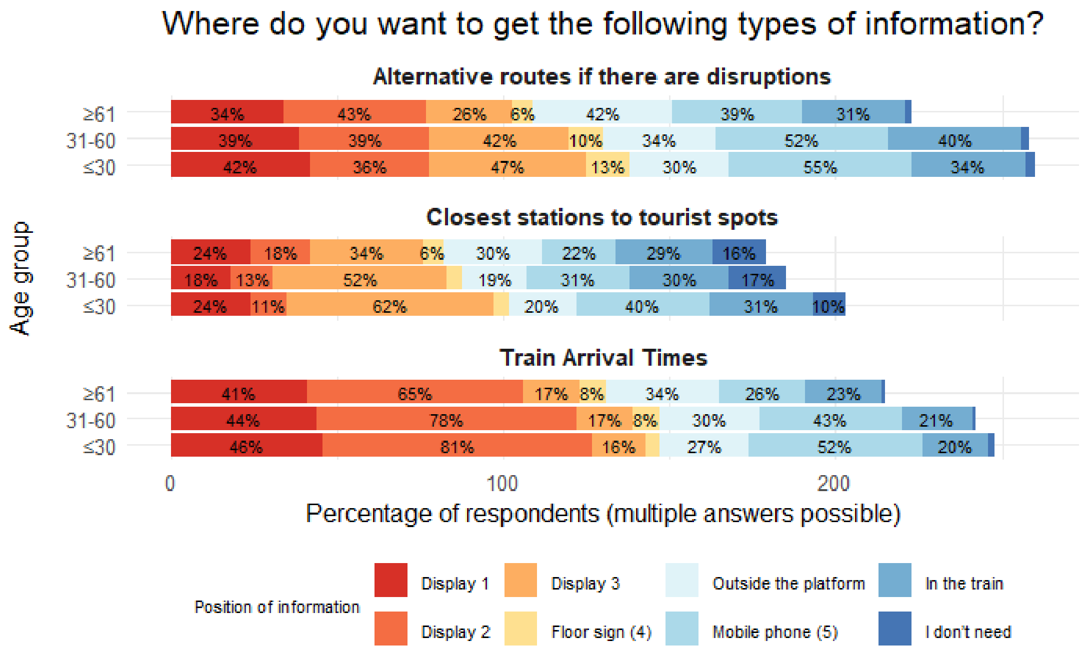

Figure 23 Survey – Required positions for displaying “Alternative routes in case of disruptions”, “Closest stations to tourist spots” and “Train arrival times”

The most popular display position for accessibility information was “In the train”. However, preferences were distributed across several options, with no clear majority. More than half of all respondents required the information “Crowded or less crowded wagons” to be placed at the platform screen door (display 1).

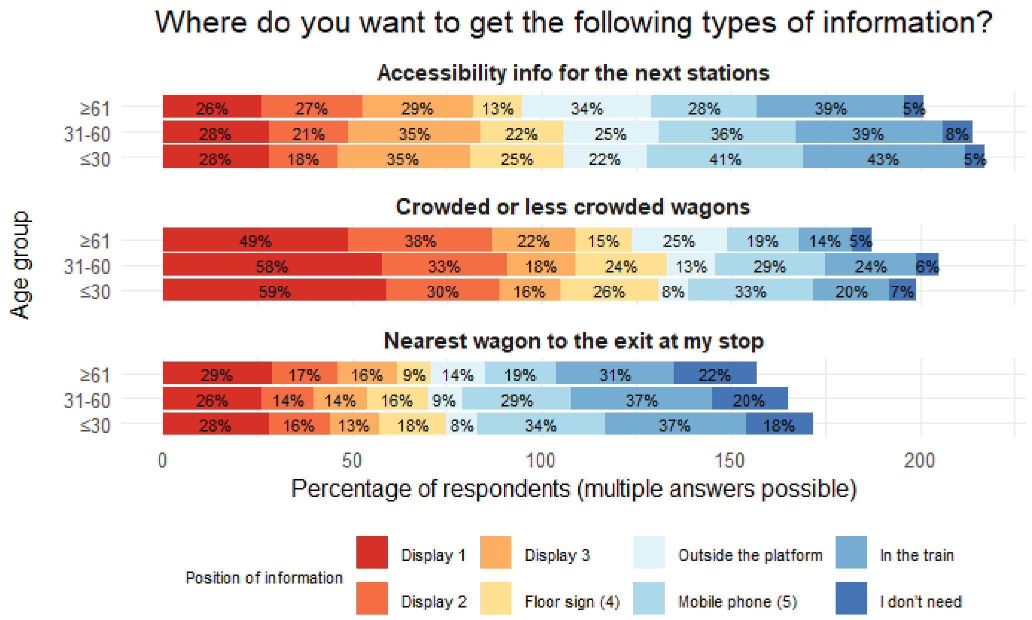

Figure 24: Survey – Required positions for displaying “Accessibility information”, “Crowded wagons” and “Nearest wagon to the exit at the stop”

59% of respondents under 31 years preferred to contact customer service via mobile phone, while the majority of respondents above 60 years required the contact information for customer service to be at the information screen on the sidewall (display 3) and outside the platform. For getting information on broken doors the younger age group requested it to be on the platform screen door (display 1) while the older age group also preferred it to be displays in the train. With a large gap “metro map with transfer points” was most frequently preferred to be shown on the information screen on the sidewall of the platform (display 3).

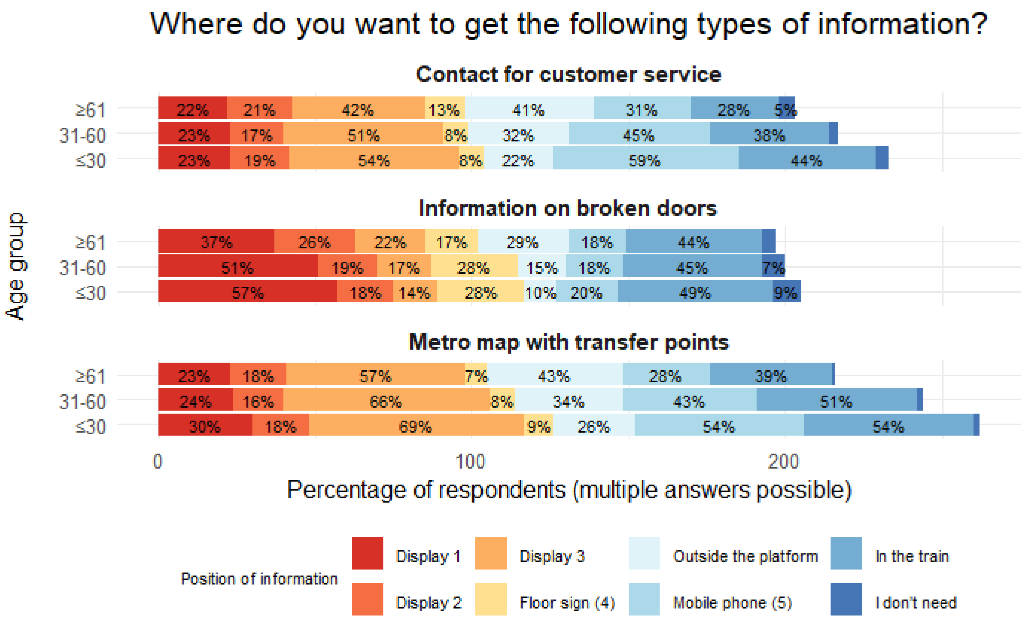

Figure 25: Survey – Required positions for displaying contact information for customer service, broken doors and metro map transfer points

52% of respondents under the age of 31 preferred the information about doors for specific needs to be displayed on the floor markings (display 4). Displays 1 and 3 were selected in equal measure by the age group 31-60. The age group above 60 required this information to be displayed at the platform screen door (display 1). “Planned disruptions or service changes” were voted evenly for display 1,2 and 3 and outside the platform at the age group above 60 years. Younger respondents more frequently preferred to receive this information on their mobile phone.

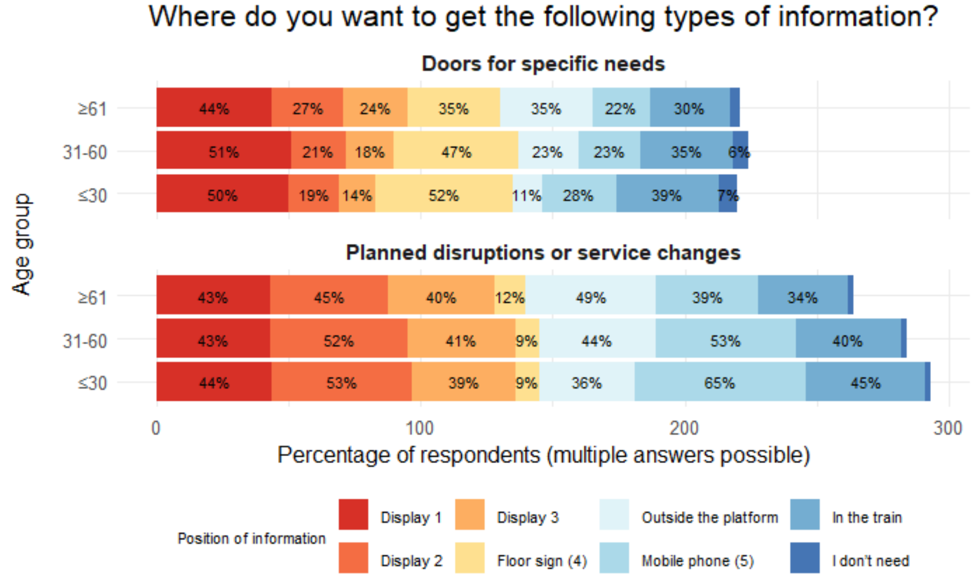

Figure 26: Survey – Required positions for displaying doors for specific needs and planned disruptions.

Additionally, many passengers wanted more information in real time, e.g. about delays, transfer options, train capacity utilization and which carriages are less crowded. Better orientation within the stations was also frequently mentioned, such as clear indications of exits, functioning elevators or the most accessible route. A user-friendly and comprehensive on-board system that combines visual and acoustic information, ideally with helpful extras such as weather information or the location of public toilets, proved to be particularly important.

4.2.6. Choice of positioning in the vehicle - Analysis and findings

To gain deeper insights into passenger behaviour within metro vehicles, the survey examined where passengers prefer to sit or stand during their ride, as well as reasons for choosing to stand. Figure 27 illustrates in which situations passengers are preferring to stand while taking the metro separated by gender and age. This question was designed as a multiple-choice format. The most frequent situation why respondents chose to stand was when passengers needed the available seat more urgently followed by “Less than 5 stations” and “During Rush hour”. The willingness to stand during the ride decreases with age, particularly among women. During rush hour, woman over the age of 60 are especially unlikely to give up their seat or choose to stand.

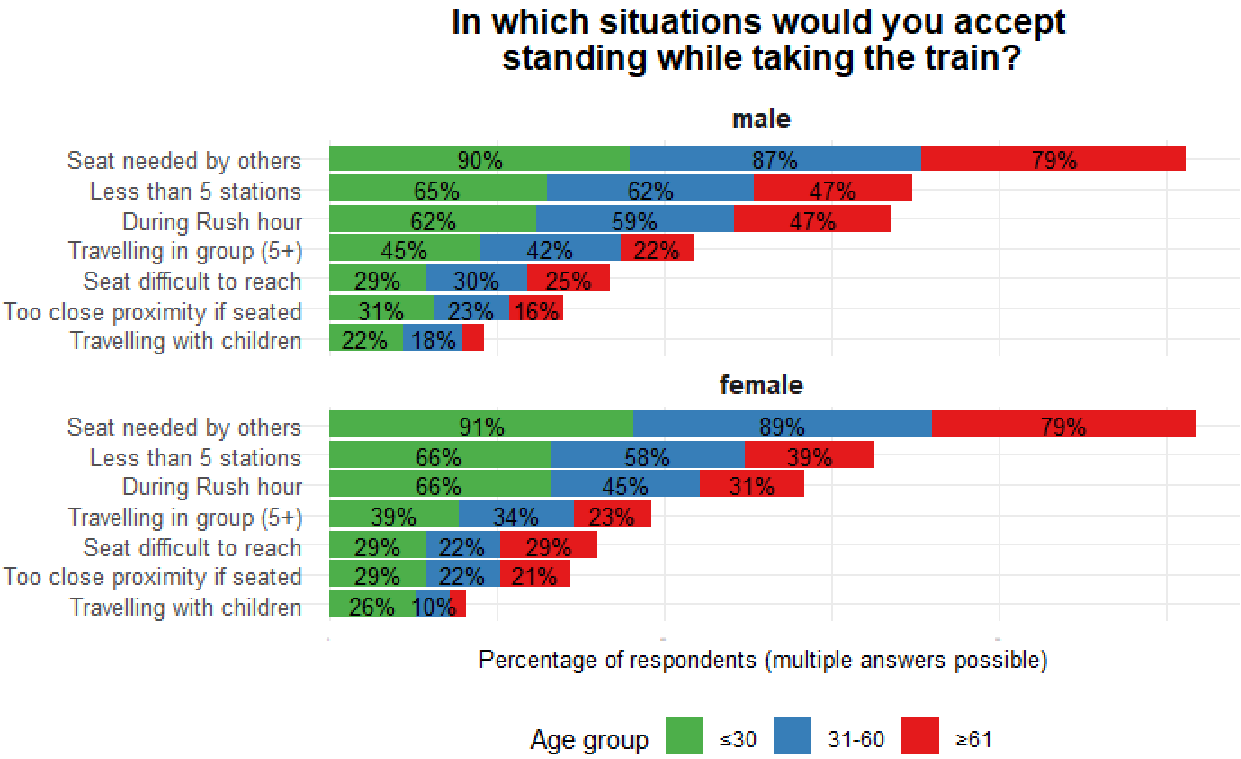

Figure 27: Survey - Situations for accept standing while taking the metro by gender and age group.

In two different metro interior layouts respondents were asked to indicate their preferred seat in the vehicle. In the lengthwise seating layout (left image) a clear majority chose seat 3, which is the closest seat to the exit door of the metro. In the crosswise seating layout (right picture) the choice of passengers depended more on the driving direction of the metro. 39.0 % of the respondents chose seat 4, which is also the closest to the exit door.

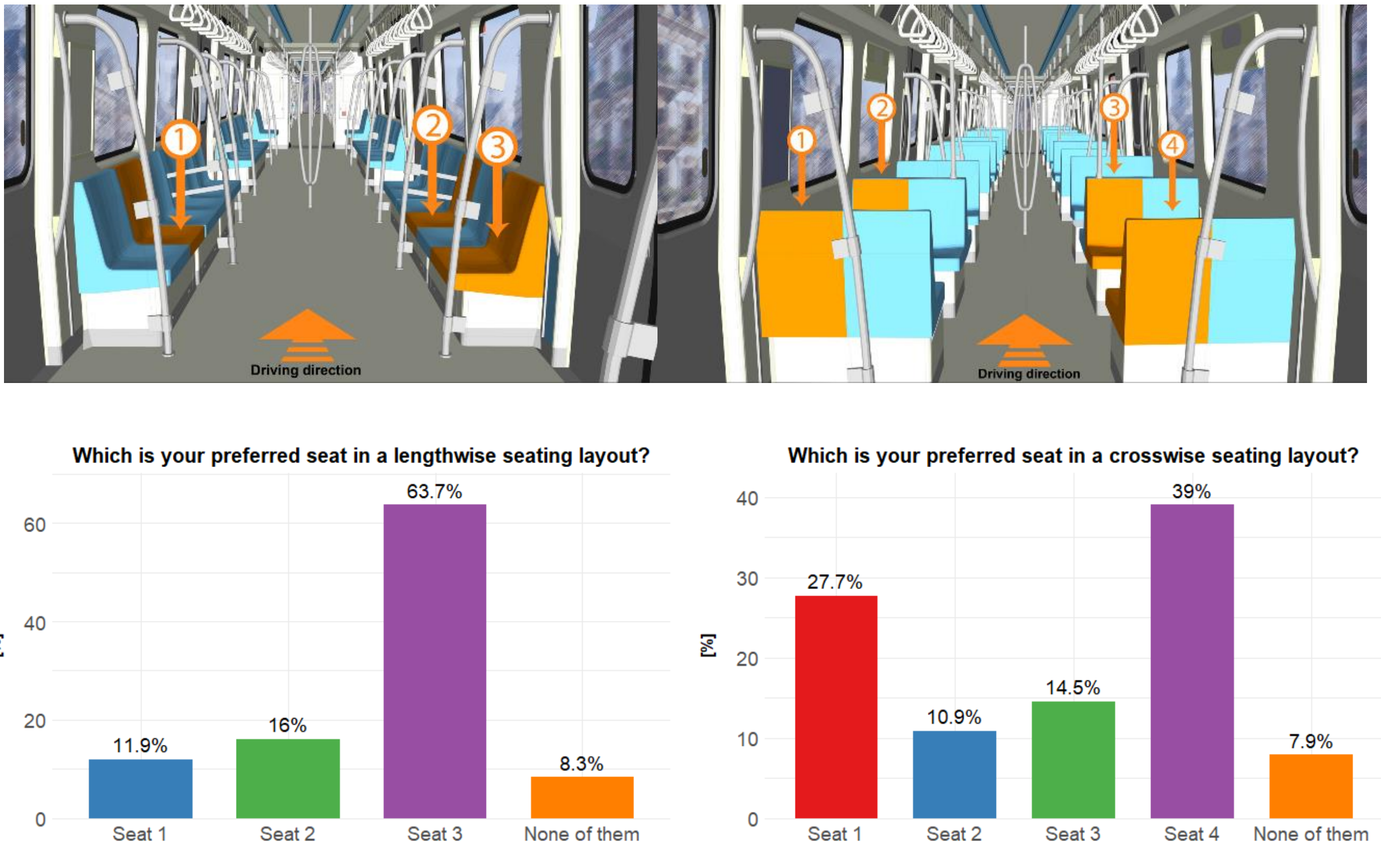

Figure 28: Survey – Preferred seat in the vehicle.

In the same metro layouts as in Figure 28 respondents were asked about their favourite standing position during the ride. The possible positions were the same in the lengthwise and crosswise seating layouts, but the favourite standing positions differed between the layouts. In the left layout the most preferred standing position was at the vertical rail in the entrance area (Position 2). In the crosswise 2x2 seating layout (right image), passengers prefer more the position next to the metro door (position 4). Position 1 was notably preferred in the crosswise seating layout due to less proximity to the seating passengers, whereas in the lengthwise sitting layout position 3 was more popular.

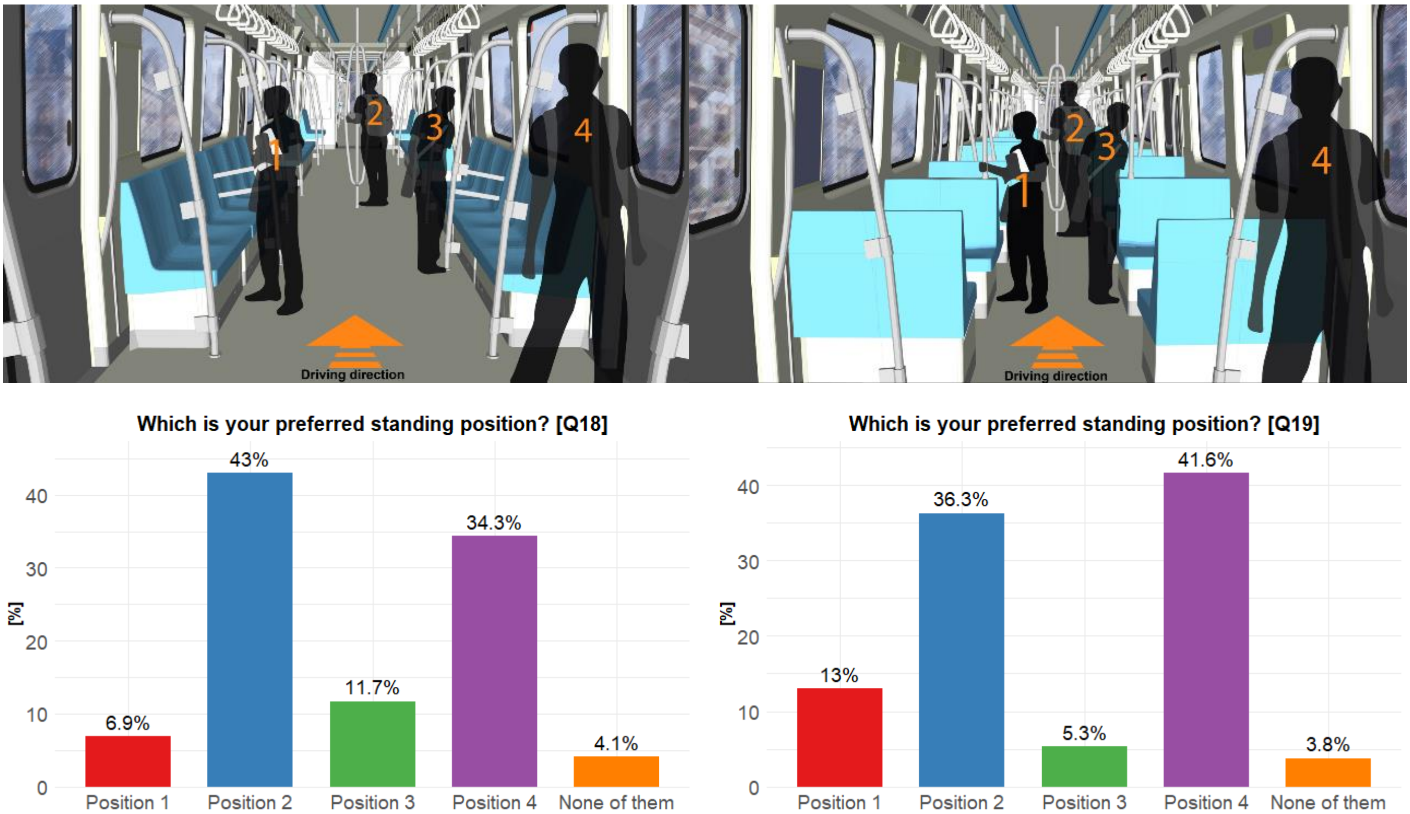

Figure 29: Survey – Preferred standing position in the vehicle

Figure 30 indicates the trend the younger the respondents were, the more likely they took the closest seat next to the vehicle door (seat 3). 70.3 % of respondents below 30 years chose seat 3, while 57.0 % of the respondents above 61 years take seat 3. Seat 1 and especially Seat 2 are less popular among all respondents. 9.2 % of respondents between 31 and 60 years and 11.4 % of respondents over 61 years would not take any of the options for seating.

Table 10 shows Chi-Squared test results from different variables affecting seat preferences in metro vehicles with two different seating layouts. For lengthwise seating the only variable with a statistically significant association age ($p = 0.0266$), suggesting that age and physical conditions influences seat selection. For crosswise seating gender is the only variable with a statistically significant correlation on the seat option ($p = 0.0010$), indicating a meaningful difference between female and male respondents for crosswise seating layouts. The variable "Impairment" was not included in the analysis, most likely due to a low number of impaired respondents, which would prevent reliable statistical testing.

Figure 30 indicates the trend the younger the respondents were, the more likely they took the closest seat next to the vehicle door (seat 3). 70.3 % of respondents below 30 years chose seat 3, while 57.0 % of the respondents above 61 years take seat 3. Seat 1 and especially Seat 2 are less popular among all respondents. 9.2 % of respondents between 31 and 60 years and 11.4 % of respondents over 61 years would not take any of the options for seating.

Table 10: Results of the Chi-Squared regarding preferred seat in the metro

Situation:	Seat lengthwise			Seat crosswise		
Variable	Chi-Squared	p-value	Significant	Chi-Squared	p-value	Significant
Gender	12.57	0.1831	No	33.05	0.0010	Yes
Age	35.23	0.0266	Yes	25.43	0.6042	No
Metro use	23.79	0.0687	No	14.54	0.8020	No
Acceptance automation	2.77	0.4290	No	5.02	0.2849	No
Waiting position	17.97	0.1165	No	15.21	0.5093	No
Moving on platform	13.47	0.1423	No	14.20	0.2879	No

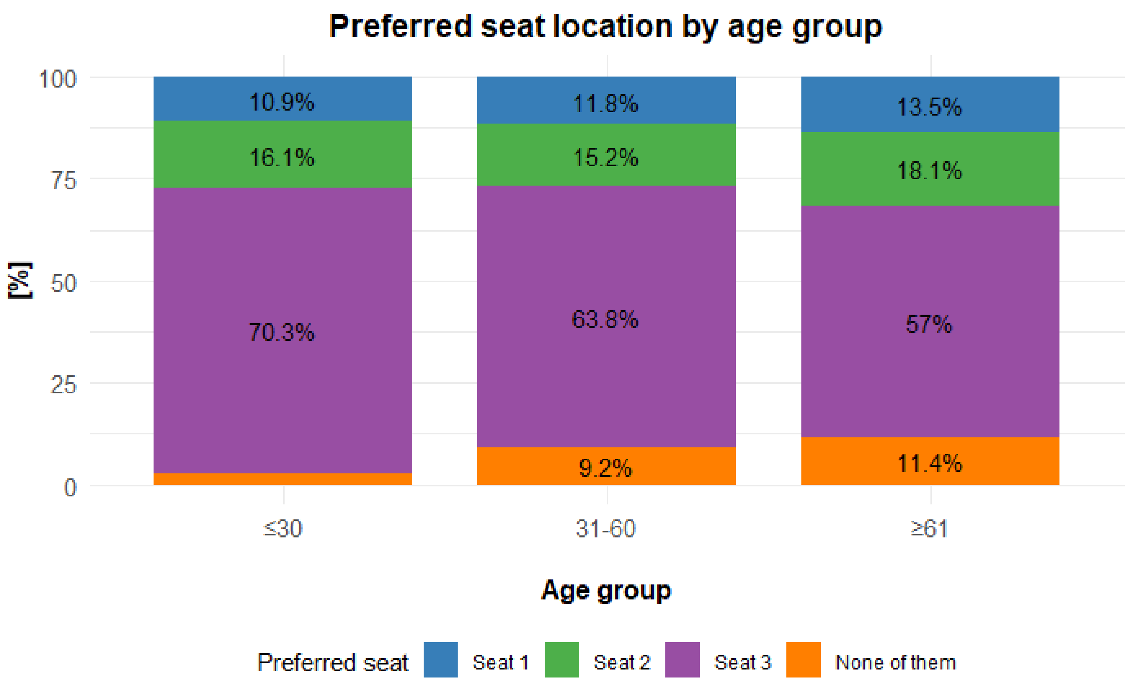

Figure 30: Survey – Preferred seat in the vehicle with a lengthwise seating layout by metro use frequency.

The statistical significance of gender for preferred seats is illustrated in Figure 31. Females are more likely to take the aisle seats and less likely to take the window seats. Especially seat 4, which is the aisle seat facing the direction of travel is the most preferred one for all genders, especially for women with a percentage of 45.7%. With a small margin, males also preferred seat 4 males, Seat 2 was also favoured by 31.7 % of males, which also faces the direction of travel, but is a window seat.

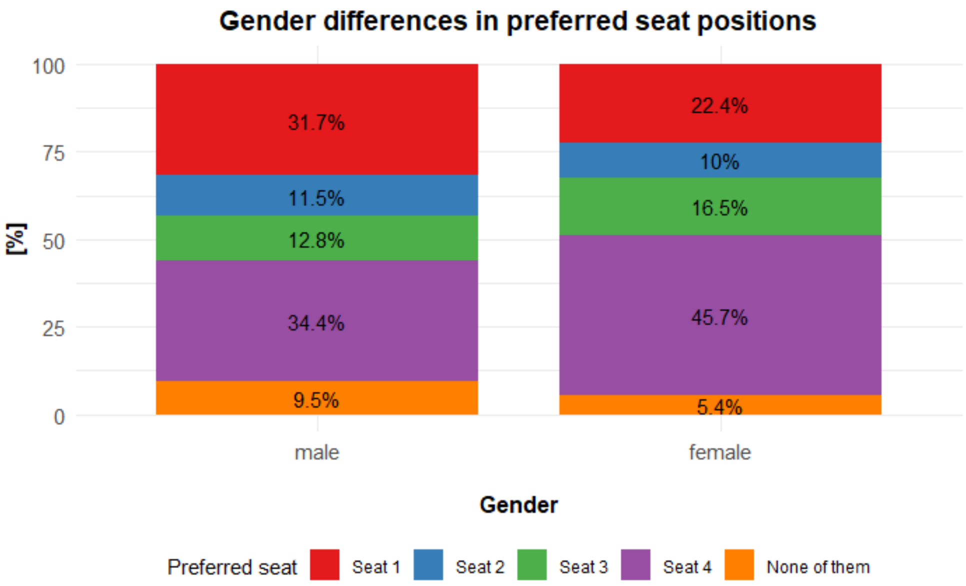

Figure 31: Survey – Preferred standing position in the vehicle with a crosswise seating layout by gender

Table 11 presents Chi-Squared test results for various influencing the choice of standing positions in two different metro interior layout concepts. None of the variables, such as age, use frequency or automatic metro acceptance had a statistically relationship for the preferred standing position. Metro use frequency and age came close to significance for standing options. The variable "Impairment" was not analysed, because of a small sample size of impaired individuals, which limits the reliability of such tests. The result suggests that other aspects, such the interaction with passengers, play a relevant role in seating preferences.

Table 11: Results of the Chi-Squared tests regarding preferred standing position

Situation:	**Standing lengthwise**			**Standing crosswise**		
Variable	Chi-Squared	p-value	Signifi-	Chi-Squared	p-value	Significant
Gender	13.54	0.3310	No	12.72	0.3901	No
Age	32.24	0.2647	No	34.70	0.1787	No
Metro use	30.63	0.0603	No	27.86	0.1126	No
Acceptance automation	8.30	0.0812	No	4.33	0.3629	No
Waiting position	22.11	0.1396	No	14.80	0.5396	No
Moving on the platform	17.99	0.1161	No	10.82	0.5444	No

4.3. Results of the expert interviews

This section presents the findings from the expert interviews conducted with professionals in human behaviour, customer experience, information systems, and special solutions of vehicle interior. The results are structured separately for each interview due to the substantial differences between the topics.

4.3.1. Interview with Elisabeth Oberzaucher

The interview with Elisabeth Oberzaucher covered the following topic: metro interior design, passengers' distribution on platforms and metro automation. As an expert in human behaviour in public transportation, she has previously conducted research on metro systems in Turin, Paris and Vienna. In particular, her work in Vienna focused on human interactions with information systems, platform design, and seating and positioning within trains. This expertise makes her well-qualified to address the following questions.

4.3.1.1. Metro Interior

Q1: What influences the choice of seating for passengers in metros?

People tend to prefer to make the least physical effort and sit down when the opportunity arises. The subjective perception of the number of stations from which people want to sit down differs greatly from reality. Basically, if the available seats are easy to reach, passengers prefer them. Of course, contact with other people plays a role.

Q2: Do passengers prefer longitudinal and transverse seating?

This depends on the width of the vehicle model. Crosswise seating is not possible due to the narrow width of the vehicle. People generally prefer it when there is a wall behind the backrest, i.e. when there are no people behind them. This is why many people prefer longitudinal seating. The new X-series carriage from Vienna offers a mixed seating option. Due to high acceleration values, it can happen that people sitting in a longitudinal seat are pushed to the neighbouring seat. Whether people want to sit in or against the direction of travel is very evenly balanced.

Q3: Which standing areas and handholds are preferred by passengers in metros?

Human consciousness does not like rooms that have corners. That is why entrance areas in metros should always be designed in a funnel shape to the seating areas. If the two outer seats are removed in a crosswise-seating layout, people feel more comfortable travelling further into the metro. The most unpopular handle in the metro is a hand strap. This is still often utilised in metros. However, people have to invest more physical energy to maintain stability. That is why they prefer handles that are fixed to the vehicle.

4.3.1.2. Platform distribution of passengers

Q5: What influence do information and guidance systems have on platform distribution?

There are two different types of passenger behaviour. The people who regularly use a metro to commute and occasional riders. Commuters in particular know exactly where to get on the metro so that they can leave the platform at their destination as quickly as possible. If real-time information systems are installed, commuters will be less likely to choose a different boarding door. Studies have shown that passengers will move at least two to three doors if they are shown that there is less capacity in the vehicle at this position

Q6: Are there any findings as to whether displays that show real-time information on vehicle utilisation have significant advantages?

The positioning of these displays plays an important role here. If the display is positioned above the passageway at the platform door, passengers block the way for those alighting. If the display is positioned between the two platform doors, people are too far away from the platform door. Floor lights, which are intended to show the occupancy level in green and red, are not ideal as they cause people to be too close to the platform edge or people can only see the lights in their immediate surroundings and do not have an overview of the entire platform.

4.3.1.3. Automation of metros

Q7: Do passengers on driverless metros feel more unsafe?

People definitely feel more unsafe on driverless metros. In the event of an emergency, it is important for them to have a contact person. Most people are not aware of the exact duties of metro drivers. Despite the fact that a driverless metro has fewer accidents, the subjective assessment is that people trust the human rather than the machine. If driverless metros had a boarding crew walking through the metro at all times, this would improve the passengers' sense of safety even more than the conventional systems that only have a metro driver on board.

Q8: Do passengers feel safer walking through platform doors than without?

Although there are very few accidents on metro platforms, the subjective perception of an accident is much higher than the actual percentage occurrence. Metro drivers also perceive incidents much more intensely and think that accidents happen more often than they actually do. Platforms do not block the path of alighting passengers, as they know where to stand due to floor markings and platform doors. The floor markings must be accurately designed and use warning colours to indicate that people must wait outside the alighting area.

4.3.2. Interview with Markus Geist (SBB)

The interview with Markus Geist covered the topic metro interior design and information systems. He is an expert in vehicle acquisition and conducted several surveys in his work carrier. In these surveys they focussed especially on the behaviour and the requirements of passengers. Especially his knowledge about the interior preferences is a fundamental input for the questions 15-19 in the passengers' survey. This expertise makes him well-qualified to address the following questions.

4.3.2.1. Metro Interior

Q1: What factors influence the choice of sitting in the vehicle? Which seats do passengers prefer?

The factors why people favour certain seats are complex. At SBB a comparison was made between 2+2 seating (two seats facing the direction of travel and two seats facing against the direction of travel) and 2-seater seats that only face the direction of travel. In Switzerland, there is mainly 2+2 seating, which is very popular with passengers. The window-side seat is favoured over the aisle-side seat. In the event of capacity bottlenecks or an occupancy rate of 80-90%, people tend to sit down in the free seats, which is why the aisle seats are occupied in this case. Younger people have fewer hesitations about sitting next to other people than older people. Many people perceive a row of seats as occupied if only one person is sitting in the 2+2 seats.

Q2: Do passengers prefer longitudinal seating (parallel to the direction of travel) or crosswise seating (opposite rows of seats)?

In the double-decker trains, there is longitudinal seating next to the stairway area in the trains due to the door technology. These seats are the last to be occupied by passengers. This may be due to acceleration. Folding seats facing the direction of travel are also very little used, which is why they are no longer installed in new models. Instead of this space, more seats were installed, and a comfortable standing area was planned. The only longitudinal seating that goes down well with passengers is the working area, where people can sit at a seat, which is like a bar stool, and look out of the window. There was a concept in which individual seat elements could be turned and passengers could decide whether they wanted to sit across or lengthways to the direction of travel. Passengers tended to get sick if they sat lengthways to the direction of travel.

Q3: Which standing areas and handholds do passengers prefer to use? Which design increases comfort and safety?

The most favoured standing position is leaning against windows and wall elements in the trains. Of the grab rails, vertical rails are preferred over horizontal rails.

Vertical bars, especially those divided into several sections at passenger height, are very popular. This makes it easier for everyone to have their own rail and prevents passengers from coming into contact with other passengers.

Q4: Which passenger information systems are used in trains? Which of these improve the distribution of passengers?

There are no separate passenger information systems on the platform that display the degree of capacity utilisation. As SBB only operates regional and long-distance trains, the real-time information is only displayed in the vehicle. Seat occupancy displays on the platform must be displayed at least five minutes in advance to allow passengers to change their position along the platform. Due to the long journey time, it is advisable to display the seat occupancy in the vehicle so that passengers can then move to areas that are less busy. This information is shown on the conventional displays. In addition, details such as the upcoming stops, the final destination, and the side of the train where the door will open are also displayed. For long-distance journeys, the map of where the train is located is also displayed, as well as the speed.

Q5: How is the boarding area designed to minimize the passenger changeover time?

All boarding areas are level with the platform or at most 55 mm above the platform edge. The door width is at least 140 cm wide allowing two passenger flows to pass through simultaneously. Excessive wide doors (e.g. 320 cm) do not provide any added value, as they do not facilitate two separate passenger flows. The boarding areas are always designed in the same way, and the luggage racks are located in the third of the carriage.

4.3.3. Expert interview with Julian Fordon (Deutsche Bahn)

The interview with Julian Fordon focused mainly on the new train concept *Ideenzug*. This concept is intended to revolutionize the rail experience for passengers. To achieve this, several traditional equipment elements have been redesigned or replaced to improve comfort and accessibility. A major focus is also on more comfortable standing, adjustable seating elements in the vehicle and the integration of displays above the windows and on the floor of the vehicle. During the expert interview, Julian Fordon explained which solutions could be incorporated into metro vehicles.

Q1: Which interior features can improve passenger distribution in the vehicle?

The entry areas of the vehicle should be spacious to encourage passengers to board the vehicle. The seats should be positioned away from the boarding area to allow passengers to board and alight more easily. It is recommended that these areas are equipped with folding seats that can also be leaned against. To increase capacity in the vehicle, standing during the journey should be as comfortable as possible. In the middle of the vehicle, and especially at the axis between two metro carriages leaning paddies to allow a combination of sitting and standing. This means that more people have space in the vehicle and the passenger changeover time can be reduced. The grab rails should be adapted to different people with different body heights. It is recommended that the grab rails are height-adjustable so that people of a smaller height can also hold on to them comfortably. There is also a concept of adjustable seating groups. These can be converted from a 4-seat combination to row seating, but they are not safe from vandalism, and the servomotor is very heavy.

Q2: Which information systems should be used in the future and where should they be displayed?

The positioning of the information displays should be clearly visible to all passengers, regardless of their position. Displays hanging from the ceiling are generally recommended. These should be in the aisle area of the train, not in the boarding area. To motivate passengers to move closer to the inside of the vehicle. As passengers are increasingly looking at their smartphones, LEDs on the floor can also be seen. However, these will only display simple pictograms, such as defective doors, exit side and stroller and bicycle storage area. Additionally, the displays above the doors should provide passengers with information on the direction they should take when alighting, helping them avoid searching for this information on the platform and obstructing the flow of passengers.

4.3.4. Expert interview with Tobias Fiebag (Deutsche Bahn)

The interview with Tobias Fiebag covered the topic metro interior design and information systems. He worked on the interior design of the suburban trains in Munich and also wrote his diploma thesis on the subject. The interaction between the theoretical knowledge of his thesis and the practical reference makes him ideally qualified to conduct this expert interview. The expert interview covered the key topics vehicle layout and information systems.

Q1: What factors influence the choice of seats on trains? Which seats do passengers prefer?

There are two types of passengers. The first type consists of passengers who know the system. They know exactly which door to board at in order to get a seat and leave the platform as quickly as possible when alighting. This type of passenger follows a similar pattern of behaviour when choosing a seat. The second type consists of people who do not know the system, and they tend to choose according to biological factors, such as seeking as much privacy as possible while also ensuring they can exit the train quickly. These passengers avoid contact with strangers and dirty seats.

Q2: Which passenger information systems are used in trains or on the platform to decrease the dwell time?

There are concepts in which the occupancy of people in the vehicle can be displayed. However, people who rarely use the vehicle pay less attention to this than those who use the vehicles more often. The information must be displayed in a timely manner so that people can react. If the passenger information is displayed too late, passengers may rush onto the platform. There are also service staff on the platform at the most important stations in Munich who are responsible for distributing the flow of passengers. This is also to stop people from blocking the doors and preventing them from closing. During the boarding process, they stand in front of the door and prevent last-minute door rushing.

Q3: Are there any special solutions for vehicle interiors? How are these perceived by passengers?

The boarding areas on the new suburban trains in Munich have been planned to be more spacious and the seat combinations in the boarding area have been optimized. Instead of the 4-seat combination, there is a 3-seat combination. The aisle-side seat next to the door has been removed to create a funnel shape, making it easier for people to enter the vehicle. In addition, higher quality seat covers and materials have been used. The area between the door and the first seat has been enlarged by 30 centimetres to allow people to stand in this area as well. The grab rails in the boarding area have also been improved, offering various solutions to ensure suitable holding options are available for different body heights. There are also cushions on the wall for people to lean on. This should encourage more people to stand. This mixture of sitting and standing reduces the physical strain on people. There is a communal seating area next to the driver's cab, which was specially designed for families. Fewer luggage racks were used, as these were not used by passengers anyway. To ensure that items of luggage such as large suitcases and bicycles are stored in the right place, there is an additional floor marking to guide people.

4.3.5. Expert interview with Sarah Fessl (ÖBB)

Sarah Fessl and her team were responsible for the design of the new high-speed trains in Austria. The interview was accompanied by Susanna Burghardt, who works as Senior Product Manager for Customer Experience, and Thomas Berger, who specializes in information systems in the vehicle and on the platform. The expertise of these three people matched the detailed questions of the topics information system and train interiors very well.

Q1: What equipment elements are planned for the vehicles in the future?

In the future, a demand-based interior design will become increasingly relevant. This should make it possible to turn 4-seat combinations into row seating. In the case of large passenger flows, the seats should also be adjustable to increase the vehicle’s capacity. Equipment elements should also be easy to replace quickly. Handholds should be integrated on the seats to encourage passengers to move further into the vehicle. In general, the grab handles should be at body height and designed to be easily gripped, using special stainless steel with antibacterial properties can further enhance hygiene.

Q2: Which passenger information systems are used in trains and at the platform to improve the change-over time of passengers?

There is an online service from ÖBB (Austrian Federal Railways) that shows the real-time occupancy rate of vehicles. The occupancy rate is divided into three different levels so that passengers can easily recognize and assign it. The occupancy rate is also displayed on the train. Here, the occupancy rate in the respective carriage is displayed next to the door, as well as the occupancy rate of the two neighbouring carriages. The sooner passengers know the occupancy rate of the individual carriages, the better. For this reason, the load factor will also be displayed on the overhead displays on the platform in future. This display will be very simple and there will be three utilization levels. Defective doors will also be displayed. The degree of utilization is determined by various information such as mobile radio data, reservation data and also the passengers' Wi-Fi usage. The problem is that if, for example, a school class gets off at a platform, the real-time information is incorrect. According to Thomas Berger, accepting this risk of incorrect data must be accepted in order to operate a real-time information system.

5. Discussion

5.1. Metro Automation:

Brief Summary of the Key Results

86.9 % of the respondents expressed acceptance of fully automated metro systems. The main concerns among the 13.1 % who would not use a driverless metro are potential technological failure and no human guidance during evacuation or emergency situations. The most frequently expected benefits of automatic metros were “extended operation hours”, “improved real time information”, and “more frequent schedules”. The expected benefits were graphically divided by acceptance of automatic metros. Elisabeth Oberzaucher reported in the expert interview that for passengers it is important to have a contact person in case of an emergency. Nevertheless, most people are not aware of the exact duties of metro drivers. Despite the fact that a driverless metro has fewer accidents, the subjective assessment is that people trust the human rather than the machine. A service staff on board could even exceed the feeling of safety, in contrast to drivers.

Comparison and Interpretation

Non-acceptors were mainly against automatic metros due to missing human presence in a case of emergency. Contradictory to this, however, less than 50% of respondents agreed with the benefit “Service staff on board”. Among non-acceptors, this benefit was ranked as forth most agreed benefit, but just 39.8 % selected completely or partially agree. Moreover, more non-acceptors completely disagreed than completely agreed with the statement “Service staff on board”. The reason for this could be a strong trust in the metro driver and a lack of awareness that service staff is also available during emergencies and could provide even more assistance.

The ANOVA test in Table 5 revealed that the frequency of using the metro doesn’t have a relationship to the acceptance of driverless metros. Only the variable gender had a strong relationship to the acceptance of automatic metros. Females were less likely to accept automatic metros than man and acceptance declines by increasing age. A reason for the age-related difference could be that males are more likely to be involved in technical processes from an early age due to their social image, while females tend to be more safety conscious. The rise in acceptance with age can be explained by the fact that older adults tend to have greater trust in public facilities and appreciate the usability, comfort, and improved accessibility of automatic metro systems. In contrast, younger people often have more mobility options and tend to be more critical of new technologies, which can influence their acceptance of automation.

Connection to Literature

A survey asking passengers about their acceptance of automatic metros was conducted by Fraszczyk and Mulley (2017) in Australia. 43% of frequent metro users and 71% of non-users voted "very important", when they were asked "How would you rate the importance of a driver on the train?". In contrast to the survey conducted eight years ago in Sidney, the survey carried out for this thesis revealed that the percentage of acceptors of driverless metros increased, even if the research question is not exactly the same. The most important benefits for the respondents were "reduced ticket pricing", "extended running periods" and "increased train frequency" in the survey from 2017. Except "reduced ticket pricing", these benefits were also the most voted in the passenger survey of this thesis.

Practical Implications

To introduce a new automatic metro system, there needs to be a lot of educational work to inform people about the new technology and to prevent misunderstandings. The advantages "Extended operation hours", "Improved real time information" and "Service staff on board" should above be advertised. It should be particularly considered that service staff on board are specially trained for all types of incidents in metro systems and that their presence also serves to increase safety inside the vehicle.

Key message

Female passengers express lower acceptance of automated metro systems, mainly due to perceived safety concerns. Addressing these concerns through visible service staff and clear communication strategies could help to build trust and increase acceptance.

5.2. Passenger Distribution:

Brief Summary of the Key Results

The results of the survey indicate that passengers' platform behaviour is influenced more by travel related attitudes and habits than by demographic factors. A clear pattern emerged showing, that those who are familiar with the metro system are more willing to adapt their behaviour, such as waiting for the second next metro or moving three carriages further in order to avoid crowding. The results show that there is a high percentage of passengers who have expressed a willingness to contribute to a better distribution on the platform influenced by the real-time information systems. Regarding Elisabeth Oberzaucher, real-time information systems influence infrequent metro users to choose a different boarding door, additional studies have shown that passengers will move at least two to three doors if they are shown that there is less capacity in the vehicle at this position. Tobias Fiebag mentioned in the interview that the information must be displayed in time so that people can react. If the passenger information is displayed too late, passengers may rush onto the platform.

Comparison and Interpretation

The Chi-Squared tests in this subsection revealed a significant correlation between the metro use frequency and the waiting position on the platform, while demographic variables don't have a significant correlation with the waiting position. Despite that the waiting position as well as the acceptance of driverless metros has a noticeable relationship to the willingness to move to another position on the platform to avoid crowding or to wait for the second next train. That implies that people who are aware of the distribution on the platform and also desire a new technology in the system, would rather change their behaviour because of information systems.

49.1 % of respondents who use the metro at least several times a week wait at the nearest train door to the exit at their destination station. Surprisingly, 29.8 % of the respondents chose bench on the platform as there most preferred waiting position on the platform. The position of the bench on the platform can also influence the overall distribution in the vehicle. The benches could be positioned on the platform next to carriages that are statistically less crowded. This measure could improve passenger distribution without requiring additional information systems.

20.3 % of infrequent metro users wait next to the information screen on the platform. Since infrequent metro users have fewer routines, their behaviour can be influenced more by local conditions.

The location of these displays could also be placed next to carriages with lower crowding. The location of exits on the platform has a big influence on the platform, but hard to change in existing metro stations, therefore a placement of information screens and benches can influence the distribution with less investigation costs. Almost two third of the respondents would move three carriages down the platform indicating, that real-time information systems. Depicting the utilization could benefit passenger distribution. This could help to improve the distribution of passengers across the vehicles, thereby decreasing the dwell time of metros.

Connection to Literature

In 2016, the University of Queensland in Australia analysed the influence of personnel information systems (PIS) on platform distribution. 77% of respondents found the introduction of information systems indicating the occupancy rate of individual carriages helpful (Ahn *et al.*, 2016). A similar approval rate can also be seen in the results of the survey. Figure 13 illustrates that 76.3 % of respondents completely or partially agreed with “Improved real time information” as a possible benefit of automatic metros. The study conducted by Yu et al. (2021) in China investigated which society groups would move to a less crowded area in order to get a certain percentage of their fare price credited. Especially males below 30 years wanted the highest discount on their fare ticket to move to other positions on the platform. Females were more likely to move, and above 40 years female passengers were willing to move on the platform even without discount. Also, the weekday had an impact on the willingness to move. Table 7 shows that gender influences willingness to wait for the second next metro. ($p = 0.0169$).

Practical Implications

To improve passenger distribution, benches and information screens can be placed where the least crowded carriages are going to hold on the platform. Designing new stations, staircases and elevators should be placed in different sections of the platform along the metro line to encourage better passenger spread. Real-time information screen that depicts the utilizations of the individual carriages have a demonstrable benefit, and passengers would be willing to change their behaviour based on this information by waiting for the second next metro or going to another location on the platform.

Key message

Restructuring the platforms with waiting areas such as benches and information displays, as well as real time information systems, have a demonstrable influence on passenger distribution within the carriages.

5.3. Information systems and platform safety:

Brief Summary of the Key Results

The survey highlights that females under 30 years old have experienced feeling unsafe due to crowding on the platform at least once a year. In all age groups the feeling of not feeling safe on the platform affects more females than males. About 15% felt in danger by being too close to the edge of the platform once a year or more frequently. Half of the respondents couldn't find the required information for their ride on the platform. Preferences for the placement of platform information vary significantly by age, which younger passengers tending to prefer more dynamic displays, while older passengers favour clearly visible and fixed information points. Elisabeth Oberzaucher declared in the expert interview that displays on the platform screen door should be positioned between the two platform doors, so people are not blocking the doors. Floor markings are not ideal, because passengers can just see their close surroundings. Julian Fordon mentioned in the interview that displays should be clearly visible to all passengers. Inside the train displays hanging from the ceiling are recommended and also floor markings inside the train can be used. Additionally, passengers should be informed in advance about which direction to take when alighting at the platform, so that they do not need to search for this information on the platform and can obstruct the flow of passengers.

Comparison and Interpretation

The reason why young women in particular often feel uncomfortable may be the potential risk sexual assault or groping in intimate areas of the body on the platform. One of the most frequent listed uncomfortable situations on the platform was the presence of unpleasant individuals who create a sense of insecurity. Improved camera systems with AI detecting can help to report these incidents and increase young women's sense of security. Platform screen doors can almost eliminate the feeling of being too close to the platform edge. To provide the necessary information for all age groups of passengers each individual information should be displayed on more different positions on the platform. Inside the train passengers should get all information they need before their alignment process, so they will not block other passengers, who want to board the carriage. Especially attention must be paid to the easy comprehensibility and accessibility of displays. Elderly passengers should be helped with the access to information systems on their mobile devices and also real-time information should be easily understandable for them. In the individual cities further survey should be conducted to ask about the required positions of each information and to provide individual information for each station.

Practical Implications

Platform screen doors can eliminate the feeling of being too close to the edge of the platform for passengers. Better monitoring of the platform by cameras with AI detection and better passenger distribution on the platform based on information systems can improve the perceived safety of passengers. Various displays should be used to show the information. The most popular locations of the information can be taken from the results section. Above all, additional displays on the train, better and more easily understandable apps and platform screen door displays can provide better information for passengers.

Key message

The perception of safety in metro traffic should be strongly considered in order to motivate as many passengers as possible to use metros. This can be improved by platform screen doors and cameras. Several locations should be used for information. However, care must be taken to ensure that there is no sensory overload.

5.4. Choice of positioning in the vehicle:

Brief Summary of the Key Results

Results of the survey show that seating and standing preferences are mainly influenced by age and gender. The main reasons why passengers choose to stand were giving their seat to someone in greater need. Younger passengers tend to position themselves closer to the vehicle door. Gender differences are particularly noticeable in crosswise seating layouts, where woman tend to prefer aisle seats. In the lengthwise seating layout, the seat located closest to the door, was the most preferred option, particularly among respondents below 31 years. Elisabeth Oberzaucher mentioned that people tend to make the least physical effort and sit down when the opportunity arises. Also, the subjective perception of number of stations from which people want to sit down differs greatly from reality. Human consciousness does not like rooms that have corners. That is why entrance areas in metros should always be designed in a funnel shape to the seating areas. If the two outer seats are removed in a crosswise-seating layout, people feel more comfortable travelling further into the metro. Markus Geist said in the interview that the most favoured standing position is leaning against windows and wall elements in the trains. Of the grab rails, vertical rails are preferred to horizontal rails. Especially vertical bars, which are divided into several bars at passenger height, are very popular.

Comparison and Interpretation

The most respondents indicate that they will leave an available seat if another passenger needs it more. It must be critically questioned whether almost 85% of all respondents would actually offer their seat to another person, or whether this answer is more likely to be affected by social rules and good conscience. Regarding Elisabeth Oberzaucher the subjective perception of number of stations from which people want to sit down differs greatly from reality. Video observation must be conducted to have real results about the number of stations when passengers tend to sit down. Also, the situations “seat difficult to reach” and “too close proximity if seated” have to be investigated with actual video observations, as they depend on many factors. In accordance with the experts interviews the seats which are the closest to the door are the most favourable ones. Especially, in the lengthwise seating layout the seat next to the entrance is the most preferred. Metro users above 60 years tend more to choose other seats, but with younger metro users, respondents prefer the seat next to the door. This may be due to the fact that they often travel during rush hour and are therefore more often confronted with the problem of having problems getting off due to too many people. The same phenomenon can be noticed in their standing behaviour, due respondents prefer the closest standing position to the door.

Since most of the responses came from cities, in which the metro is designed with a lengthwise seating layout, the positioning behaviour is influenced more by metro use frequency. Crosswise seating layouts aren't that frequent used in Europe and are influenced by gender and the driving direction. Female metro users prefer the aisle seat in driving direction, which gives them the opportunity to leave the metro the quickest.

Connection to Literature

Similar to the findings of Wardman and Murphy (2015) there is a slightly preference for facing in the driving direction. Also, the results of the survey match with the statement that in longitudinal layout designs, passengers prefer a seat, that allows as least as possible passengers to sit next to them, e.g. at the end of the row of seats. In an empty train, passengers choose window seats, which provides more privacy and avoid aisle disturbance in 2+2 seating layouts. In crowded situations, aisle seats become more attractive as they allow easier movement and reduce the feeling of being "trapped". In crosswise seating layouts passenger tend to sit on the window seat, if their neighbour seat was unoccupied, and decreases about 10 % if the vehicle was more crowded according to Kubanik (2017). In the images of the survey an interaction with other passengers was not considered and would also influence the choice. The alignment of the previous study by Kubanik (2017) align with the results of the survey, indicating that 75 % of the passengers stayed in the entrance area, if the seating area was more or less separated to the entrance area. Similarly, Yang et al. (2022) found that vertical poles are the most preferred type of handhold.

Practical Implications

Incentives could include information systems in these areas and additional vertical grab rails. There should also be a combination of sitting and standing, whereby passengers can partially sit down on a small pad on the wall when standing. These areas can also be positioned at carriage crossings. When designing the seating and standing areas, the entrance area should be as spacious as possible, while seating areas should offer as much privacy as possible and allow passengers to alight quickly.

Key message

Standing behaviour is primarily characterised by interaction with passengers, while passengers generally prefer to sit in the metro. Sitting behaviour is nfluenced by the desire for privacy, ease of alighting, and travel routines.

5.5. Methodological Limitations

Several methodological limitations of this study should be acknowledged. First, there is a potential selection bias due to the distribution of the survey via a QR code. This may have excluded older individuals or those that are less familiar with digital technologies. Furthermore, the sample is not demographically balanced, with certain age groups and females being underrepresented. A notable overrepresentation of frequent metro users may have also influenced the result, as their travel experiences differ from those who never or rarely use the metro.

Second, some survey items and concepts may not have been fully understood by all participants, potentially affecting the reliability of certain responses. The survey design prioritized breadth over depth, which limited the opportunity to explore specific topics in greater detail.

Third, the expert interview was conducted with a relatively small number of experts, which were all based in German-speaking countries and were more specialized in conventional trains and suburban trains than metros. As such, perspectives from other regions, particularly those with more advanced metro systems, may be missing

This study relies on self-reported data, which may not always accurately reflect actual passenger behaviour. In addition, the statistical analyses conducted are correlational in nature, therefore no causal relationships can be inferred from the findings.

6. Conclusion

This study provides a multifaceted view of passenger requirements and behaviour in metros, focusing on topics such as, metro automation perception, platform distribution, real-time information systems, and interior design. A clear majority of passengers would take an automatic metro, and non-acceptors are mainly concerned about the absence of human in emergencies. There is a great willingness of passengers to change their position on the platform if real-time information about carriage occupancy is shown. A considerable amount of respondents' experience feeling insecure on crowded platforms and not finding the required information for their travel. Display positions were often desired in several positions and should therefore be displayed in more than one position.

Based on the findings of this study, several recommendations for future research and practice can be made. If an automated metro is implemented, passenger numbers can be checked to see if the acceptance rate matches the response to the survey in this thesis. Based on the perspective of passenger and their concerns about automatic metros targeted, awareness-raising work can be carried out to minimise safety concerns about automation. With video observations, the effectiveness of real-time information screens can be measured, and conclusions can be drawn about which aspects the willingness of passengers depends on. A repositioning of benches and information screens can be analysed to determine whether this affects passenger distribution. Surveys can be carried out to determine whether platform screen doors improve the perception of safety on the platform. Sensor goggles can be used to analyse what information is observed on the platform and where it can actually be best perceived. Inside the vehicle, video observations may be used to track how many stations passengers remain standing before sitting down, while interactions with other passengers can be analysed to investigate behaviour. The improvement of dwell times can be investigated with improved interior design.

The combination of quantitative survey data and qualitative expert interviews offered both breadth and depth. Particularly valuable are the insights into the acceptance of automatic metros, the actual acceptance of real-time information systems, the high subjective perception of a lack of information and discomfort on the platform, as well as correlations between seat and standing preference with metro use frequency and demographic items.

Appendix

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NEXUS - Next-gen technologies for enhanced metro operations

Dear passengers!

Thank you for participating in our survey! Your answer is important to us.

It will help us to enhance our metro system to improve the capacity, safety and the comfort in the vehicles and stations.

This survey contains **19 questions** and takes about **10 minutes** to fill out.

We adhere to strict data protection regulations, including General Data Protection Regulation, ensuring your information is handled responsibly.

By participating in this survey, you acknowledge that you have read and agree to the data protection information: NEXUS - Data Protection Information

Thank you for your time and your support.

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General information

* 1. Gender

- ◯ Female
- ◯ Male
- ◯ Non-binary
- ◯ Prefer not to answer

* 2. Age

- ◯ 17 years old or younger
- ◯ 18-30 years
- ◯ 31-40 years
- ◯ 41-50 years
- ◯ 51-60 years
- ◯ 61-70 years
- ◯ 71-80 years
- ◯ Over 80 years old

* 3. Do you have any long-term mobility impairment?

- [ ] No, I don't have any impairment.
- [ ] I have a restriction in movement.
- [ ] I have a small stature.
- [ ] I have an auditive impairment.
- [ ] I have a visual impairment.
- [ ] I have an inability to speak.
- [ ] I have an intellectual impairment.
- [ ] I have a psychological restriction.
- [ ] Other (please specify)

* 4. Place of residence: Which sentence describes your situation the best:

- ◯ I live in or close to a place with a metro.
- ◯ I live in a place without a metro.
- ◯ None of above.

* 5. How often do you use the metro?

- ◯ Daily
- ◯ Several times a week
- ◯ Once a week
- ◯ Few times a month
- ◯ Rarely
- ◯ Never

Metro operation

* 6. How do you think the metro that you last used is operated?

- ◯ Manual (controlled by driver onboard)
- ◯ Automatic (monitored by driver onboard)
- ◯ Automatic (monitored by control centre)
- ◯ Fully automatic (no monitoring)
- ◯ I have no idea / I don't know

Automation benefits

In the future, technological advancements may lead to more automation in metro systems.

7. Would you take this metro if it becomes fully automatic without a driver?

◯ Yes.

◯ No.

If no, please specify why:

* 8. Automation of the metro can bring several benefits to you.
Do you think that automated metro systems have a positive impact on the listed aspects?

	Completely disagree	Partially disagree	Neutral/ I don't have any opinion	Partially agree	Completely agree
More frequent schedule (e.g. every 2 minutes)	◯	◯	◯	◯	◯
Extended operation hours (e.g. early morning / late night)	◯	◯	◯	◯	◯
Improved platform safety	◯	◯	◯	◯	◯
Front view (without driver cab)	◯	◯	◯	◯	◯
Less Crowded	◯	◯	◯	◯	◯
Service staff on board	◯	◯	◯	◯	◯
Fare reduction	◯	◯	◯	◯	◯
Network expansion (more stations and lines)	◯	◯	◯	◯	◯
Improved real time information	◯	◯	◯	◯	◯
Smoother / more comfortable ride	◯	◯	◯	◯	◯
Less disruptions	◯	◯	◯	◯	◯

Do you expect any other benefit?

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Waiting position

Please imagine that you are about to start a journey with a metro.
Answer the following questions.

* 9. You have reached the (underground) metro platform. The next train departs in 5 minutes.
Where do you wait on the platform?

◯ At the point where I enter the platform.

◯ At the nearest train door to the exit at my destination station.

◯ At the point where the information screen is located at the platform.

◯ At a bench on the platform.

◯ Other (please specify)

* 10. The display on the platform shows that the next train will be full, but the next one will have more space available. You are not in a rush. Would you wait?

◯ Yes, in all cases.

◯ Yes, but only if I have to wait up to 5 minutes longer.

◯ Yes, but only if I have to wait up to 2 minutes longer.

◯ No.

* 11. The display shows that if you move three carriages down the platform, there will be seats available. When you look around, not so many passengers are waiting in that part of the platform. Would you move there?

- ◯ Yes, in any case.
- ◯ Yes, but only if I take the train for at least 3 stations.
- ◯ Yes, but only if I take the train for at least 5 stations.
- ◯ No.

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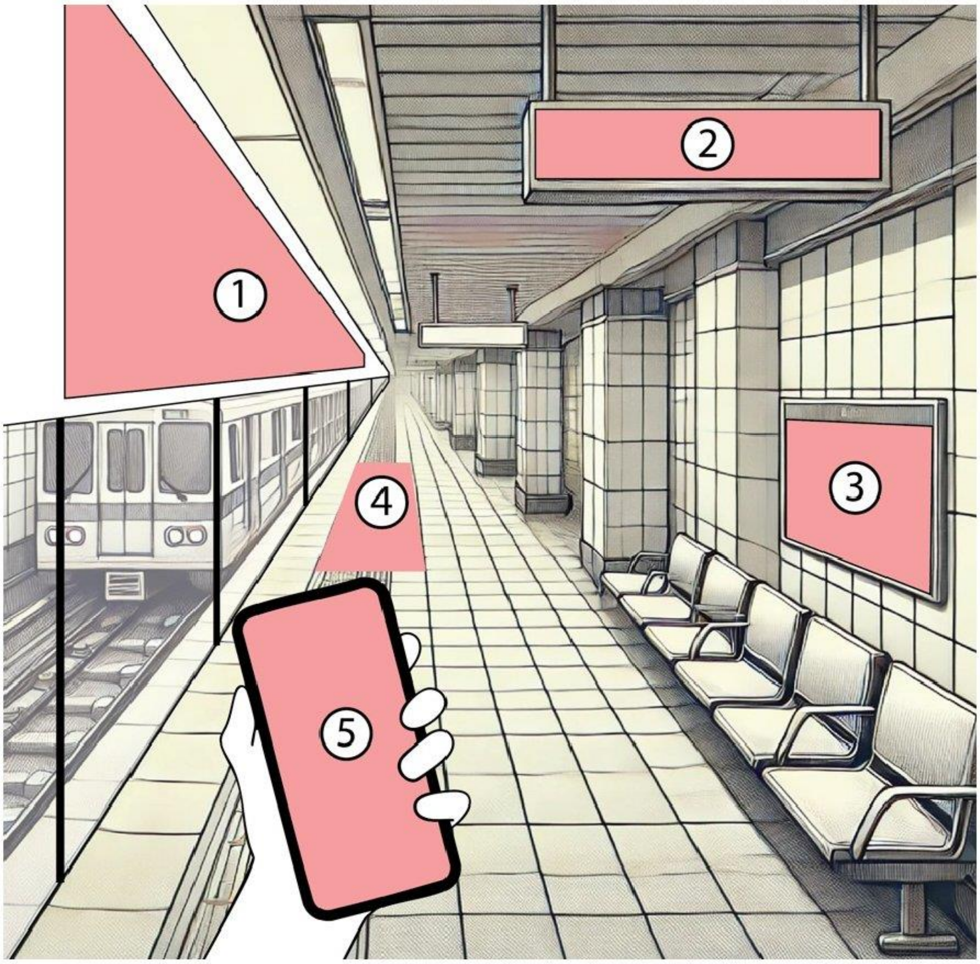
Information system



* 12. Please imagine that you are about to start a journey with a metro.
Where do you want to get the following types of information?

	Outside the platform	Display 1	Display 2	Display 3	Floor signs (4)	Mobile phone (5)	In the train	I don't need
Train arrival times	☐	☐	☐	☐	☐	☐	☐	☐
Closest stations to tourist spots	☐	☐	☐	☐	☐	☐	☐	☐
Alternative routes if there are disruptions	☐	☐	☐	☐	☐	☐	☐	☐
Accessibility info for the next stations (elevators, escalators, etc.)	☐	☐	☐	☐	☐	☐	☐	☐
Nearest wagon to the exit at my stop	☐	☐	☐	☐	☐	☐	☐	☐
Crowded or less crowded wagons	☐	☐	☐	☐	☐	☐	☐	☐
Contact for customer service	☐	☐	☐	☐	☐	☐	☐	☐
Metro map with transfer points	☐	☐	☐	☐	☐	☐	☐	☐
Information on broken doors	☐	☐	☐	☐	☐	☐	☐	☐
Doors for specific needs (wheelchair, strollers, luggage, bikes)	☐	☐	☐	☐	☐	☐	☐	☐
Planned disruptions or service changes	☐	☐	☐	☐	☐	☐	☐	☐

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Information / Safety

13. Do you wish any other type of information when travelling by metro?

* 14. Have you ever experienced yourself any of the following situations on the metro platform?

	Never	Once in my life	Once in a year	Once a month	More often
I was too close to the edge of the platform when the train arrived.	○	○	○	○	○
My stroller, scooter, or other items started rolling toward the tracks.	○	○	○	○	○
I accidentally dropped something on the metro track.	○	○	○	○	○
I didn't feel safe, because there were too many people on the platform.	○	○	○	○	○
I didn't find necessary information for my travel on the platform.	○	○	○	○	○

Other (please specify)

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Choice on board

* 15. In which of the following situations would you accept standing while taking the train?

- [ ] Taking the train for less than 5 stations.
- [ ] When other passengers need my seat (e. g. expecting mothers, elderly etc.)
- [ ] Travelling during rush hour.
- [ ] Too close proximity to other people if seated.
- [ ] If available seat is far / difficult to reach.
- [ ] Traveling in a group of 5 people or more.
- [ ] Travelling with a child / children.

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Choice on board

Now you are entering into the train and the situation is like the picture below.
You are travelling for 5 stations (about 10 minutes).

* 16. Which is your preferred seat?

◯ Seat Number 1

◯ Seat Number 2

◯ Seat Number 3

◯ None of them

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Choice on board

Now you are entering into the train and the situation is like the picture below.
You are travelling for 5 stations (about 10 minutes).

17. Which is your preferred seat?

- ◯ Seat Number 1
- ◯ Seat Number 2
- ◯ Seat Number 3
- ◯ Seat Number 4
- ◯ None of them

Choice on board

Now you are entering into the train and the situation is like the picture below. You are travelling for 5 stations (about 10 minutes).

* 18. Which is your preferred standing position?

- ◯ Position Number 1
- ◯ Position Number 2
- ◯ Position Number 3
- ◯ Position Number 4
- ◯ None of them

23

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Choice on board

Now you are entering into the train and the situation is like the picture below.
You are travelling for 5 stations (about 10 minutes).

* 19. Which is your preferred standing position?

◯ Position Number 1

◯ Position Number 2

◯ Position Number 3

◯ Position Number 4

◯ None of them

Thank you for participating in our survey!

We appreciate your time and effort.

We'll use your feedback to improve the capacity, safety and the comfort in the vehicles and stations in your metro system.

Further information about the project can be found at: NEXUS

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