Faculdade de Design, Tecnologia e Comunicação
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LISBON METRO SYSTEM NAVIGATION:
HOW TO IMPROVE INFORMATION PERCEPTION FOR INCOMING TOURISTS AND MIGRANTS

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HOW TO IMPROVE INFORMATION PERCEPTION FOR INCOMING TOURISTS AND MIGRANTS

Dissertation submitted to IADE - Faculty of Design, Technology and Communication of the European University, in fulfillment of the requirements for the Master's degree in Design and Visual Culture, conducted under the scientific supervision of Dr. Juliana Raquel do Espírito Santo Fonseca Duque, Assistant Professor at IADE - Faculty of Design, Technology and Communication of the European University.

I dedicate this work to the wanderers who follow the path and, relying on landmarks and signs, reach their goals and find a way out of any situation.

agradecimentos

I would like to thank Professor Juliana Duque for her patience, academic expertise, and willingness to assist at any moment. Thank you for inspiring me and guiding me throughout my dissertation.

I want to thank my entire family for their unwavering support. Especially my husband and children; thank you for always being there for me.

Finally, I would like to thank designer Mark Rodionov for his time and expertise in developing navigation, which he was happy to share in the interview.

Keywords Effective navigation, information visualization, intuitive navigation, signs in public places, Lisbon metro, wayfinding systems

abstract This dissertation examines the perception of the navigation and signage system of the Lisbon Metro by tourists, migrants, and first-time users. The Lisbon Metro navigation project was updated between 1995 and 1998, before the opening of the World Expo '98 and the introduction of the new red line. Later, in 2011, the symbols, lines, and signs in the metro were redesigned. However, after many years, the navigation solutions require review and improvement. To achieve this, it is essential to generate accurate statistics and determine how well the navigation works for tourists, migrants, and first-time users while also paying attention to crowds at tunnel intersections and the overall flow of people. By studying the current wayfinding system of the Lisbon Metro, it is necessary to draw parallels with existing wayfinding in large cities with metro systems. To identify which wayfinding signs are not effective and why. Based on information design research, this study aims to identify problems with wayfinding perception and propose solutions to improve wayfinding experience in the Lisbon Metro system.

Metro navigation is one of the first impressions and interactions that tourists and migrants have in Lisbon. A repeated review and in-depth analysis of the Lisbon metro navigation can help minimize crowding in some areas of the metro, reduce anxiety, and make it easier for people visiting it for the first time.

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Introduction

The Relevance of the Topic and Identification of Problems

With the growth of tourism and migration in Lisbon, the metro has become a vital mechanism for organizing the flow of people on the move. The Lisbon Metro is a critical part of the transportation infrastructure in the Portuguese capital, connecting the airport, central areas, and tourist destinations. The metro system has undergone significant changes over the past decades. When it opened in 1959, the Lisbon Metro had 11 stations and one Y-shaped line. Nowadays, the Lisbon Metro has 56 stations and four operating metro lines. The most significant breakthrough in the development of the modern metro was in 1998, when the Red Line (line Oriente) opened during the World Expo '98. The Red Line included seven stations (six of which are new), which were served by six-car trains—this increased capacity and provided access to the part of the city where Expo '98 was held.

Another boost to development came in 2004 when Portugal hosted the UEFA European Football Championship; the metro played a crucial role, helping to distribute the flow of foreign visitors and reduce the load on surface transportation. By this time, the Lisbon metro had seen improvements in accessibility, the opening of new stations on the blue and yellow lines, and the introduction of bilingual navigation at the main stations.

Today, the Lisbon Metro continues to modernize. The opening of new stations such as Estrela and Santos, as well as the extension of the Green Line and its conversion to a circular type, testify to the desire to expand coverage and improve convenience.

However, the navigation system and the overall concept of the Lisbon metro image remained unchanged for many years. For example, it was not until 1995 that the company's "New Image" was presented, featuring a new logo, signboard, and network presentation.

As Portugal prepares to host part of the 2030 FIFA World Cup, new transformations and openings of new stations are expected, making the topic of navigation particularly relevant. These changes offer the opportunity not only to improve the infrastructure but also to rethink the principles of visual navigation, especially for foreign users.

Despite the laconic design of the Lisbon metro navigation system, many tourists and migrants face difficulties: misunderstanding of signs, burnt-out or broken station name boards,

lack of visual logic and language barriers create disorientation and provoke crowding, as well as increase anxiety. This raises the question of revising the entire navigation system and the need for effective, intuitive, and visually accessible communication in the metro space.

My motivation

Over the past few years, I have frequently traveled both within European countries (Spain, Italy, Portugal, and others) and within Russian cities (Moscow, St. Petersburg, and many other smaller cities). While exploring new locations, and traveling to different countries and cities, my attention was drawn to the environment and the system of organizing navigation systems. Before each trip, it was necessary to imagine and plan a route. Information was usually collected from various sources such as the Internet (travel sites, social networks, and special channels on a mobile phone dedicated to travel), and navigation applications. During the trip, it was usually necessary to follow the route on foot, by land transport, or by underground transport - the metro. During the trips, it was interesting to observe the following: in some places, the process of orientation on the spot was quite simple and intuitive, and in some more complicated. This observation prompted my interest in the topic of navigation and in the analysis of the visual approach in signs in different countries, cities, and public places. In addition, I started asking friends and acquaintances what they feel when traveling or visiting new places. It turned out that most of them experience similar feelings. This strengthened my interest in this topic.

After entering the Master's course at IADE, the Faculty of Design, Technology and Communication of Universidade Europeia, and moving to Lisbon in 2023, my interest in environmental management only increased. One of my first experiences after moving to Lisbon was visiting the arrivals area at the airport, the next place was visiting the Lisbon metro. Despite the small number of metro lines and the aesthetically attractive walls in the interior of the metro made of various colored tiles (azulejos), I had some difficulties. First, choosing the right direction of the metro line. Then, at the transfer point from the red line "Vermelha" to the yellow "Amarela" I had to doubt and wander around the metro to find the right way, and then, looking for the right exit to the city. If you make a mistake with the chosen exit, you have to go down into the metro again and look for the necessary exit from the metro once more.

By understanding that the perception of the environment can be different for different categories of people, especially for those who found themselves in this situation for the first time, an idea came up to observe the actions of other passengers inside the metro. Some of them stopped to look around and make their next decision, and sometimes they asked other people for the direction of the train or where this or that exit to the city goes. After observing, I began to ask my friends about their experiences during their first and subsequent visits to the Lisbon metro. Having received detailed answers and heard discussions about orientation inside the metro, new questions arose: how does navigation affect decision-making during travel? What helps people during their journey and makes them more confident, and what confuses them? Why do people perceive the same visual message differently? Does the knowledge of the language in which the information on the sign is written affect it? What helps people find their stations and exits to the city faster and plot more optimal routes? What is the difference in the perception of navigation between those who are following a route in the metro for the first time and those who use underground transport almost every day? These and similar questions captured my consciousness and demanded answers.

During my first year of the Master's degree course "Design and Visual Culture" in the Faculty of Design, Technology, and Communication at the Universidade Europeia, I was lucky enough to attend lectures on the subject "Information and Visualization" led by Professor Juliana Duque. In these lectures, there was an introduction to the history and display of information in different periods, including the display of geographical and statistical maps, graphs, and analytical tables. In the materials provided and the recommended literature, there was an inextricable connection between the display of information in a two-dimensional projection and socially important issues. This inspired me to conduct a more in-depth study related to the study of the display and perception of navigation systems in public spaces, especially inside the Lisbon metro. I became interested in analyzing the differences in the perception of visual messages, understanding what forms effective navigation, and what aspects need to be addressed to improve the situation.

Research Objectives and Specific Goals

The dissertation aims to analyze the existing navigation system inside the Lisbon metro and develop recommendations to improve the perception of information for tourists, migrants, and those visiting the metro for the first time. The study touches on aspects of graphic and information design, cognitive load, visual perception, and spatial structure. Using Lisbon as an example, the work contributes to a broader discussion on the inclusive design of the urban environment and navigation systems sensitive to the multilingual and cultural diversity of users. The objective of the dissertation is to compare different approaches to visual communication in the metro, analyzing the historical context of the development of map display, metro schemes, and navigation. Drawing on experiences in different countries, it aims to identify effective solutions that can be adapted to the Lisbon context.

Research Methodology

To better understand the perception of the navigation system in Lisbon, a literature review was conducted on information perception, information anxiety, the basics of color and typography, the basics of visual communication, the image of the city, and the historical evolution of metro map schemes and navigation systems. Then, a survey was carried out among 100 people using Google Forms, in which participants were asked to rate the clarity of several symbols and their perception of color schemes and also to express their opinions on possible improvements to the Lisbon metro's orientation system. Additionally, an interview was conducted with designer Mark Rodionov, who played an active role in the development of the new navigation system in the Moscow Metro from 2018 to 2019, working at the Artemy Lebedev design studio. A study of the metro was also done, using photo fixation on the ground. In addition to the primary research methods, an art installation was created during the work on the dissertation, which rethinks and emphasizes the meaning of the concept of "wayfinding".

Structure of the Dissertation

Chapter 1: Literature Review

This literature review details the main stages and principles that influenced the development of transport navigation, including early forms of wayfinding, the first map-making, the use of statistical data, the development of traditional images, and the emergence of digital graphic systems. This chapter also describes the principles of visual communication for the perception of subway navigation, based on the main academic sources (books and research papers).

Chapter 2: Methodology

This chapter describes the applied research methods, including qualitative and quantitative analysis, field observations, and comparative analysis. Abstract Rethinking of the Problematic through Installation is also presented, emphasizing the importance of wayfinding for each person.

Chapter 3: Overview of the Lisbon Metro System

The chapter provides an overview of the Lisbon Metro, including its history, current structure, and development plans. It also provides a detailed overview of the lines, stations, and wayfinding system. In addition, this chapter identifies and analyzes the problems associated with the perception of wayfinding in the Lisbon Metro. Key moments of wayfinding were photographed and described here.

Chapter 4: Case Studies: Successful International Metro Systems and Practices

Three famous metro systems —London, Paris, and Moscow —are considered. Their approaches to wayfinding, line identification, language use, map design, and passenger information systems are analyzed. A table has also been compiled to compare the London, Paris, Moscow and Lisbon metro systems.

Chapter 5: Analysis and Discussion

Based on the collected data, this chapter provides a summary and analysis of results. It examines the strengths and weaknesses of the Lisbon metro navigation system and suggests possible improvements based on international experience and best practices.

Conclusions: This chapter formulates the main conclusions of the study.

References: This section lists all sources used in the study, formatted according to the APA 7th edition standard, including scientific articles, books, and official websites of transport systems.

Appendices: This chapter contains additional materials, including supplementary text information, images from books, comparison tables, visual examples from field observations (photographs), results of an online survey, and an interview with a designer. References to appendices are provided in the main text of the dissertation.

1. Literature Review and Analysis of Existing Research

1.1. The history (or evolution) of Navigation Systems and Maps

The human need to navigate in space, as well as to record places, paths, and events with graphic images, was formed in prehistoric times. As mentioned by Gibson (2009, p. 6) "Wayfinding, of course, has been around ever since the first bunch of cavemen got lost trying to find their way home from a wooly mammoth hunt, but it only became a profession in the twentieth century". Cheirchanteri (2021) came to a similar conclusion. According to the author, people created images on different surfaces to exchange information through visual communication. Therefore, the visual communication of information in the environment that surrounds us is "one of the world's oldest professions" (Cheirchanteri, 2021, p. 2).

Before maps acquired their modern, familiar appearance, they went through a long path of evolution - from primitive images of landmarks on cave walls to highly accurate interactive maps displayed in real-time on the screens of mobile devices. Over time, the style, graphic techniques, and methods of visual encoding of information have changed, but their main function has remained unchanged - to help a person navigate in space and plan routes. The map has always been and remains a tool that connects knowledge of the environment with the ability to effectively move in it.

> Throughout history, maps have always been equated with power, whether they depicted hunting grounds, trade routes, military sites, or buried treasure. The South Sea Islanders made maps with shells and twigs. The twigs represented ocean currents and the shells denoted islands. These maps gave them mobility (Wurman, 2000, p. 155).

According to Bertin (2010), graphic representation constitutes one of the basic sign-systems conceived by the human mind for the purposes of storing, understanding, and communicating essential information. This is confirmed by the late Paleolithic cave paintings of Lascaux, created around 17,000 BC, which contained approximately 2,000 images of people, animals, and abstract signs. Figure 1 illustrates how prehistoric people used graphic forms to communicate information long before writing was invented. Another striking example of the display of information by ancient people is the painting of the walls of ancient Egyptian tombs

dating back to 1144 BC. Hieroglyphs and images of deities were used to record information about the deceased's life (Rendgen & Wiedemann, 2020; see Figure 1).

Figure 1. Left: *The cave paintings of Lascaux, ca. 17,000 BC. From Information Graphics (p. 6*), by S. Rendgen & J. Wiedemann, 2020, Taschen. Right: *Walls in ancient Egyptian tombs, 1144 BC. From Information Graphics (p. 8),* by S. Rendgen & J. Wiedemann, 2020, Taschen.

During the Iron Age, in Valcomonica, Italy, rock art known as the Bedolin map was created. The petroglyphs are divided into various categories, including warriors, horse riders, animals, geometric figures, plowing scenes, and buildings. Of most significant interest in these drawings are the *mappiforms*, a structure resembling maps (Crag, 2007; see Figure 2).

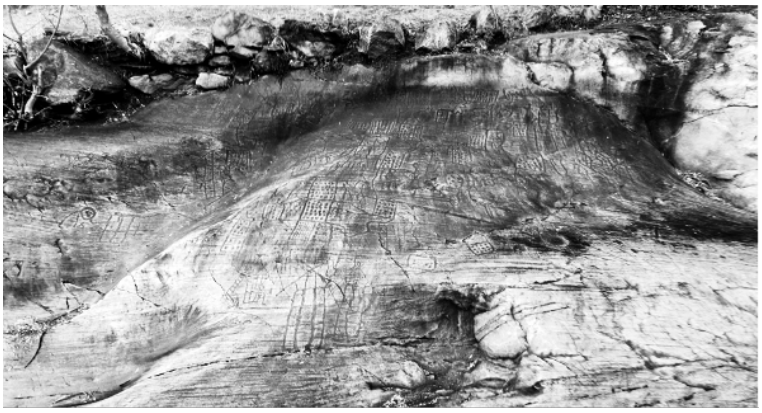


Figure 2.The Bedolina Map. Source: Crag, A. (2007). *The Bedolina map – An exploratory network analysis.* University of Cambridge, Department of Archaeology. https://www.academia.edu/454722/The_Bedolina_Map_An_Exploratory_Network_Analysis

Claudius Ptolemy (2nd century AD) created one of the most famous maps of antiquity, his work "Geography", in which he introduces a simple method for reproducing proportional maps that indicate the positions of different places, both globally and within various regions. He used an innovative method of creating maps using coordinates and grids - latitude and longitude, which

allowed the reproduction of maps almost without errors (Brodersen, 2017; Kupfer, 2020; see Figure 3).

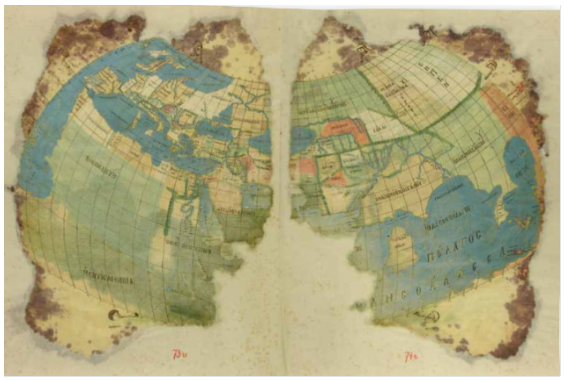


Figure 3. World map from *Geography* by Ptolemy, Istanbul, Topkapi Palace, Seragliensis GI 57, fols. 73v–74r. Photo courtesy of Topkapi Palace Museum, Istanbul. From: Kupfer, M. (2020). *The Rhetoric of World Maps in Late Antiquity and the Middle Ages* (p. 261).

The history of navigation is inextricably linked to the development of civilization, trade, urbanization, and technology. The unique surviving map of the road system of the cursus publicus, the public transportation system used in the Roman Empire in the late 12th century, is the Tabula Peutingeriana (it survives in 11 segments written on parchment). It encompasses the entire territory of the provinces under Roman rule, as well as the territories conquered by Alexander the Great in the East. The Tabula can be seen as a medieval facsimile, imitating the book scroll used in antiquity. The purpose of the Tabula was not to depict the regions in question in the form of a geographical map, but to demonstrate the structure and network of the cursus publicus. It explains the absence of a sea and the orientation of the map from west to east, and is a parallel to the actual diagrams used in metro trains in European cities (UNESCO, n.d.; see Figure 4).

Figure 4. Fragment of the Tabula Peutingeriana, a Roman road map preserved as a medieval copy. Source: UNESCO, n.d., https://www.unesco.org/en/memory-world/tabula-peutingeriana. © UNESCO.

As for the Middle-Ages, an example of a large world map that is crucial to our understanding of medieval cartography is the Hereford Mappa Mundi (it was made around the year 1300). It is very different from our modern idea of a world map, as it shows not only the locations of places and geographical features, but also acts as a visual encyclopedia with historical, anthropological, ethnographic, biblical, classical and theological information (UNESCO, n.d.; see Figure 5).

Figure 5. The Hereford Mappa Mundi. Source: UNESCO, n.d., https://www.unesco.org/en/memory-world/hereford-mappa-mundi. © UNESCO.

Cartography was developed during this period, but the first maps of the Middle Ages did not distinguish between the geographical features of the earth's surface and the historical or religious character of the landscape. A typical map at that time was a visual representation of knowledge arranged in a single image. For example, Ebstorf's map, which was created around 1300 in Northern Germany, depicted the world as a circle divided into three parts with Jerusalem in the center. Europe was shown at the bottom left, Africa at the bottom right, and Asia and India at the top center of the map (Rendgen & Wiedemann, 2020; see Figure A1 in Appendix/Annex A).

During the period of great geographical discoveries of the 15th–17th centuries, attempts were made to create more detailed maps, due to the need to more accurately depict new lands and sea routes.

The earliest surviving map showing Vasco da Gama’s Portuguese discoveries, Africa, India, and more, is the Cantino Planisphere, created in 1502 by a Portuguese official for Italian agent Alberto Cantino. The map reflects Portugal’s rise to global trade, depicting sources of spices,

jewels, and other goods in bright green. It marks the division of the territory between the Portuguese and Spanish territories as outlined in the Treaty of Tordesillas (1494). The map highlighted the importance of overseas trade routes at the time and shaped European cartography for the next century (World History Commons, n.d., see Figure 6).

Figure 6. Cantino Planisphere, one of the earliest surviving maps showing Portuguese discoveries. Adapted *from World History Commons*, https://worldhistorycommons.org/cantino-planisphere.

A revolution from the 16th century, the Mercator projection is the visualization we still use today on world maps. Although Gerardus Mercator's map miscalculated and misscaled (especially inflating regions farther from the equator), by using a consistent east-west and north-south grid, it allowed for more accurate orientation along the direction line. However, this Eurocentric projection exaggerated the landmasses of Europe, North America, and Greenland, with Greenland appearing 16 times larger than it is (World History Commons, n.d., see Figure 7).

Figure 7. The Mercator Projection Map, ca. 16th century. Adapted from *World History Commons,* https://worldhistorycommons.org/mercator-projection-0.

From the late 17th century onwards, typical geographical maps began to be layered with information, such as the first of its kind, Edmond Halley's map of wind patterns and monsoons in 1686 (Tufte, 2007; see Figure 8). From then on, maps became more than just a collection of geographical points strung together.

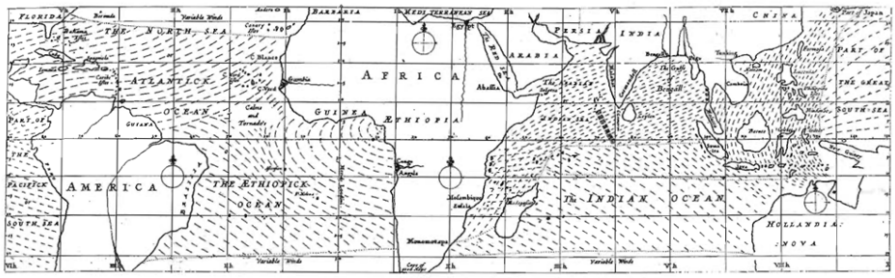


Figure 8. Fragment of a map. From *The Visual Display of Quantitative Information* (p. 23), by E. R. Tufte, 2007, Graphics Press. Originally from 1686, Edmond Halley, *Philosophical Transactions.*

Later, in 1741, the German linguist Gottfried Hensel developed four maps that depicted the continents known at that time and the languages spoken there. Individual regions were marked with symbols from their respective alphabets and special tables were created to substantiate the theory of human language (Rendgen & Wiedemann, 2020; see Figure 9).

Figure 9. Map by Gottfried Hensel, 1741. From *Information Graphics* (p. 47), by S. Rendgen & J. Wiedemann, 2020, Taschen.

Collecting, displaying, transmitting, and analyzing information is an integral part of human development, since "information is that which leads to understanding" (Wurman, 2000, p. 19), and understanding is an important step in decision-making. As mentioned by Rendgen & Wiedemann (2020, p. 13) "The last level of wisdom implies not only a deeper understanding, but also the

possibility of acting in line with this understanding. Therefore, whoever has processed the data and has achieved wisdom via information and knowledge knows what needs to be done".

By the end of the 18th century, there was a growing need to base policy decisions on reliable data on demographics, economics, military situation, etc. This type of information became available in Europe mainly from government sources. At that time, new branches of graphical data display emerged, such as statistics, tables, and charts. They required large amounts of information to be displayed understandably so that it was convenient to compare the data with each other. The earliest statistical charts displaying economic indicators were first developed by Swiss-German mathematician J. H. Lambert (1728–1777), and then expanded in 1786 by English political economist and engineer William Playfair (1759–1823) (Wildbur & Burke, 1998). Later, in 1820, August Crome developed a comprehensive graphical overview of statistical data for the King of Prussia, including information on all German states, state income, military budget, and the number of army troops (Wildbur & Burke, 1998; Rendgen & Wiedemann, 2020). One of the most famous infographic maps, which is referred to by various authors such as Rendgen & Wiedemann (2020), Wildbur & Burke (1998), Tufte (2007), is a map of Napoleon's disastrous Russian campaign, known as *Napoleon's March to Moscow*, developed in 1869 by the French engineer Charles Joseph Minard (1781-1870). It displays numerous variables such as the direction of the army, its reduction, the dates, and a temperature chart (see Figure 10). Another map related to the war period and the display of statistics was created by the English nurse and statistician Florence Nightingale (1820-1910). Following her experiences in the Crimean War, where soldiers suffered from terrible medical care, she recorded the mortality of soldiers over two years and called them 'coxcomb' diagrams (Wildbur & Burke, 1998; Rendgen & Wiedemann, 2020). In 1854, Dr. John Snow created a map showing patterns of disease and the locations of cholera deaths in central London. The map showed deaths as dots and water pumps as crosses. Using this map, Snow was able to visually trace the relationship between mortality and the location of water pumps, and by blocking one of them he was able to stop the cholera epidemic in London (Tufte, 2007; see Figure 11). A similar idea of mapping socially significant phenomena was at the core of Charles Booth's monumental study of the London poor published in 1889. He created an extensive research project that covered the whole of London. The full text filled seventeen volumes, each containing lithographed portions of the map, and one of the maps was hand-colored (Wildbur & Burke, 1998; see Figure 11).

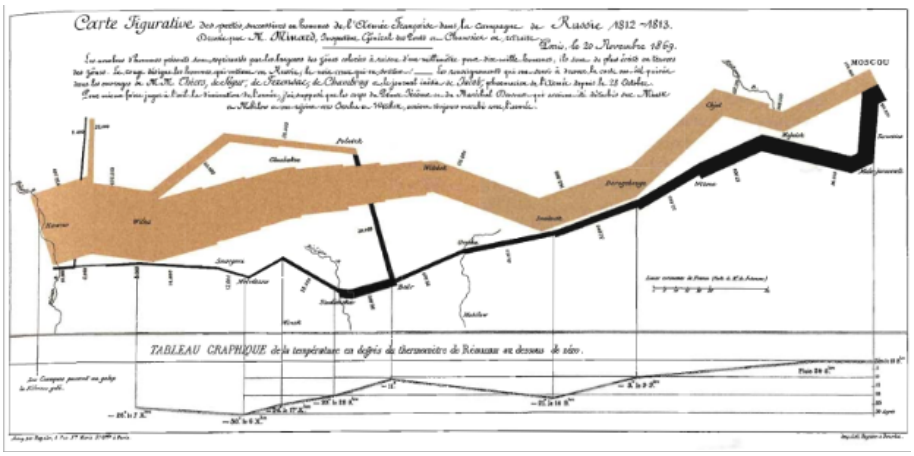


Figure 10. *Flow map by Charles Joseph Minard visualizing Napoleon's Russian campaign,* 1869 From *The Visual Display of Quantitative Information* (p. 24), by E. R. Tufte, 2007, Graphics Press.

Figure 11. Left: John Snow's map. From *The Visual Display of Quantitative Information* (p. 24), by E. R. Tufte, 2007, Graphics Press. Right: Excerpt of Map of London by Charles Booth. From *Information Graphics: Innovative Solutions in Contemporary Design* (p. 11), by P. Wildbur & M. Burke, 1998, Thames & Hudson.

These striking examples of displaying statistical graphics marked the beginning of the development of infographics and wayfinding. One of the most significant advances in infographics and wayfinding was the introduction of the London Underground map by Harry Beck in 1933. Earlier versions of the Underground maps displayed the actual routes of the lines on a city map, which made it difficult to understand. Beck moved away from geographical accuracy in the map, realizing that the main function of the map was to help people navigate the underground network. Therefore, he adopted a schematic approach, using lines parallel to the edges of stations or at 45 degrees, and the distance between stations was of equal length. A stylized riverbed of the Thames provided the only visual landmark in the city (Rendgen & Wiedemann, 2020; see Figure 12). This innovation influenced underground maps around the world, including the Lisbon metro system, having a long-lasting impact on information design for public transport wayfinding. As mentioned

by Gibson (2009, pp. 15-16) "The most iconic examples of wayfinding maps were designed to help the public navigate early transportation systems such as railway networks and subways".

During the 1960s Cold War period, there was a need to humanize complex urban spaces. Therefore, design disciplines such as architectural graphics, signage design, and environmental and wayfinding graphic design began to develop dynamically (Gibson, 2009). In the 1960 book 'The Image of the City', Kevin Lynch investigates how people perceive and structure urban space. As mentioned by Lynch (1990, p. 2) "Not only is the city an object which is perceived (and perhaps enjoyed) by millions of people of widely diverse class and character, but it is the product of many builders who are constantly modifying the structure for reasons of their own".

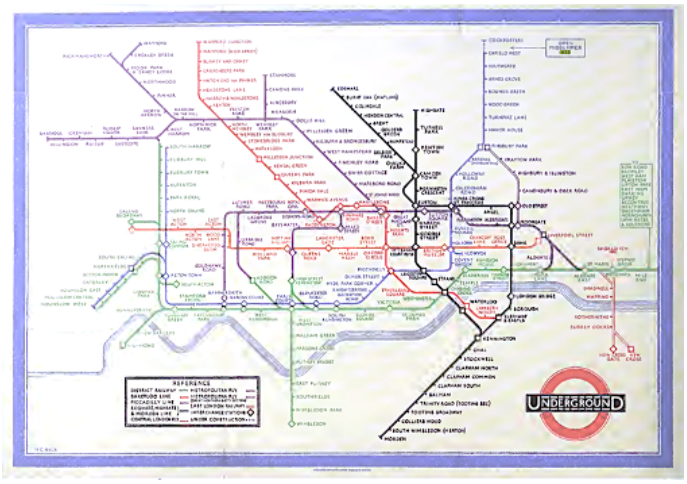


Figure 12. *London Underground map by Harry Beck*, 1933. From *Information Graphics* (p. 82), by S. Rendgen & J. Wiedemann, 2020, Taschen.

Nowadays, the infrastructure of cities is actively developing, new road junctions appear, new metro stations are opened, new public spaces are opened, new architectural structures appear, etc. This undoubtedly entails the active development of information design and navigation. The travel industry is also quite popular among people of different ages and nationalities. In this regard, maps and navigation systems to help find the way are still in demand . These can be special signs in the city's navigation system, as well as electronic maps downloaded to a phone or special devices. Interest in maps remains relevant, since "Maps provide the comfort of knowing that they orient us to the reality of a place. They enable us to make comparisons between places, and they tell us where we are in the grand scheme" (Wurman, 2000, p. 155).

According to Gibson (2009, p.15), "Map design is an important subfield of navigation with its own fascinating history. Having existed since the dawn of language, maps represent a chronology of all manner of human endeavors, whether cultural, intellectual, economic, or political". Ultimately, the evolution of navigation systems is a complex and multifaceted process spanning millennia, from the first attempts of ancient humans to navigate in space and display information in caves to modern digital solutions using satellite communications, dynamic online scoreboards, and user interfaces. At the same time, it is worth understanding that "Though global positioning and other digital technologies have moved spatial diagrams of sign panels and into cars or handheld devices, mapping remains at the forefront of the field today" (Gibson, 2009, p. 15-16).

1.2. User perception on navigation systems

Understanding visual perception is crucial for the design of effective navigation and wayfinding systems and is a fundamental mechanism that allows people to interpret signs, symbols, and spatial arrangements. Gestalt principles help users to quickly interpret visual information through mechanisms such as grouping, proximity, contrast, and figure-ground. According to Wagemans et al. (2012, p. 1219), "Gestalt is an integrated, coherent structure or form, a whole that is distinct from the sum of its parts", which emerges spontaneously in the human brain due to organizational processes and is a "result from global field forces that lead to the simplest possible organization, or minimum solution, given the available stimulation". In other words, humans tend to generalize, organize and minimize the information they receive. It makes it easier to navigate complex environments, such as the subway, where instant decision-making is required.

However, it is worth considering that the built environment usually provides a large amount of information and passengers have to evaluate and select the information that is truly useful to them in order not to become oversaturated with data (Puttipakorn & Upala 2018). According to Cheirchanteri (2021, p.1), "Wayfinding is how people get from one location to another, including their information-gathering and decision-making processes for orientation and movement through space". Problems often arise when traveling in a new environment. Navigation is not only about moving; it is a set of cognitive and behavioral actions related to planning a path between a starting

point and a destination, including recognizing landmarks in the environment and remembering routes. (Bae et al., 2024).

Modern cities with their multi-level transport systems, international flows of people, and fast pace of life create a complex navigation environment, especially for new users - such as tourists and migrants - but also the elderly, or those with difficulty with spatial orientation. The diversity of public transport users requires consideration of different cognitive, linguistic, and visual characteristics. "Aspects of the characteristics of passengers, including gender, age, education, occupation as well as objective and frequency of travelling are components that affect the level of need for location information" (Puttipakorn & Upala, 2018, p.164). Transliteration and duplication of signage into English is especially important in places with high multinational traffic and is often used in public places such as international airports or railway stations. For example, at the departure terminals of Eurostar trains in the UK, signage is presented in French and English. At Schiphol Airport in the Netherlands, navigation is also carried out in two languages - Dutch and English (Wildbur & Burke, 1998). The Moscow metro navigation system also uses two languages - Russian and English, with the inscriptions transliterated from Cyrillic to Latin (M. Rodionov, personal communication, April 14, 2025). As shown in Figure 13, Figure 14, and Figure A2 in Appendix/Annex A, the signage systems at Moscow Metro, Schiphol Airport, and Waterloo International Station[1] all feature two languages, with one being English, facilitating clear navigation for international users.

Figure 13. *Public signage system design at Schiphol Airport, Netherlands*. From *Information Graphics: Innovative Solutions in Contemporary Design* (p. 23), by P. Wildbur & M. Burke, 1998, Thames & Hudson.

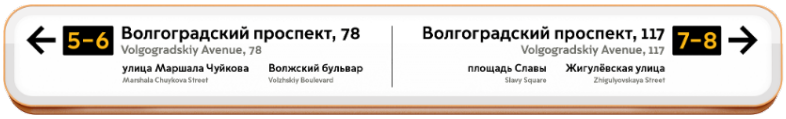


Figure 14. *Information signage inside Moscow Metro, displaying both Russian and English*. From *Passage Navigation in Moscow Metro*, by Art. Lebedev Studio, 2025, https://www.artlebedev.com/metro/passage-navigation/

[1] As of 2025, Eurostar trains no longer depart from Waterloo International Station. Services were moved to St Pancras International in 2007. The signage photograph used here was taken during the time when Eurostar still operated from Waterloo.

The problem of perceiving new information regardless of language proficiency is mainly solved through visual systems built on universal2 codes. "Many people with different types of cognitive abilities, as well as those who cannot read at all or who cannot read their mother tongue are based on milestones to mark and remember a path" (Cheirchanteri, 2021, p. 4). This emphasizes the importance of building sign systems and creating color codes that are intuitively understandable regardless of language and education level. According to Gibson (2009, p.16) "Symbols provide a shortcut way for large groups of people who may not share a common language to communicate". Also, for Cheirchanteri (2021, p.3) "Spatial semiotics and orientation (wayfinding) are more often expressed in uniform signage systems, which both in terms of information and visualization are linked together in a space".

Research by Puttipakorn and Upala (2018) shows that perceptions of metro navigation differ depending on gender: "Females focus on minor details, and there is a need for more information in diverse locations for decision making in wayfinding. This is different to males, who focus on memorizing the way as a whole while they are travelling" (p. 164). During the design of the new navigation system inside the Moscow metro, surveys were also conducted on the perception of navigation among metro users of different ages and different genders. As a result, each user had their perception of navigation, taking into account individual factors, intersecting with the perceptions of other users, regardless of belonging to a particular user group. This led to the creation of a more universal, easy-to-read, and understandable system of metro navigation signs (M. Rodionov, personal communication, April 14, 2025).

In addition to individual factors, social context is also important. Bae et al. (2024) conducted several studies in their research where different groups of people (individuals, in the company of a friend, and the company of a stranger) followed the same unfamiliar route and their task was to minimize the time and distance during the journey. This study showed that friends navigated more efficiently than strangers and individuals. The data indicate how social behavior affects route planning in the context of navigation in a new environment and confirms the need for a universal navigation system that is simultaneously understandable to different people.

[2] In the context of this text, the universal is meant to be the desire to ensure that as many people as possible can understand the message being conveyed, regardless of their cultural, social or linguistic differences.

The interior design of the metro station is another factor that influences the perception of wayfinding. Sarıkahya and Tuğral (2022) showed that almost half of the surveyed participants in their study on Ankara's metro system in Turkey acknowledged that interior design helps them find their way. Lighting, color, and materials serve as landmarks. "A good environmental image gives its possessor an important sense of emotional security..." (Lynch, 1990, p. 4). Sarıkahya and Tuğral (2022) surveyed 346 people with the aim of determining the impact of the interior design in the Ankara metro on the movement of travelers. It is worth noting that socio-demographic factors such as gender, age, education, profession, income, and residential status were the independent variables, and the interior design of the metro was dependent. The study showed that 49.6% of the surveyed people believed that the interior design of the metro helps them easily find their way. The importance of using color code and light in the interior, which facilitates wayfinding inside the metro, especially in crowded places, was also confirmed. In addition, to improve the perception of the graphic image before developing the design, Bertin (2010) suggested to first define the boundaries of the graphic system and strictly separate "the content (the INFORMATION to be transmitted) from the container (the PROPERTIES of the graphic system)" (Bertin, 2010, p. 5). Moreover, Bertin (2010) says that in the sign system, designers use MARKS, which can be drawn in different ways and vary in size, value, texture, color, orientation, and shape, and also express the correspondence between its position on the plane and its position in the row. Bertin (2010) notes that although people easily classify a range of values from black to white, they do not order different shapes so clearly (see Figure 15). Based on this, he identifies four types of visual variables. SELECTIVE (#) allows you to select elements that belong to the same category (e.g. all red or all light signs); ASSOCIATIVE (=) groups similar elements (e.g. different shapes of the same color and size); ORDERED (O) arranges perception into a hierarchy (e.g. gray as an intermediate color between white and black); Finally, QUANTITATIVE (Q) allows you to express a numerical relationship between elements, but is not applicable to color perception (e.g. one line is perceived as three times longer than another).

According to Bertin (2010), any form of communication, whether expressed in words or visually, aims to simplify the original complex content by highlighting key elements. Any logical reduction of information is information processing and is carried out "either verbally, mathematically, or graphically" (p. 166). According to Wurman (2000), our ability to perceive and process images is limited, which leads to a distortion of our perception of the world: the more

images we have, the more distorted our view of reality becomes. According to Arthur & Passini (1992), a person navigating a landscape can read the information in a few glances, as if scanning it, and the resulting image is retained in short-term memory. However, the capacity of short-term memory is limited: “Studies have shown that on signs and maps only a small number of written items, generally three at most, can be read at a glance. If more than three items are presented, they should be grouped into packages not exceeding that desired limit” (p. 50).

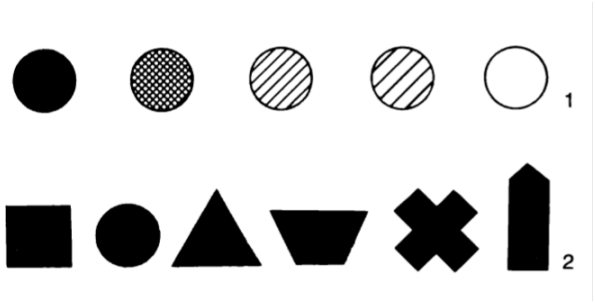


Figure 15. *Graphic representation of variables* From *Semiology of Graphics* (p. 48), by J. Bertin, 2010, Esri Press.

Thus, to organize any type of information, Wurman (2000) proposed using the LATCH method (Location, Alphabet, Time, Category, Hierarchy): (Location, Alphabet, Time, Category, Hierarchy): Location is useful when studying comparisons of data from different sources or locations; Alphabet helps to structure large amounts of information, such as in dictionaries or telephone directories; Time is effective for displaying events occurring at a fixed time in chronological order; Category refers to the organization of something into different types, such as products in stores; Hierarchy arranges items by size from small to large, cost, or importance.

Considering all of the above, it is necessary to take a comprehensive approach to the development of a navigation system: simplify large blocks of information to improve its perception, take into account the universality of information on signs, visual variables, color coding, ensure the readability and structure of elements, their connection with each other, and also pay attention to lighting and interior. As Wurman noted: "Before any solutions to any undertaking can be developed, a movement must begin to discover its beginning" (Wurman, 2000, p. 51). This approach promotes better orientation and perception of navigation for people with different cognitive skills.

1.3. Information Anxiety

Wurman (2000) describes digital information anxiety in modern people, however, not only the digital space but also the familiar environment is oversaturated with information. In addition to the fact that a person needs to analyze the environment while following a path - weather, location, location indicators such as houses, bridges, roads, etc. - it is also necessary to analyze additional information that surrounds a person everywhere. Not only in magazines, on websites, or on a phone, but also on the street, from advertising banners, bright shop windows, and ending with navigation in the city or indoors. An excess of unimportant and a lack of understandable and structured information provokes a state of anxiety. This is especially pronounced in conditions of difficult transfers, unfamiliar routes, or multi-level spaces. "Information anxiety is produced by the ever-widening gap between what we understand and what we think we should understand..." (Wurman, 2000, p. 14). According to Arthur & Passini (1992), "Airports, bus, train, and marine terminals, and subway stations are all characterized by a combination of confusion, apprehension, and disorientation" (p. 77). This is because passengers may be deprived of cues that would help them navigate. This causes anxiety and worry about missing their flight, stop, or subway connection.

Navigation systems should include regular intermediate conformations of the correct direction to enhance psychological confidence. "Knowing what you can expect to see along the way reassures you that you are proceeding correctly..." (Wurman, 2000, p. 219). This is also important because knowledge arises in the process of comparing the new with the already known. "Knowledge involves a continuing effort of comparison..." (Bertin, 2010, p. 171). For instance, the designers of the new Moscow metro navigation system were guided by the same principle, confirming the user's location while following the route (M. Rodionov, personal communication, April 14, 2025). A visual navigation system, especially in places such as the metro, performs not only an informational function, but also plays the role of a regulator of anxiety, psychological comfort, and the user's confidence in their ability to make decisions in an unfamiliar space. "The passengers always need to choose a way" (Puttipakorn and Upala, 2018, p.158). It is worth noting that "A higher frequency of travelling leads to a decrease in the level of need for further location information among passengers. This shows that experience and familiarity with locations are a factor that supports wayfinding" (Puttipakorn and Upala, 2018, p.164). Anxiety when following a path, losing one’s bearings, as well as absent-mindedness during a journey, are well reflected in a

humorous children's poem, in which the external absent-mindedness of the protagonist reflects internal anxiety, uncertainty in choosing a path which echoes the tone of Marshak's poem *The Absent-Minded Fellow* (see Appendix B).

This character can cause a good laugh, but can also remind us of the fear of making a mistake in the chosen direction. In fiction, the importance of knowing the hero's location, and the importance of landmarks for his inner peace is often emphasized. For example, in the work "The Little Prince": "At a glance I can distinguish China from Arizona. If one gets lost in the night, such knowledge is valuable" (de Saint-Exupéry, 1995, p. 10). Another example is vividly described by Carroll, L. (1916) in his book about the heroine Alice, who throughout the work is in periodic confusion and searching for the right path. She worries about the wrong path, and the desire to go back: "Indeed, I shan't!" Alice said rather impatiently. "I don't belong to this railway journey at all — I was in a wood just now — and I wish I could get back there!" (Carroll, 1916, p. 147). Another important dialogue between the Cheshire cat and Alice, emphasizes the absent-mindedness of the main character, the lack of understanding of where to go in a new world her, in which all logic is violated, in which it is difficult to determine even the direction: "Come, it's pleased so far," thought Alice, and she went on. "Would you tell me, please, which way I ought to go from here?" - "That depends a good deal on where you want to get to," said the Cat. - "I don't much care where" said Alice. - "Then it doesn't matter which way you go," said the Cat. "— so long as I get *somewhere,"* Alice added as an explanation. -"Oh, you're sure to do that," said the Cat, "if you only walk long enough" (Carroll, 1916, p. 60)

It is difficult to imagine such dialogues in real life, but when people find themselves in a new country while traveling, they also tend to look for landmarks that will help them form and build a route and reduce anxiety while traveling. In their book, Arthur & Passini, (1992, p.7) write about the frustration and stress that a person experiences when moving through a built environment, or even worse, getting lost in an environment unknown to him: "is just something we feel we have to put up with - like being stuck in traffic jams, breathing noxious emissions, sharing the roads with drunks and the sidewalks with muggers". Although this problem is considered minor since it does not lead to physical injury or death from the stress associated with disorientation, it still exists. "Everybody knows, and has known all along, that wayfinding problems exist. Everybody knows it, and everybody deplores it. That, however, is not a solution" (Arthur & Passini, 1992, p. 13). Most people can get lost for various reasons: they did not see the

signs because the sign was too small or too big, and they could not read or understand it, or the signs were poorly placed, and people could not find them, or people doubted the reliability of the sign and deliberately ignored it. The author also suggests that people usually experience a similar chain of emotional reactions when they make a mistake while traveling.

> First, you blame yourself. Not only do you feel stupid, but you are frustrated because you are lost and anxious that you might be late or miss your appointment altogether. When you discover that you are neither stupid, nor lost, nor late, you feel resentment, possibly anger, that something so seemingly simple and inconsequential should be made so damnably difficult (Arthur & Passini, 1992, p. 8).

As Wurman (2000, p. 219) writes: "Unfamiliarity breeds anxiety. Most people are apprehensive about going to some place they've never been." The author also emphasizes the role of clear instructions while traveling: "Most people want to follow instructions. When you're walking down the street and someone behind you yells, "Stop!" that's what you'll probably do" (Wurman, 2000, p. 200). The effect of instructions while traveling along a route is also reflected in fiction. Lewis Carroll describes a situation when the main character Alice, frightened, immediately obeys the instruction: "And Alice was so much frightened that she ran off at once in the direction it pointed to, without trying to explain the mistake that it had made" (Carroll, 1916, p. 35).

Thus, effective visual communication is based not only on the task of informing, but also on caring for the human condition - reducing internal anxiety in the process of interaction with the urban environment. As Wurman (2000, p.108) notes, "Design can also make information less threatening. If the design is simple, functional, and yields a lot of information, users will be satisfied and propelled to continue their interest".

1.4. Metro Maps and Diagrams

Maps and diagrams are an integral part of urban navigation and play a vital role in understanding complex transportation systems such as subways. In addition, "there is significant evidence that maps are a mental aid to navigation. Numerous environmental and spatial cognition

studies have examined how maps work in the mind, and it is accepted that maps help people to create a spatial mental model as a 'cognitive map'" (Zheng, 2020, p. 533). This is also supported by Wurman (2000) when describing a walk in Morocco, during which he felt the need to know where he was about the market to "make a mental map" (Wurman, 2000, p. 155). The author also says that "Most people have a fairly limited concept of a map as a depiction of a particular geographic location" (Wurman, 2000, p. 156). In fact, the way people represent their environment is called "an image or a cognitive map" (Arthur & Passini, 1992, p. 23) and is the basic psychological concept in spatial orientation. To obtain a more comprehensive representation, it is necessary to gather information from multiple perspectives and vantage points. In this case, "cognitive mapping" is created – the process of structuring and combining the received information. Spatial orientation also depends on a person's ability to determine their location in the environment and to form "cognitive mapping" (Arthur & Passini, 1992). Therefore, to obtain information about their location, people turn to maps, which provide a sense of perspective and enable comparison of the received data.

Maps are an understandable template, a strict form, and a table of records that follow implicit principles and rules, and provide people with the means to share the perceptions of others. Maps can also be compared to a reference book, which is consulted every time it is necessary to choose the right direction or change course (Wurman, 2000). M. Rodionov (personal communication, April 14, 2025) expressed a similar opinion about maps and diagrams, noting that a metro diagram is loaded into the consciousness as a structure with the help of which a person builds a strategy of movement from the general to the specific: first, the general line of the route is imagined, then the transfer point, and only after that the specific station. This allows the task of movement to be broken down into hierarchical levels. Bertin (2010) argues that "Diagrams, networks, and maps permit us to reduce information to its essential elements, by internal processing; whereas symbolism, like language, seeks only to resolve the problem of external identification, through immediate recognition" (Bertin, 2010, p. 51). It is important to display information accurately and clearly on maps and diagrams to make the information easier for people to understand.

Before the advent of underground maps, city or national maps were used for orientation in space. These maps reflected the geographical position of streets, rivers, squares, and buildings, and they became the basis for understanding the relative positions of objects in the city (Tufte,

2007). It was from geographical maps that the first schemes of underground systems gradually began to form, which over time began to move away from topographic accuracy in favor of simplification, increased memorability, and readability. This made it easier to plot routes and plan transfers. A map is a two-dimensional representation that results from a high degree of abstraction. In other words, it is significantly removed from the reality it seeks to depict due to its compactness and flat representation. In addition, people tend to perceive more abstract or stylized maps more easily when it comes to interior spaces than when it comes to exterior environments (Arthur & Passini, 1992).

A breakthrough in the display of maps and the simplification of the presentation of visual information is undoubtedly the first of its kind schematic map of the London Underground, created by engineer and draftsman Harry Beck in 1933 (see Figure 16). Unlike previous geographical maps with topographic accuracy, Harry Beck proposed a new solution, inspired by electrical circuits. He displayed the Tube map as interconnected colored straight lines at 45 and 90-degree angles and retained the River Thames as a geographical landmark. The updated map immediately became a hit with the traveling public. Today, Beck's map is rightly considered "a radical breakthrough in the design of communication graphics, but often wrongly attributed to the culture of modernism that Pick had established at the Underground" (Green, 2023, p. 162). Interestingly, unlike the Joston font and the commissioned redesign of the Tube symbol, the new Tube map was designed by Beck in his spare time and submitted to the Underground's advertising department. Beck was a young engineering draughtsman who had worked for the Underground since 1925. After his dismissal in 1931, he developed the first version of his map (see Figure 16). Before Beck's map, there was the pocket Tube map designed by Fred Stingemore, which provided a more realistic and geographically accurate representation of the Tube lines (see Figure 16). From observing commuters, Harry Beck realized that they did not need a geographically accurate map, but might prefer a simple diagram showing them the sequence of stations and where to change to get to their destination. As a result, as the familiar layout of the London Underground changed, so did the way people thought about the city: "The result is a complete distortion of London, the River Thames, and the London Underground system, but as a travel aid it is brilliantly simple, being very easy to read and use" (Green, 2023, p. 162). Following the public acceptance of the published map in 1933, Beck was appointed as a freelance contract worker to work on the map, and he continued to

oversee any changes to it until 1959 (Green, 2023). This principle of displaying information on a metro map has gradually become integrated into metro maps of other cities.

Figure 16. Top left: The 1931 pocket Tube map designed by Fred Stingemore. Top right: Harry Beck's original presentation design, submitted to the Underground in 1931 and initially rejected. Above: The first printed version of Beck's diagrammatic map, 1933. The cover included a polite request: "A new design for an old map. We should welcome your comments". From *London's Underground* (p. 163), by O. Green, 2023, Frances Lincoln.

For example, a map of the railway system, including underground and suburban services in Berlin, resembles classical London maps, but the Berlin system comprises multiple networks and greater detail (Wildbur & Burke, 1998; see Figure A3 in Appendix/Annex A).

The New York City Subway is famous for its unique map, designed by Massimo Vignelli in 1972. His diagram was innovative, minimalist, and geometrically rigorous but was criticized for deviating too much from real geography. It was later replaced by a map closer to geography, but Vignelli's idea remains vital in the history of design (Tufte, 1990).

Thus, subway maps are not just a navigation tool but also an essential element of visual communication, providing accessibility, safety, and confidence for all categories of users. Although maps and subway maps can be helpful during travel, "many people experience great

difficulties in using them" (Arthur & Passini, 1992, p. 147). Therefore, it is essential to adopt a comprehensive approach to developing a navigation system, incorporating maps and schemes, as well as signs and online navigation services. A more complete understanding of the location and route will facilitate any movement.

1.5.Wayfinding Systems

The term *wayfaring*[3] has been around since the 16th century. However, much later, in the 20th century, the term wayfinding "was first used by the American architect Kevin Lynch in his influential book, The Image of the City (1960)". The purpose of navigation is "to assist people first in the decision-making process and then in the decision-executing process", i.e., to help people during the entire period of travel (from the first decision point to the final destination) along their chosen route (Arthur & Passini, 1992, p. 150). In other words, "Wayfinding design provides guidance and the means to help people feel at ease in their surroundings" (Gibson, 2009, p. 12).

Arthur & Passini (1992, p.14) raise the issue of the unfairly underestimated importance of wayfinding in everyday life: "the idea that excellence in wayfinding can do a developer just as much good in the public eye as art can, is still in its infancy". It is perceived as a simple help to people and something ordinary. Therefore, the development of wayfinding in any room is typically considered last after the building's design is complete. However, it is also important to understand that pathfinding does not only happen inside buildings, and before you can get into that building, you need to somehow get there Arthur & Passini (1992).

The goal of wayfinding is to reach a planned destination during a journey. To achieve this goal, several important points are fulfilled: 1) understanding previous experience; 2) assessing the environmental context; 3) analyzing the characteristics of the spatial environment; 4) taking into account information displayed on maps, signs, and pointers; 5) assessing various scenarios; 6) taking into account such factors as time, interest, and safety associated with the route. During the journey and movement, a person creates mental maps and continually takes action to solve various problems to reach the destination (Arthur & Passini, 1992). There is a difference between those who move along a familiar route and those who are following a route for the first time (e.g., travelers, migrants, international students, etc.). When following a familiar route, a previously

[3] Wayfaring - traveling, esp. on foot. Synonyms of 'wayfaring' roving, walking, journeying

written decision plan is carried out, and therefore, "emphasis has shifted from decision making to decision execution" (Arthur & Passini, 1992, p. 28).

Maps are essential when traveling, however, when using public transportation, it is the wayfinding system and signs that are more effective. This is the conclusion reached by Zheng (2020) during a study on the relationship between map reading and route navigation in the Tokyo subway system: "The provision of spatial information enables underground transport users to enjoy a highly effective wayfinding service. Every underground station has maps, but their usage rate is low, and hence they might be easily ignored" (Zheng, 2020, p. 533). Another important conclusion from this study is: "Regardless of the type of map used, signages are the most frequently used landmark for people to find their way" (Zheng, 2020, p. 532). In a study conducted by Mustikawati et al. (2018, p.3), "signage becomes the most frequently sought information by the participants", while it "refers to the board containing textual and graphic information telling location, direction or place naming/numbering".

In essence, navigation provides a mental tool with which a person can make predictions and plan the next actions based on spatial knowledge. For example, if a building is constructed symmetrically, it can be imagined that at the end there will be stairs that can be used to move to another level (M. Rodionov, personal communication, April 14, 2025). Physical elements of the environment, such as buildings, elevators, and stairs are also part of navigation and can be used as landmarks. In a study by Mustikawati et al. (2018), participants used stairs, elevators, and doors as landmarks during movement. They found that vertical movement such as stairs and elevators provide an unambiguous understanding of a possible transition to a level higher or lower, and a door is a horizontal transition from one space to another. And they concluded "Stairs could also be used as a place marking" (Mustikawati et al., 2018, p. 4). Arthur & Passini (1992) also write about architectural elements that can serve as landmarks, citing the following dialogue as an example: "Not knowing where this particular store kept this item, the Lacys asked a clerk. Her (almost aggrieved) response was instantaneous: "It's where it's always been... over there, under the escalator"" (Arthur & Passini, 1992, p. 7).

Despite the similar cognitive features used during travel, "People’s wayfinding process in an underground station differs from their usual wayfinding method" (Zheng, 2020, p. 532). Puttipakorn and Upala (2018) compared the environmental design with the choice of pedestrian paths in subway stations in the city of Bangkok, Thailand, using MRI and proposed to decompose

the quality of subway stations into several attributes: "ease to access, cleanliness, subjective (perceived) and objective security, lighting, climate control, and information availability" (Puttipakorn and Upala, 2018, p.151). "Wayfinding is one of the significant aspects to be considered in enhancing the quality of service and sustainable use of a public facility by its user" (Mustikawati et al., 2018, p. 1). It is worth noting that special care must be taken in developing the graphic design of the environment in more complex places where additional location information is required. That is because "the information that exceeds the passengers' limit will affect the need for less location information for wayfinding" (Puttipakorn and Upala, 2018, p.161). Undoubtedly, the complexity of the environment often leads to visual oversaturation. "We have a limited capacity to transmit and process images... The more images with which we are confronted, the more our view of the world is likely to be distorted" (Wurman, 2000, p. 17).

According to Cheirchanteri (2021), "Spatial semiotics and orientation (wayfinding) are more often expressed in uniform signage systems, which both in terms of information and visualization are linked together in a space" (p. 3). This points to the need for a holistic systems approach, where each part of the visual design should support the other—maps, signs, color system, and lighting should work as a whole. Therefore, the designer's task is not just to provide a person with as much data as possible, but to structure and simplify the presentation. "Simplification is an obligation of the communication process" (Bertin, 2010, p. 166).

1.5.1. Decision-Making

The availability of information is crucial for decision-making. If, at a certain point along the route, there is no necessary information or there is conflicting information, which is quite common, one will have to resort to trial and error, taking random or intuitive actions. Suppose one examines all the decisions outlined in the action plan. In that case, it becomes evident that all the general choices are at the top and left (i.e., at the beginning of the path). The decisions leading to spatial behavior, with more specific small actions, are illustrated on the right below (Arthur & Passini, 1992; Figure 17). That is, before reaching the destination, the action plan is divided into several different decisions, which are taken from the largest to the smallest. The path decision consists of two parts: 1) Behavior (e.g., turning left or moving up or searching for information) and 2) An environmental entity (e.g., an intersection, a staircase, or a billboard) (Arthur & Passini,

1992). Reasoning and searching for landmarks in the environment were described in detail in the work of Lewis Carroll (1916): "I SHOULD see the garden far better," said Alice to herself, "if I could get to the top of that hill: and here's a path that leads straight to it — at least, no, it doesn't do that— " (after going a few yards along the path, and turning several sharp comers), "but I suppose it will at last. But how curiously it twists! It's more like a corkscrew than a path! Well, this turn goes to the hill, I suppose— no, it doesn't! This goes straight back to the house! "Well then, I'll try it the other way" (Carroll, 1916, p. 133). Navigation is essential to life and is a complex cognitive process that involves perspective and situational planning, spatial memory, orientation to the terrain, and real-time decision-making (Bae et al., 2024). Wayfinding is not just a new and, we have to admit, now quite fashionable term for an old concept. It reflects a new approach to studying people's movements and their relationship to space (Arthur & Passini, 1992, p. 22).

Some routes will always be more popular (primary), while others will be less popular (secondary and tertiary). Understanding this, Arthur & R. Passini (1992) described three types of primary routes: 1) the central circulation between the entrance and exit, 2) movement from one destination zone to another, and 3) movement within the central zone. Let's take as a basis the ideas of the hierarchical construction of the action plan and look at the primary routes proposed by Arthur & R. Passini (1992), and also take into account that people generally make a similar series of decisions when searching for a route, regardless of whether they are following the path for the first time or not. We can compare the circulation of people inside the subway with the distribution of the magnetic field in a magnet (see Figure 18).

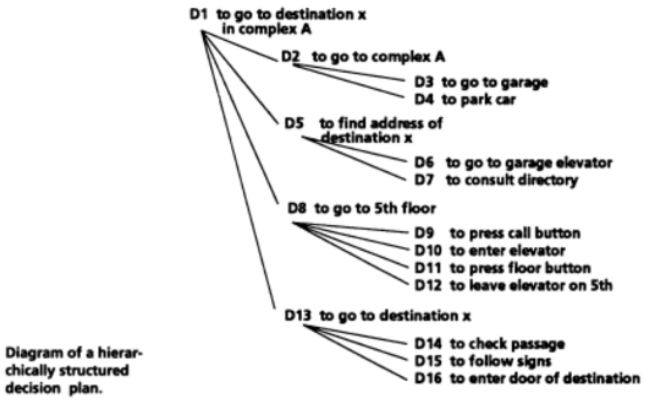


Figure 17. Diagram of a hierarchically structured decision plan. From *Wayfinding: People, Signs, and Architecture* (p. 30), by P. Arthur & R. Passini, 1992, McGraw-Hill Book Company.

It is possible to propose an alternative general scheme for decision-making in the subway by analyzing the movement of people in the subway:

1. Before entering the subway building, it is necessary to locate its entrance. Usually, the path to it is possible along different trajectories (from other streets, from the station) (see Figure 18, 1).

2. Then, it is necessary to make a series of decisions and actions, such as going up-down, turning left-right, forward, etc., and going in search of the right subway line and the entrance to the right car (see Figure 18, 2).

3. The subway car is a neutral and, at the same time, constant variable since the passenger inside the vehicle does not need to make decisions about where to go (see Figure 18, 3).

4. After exiting the subway car, the type of pathfinding changes, aimed at the "Exit" (see Figure 18, 4). The passenger makes a series of decisions and actions aimed at finding an exit from the subway or a transition to another station (see Figure 18, 6).

5. Achieving the goal, i.e., "Exit" and movement from the exit in different directions (see Figure 18, 5).

Analyzing the data on the movement of people in the subway, it is possible to draw an analogy between the general distribution of the passenger flow and the distribution of the magnetic field in a magnet. As is known, a magnet has a south (S) and north (N) pole, and the magnetic lines of force enter the south pole and exit from the north pole. That is, there must be an entrance and an exit, and the flows interact well with each other. In this analogy, the magnet will be the subway. Then, the South is the entrance (Figure 18, 1), and the North is the exit (Figure 18, 5). The middle of the magnet is the place where the polarity of the magnet changes, and in the subway, the car (Figure 18, 3) is the place where the type of route planning changes from "Entrance search" to "Exit search". According to Arthur & Passini (1992, p.126), "The wayfinding tasks of reaching an entrance are quite different from those for an exit". The concepts of "Entrance Finding" and "Exit Finding" cannot exist separately without each other and interact with each other like the poles of magnets "+" and "-" (See Figure 18). According to Arthur & Passini (1992, p.43) "Spatial planning determines the location of the entrances and exits of a setting, the location of the major destinations and, therefore, the nature of its circulation system, the organization of its spaces, and the visual accessibility of its architecture". It is also essential to understand that entrances, exits and gates are

"the transition points from one scale and circulation pattern to another" (Arthur & Passini, 1992, p. 131).

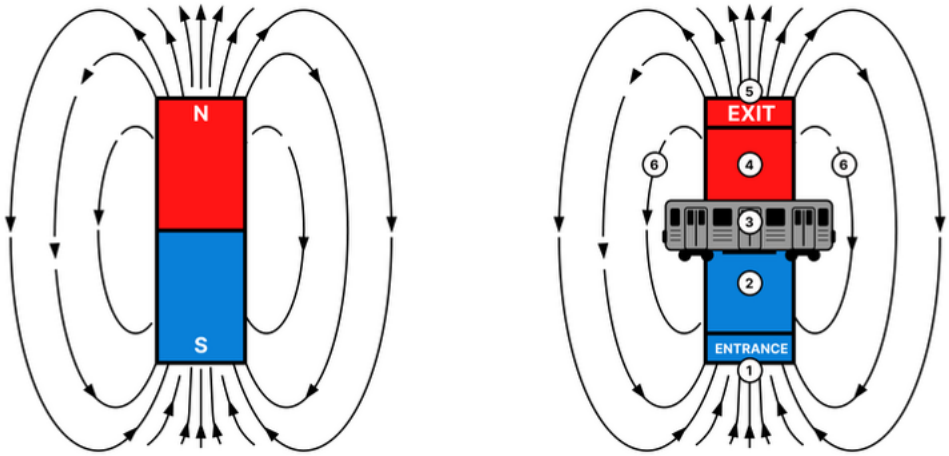


Figure 18. Visualization of a magnetic field (left, adapted from "Magnetic field. Vectors of magnetic induction" n.d., 99ballov.ru) and an author's analogy showing the similarity between magnetic field distribution and passenger flow in the metro (right). Adapted modified by the author.

The distribution of information in space plays a key role in different stages of decision-making, depending on the type of request. The placement of information is a critical aspect: Information that is not located where it is needed is almost equivalent to its complete absence (Arthur & Passini, 1992). The organization of space has a significant impact on the perception and understanding of the environment and is considered a crucial element in the design of a navigation system. Therefore, it is essential to establish a clear and logical system for visualizing information that effectively supports the process of orientation and decision-making.

1.5.2. Orientation and strategy

Arthur & Passini (1992) compiled a table showing the basic orienteering tasks and the corresponding cognitive manipulations (see Figure A4 in Appendix/Annex A). Referring to this table, the orienteering process is complex. The features of the environment usually cause difficulties in this process. It can be too complex or unclear, or it becomes difficult (or impossible) to obtain information about the environment. At such moments, a person is forced to use a more effective strategy - to find and remember reference points during wayfinding and use them as

"mental anchors" (Arthur & Passini, 1992, p. 105). Mental anchors help to structure information in a complex, disorganized environment, such as a "shoestring" situation. Reference points can be different physical features, events, and/or destination areas. Also, they should coincide with decision points in the environment (see Figure 19, left). Gibson (2009) also came to a similar conclusion: "Sign programming begins with an analysis of arrival, departure, and decision points; circulation pathways; and signing opportunities" (p. 57).

A more organized principle is the Gestalt circulation model (see Figure 19, right). This model helps to structure the decision-making plan based on the joints: "It is the joints that structure the decision plan" (Arthur & Passini, 1992, p. 109). The Gestalt principle of visual perception helps simplify and remember information by creating mental cues based on repetition, proximity, similarity, and continuity. As a result, people intuitively perceive and follow spatial routes. These perceptual rules contribute to the clarity and logic of navigation, allowing users to navigate more naturally and efficiently.

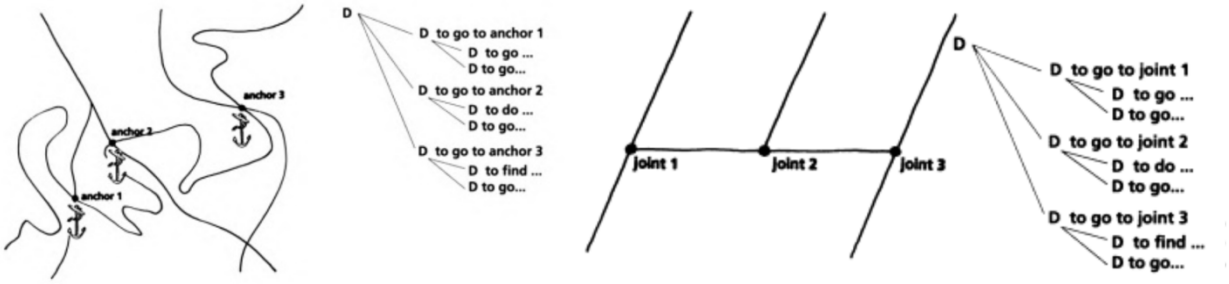


Figure 19. Left: Mapping using "mental anchor" reference points (left) corresponding to the decision diagram (right). From *Wayfinding: People, Signs, and Architecture* (p. 107), by P. Arthur & R. Passini, 1992, McGraw-Hill Book Company. Right: Gestalt pattern of circulation (left) corresponding to the decision diagram (right). From *Wayfinding: People, Signs, and Architecture* (p. 109), by P. Arthur & R. Passini, 1992, McGraw-Hill Book Company.

In exploring the image of the city as a place for orientation, Lynch (1990) identified five basic elements that help to correctly organize different information and facilitate further navigation: "path, edge, district, node, and landmark" (p. 109). Paths are the lines that represent the main routes of people's movement, such as pedestrian paths, streets, canals, and transportation lines. Edges are linear elements that are not paths but divide the territory into zones. For example, banks, railway cuts, walls, and the edges of buildings. Such edges can be solid barriers or have negligible permeability. Districts are medium and large areas of the city that have a recognizable character and that one can mentally "enter" into. Depending on the person or the city, districts help

to structure the city in different ways. Nodes are key points in the town where the observer can enter or begin their movement. Such points may be intersections, closed areas, or places where people gather that acquire significance, as well as locations in the transportation system, such as breaks, crossings, or converging paths, or the transition from one structure to another. A landmark is another type of reference point, a physical object, such as a building, a sign, a store, or a mountain, that stands out from the rest. Landmarks may be distant and visible from a distance (such as towers, domes, and mountain peaks) or local (including storefronts, trees, and door handles) (Lynch, 1990). Similarly, it is possible to categorize the information that a passenger can receive on the subway.

Before discussing the design of a wayfinding system, it is helpful to delve into the process of understanding wayfinding, conduct thoughtful research, and define "The wayfinding strategy" (Gibson, 2009, p. 37), which serves as the basis for further development of the signage program system. The wayfinding strategy in urban planning encompasses a neighborhood, streets, connectors (paths that connect all destinations), and landmarks (nodes, such as elevators or major destinations), enabling one to define a clear and understandable network in space. To begin with, it is necessary to consider the different groups of people (e.g., employees, passengers, people with disabilities, etc.) separately and display their paths on a map. Then, it is necessary to develop master maps of the overall circulation patterns. From these maps, the designer can "establish a family of sign types and devise a site-specific wayfinding strategy" (Gibson, 2009, p. 42, see Figure 20).

> The unifying language of a wayfinding system creates a public narrative of how people witness, read, and experience a space. Each sign in a system, each separate voice, serves a particular function and displays a specific kind of content called a message, which might include nonverbal graphic symbols, images, and words (Gibson, 2009, p. 46).

As a result, the design of navigation systems is a complex process that requires an understanding of the principles of ground orientation and decision-making in a limited environment. It should be based "on people's wayfinding behavior" (Arthur & Passini, 1992, p. 45). Understanding these aspects will improve the conditions for decision-making and determine

the required number of signs needed for comfort in following the route. To enhance the perception of space (public, commercial, or private), the wayfinding designer "is experienced by finding order in chaos without destroying character" (Gibson, 2009, p. 13).

It is essential to recognize that there is no single definitive solution for implementing a wayfinding system. It is necessary to consider multiple factors and structure the information within the context of the space and the decision-making process. The process of designing the wayfinding is a complex multistage process, in which it is necessary to "first start with a spatial idea and only then think about the circulation and the decision diagram" and finally "Providing the actor with a script to perform wayfinding" (Arthur & Passini 1992, 45).

Designing wayfinding is not only a graphic function in design. Wayfinding signs differ from simple signboards in their greater significance and importance. It is necessary to understand the basics of environmental perception and cognition, as well as the principles of orientation. Designing navigation signs requires more detailed study and cooperation of two professions: the architect and the graphic designer. As Arthur & Passini (1992, p. 139) note, "Architectural and graphic information systems go hand in hand".

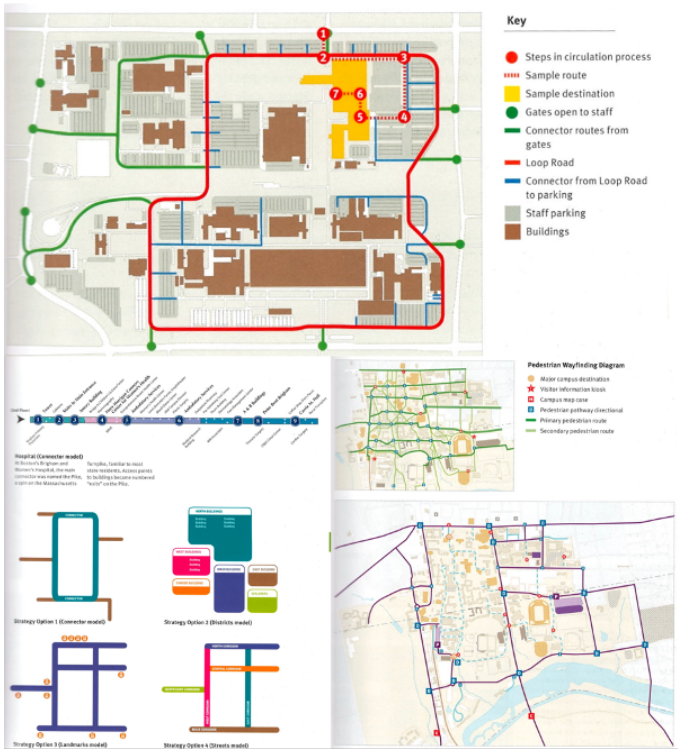


Figure 20. Options of wayfinding strategy development. Adapted from *The Wayfinding Handbook: Information Design for Public Places* (pp.41, 43, 45), by D. Gibson, 2009, Princeton Architectural Press. Copyright 2009 by Princeton Architectural Press.

1.5.3. Types of information and signs

There are many types of information that people encounter in public places. Each type of information requires corresponding kinds of signs that will help to isolate and emphasize the information. Each type of sign performs a specific function - directing, informing, warning, prohibiting, or identifying - and, together with others, forms a complete and understandable navigation system.

Arthur & Passini (1992) identified two types of information in navigation: 1) linear and sequential – displayed on signs; 2) spatial and global – derived from the spatial environment. They are not mutually exclusive, and most people use both types of information. Preferences for these types are adjusted depending on the situation, for example, for everyday and emergency use.

In public places, especially in crowded places under extreme circumstances such as fire, finding the right way becomes a vital action. As Arthur & Passini (1992, p.10) state, "Two areas link this issue to wayfinding, the design and signage of exit routes and the general quality of wayfinding design of a setting". The design of escape routes, as well as the use of special signs to indicate emergency exits, has its own strict rules and regulations for use and is regulated at the national level.

When following a route from a starting point to a destination, a person needs to orient themselves in the area and mentally imagine the route. Therefore, the traveler collects information from the external environment and looks for any landmarks or signs to make the necessary decisions for further actions. In this case, the task of the navigation system designer "is to determine where to locate signs, what they should say, and how they should say it" (Gibson, 2009, p. 37).

Arthur & Passini (1992) identified three types of information necessary for decision-making in an unfamiliar environment:

? - Orientation and general information about the setting. Here, a person receives decision-making information, such as an idea of the building's shape, an indication of one's location, or a destination. Such information is obtained with the help of maps, floor plans, coordinates, and arrows indicating one's location or destination area, in addition to displaying rules of conduct (marked on the plan map) throughout the building, including safety guidelines.

➜ - Directional information to destinations. Here, a person receives decision-executing information. For example, information directed to a destination includes signs with arrows and descriptions in plain language, utilizing elements of the building and landmarks, floor indicators in elevator lobbies, and color-coded lines on ceilings and walls that direct to destination areas.

id - Identification of destinations. Here, a person receives information to complete the decision-making or execution process. For example, information indicating the destination upon arrival: signs with names or pictograms at the entrance area of the destination, as well as signs identifying an object or hazard in the area.

As a result, Arthur & Passini (1992, p.147) formed three types of signs: "Orientation sign: building directories, maps, hours of service; Directional signs: signs with or without arrows; Identification signs: signs in verbal and/or non-verbal form". They also brought up the example of abstract or conceptual pictograms (see Figure A5 in Appendix/Annex A), mentioning that only a small number of pictograms can be used without textual support. For example, the pictogram "?" shown in Figure A5 in Appendix/Annex A implies the meaning "information". However, it is often possible to see the pictogram "i" alone or together with textual support in different countries with the same meaning. For example, if you type "information sign" into the Google search engine, many signs will be displayed in response, and most of them will be like the pictogram "i" (see Figure A6 in Appendix/Annex A). Also, the pictogram "i" is used inside the Lisbon metro (see Figure 21).

Figure 21. Information sign in the Lisbon Metro at Oriente station. Photograph by the author, 2025.

Mustikawati et al., 2018 considered the role of objects in space that provide information to building users in the process of finding their way around different independent groups of people and identified three types of signs depending on their purpose. Also, for Arthur & Passini (1992): "A directory board is used to get information of location; a directional sign for route information, whereas an identification sign, is used to confirm the identity of a place" (p. 3). Cheirchanteri (2021) also refers to the three classifications proposed by Arthur & Passini (1992) in his study. However, he adds a fourth type of signage: "Warning signage, indicating security procedures, such as fire protection routes, non-smoking areas and other regulations that are or are not allowed in a specific area" (Cheirchanteri, 2021, p. 9). A similar classification of wayfinding signs is proposed by Gibson (2009, p.47): "Most wayfinding systems can be broken down into several categories of signs: identification, directional, orientation, and regulatory". Also, Gibson (2009) divides signage types into interior and exterior, proposing variations within each category (see Figure 22).

In any case, the authors Arthur & Passini (1992), Gibson (2009), Mustikawati et al., (2018) and Cheirchanteri (2021) almost unanimously identified three main categories of signs (slightly different within the category) and additionally, the fourth category was identified by the authors Gibson (2009) and Cheirchanteri (2021) (they call this category differently, but include the same signs). Based on the above categories, we can make a universal general classification of sign types:

1) Identification signs - plates with names, pictograms or logos that create a first impression of the destination, identifying the name of the place or its purpose. They can appear both at the beginning and at the end of the route (for example, entrance and exit), and are also used before the transition from one type of space to another. They can also indicate a hazard in the area (see Figure A7 in Appendix/Annex A).

2) Directional signs – signs with/without arrows with/without typographic description – hints. They indicate the direction between the main decision points and to the final destination (destination area) (see Figure A8 in Appendix/Annex A).

3) Orientation signs – signs that provide an overview of the surroundings in the form of detailed plan maps (e.g. a floor plan or a general map of the area) and directories (e.g. a list of

company names on a given floor), and also indicate the location of themselves "You are here" or the destination (see Figure A9 in Appendix/Annex A).

4) Regulatory or Warning signs – signs that indicate what can and cannot be done in certain places, and also indicate fire protection routes. Such signs are usually subject to regulatory controls and may differ in different countries (see Figure A10 in Appendix/Annex A).

Figure 22. Sign Types List. Adapted from *The Wayfinding Handbook: Information Design for Public Places* (p. 47), by D. Gibson, 2009, Princeton Architectural Press. Copyright 2009 by Princeton Architectural Press.

Gibson (2009) cited the Children's Hospital Boston (see Figure 23) as an example of effective wayfinding in a public space. The hospital consists of five buildings, which were highlighted in the wayfinding using color and a pictogram. At all major intersections, as well as at decision-making points, wall signs were installed listing the names of buildings, destinations, and locations of public spaces.

According to Arthur and Passini (1992, p.192), "visitors to an unfamiliar setting will need different types of information to assist them in getting efficiently to their chosen destinations", which suggests that it is more effective to use multiple types of signs that support one another. At the same time, Arthur & Passini (1992, p.192) emphasize that "few of these "types of information" have ever been standardized and, as a result, they are called different things in different builds" (p. 192). For example, the designation of floors in different countries or various types of buildings within a country may differ: the floor on which the main entrance to a building is located in Russia, the USA, and Canada is called the "First floor", in Portugal "Floor 0" or "Ground 0"(elevators,

mainly) or "RC" (rés-do-chão), in Turkey and Britain "Ground floor", and sometimes there is no relation to the floor number at all, indicating only the main points on it: Reception, Gym, Lounge area, etc. (see Figure A11 in Appendix/Annex A).

Figure 23. Wayfinding system in Children's Hospital Boston. Adapted from *The Wayfinding Handbook: Information Design for Public Places* (pp. 61, 62), by D. Gibson, 2009, Princeton Architectural Press. Copyright 2009 by Princeton Architectural Press.

When people travel, they encounter differences in one way or another that can be confusing. For example, when they need to reach the right floor in a shopping mall or locate the correct floor and room in a hospital. It is difficult to imagine how a unified approach to designing navigation systems would simplify orientation in a new country, city or building. However, Arthur and Passini (1992, p. 200) speculate on the possibility of unification and the creation of at least a principle of fixing information in a "horizontal band". They propose defining two types of bands (VisuCom's InfoBand 1 and InfoBand 2) in the range of which different types of information should be placed (See Appendix C for a full description, see Figure C1).

In terms of physical and technical characteristics, signs can be classified into three types: 1) signs supported by a pole, slab, or base; 2) wall signs attached flat to a vertical surface or protruding; and 3) signs suspended from a cornice or ceiling. Also, signs within different categories can be dynamic (video displays and electrical displays in which information changes on demand depending on the need/context) or static (using a constant picture and information), one-sided or two-sided; they can be illuminated from the inside or have external lighting, or have no artificial lighting at all (Arthur & Passini, 1992). Pictograms, glyphs, and symbols in an

information system (these words are used interchangeably) usually have the following functions: 1) warn people of danger; 2) indicate actions that must be performed; 3) identify things. However, the use of pictograms alone will not always be practical. To minimize confusion in the perception of information, it is necessary to use signs in the context of each place separately and also to refer to the existing basic symbol sets. Different countries may have developed various guidelines or recommendations for the use of symbols and pictograms in public places. For example, the American Institute of Graphic Arts (AIGA) developed a system of DOT symbols for the US Department of Transportation, which included about thirty individual glyphs divided into "general service symbols": toilets, telephones, smoking, and other more specialized ones: identifying customs, immigration, etc. Since these symbols are not copyrighted, they are widely used in other public places that have no connection to transportation. In the mid-1970s, the Canadian Standards Association (CSA) developed standards for symbols and signs in the work environment, which indicate the contexts in which the use of glyphs is acceptable. There are three categories of glyphs and symbols: 1) Object-related (telephone receiver, smoking a cigarette); 2) Concept-related (an arrow conveying the concept of movement and direction); 3) Abstract (a "no entry" sign in the form of a white horizontal rectangle on a red circle). Also, for effective communication it is necessary to provide the viewer with a combination of components participating in the display of information: 1) Color and shape, which are read first and determine the context: permitting or identifying (square), prohibiting (circle), warning (triangle); 2) Glyph (pictogram, symbol), which are read next after the color and show what is permitted, prohibited, etc.; 3) Verbal message, which confirms the meaning of the visual information received before. It is also essential in verbal communication. By combining components, the meaning of the transmitted information can change. For example, the same glyph, accompanied by an image of a man, combined with different shapes and colors, changes the context (Arthur & Passini, 1992; see Figure 24).

Figure 24. An example of how the same glyph, when combined with different shapes and colors, can change its meaning. From *Wayfinding: People, Signs, and Architecture* (p. 146), by P. Arthur & R. Passini, 1992, McGraw-Hill Book Company.

The symbol "Arrow" belongs to the Concept-related category and specifies the direction: up, down, left, right, etc. But despite the simplicity of this sign, ambiguous situations may arise. For example, an arrow pointing "up" does not always indicate only the direction up; it can also indicate movement forward, as well as an arrow pointing down, which can indicate the direction down or back. Sometimes, arrows can be confusing, and when there are too many, it becomes difficult to navigate and choose the right direction. According to Arthur & Passini (1992, p.176), "mindless and gratuitous repetition does more to puzzle people than to help them", and they also believe that "interior signs should never contain more than two directions - and two arrows" (see Figure 25).

Figure 25. Example of using an unacceptable number of arrows. From *Wayfinding: People, Signs, and Architecture* (p. 146), by P. Arthur & R. Passini, 1992, McGraw-Hill Book Company.

According to Arthur & Passini (1992, p.180), "There is a rule of thumb to the effect that no signs should ever contain more than five or six messages or "bits" of information, of which the sign itself is one. There is, however, some latitude in the meaning of "bits". They also suggest some deviations from the rules, depending on the context. For example, in road signs, bits are separate lines, of which there should be no more than three in a road sign. However, for pedestrians, the number of lines can be significantly increased. It is also worth considering that a person does not read signs as printed texts but reads the environment and signs: "using a scanning and glancing process that is akin to a person looking for "meaning" in a non-objective work of art", therefore it is necessary to group large amounts of information into smaller blocks. For example, three columns of three messages are learned better than one vertical column with nine messages (Arthur & Passini, 1992, p. 180; see Figure 26).

According to Bertin (2010), before planning the design and defining the boundaries of a graphic system, it is first necessary to separate the content (i.e., the information to be conveyed) from the container (the properties of the graphic system). In doing so, "A rigorous definition of the components of the information, specifying their number, length, and level, must precede any graphic construction" (Bertin, 2010, p. 15).

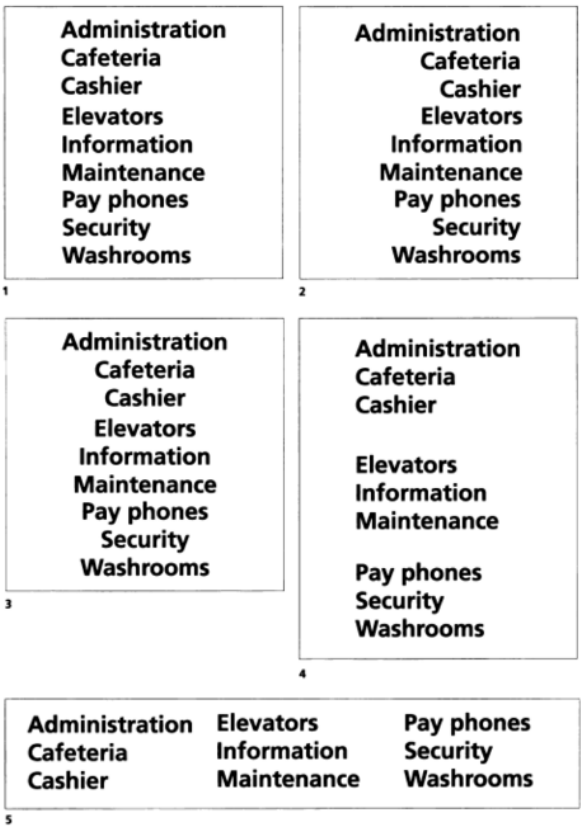


Figure 26. Different types of typographic information display. From *Wayfinding: People, Signs, and Architecture* (p. 146), by P. Arthur & R. Passini, 1992, McGraw-Hill Book Company

To create a homogeneous series of information carriers, Bertin (2010) emphasizes the importance of having components that extend across the series always be transcribed in the same place. Additionally, the categories of these components should have maximum visibility and be written in bold and capital letters. To better understand complex information and determine the best graphical representation, Bertin (2010, p.16) introduced the terms "INVARIANT" and "COMPONENTS", where the INVARIANT "is the complete and invariable notion common to all the data" and the COMPONENTS "are the variational concepts" (see Figure A12 in Appendix/Annex A). Bertin (2010, p.171; p.183) also defined the basic rules for constructing

information: "A rigorous definition of the components of the information, specifying their number, level, and length, must precede any graphic construction", while "the combination of several variables reinforces selective legitimacy". When using a large number of components, Bertin (2010) recommends taking into account several key points: 1) "The number of visual variables necessary for the representation is at least equal to the number of components in the information" (p. 28); 2) "With three components, the information can be perceived as a single image. Beyond that, the perception of several, successful images is often necessary" (p. 28); 3) "There are at least as many types of possible questions as there are components" (p. 28); 4) "The number of components is the best basis for a classification of graphic constructions" (p. 28). In this case, the information can be voluminous and consist of many components, in which case just one larger component or invariant that would be common to all is sufficient.

Also, there are several ways to align a text message in signs: left, centered, and right. Left, or proper alignment, is considered more acceptable because it allows for better organization and structure of information - especially in places where reading is done from left to right. Exceptions may be arrows showing direction, which may also be highlighted in a separate line and/or color (Arthur & Passini, 1992, see Figure 27).

Figure 27. Left-align typographic information. From *Wayfinding: People, Signs, and Architecture* (p. 146), by P. Arthur & R. Passini, 1992, McGraw-Hill Book Company.

1.5.4. Typography

Typography, like wayfinding design, has its origins in architectural lettering used to mark important buildings and monuments, landmarks, or destinations in ancient times. From Egyptian hieroglyphs glorifying the pharaohs to Roman inscriptions, these letterings were originally created by artisans to convey religious or civic messages and later became the basis for the modern alphabets. Cuneiform is recognized as the world's oldest writing system, developed by the

Sumerians around 3200 BCE in Mesopotamia (present-day Iraq). This type of script has no letters, instead containing between 600 and 1000 pictogram-like symbols (The British Museum, n.d.). Chinese writing originates from early depictions of symbols on handicrafts—Neolithic pottery from around 5000 to 1600 BCE and later oracle bone inscriptions used during the Shang Dynasty. This shows the long development from logographic images to modern writing (Rutgers University, n.d.).The Mayans, in turn, used a unique system of writing (illustrating stories) and numbers to record their conquests on their temples and steles. In medieval Europe, Blackletter on tombstones, evolving from the Carolingean script, echoed architectural ornamentation and the manuscripts of monks. With the advent of the industrial capitalist era of the 19th century, typography took to the streets: the facades of American and European cities were filled with advertising signs to attract customers. The letters in the typeface were created by hand, reflecting the fashions and preferences of the times, as well as the tastes of the owners. As a result, signage became a visual clutter in many cities and a symbol of excessive commercialization (Gibson, 2009). In the first half of the 20th century, as taller buildings began to be constructed, lettering became an integral part of the architecture – engraved on facades, incorporated into decorative elements, or displayed separately on metalwork. By the end of the 20th century, the need for wayfinding systems increased: large buildings and infrastructures required the creation of complex systems of directional signs and signals. Graphics and typography became key tools in organizing space for users (Gibson, 2009).

Typography is used in verbal communication and is an essential component of visual communication. In the context of the metro, it is necessary to scan information from a sign. Therefore, it becomes critical to find the best font solutions when creating navigation systems, as well as to understand the parameters that make information easy to read from signs. Competent use of fonts in navigation will help to facilitate the process of moving to the desired destination. Fonts can be divided into two large groups: fonts with serifs and fonts without serifs. In navigation systems, fonts without serifs are primarily used, as they offer good readability and visibility from a distance. Sans-serif fonts are more effective in signs than serif fonts, as the latter usually "have greater differences between thick and thin strokes within the same letter" (Arthur & Passini, 1992, p.156; see Figure 28).

Figure 28. Comparison of a serif font (left) and sans serif font (right). *From Wayfinding: People, Signs, and Architecture (pp. 157-158), by P. Arthur & R. Passini, 1992, McGraw-Hill Book.*

Arthur & Passini (1992) singled out Rail Alphabet, designed by Jock Kinneir specifically for use on signage (see Figure 29), as a highly legible sans-serif font. The advantage of this font is that it is quite readable in both positive (black font on a white background) and negative (white font on a black background) versions. However, font size is usually perceived differently in the negative and positive versions. White font on black appears approximately 10-15% larger than the black font on white, but in Rail Alphabet, the distortion is minimal. According to Arthur & Passini (1992, p.168), the difference in the perception of text in a positive and negative key is called halation or irradiation, since light letters on a dark background "will seem to radiate and as a result appears to be considerably larger".

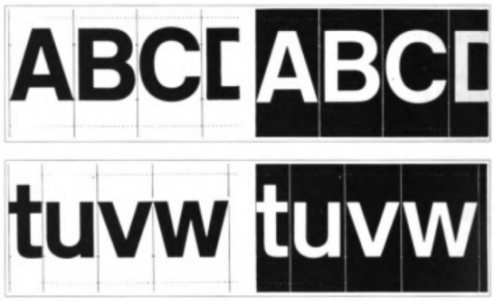


Figure 29. Rail Alphabet black letters and white letters, designed by Jock Kinner of British Rail. From *Wayfinding: People, Signs, and Architecture* (p. 154), by P. Arthur & R. Passini, 1992, McGraw-Hill Book Company.

According to Arthur & Passini (1992, p.154), the rendering efficiency of a font depends on the ratios "between the stork width and the height of the capital letters (cap-height)", but despite the difference in stroke width, the well-known Helvetica font (widely used in signage in the 60s and 70s) remains well readable in both the medium and regular versions (see Figure 30). Therefore,

Arthur & Passini (1992) concluded that the best letters for signage should have a ratio between the x-height and the cap height of 3:4.

Figure 30. Helvetica letterforms in regular and medium. From *Wayfinding: People, Signs, and Architecture* (p. 146), by P. Arthur & R. Passini, 1992, McGraw-Hill Book Company.

Also, the efficiency of font display is affected by the use of a register.There are several variants of writing a word: 1) all letters are capitalized; 2) all letters are lowercase; 3) the first letter is capitalized; the rest are lowercase. In this case, the inscriptions on signs are not read letter by letter, but are perceived as a single whole, "wordforms" (Arthur & Passini, 1992, p. 162). Writing words on signs in all capital letters was popular in the mid-1960s, and this approach can still be seen in corporate logos (e.g., IBM), store names (EATON'S), or safety signs, such as "DANGER". However, "contemporary orthodoxy is to display messages in upper- and lower-case letters because these are "more easy to read"" (Arthur & Passini, 1992, p. 162). Previously, only inscriptions in all capital letters were used in road signs; now, both types of text writing can be used (see Figure 31).

Figure 31. Using both ways of writing text on a sign: the first letter is capital; the rest are lowercase; and all capital letters. From *Wayfinding: People, Signs, and Architecture* (p. 162), by P. Arthur & R. Passini, 1992, McGraw-Hill Book Company.

There are many opinions on the best way to use cases when writing text on signs. According to Arthur & Passini (1992, p.162), professional graphic designers, when presented with a sign with an inscription in all capital letters, believe that the inscription would be better if "had it only been done properly, what is to say, in upper-and lower-case letters". They give an argument in favor of upper and lower-case letters: if we take as a basis that a person perceives words on signs, not letter by letter (structured reading) but as a whole form (reading as a whole, scanning with the eye in an

unstructured way), then the perception of text written only in capital letters will be perceived as a uniform rectangular silhouette. Conversely, a combination of different cases makes it possible to create a more varied silhouette and emphasize ascenders (see Figure 32). However, the Romans initially wrote words in capital letters, and much later, with the need to increase writing speed, lower-case letters emerged. All-capital writing is also widely used by therapists teaching reading. This is because, among lowercase letters, 70 percent of the letters have similar shapes, which can confuse. While all-capital writing reduces confusion and makes it easier to identify each letter (see Figure 31), it should be kept in mind that these therapists are primarily working with people who cannot read in a print context, which may differ from how literate people read text in a sign context. All-capital writing of text (and numbers) is most often used in electronic signboards. Although the signboard matrix consists of dots, the font remains legible (Arthur & Passini, 1992).

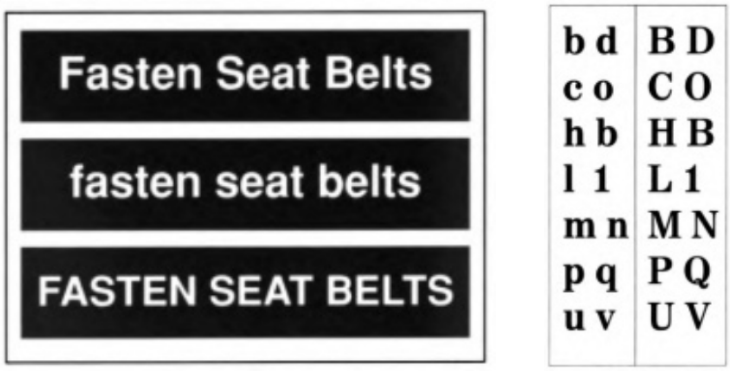


Figure 32. Left: An example of using different registers in writing text on signs. From *Wayfinding: People, Signs, and Architecture* (p. 162), by P. Arthur & R. Passini, 1992, McGraw-Hill Book Company. Right: Similarities and differences in letter shapes in different registers. From *Wayfinding: People, Signs, and Architecture* (p. 162), by P. Arthur & R. Passini, 1992, McGraw-Hill Book Company.

1.5.5. Legibility, readability and size

According to Arthur & Passini (1992, p.50), "The information may not be legible in that it is obstructed, poorly placed, too small, blurred, garbled, or tactually too mushy to be perceived" or "the information may not be readable in that it can be perceived but cannot be understood" and introduces the terms "legibility" and "readability" saying that they are not interchangeable. "Legibility is the ease with which information is able to be perceived" and "readability is the ease

with which information is able to be understood" (Arthur & Passini, 1992, p. 50). Legibility and readability are crucial components in creating an effective navigation system.

The use of typography in a navigation system presupposes that the traveler is literate or knows the language and that the font is easy to read and visible from a distance. However, these conditions do not always correspond to reality. To expand the range of information perception, it is necessary to use typography in combination with supporting pictograms. It is also essential to understand that pictograms, despite their ease of perception, can rarely be effective alone without verbal support (Arthur & Passini, 1992).

When using typography in signs, consideration should be given to the size of the sign and the size of the text to ensure the information can be read clearly at the required distance. Under ideal conditions (no angle distortion of the sign, good lighting, and clear vision of the viewer), it is possible to identify an acceptable letter size that is legible at the appropriate distance. According to Gibson (2009, p.82), "Establishing the correct scale and arrangement of lettering for messages is key to good wayfinding design". The context in which the typeface is used is critical. For example, the font size standards for reading books differ from those for road signs. Factors such as the distance from the viewer to the sign and the speed of travel will affect the font size and should ideally be studied and tested during the design process (Gibson, 2009). According to Arthur & Passini (1992, p.165), the Helvetica letterform is the classic criterion for determining legibility at a distance and, "theoretically, a one-inch (25 mm) letter can be seen from 50 feet (15m) away, and consequently a 4-inch (100mm) letter will be required if the sign is to be seen from a distance of 200 feet (60m)" (see Figure A13 in Appendix/Annex A). Based on the graph, which was developed for ideal conditions, some allowance can be made for real-life use under less-than-ideal conditions. In doing so, it is necessary to take into account the minimum capital letter size: for use in orientation (nearby) signage at a distance of 50 feet (15 meters), the minimum capital letter size is 1 inch (25 mm or 72 pt); for directional signage, the minimum capital letter size increases to approximately 1.75 feet (45 mm or 126 pt). However, in a navigational chart, the minimum size of capital letters should not be less than 0,625 inches (45 pt) or 10 -15 mm (28 pt- 42 pt) (Arthur & Passini, 1992).

Arthur & Passini (1992) suggested using a special 10-unit line spacing system (see Figure 32), in which the "message module" has a unit height of 10 and a capital letter height of 6. The distance between the top of the capital letter and the top line of the module is 1.5, and the distance

between the bottom line of the capital letter and the bottom line of the module is 2.5. This graph of the relationship between the distance from the viewer to the sign and the optimal font size can help inform the design of wayfinding text. However, it is not only the font size that matters for the readability and legibility of the text in wayfinding. Another important factor to consider is the size difference between words and letters. The space between words, according to Arthur & Passini (1992, p.168), should "be equal to the space occupied by a lower-case "r"". However, the amount of space between letters varies to compensate for the shape of the letter, to create "the illusion that the spacing is equal" (Arthur & Passini, 1992, p. 168). Before the advent of computers, type designers determined the amount of space between letters by eye, and type manufacturers, when selling letter tiles, included a special explanatory chart showing the required space for different letters (Arthur & Passini, 1992; see Figure 33).

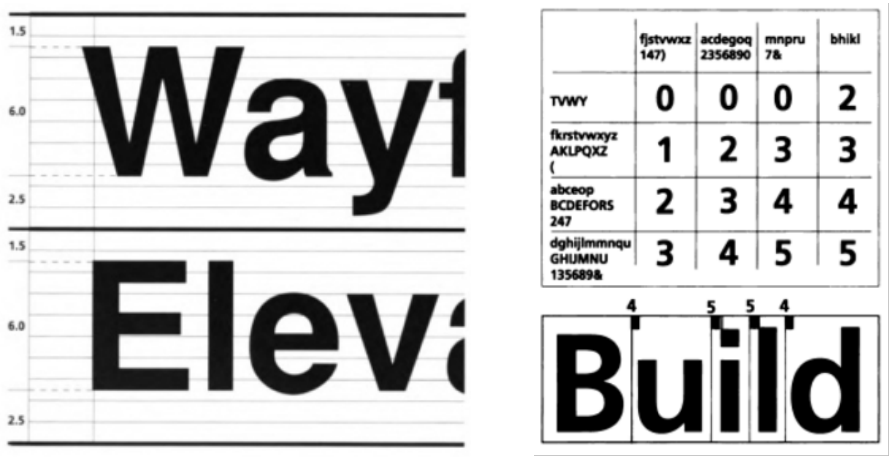


Figure 33. Left: 10-unit message module system. From Wayfinding: People, Signs, and Architecture (p. 167), by P. Arthur & R. Passini, 1992, McGraw-Hill Book Company. Right: Traditional method of determining inter-letter spacing using a 5-unit tile system. From Wayfinding: People, Signs, and Architecture (p. 168), by P. Arthur & R. Passini, 1992, McGraw-Hill Book Company.

When using a font, Gibson (2009) recommends paying attention to 1) Line Length and Type Size, since line length affects line breaks, abbreviations, and font size selection; 2) Letter Spacing or Tracking, since for good readability, especially on the move, letters and words in signs are placed with a larger interval than in printed publications, and light text on a dark background requires an increase in letter spacing; 3) Line Spacing or Leading, since correct spacing between lines helps to perceive groups of messages, this is especially important in lists; 4); Type with

Symbols and Arrows, since it is necessary to maintain the correct proportions between text and graphics so that the message is perceived as a single whole (see Figure 33).

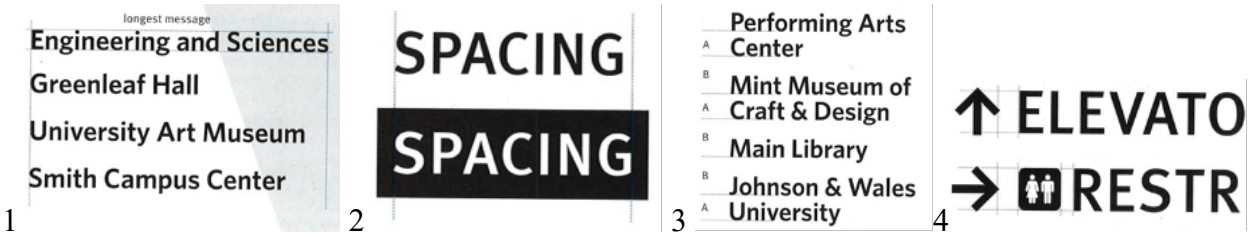


Figure 34. Examples: 1) Line Length and Type Size; 2) Letter Spacing or Tracking; 3) Line Spacing or Leading; 4); Type with Symbols and Arrows. Adapted from *The Wayfinding Handbook: Information Design for Public Places* (p. 60), by D. Gibson, 2009, Princeton Architectural Press. Copyright 2009 by Princeton Architectural Press.

Typography plays a key role in the effectiveness of navigation systems, influencing both visual perception and the clarity of information indicated on signs. Properly selected fonts, their size, line spacing, letter spacing, contrast, and readability determine how easily and quickly information is transmitted to the user from the sign. Easily accessible information and clear cues on signs help people navigate in space, especially in the context of the metro, where conditions of increased dynamics require instant decisions.

1.5.6. Color and light in Wayfinding system

1.5.6.1. Color

Color meaning plays a vital role in navigation, and designers need to have a deep understanding of how color works. The generally accepted color system, formulated by Isaac Newton (see Figure A14 in Appendix/Annex A), includes a spectrum from red to violet (red, orange, yellow, green, blue, indigo, violet). In this model, the primary colors—red, blue, and yellow—can be mixed to produce secondary hues such as green, orange, and violet. When light (such as from screens) is emitted, the color system changes: red, green, and blue (RGB) become the primary colors. Combining these three colors produces either natural or artificially created white light. Colors are also characterized by three primary parameters: hue, intensity, and value. Hue determines the difference between colors, such as between pure red and pure green. Saturation reflects the intensity of a color, and value reflects its lightness or darkness. Knowing these

characteristics helps designers select a color palette that achieves the desired readability and conveys a specific meaning. For example, when creating a color code, it is helpful to choose hues of similar brightness so that they work harmoniously together. In addition, the saturation contrast between the background and text enhances the distinction between the two, which is especially important for the visual perception of information on wayfinding media (Gibson, 2009; see Figure 35). According to Tufte (1990, p. 91), "Color brings to information more than just codes naming visual nouns—color is a natural quantifier, with a perceptually continuous (in value and saturation) span of incredible fineness of distinction, at a precision comparable to most measurement".

Human vision is extremely sensitive to differences in color: Experts can distinguish up to a million shades under controlled conditions of paired comparison, and in everyday life, the average person can identify about 20,000 colors, although practical use is limited by the peculiarity of visual memory rather than by the skill of distinguishing colors. However, when it comes to color coding of abstract information, the use of more than 20-20 colors can lead to confusion, that is, to a deterioration in perception (Tufte, 1990).

Figure 35. Colour contrast in signs. From *The Wayfinding Handbook: Information Design for Public Places* (p. 60), by D. Gibson, 2009, Princeton Architectural Press. Copyright 2009 by Princeton Architectural Press.

For effective color coding, no more than nine colors are required (grouped colors into categories) plus black, white, and gray: 1) Red, yellow, and blue; 2) Orange, green, and purple (or violet); 3) Brown and beige; 4) Pink; 5) Black, white, and gray. Although a large number of shades of these colors may be used, they will still be called by common names such as red, yellow, etc.

Furthermore, no two colors can be the same in a color code, such as light blue and dark blue (Arthur & Passini, 1992).

As with the use of color coding in maps and navigation systems, it is also important to not only know the name of the color but also to understand the color symbolism:

> Throughout the entire world, water, seas, and rivers are never red; fire, heat, and dryness are not generally accompanied by a blue sensation; vegetation is most often green…At the same time, birth, marriage, and death are often associated with particular colors (Bertin, 2010, p. 90).

Understanding color symbolism is especially important when, along with the color association, there are pictograms or thematic contexts in the navigation. For example, it would be strange if the fish department in a supermarket had red or green signs. As a rule, designers typically use blue (associated with water, ice, and cold) for the fish department and red (the color of blood and red meat) for the meat department. A computer helps designers identify a large spectrum of colors. In computer graphics programs, most have a variety of color palettes and catalogs with numbered names. The most popular palettes that designers use on the computer, suitable for further printing or painting of signs, are PMS (Pantone Matching System) and CMYK (cyan, magenta, yellow, black). In these palettes, you can not only select a color but also change its saturation or hue by changing the proportions of colors (Gibson, 2009).

Drawing on the strategies of constructing Swiss maps, Tufte (1990, p.82) emphasized four important principles aimed at "minimizing color damage": 1) Pure, bright, saturated colors can produce an overwhelming effect when used in large adjacent areas. However, for more interesting effects, you can use bright colors in dots next to muted background colors. When small saturated color areas are surrounded by large areas of calm colors, expressive and beautiful patterns appear; 2) Placing light colors (mixed with white) next to each other usually gives unpleasant results, especially if the colors occupy large areas; 3) Large background or base colors should be calmer (muted, grayish or neutral), allowing smaller, bright regions to stand out most brightly. That is why gray is considered one of the most universal and essential colors in painting; 4) If an image consists of two or more large closed areas of different colors, the picture falls apart. To prevent this from happening and to preserve the unity of the image, it is necessary to combine and interweave colors with each other, creating a "carpet" effect (p.90). Based on the above, we can

conclude that the best solution for displaying color information is to use combinations and alternations of different colors in tone and hue and also to avoid identical large color fills (both bright and pale), as well as mixing or interweaving colors with each other.

If the sign does not belong to the main series of color-coded signs, it is possible to remove the strict restriction on the use of colors. However, the condition must be met that the relationship of the color and tone of the background of the sign with the color and tone of the text is sufficiently contrasting: "Messages that have to be read benefit from a strong brightness contrast. The use of color in combination with brightness can optimize reading" (Arthur & Passini, 1992, p.35).

Some artists "squint" and look at the picture from a distance to determine the tone and color relationships in the picture. However, despite its practicality, this approach can be subjective when applied in the context of wayfinding systems. To gain a clearer understanding of how much the colors contrast with each other in tone and color, one can refer to a special table based on light reflectance readings (LR/LRS) (see Figure A15 in Appendix/Annex A), which was presented in the book by Arthur & Passini (1992). These readings are given as a percentage for each of the two colors involved, which are planned to be used in the sign. It is necessary to subtract the number assigned to the darker shade from the corresponding number of the light shade. Then, divide the difference by the value of the light shade and multiply by one hundred. This formula looks something like this: (B1-B2): B1x100=LR. If the result of these calculations is 70 percent or higher, this means that the ratio of colors is adequate, and their combination on the sign will be guaranteed to be legible. If the result is a number less than 70, then the lower the indicator, the less recommended it is to use the combination of these colors, or it is not recommended at all (Arthur & Passini, 1992).

> The target value of a sign is its ability to be seen easily on a wall. This is always greater when the background of the sign is the darker color. However, the brightness differential will be the same regardless of which color (the lighter or the darker) is used for the background (Arthur & Passini, 1992, p. 179).

Color cannot be perceived in isolation from other colors; it is essential to understand the relationship between colors in terms of hue and value, that is, to comprehend the color context. According to Tufte (1990, p.92), "Any color coding of quantity (whether based on variations in

hue, value, or saturation) is potentially sensitive to interactive contextual effects". As Figure 36 shows, the same color can be perceived differently when surrounded by different colors, which may mean that "even simple visual effects can involve a simultaneous complexity of design issues" (Tufte, 1990, p. 95). Therefore, it is necessary to constantly compare and contrast colors with each other to see how they work in context.

Figure 36. The same colors (small square) displayed within different surrounding colors. From *Envisioning Information* (pp. 92–93), by E. R. Tufte, 1990, Graphics Press LLC. Copyright 1990 by Graphics Press LLC.

Wildbur & Burke (1998) discuss the importance of colour coding and give several examples of its successful application, such as in public transport in Austria (route colours correspond to the colours of the buses, displayed on tickets, station furniture, and route maps) (see Figure 37) and in the wayfinding system at Schiphol Airport (developed by the airport's design department between 1991 and 1994) (see Figure 38). The comprehensive wayfinding system at the airport included a new sign system, typography, and colour coding for road and interior signs, as well as information displays and flight maps. Blue is used for road signs, while yellow and green are used inside the terminal for information on operational facilities. Grey is used for non-directional information, black for office areas, and red for stop and danger signs. Green is used for exit and confirmation signs. Wildbur & Burke (1998) also cite the example of colour coding in the Argentine metro navigation system developed by Estudio Shakespear (see Figure A16 in Appendix/Annex A). This system used different types of signs: flags, hanging signs, and longitudinal (strip) signs. The strip sign, or "Main Strip", is actively highlighted with the appropriate colour and can be used either as a whole or as two horizontal zones: the upper part indicates the name of the line, and the lower part lists exits and landmarks at street level.

Figure 37. Color coding in public transportation in Austria. From *Information Graphics: Innovative Solutions in Contemporary Design* (p. 44), by P. Wildbur & M. Burke, 1998, Thames and Hudson. Copyright 1998 by Thames and Hudson.

Figure 38. Example of colour coding in the sign system of Schiphol Airport, Netherlands. From *Information Graphics: Innovative Solutions in Contemporary Design* (p. 22), by P. Wildbur & M. Burke, 1998, Thames & Hudson.

As an example of the application of color coding in a public place, consider the navigation system inside the Lisbon airport (see Figure 39). The color blue is used for important public places, such as toilets, areas for people with disabilities, information desks, taxis, and metro exits. Dark gray and light green colors are used to mark important places, such as departure and arrival terminals, as well as the numbering of boarding gates. The color panels are large enough to be visible to passengers from a distance, even in crowded areas. The pictograms on the signs are large since this is the next thing a person reads while following the path, and smaller but still legible text. This approach to creating information navigation in a public space aligns with the principles proposed by Arthur & Passini (1992), making it a highly effective method.

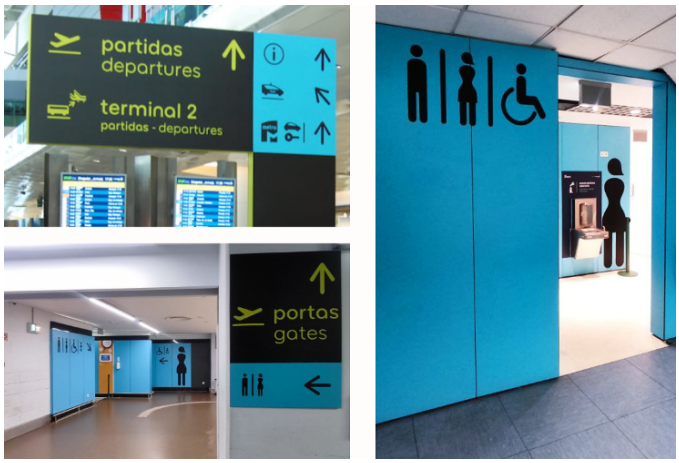


Figure 39. *An example of colour coding in the sign system of Lisbon Airport, Portugal.* Photo taken by the author, 2025.

Gibson (2009) cites the example of the wayfinding system at Children's Hospital Boston, which incorporates a system of symbols, names, and colors. This system helps identify the hospital's buildings (the hospital has five buildings) using a single visual concept (see Figure 40).

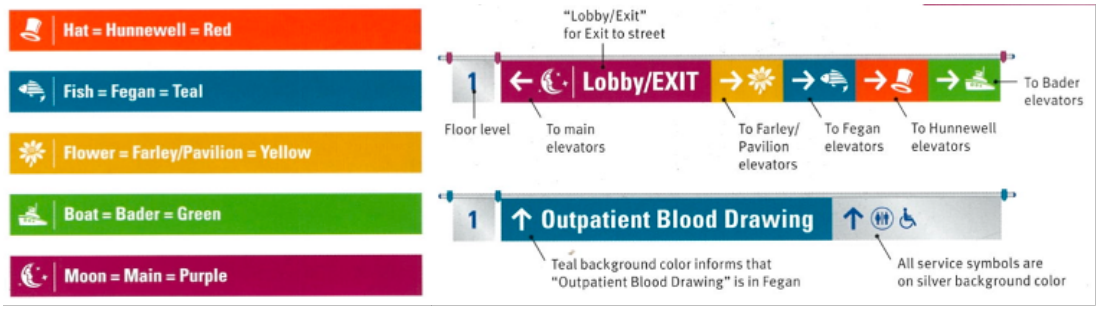


Figure 40. Color Coding in the Wayfinding system in Children's Hospital Boston. Adapted from The Wayfinding Handbook: Information Design for Public Places (p. 60), by D. Gibson, 2009, Princeton Architectural Press. Copyright 2009 by Princeton Architectural Press.

Color coding involves using multiple colors and associating each color with a specific object or space. This method is commonly seen on route maps of metro stations, where each line is represented by a distinct color. This way, passengers can easily identify lines by their colors rather than focusing on the transfer points. Color coding is also utilized in information systems. By assigning a unique color to each logo, it becomes easier to recognize and remember the content associated with that logo (Sarıkahya and Tuğral, 2022).

When choosing colors for color coding, selecting their brightness and their contrast, it is also necessary to know that there are limitations in color perception: "9 percent of males and 2 percent of females are color blind, particularly with respect to red and green. Up to 50 percent of

elderly people also have difficulties distinguishing various hues of dark or light colors" (Arthur & Passini, 1992, p.35).

In navigation systems, green is typically used for permissive signs, while red is reserved for prohibitory or restrictive ones. According to Arthur and Passini (1992), the sign with the spelling "EXIT" is found in both red (in the USA) and green. However, in North America, it is used in green for a good reason: "the safe assumption that in case of fire, the red sign would not be legible, but would be reduced to a red glow or a blur" (p. 179). Russia and all European countries, including Portugal, use green for "Exit" and "Emergency exit". In the European Union, green is the standard color for emergency exits and first aid signs indicating a safe route or place. This is prescribed by the EU Health and Safety Signs Directive (92/58/EEC). The green color in the sign "permits" proceeding to the appropriate exit in an emergency. Red is used in "stop" signs or the "do not use the elevator in case of fire" sign and is therefore considered "prohibitory" (see Figure 41). To see that both color variants are in use, it is enough to enter the query "sign exit" into the Google search engine. The response to this query will display many images featuring the "EXIT" sign, with approximately equal proportions of red and green elements, and only a few images using blue and black (see Figure A17 in Appendix/Annex A).

When selecting colors for color coding in navigation systems, it is also necessary to take into account that "there are certain colors that should be reserved for public safety uses only. These are red, yellow, and green" (Arthur & Passini, 1992, p. 180).

In the context of the metro, color is perceived by passengers first and foremost, so it plays an essential role in the effectiveness of metro navigation systems. It not only simplifies the visual identification of lines and directions of movement but also forms stable associations that help passengers navigate more efficiently in complex infrastructure. There are universal associations that are understandable to most people, but there is also a cultural context that can change the association of color. Therefore, it is essential to understand how to use color within a cultural context effectively. In addition, it is necessary to take into account the color context, i.e., consider how colors "work" when next to each other. Moreover, you can adjust the color by brightness, saturation, and tone to improve the perception of a color plate. Competent use of color codes, contrasts, and combinations helps improve readability, reduce cognitive load, and create a visual hierarchy in space. In the navigation system, it is essential to use clean, understandable colors that

a person can easily identify and name. Nine colors are sufficient for effective navigation, but if more colors are required, the maximum recommended number should not exceed 20.

Figure 41. *An example of using red and green signs.* Photo taken by the author in the hallway of the Holiday Inn hotel, Beja, Portugal, 2025.

It is essential to consider the universality of color perception, including its accessibility for people with color vision impairments, as well as the interaction of color with other visual elements, such as fonts, pictograms, and lighting. Thoughtful color design becomes an integral part of a holistic orientation strategy, directly affecting the convenience, speed, and safety of passenger movement.

1.5.6.2. Light

Lighting in underground transport systems is a necessity, as the metro has limited space and does not receive sunlight. In this case, lighting is a matter of passenger safety and the functional perception of space, as well as an essential element of navigation infrastructure. Since there is no natural light in the metro, artificial light plays a crucial role in creating a legible and comfortable spatial orientation. According to Sarıkahya and Tuğral (2022, p.1876), "The lighting system is the first element that increases the perception and helps to provide visual comfort in a place", and also, artificial lighting facilitates movement around the station and "suggests that lighting elements should be increased in areas where passengers form a crowd". Uniform illumination of platforms, stairs, passages, and entrance areas reduce the risk of falling and improves orientation in these areas. In the navigation context, lighting also serves as a means of highlighting key objects, such as signs, plates, maps, and landmarks, including those that help find the exit in an emergency. Light accents can direct the user's attention to exits, ticket offices, or

transitions between lines. This approach enhances the effectiveness of visual information and reduces the cognitive load during orientation.

Regardless of where the signs are located, they require different types of lighting. Lighting is divided into artificial (using electricity, special lighting systems, and devices) and natural (obtained from the environment without the use of special lighting devices and electricity). According to Arthur & Passini (1992), natural lighting is sufficient for minor signs placed inside a building, such as corridors, lobbies, reception areas, or office spaces. However, this form of lighting may be insufficient in larger spaces such as airports, train or bus stations. Additional artificial lighting is used for more adequate illumination.

In metro practice, various types of lighting are used, and each of them performs its own role: 1) general diffused lighting - provides a uniform level of brightness on the platform and in the transitions; 2) Directional light, or local lighting - aimed at highlighting specific navigation elements (e.g. signs, maps); 3) Lightboxes - allow you to integrate navigation information directly into the lighting element; 4) Contour lighting and interactive light panels are used less often, but also help highlight information.

Arthur & Passini (1992) divided artificial lighting for signs into two types: external and internal. Internal lighting refers to the location of the light source inside the sign or behind it (sign designers refer to this as a "lightbox"). With this type of lighting, the colors on the sign may shift towards the light side due to strong "show-through" in the lightbox, or conversely, appear darker if the backlight is positioned under the sign, resulting from backlighting. According to Arthur & Passini (1992), a more popular and energy-efficient type of lighting is external or natural since the colors used in the sign remain as close as possible to the original appearance. However, it is worthwhile to position the lighting fixtures in relation to the signs to avoid intense glare and also to consider the material used for sign production, which minimizes the strong reflection of light. The contrast between light and background is one of the most critical factors in the perception of wayfinding elements. Inscriptions and pictograms illuminated from within or by directional light become more noticeable in the difficult visual conditions of underground spaces. This is especially important for individuals with limited vision or those in high-density passenger traffic, where visual clarity is crucial. According to Arthur & Passini (1992, p.35), "Vision is dependent on an adequate light level", while at different ages, a person needs different amounts of illumination:

"Optometrists say that a 50-year-old needs almost twice as much light to see clearly as does a 20-year-old. People who are 70 or older need four times as much light".

Poor or poorly directed lighting can make signs difficult to read, especially if they are placed at an angle or in areas with glare and shadows: "the combination of inadequate lighting conditions, glare, angular distortion, and halation can cause all of us to misread messages in upper- and lower-case letters" (Arthur & Passini, 1992, p. 163).

The color temperature of lighting also affects the perception of space and navigation. Warm light creates a feeling of coziness and calm but can reduce the readability of small text. Cold light, on the contrary, increases clarity and promotes concentration. Neutral white light is also used for lighting in public spaces.

Integrating lighting solutions into a navigation strategy requires an interdisciplinary approach involving the participation of designers, lighting engineers, and architects. Effective lighting can not only facilitate navigation but also improve the overall perception of the metro space. Its thoughtful use will help guide passengers, increase the visibility of signs, and create a visual hierarchy of space.

1.5.7. Durability and Wear Resistance

An effective metro navigation system requires not only visual clarity and legibility but also high resistance to external factors, physical and climatic (Arthur & Passini, 1992). Due to the intense flow of passengers, vandalism, and environmental influences, wayfinding elements are subject to wear and tear, making durability a key aspect of the orientation system. Inside stations, there is high humidity, dust, vibrations from trains, and temperature changes, which can lead to damage to materials. External signs at station entrances are exposed to ultraviolet radiation, precipitation, pollution, and mechanical damage from pedestrians, cleaning equipment, etc. Signs of wear appear faster at stations with high traffic. The main damage includes: 1) Fading of colors, especially on printed or painted surfaces; 2) Scratches, abrasions, graffiti, and vandalism; 3) Peeling of vinyl films or self-adhesive letters; 4) Damage to the lightbox, malfunction of the lighting elements; 5) Corrosion of metal structures.

To increase wear resistance, materials resistant to mechanical and climatic influences are used: 1) Stainless steel and aluminum are used for load-bearing elements due to their resistance to

corrosion; 2) Tempered glass and polycarbonate are used in places with high contact - they are transparent and impact-resistant; 3) Anti-graffiti films and protective coatings protect the surface and make it easier to maintain; 4) UV-resistant paints and specialized UV printing prevent fading in the sun.

Therefore, regular maintenance is necessary, including cleaning, checking the functionality, and replacing damaged elements.

Wear resistance is an essential criterion for a successful metro navigation system. The selected materials, printing methods, design solutions, and regularity of maintenance determine how long the navigation will retain its readability and visual integrity. A well-designed and durable system not only improves the user experience but also reduces long-term infrastructure maintenance costs.

2. Overview of the Lisbon Metro System

2.1. History and Development of the Lisbon Metro

2.1.1. The first mentions of the metro in Lisbon

Before talking about the development of the metro in Lisbon, it is worth starting with the fact that by the end of the 19th century, a transport infrastructure already existed and was developing under the management of the largest operator at that time, "Carris", and "The trams operated by Carris since 1873 were the most popular form of transport in the city at that time[4]" (Rollo, 1999, p. 29). Despite this, the volume of passengers transported was small; on average, a Lisbon resident used the tram 19 times a year (Rollo, 1999).

The first trams were more like simple horse-drawn carriages than the trams of today (see Figure 42). From 1897 to 1898, the Carris company's request for the modernization of the tram lines was granted by the Lisbon City Council. This request included replacing animal traction with electric traction, using overhead wires, and adapting the lines under the Carris concession. In 1901, the official opening of the new public transportation service in Lisbon took place, and on August 31 at 4:00 a.m., the first Carris tram was launched (Rollo, 1999; see Figure 43).

Figure 42. The first trams in Lisbon. Left: Tram of the Joaquim Simplicio company at Largo de São Domingos in the late 19th century. Photo by Joshua Benoliel. AFCML. Right: Tram of the Salazar company heading to Conde Barão, in 1912. Photo by Joshua Benoliel. AFCML. From: Rollo, M. F. (1999). *Um metro e uma cidade: História do Metropolitano de Lisboa* (Vol. 1, p. 34). Metropolitano de Lisboa, E.P.

In 1885, the first mention of the construction of a metro in Lisbon appeared, drawn up by engineers Costa Lima and Benjamim Cabral, but the project was postponed (Rollo, 1999). In 1888, the military engineer Henrique de Lima e Cunha presented in his report to the Association of

[4] original version in portuguese "Os tramways, explorados pela Carris desde 1873, eram por essa altura o meio de transporte mais procurado na Cidade"

Portuguese Civil Engineers a project for the construction of a metro in Lisbon, which included several tables: a plan of curves, the profile of ramps and descents, as well as tunnels, aqueducts, stations, and a cost estimate. However, this project was not developed further either (Rollo, 1999).

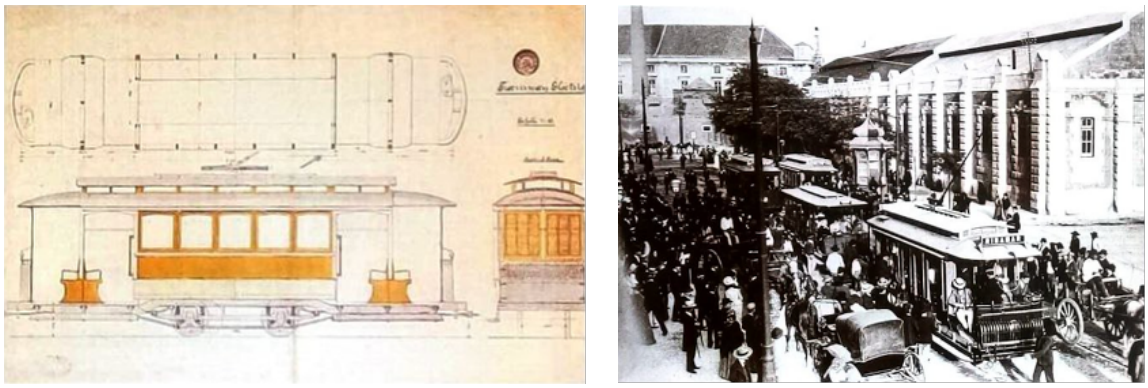


Figure 43. Left: Closed electric tram. Illustration from the exhibition catalogue Lisboa de Frederico Ressano Garcia 1874–1909 (Câmara Municipal de Lisboa & Fundação Calouste Gulbenkian, 1989). Right: Departure of electric trams from Cais do Sodré, marking the inauguration of electric traction in Lisbon on August 31, 1901 (from the photo album *História da Carris*). From: Rollo, M. F. (1999). *Um metro e uma cidade* (Vol. 1, pp. 37,39). Metropolitano de Lisboa, E.P.

In 1922, three merchants residing in Lisbon, António Maria de Oliveira Belo, Boaventura Mendes de Almeida, and Henrique Muncó dos Anjos, submitted an application to the Lisbon City Council for a concession to construct a metro in Lisbon. They presented a document, "The Creation of the Lisbon Metro. A Descriptive and Reasoned Report," in which they defined the characteristics of the planned metro, consisting of two lines and eleven stations. The railway they intended to build was to have the same track width as the trams so that the cars could also travel on the Carris lines, making the use of transport more universal (Rollo, 1999; see Figure 44). However, this project also failed.

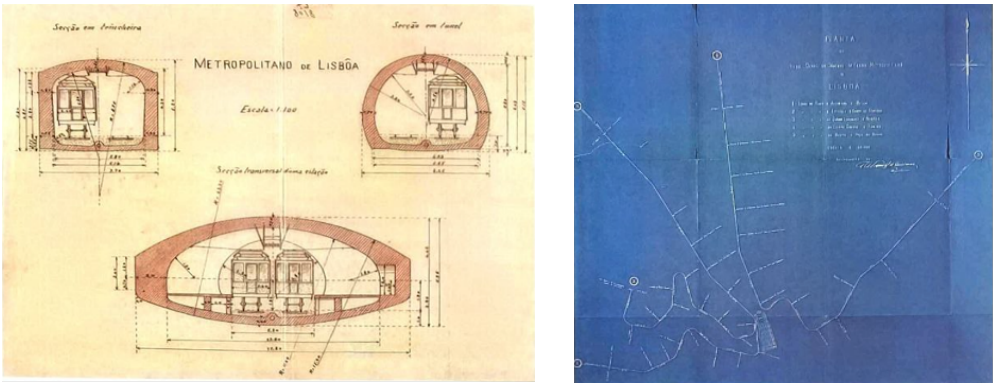


Figure 44. Left: Open trench section, tunnel section, and cross-section of a station: drawings included in the proposal submitted to the Lisbon City Council in July 1922 by António Maria de Oliveira Belo, Boaventura Mendes de Almeida, and Henrique Muncó dos Anjos for the concession and construction of a metropolitan railway in Lisbon. AMAC/CML, Metropolitano de Lisboa, Process 8108, 1922–1924, sheet 27. From: Rollo, M. F. (1999). *Um metro e uma cidade* (Vol. 1, p. 44). Metropolitano de Lisboa, E.P. Right: Plan for the overall Lisbon metro network, proposed by Gastão Lanôel d'Osenac and Abel Coelho,

AMAC/CML, Lisbon Metro, Preliminary Project, Process 3342. From: Rollo, M. F. (1999). *Um metro e uma cidade* (Vol. 1, p. 44). Metropolitano de Lisboa, E.P.

In the following years, the City Council received various proposals and requests to organize a concession for the construction of the metro. Consequently, in 1924, it was proposed to announce a public tender for the construction and operation of the railway in Lisbon. After the announcement of the tender, a long and challenging period ensued during which various participants attempted to advance their projects (and even won the tender), but they were never realized. Following this, there was a long pause, and the metro's design was postponed for many years.

In 1936, during the government of Oliveira Salazar in the Lisbon City Council, a new request for the construction of the metro appeared again on behalf of Don Guillermo W. Solms (a resident of Paris) and Don Ildefonso G. Fierro (a resident of Madrid). However, the project also ended with virtually no progress since the government and the City Council found it impossible to satisfy the requested requirements. In 1945, Engineer de Funchal Sousa Coutinho requested a concession for the construction of a metro in Lisbon, presenting a preliminary project to the CML and the Ministry of Public Works, but without success. In 1947, Sousa Coutinho presented a general study for the construction of the Lisbon metro. In the same year, José Coelho da Cunha (director of the London firm C.G. Wade, Ltd. and president of Companhia Anglo Portuguesa de Iniciativas, SARL) requests a concession for the construction and operation of an underground public transport network in Lisbon, asking for the application date to be 15 August 1945 (Rollo, 1999; see Figure 45).

Figure 45. Left: Map of the city of Lisbon on which the route of the metro network designed and proposed for concession by CML by José Coelho da Cunha and C. G. Wade was drawn. AMAC/CML, Process 2.292. Right: Map of the city of Lisbon with the route of the metro network designed by António Lopes Pinto Coelho and João Carlos Adrião de Sequeira marked. AMAC/CML, Lisbon Metro, Process 34502. From: Rollo, M. F. (1999). Um metro e uma cidade (Vol. 1, pp. 102). Metropolitano de Lisboa, E.P.

2.1.2. Construction and opening of the subway

In 1947, the Portuguese Government and the Lisbon Municipality initiated efforts, and meetings were held between the lawyer Bustorf da Silva, the Minister of Communications, Cancela de Abreu, and the Mayor José Nascimento Ferreira Dias Júnior. The outcome of these negotiations was the formation of a firm intention to build a metro. A key point was the desire to involve Companhia Carris de Ferro de Lisboa (CCFL) in the project, which underscores the intention to leverage the existing transport infrastructure and experience. The creation of a research society, with the participation of CCFL, marked the transition from the discussion stage to the practical preparation for implementing the Lisbon metro project. Additionally, at a meeting of the Lisbon Municipal Chamber (CML), the President's proposal to establish a society called Metropolitano de Lisboa was officially approved (Rollo, 1999). Later, on January 26, 1948, the companies Metropolitano de Lisboa and SARL were registered, and their corporate law included exclusivity in carrying out the technical and economic analysis of the underground public transport system, as well as a possible concession for its installation and operation (Rollo, 1990; Metropolitano de Lisboa, n.d.).

The first phase was planned for the period from 1949 to 1955: Line 1 was to be built from 1949 to 1951, and Line 2 from 1952 to 1954. Thus, the names line 1, line 2, line 3 appear to identify the lines (Rollo, 1999).

During the preparations for the construction of the Lisbon Metro, the relationship between Carris and the CML–Metropolitano de Lisboa tandem was tense. After 1950, Carris, while retaining its status as a shareholder, limited itself to criticizing the economic inexpediency of the metro (Rollo, 1990).

Despite all the difficulties, the construction of the metro began on August 7, 1955. That same year, the Lisbon Metro Company applied to the General Directorate of Commerce with a request to register the Metropolitano de Lisboa emblem, which consists of the letter "M" drawn on a representation of the tunnel. The company emblem was presented in the form of a red letter M on a blue background, symbolizing the cross-section of the gallery of tracks along which the metro would pass (Rollo, 1999; see Figure 46).

Figure 46. Left: Study of the letter M indicating the entrance to a station. Right: The metro emblem. From: Rollo, M. F. (1999). Um metro e uma cidade (Vol. 1, pp. 229, 289). Metropolitano de Lisboa, E.P.

Four years after construction began, on December 29, 1959, the new transport system was inaugurated. The new metro network consisted of 11 stations, a Y-shaped line consisting of two separate sections: Sete Rios (currently Jardim Zoológico) - Rotunda (currently Marquês de Pombal) and Entre Campos - Rotunda (Marquês de Pombal), both converging into a common section - Rotunda (Marquês de Pombal) - Restauradores (Rollo, 1999; Metropolitano de Lisboa, n.d.; see Figure D1 in Appendix D). At that time, the Lisbon metro was considered one of the most technologically advanced systems; it was equipped with an automatic signaling system, which effectively eliminated accidents. The underground section included tunnels 7.35 m wide stations with a span of 14 m, and two side platforms 4 m wide and 40 or 70 m long (at Rotunda, Entre Campos, and Sete Rios stations), designed for two carriages, but with the possibility of increasing to four. The architectural design of the stations was developed by Francisco Keil do Amaral[5] (Rollo, 1999).

Due to the active development of the Lisbon metro, Carris was forced to review its existing tram routes and predicted a significant reduction in personnel and public ground transport within the company. On this basis, the conflict between Carris and Metropolitano de Lisboa grew (Rollo, 1999).

The first phase of the metro's construction was carried out in successive stages. The Restauradores/Rossio section opened in 1963, the Rossio/Anjos section opened in 1966, and finally, the Anjos/Alvalade section was completed in 1972. For cyclical economic reasons, the expansion projects were interrupted in 1972 and only resumed in 1988 (Metropolitano de Lisboa, n.d; see Figure D2 in Appendix D).

In 1978, the company was transformed into a state-owned company with new statutes, changing its name to Metropolitano de Lisboa E.P. (Metropolitano de Lisboa, n.d; Rollo, 1999).

[5] His wife, Maria Keil, did the tile design for the walls.

In 1995, the company's "New Image" was presented, including a new logo, a new signboard, and a new network presentation (Rollo, 1999). In 1997, on October 19, a fire broke out in the early morning at the Alameda station, killing two people and almost destroying the station. The station did not resume operations until March 1998 (Rollo, 1999).

In 1998, the day before the opening of Expo'98 international exhibition, line D (red line) was opened, which had seven stations: Alameda II, Olaias, Bela Vista, Chelas, Olivais, and Cabo Ruivo. In June 1998, six-car trains were introduced on Line D (the red line) only. The increase in capacity was intended to meet the demand on this route, serving Expo'98. In October 1998, the Lisbon Metro was awarded the "Golden Caduceus", "Empresa do Ano" award. An award was presented by the Union of Lisbon Merchants' Associations for the Lisbon Metro's contribution to the revitalization of the city's commerce (Rollo, 1999).

In 1998, the names of some Lisbon Metro stations were changed: Palhavã became Praça de Espanha; Rotunda became Marquês de Pombal; Sete Rios became Jardim Zoológico; and Socorro became Martim Moniz. The names of the four lines that will be part of the metro network, are also presented: linha A (Azul) - linha Gaivota (Pontinha-Santa Apolónia); linha B (Amarela) - linha Girassol (Campo Grande-Rato); linha C (Verde) - linha Caravela (Campo Grande-Cais do Sodré); linha D (Vermelha) - linha Oriente (Alameda-Oriente) (Rollo, 1999; (see Figure D3 and Figure D4 in Appendix D).

As of 2025, the Lisbon Metro comprises four lines, with a total of 55 stations. Each line has its color, name, and logo. The Lisbon metro also has a logo with a white letter "M" on a red background (see Figure 47, Figure D5 and D6 in Appendix D).

Figure 47. *Lisbon metro logo.* Adapted from Metropolitano de Lisboa, 2025, https://www.metrolisboa.pt/company/ .

The Metropolitano de Lisboa, with the initiative and participation of Carris, played a pivotal role in the city's development, paving the way for urban expansion and serving as a key driver of the city's transport system, thanks to its safety, speed, and regularity.

Lisbon has a Carris Museum dedicated to the development of the transport company. It illustrates the company's evolution from the first horse-drawn carriages to modern trams, with a focus on the history of the first electric lines and the introduction of electric traction (see Figure D7 in Appendix D). However, surprisingly, there is no mention of Carris's involvement in the development of the Lisbon Metro in the museum. Even more disappointingly, Lisbon lacks a museum dedicated to the history of the metro's growth, despite the metro company's close cooperation with museums and its participation in the city's cultural development.

2.1.3. Lisbon Metro Development Plans

The Lisbon Metro continues to evolve today, aiming not only to expand its transport network but also to improve efficiency, sustainability, and accessibility. Between 2025 and 2030, several major projects will be implemented, including the construction and opening of new metro stations, the extension of existing lines, and integration with other types of public transport.

According to information received from the official website of the metro, the approved plan for the expansion of the metro network will connect the lines from Rato (yellow line) to Cais do Sodré (green line), including the construction of two new stations: Estrela and Santos. Thus, a circular green line will be created. This network extension will cover parts of the city not yet served by the metro and will be linked to other public transport operators, including the CP Lisboa-Cascais rail network and the river ports connecting Lisbon and Montijo, Seixal, and Almada (Metropolitano de Lisboa, 2025; see Figure 48). This reorganization aims to improve access to growing residential areas, creating an alternative to road transport. The construction of the Circle Line is nearing completion, and preparatory work has already begun to extend the Red Line to Alcântara.

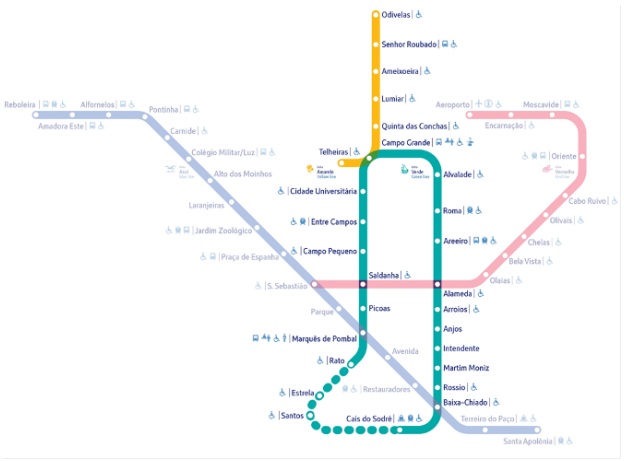


Figure 48. Lisbon Metro Network Map. Adapted from Metropolitano de Lisboa, 2025, https://www.metrolisboa.pt/company/inform/network-expansion-plan/ . © Metropolitano de Lisboa.

One of the major projects is this extension of the Red Line (Linha Vermelha). According to the official development plan published on the Metropolitano de Lisboa website, the line will be extended from São Sebastião station to Campo de Ourique, which includes the construction of four new stations: Amoreiras, Campo de Ourique, Infante Santo and Alcântara (see Figure 49). This project aims to enhance connectivity between the eastern and western parts of the city, while also creating new interchange hubs for suburban trains and trams. Particular attention is paid to the Alcântara area, where the metro will be integrated with the Linha de Cascais railway line, enabling passengers to reach the city centre and the airport more quickly. This extension will also eliminate 3,700 individual vehicles from daily traffic in Lisbon, which means a reduction of 6,200 tonnes of CO2 emissions in the first year of operation (Metropolitano de Lisboa, 2025).

Figure 49. Map of the Lisbon Metro showing the Red Line extension project, including four new stations. Adapted from Metropolitano de Lisboa, 2025. https://projetos.metrolisboa.pt/prolongamento-da-linha-vermelha-inclui-construcao-de-quatro-novas-estacoes/. © Metropolitano de Lisboa.

The Violet Line project, first presented as part of a long-term strategy to expand transport infrastructure, aims to connect the western districts of Lisbon with the north-eastern districts, providing a new radial axis and relieving congestion on existing lines. According to the plan, the line will connect Alcântara with Loures, passing through densely populated areas that still lack direct access to the metro.

The first public tender for the construction of the Violet Line was launched on 15 March 2024, but resulted in the exclusion of all bids. A second public tender was launched on 15 April 2025, for the construction of the Odivelas-Loures light rail system, also known as the Violet Line. The work is expected to be completed by 2029, and the line will feature 17 new stations (12 on the surface, 3 underground and 2 in trenches), including strategic interchanges with commuter trains, trams and buses. The proposed route will cover the districts of Ajuda, Benfica, Pontinha, Odivelas, and further to Loures, expanding the metro's coverage area and improving connections between the capital's central and peripheral areas (Metropolitano de Lisboa, 2025; see Figure D7 in Appendix D).

Most of the current projects are in active construction or the planning approval stage, with expected completion dates between 2026 and 2030. These projects and the expansion of the Lisbon metro network indicate the confident development of the metro in our days.

2.2. Connection between People and Metro

The Lisbon Metro is more than just an underground transport system; it is a living cultural space, a social hub, and a reflection of the city's identity. Over time, it has evolved into a unique environment where mobility, art, and human interaction coexist. From the very beginning, the Lisbon Metro's architecture has been built with artistic and cultural elements in mind. Many stations are adorned with traditional Portuguese azulejos, ceramic tiles created by renowned artists, transforming everyday travel into an aesthetic experience. These works of art do more than decorate the space; they connect passengers with Portugal's cultural heritage, transforming the stations into accessible exhibition spaces. The Lisbon Metro also serves as a venue for exhibitions and cultural events. Nowadays, there are regular cultural events on the metro, such as themed performances at Christmas and New Year's, among others. These initiatives highlight the metro's role as a platform for public culture, making art and museums an integral part of everyday life. As a rethinking of the image of the city in close connection with the Lisbon metro, the "Architectural thinking school", part of a children's project in 2025, created the "Atlas of Lisbon", in which children showed how they imagined the city by displaying notes and sketches on a map of the city and the metro (see Figure 50).

The metro also features temporary advertising installations, promotions, and concerts that attract passengers in the spacious metro halls. Thanks to their expressive architecture and vibrant design, metro stations often become venues for excursions and photo shoots, serving as a popular backdrop for social media content (see Figure 51). Their visual appeal attracts photographers, brands, and bloggers, for whom the metro is not only infrastructure but also an open space for creative ideas and potential in the marketing field.

Every day, thousands of people use the metro to commute to work, school, or a meeting, spending a considerable amount of time on the way. During this time, the metro becomes a space for informal communication, solitude, reading, scrolling through one's phone, and listening to music on headphones. The metro also becomes a place for reflection, whether these reflections are connected with the metro and movement in space or not. People of different ages, cultures, and goals intersect in the metro. It is one of the few places where representatives of various social strata coexist in a familiar rhythm.

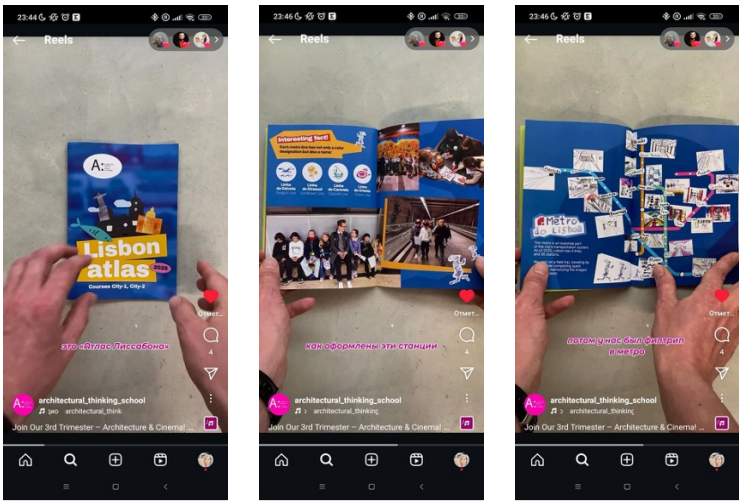
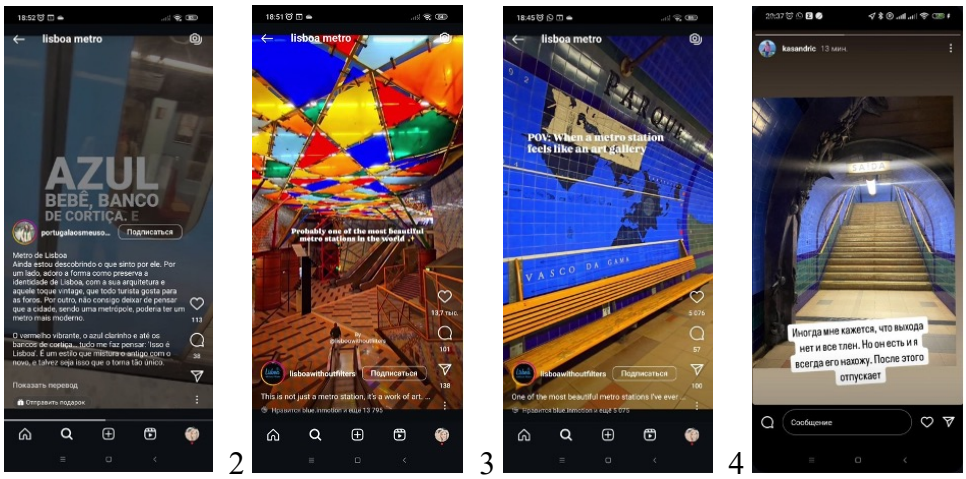


Figure 50. Collage of screenshots from Instagram posts by @architectural_thinking_school. Source: Instagram, accessed on June 13, 2025.



1 2 3 4

Figure 51. Collage of screenshots from Instagram posts by @portugalaosmeusolhus (1), @lisboawithoutfilters (2-3), and @kasandric (4). Source: Instagram, accessed on May 30, 2025.

For many people, the metro is associated with personal memories - the first trip to a new job, a chance acquaintance, or a habitual stop in front of the house. These moments form a mental map of the events experienced, strengthening the feeling of belonging to the city. The Lisbon metro is an integral part of the life of residents or visitors to the city. Therefore, the design of the interiors and navigation in the metro, as well as the creation of an understandable, safe, and prosperous environment, are inextricably linked with the image of the city and its brand.

2.3. Current Lisbon Metro Map and Navigation System

As of May 2025, the Lisbon Metro features a visually simplified map, comprising four active lines (blue, yellow, green, and red) with 56 stations (Metropolitano de Lisboa, 2025). The map is designed according to the principles of transport cartography, where the accuracy of the geographical position is secondary to the clarity of the routes, which are shown schematically. The metro lines are placed at angles of 90 degrees and 45 degrees to each other. It brings it closer to the classic Harry Beck diagrams, where the main objective is to maintain legibility and structure (see Figure 52).

Figure 52. Lisbon Metro Map. *Photo taken by the author*, 2025.

In addition to the color, the lines have names that identify the color and are supplemented by logos that display the name of the metro lines (given to them in 1998). In addition, the metro lines are identified by the direction of the lines:

Linha Azul (Blue) - linha Gaivota (Seagull) - (Pontinha-Santa Apolónia);

Linha Amarela (Yellow) - linha Girassol (Sunflower) - (Campo Grande-Rato);

Linha Verde (Green) - linha Caravela (Caravela) - (Campo Grande-Cais do Sodré);

Linha Vermelha (Red) - linha Oriente (East) - (Alameda-Oriente).

On the official Lisbon Metro website, in the metro brochures, and in the metro navigation system, the lines are presented as Linha Azul (Blue), Linha Amarela (Yellow), Linha Verde (Green), and Linha Vermelha (Red) (see Figure 53). The results of an online survey conducted as part of the dissertation showed that the majority of people (almost 75% of respondents) identify the metro lines in this way.

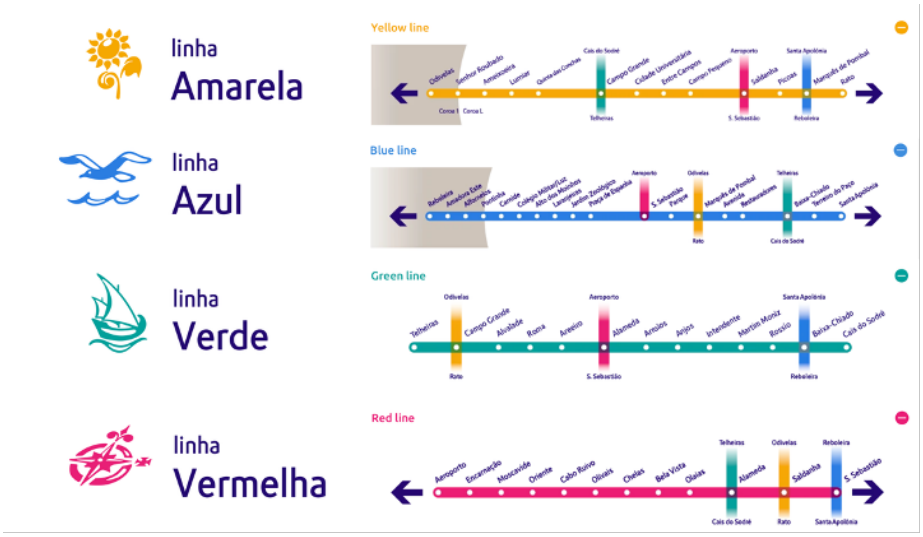


Figure 53. Lisbon metro lines. Collage assembled from images from the official website. Adapted from *Metropolitano de Lisboa*, 2025, https://projetos.metrolisboa.pt/expansao/linha-violeta/. © Metropolitano de Lisboa.

The Lisbon Metro navigation system features a standard set of navigation elements, including entrance maps, platform signs, signposts, route maps displayed inside the cars, as well as audio announcements, electronic boards, and warning signs. Based on authors such as Arthur & Passini (1992), Gibson (2009), Mustikawati et al., (2018) and Cheirchanteri (2021), along with the universal general classification of sign types compiled in the previous chapters, the correspondence of sign types in the Lisbon Metro navigation system is compiled:

1) Identification signs - plates with names, pictograms or logos that create a first impression of the destination, identifying the name of the place or its purpose. They included signs such as exit signs, station indicators, signs with the letter "M" identifying the metro, pictograms indicating the elevator, ticket office, information desk, and children's room, among others (see Figure 54).

Figure 54. Examples of Identification Sigs in the Lisbon Metro System. *All photographs in this table were taken by the author*, 2025.

2) Directional signs – signs with/without arrows with/without typographic description – hints. This category includes all signs supplemented with an image of an arrow, i.e., indicating the direction to a particular destination (see Figure 55, Figure D8 in Appendix D).

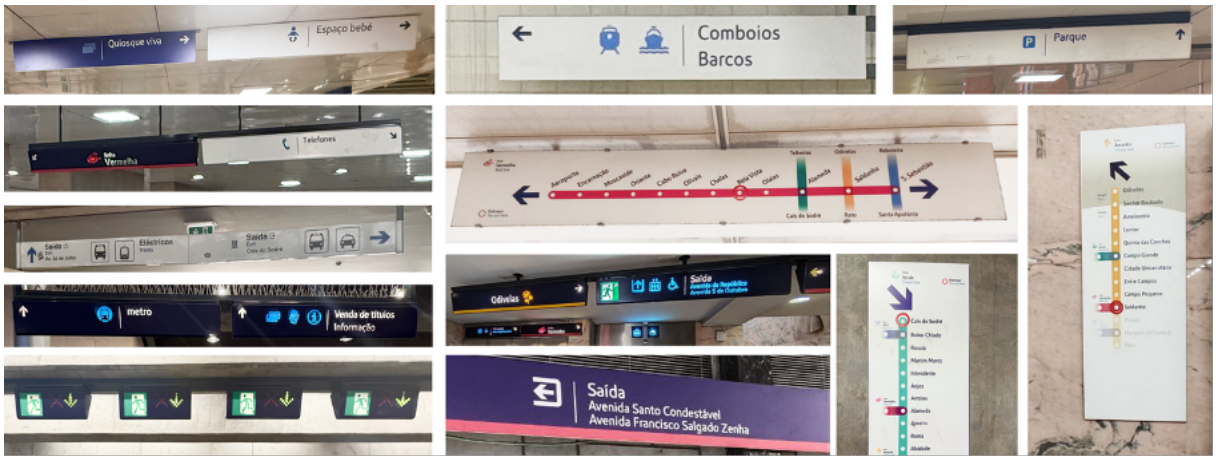


Figure 55. Examples of Directional Signs in the Lisbon Metro System. *All photographs in this table were taken by the author, 2025.*

3) Orientation signs – signs that provide an overview of the surroundings in the form of detailed plan maps. This category includes signs such as a metro map, a floor plan, a general (geographical) map of the area with metro lines, metro exit maps, as well as signs indicating the passenger's location, "You are here" (see Figure 56).

Figure 56. Examples of Orientation Sigs in the Lisbon Metro System. *All photographs in this table were taken by the author*, 2025.

4) Regulatory or Warning Signs – signs that indicate what can and cannot be done in designated areas, as well as fire protection routes. This category includes the following subcategories: permitting (green and blue colors), warning (yellow color), and prohibiting signs (red color) (see Figure 57).

Figure 57. Examples of Regulatory or Warning Signs in the Lisbon Metro System. *All photographs in this table were taken by the author*, 2025.

A series of pictograms were developed specifically for the metro navigation system in 2011 and implemented into the navigation (see Figure 58). These pictograms are used in all types of signs: Identification sig, Directional signs, Orientation signs, and Regulatory or Warning signs. In this guide, all pictograms are depicted as a blue silhouette on a white background; however, in the

Lisbon metro navigation system, these pictograms are used in different colors, depending on the type of sign.

Figure 58. Series of pictograms developed for Lisbon Metro. Adapted from *Manual de identidade visual do Metropolitano de Lisboa* [Corporate identity handbook: Lisbon Metro's graphic rules handbook], by Metropolitano de Lisboa, 2011, May. Retrieved from https://ru.scribd.com/document/285911009/Manual-de-Identidade-Visual-Metropolitano-de-Lisboa-2011.

The navigation system includes all types of signs, which can help to understand the navigation as a whole and make orientation easier. Color coding is also used. However, in color coding, the color of the font, background or icons sometimes appear brighter than the color identifying the line. Some signs have information in small print, arrows sometimes point in the wrong direction, and all street names are missing before the metro exits. Additionally, many stations lack English translations of key information, which can create difficulties for foreign passengers.

2.4. Language Features

Despite Lisbon's status as one of Europe's major tourist destinations, the metro system still exhibits a Portuguese-dominated language, which can cause difficulties for foreigners. In most stations, basic signage such as exits, directions, line and station names is only in Portuguese. English translations, although present in some stations and on official maps, are not universal. This creates a language barrier, especially for non-Portuguese speaking tourists, and makes orientation difficult.

Audio announcements on trains are also predominantly in Portuguese. This can be a serious obstacle to understanding for foreign passengers when there are route changes or technical problems.

However, the Lisbon Metro extensively utilizes visual elements as a means of overcoming language barriers. International pictograms (e.g., exit symbols, information signs, lifts, escalators, prohibitory signs) provide basic navigation without the need to read text. Their versatility allows passengers, regardless of their language proficiency, to receive key information.

Although both Portuguese and English use the same Latin alphabet, their visual similarity does not guarantee full understanding. The grammar, vocabulary, syntax, and phonetics of these languages differ significantly. Additionally, some information may seem difficult for foreigners to pronounce and remember. For example, the words "correspondência" (transfer) or "saída" (exit) are not always easily identified by native speakers of other languages, even if they see familiar letters.

Thus, despite the alphabetical proximity, the language barrier remains. Therefore, the presence of an English translation remains an important factor in navigation accessibility (Rodionov, personal communication, April 14, 2025). Without it, foreign-speaking passengers find it difficult to interpret information, especially in stressful situations when quick decisions are crucial.

2.5. Analysis of Navigation Problems in the Lisbon Metro

As a rule, all people somehow get to the point they planned:

> I think we usually find our way around. Where there's a will there's a way. It's confusing at times, you may lose some minutes in trying to find a place, but I think eventually you get where you want to go to (Lynch, 1990, p. 32).

However, even in an already established and organized environment, such as the Lisbon metro, many users - especially tourists and migrants - struggle to perceive navigation signs due to a lack of multilingual support, poor lighting, a shortage or excess of signs, and other factors. It complicates orientation, causes stress and reduces the overall effectiveness of the system.

Gibson (2009), Wildbur & Burke (1998), and Lynch (1990) emphasize the importance of navigation not only for pedestrians but also for maintaining the city's image. If we consider the

metro and its internal content as an integral part of Lisbon's city image, then it is necessary to take into account the city's identity.

This analysis of the navigation system was conducted based on the study of two routes: from Bela Vista to Cais do Sodré and back, as well as from the Bela Vista station to Saldanha and back. Mostly, the photographs were taken within these stations, only a few photographs were taken at other stations. These routes were chosen as the most popular with the author.

2.5.1. Line designations: name, color, graphic image

Currently, the Lisbon metro has four metro lines, each with its name and color. According to the data obtained from the online survey, it is clear that the majority of people (71-75 people) think that the lines in the Lisbon metro are called Linha Vermelha (Red Line), Linha Amarela (Yellow Line), Linha Azul (Blue Line), Linha Verde (Green Line). On the Metro website, as well as in printed booklets, these names are also displayed. However, the lines also have several identifying correspondences:

The Blue Line has:

- The name corresponding to the color: Linha Azul (Blue);
- The name corresponding to the old name (1998) and pictogram: Linha Gaivota (Seagull);
- The name corresponding to the directions: Amadora -Santa Apolónia.

The Yellow Line has:

- The name corresponding to the color: Linha Amarela (Yellow);
- The name corresponding to the old name (1998) and pictogram: Linha Girassol (Sunflower);
- The name corresponding to the directions: Odivelas - Rato.

The Green Line has:

- The name corresponding to the color: Linha Verde (Green);
- The name corresponding to the old name (1998) and pictogram: Linha Caravela (Caravel);
- The name corresponding to the directions: Telheiras - Cais do Sodré.

The Blue Line has:

- The name corresponding to the color: Linha Vermelha (Red);
- The name corresponding to the old name (1998) and pictogram: Linha Oriente (East);

- The name corresponding to the directions: S. Sebastião - Aeroporto.

Moreover, as announced by the Lisbon Metro in 2024, shortly, the metro will add additional line markings - pictograms indicating the color ColorADD, aimed at helping people with color perception problems (color blindness). These markings are currently being implemented and are already used on some metro maps and on the official metro website (see Figure D9 in Appendix D).

However, additional pictograms are difficult to pronounce verbally, since the pictograms consist of triangles and sticks. Moreover, these designations are not known to most users. The problem with line color perception in color-blind people (and not only) is solved not by additional pictograms denoting color, but by effective line identification. That is, in addition to color, the line should have an easy-to-read line name and graphic support, such as a clear pictogram in the form of a simple, understandable image, number or letter. In other words, the line should have appropriate coding for variations in perception, understandable and accessible to most metro users. In order not to use additional pictograms denoting the color of the lines, a more universal approach is needed, for example, line numbering (used in many metros, including the Moscow metro) or their letter designation, as was the case in the Lisbon metro until 1998: Linha A (Azul), Linha B (Amarela), Linha C (Verde), Linha D (Vermelha). It is worth noting that the ColorADD pictogram corresponding to pure red denotes the Vermelha line; however, the shade of red used for the Vermelha line in the Lisbon metro differs from the red in the ColorADD palette and has a more saturated pink hue. According to the survey conducted as part of the study, 94.9% identified the color of the Vermelha line as pink, not as pure red (see Figure D10 in Appendix D). As a result, it can be concluded that the introduction of additional graphic pictograms can further confuse metro users. And there is no point in using ColorADD pictograms in this case.

As mentioned above, the navigation system already uses pictograms to identify them. They correspond to the names of the colors and show the meaning of the names of the lines given in 1998:

- Linha Azul (Blue) - Linha Gaivota (translated from Portuguese as Seagull) - the pictogram depicts a seagull.

- Linha Amarela (Yellow) - Linha Girassol (translated from Portuguese as Sunflower) - the pictogram depicts a sunflower.

- Linha Verde (Green) - Linha Caravela (translated from Portuguese as Caravel ship) - the pictogram depicts a caravel (type of ship).

- Linha Vermelha (Red) - Linha Oriente (translated from Portuguese as East) - the pictogram depicts a compass.

Although the images imply compliance with the name of the line, the majority of the surveyed participants (55.1%) did not perceive the relationship between the image of the line and its name, suggesting that the pictograms (each painted in its own color) primarily emphasize the color of the corresponding line.

Additionally, the associative connection between color and image in the pictogram is controversial. A seagull can be associated with the sky and, accordingly, with blue or light blue color, a sunflower can be directly associated with yellow color due to the color of the petals. However, the image of a caravel is not typically associated with green, which is often linked to the ocean, sea, and, as a result, blue or light blue colors are more likely. It is possible to assume that the originally bright green color used to designate Linha Verde (until 2011) was deliberately made more complex and closer to the color of sea water to create a stable association with the image. However, the color has become less distinct, which may cause difficulties in identifying the color of the line. The red line has a pictogram in the form of a red compass. It is easier to associate the east with a compass than with the color red, which may make it difficult to establish a stable connection between the image and the color. In addition, due to the presence of small elements in the pictograms, when displayed on signs, the images are poorly identified, forming a color spot of an incomprehensible shape (see Figure 59). To solve these problems, the pictograms should be made more concise and understandable, or the use of a pictogram should be abandoned in favor of indicating a number or letter to designate the line.

Figure 59. Left: Pictograms representing the Lisbon Metro lines, adapted from Metropolitano de Lisboa. (2011, May). Manual de identidade visual do Metropolitano de Lisboa. Right: Pictograms on signage displaying the metro line names. *All photographs in this collage were taken by the author*, 2025.

It is also necessary to be careful about the use of color, the line symbol, and to depict it only with the line name, but not next to the station name. This solution will allow for distinguishing signs that identify the station name from signs with the line name. That is because these signs can become equivalent and disorient the metro user (see Figure 62).

2.5.2. Using Lighting and Influencing Color

Lighting plays a crucial role in the perception of color and conveying information. Different types of lighting have their specific tasks in the navigation system, but one primary task is to make information more noticeable and accessible. However, incorrect use of lighting equipment can lead to the opposite effect: complicating the perception of information, as can be seen in the Lisbon metro (see Figure 60). The Lisbon metro utilizes external diffused lighting (Figure 61) and internal lighting, including a light box (Figure 60). With diffused lighting, information is almost always readable, and colors are displayed close to the colors indicated on the diagram. While with light boxes there are often problems: 1) Overexposed letters - because of this, the information is not readable, especially from a distance, 2) Partially missing indication in the light box - complicates the reading of information or makes the information completely countable; 3) Incorrect use of a light box and the simultaneous use of translucent and non-translucent films in a light box will radically change the color of the sign.

As shown in Figure 60, the color of the line in the light box where the opaque colored film is glued is almost invisible from a distance and does not correspond to the original color of the lines. At the same time, in places where the translucent film is used, the color becomes too bright, which also does not correspond to the color of the lines shown on the subway map. Due to incorrect lighting of the signs, the color of the lines in the signs may not correspond to the color on the subway map, creating different variations of shades, which makes it difficult to form a holistic idea of the color of the lines, and also forces one to doubt and compare colors, looking for additional reference points. In a signifying space any visual variable appears as meaningful; the introduction, for example, of a color variation whose only aim is aesthetic or decorative will lead to confusion if the color differences do not correspond to a component (Bertin, 2010, p. 46).

Figure 60. Example of interior sign lighting. Use of lightbox in signs and incorrect display of colours in the Lisbon Metro. *All photographs in this collage were taken by the author*, 2025.

Figure 61. An example of ambient diffuse lighting on a sign. Approximate colour rendering in the Lisbon Metro. *All photographs in this collage were taken by the author*, 2025.

To accurately display the colors in the signs, it is necessary to review the lighting system in the Lisbon metro, particularly the use of light boxes. It is possible to eliminate the light boxes

in the navigation, leaving only external diffused lighting (except for the emergency exit indication, which should always be visible and additionally illuminated). As an alternative, one might keep the light boxes in the navigation, but bring them to a uniform look using a translucent film.

2.5.3. Barriers to Multilingual Support and Effective Communication of Information

Most of the signs in the Lisbon metro navigation system (station names, exits, directions) are only in Portuguese. Although English translations are available (on additional signs and metro maps), they do not cover the entire system, and the size of the English text is too small to be read from a distance (see Figure D11 in Appendix D).

The fact that audio announcements on trains are Portuguese-only (while the train is moving, accompanied by the noise of the wheels), further complicates understanding in the event of failures or route changes. To solve this problem, it is necessary to reproduce the name of the station after the train comes to a complete stop. Additionally, during the audio message, only the current station is identified. For a more comfortable journey, it would be beneficial to announce the next station, as is done in the Moscow Metro. At the same time, on the official website and in the ticket machines in the metro, it is possible to switch the language to English, which simplifies the travel process.

The navigation system actively uses international pictograms to facilitate the perception of information, such as emergency exits, elevators, escalators, and information signs, which help overcome the language barrier. Although both English and Portuguese use the Latin alphabet, the languages themselves differ. As a result, differences in grammar, vocabulary and pronunciation make navigation more difficult. Words such as saída (exit), rua (street), avenida (avenue), and poente (west, often found at metro exits), among others, may be incomprehensible to tourists, despite being able to identify the letters.

According to the results of the online survey conducted as part of the dissertation, 66.7% of respondents believe that translating information on signs into English in the Lisbon metro system is necessary for comfortable orientation. Thus, transliteration into English is a crucial addition to navigation within the metro. At the same time, to maintain understanding of navigation among residents, names in Portuguese should be presented in a larger font and have a more prominent role in the sign.

2.5.4. Analysis of the Use of Navigation Signs and their Effectiveness

A large number of signs of equal importance but different information in one place can confuse the user, especially if they are present at a single station, such as Cais do Sodré station. Such signs are confusing, as in this case, three different names indicate the same place, have the same meaning, and employ the same visual approach. Let's say you are looking for Cais do Sodré station using the signs, go down to the station, and instead of the confirmation sign "Cais do Sodré" there is a sign "Telheiras" (the name of the final station in this direction), or, even more confusing "Cais terminal", which also looks like the name of the station. However, "Cais terminal" is just an indication of the final station (see Figure 62). In this case, it makes sense to visually separate concepts such as the station name, the line name, the line direction, and other designations.

Additionally, the font size and placement of the inscription relative to the sign's width vary significantly. And the arrows often point towards the wall, not to the location of the station. In addition, the signs shown in Figure 62. utilize different materials and lighting, which undoubtedly creates a visual inconsistency between them.

Figure 62. The use of different signs at the Cais do Sodré station in the Lisbon Metro. *All photographs in this collage were taken by the author*, 2025.

There is no need to indicate "Cais terminal" at the station, as the metro user is already informed that "Cais do Sodré" is the final stop (this is indicated while traveling on the green line, and confirmed at the station). A better solution would be to post a "no entry" or "no boarding" sign, so that the user does not approach the platform labeled "Cais terminal", which implies that this is the name of the station or direction (see Figure D12 in Appendix D). In addition, the arrow displayed on the "Cais terminal" sign points towards the side wall, not towards the platform (this is a fairly common problem at stations (see Figure D13 in Appendix D).

Similarities in the designation of line names, metro stations, and the final station (to understand the direction of the train) are quite common. For example, in Figure D14 in Appendix D, a metro user is looking for the station "Alameda" before descending to the station Here, one can see the directional signs "Linha Verde" and "Cais do Sodré", but there is no confirmation that the traveler is moving in the right direction to the station "Alameda". The traveler is forced to doubt his actions, stop, or make unnecessary movements in the hall in search of additional confirming information.

Another common problem is the limited visibility of signs. It may be due to large crowds, or it may be due to improper installation of signs or other objects that interfere with the perception of information. The solution to this problem may be: revising the placement of signs in order to increase the possible range of information perception. It is also recommended to remove or relocate secondary objects, such as video displays and advertising stands, away from the passenger flow and from signs displaying main information (see Figure 63).

Figure 63. Signs hidden from user view at Alameda station in the Lisbon Metro. *Photo taken by the author,* 2025.

Additionally, in the metro, users may encounter problems with a lack (see Figure D15 in Appendix D) or an excess (see Figure D16 in Appendix D) of signs, which in both cases do not facilitate effective orientation and movement in the Lisbon metro. Therefore, it is necessary to revise the system of placement and display of signs so that at decision-making points there is correctly guiding, supporting information in the required quantity.

2.5.5. Mind map

Authors such as Arthur and Passini (1992), Lynch (1990), and Rodionov (2015) write about the importance of the mental map that a person creates while navigating the environment, including the metro. The Lisbon metro map is easy enough to remember and transform into a mental map: four metro lines, a clear structure, north-south, west-east orientation are preserved in the map display.

However, inside the Lisbon metro cars, the metro map is presented in a different way, where the basic location of stations and lines relative to each other differs from the main metro map: for example, the Odivelas area and the Airport, the latter such a significant for tourists station, usually shown in the northern part of the metro map, are now shown in the west (see Figure D17 in Appendix D). This contradicts the original image obtained from the metro map. In the map presented inside the metro, the direction of the lines changes dramatically, the north-east, west-south arrangement loses its significance. This distortion, combined with the use of both options inside the metro, makes it difficult to form a single mental representation and remember the directions of the metro lines. The solution to this problem would be to eliminate the distorted display of the metro map on the metro cars. Instead, present the train route with marks indicating the intersections of other lines (such images are already used in the Lisbon metro station, and this approach is used in many countries). For a more complete presentation of the route, it is necessary to hang a full-fledged metro map in the cars.

2.5.6. Analysis of the wear resistance of the navigation system

A field study on the Lisbon Metro revealed numerous examples of signage deterioration: broken backlit panels, faded street maps, irregular replacement of lightbox bulbs, damage to lightboxes, and graffiti (see Figure 64; see Figure D17 in Appendix D). These changes create visual noise that can degrade the perception of wayfinding.

It is also important to understand that it is not only the sign that can deteriorate over time. The colors on the sign can change due to fading in the sun or due to an incorrectly chosen printing method. The issue of color fading in the sun in wayfinding signs located at the entrance of the subway is as important as the integrity of the elements used in the wayfinding. According to Arthur

& Passini (1992, p. 178), it is precisely the understanding of wear and tear and fading that can stimulate the use of more diverse colors. Over time, one way or another, all colors are subject to change: "The old signs will have faded and, as a result, one will have two blues, two greens, and so on" (Arthur & Passini, 1992, p. 178).

Figure 64. Aesthetic and technical problems with signage in the Lisbon metro. *All photos taken by the author*, 2025.

The use of approximate hues to represent the Blue Line and Green Line to map the Lisbon metro lines (the Green Line is a bluish tint or turquoise) has resulted in the colours appearing almost identical on the map after years of exposure to the sun.

Turquoise is the sort of ambiguous hue that is not available for this purpose because for the many people who call it "blue", there is an equal number who call it "green" which, of course, defeats the whole purpose of colour coding (Arthur & Passini, 1992, p. 178).

Also, observation showed that yellow color faded more intensely than all other colors. As shown in Figure A18 in Appendix/Annex A, the yellow color printed on the card was uniformly faded the most, and the Yellow Line was almost invisible on the card.

These observations highlight the importance of not only the choice of colors in the navigation system, but also the selection of printing methods and the use of reliable, wear-resistant materials. For example, to prevent rapid fading of signs and maps in the sun, you can place them

on the shady side, create a special canopy, or use special printing that resists ultraviolet light. Also, to maintain the condition of signs and navigation elements, a well-coordinated system of maintenance work is necessary.

2.5.7. Metro exits: exit identification, street names and landmarks

The system of organizing and identifying metro exits is not only an important part of metro navigation, but also helps to connect the metro with the external urban environment. The Lisbon metro system faces difficulties in providing consistent and complete information about exits. The online survey, conducted as part of the dissertation, confirmed this. In the free-form comments left by respondents, there were many requests for exit numbers or landmarks, as well as translations of key words to help identify the exit in English. Although the signs may include street names, the indication of landmarks is often absent, or too abstract and small (see Figure 65).

Figure 65. Direction towards the exit towards significant places at the Cais do Sodré station in the Lisbon Metro. *All photos taken by the author*, 2025.

The exit numbers in the Lisbon metro are absent either in front of the exits themselves or on the maps. The exception is the map scheme at Alameda station, which has numbered exits (see Figure A19 in Appendix/Annex A).

However, the map with the exits is located in the metro hall, next to the platform. There is no supporting information before the exit to the city, and there are no numbers near the exits. This makes this map ineffective. For the exit identification system to be effective, it is necessary to take a comprehensive approach to solving the problem: indicating the exit numbers on the maps to form a mental map, indicating landmarks both on the map and on the signs directing to the exits, as well as directly in front of the metro exits. This approach will simplify the navigation process, especially when exiting to the city at complex city intersections or when several exits serve different sides of a large area (see Figure 66).

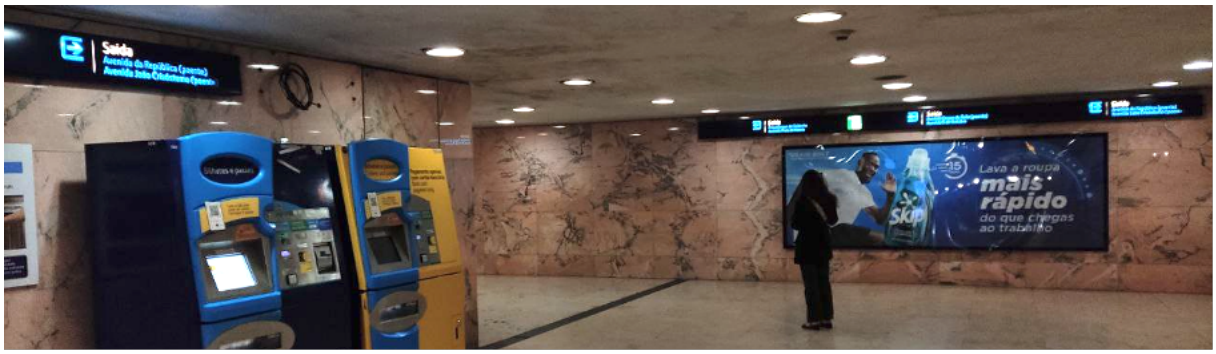


Figure 66. Exits to different streets at Saldanha station. *All photos taken by the author,* 2025.

Emergency exits are located at every Lisbon metro station, and are always illuminated and visible. However, emergency exit signs are often located on the same plate as the standard exit, displaying the street name or the name of the line. The arrangement of the information on one plate unifies the meaning of the messages, in this context "Exit", but the standard exit and the emergency exit do not always lead to the same street, and their use next to each other conveys mutually exclusive information that can confuse the user (see Figure 67). In this case, the signs convey different types of information and solve different problems, so they should be separated and presented on different plates.

Figure 67. Signs indicating the direction to the emergency exit and the normal exit in the Lisbon metro at Saldanha station. All photos taken by the author, 2025.

Additionally, there is a difficulty in finding the necessary exit by street name. For example, a traveler who leaves a metro station and moves towards the exit, first receives information about the location of the exit, along with an indication of 1-2 street names. Approaching the exit, the

number of street names on the signs can increase to 4-6 (see Figure 68). This can confuse the user and lead them to doubt the correctness of the decision made.

Figure 68. Signs directing to exits with street names at different stages of travel at Bela Vista station. All photos taken by the author, 2025.

In well-designed systems, each exit is identified by a unique number or letter, accompanied by signage that includes the names of nearby streets, institutions (such as museums, universities, or hospitals), and notable public spaces (squares, parks, historic sites, or public transport stops).

> The wayfinding requirements of a municipal client must often address different user groups in various settings. The institution interacts with a diverse community, including locals and tourists, all of whom come to visit city centers, city parks, or other public spaces (Gibson, 2009, p. 18).

Systems such as the Paris Métro, London Underground, or Moscow Metro provide detailed exit maps at station entrances and platforms, enabling passengers to choose the most convenient exit based on their destination. Clear identification of exits, as well as their relationship to public transport, street names, key landmarks, and surrounding neighborhoods, greatly enhances a passenger's ability to navigate when exiting an underground environment.

3. Methodology

3.1. Description of Methodology

This study includes qualitative and quantitative research methods that are aimed at a deeper understanding of the problem, as well as finding answers to the questions posed in the dissertation:

1) Literature Review: studying and analyzing thematic scientific research, books, articles, and additional information on the Internet, on specialized sites. Topics covered: The history (or evolution) of Navigation Systems and Maps, User Perception on Navigation Systems, Information Anxiety, Metro Maps and Diagrams, Wayfinding and Decision-Making, Types of information and signs, typography, color, light and durability in navigation systems. (Presented in Chapter 1 and Appendix/Annex A).

2) Case Studies: analysis of existing navigation systems and diagrams in large cities of different countries (Presented in Chapter 4 and Appendix G).

3) Analytical: a) collecting quantitative data obtained in an online survey among metro users of different linguistic cultures and with different experiences of using the metro (locals, tourists, immigrants), as well as analyzing the information obtained (Presented in Chapter 3 and Appendix E). b) conducting an audio interview with designer Rodionov Mark, who specializes in the development of modern navigation in the Moscow metro. Transliteration of the interview from audio format to text, as well as translation from Russian into English (Presented in Chapter 3 and Appendix F).

4) Practical: photographing elements of the metro navigation system (signs, diagrams, pictograms, etc.) and analysis based on the methodologies of reading the environment proposed by Lynch (1960), Arthur & Passini (1992) (Presented in Chapter 2 and Appendix D).

5) Exploratory: analysis and rethinking of the problem, as well as an abstract display of the problem in the form of an installation presented by the author (Presented in Chapter 3).

3.2. Surveys and Interviews with Immigrants, Visitors, and Local Residents

To answer the research questions, a survey was compiled and published on Google Forms. This online survey was conducted anonymously among 100 individuals from various categories (locals, migrants, international students, and tourists) from February 5 to May 30, 2025. This

survey aimed to collect and analyse information on the effectiveness and perception of information on signs inside the Lisbon metro (see Figure E1 in Appendix E).

The question "Are you from Portugal?" was answered by 100 people, 57% of whom were from Portugal and 43% from other countries (see Figure E2, Appendix E).

The answers to the question "What type of person living in Lisbon do you consider yourself to be?" were as follows: 54.7% Migrants or expats; 26.7% locals; 7% tourists; 8.2% (5.8%+1.2%+1.2%) do not live in Lisbon, come there for work or personal reasons; <2.2% international students; <1.2% just students (see Figure E3 in Appendix E).

The following data were obtained in response to the question, "What language do you mostly speak?": 40% English; 36% Portuguese; 16% (12%+4%) Russian; 4% Italian; 4% Russian and English equally; <1% Spanish; <1% Serbian and Russian equally (see Figure E4 in Appendix E).

To the question: "How often do you use the metro in Lisbon?" respondents answered as follows: 13% Every day; 39% Several times a week; 27% Few times a month (25% Few times a month + 1% A few times a month + 1% 2-5 times per month); 5% Sometimes (2% Sometimes; 1% Some of the times; 1% De vez em quando (sometimes)+1% Every few months); 6% Rarely (2% Raramente (rarely) + 1% Ocasionalmente (occasionally) + 2% (Rarely)+1% Few times per year); 2% Just once; 6% Never; (see Figure E5 in Appendix E).

A total of 85 people answered the question, "Which station do you use most often?" Four people sent blank forms, and the rest did not answer this question. The survey results correspond to the number of people who chose a particular station: Aeroporto - 2, Alameda - 6, Alvalade - 2, Ameixoeira -1, Anjos - 2, Arroios -1, Baixa-Chiado - 9, Bela vista - 4, Benfica -1, Cais do Sodré - 12, Campo Grande -1, Cidade Universitária - 1, Entre Campos – 3, Intendente – 1, Jardim Zoológico – 1, Lumiar – 2, Luz -1, Marquês de Pombal – 4, Moscavide – 1, Olivais – 2, Oriente - 1, Picoas – 2, Pontinha -1, Praça Espanha -1, Rato -1, Reboleira – 2, Restauradores -1, Roma -1, Rossio -3, Saldanha – 5, Santa Apolónia - 3, São Sebastião 3, Sete Rios - 1, Telheiras - 2, Terreiro do Paço – 1 (see Figure E6 in Appendix E). The results of this survey indicate a relatively uniform load on the metro stations. However, it is worth highlighting two neighboring stations, Baixa-Chiado and Cais do Sodré, which were used much more often by the respondents. Baixa-Chiado is located on the Green metro line and is the previous station before the final station, Cais do Sodré. Also, Baixa-Chiado intersects with the blue line. Cais do Sodré is the final station on the Green Line. Both stations, although considered the final ones on their respective lines, are conveniently

located in the center of Lisbon, where there are not only tourist and historical attractions but also cafes, bars, and museums. Near the exits of these metro stations, various systems of land and water transport interchange are organized, including buses, trams, electric trains heading to the suburbs, and ferries. Consequently, the new stations being built on the green line, Santos and Estrela, which go after Cais do Sodré and complete the green line in a ring, could be used to reduce the load at the Baixo-Chiado and Cais do Sodré stations.

To the question, "Do you use navigation signs inside the metro?" 87.5% answered "yes," and 12.5% answered "no" (see Figure E7 in Appendix E). This indicates that significantly more than half of the respondents prefer to use the navigation system in the metro, and the signs inside the metro play a crucial role for passengers.

Next, the question was asked: "How effective do you rate the navigation system inside the Lisbon metro?" and a proposal to rate efficiency on a five-point scale: 1 star – "not efficient at all, every trip is stressful for me and takes a lot of time while searching for the way, I often get lost inside the metro and have a hard time finding the right direction"; 2 stars – "not efficient enough, I often have to stop or return to the starting point to see a landmark or sign that will help me choose the right way"; 3 stars – "average efficiency, sometimes I have to look for landmarks and signs or slow down to figure out where to go next"; 4 stars – "good efficiency, overall I can easily follow the route without stopping, but sometimes I can doubt something"; 5 stars – "excellent efficiency, everything is clear, I quickly find the right direction and follow it" (see Figure E8 in Appendix E). The average of this survey is 3.32. Of these, 5.1% chose 1 star, 14.3% chose two stars, 32.7% chose three stars, 39.8% chose four stars, and 8.2% chose five stars. This survey provides a confident average indicator, which suggests that the navigation system works effectively for only 8.2% of respondents. However, 39.8% of respondents are satisfied with its effectiveness, although there are some nuances. In other cases, the surveyed people experience difficulties in making decisions, receiving information on signs, and finding the right path, as well as difficulty choosing the correct exit to the city.

The answers to the question "What confuses/disorients/distracts you the most about the Lisbon metro navigation system?" (see Figure E9 in Appendix E) were as follows: more than half of the respondents, namely 62.2%, were most disoriented by the signs indicating the street names of the metro exits. Signs present at the metro line transfer a disoriented 26.5% of respondents. The designation of the metro line colors confused 10.2% of people, and the images accompanying the

line colors confused 7.1%. Understanding the sense of the lines was difficult for 18.4% of the participants. Nothing in the Lisbon metro confuses 21.4% of people. In this question, there was an opportunity to add a custom answer, and some of the answers were: "Unpredictable and long waiting time between trains, impossible to calculate the time of travel", "Google maps does not have enough info about entrances and exits to the station", "When it's busy, several clients are there blocking the information", "If I am already on the platform, there is often no sign indicating in which direction the train is going from this platform (it is only on the board)", "Bad placement of signs. No signs where I need to choose the direction", "Some exits may be closed. Not clear which side of the street I'm exiting", "Direction of travel within the line (sometimes there is no list of stations before entering the platform, but this is rare)", "Not enough navigation signs". As the result of this survey shows, most people were disoriented, confused, bewildered, or experienced a lack of appropriate signs in certain places.

The online survey also included a more specific question: "Have you ever exited the metro onto the wrong street?" (see Figure E10 in Appendix E). Ninety-eight people answered it, of whom 57.1% answered "yes, sometimes," 33.7% answered "yes, often," and 9.2% never exited the metro onto the wrong street.

The next question: "What is the meaning of the word SAÍDA?" (see Figure E11 in Appendix E), is aimed at understanding how much people need a translation of the sign's inscriptions from Portuguese into English. For example, the name of one of the essential signs indicating the exit from the metro provided. This survey also aimed to determine the intuitive understanding of the meaning of the word on the sign in a foreign language. Additionally, whether the sign is effective in the context of visibility of the exit with the inscription "SAÍDA" (considering the direction of pedestrian flow). Almost all respondents, namely 97%, answered: Exit, exit to the street, way out, etc. Only 3% of respondents were unfamiliar with the meaning of this word.

The next question is related to the interest in determining the need to introduce the numbering of exits from the metro: "Do you think that if the exits from the metro to the street were numbered, it would help you choose the right exit?" (see Figure E12 in Appendix E). 78.8% of respondents answered "Yes", thereby emphasizing their interest in numbering. In comparison, 21.2% answered "No," indicating that they are satisfied with simply displaying the names of the streets before exiting the metro into the city.

To the question about the need for transliteration into English, "Do you think that English translation is necessary for navigation signs for better orientation in the metro?" a variety of responses received: 66.7% answered "Yes" and 25.3% "No" (see Figure E13 in Appendix E). In the additional field, respondents also wrote down their answer options, such as: "Perhaps", "Yes, for foreigners", "Yes, for tourists", "Most people would be helped by just colors". Since more than half of the respondents answered positively, this indicates that Lisbon metro users need translation of signs into English at metro stations. However, it is also worth considering the wishes presented in the free field of the questionnaire.

A survey with a "Catch" was also compiled to gather information about the names of the lines to understand which line names people use more frequently. In this section, several line names were presented to choose from, from which it was necessary to "Choose four correct names of Lisbon metro lines" (see Figure E14 in Appendix E). According to the data obtained, it is clear that the majority of people (71-75 people) believe that the lines in the Lisbon metro are called: Linha Vermelha (73), Linha Amarela (73), Linha Azul (75), Linha Verde (71). To a lesser extent, but in approximately the same number of opinions (12-16), respondents consider the names of the metro lines to be: Red Line (15), Yellow Line (13), Green Line (12), Blue line (15), Linha da Gaivota (16), Linha do Girassol (16), Linha da Caravela (15), Linha do Oriente (16).

The data obtained show that the names indicated in the Lisbon metro, Linha Vermelha, Linha Amarela, Linha Azul, and Linha Verde, are reasonably well-read and associated with the name of the metro line, although they indicate the name of the color of the metro lines. Respondents also chose the names of the lines, Red Line, Yellow Line, Green Line, and Blue Line, which are also displayed in the Lisbon metro's navigation system, albeit in a smaller format as a transliteration of the line names from Portuguese to English. It is essential to note that this transliteration of the metro line colors is not used at all metro stations. It is also used only in conjunction with much larger inscriptions in Portuguese (Linha Vermelha, Linha Amarela, Linha Azul, Linha Verde). Similar results were obtained from the survey for the names Linha da Gaivota, Linha do Girassol, Linha da Caravela, and Linha do Oriente. These line names were introduced in 1998. Nowadays, one can guess such names of lines only if one knows Portuguese and makes a connection between the pictograms (depicted next to the name of the color of the metro lines) and their meaning or if the traveler reads information about the names of the Lisbon metro lines on the Internet, for example, on Wikipedia, before using the metro. It is challenging to determine the

official names of the lines, and a deeper examination of the metro's development history is necessary. However, this survey revealed that the most popular names among passengers are Linha Vermelha, Linha Amarela, Linha Azul, and Linha Verde.

At the same time, 65.7% confidently answered "Yes" to the question "Do you know the names of the Lisbon metro lines?" while 34.3% answered "No" (see Figure E15 in Appendix E). This may indicate that people do not always understand the difference between the name of a metro line and other names (for example, the color of the line, the direction of the line, or the name of the station).

The next question was about the meaning of the pictograms that are indicated next to the line designation: "These symbols that you can see in the metro are painted in the colors of the metro lines. What do they mean?" (see Figure E16, E17 in Appendix E). Slightly more than half of the respondents, namely 55.1%, answered that these pictograms emphasize only the color of the metro line (Yellow Line, Green Line, Blue Line, or Red Line). 37.8% responded that the pictograms indicate the color and name of each line (Linha do Girassol (Sunflower), Linha da Caravela (Caravela), Linha da Gaivota (Seagull), Linha do Oriente (East)). 5.1% of respondents assumed that the pictograms indicate "The main intersections of metro lines and transfer points". 1% answered "Não sei" (I don't know) and 1% answered "Never think about it". As a result, most people did not see the connection between the meaning of the pictogram and the name of the metro line, assuming that it was simply a symbol painted in the color of the metro line.

The next question, "What colors do you think are shown here?" (see Figure E18, E19 in Appendix E), aims to understand passengers' perception of specific colors. For this purpose, two colors are presented: "red", which is used in the metro logo, and a more complex color, which is used as an indication of the color of the "red line" of the metro in Lisbon. As a result of this survey, almost all respondents, namely 94.9%, answered "Left red, right pink"; that is, they clearly distinguish the difference between these two colors and have no doubts about the correspondence between the color and its name. Only 3% answered, "Both red". 2% had difficulty determining the correspondence between the colors and names. However, none of the respondents answered "Left pink, right red" or "Both pink". This may indicate that it is quite difficult to confuse the color with its name in this context.

To the question, "Would you like to see the navigation inside the Lisbon metro improved?" 78.6% answered "Yes", 15.3% "I don't care" and only 6.1% answered "No" (see Figure E20 in

Appendix E). This shows that the majority of Lisbon metro users have a need to see more efficient navigation inside the metro.

To the question, "What changes or suggestions would you recommend to improve the navigation system inside the metro?" 50 people filled in the form, of whom 6 answered "no" or put a dash or refrained from answering, 44 wrote answers in free form (*For the full version of the answers, see Appendix E; see Figure E21)*. Among the answers: "Some cities create apps that automatically calculate the optimal route and also show which carriage (from first to last) will be closer to the exit. This would be helpful to have in Lisbon", "Add a map on the exit, showing you the position and exits with numbers. Also, those numbers can be shown on Google maps to make it easy to plan the journey. To make shorter breaks between trains and make it more predictable (like fixed intervals or a schedule)", "Making it easier to understand which side to exit on to get to the correct street", "Add a map on the exit, showing you the position and exits with numbers. Also, those numbers can be shown on Google maps to make it easy to plan the journey. To make shorter breaks between trains and make it more predictable (like fixed intervals or a schedule)", "To number exits, mark exits to well known places (Loja da Cidadão, McDonald's, etc)".

After all the questions, respondents were given the opportunity to leave important comments and suggestions in the free form related to navigation inside the Lisbon metro (*For the full version see Appendix E, Figure E22)* . Among the proposals was a wish to indicate not only the final station, but also the entire list of stations in the direction on the platform. To improve the metro, individual changes will not be enough; a comprehensive approach to revising the navigation system is needed. A proposal was also presented to simplify the designation of lines by using numbers or letters instead of pictograms, and to place more signs at eye level. And a request to indicate intermediate and final stations on the platform.

As a result, we can conclude that, in general, the navigation in the Lisbon metro copes with the main function of navigation but not as effectively as metro users would like. To improve the navigation system, it is necessary to review the existing system, identify signs that work well and poorly, and, based on the responses received from respondents, apply a comprehensive approach. For example, it is necessary to pay attention to the designation of exits from the metro to the street, the relationship between the color of the metro lines and its names, explain the meaning of pictograms, add additional signs in places where decisions are made, etc. It is also important to note that none of the participants expressed an opinion about the difficulties in reading what is

written on the signs. This means that the font used in the navigation is quite legible and does not need to be revised for further changes.

3.3. Interview with Designer Rodionov Mark

In addition to the collected quantitative information in the form of an online survey, a qualitative study was conducted, an interview with designer Mark Rodionov, which took place on April 14, 2025. This study allowed us to delve deeper into the specifics of the topic of navigation inside the metro, based on the practical experience of Mark Rodionov, who took an active part in the development of the internal navigation of the Moscow Metro in the period from 2018 to 2019. The interview was conducted via video communication over the Internet in Russian and recorded in audio format. Then, from the audio format, the recording was transcribed into text format in Russian, with minor edits to the text, and then translated into English. The full interview in English is presented in Appendix F.

Mark Rodionov is a modern Russian Art Director and designer who currently runs the design communications studio at SberDevices. In the past, he was the leading designer of Art. Lebedev Studio. He worked at Artemy Lebedev's studio from February 20, 2013, to October 23, 2020, and during this time, he completed many different projects related to the development of identities, interfaces, and navigation, including navigation in public places such as the Moscow Metro (see Figure 69).

The following conclusions can be drawn from this interview: 1) any project related to the development of navigation in a public place requires a deep analysis and understanding of the context (language, cultural characteristics, public preferences, cultural and socially significant landmarks and unique objects in the city near the metro exits); 2) the numbering of anything is introduced "when you have a number of objects that do not have sufficiently unique characteristics for you to be able to describe them out loud as something independent" (Rodionov, personal communication, April 14, 2025), for example, when there are identical doors on the floor, or in the same building, houses located on the same street, entrances or exits (if there is more than one); 3) Before the final introduction of navigation systems in the subway, "pilot launches" are required, that is, testing, to track the effectiveness of the new signs; 4) Kevin Lynch's principles, described in his book "The Image of the City", are well applicable in the design of public place navigation.

Which describes in detail the decision points when moving in the new meta, as well as visual landmarks and mental maps; 5) Signs must be installed at decision points, as well as in long corridors, to confirm the location.

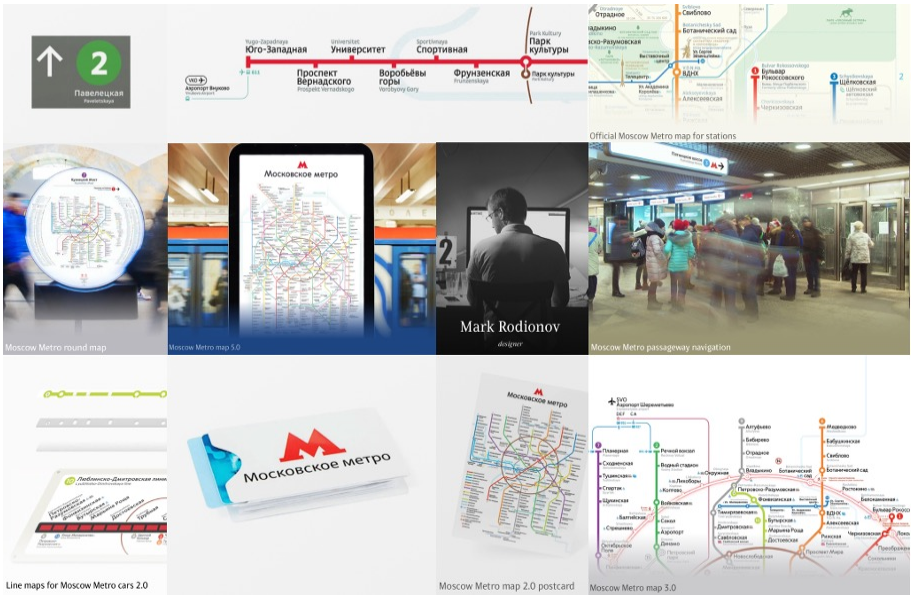


Figure 69. Collage of selected navigation design projects by Mark Rodionov for the Moscow Metro, created by the author using screenshots from the Art. Lebedev Studio website. Source: Adapted from https://www.artlebedev.com/rodionov/

3.4. Abstract Rethinking of the Problematic through Installation

A creative approach to rethinking the problem of the research work was not initially expected, but after immersing myself in the topic and studying the literature, an idea appeared to draw an analogy between finding a way in the subway and following the path of life. The questions that are asked while following a route in unfamiliar places seem very similar to the questions that a person asks himself throughout his conscious life. Doubts and anxiety that accompany a traveler on a journey to a new place, as well as decision points, are also comparable to the experiences that a person experiences when he finds himself in a new situation or in an unfamiliar situation. It is natural for a person to follow instructions (Wurman, 2000), look for signs in an unfamiliar environment, turning to the navigation system (signs) in order to reduce anxiety and feel calmer (Wurman, 2000; Gibson, 2009). In the same way, in life, a person sometimes tries to find signs, "clues of fate" or justification for a particular event that happened in his life. When a person gets

lost while traveling or "gets confused in life", he can ask for help from another person who can show the right direction or knows how to get to the "right point", i.e., will help to get out of a confusing situation. Finding an exit from the subway can also be compared to a way out of a difficult situation. People often doubt, are in search of the right path, and at the same time solve a series of tasks (Arthur & Passini, 1992). Signs cannot always effectively lead a person to the exit. Sometimes, signs and clues contradict each other, thereby confusing the landmarks. However, sometimes, to achieve the goal, it is enough to trust intuition in life or turn to intuitive universal navigation.

The questions that may arise in life, worrying and thinking about the future and the correctness of choice, are also similar to the thoughts and questions that arise during a trip to a new place.The questions that may arise in life, worrying and reflecting on the future and the correctness of the choice, are also similar to the thoughts and questions that arise when traveling to a new place. As Instagram user @kasandric expressed: «Иногда мне кажется, что выхода нет, и всё тлен. Но он есть, и я его всегда нахожу. После этого отпускает» [Sometimes it seems to me that there is no way out and everything is meaningless. But there is one, and I always find it. After that, I feel relieved] (Instagram, 2025; see Figure 70). At the same time, the stair tunnel exit from the Parque station of the Lisbon metro serves as a supporting background for such reflection. The connection of human reflections with the metro, the search for a way, and finding an exit became the key idea for the creative project. The tunnel, with stairs leading up to the exit, became the center of the composition.

This creative project-rethinking is an installation consisting of a triptych made in color on canvas (acrylic paints and acrylic markers) and complemented by a hanging structure made of ceramics, wood, and colored plastic plates (see Figure 71, 72). The triptych in a flat technique displays the subway as an allegory of the place of decision-making in human life. The center of the composition is an illuminated exit with a staircase leading from the subway to the top as an image of an exit from any difficult situation. At the stations, there are basic signs, "my station" and "some station", symbolizing human focus. Since a person better reads information received at eye level at 90 degrees, if the angle of the sign changes, its perception changes (Arthur & Passini, 1992), and with this, its meaning decreases. Also, the project contains contradictory signs that can confuse the traveler or make him make the wrong decision. This is also emphasized in the suspended structure: horizontal rectangular ceramic tiles depict direction signs that change their

direction while spinning around their axis. Accordingly, a person can change their decision while following the path, just like in life, when some circumstances change or new inputs appear. Colored vertical plastic rectangles symbolize the Lisbon metro lines and have corresponding colors. The project uses five lines, implying that Lisbon will soon have a fifth purple metro line in the northern part of Lisbon.

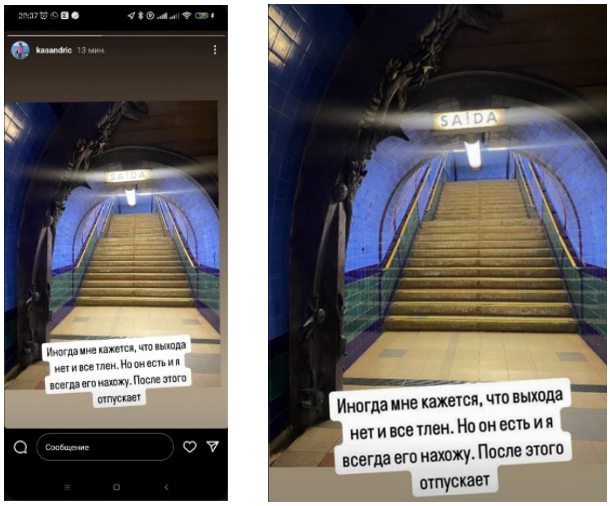


Figure 70. Screenshots from Instagram posts by @kasandric. Source: Instagram, accessed on May 30, 2025.

This approach helped to rethink the problems of the project through applied art. It displayed problems associated with information anxiety during travels in unfamiliar places, such as the metro, and internal experiences in a person's life through understandable simple shapes and colors. The project showed the connection between pathfinding during life and pathfinding during travel, as well as the connection between the series of decisions on the path of life and the decisions on the path of the traveler.

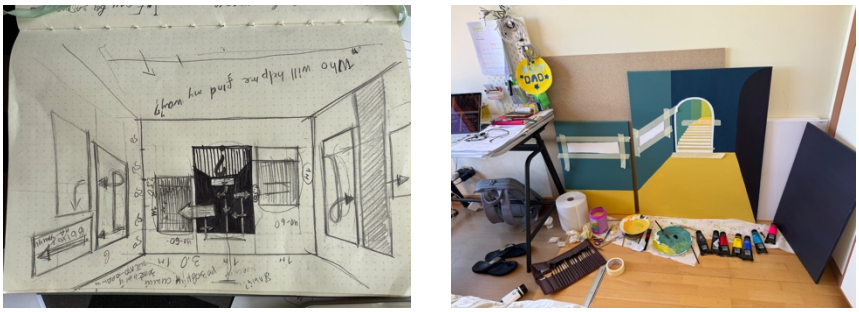


Figure 71. Sketch and creation process of the author's installation (2025). Author's own work.

Figure 72. Process of the author's installation (2025). Author's own work.

4. Reference Cases: Successful International Metro Systems and Practices

Studying navigation solutions and user experiences in international metro systems helps identify best practices that can be applied to local contexts. This section presents three major metro systems – London, Paris and Moscow – as examples of mature and evolving, highly organised urban transport systems (see Table G1 in appendix G).

4. 1. London

The London Underground, opened in 1863, is the oldest underground system in the world. It is also a prototype for the development of modern underground schemes in various countries, where the lines are positioned at 45 and 90 degrees and deviate from geographical accuracy in favor of a simplified and understandable scheme. Today, it has 11 lines, each with a unique name and color (e.g., Central Line – red, Jubilee Line – grey) (see Figure 73). The color system is supported throughout the navigation, and the schemes use high-contrast lines, which makes it easier to navigate.

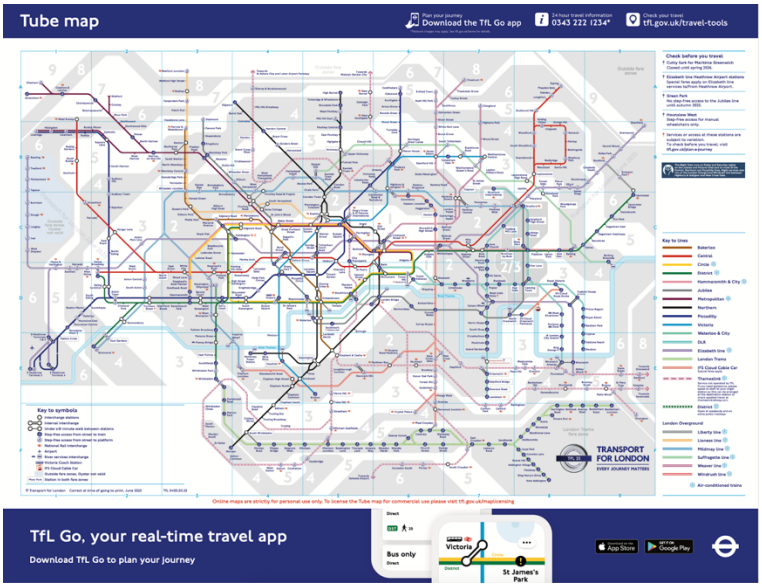


Figure 73. London Underground Map. From Transport for London, 2025, https://tfl.gov.uk. © Transport for London.

The visual system of the underground uses the sans-serif typeface Johnston, specially developed for Transport for London, which is distinguished by its high legibility. The logo, in the

form of a red circle with a blue stripe and text in the middle (Roundel), has become not only a navigation element but also a symbol of the entire London transport system (see Figure 74).

Figure 74. London Underground logo. Adapted from Transport for London, 2025, https://tfl.gov.uk. © Transport for London.

The metro is aimed at an English-speaking audience, but in tourist areas you can find duplicate information in other languages. Inside the trains, passengers can hear voice announcements and electronic boards indicating the next station and possible transfers. All stations have a clear system of exit markings with streets and landmarks (sights, parks). Interactive maps are available both at the station and online on the metro website. The TfL Go mobile app provides data on routes, delays and congestion levels. There are also integrations with applications such as Citymapper and Google Maps. Visual line indicators are duplicated on plates and platforms, and transfers are intuitively indicated with colors and pictograms.

4.2. Paris

The Paris Metro, opened in 1900 as part of the World's Fair, is one of the oldest and most extensive urban transport systems in the world (see Figure 75).

The system currently has 16 lines (including the short lines 3bis and 7bis). Each metro line is identified by a unique number and color, which is the primary element of the line's visual identification and is widely used in metro maps, signs, and electronic boards, making navigation easier for both locals and tourists. The lines do not have individual names, unlike other international systems, such as those in London, Moscow, and Lisbon.

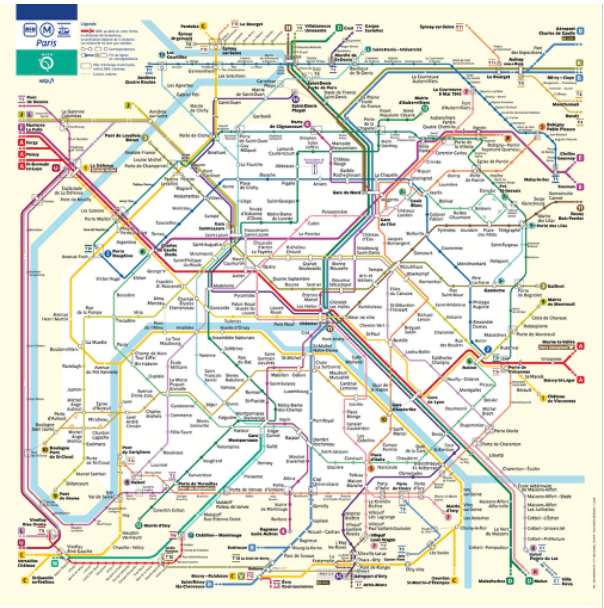


Figure 75. Paris metro map. Adapted from RATP, 2025, https://www.ratp.fr. © RATP.

The visual style of the navigation system is based on the use of the Parisine font, designed by Jean-François Porches specifically for the Île-de-France transport network. This font was introduced by the RATP (Régie Autonome des Transports Parisiens) in 1996 as part of a general redesign of transport information. Its legibility and modernity meet the high requirements of urban navigation. The RATP logo is an abstract silhouette of a face in profile, inscribed in a circle, symbolizing the passenger and the River Seine, a central element of the city's topography (see Figure 76).

Figure 76. Logo of the Paris Metro (RATP). Adapted from RATP, 2025, https://www.ratp.fr. © RATP.

The Paris Metro navigation information is mainly provided in French. However, in tourist areas such as Gare du Nord, Châtelet or Charles de Gaulle – Étoile, the signs are duplicated in English. Audio announcements on trains are usually only in French.

The official Paris Metro website provides detailed information on routes, transfers, and travel times. Also available are the Bonjour RATP and Next Stop Paris mobile apps, as well as integration with Google Maps, offering interactive maps, route recommendations, and information on cultural attractions.

The stations utilize modern navigation elements, including illuminated signs, boards with train arrival forecasts, and transfer maps. Line names are shown in large print, line colours are duplicated on signs and platforms, and transfers are indicated by colours and numbers (see Figure 77). Inside the carriages there are route maps with the current station designation, and on some lines there are LED indicators. Station exits are marked with letters (e.g., Sortie A, B, etc.) and accompanied by signs that point to nearby streets and attractions. This helps passengers get their bearings and quickly find the right exit.

Figure 77. Navigation signs in the Paris metro. Adapted from RATP, 2025, https://www.ratp.fr. © RATP.

4.3. Moscow

Opened in 1935, the Moscow Metro is the largest metro system in Russia, having 14 lines plus the Moscow Central Circle (MCC) line (see Figure 78). The Moscow Metro is known for its high level of efficiency, architectural heritage, and the active digitalization of navigation solutions introduced after 2018.

Figure 78. Moscow Metro Map. Adapted from Art. Lebedev Studio, 2025, https://www.artlebedev.ru. © Art. Lebedev Studio.

Each metro line has a number, name and unique color, which makes it easier for passengers to navigate (For example: Line 1 – Red Sokolnicheskaya). The names of the lines reflect both the geographical and historical features of the city (for example, Arbatsko-Pokrovskaya or Kaluzhsko-Rizhskaya line). Color coding is used in all navigation elements, from metro maps to signs on platforms and at crossings.

The main font used in the navigation is Moscow Sans - a modern, easy-to-read sans-serif font, specially designed by Ilya Ruderman & Yury Ostromentsky in collaboration with the Moscow Department of Transport. It ensures visual unity of all city transport, including the metro, buses and trams.

The Moscow metro logo is a red letter "M", first appeared in the 1930s and after the redesign in 2018, remains a recognizable symbol in the urban environment (see Figure 79). As part of the latest changes, it has become part of the general transport navigation system "Moscow Transport", which unites the metro, the Moscow Central Circle, ground transport and commuter trains.

Figure 79. Moscow Metro Logo. Adapted from Art. Lebedev Studio, 2025, https://www.artlebedev.ru. © Art. Lebedev Studio.

The system is distinguished by its high language accessibility. The names of stations are announced in Russian and English both on trains and at stations. Signs, maps and diagrams are also duplicated in English, especially in the central part of the city and at transfer hubs (see Figure 80). This makes the Moscow metro convenient for foreign tourists.

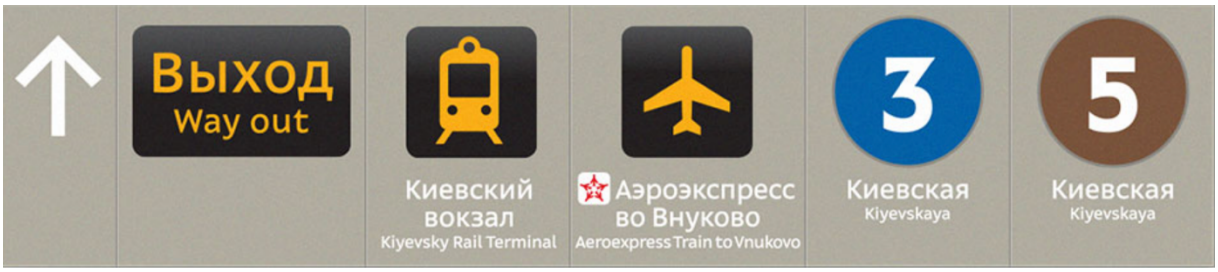


Figure 80. Moscow metro signs with translation into English. Adapted from Art. Lebedev Studio, 2025, https://www.artlebedev.ru. © Art. Lebedev Studio.

The official website of the Moscow metro provides interactive maps, information on schedules, transfers and services. The Moscow Metro mobile application also provides access to routes, travel times, and even allows you to view the occupancy of cars in real-time. Also, Moscow metro routes are integrated into Google Maps and the 2GIS application.

Inside the trains, modern route diagrams with illumination of the current station are used, as well as LED screens with information on transfers, exits and nearby streets. Digital signs, information stands and interactive panels for plotting routes are installed at the stations.

Exits from platforms are designated by letters and additionally indicate which streets and attractions they lead to. Many stations are equipped with navigation systems for passengers with limited mobility and tactile tiles, providing a more accessible experience.

4.4. Comparative Table of Metro Navigation Systems in Other Countries

The result of the previous chapters is a comparative table of four major metro systems: London, Paris, Moscow and Lisbon. Each illustrates unique approaches to wayfinding, graphic design, and passenger interaction, shaped by their historical and cultural contexts (for a detailed comparison table, see Appendix G).

The London Underground (opened in 1863) was a pioneer in the development of metro maps. Characteristic elements are the legendary Beck map, the Johnston Sans typeface and the iconic roundel logo. The system is highly accessible, thanks to the use of English, user-friendly mobile apps, and audio announcements.

The Paris Metro (opened in 1900) is characterized by a dense network of lines, the Parisine typeface, and a consistent visual identity. The primary language is French, but since the system's redesign in 1996–98, navigation has become increasingly accessible to international users, including through digital and interactive solutions. However, audio announcements are still broadcast in French, which hurts the perception of information for foreigners.

Moscow Metro (opened in 1935) is known for its architectural expressiveness and development of the navigation system, as well as its radial, ring metro lines. Two languages are used (Russian and English), a clear color system, and modern digital maps. There are a number of lines and exits from the metro. However, the Cyrillic alphabet without support in English can create difficulties for tourists unfamiliar with the alphabet.

The Lisbon Metro (opened in 1959) is the most compact system among those compared, but it is actively expanding. Pictograms and color-coded lines are used. However, the numbering of exits and the level of translation of information into English remain incomplete, which can complicate orientation for foreigners.

Each system demonstrates its approach to user experience and environmental design, based on the scale of the city, linguistic cultural characteristics and technical capabilities. However, colour coding, numbering, and simplification of information, along with support from digital applications (such as electronic maps on Google Maps and the metro website), are fundamental to the creation of all presented metro navigation systems.

5. Analysis and Discussion

5.1. Data Analysis

Ultimately, the analysis based on the triangulation methodology allowed us to collect a variety of data necessary for a deep understanding of the problem:

a) Theoretical data were obtained from the literature, highlighting the human need to display and receive information about their location from ancient times (as evidenced by the first rock carvings) to the present (in modern maps). Additionally, research was conducted on data related to information anxiety during travel in unfamiliar places (including the metro), the principles of creating metro maps, the fundamentals of typography in information design, the basics of color coding in public spaces, lighting features, and the parameters of durability in visual communications for navigation.

b) Qualitative and quantitative data were collected through an online survey, interviews, and photographic recording of navigation elements in the Lisbon metro, which helped identify problems with the perception of navigation in different categories of people, as well as track the effectiveness of the navigation system in the metro.

c) Empirical data were collected based on a comparative table of navigation systems and metro maps for Lisbon, London, Paris, and Moscow, which highlighted the similarities and differences in the display of metro line identification, language accessibility levels, visual navigation techniques, and metro maps. Based on the artistic rethinking of an author's installation, the connection between navigating an unfamiliar space and navigating life was analyzed, highlighting the importance of having landmarks in a person's life.

5.2. Proposal for Improving Indoor Navigation and Signage

The analysis of the results obtained from the theoretical and empirical study allowed us to identify key navigation problems in the Lisbon Metro and areas for improvement.

Visual Solutions:

The visual component of the navigation system plays a critical role, especially in a multilingual and tourist environment. Although the Lisbon Metro has a recognizable visual style based on color-coded lines and pictograms, the following shortcomings have been identified:

- Insufficient consistency in the design of signs and indicators between stations.

- Absence or inconsistency of visual information on signs (arrows, elevators, etc.),

- Lack of standardization of the size, location and illumination of signs.

- Local shortage or excess of signs

- Difficulty in identifying similar metro exits and difficulty in matching the metro exit with the external urban environment.

- Low readability of information due to fading colors, improper lighting or structural failure.

- Difficulty in identifying the names and meanings of metro line pictograms

- Difficulty in perceiving and identifying the colors of metro lines, as well as different color displays at stations.

- Difficulty in distinguishing between concepts such as regular and emergency exits

Proposal:

- To develop standardized visual templates for signs taking into account the principles of information placement and readability

- To check for compliance with the correct display and placement of signs in the guiding signs.

- To increase contrast, font size and use anti-glare surfaces.

- To improve the placement of navigation elements at key points along the route: at decision-making points, at entrances, exits, transfers and platforms, as well as in long corridors (to confirm the correctness of the direction).

- To pay special attention to the designation of exits: number the exits and add landmarks (sights, parks, unique and significant places for people) in the form of graphic images or signatures that link the urban environment with the metro. Also, indicate the names of streets and numbers (taking into account the evenness or oddness of the houses) of the houses closest to the metro exits.

- To organize a regular committee to monitor the integrity and correctness of the navigation system.

- To replace the pictograms used to designate lines with more neutral and unambiguous graphic identification, such as numbers (used when the first Lisbon metro lines appeared) or the letter designations A, B, C, D (used to identify Lisbon metro lines until 1998).

- To clarify the colors used to designate lines and their names. If the line is pink, call it the "Pink Line", if the line is called the "Red Line", then display the metro in red. These changes will allow the name and color to be correctly matched. Throughout the entire display of the color of the lines in the metro, adhere to strict compliance with the display of color, regardless of the type of sign and type of lighting, i.e. minimize color migration.

- To move the emergency exit sign outside the signs indicating the names of streets, stations and metro lines. Always place the emergency exit sign separately from other signs. Also always use a backlight with an image of an emergency exit.

Multilingual Solutions

The survey revealed that the prevalence of Portuguese in text information creates a significant language barrier for foreign passengers. English is used selectively and irregularly.

Proposal:

- To introduce duplication of navigation information in English as a secondary language, while maintaining the significance and readability of information indicated in Portuguese.

- Duplication of audio notifications in English.

- Standardization of the signature at recurring significant locations, such as exits, transfers, platforms, etc.

Information Technology

Information technology is a powerful resource for adapting navigation in conditions of high mobility and multilingualism. Currently, the Lisbon Metro has limited capabilities in terms of digital navigation.

Proposal:

- Development of an official user-friendly mobile application with the function of navigating through stations, finding exits, building a route, receiving notifications, and planning time in several languages. The application should provide the function of purchasing or replenishing an electronic ticket in advance.

- Improving integration with existing travel applications, for example, Google maps, etc., in which it is necessary to indicate not only the route and abstract metro current on the map, but also to supplement it with information on the number of exits from the metro, with the display of numbers.

- Implementation of hints inside the cars to track the train's movement and plan possible transfers, utilizing displays. On the platforms, installation of interactive metro maps with the ability to confirm your location and find an exit to the city, as well as directions for making a transfer.

The proposed measures aim to create a more efficient, intuitive, accessible, and universal navigation system that takes into account the needs of passengers with diverse cultural and linguistic backgrounds, including both residents and visiting tourists and migrants. An integrated approach combining visual, linguistic, and digital solutions can significantly enhance the user experience, reduce anxiety, and increase the efficiency of transport infrastructure, while also complementing the city's image.

Conclusions

Synthesis of the Core Findings of the Study

Based on the literature review, the following insights can be drawn:

- Subway navigation systems play a crucial role in orienting users in complex underground spaces.
- Effective navigation reduces anxiety when using public places, particularly the subway.
- Well-read and legible signs help users quickly scan information, facilitating quick decision-making and, consequently, smooth movement.
- Navigation systems should include regular intermediate conformations of the correct direction to enhance psychological confidence.
- An effective navigation system requires a holistic systems approach, where each part of the visual design supports the others—maps, signs, color system, and lighting should work as a cohesive whole.
- Each sign in a system, each separate voice, serves a particular function and displays a specific kind of content called a message, which might include nonverbal graphic symbols, images, and words.
- The designer's task is not just to provide a person with as much data as possible but to structure and simplify the presentation.
- It is essential to recognize that there is no single definitive solution for implementing a wayfinding system. It is necessary to consider multiple factors and the structure of the information within the context of the space and the decision-making process.
- Typography directly affects the perception and clarity of navigation: a readable font with optimal parameters (font size, line spacing, letter spacing, contrast, and readability) ensures quick reading of information, which is especially important in a dynamic metro environment.
- There are specific rules for using color in public places: it is necessary, if possible, to use no more than nine colors in color coding. Colors should be simple (which can be named out loud), the same in brightness, but distinguishable by color (for example, avoid using two shades of red or two shades of blue). It is necessary to understand how color works in

the context of other colors and avoid using colors of the same tone or the same area of fill (it does not matter whether they are light or dark).

- Well-organized lighting not only facilitates navigation but also forms the overall perception of the metro space. Thoughtful lighting design helps guide passengers, improves the readability of signs, and builds a visual hierarchy within the station.
- Durability, specifically the quality of materials, printing, design, and maintenance, impacts the preservation of readability and appearance, enhancing user experience and reducing the cost of restoration and maintenance of navigation system elements.

Based on the analysis of existing metro maps and navigation systems in various countries, we can draw the following conclusions: conciseness, clarity, and logic are the primary principles of successful metro systems and maps. Generally, the information is intuitively understandable for various user groups, including residents, tourists, and migrants, and is translated into English for easy comprehension. Additionally, effective systems have minimal or no visual overload, employ a single approach and color coding in their design, and utilize readable sans-serif fonts. According to the results of the online survey, navigation in the Lisbon metro generally performs its function but not as effectively as users would like. Particular attention should be paid to the designation of exits, the correspondence of the color of the lines to their names, the explanation of pictograms, and the installation of additional signs at key points and at transfer points to another line. Transliteration should also be carried out where it is truly necessary. At the same time, there were no problems with the readability of the text, which indicates sufficient legibility of the font (font type, font size, font color to background color ratio).

An essential role in the study was played by the interview with the designer Rodionov Mark, which confirmed the difficulties of integrating visual elements into the metro environment familiar to residents, taking into account the architectural aspect, as well as the need to adapt information for different user groups, including tourists. In addition, an essential role in the creation of navigation systems is played by the following elements: language, cultural characteristics, public preferences, cultural and socially significant landmarks and unique objects in the city near the metro exits. The numbering of repeating elements, such as metro exits or metro lines, is important. It is also essential to install signs in decision-making places, and in long corridors, confirming the location or direction.

Field observations conducted in various Lisbon metro stations revealed some differences in approaches to visual coding. It allowed us to identify systemic problems: lack or discrepancy of visual information on signs (arrows, elevators, etc.), backlighting of signs in some cases interfering with reading information, discrepancy of line colors between those used in light boxes and those printed on signs without backlighting, incorrect indication of streets before exiting the metro into the city, lack of additional landmarks before exiting into the city, lack of transliteration, low wear resistance of materials (wrinkling and breakage), especially on signs located on the street at the entrance to the metro.

The creative author's installation illustrates the connection between finding one's way in life and finding one's way in travel. Thus emphasizing the importance of the task "Find your way" and, as a result, the importance of navigation in the life of any person.

These findings formed the basis of the current study. With that, it was possible to identify problems in the Lisbon metro navigation system, and to propose possible solutions that are understandable to residents, tourists, and migrants, adapted to the metro environment.

Research Limitations

Despite the in-depth analysis and extensive data obtained using the triangulation methodology, this study has several limitations:

1. Photographic recording and in-depth on-site research was conducted only in the Lisbon metro, while data for other systems (London, Paris, Moscow) were collected to a greater extent remotely. This may affect the conclusions.
2. The field study was conducted on only two metro ways: from Bela Vista to Cais do Sodré and from Bela Vista to Saldanha. This limits the full understanding of the perception problem of the metro navigation system. It is therefore necessary to conduct a more extensive study on all Lisbon metro stations.
3. The online survey was conducted among a limited number of participants and does not cover the entire age range of users and all demographic groups (e.g., elderly people, individuals with special needs), whose perceptions of navigation may differ. Additionally, an offline survey among metro users directly inside the metro was not conducted, which would have allowed for the collection of more relevant information on the spot.

4. Only one interview was conducted with the navigation designer. Interviews with specialists with different experience and related professions related to navigation in public spaces could have expanded the range of knowledge from a practical point of view.
5. Some sources, interviews, and questionnaires were translated from Russian and Portuguese into English, which may have distorted the interpretation of the data.
6. Due to limited time, it was not possible to analyze the distribution of people flows inside the metro and their behavioral changes and reflections while moving inside the metro.
7. During the entire period of the study, several attempts were made to contact the Metro staff via the email address (atendimento@metrolisboa.pt) indicated on the official Lisbon Metro website, but no response was received within three months. Accordingly, there was no interaction with Metro staff. Both with employees at the station and with employees in the main office. Interviews and interactions with metro employees could have provided an alternative perspective on the navigation problems in the metro, as well as expanded the possibilities of the study.

Recommendations for Future Studies

1. To conduct an analysis of navigation systems in London, Paris, and Moscow through field research and interviews with various users and specialists, and expand the comparative analysis of navigation systems in other countries.
2. To consider how people who are colorblind, blind, visually impaired, or have cognitive or motor impairments perceive navigation. This may change the approach to designing navigation systems in the metro.
3. Based on the conclusions and proposals made in the dissertation, it would be possible to develop prototypes and conduct user testing in real conditions.
4. A separate study may be devoted to analyzing digital travel trends, mobile applications, AR/VR navigation, and their integration into the physical environment of the metro.
5. To conduct a comprehensive study together with different specialists in the field of navigation design, with the support of the metro.

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Appendices/Annexes

Appendix/Annex A: Visual Support for Literary Review

Figure A1. *Medieval world map from around 1300.* From *Information Graphics* (p. 14-15), by S. Rendgen & J. Wiedemann, 2020, Taschen.

Figure A2: *Wayfinding system at Waterloo International Station, London.* From *Information Graphics: Innovative Solutions in Contemporary Design* (p. 29), by P. Wildbur & M. Burke, 1998, Thames & Hudson.

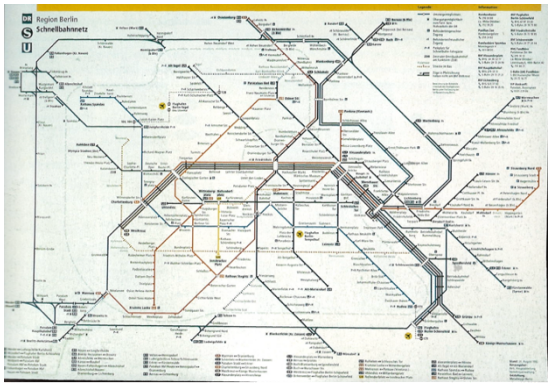


Figure A3: *Berlin railway map showing the subway and suburban train routes.* From *Information Graphics: Innovative Solutions in Contemporary Design* (p. 49), by P. Wildbur & M. Burke, 1998, Thames & Hudson.

Basic wayfinding task	Corresponding spatio-cognitive manipulation
1. learning a new route	recording a decision plan and/or developing a cognitive map
2. returning to the point of origin (retracing one's steps)	inverting a decision plan or the mapped route
3. linking known routes to new configurations	combining decision plans or sections of mapped routes into new combinations
4. learning a route from a small display and making the journey	making a transfer of scale
5. pointing to the directions of locations visited on a journey	making a triangulation
6. learning a route from a non-aligned display	making a mental rotation
7. understanding the overall layout of a visited setting	identifying the underlying principle of spatial organization

Figure A4: The basic wayfinding tasks and the corresponding spatio-cognitive manipulations. From *Wayfinding: People, Signs, and Architecture* (p. 39), by P. Arthur & R. Passini, 1992, McGraw-Hill Book Company.

Figure A5: Three typical pictographs: "information" (left), "enter" (middle), "no entry" (right). From *Wayfinding: People, Signs, and Architecture* (p. 146), by P. Arthur & R. Passini, 1992, McGraw-Hill Book Company

Figure A6: Screenshot of Google Images search results for "information sign". Retrieved from https://www.google.com/

Figure A7: Example of Identification Signs. Adapted from *The Wayfinding Handbook: Information Design for Public Places* (p. 48), by D. Gibson, 2009, Princeton Architectural Press. Copyright 2009 by Princeton Architectural Press

Figure A8: Example of Directional Signs. Adapted from *The Wayfinding Handbook: Information Design for Public Places* (p. 50,51), by D. Gibson, 2009, Princeton Architectural Press. Copyright 2009 by Princeton Architectural Press

Figure A9: Example of Orientation Signs. Adapted from *The Wayfinding Handbook: Information Design for Public Places* (p. 52), by D. Gibson, 2009, Princeton Architectural Press. Copyright 2009 by Princeton Architectural Press

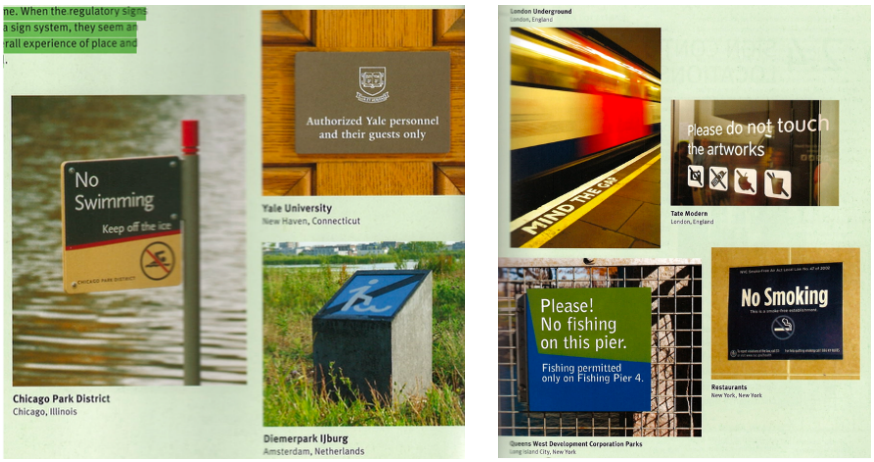


Figure A10: Example of Regulatory or Warning signs. Adapted from *The Wayfinding Handbook: Information Design for Public Places* (pp. 55-56), by D. Gibson, 2009, Princeton Architectural Press. Copyright 2009 by Princeton Architectural Press

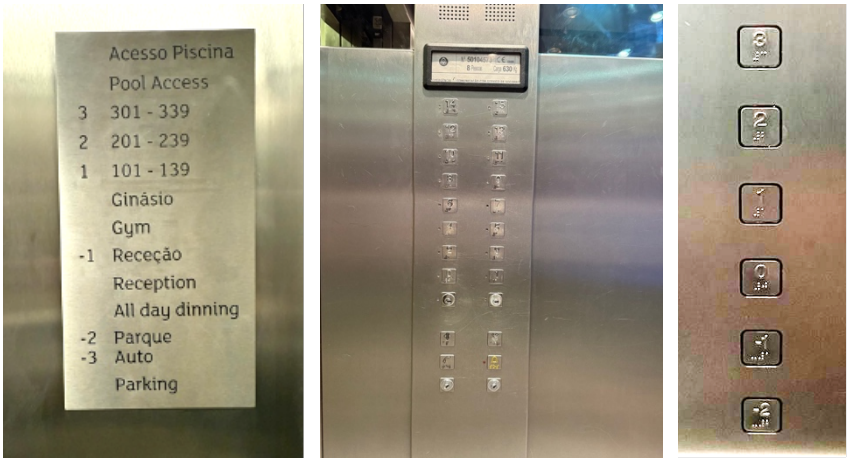


Figure A11: Different floor markings in elevators. Photo taken by the author in different buildings in Lisbon, Portugal, 2025

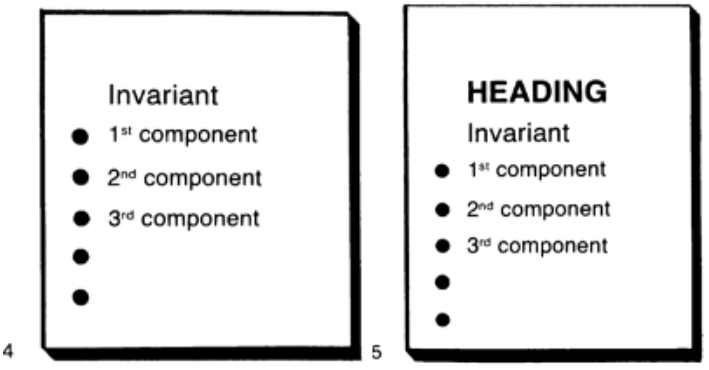


Figure A12: Invariants and components. From *Semiology of Graphics* (p. 21), by J. Bertin, 2010, Esri Press.

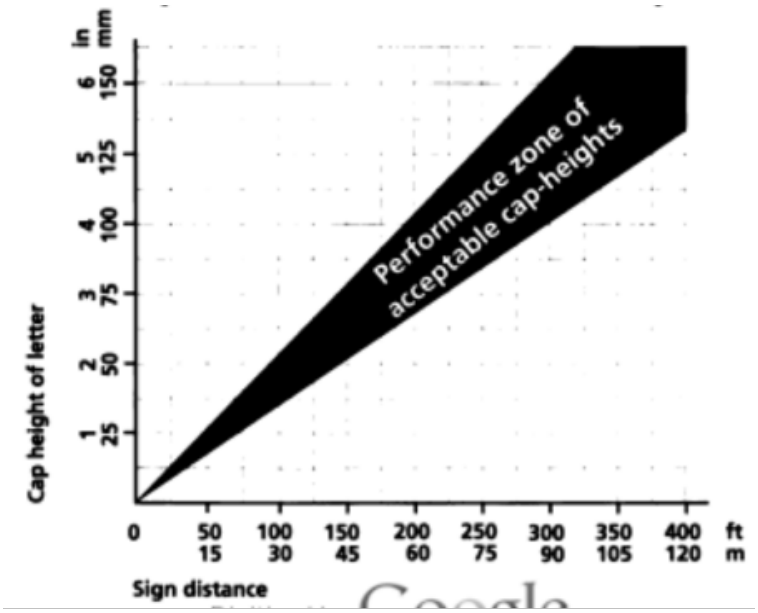


Figure A13: Chart illustrating legibility-distance data based on cap-heights in Helvetica – under perfect conditions. From *Wayfinding: People, Signs, and Architecture* (p. 165), by P. Arthur & R. Passini, 1992, McGraw-Hill Book Company

Figure A14: The Spectrum. From *The Wayfinding Handbook: Information Design for Public Places* (p. 60), by D. Gibson, 2009, Princeton Architectural Press. Copyright 2009 by Princeton Architectural Press

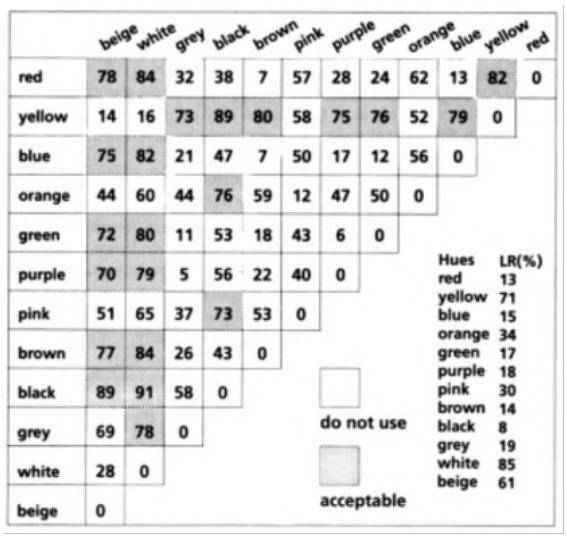


Figure A15: A table for calculating brightness differentials between the two colors that normally constitute the letters and the background of a wayfinding sign. From *Wayfinding: People, Signs, and Architecture* (p. 179), by P. Arthur & R. Passini, 1992, McGraw-Hill Book Company

Figure A16: *An example of color coding in Argentina's metro sign system.* From *Information Graphics: Innovative Solutions in Contemporary Design* (p. 46-47), by P. Wildbur & M. Burke, 1998, Thames & Hudson.

Figure A17: Screenshot of Google Images search results for "sign exit".
Retrieved from https://www.google.com/

Figure A18: The colors on the Lisbon metro map are washed out by the sun. *All photos taken by the author, 2025.*

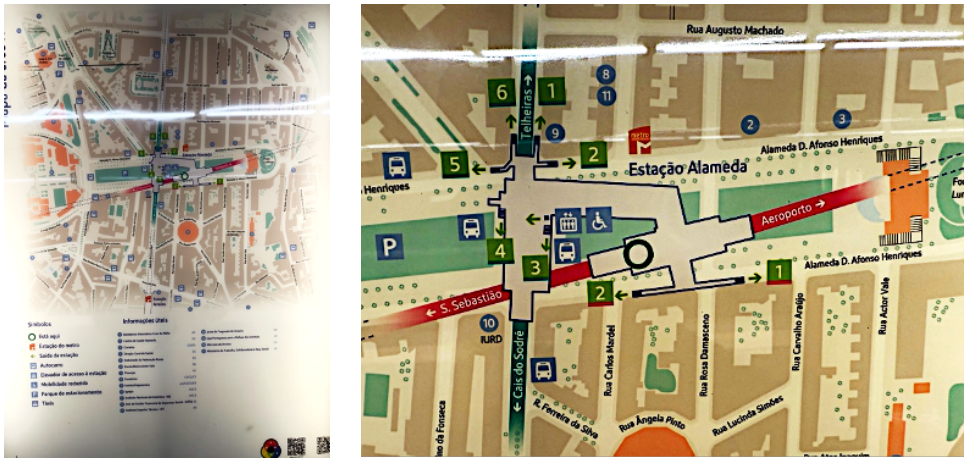


Figure A19: Metro exit numbers marked on a map of the Lisbon metro at Alameda station. *All photos taken by the author,* 2025

Appendix B: Marshak's poem *The Absent-Minded Fellow*

He climbed into the uncoupled carriage,
Brought in his bundles and suitcases,
Pushed them under the sofas,
Sat in the corner by the window
And fell into a peaceful sleep.
- What kind of a stop is this?
- He shouted early in the morning.
And from the platform they say:
- This is the city of Leningrad!
He slept a little again
And again, he looked out the window,
Saw a large station,
He was surprised and said:
What kind of a station is this
- Dibuny or Yamskaya?
And from the platform they say
- This is the city of Leningrad!
He shouted:
- What kind of joke is this!
I've been traveling for two days,
And I came back,
And I came to Leningrad!
What an absent-minded person
From Basseynaya Street![6]
(Marshak, 1930, p. 7-10)

[6] Marshak, S. (1930). *The absent-minded fellow*. State Publishing House. *(Original work in Russian)*

Appendix C: Arthur and Passini's "horizontal band" Principles *VisuCom's InfoBand 1* and *InfoBand 2* (1992, pp. 200-201)

1. VisuCom's InfoBand 1 refers to information being captured in a horizontal band exactly 16 inches (400 mm) deep and located 47–63 inches (1200–1600 mm) above the ground or floor. These size restrictions are based on the fact that the band "Comfortably within the cone of vision of pedestrians, both adults and children and of people in wheel-chairs." This level "may extend no more than 16 inches (400 mm) in height, allowing for no more than five lines of type" and "the cap-height of the typeface used should be 1.75 inches (45 mm). VisuCom's InfoBand 1 relates solely to wayfinding information and therefore does not include thermostats, light switches or fire alarms, which must be located within it and are also limited to the level.
2. InfoBand 2 - this type of band is installed directly above the door, has its own dimensional parameters: distance from the ground/floor "the 87 inches (2200 mm) level and extending to the ceiling, or a maximum height of 118 inches (3000 mm)" and is used: "for the display of large pictographs on walls over doorways to identify their use from a distance. It may also include suspended signs that have a similar (or a directional) function".

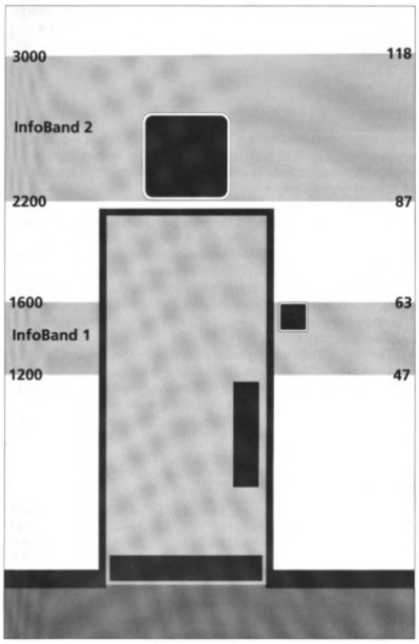


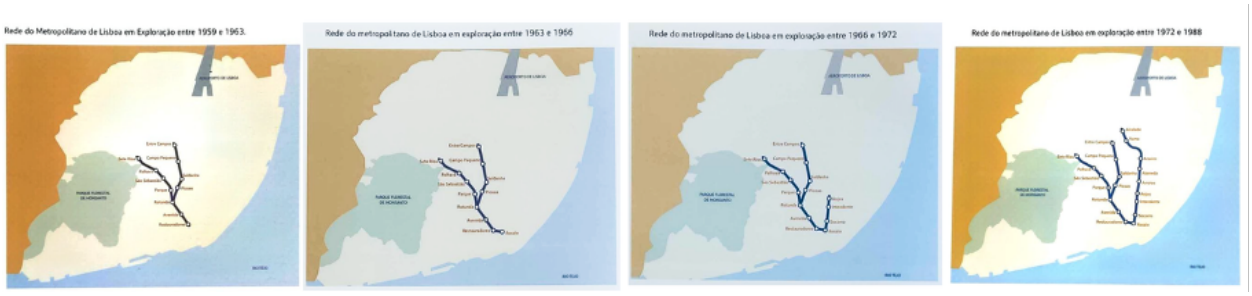
Figure C1: Visual arrangement of two information bands: VisuCom's InfoBand 1 and InfoBand 2. On the left side are the dimensions in millimeters, on the right in inches. From *Wayfinding: People, Signs, and Architecture* (p. 146), by P. Arthur & R. Passini, 1992, McGraw-Hill Book Company

Appendix D: Visual Support for Overview of the Lisbon Metro System

Quadro 6 **1.º escalão da 1.ª fase da rede do Metropolitano de Lisboa**

Data da Inauguração	Extensão (quilómetros)	Estações		Número de estações	Distância média entre estações (metros)
29.12.1959	6,513	Entre Campos	EC	11	592
		Campo Pequeno	CP		
		Saldanha	SL		
		Picoas	PI		
		Rotunda	RT		
		Avenida	AV		
		Restauradores	RE		
		Sete Rios	SR		
		Palhavã	PL		
		São Sebastião	SS		
		Parque	PQ		

Figure D1: 1st phase of the Lisbon Metro network, 1959. From: Rollo, M. F. (1999). *Um metro e uma cidade* (Vol. 1, p. 44). Metropolitano de Lisboa, E.P.



1 **2** **3** **4**

Figure D2: Development of the Lisbon metro in different years: 1) 1959-1963; 2) 1966-1972; 3) 1972-1988. Adapted from: Rollo, M. F. (1999). *Um metro e uma cidade* (Vol. 1, pp. 305, 354, 364, 394). Metropolitano de Lisboa, E.P

Figure D3: Lisbon Metro network in December 1999. From: Rollo, M. F. (1999). *Um metro e uma cidade* (Vol. 2, p. 309). Metropolitano de Lisboa, E.P

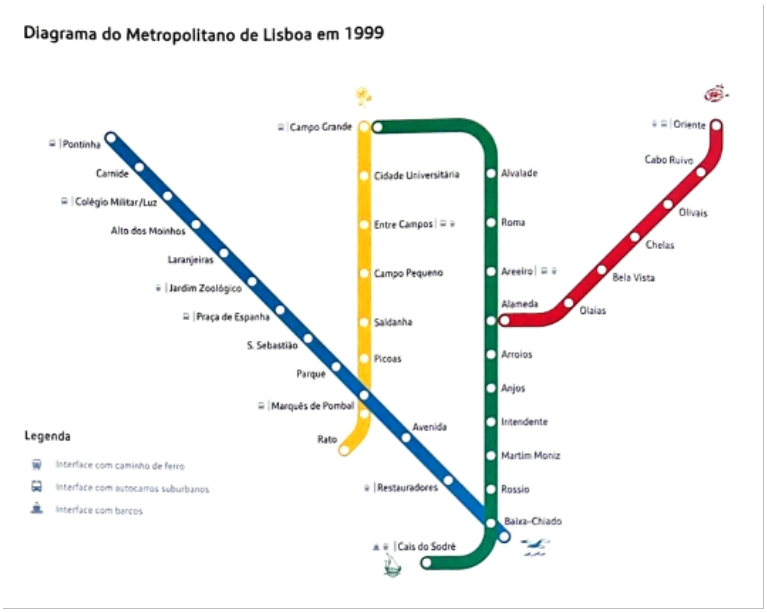


Figure D4: Lisbon Metro Diagram in 1999. From: Rollo, M. F. (1999). *Um metro e uma cidade* (Vol. 2, p. 310). Metropolitano de Lisboa, E.P

Figure D5: *Lisbon Metro Network Map.* Adapted from Metropolitano de Lisboa, 2025, https://www.metrolisboa.pt/en/travel/diagrams-and-maps/. © Metropolitano de Lisboa.

Figure D6: *Name of the lines indicated on Status updates for lines on the site.* Adapted from Metropolitano de Lisboa, 2025, https://www.metrolisboa.pt/company/ .© Metropolitano de Lisboa.

Figure D7: Collage of photographs taken by the author at the Carris Museum in Lisbon, 2025

Figure D7: *A fragment of the Lisbon metro map showing the Purple Line extension project.* Adapted from Metropolitano de Lisboa, 2025, https://projetos.metrolisboa.pt/expansao/linha-violeta/ . © Metropolitano de Lisboa.

Figure D8: Examples of Directional Signs in the Lisbon Metro System (2). *All photographs in this table were taken by the author, 2025.*

Figure D9: Lisbon metro lines. Collage assembled from images from the official website. Adapted from *Metropolitano de Lisboa*, 2025, https://projetos.metrolisboa.pt/expansao/linha-violeta/. © Metropolitano de Lisboa.

Figure D10: ColorADD code system for colorblind users. Adapted from ColorADD,n.d., https://www.coloradd.net/en/coloradd-code/. © ColorADD.

Figure D11: Minimal use of English in signage in the Lisbon Metro. All photographs in this collage were taken by the author, 2025.

Figure D12: "Cais terminal" sign at "Cais do Sodré" station in the Lisbon Metro. All photos taken by the author, 2025.

Figure D13: Signs pointing into the wall at Saldanha station in the Lisbon Metro. *Photo taken by the author*, 2025.

Figure D14: Signs at the Alameda station in the Lisbon Metro. *Photo taken by the author,* 2025.

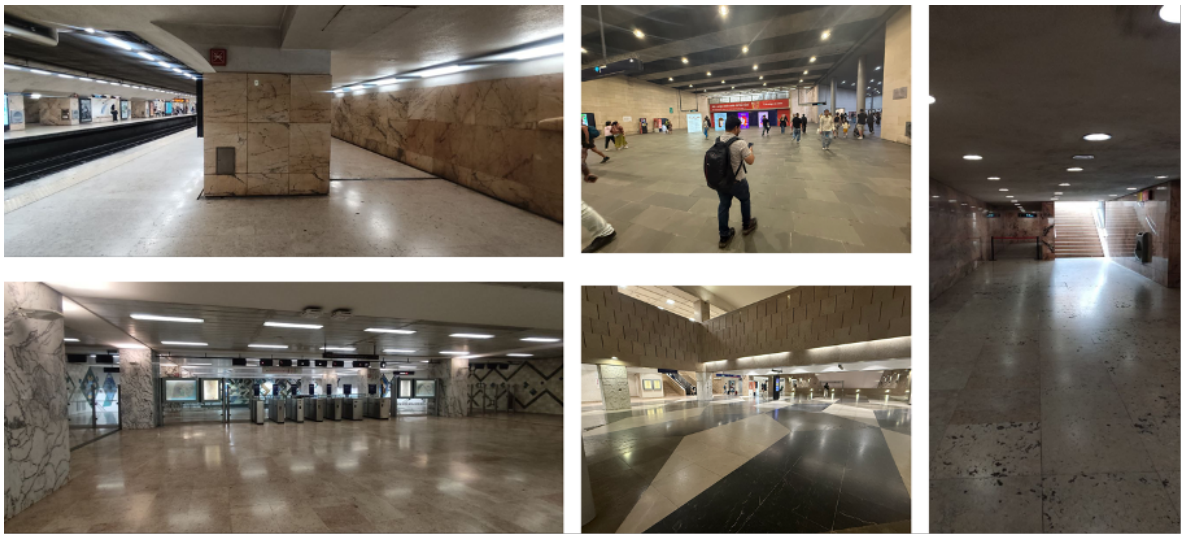


Figure D15: Lack of signs at different stations in the Lisbon Metro. *Photos taken by the author*, 2025.

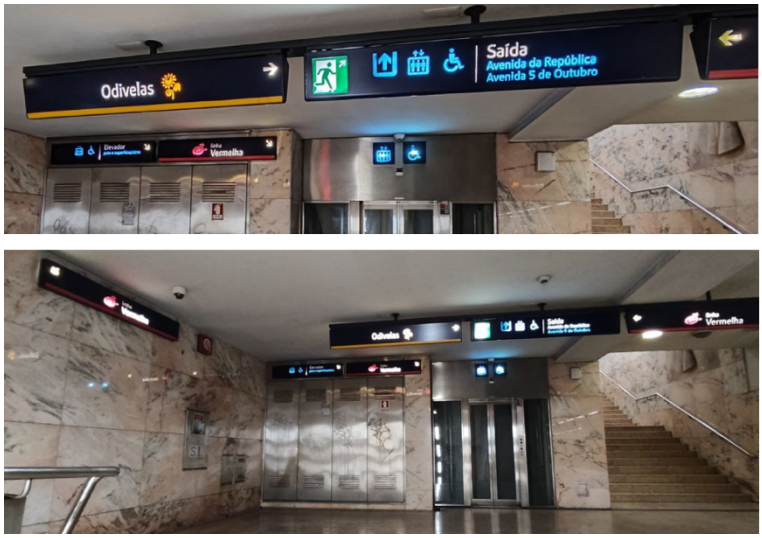


Figure D16: Too many signs at Saldanha station in the Lisbon Metro. Photos taken by the author, 2025.

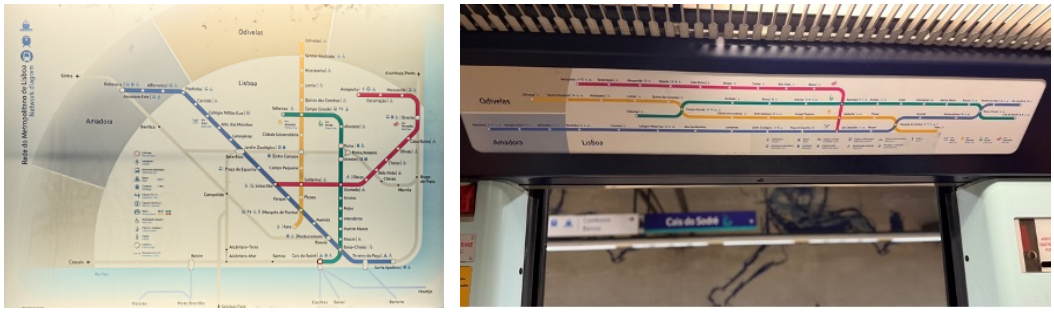


Figure D17: Left: The full Lisbon metro map. Right: The modified Lisbon metro map inside a metro car. *All photos taken by the author, 2025.*

Figure D18: Aesthetic and technical problems with signage in the Lisbon metro. *All photos taken by the author, 2025.*

Appendix E: Survey with Immigrants, Visitors, and Local Residents

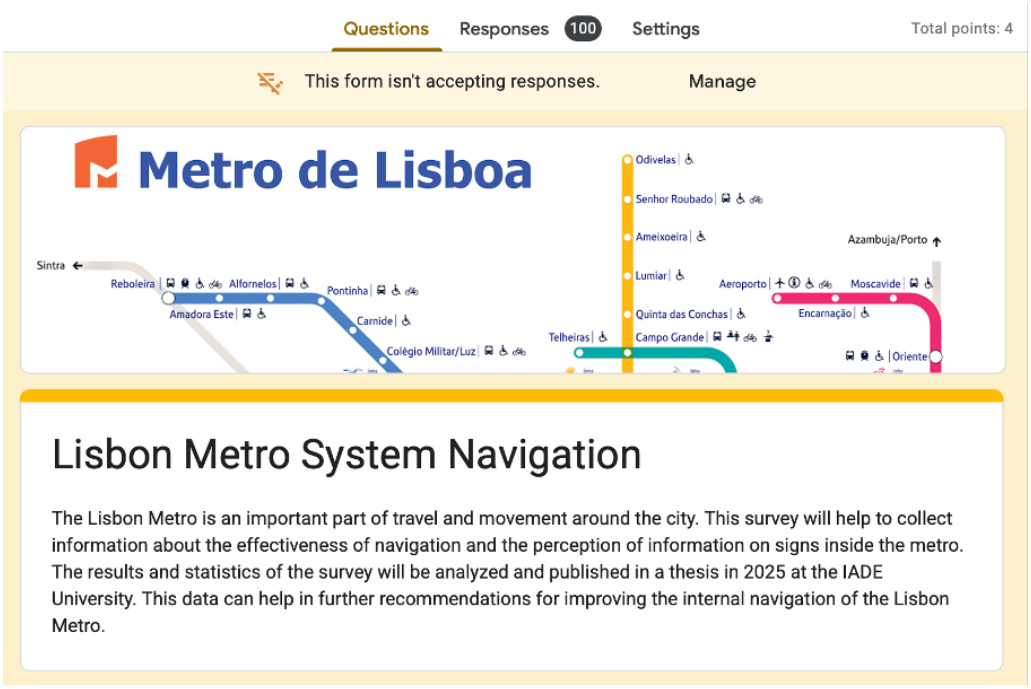


Figure E1: Online survey cover header

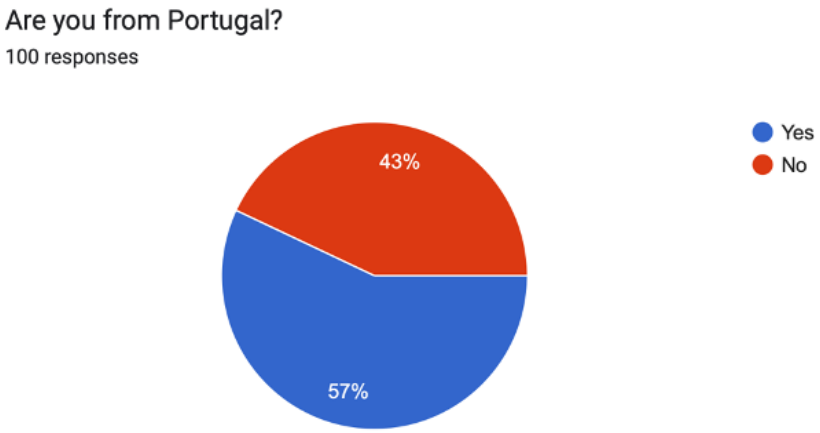


Figure E2: Results of the first question of the questionnaire: "Are you from Portugal?"

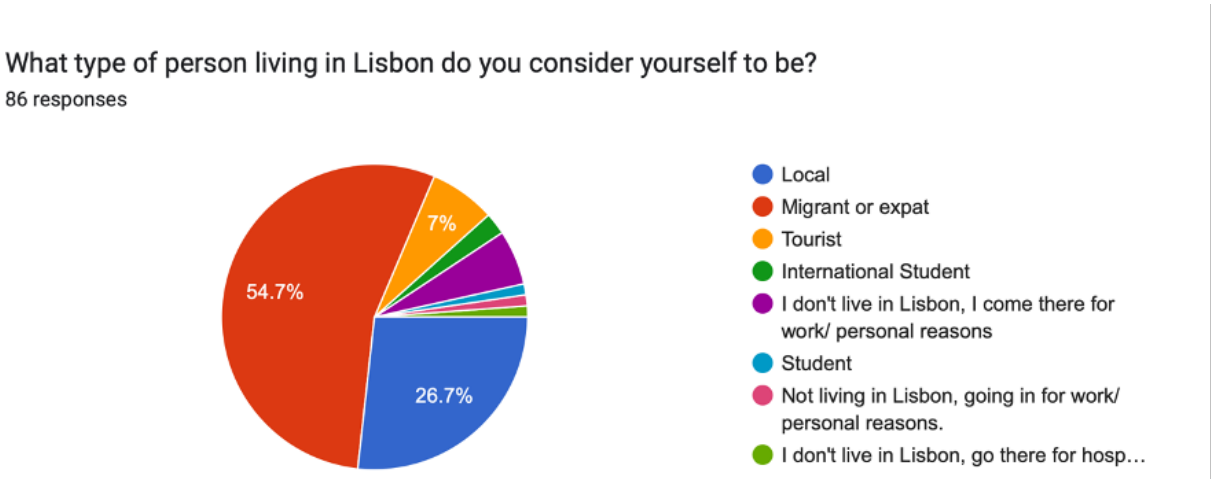


Figure E3: Results of the second question of the questionnaire: "What type of person living in Lisbon do you consider yourself to be?"

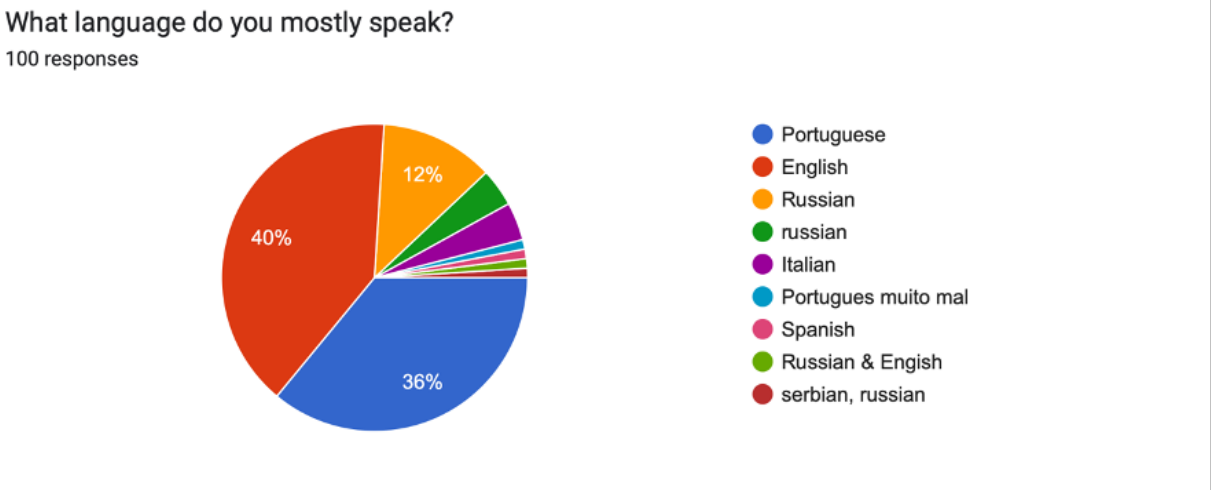


Figure E4: Results of the third question of the questionnaire: "What language do you mostly speak?"

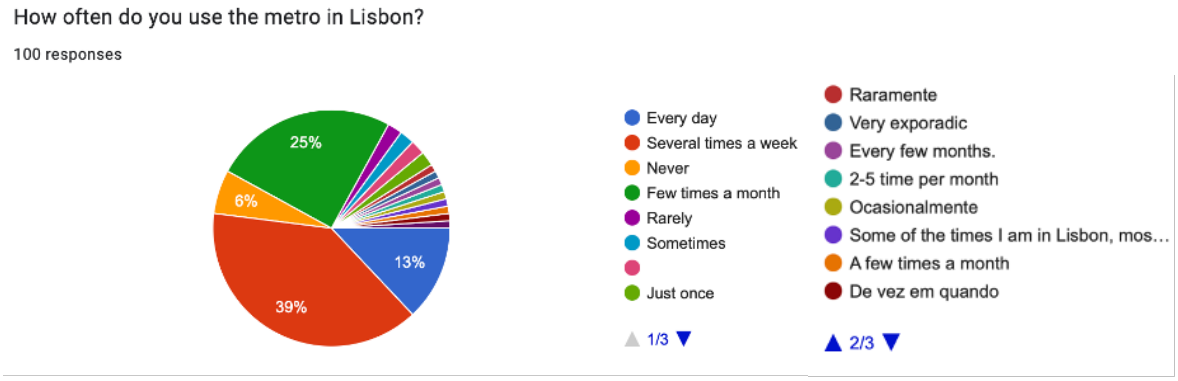


Figure E5: Results of the fourth question of the survey: "How often do you use the metro in Lisbon?"

Figure E6: An excerpt from the results of the fifth question of the questionnaire: "Which station do you use most often?"

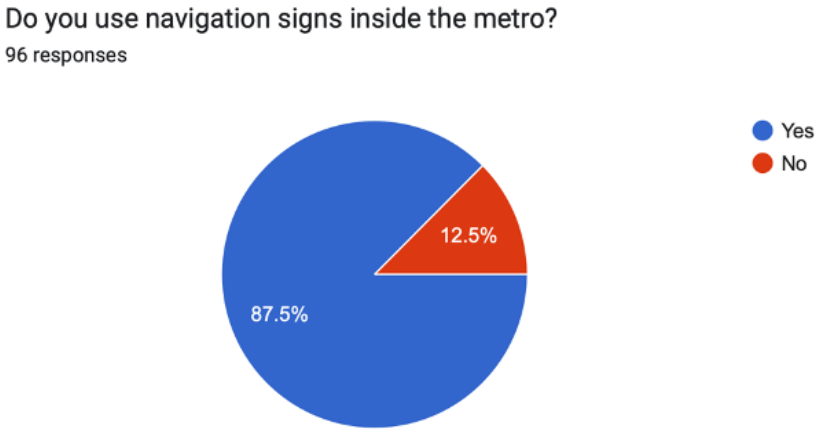


Figure E7: Results of the sixth question of the survey: "Do you use navigation signs inside the metro?"

Figure E8: Results of the seventh question of the survey: "How effective do you rate the navigation system inside the Lisbon metro?"

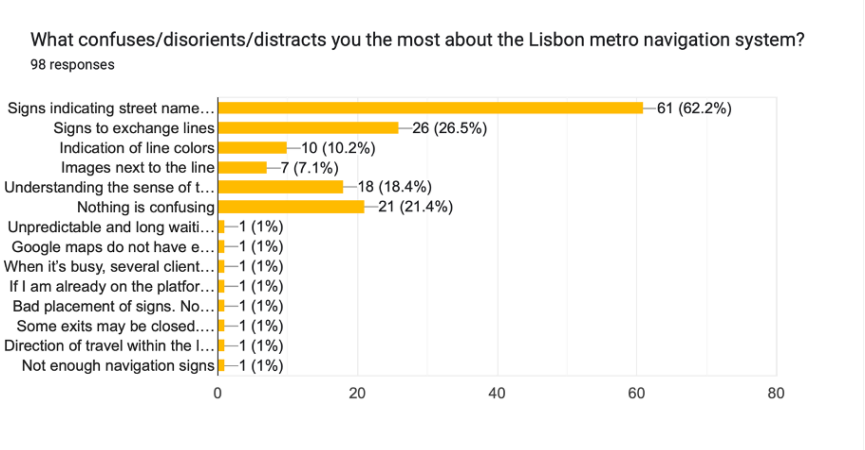


Figure E9: Results of the eighth question of the survey: "What confuses/disorients/distracts you most about the Lisbon metro navigation system?"

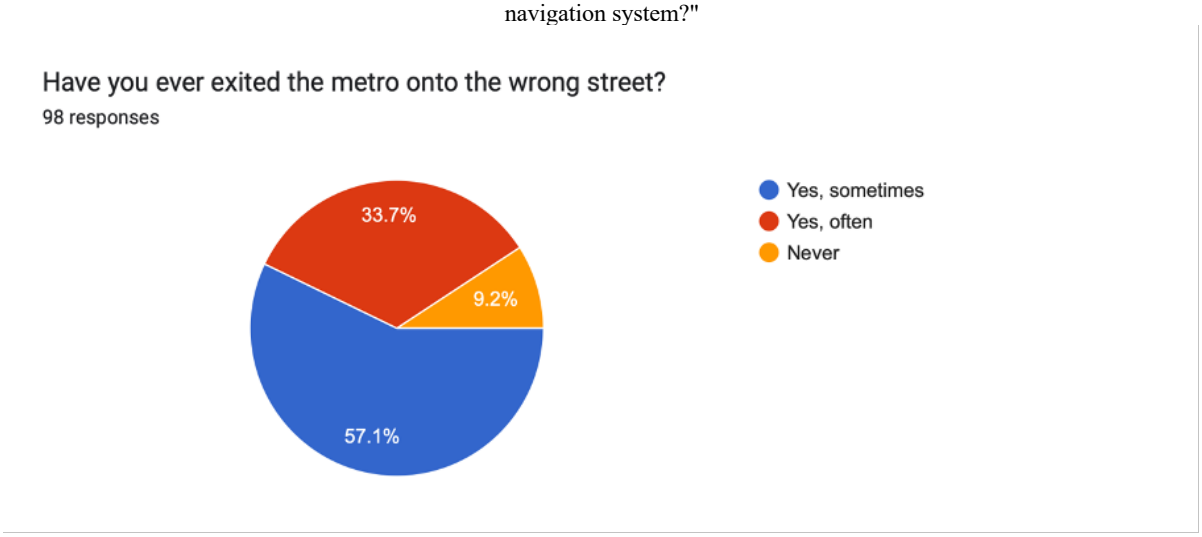


Figure E10: Results of the ninth question of the survey: "Have you ever exited the metro onto the wrong street?"

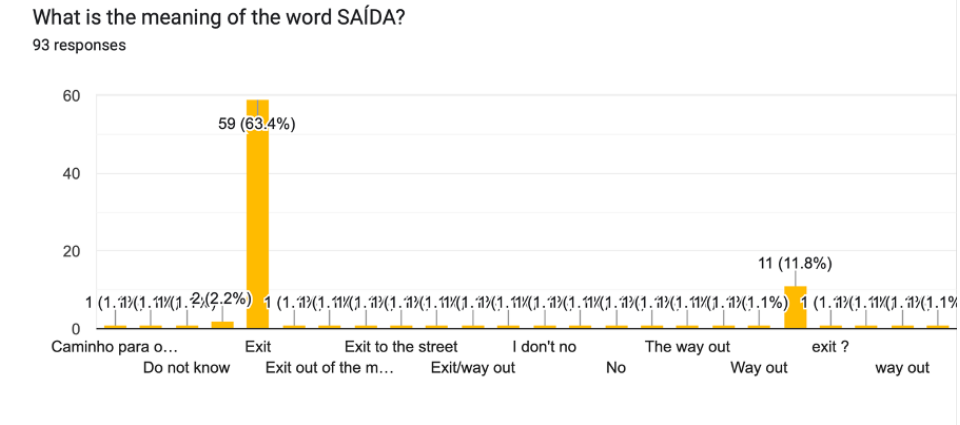


Figure E11: Results of the tenth question of the questionnaire: "What is the meaning of the word SAÍDA?"

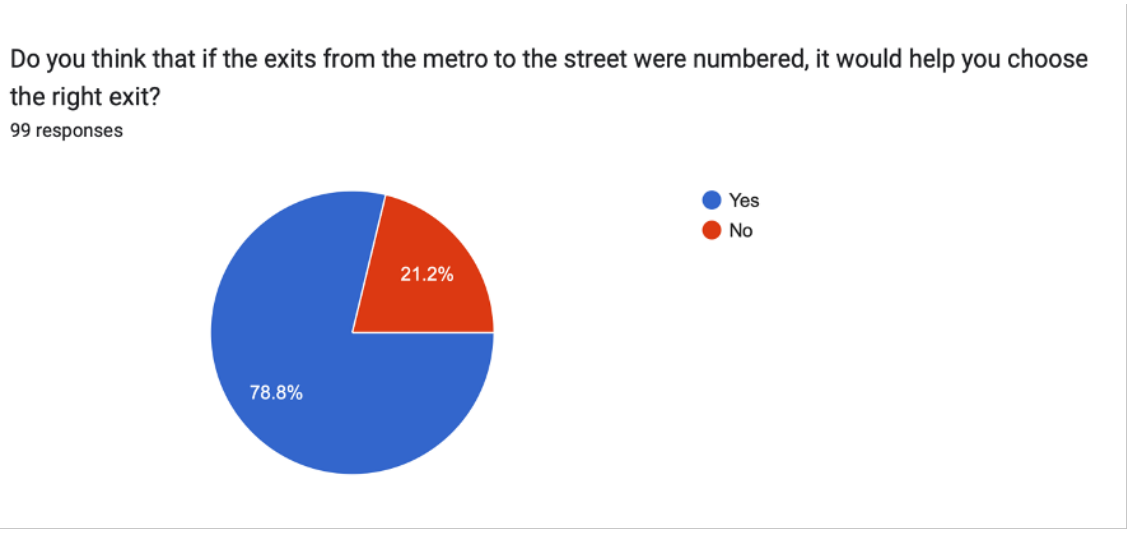


Figure E12: Results of the eleventh question of the questionnaire: "Do you think that if the exits from the metro to the street were numbered, it would help you choose the right exit?"

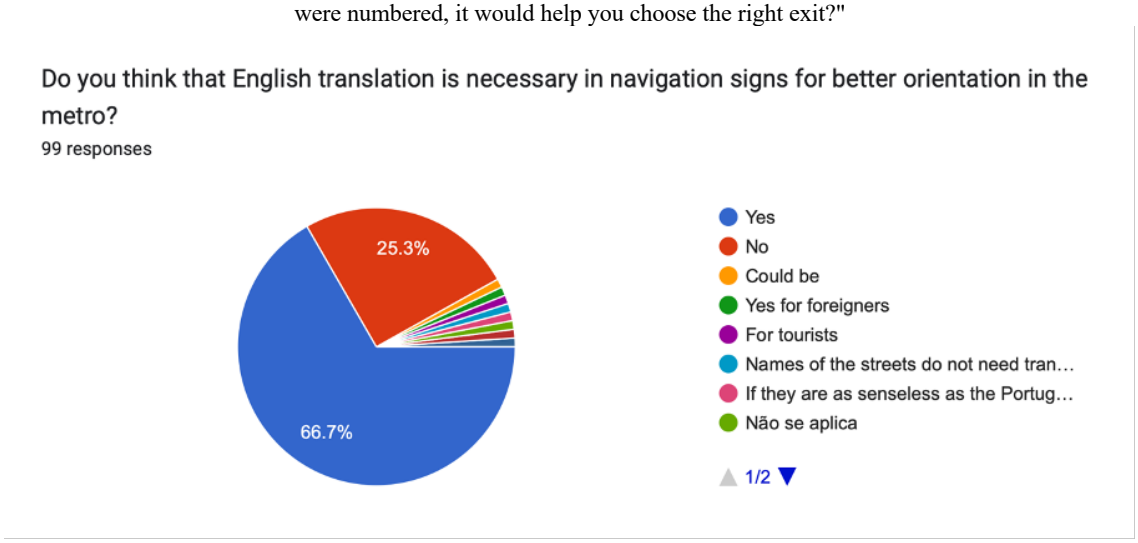


Figure E13: Results of the twelfth question of the questionnaire: "Do you think that English translation is necessary in navigation signs for better orientation in the metro?"

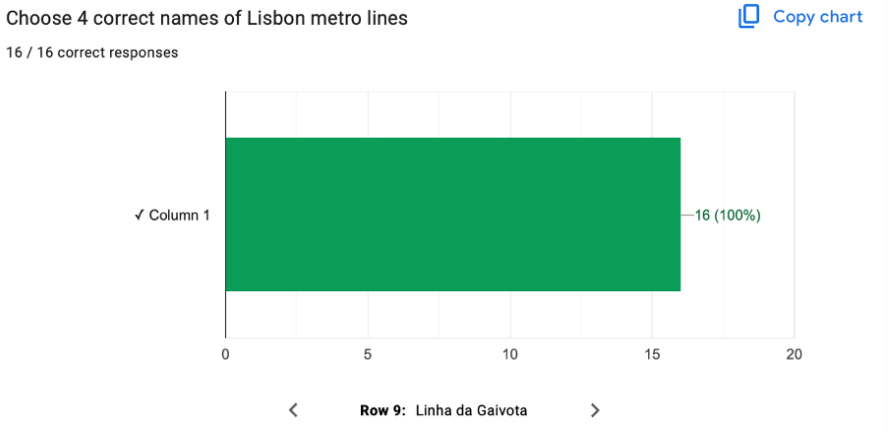


Figure E14: An excerpt from the results of the thirteenth point of the questionnaire: "Choose 4 correct names of Lisbon metro lines" (using "Linha da Gaivota" as an example)

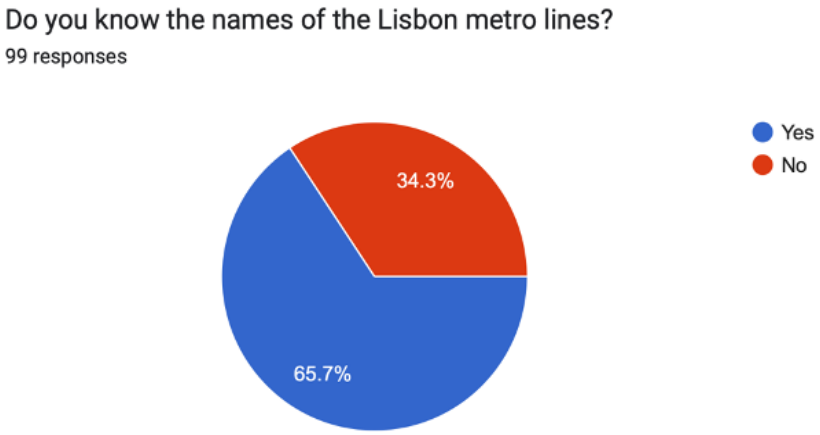


Figure E15: Results of the fourteenth question of the questionnaire: "Do you know the names of the Lisbon metro lines?"

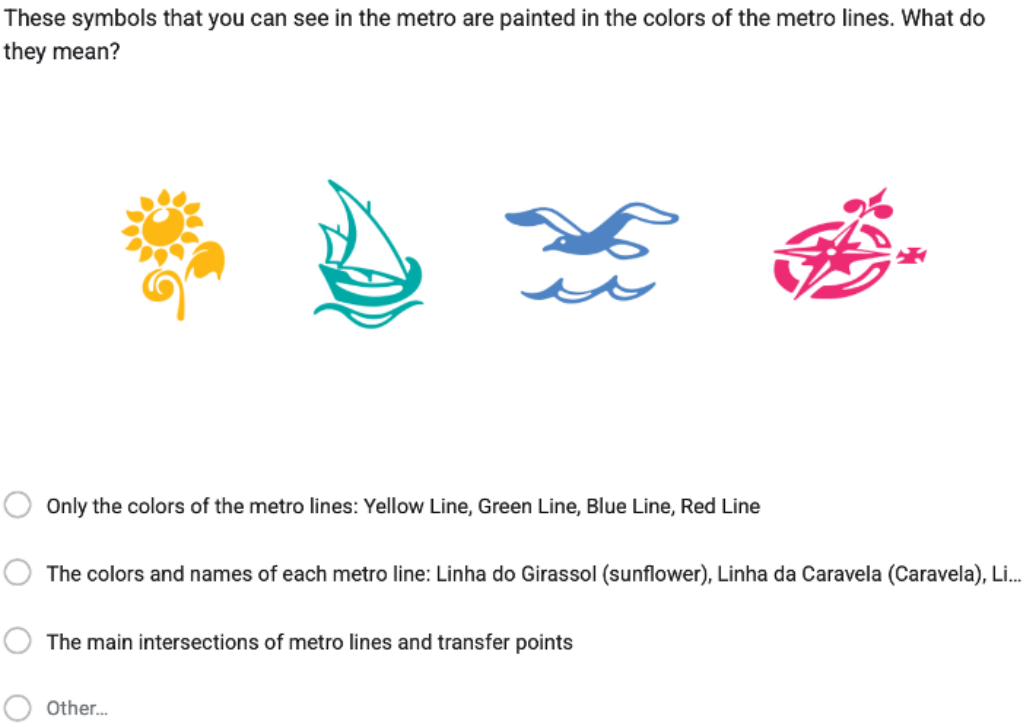


Figure E16: Symbols shown in question fifteen of the survey

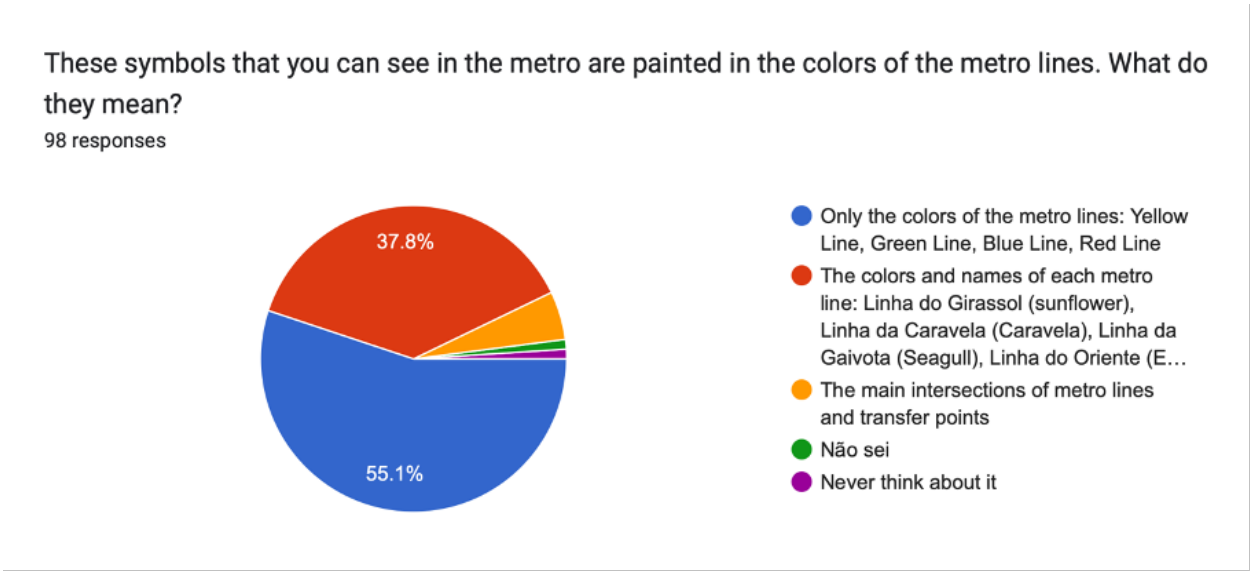


Figure E17: Results of the fifteenth question of the survey: "These symbols that you can see in the metro are painted in the colors of the metro lines. What do they mean?"

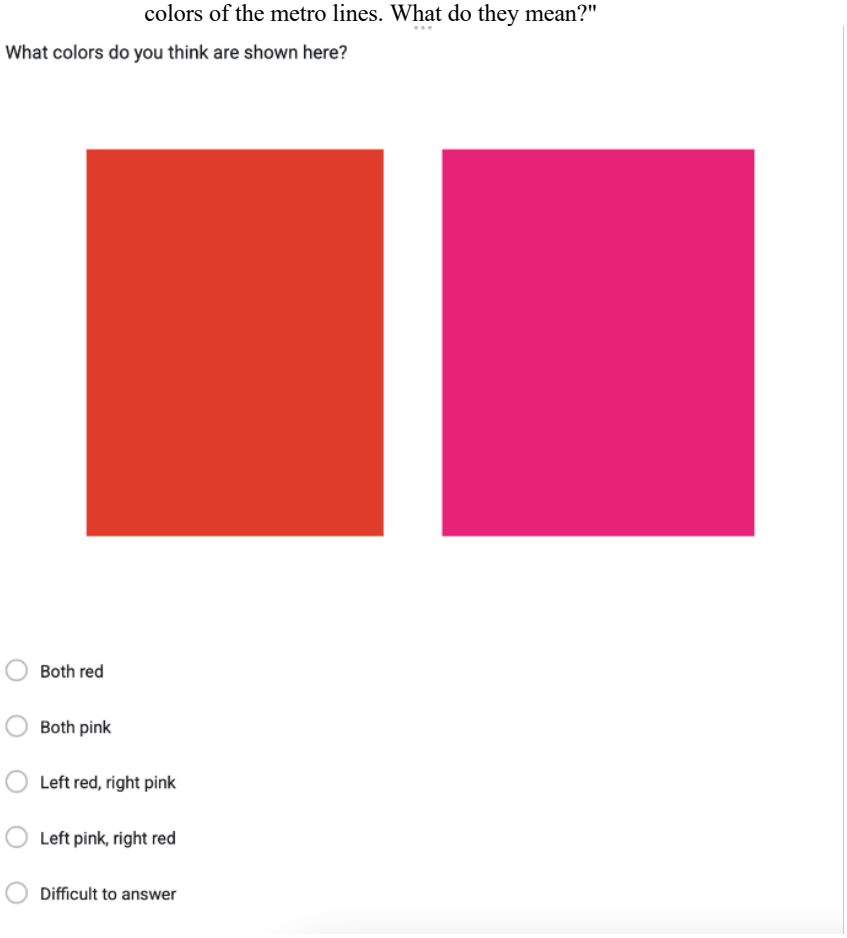


Figure E18: Colours used for the sixteenth question survey

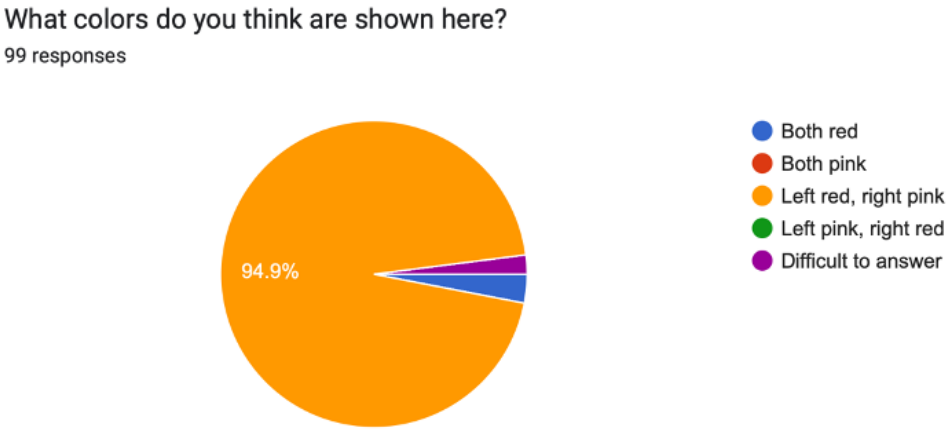


Figure E19: Results of the sixteenth question of the survey: "What colors do you think are shown here?"

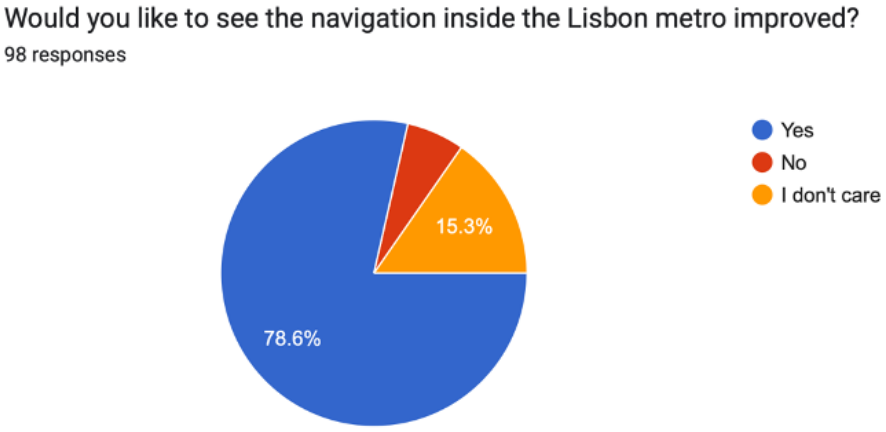


Figure E20: Results of the seventeenth question of the survey: "Would you like to see the navigation inside the Lisbon metro improved?"

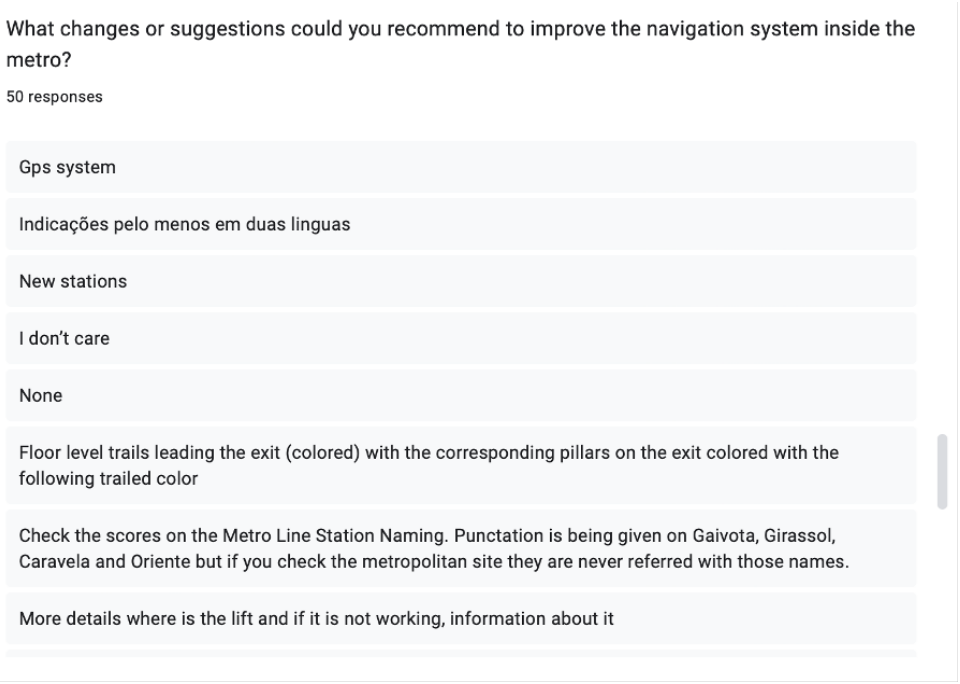


Figure E21: An excerpt from the results of the eighteenth question of the survey: "What changes or suggestions could you recommend to improve the navigation system inside the metro?"

Full weight of answers to the question: "What changes or suggestions would you recommend to improve the navigation system inside the metro?":

"Demolish everything and start a new one", and "Some cities create apps that automatically calculate the optimal route and also show which carriage (from first to last) will be closer to the exit. This would be helpful to have in Lisbon", "Add a map on the exit, showing you the position and exits with numbers. Also, those numbers can be shown on Google maps to make it easy to plan the journey. To make shorter breaks between trains and make it more predictable (like fixed intervals or a schedule)", "Integration with google maps", "Better warning for people with disabilities", "Moscow metro map", "Making it easier to understand which side to exit on to get to the correct street", "The information to be bigger and clearer", "Real time connected to google maps", "A sinalética das ruas nas saídas poderia ser mais clara, com mais pontos de referência e estarem melhor identificadas nos mapas que estão afixados nas estações", "Floor prints guiding people inside the station on line intersections", "Bring metro maps to train departure platforms", "Number the street exits. Then, more definite signs on junction stations. Use different names on junction stations from different lines to make it more clear", "Redo all the navigation. Make flows

of people not intersect at entrance/exit/transfer. Make signs relevant to places. Get rid of sul/norte/oeste indications - no one uses a compass and map in the metro. Assign directions to meaningful buildings and monuments in the streets", "English translation", "Authority must listen to customers who use the metro everyday", "Bigger signs", "Line should have "number" name. A platform should have a clear sign with the current line name and the direction. Paris's subway is a good example", "Numbers of the exits", "Map with street near the metro station and near the exits", "Indications of the exit, where do they lead", "Maps (including in the platforms) displaying what each exit gives access to", "Numbers of exits, or names like A, B, C etc.; bathrooms", "To number exits, mark exits to well know places (Loja da Cidadão, McDonald's, etc)", "Hire a professional company with experience in this field that could develop a complete design and a set of requirements for the placement of diagrams and signs in the metro and underground passages", "Gps system", "Indications in at least two languages", "New stations", "Floor level trails leading the exit (colored) with the corresponding pillars on the exit colored with the following trailed color", "Check the scores on the Metro Line Station Naming. Punctation is being given on Gaivota, Girassol, Caravela and Oriente but if you check the metropolitan site they are never referred with those names", "More details about where the lift is and if it is not working", "Make the line colors more prominent instead of just a thin line on a dark blue background", "Better explanation about street names, when I'm leaving the train I want to know what street will be if I will turn left or right side", "indicate not only the final destination of the train (its direction), but also all stations along the route in this direction", "A better map of the exits positioned close to them", "Clear understanding about the exit navigation", "As informações deviam de ser em português e pelo menos, inglês", "Add more navigation signs, improve color marking of metro lines, visit metro of other cities", "Clear exit indications, numeration system for example could be a good improvement", "metro map inside the train, colors and pictures of lines", "Take a look at the metro design in Moscow and Saint-Petersburg. It is designed perfectly for foreigners and locals!", "Have some more words in English for tourists. Clearer directions on how to get to a line", "I would better talk and show myself, it’s customer experience map, not just a comment", "Better explanation of the exit".

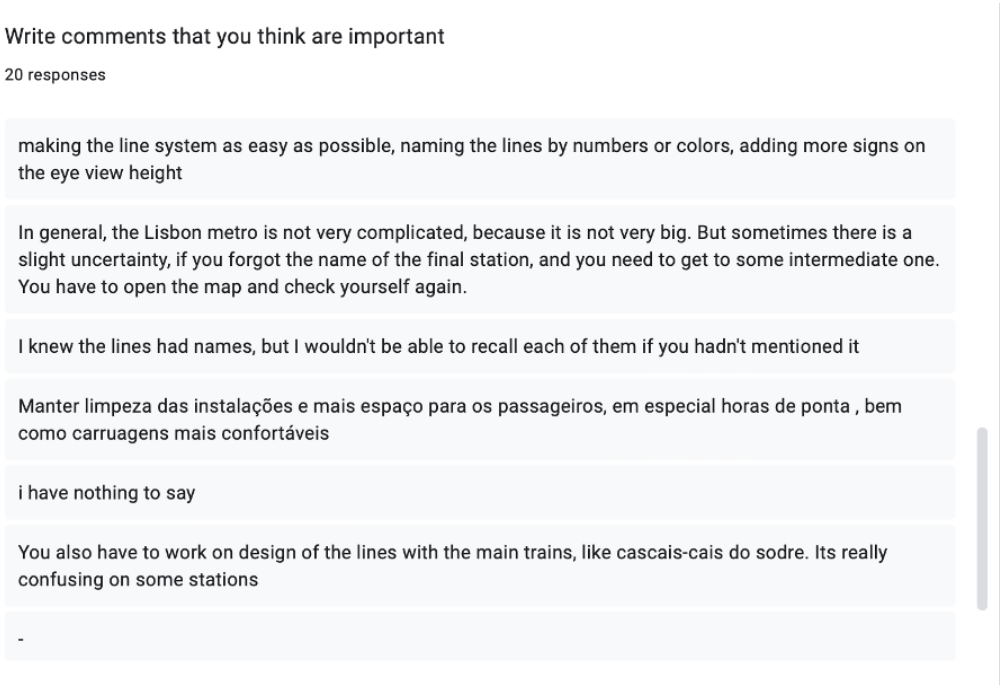


Figure E22: An excerpt from the results of the nineteenth point of the questionnaire: "Write comments that you think are important"

Comments and suggestions written in free form related to navigation inside the Lisbon metro:

"Write comments that you think are important" (see Figure E22 in Appendix E): "In addition to the name of the final station of the line, the entire list of stations in this direction should be indicated on the platform"; "The main problem is 1) from entrance to platform takes a number of turns 2) metro runs in reverse direction to public transport (the same as trains) -> passenger loses any sense of orientation and inner map alignment in using metro. Metro navigation is as bad as traffic signs and navigation. For a nation so proud of its navigators past it's a disgrace and a disaster"; "Changing lines can be confusing", "The options "Linha Caravela" and "Linha Oriente" were disabled to selection", "More escalators that work are needed. I have an elderly mom, it's difficult for her to go up so many stairs"; "Overall, the navigation system in the Lisbon metro is quite good. To make it absolutely perfect, a comprehensive professional approach is needed. Small changes and solutions to specific problems will not give any significant improvements"; "Limpeza

das instalações e maior frequência nas horas de ponta" (?); "Making the line system as easy as possible, naming the lines by numbers or colors, adding more signs on the eye view height"; "In general, the Lisbon metro is not very complicated, because it is not very big. But sometimes there is a slight uncertainty, if you forgot the name of the final station, and you need to get to some intermediate one. You have to open the map and check yourself again"; "I knew the lines had names, but I wouldn't be able to recall each of them if you hadn't mentioned it"; "Manter limpeza das instalações e mais espaço para os passageiros, em especial horas de ponta, bem como carruagens mais confortáveis" (?); "You also have to work on the design of the lines with the main trains, like cascais-cais do sodré. "It’s really confusing on some stations".

Appendix F: Interview with designer Mark Rodionov, who is taking part in the development of a new navigation system inside the Moscow metro in 2018 - 2019

April 14, 2025

[Alisa Koroleva]

Good day, Mark! I would like to thank you for the opportunity to take part in the interview. Please tell us about such a global project (in which you took an active part) as the revision and development of the navigation system inside the metro. When did it start? What were the initial requests and questions, and how were they solved?

[Mark Rodionov]

In general, if we talk about the project now, it began when the project was announced by the Moscow Department of Transport. Probably, during the same period when there were competitions for the metro scheme, and at the same time, there was a request for how to make Moscow transport more convenient, better, more modern, more beautiful, and so on. And one of these there were as many requests as to improve Moscow transport, improve the benefits of transport for passengers, for tourists. The answer was to develop a single navigation system that would unite everything at once under one principle: the metro, buses, pedestrian legitimacy in the center, pedestrian location in residential areas, and connections with commuter trains, train stations, and airports. That is, according to the plan, there was such a large, grandiose project that immediately set the task of creating such a seamless system that would, in general, help people navigate the city.

While all this was still based on some, conditionally, old principles, when some information on signs is more important than what you have in your phone, for example. That is, only everyone began to understand that pedestrian navigators in phones are also convenient, and important, and you can also use them. Now, probably, this has a much higher priority than what it was then.

That is, if we are talking about some kind of integral, consistent system, then now we can immediately take into account the story of how these principles will be reflected on Google Maps, how these principles will be reflected on other popular services that are used there in Portugal, or by tourists . Will there be some kind of application that will also inherit all this. That is, all this

has already become part of this single navigation. In Moscow , Russian services, 2 GIS and so on, I am also gradually integrating the designations of metro lines, the designations of exits, as well as on signs, that is, it is all connected into some more unified system.

And here my main point is that the main thing is not what is written inside the metro, but how it is all connected with the city and with the services that people use today. That is, this is the part of the first strategic work that was carried out.

The work on all this was started by the British company “City ID". They have a website . They also have several projects that they do for other cities, and there are some quantity brochures on their website or just somewhere on the internet where you can also read about principles that they put into their projects. And there is another British company called "Applied Wayfinding". They were doing a project on "Unified Navigation for London". It's about the mid- 2000s there was a project. It's called "Legible London". And they also provided a certain amount of materials, some brochures, some presentations, in which they describe the basic principles of how everything will be connected into one . For example, in the city, pedestrian steles, some signs - this is a single system, a separate system for buses, for stops, for interchanges, for transport hubs, these are all such interconnected stories. And these companies with such experience came to Moscow and did the first pre -project studies, did the first visual concept of how the new navigation might look. It is, in fact, very similar in style to what was done for London, for Buckingham, in which these companies took part.

There was a lot of political wrangling going on . Lebedeva's studio, of course, wanted to do everything its own way, the Department of Transport wanted it its own way, the people who started it wanted it their own way. It can't be said that the studio itself came up with what this navigation should be like. Studio appeared in this project (development of a navigation system in the Moscow metro) at a time when some first, at least visual, solutions had already been formulated. The semantic solutions had to be slightly finished, and not all of these semantic solutions survived. This is if we talk about the project in general . It began in 2013. In 2015 or 2016, the first sign appeared on the MCC. It was a very long cycle for various reasons . And then closer to the World Cup (2018), in the metro, in Moscow there are signs. This is a long topic (long process), but it was also, for the most part, connected with implementation: with history, with

bureaucracy, with tenders , to whom what is ordered, what money will be used to produce all this, who will do the layout of all this .

Now, this project is currently developing. I have a couple of people who I can probably ask some questions about. Because I have not been in the context for a long time. I am in the context of, say, seven years ago. Now it is already twenty – five years. I finished working at Lebedev's studio in the twentieth, and participated in the project in the nineteenth, eighteenth years .

As for exiting into the city, what you just said is the story that worries you the most... So, when does numbering appear in navigation? Numbering appears when you have a number of objects that do not have sufficiently unique characteristics for you to be able to describe them out loud as something independent. I will give you an example . Some time ago I made navigation for a Moscow school. There are very beautiful modern buildings, but they are designed in such a way that you can get confused. There are the same interiors on all floors and so on. And we started conducting interviews. What people know, where things are, how they navigate, what important rooms are in the corridors for them. And at some point I noticed that they were using numbers for some offices. The deputy head teacher is in 315, and the biology department is in 31, for example. At the same time, everyone knows where the library is, everyone knows where the gym is, everyone knows where something else is. They are in the same corridors. But no one knows the number of the library. No one knows the number of the gym. No one knows the number of any laboratory with a glass façade. That is, these objects have such a unique visual characteristic, such a unique structure, that people are satisfied with this uniqueness so that there is no need to use a number for all this. Accordingly, as soon as we have a corridor with identical doors, a street with identical houses, identical rows in a supermarket, identical rows in a warehouse, when you can’t just say “you go to such-and-such a row” and you will understand everything. They are all so similar that there is no way to explain to you which row this is.

Accordingly, if we go down to the story about leaving the city, then in Moscow, of course, there is also a huge number of stations, where, for example, there are 12 exits to some Southern or some Prague station. And they all come out on the same street. That is, they all come out on some street of Krasny Mayak , for example, and there are eight of them. This, of course, is a very difficult task, in terms of orientation , how to tell people where you will end up. Because they all go to the

same street. Four of them will go to one mall, and the other four will go to another mall. And you start to sort through them.

What else do you have as a reference point? There is the opposite. There are some stations in the center, from which there are also many exits. But they all lead to such bright and clear objects, for example, the Bolshoi Theater, the Moscow Kremlin , Red Square, that the problem of numbering there is much lower. Because, despite the similarity of these exits from the inside, but you write above the exit that leads to Red Square, no one will ever say "Go to exit 3". You will arrive at "Revolution Square", go to "Red Square", you will see where I will be pointers. But you can't say the same thing: "You arrive at Prazhskaya and go to the exit on Krasny Mayak Street," because almost all the exits go to Krasny Mayak Street. And you have different approaches to how you act in different situations inside the city. That is, you have in the city, the center, where there are a lot of unique streets, a lot of unique monuments, fountains, all sorts of things like that. There is an intermediate part, when there are unique objects, but there are not many of them. There are residential areas, where there are few unique objects and everything is more or less the same.

For each, come up with your own system, how you will decide where what becomes a priority. If in your residential areas the exit numbers become a priority, under the following conditions, that there is a huge bus traffic near the station, then people go to neighboring areas, then the direction of the stops is important, because exit number 5 leads to such-and-such street to buses that go to such-and-such area, for example. Or exit number 7, such -and -such street, leads to buses that go to the airport. That is, another layer of transport appears, which helps people move further. In the Center, of course, you try to pull out the most unique from the urban environment: museums, monuments, other attractions. And you try to give them priority, so that they are written on the signs, and they have some recognizable icons on the selector objects.

Quite a serious difference in the approach to about the same station with the same outputs, which dictates to you that you must have solutions for these different contexts inside the system. And since we have introduced numbering, let's have it everywhere, but we must understand that somewhere it plays the main role, and somewhere it plays a secondary role.

Somewhere the story about transport at stations in residential areas plays an important role, and the story about transport in the city center plays a minimal role, because people there are not inclined to travel by bus, and for them it is not so important. But there they have some intermediate ones, closer to the center, where transport is not so important, but you already have few objects, and you start to invent. For example, this is the exit to Leningradsky Prospekt towards the north, or towards the city, and this is the exit to Leninradsky Prospekt towards the center.

[Alisa Koroleva]

Have you conducted any kind of survey about the sights and key landmarks in the center, among the local people who live there, who are already accustomed to some landmarks? Or did you analyze the area yourself, go out into the street, look at what is nearby, and highlight the main objects?

[Mark Rodionov]

We did a lot of things. In fact, if you just start talking to people, you get a lot of irrelevant answers, because they often think "from their own bell tower" (with their own perception). It is difficult to understand how massive an object is as a reference point.

If we are talking about the center and the sights, then modern mapping services and social networks are very helpful here. That is, you can, for example, open Instagram and put a mark (they definitely used to be, but I don't know now) for your current location. Or you can, for example, "google" (write a request in Google): "the most popular photo spots in the city" or find a service that can help with this. And as a result, all Instagram photos are distributed among some points, so to speak. And you see such "hot spots" on the map, where many people take photos. And then everything is clear, this is a super landmark, a super object, a super point of attraction, it must be on the map, you just have to be there. On the signs, you need to find out what it is called and so on. Well, there are a number of non-obvious points there. There are so many obvious ones. When you open a conditional guide to Lisbon, you have the first list of 20 locations - these are generally "must-haves". This should definitely be on the signs if there are any stations, metro or bus stops nearby, etc. This is one way.

The second way was for me to talk to the station employees. They are constantly asked about everything. The police, the women near the escalators (for reference, in the Moscow metro, at the bottom of the escalator there are special booths in which metro workers sit, usually women), cashiers, just some caretakers, and so on. I remember, I found talkative police officers on the frost line and, who told me about the whole line. They work on the whole line, shifts in different places. And they told me that they are asked about this here, about this on Kurskaya, about this on Shelkovskaya, about this on this one. And this is in addition to what is on the signs. There is some information missing on the signs . And so they say that in "Mitino" we were constantly asked about the radio market, and why not write about it? This is also a way to get some kind of indirect way to get average information. Of course, you also encounter some kind of personal assessment, but it is still a little broader, because a person is often at these stations and asks questions all the time.

Another indirect way, I don't know if they have this in Lisbon or not, when they stick a piece of paper. When the navigation fails, and the conditional stationmaster gets tired of answering the question, he prints out A4 sheets of paper, like " this is there". When the passenger flow is large, when everyone is all the time they ask about the direction, sooner or later you start to fence yourself off from everything, pasting up leaflets. There is another way.

So, we had a separate interesting story. At that time, I still didn’t understand this difference in the urban context very well. And we designed signs for the conditional station Mitino. This is also in the east, on the blue line. And there is a situation where all the exits go out onto the same streets. And you come up with something like, well, let's write a park here, write some nearby street here, something else here. And there was some group of participants in our project who, on the contrary, said, "Why the hell are you writing this? There's a shopping center there, for example, there's "Radost", there's a shopping center "Voyage", there's a shopping center or something else. We need to write them down. "And how often does the question arise, how commercial some establishments are worth using as a reference point. Because it is a kind of advertising, and you do not know how much passenger flow goes to all these establishments and so on. This is also unclear. And then after some time the first test indicators weighed or, Mitino was tested, and then I came there for a walk. And I realized that everything that I had fought for and proved there a year ago was necessary writing about streets, and not a shopping center, seemed like complete stupidity,

because the reality is different. This is an area in which shopping centers are super-significant objects. By which locals navigate, and these same locals tell their guests which way to go to find his house. Here the context is important, that you don't have a single principle for the whole system, for the whole city, you have different principles for different areas by their nature. If the whole area is the same again and only the shopping center is different, well, you'll have to do it. I believe in streets because they are on maps and because they have some unique names. But the streets themselves do not have any uniqueness either. They all look like this: select and insert identical streets with lanterns. They are no different. Unlike the streets in the center, which have their own character. People can remember that a street that looks like this is street such -and-such, and a street that looks like this is another street. That's what concerns exits into the city.

Well, and the last little thing was also about the exits. A station with 15 exits, if these are exits on different sides of the same street. In Moscow, how is the system for even and odd sides arranged? This also adds clarity. In general, the approach to this whole topic of "how to decide what to write, which option to choose "is that you need to choose not just one approach, but several at once. And numbering, and houses, and landmarks, and transport, and something else. And to think about which of these tools are more suitable for which station, and which are less suitable, but at the same time they use everything everywhere. Because all people think differently. They have their own ideas about the city, their own moments.

I also have another story about how we chose what to write on the train direction signs. That is, in Moscow, as if you were going down an escalator, then you have to choose right or left. In the classic navigation of the 80s, there was simply a list of all stations to the right, all stations to the left. Since then, the metro has grown a lot, these lists have become somehow dimensionless, from the station new ones are being built, and so on. Although, conditionally, it is like in London, for example. In London there was Northbound, Southbound, and East -West.

In other cities, for example, there is a story with terminal stations. In Paris, for example, terminal stations are connected. In some other megalopolises it is different. Somewhere, like in New York, the routes are more important than the direction. Because there all these lines on different platforms are present in different quantities. In Moscow there is still a “meaningful

construction out loud ”of how people explain routes: "the first carriage to the center", "the first carriage from the center", "trains to the center", "trains from the center", "last carriage from the center, exit on the right. "It's difficult, but after some time you start using it yourself, because it works . And we also had discussions within the department about what to write: To the north? To the south? To the center And from the center? Vykhino? To the hoteliers? Planernaya? Or the option to always write a complete list of stations. There was another option: paint only circles with the colors of the lines that will be transferred in the direction you are going. If you are going to the center, then you draw there so that you will have a transfer there to orange, green, purple, blue, yellow. And if you are going to the south, nothing is drawn there, because there are no transfers there. Thus, to indicate the importance of transfers. In general, we started testing inside the studio. We put a projector on the wall, but then abandoned making it. Then they showed people the JPEGs : you went down to the station, you need to, say, go to the Sokol station. So, you have a sign hanging on it that says north, south, and you are on Tverskaya (conditionally), and which way are you going? So we showed him the north-south option, we showed him the option with terminal stations, and we showed him the option with a list. And surprisingly, we discovered that there is no clear leader among all these options, with the help of which a large number of people would more often make the right decisions . And in the end, we realized that there is no right decision. Each of these decisions is right and more convenient for someone. Some people remember the final stations, just for no reason, some people navigate by north-south, and some people don’t. For example, Lisbon is on the banks of the Taxo River in the center is located. This is also some kind of landmark in the city relative to which one can talk. But it must be in the context of the city. Speaking about Moscow, there is the Moscow River, but it is, nevertheless, a bad landmark, because it is very difficult to "beat " (difficult to compare). But in some cities where the river runs through, almost in a straight line, on the contrary, it is a good landmark, because people are well oriented relative to the banks.

And we, in the end, brought these results to the metro and agreed that we would have north-south, and final stations , and a list of stations on the signs. And this is written on all of these signs at the same time . And it is still like that. The only thing that didn't survive for some reason was the story about "to the center" and "from the center", because there were a number of skeptics about, like, what are we going to do there on Koltsevaya, and what are we going to do on the line

that clearly doesn't go to the center. And in the end, this solution fell apart, although for most lines it would have been super convenient. We also drew a star - "and go towards the star". If it's in the center, you put a star next to it, because it's like a Kremlin association. But this one didn't survive. And all the other options are hanging now. As soon as you enter, you have a list in front of your eyes, written in large letters: "to the north, to Planernaya , "to the south to Kotelniki". This is just a continuation of my previous conversation about exits, that there is no single solution for the entire city.

There is no one solution for all people. The funny thing is that each of these methods has some power, but you just decide how relevant they are to a particular station line. For example, for the Circle Lines we couldn't come up with anything normal at all. It now says "clockwise" and "counterclockwise". But this blows everyone's mind, because "clockwise" - where does that even go? How can you imagine it? Where am I? I don't think there are any Circle Lines in Lisbon ?

[Alisa [Koroleva]

No, not yet . But they are planning to launch a green ring line in the coming years (before 2030) and complete several stations. And in fact, this is the relevance that you were talking about, that the metro navigation was quickly implemented for the 2018 football championship in Moscow... There is a similar story here, when some changes in the navigation inside the metro took place in 2004 before the European Football Championship. For example, additional signs and transliteration from Portuguese to English were added on some signs (not on all stations, mainly those with a transfer to another station or close to the stadium), since until then only Portuguese signs were used. And by the way, by 20230 Lisbon is also planning to host major matches of the FIFA World Cup, perhaps this will also stimulate the rapid introduction of new stations and improvement of internal navigation. And it will be good if transliteration is introduced where possible, because sometimes it misleads you, somewhere there are duplicated names from Portuguese to English, somewhere not.

[Mark Rodionov]

The difference between the Moscow navigation system and the Portuguese one is that in Russia it all becomes more complicated, since there the Cyrillic alphabet is written on the sign. In

principle Foreigners don't understand how to read it. That is, they can't even reproduce with their mouth what is written there. But in Lisbon, after all, Latin is used, so it's not such a big problem.

[Alisa [Koroleva]

The moment of translation of signs indicating the exit from the metro or transfer is a little more complicated. In Lisbon, the metro has named lines; there are currently four of them. There are colors of the lines, and they are accordingly signed in the metro in Portuguese; for example, the red one is Vermelha, etc. Tourists may have questions: "Vermelha" - is this the name of the current station? Direction? Next station? Final station? And it can be confusing. And somewhere, it is written only "Vermelha," somewhere near the signature "Red Line." Also, this line has an ambiguous red color, which is more like magenta or bright crimson, which can also be confusing. In the context, not right away, but you understand that "Vermelha" is the name of the color and not the name of the direction of the line ... How did you work in such situations? I mean, when was the use of complex colors for the metro line or complex names of lines for foreigners?

[Mark Rodionov]

I remember this feeling in Lisbon. And by the way, in Moscow the same story happened. The lines had no numbers. Never. Historically. They all had their own name, for example, “Zamoskvoretskaya line”, “Sokolnicheskaya line”, “Tagansko - Krasnopresnenskaya”. Moscow residents have also learned to use this. They have learned Taganskaya, Krasnopresnenskaya... When external specialists came and said that it was impossible to use all of these, and who would remember all of this, let's do it by numbers. They did. But what a lot of "Hate" we got from Muscovites for the fact that the names with signs disappeared. It was hard to imagine. And today (almost 10 years of this navigation), of those who live in Moscow, no one still uses numbers. They don't recognize it. Tourists and visitors started using numbers. It's convenient for them. They saw, well, okay, these are all the line numbers - convenient. The numbers never appeared in the Russian voiceover. And they say, "this is a transfer to the Tagansko-Krasnopresnenskaya line". In the English dubbing, it's "a transfer to line seven". And it's like, it's all clear. And what's more, there are these stations, "Kievskaya", "Kurskaya", and so on, where there are many identical stations in the same place. There are different systems in Moscow. There are some where the stations have different names, like "Tverskaya", "Pushkinskaya", "Chekhovskaya". And there are some where

they are all in one place and have the same name, like the three "Kyiv" stations. And there, too, they started putting up signs. Well, line numbers, like, 3, 4, 5. And at that moment, the locals broke down. And they asked themselves, where to transfer? After some time, they returned the names at these stations, that this is a transfer to the "Filyovskaya Line", this is a transfer to the "Arbatskaya-Pokrovskaya Line", and this is a transfer to the "Koltsevaya Line". They also left the numbers, but returned these historical names, as a way for locals to navigate. Because the locals not only broke down, they did not understand what these numbers were, did not know where it all went?

Again, how does the context of a specific station, and how does the context of the history of the city's perception influence decision-making, that you don't burn out all the other decisions with one decision. You have stations where historical names suddenly remain on the signs. Not at all the others, but here they do, because this is an important, distinctive feature of how people here perceive these installations.

And also, from the funny thing, when the navigation was strengthened, at some new stations in the south of Moscow, where the Sokolnicheskaya line goes down, there, probably, is Olkhovaya, Pyhtino (line 8A). There was some big center for registration of migrants from Central Asia. And people often came there, faced with the fact that it was also unclear where to go... So for them in Uzbek they wrote on the sign, "go there, friend, brother". There was a scandal later, yes. For some reason, some... inflamed people did not like that in the Moscow metro something was written in Uzbek. And after some time they removed it. But, like, the idea itself is correct. Here is the context of the station, where a huge number of people speak Uzbek. Why not write for them in Uzbek? You don't have to write it all over the metro, but if there are so many of them here, and they put such a strain on the people who work at the station... And you're like, okay, here's the exit in that direction, here's the word "exit" in Uzbek, here's the word with the direction, which way to go in Uzbek. Some warnings in Uzbek too.

[Alisa [Koroleva]

About floor navigation. How did you come to this? And what conclusions did you draw after implementing it? Because before, as I understand, it didn’t exist at all.

[Mark Rodionov]

Oh, they never came. Absolutely pointless and useless. Don't even waste time on this.

[Alisa [Koroleva]

It's just that somewhere it exists and is used. For example, it exists in airports and is encountered when there is a large flow of people...

[Mark Rodionov]

You have to really understand why this is being done. Floor navigation is a way to solve a specific, local problem, which is, in principle, complicated by the surrounding architecture, complicated by the impossibility of installing signs, complicated by huge crowds of different people in intersecting flows, and so on. And you, having already gone through so many options, well, okay, but they don't understand, but people walk past. Anyway, And like, okay, let's stick a huge red circle on the floor, on which we'll write "no, that's it, you can't". But this will already be some kind of point solution. A system definitely shouldn't be built on this, because after all, everyone is used to looking at walls. And it works very poorly during rush hour. It works as a confirmation of the decision made. For example, you realized that, it seems, you need to go there to transfer to some line, you looked at the sign, and suddenly you see something green flashing under your feet, you're like, oh, that's it, everything's fine.

[Alisa [Koroleva]

A question on the topic of location confirmation. How often do people need to confirm where they are? For example, there is a corridor, then there is the next turn, there are stairs, there is an escalator. Before which points is a duplicate or confirmation of where a person is made?

[Mark Rodionov]

I highly recommend reading Kevin Lynch's book "The Image of the City". It's very cool how it describes nodes, squares, that you have roads along which you move, and there are some places that in themselves are some kind of place in your head, a name, which, perhaps, has some kind of visual landmark. But if you translate it a little to a more abstract level, that's all, that is, some paths, and there are some spaces that a person gets into, passing some kind of visual, some

kind of boundary of sensations, that you stopped walking along the stairs, conditionally, and entered the hall, or entered some kind of crossroads. All these boundaries are always located at the entrance, at the station, at the connection of the station with a new path down, there the escalator went, for example - this is a new boundary. You finished your existence in the lobby and again you are in some intermediate place. And then this intermediate place ended, and some place came again, tangible, understandable, that this is a station platform or some distribution hall. At each of these borders you at least need to say where you are or where you are going, depending on the context. That is, if we, for example, talk about a metro station, yes, you enter it from the outside. From the outside you need to write that you are entering a specific station. This hall, somewhere there is an escalator, somewhere else there is an exit. You also need to write again above the desired escalator that this is the station you entered, it is now over there. That is, for a person from the city, when you look, the station is in this building of the vestibule. That is, the metro is here. As soon as you are inside, the context has changed. And again, in order to reach the station, you need to go somewhere else. That is, you need to say again where it is. You say, downstairs. Go up the escalator. Then when you go down, you need to kindly tell that everything, look, you have arrived at the platform of such-and-such station, as if you have reached your point, conditionally. But for a person in the city, you reached your point when you entered the building for the first time. This is my first achievement. That is, every time you draw this diagram of where the context in which you find yourself changes.

When I first realized all this, I tried to comprehend it. The association is this. When you get on a plane and fly, you arrive in another city, sometimes you arrive away from the city, sometimes you arrive in the city itself. It is written on your airport that you arrived, for example, in Moscow. They signed the city for you. Because from your context you moved from one city to another city. Conventionally, this is important. It is clear that you could not land in an unnecessary city. But you don’t care, for this feeling, it is important to you that they signed it for you, that yes, you arrived in Moscow. You moved at the level of this upper context, you moved to Moscow. And if you also flew to another country, how nice it would be to have “Russia. Moscow” written there, or “Netherlands. Amsterdam”, for example.

Or another similar example. The same train. It arrives in the city center. You have a sign in the city center that says "Moscow". Because all this time you were not in the city. You were in this transport connection. And now you enter the conditional city for the first time, you move into this context. And that's why they hang this sign that you are in Moscow. Or there, at any other station, you also have the name of the station. It’s as if it’s already Moscow, but it’s not the same one yet.

You can look at this story about contexts and Moscow the other way around. For example, let's imagine that today I need to go to Sheremetyevo, to the airport. I'm in the city now. For me, right now, Sheremetyevo is a dot. A small one, on the map. Which is somewhere far away. But as soon as I get closer to it, to this airport, it stops being a dot. It stops being a set of terminals, parking lots and hotels, from which I need to choose again where to go next. That is, accordingly, when approaching all this, Sheremetyevo is here, and in fact there is also Terminal 1, Terminal 2, Terminal 10 and so on. Like, choose which one you need. And they already sign these separate buildings for you. No longer as Sheremetyevo, but as some entities of this Sheremetyevo. That is, for you, Sheremetyevo suddenly disintegrated into separate semantic things. And then again you drive up to the terminal, and at that moment it has split into arrivals and departures, a transition terminal, and so on. But just now you had it in your head that you only needed this point. And you are constantly thinking about what happens to these contexts when you choose black writing symbols.

Well, this is such a cool topic, my life experience. Where from, where did you move to. Because even just, like, when you move from building to building, to different floors, if you are in one building, then you just need to tell the person, "I'm on the sixth floor," and if the person is in the next building, you need to say, "I'm in building number two on the sixth floor". Because you are talking to a person who is outside your context.

[Alisa [Koroleva]

How often should a person be told or repeated information to reduce their anxiety level, to make them feel comfortable, so that they are here, not making unnecessary body movements left and right or unnecessary turns. How intuitive should navigation be? That is, roughly speaking,

they are walking, and they already understand, aha, this is over there, and I don’t need to stop there, turn and look left and right, that is, they are moving in the flow, already turning right, seeing this sign from afar and turning right, for example.

[Mark Rodionov]

Conditionally, yes, that's right. That is, this is also about the feeling of the correctness of the chosen path. It is important. Most of all, a person worries at these points of context change. You arrived at the sixth floor, you want to see on the wall that this is the sixth floor. It is very important whether it is there. And another important place, where it is important to encourage people all the time, is a long passage, long corridors, which you kind of made a decision there, and you were sure, but you go, go, go, go, go... When there are such places, you usually place an additional sign there. You do not have a change of context there, but you need to calm down. Everything is correct, the metro is in that direction. Yes, everything is correct, the metro is in that direction.

[Alisa [Koroleva]

How often can this be done so that there are not too many signs, and at the same time the person feels comfortable while following the path?

[Mark Rodionov]

It depends on the environment. If it's just a dead-end corridor, and there's nothing else there, nothing happens, then maybe even block it (not to attach importance and do nothing), because you will still come there somewhere. For example, you go from one end of the shopping center to the other end of the shopping center, and there are so many different other directions and other temptations to turn and get confused (to waste time, and go the wrong way), and not understand where to go next, that you really need to make signs with some frequency. This is what I call, there are two types of navigation. Another such, big topic. There is a story about navigation, which gives you an idea of how spaces are arranged, yes, so that you can make some assumptions. For example, a subway map or somehow a city, or a floor plan, for example . This is some kind of thing that tells you: "dude, everything is arranged like this". You are like: "a-a-a, so if this is a subway map, then if I go, I can transfer here and get there, I will achieve some kind of result there". And you

already know how this story is arranged. You have, say, 200 stations in the Moscow metro and you can't write them all down for each person, so that they can get from Yuzhnaya to Sokolniki. And you can't write Sokolniki there, Sokolniki there, Sokolniki there on every corner, because there are 200 directions, and it's pointless. You load this conditional scheme into his head: this is the metro, it has different lines, and in order to get from one line to another, you need to find where the lines intersect, transfer there, and only then will you look for your specific Sokolnicheskaya line. That is, you again, with the help of the scheme, with the help of the map, divide the context into a more general one, into a more detailed one, that is, in order for you to get to Sokolnicheskaya, you first need to get to the Red Line, you need to drive up to the Red Line, and then you will look for your station. And it turns out that navigation gives some kind of tool into your head, relative to which you can make predictions. If you are in a building, if it is symmetrical, you can imagine that there will be stairs at the end, I will be able to move somewhere else there. Or there should be an elevator somewhere in the center. It works in large areas. In parks, in shopping centers, in the metro. Where there are a billion different scenarios. But if it is an airport, for example, or a train station, or something else, then on the contrary, there is a very limited number of scenarios, necessary, important. It is like boarding a train, boarding a plane. And it is important for you to take a person through a certain "Check Point". Registration, baggage, inspection, control and so on. And here a different navigation is needed. If you just draw a map at the entrance, no one will benefit from it. The airport is complex, it is difficult to navigate in this, there is no need to remember how the airport is laid out at all, since I am here only once, and so on. And the airport tells you: "Okay, dude, I'm leading you by the hand. Flight there, flight there, flight there, flight there, check-in for flight there". After registering, you are immediately told, you need to go there, they repeat the sign there, there, there. And so on. That is, you are all sort of driven into one semantic conditional flow. And they duplicate it on the sign all the time. Accordingly, you, too, as always, are trying to understand what type of navigation you will be dealing with now. Do you need to orient people or lead them by the hand? In a shopping center, they need to be oriented conditionally, and led by the hand from a specific floor, for example, to the toilet. You need to indicate the toilet there- there-there -there. Or the exit there- there-there -there. You will not write that, for example, McDonald's there -there-there, or conditionally Zara there-there-there. Because you will not have enough space to tell everyone about McDonald's, and tell everyone about Zara, and about the other 50 stores. You select from them, from all the objects on the floor, some places

that are needed by many people, this is the exit and the toilet, for example. And for them you make such a thorough navigation. And everything else you give to the map or to lists of some objects.

[Alisa [Koroleva]

I have another question, probably the last, final one. How do you feel about dividing the navigation system, singling out one group of people, for example, for colorblind people? Let me explain what the question is about. In the fall of 2024, the Lisbon metro announced that they were planning to revise the maps and navigation with the introduction of new signs for colorblind people. That is, for colorblind people, there is a graphic designation of colors: these are triangles and sticks, folded differently on top of each other. Considering that there are not many metro lines in Lisbon, each has its own graphic designation and name and has only 4 line colors, how critical is this for colorblind people? How relevant is this, and how much does it affect the perception of navigation, in your opinion?

[Mark Rodionov]

What is the most important thing to know about colorblind people? The problem is not that they do not see colors specifically, the problem is that their brain cannot distinguish one color from another. For example, most people cannot say which note was higher, which note was lower, if several were played at once. You cannot say that the music went up, then down, then back, then went up again. How did you hear it? Something changed there, yes, but it is impossible to formulate. The problem of a colorblind person is that even if you tint the shades so that the lines really look different, in tone and so on, it does not help much, because in general there is difficulty in comparing one relative to another. That is, this is some kind of main problem. Therefore, the introduction of symbols, numbers, names, words, arrows and so on, this solves the problem of a colorblind person, if they have an additional way to distinguish what others answer by colors, to distinguish one from another. Icons are great, everything is clear. Numbers are great, words in most cases are great. Well, and only my main “message”- it is not to play with the division of shades, so that they understand them from their "bell tower" (with their individual perception). The problem is that this is precisely what does not work.

[Alisa [Koroleva]

As far as I understand correctly, the Lisbon metro plans to introduce symbols that are understandable to colorblind people with each station name or at the intersection of these stations. That is, the designation of colors using additional pictograms of triangles and sticks. How much will this confuse ordinary people, who are the majority? Considering that each line already has a color, name and symbol. Will this not be superfluous?

[Mark Rodionov]

I don't know at all. I don't really understand why each station has its own symbol? I know that there are such systems in Latin America. There is a story that there was a huge illiterate population there, and therefore each station has its own pictogram. Somewhere a beaver, somewhere a Christmas tree, somewhere a ball, somewhere a ball. Let's say he goes to the ball station, and he can stand on the ball diagram and understand how to get to the ball, that he needs to go to the triangle, and then transfer to the beaver. This theme works. The introduction of visual symbols of lines, they began to do this for orientation, is also a cool theme. In my opinion, in the same Lisbon, the lines have some pictograms.

[Alisa [Koroleva]

Yes, they have a graphic designation. In addition, in Lisbon, the line is designated by color, that is, "Vermelha" - red, "Verde" - green, "Azul" - blue, "Amarela" - yellow. And also, they have directions for each line, like in Moscow "Serpukhovskaya line", "Sokolnicheskaya line". They have another name that not many people know and use. According to the survey, most people do not know that there is a "Caravel" line, and this is a green line. Caravel is a ship, and the image in the symbol is appropriate, etc. In principle, there is enough information for any person to be able to navigate. And if, in addition to everything else, additional signs are added indicating the name of the color for colorblind people, it seems to me that this can complicate the perception for most people in the metro.

[Mark Rodionov]

Perhaps it is worth making the icons convenient, so that these stories with "ships" are perceived as part of navigation. Because I did not immediately understand that "Caravel" has its own purposes. Because it looks more like a decoration.

[Alisa [Koroleva]

As if the pictograms are stylistically different from the names. And they are not very well read from afar. That is, there is some image, and it is connected with the name of the line and it has a deep meaning. Very interesting!

Cool. Thanks for such a great review, Mark!

If we go back to the beginning, you talked about the guys who came from London and offered some solutions. Can you give more details, where can I read about them and find additional information? Since I plan to mention them. Since the London Underground is the foundation of foundations, it all started from there. And it would be interesting to mention them in the context of the first step in the formation of modern navigation of the Moscow metro. Because the logic is taken from there after all.

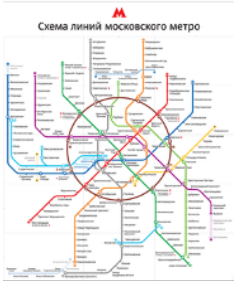
[Mark Rodionov]

But you have to understand that they also have a different context. The city is organized in its own way, the districts are invented in their own way. If you compare Moscow and St.Petersburg, then, for example, in St.Petersburg, the islands have very important meanings. Vasilievsky Island, Petrogradskaya Side, and everything higher to the north is its own world. In the center, this is the whole story about where all the rivers are, the Moika and the Griboyedov Canal. And then there, beyond the Obvodny Canal, a new story begins. That is, these are also some important parts in the consciousness of people in the city. That is, if in Moscow it is the Boulevard Ring, the Garden Ring, "Treshka" (colloquial abbreviation for "Three Station Square") and everything else, then there are such separate things.

For example, I live in Tbilisi now. Here, too, because Tbilisi is heavily cut by some district hills and mountains, it feels like each district is a separate bridge. That is, you navigate relative to these large semantic blocks, like districts. Somewhere there, the railroad is “cut” independently. Well, like in the book, too... Part of that railroad is a separate world, and through the railroad, another world. Because there are very few connections between them. This also affects how you draw a city map, or how you draw a metro map, how you tell where things are.

What is important is that you are in the environment. What I can say now, what was applicable to Moscow, or what people used in London, may not be applicable to Lisbon due to the city's structure. And due to the way locals explain this city today. And, by the way, there is a cool exercise for creating a "Mental Map". When you ask people to draw their city or their district, landmarks "pop up" (appear) there too. What exactly do people draw? For example, if there is a cathedral in the center, everyone will draw it. This is a super landmark, if you want to draw a map of the city or some kind of city diagram, or you have a metro nearby or buses passing by, then you should write that this bus goes to this cathedral.

Appendix G: Comparative Table of Metro Navigation Systems in Other Countries

Metro	London	Paris	Moscow	Lisbon
Year of Launch	1863	1900	1935	1959
Updated navigation and design	2007	1996-1998	2018-2019 integration to this day	2011
Number of lines	11	16 +RER regional trains	14 + MCC and MCD lines	4 + 1 planned
Line Identification	Color-coded with unique names, for example: Central Line – red, Jubilee Line – grey	Color-coded and numbered, for example: Ligne 1 — yellow	Numbers and colors, also named, for example: Line 1 – Red Sokolnicheskaya	Color-coded lines with thematic names, for example: Linha Azul – Blue Line accompanied by pictograms unique to each line
Typeface	Johnston	Parisine	Moscow Sans / Mosmetro	Metrolis
Language Accessibility	Primarily English; limited multilingual signage, supported by digital platforms	Mostly French, with English on tourist-heavy routes; limited inside trains supported by digital platforms	Russian and English on signs, maps, and announcements (especially since 2018 FIFA WC) supported by digital platforms	Mostly Portuguese; English translations appear inconsistently — often present in maps and tourist stations supported by digital platforms
Logo				
Metro Map	First Harry Beck's schematic diagram (1933) 	Classic schematic, compact and legible, with geographic elements 	Circular + radial layout, updated for clarity, printed and digital formats 	Simple schematic layout showing color-coded lines and connections 

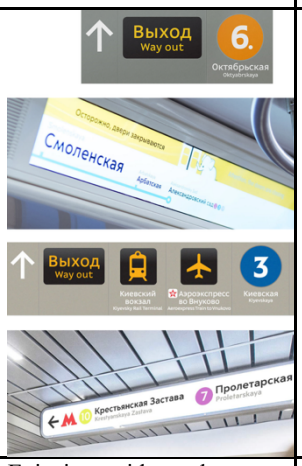
Interactive Maps	Available at stations and online	On ticket machines, apps, and station walls	Touch screens at major stations; online tools	Available online
In-Train Navigation Support	Real-time display of next stations, connections, delays	Automated announcements, line diagrams above doors	Line maps above doors, audio and visual announcements in Russian and English	Line modified map above doors; station announcements mostly in Portuguese; no screen-based updates in older trains
Website:	https://tfl.gov.uk	https://www.ratp.fr	https://www.mosmetro.ru	https://www.metrolisboa.pt
Mobile Apps:	TFL Go, Citymapper, Google Maps integration	Bonjour RATP, Citymapper, Google Maps integration	Yandex.Metro, Moscow Metro app, 2GIS, Google Maps integration	Metropolitano de Lisboa App, Google Maps, Moovit
Signs in navigation				
Exit Identification	Numbered and named exits with street and landmark references	Exits labeled "Sortie" numbered and associated with streets or institutions	Exit signs with numbers, street names, and landmarks; overhead directional panels	Exits labeled "Saída" with some street names; landmark references are not always visible

Table G1: Comparison of metro navigation systems between the London, French, Moscow and Lisbon metros.