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Management and safety of passenger urban public transport in Berlin – a case study

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Abstract
The aim of this article is to identify the best practices to reduce potential risks in passenger transport using the example of urban public transport in Berlin. Due to dynamically progressing urbanization processes and the related development of the German capital, the demand for transport services increases. A significant problem has become the coordinated management of public transport for passengers and ensuring safety in the means of transport and available infrastructure. Local government and public transport managers in Berlin have decided to introduce solutions to reduce potential threats to public transport participants, thereby contributing to improving the quality and safety of the transport services provided. The methods of source analysis, descriptive analysis, and deduction are used to conduct the analysis in this study. The results show that the constant search for new solutions to transport problems is a challenge for city managers in the era of rapidly progressing urbanization processes.

Introduction

This article focuses on how local authorities and urban public transport managers in the German capital attempt to reduce the risk of potential threats to passengers within various means of transport and their infrastructure. The subject of the research is Berlin, its urban passenger transport system and the solutions introduced to limit the occurrence of potentially dangerous events for public transport participants.

Berlin has a complex and highly efficient urban passenger transport system. Without it, a metropolis like Berlin could not function efficiently. The German capital is a good example of the current migration in Europe. The continuous flow of people from the countryside to the cities alongside economic and political migration means that public transport requirements are constantly changing, so the demand for innovative solutions in Berlin is very high. This is driven by the need to increase the efficiency of the transport services provided and the need to improve safety and reduce the environmental impact of transport.

The design and implementation of new or improved transport solutions in Berlin is based on greater cooperation between the private sector, non-governmental organizations, and research and development units, both national and foreign. Improving regional passenger transport depends on the ability to implement the projects of all the actors involved.

The dynamic development of Berlin has created problems related to coordinated management and ensuring passenger safety in urban transport. The growing demand for transport services and the need to meet them forces city authorities to seek new solutions. An efficient and effective transport system in the city should limit existing transport problems, mainly in the event of threats to its participants.

Human functioning has always been associated with the need to move. In urbanized areas, it takes place as part of urban transport, which can be defined as regular, public collective transport conducted at the request of a specific local government transport organizer in the area of one, two, or more communes on the basis of inter-municipal agreements and communes forming an inter-municipal association (Wyszomirski, 2008). Urban passenger transport plays an important role in the functioning of urbanized areas. It includes a set of mutually dependent and coordinated activities, the end result of which is to ensure the flow and service of passenger traffic in a given agglomeration (Kosobucki, 2013, p. 31). The larger the agglomeration, the more difficult it is to manage urban transport of passengers, taking into account their safety. This study is devoted to these issues, focusing on one of the European metropolises, which is the city of Berlin.

Literature overview

It is estimated that 68 % of the world's population will live in urban areas by 2050. The trend of migration of people from rural areas to cities has been continuing since 1950 (United Nations, 2018). The dynamic development of cities and the ongoing urbanization processes they undergo are perceived as creating economic growth for the state and ensuring the well-being of citizens (Pradhan, Arvin & Nair, 2021).

The intensification of migration from rural areas to cities has resulted in the evolution of the social needs of the population. The assessment of needs does not change their type but their level (Szołtysek, 2005, p. 12). As a result of the progress of urbanization, there is an increasing demand for transport services (Noussan, Hafner & Tagliapietra, 2020). Due to the nature of the urban system, which aims to serve users, this can be a challenge for city managers. For cities in highly developed countries, emphasis is placed on the quality of the transport services used.

The implementation of tasks in the field of urban transport is possible thanks to the transport infrastructure, public transport means, and transport offer, as well as the integration and coordination of the network of all means of transport in a given agglomeration. Infrastructure in cities exists in three dimensions: physical, information, and communication technologies (ICT). Physical infrastructure is called the only non-intelligent element of city infrastructure and means linear and nodal infrastructure. Elements of linear infrastructure include, among others, roads, railways and inland navigation, and the nodal infrastructure includes stops, terminal stations/loops, transfer hubs, parking lots, vehicle control stations, passenger service stations, and others (Mohanty, Choppali & Kougianos, 2016).

The aim of the implemented activities should be, on the one hand, to improve the potential that already exists and, on the other hand, to create new potential. Urban transport is very vulnerable to threats, but it is also burdened with the high costs of implementing new solutions or good practices (Janczewski & Strzelczak, 2009). Moreover, due to the spatial limitations of cities, the development of infrastructure taking into account the need to ensure security is difficult, and work on its modernization is often complicated and expensive. Additionally, it seems important to act beyond the physical layer of the city by also focusing on its social dimensions. Therefore, it is important to promote safe practices and behaviors that will, at least to some extent, limit the negative effects of potential hazards in public transport, thus creating a friendly living environment (Anthopoulos & Fitsilis, 2014).

The Community Policy of the European Union assumes that member states have to act more intensively and deal with the problem of ensuring safety in public transport to a greater extent. The effectiveness of these countermeasures depends on the policies and goals adopted by individual countries, regions, and (even more often) on decisions made at the local level. The decision to implement technological, technical, or organizational solutions is made by local authorities in order to improve the health and quality of life of residents. The implementation of intelligent solutions in the field of urban transport systems involves large financial outlays, which is why local authorities often look for other countermeasures (European Commission, 2021).

Methodology

This article uses the methods of source analysis, descriptive analysis, and deduction to examine how the authorities and managers in Berlin

limit the possibility of potential threats to participants of urban transport – i.e., the passengers. The capital of Germany is chosen due to the availability of source data.

The analysis is based on published local strategies from the websites of local governments and responsible bodies where activities related to the discussed urban transport system are undertaken. During the analysis of strategic documents and other publicly available sources regarding the planned development of urban transport systems, a large amount of information can be discovered, which necessitated the creation of this study and the general interpretation of the analyzed policies.

Research results – case study

Passenger transport management in Berlin's urban public transport

Berlin is the largest city in Germany, one of the largest in Europe, with a well-developed public transport network and aspirations to become a global city (Kozielska, 2008, pp. 155–163). It is inhabited by 3,770,534 people, which increases to about 6 million people when accounting for the surrounding metropolitan region (Statistik Berlin Brandenburg, 2021). This constitutes a huge challenge in the context of organizing and managing urban public passenger transport, the services of which were used by 1.371 billion people in 2022, i.e., an average of 3.76 million people per day (VBB, 2023). However, the territorial scope of Berlin's transport services is much wider and also extends to Brandenburg. This creates a de facto coherent functional area due to the existence of the transport association of Berlin and Brandenburg (*Verkehrsverbund Berlin-Brandenburg*, *VBB*), which organizes public transport. In terms of territory, it is the largest transport link in the world and covers an area of 30,546 km² (VBB, 2023).

The urban passenger transport system managed by VBB consists of bus lines (911 lines), tram lines (49 lines), urban railway lines (16 lines), and metro lines (9 lines). The remaining ones involve ferry services (8 lines) and trolley buses (2 lines). A total of 13,537 stops and stations are served (VBB, 2023).

The beginnings of the VBB date back to 1990, when there was a need to organize urban transport to provide high-quality services that cover the areas of both Berlin and Brandenburg. The main task conducted by VBB is management, including the organization and coordination of the activities of 36 companies (forming this association) operating in the area of urban public transport in the capital and the state, as well as (among others) developing a common tariff system. VBB is a member of *the European Metropolitan Transport Authorities*, *EMTA*, and *the International Association of Public Transport*, *UITP*.

The most important and largest entity within the VBB structures is the *Berliner Verkehrsbetriebe,* (*BVG*), which is directly responsible for organizing public transport and is also the main entity responsible for providing public transport services in the German capital. It is owned by the state of Berlin, which has a complex and highly efficient urban passenger transport system (BVG, 2023). Without this entity, this metropolis could not function efficiently. It is worth emphasizing that the requirements for the urban passenger transport system are constantly changing. The main reasons are the need to increase the efficiency of the transport system, improve safety, and reduce the negative impact on the environment.

Three units of the Berlin Senate (the executive body of the city authorities) are responsible for the efficient functioning of the BVG: the Department for City Development, the Department for Economic Affairs, Technology and Research, and the Department for Financial Affairs. From the formal and legal side, BVG is a public law enterprise and, together with four other carriers associated with VBB, is responsible for operating the metro, bus, tram, and ferry networks in Berlin (BVG, 2023). Its responsibilities include the operation of the *S-Bahn* network of the German railways *Deutsche Bahn*, connecting the city with surrounding towns in the state of Brandenburg.

Safety in public transport for passengers in Berlin

The problem of ensuring the safety of passengers on public transport and around places where they interchange has its own specific nature, and its basic feature is the movement of both users of public transport services and the means of transport themselves. According to the classic definition of *the Dictionary of the Polish Language*, safety is a state of non-threat, peace, and certainty (Sobol, 2003, p. 46); Geysen defines it as the absence of risk or protection against it (Geysen, 1990).

Detecting a danger or crime requires the use of sophisticated methods of action – both from the services responsible for security (e.g., police, security, and other services) and entities responsible

for providing transport services for people and their property. The state of safety in the above-mentioned areas mainly determines whether a potential customer chooses (or not) the transport offer of a given company.

Systems for recording the most important parameters of bus, train, metro, S-Bahn, and tram traffic and the activities of their managers are constantly being developed. Their task is to collect and store the most important information and measurement results, which are then used, among others, for (Prochowski & Żuchowski, 2006, pp. 306–307):

- monitoring the driver's work (driving speed, driving time, breaks, and driving technique affecting fuel consumption);
- analysis of the pre-accident situation (also using video monitoring outside and inside the vehicle);
- ensuring the safety of the means of transport, passengers, and potential passengers;
- maintaining transport conditions in terms of arrival and departure in accordance with the timetable, selection of vehicle size, and correct operation of information devices for travelers and ticket machines;
- optimization of the use of the means of transport (i.e., current cost analysis, planning of transport tasks and maintenance activities, and performing statistical and prognostic analyses).

An integrated system for recording vehicle movement parameters and driver actions is currently supported by sensors and transmitters located in passenger urban transport and facilitates the collection of information necessary to achieve the above objectives. It also enables the driver to quickly and efficiently understand the correct operation of assemblies and systems (the most important in terms of safety and optimization of the use of the means of transport) at a given moment (Salmon, Stanton & Young, 2012). This allows the vehicle driver to be more able to concentrate on the situation and events occurring in road traffic (Fletcher & Zelinsky, 2009).

A summary of the most important actions to improve the safety of passengers on public transport and at their exchange points in Berlin is presented in Table 1.

At least two SOS (*NOTRUF*) bollard panels are installed in every Berlin metro station, usually near the exit/entrance (Figure 1).

Figure 1. Location of emergency buttons, fire extinguisher, and first aid kit in metro trains and the SOS (NOTRUF) bollard panel at the station (BVG, 2023)

The red button is for emergency calls. After pressing this button, the person is immediately connected to the metro security management center. The installed camera, microphone, and loudspeaker allow quick contact with the person calling for help and assist the decision on whether to call the appropriate rescue or security services (Figure 2).

Figure 2. Operational diagram of the SOS (*NOTRUF*) bollard panel at a Berlin metro station (BVG, 2023)

Those managing the urban passenger transport system in Berlin have proven tools to combat pathological behavior in urban transport in the form of an integrated monitoring network.

Table 1. A summary of the most important actions to improve passenger safety in selected means of public transport and at their exchange points in Berlin

Actions to improve safety			
Metro car	Metro stations	Trams	Buses
In metro cars, alarm buttons and fire extinguishers are installed, which are located on the right side of the doors. After pressing the emergency button, the metro train continues its journey to the nearest station, where a mobile employee contacts the passenger. A first aid kit is located in the driver's cab.	In situations where a passenger needs to be provided with broadly understood assistance, SOS (NOTRUF) bollard panels are installed at metro stations.	In trams, intercoms are installed at the doors, which can be used to communicate with other people in emergency situations with the driver.	In buses, buttons are installed above the doors to alert the driver about a threat in the vehicle.An engine compartment fire extinguishing system is also installed and covers all newly purchased vehicles.

For example, 1843 cameras were installed at 173 stations in the Berlin metro (BVG, 2023). Improving the safety of passengers in urban transport by monitoring video monitoring inside the rolling stock and nodal infrastructure in real time allows for the detection of those responsible for acts of vandalism or violence. It also acts preventively in the event of noticing dangerous people who pose a threat to other passengers in the vehicle. CCTV placed inside public transport passes the image through a network of receivers to the monitoring center. This is possible thanks to radio data transmission and an image that should be clear enough to enable the entire interior of the vehicle or station/stop to be observed and then the ability to recognize individual people inside. The use of the technologically fastest data transmission medium allows for minimized delays between events and their reception at the monitoring center. Then, the effect of early reaction to events is possible (Smyczek, 2013).

The BVG manages the bus and tram transport control centers in one integrated control center (Figure 3). The center operates 24/7, ensuring safety in means of transport and in the area of linear and nodal transport infrastructure.

The tasks of individual, organizational units of the integrated bus and tram transport control center are presented in Table 2.

The innovative metro management center (U-Bahn) is the most important location for metro management. It covers an area of 400 m^2, with 21 operating stations (Figure 4). Berlin's underground railway traffic, as well as monitoring and control processes, are organized here 24 hours

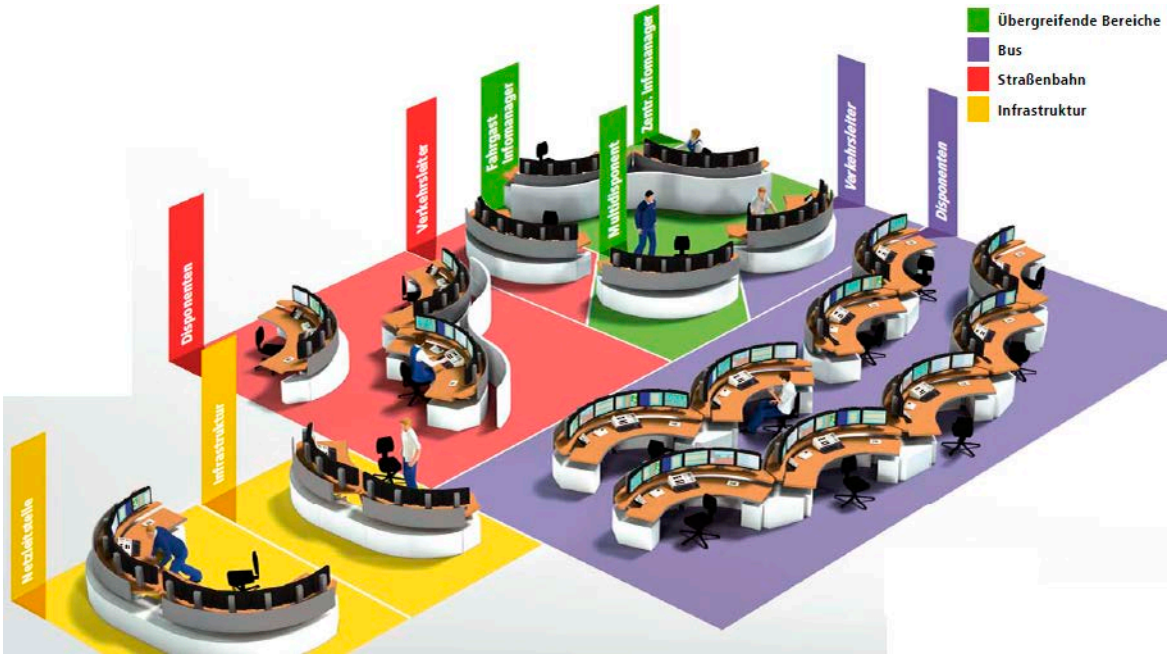

Figure 3. Joint management center for bus and tram transport in Berlin (BVG, 2023)

Table 2. Tasks of individual organizational units of the joint bus and tram transport management center in Berlin

Tasks of organizational units	Characteristics of tasks
Power supply network management	Monitoring and piloting of all power supply systems for trams
Infrastructure management	The area of management of linear and nodal infrastructure of tram transport
Bus/tram transport dispatchers	Monitoring and controlling deviations from the timetable and organizing replacement transport
Network management	The area of economic control and management of operational procedures in the event of disturbances
Multi-tasking dispatcher	Coordination of substitute connections (buses and trams) as alternative means of transport
Passenger information management dispatcher	Coordination of the passenger information system on electronic boards in the event of deviations from the timetable
Information management center	Coordination of information flow between all entities responsible for the provision of transport services and with security services

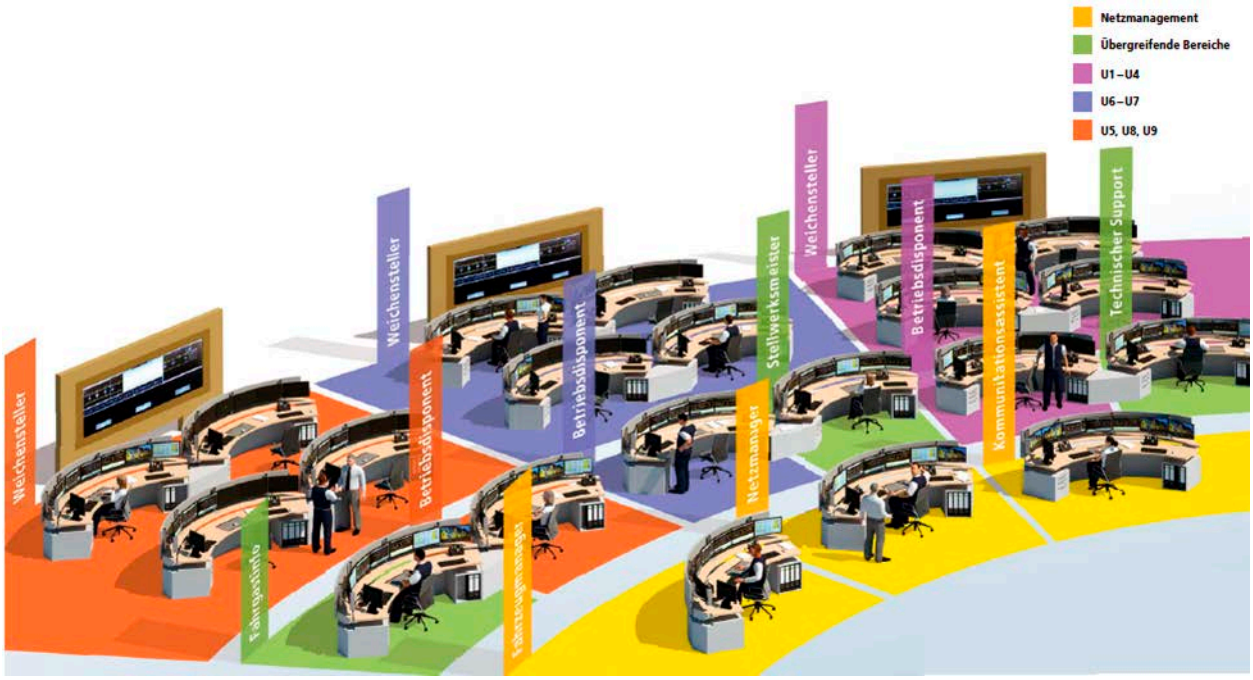

Figure 4. Innovative metro management center (U-Bahn) in Berlin (BVG, 2023)

Table 3. Tasks of individual organizational units of the innovative metro management center (U-Bahn) in Berlin

Tasks of organizational units	Characteristics of tasks
Switching point department	Area where metro cars are set up and prepared for work
Dispatcher	Monitoring the execution of journeys and their punctuality in accordance with the timetable
Passenger information	Area of passenger information and actions in strategic situations
Specialist in the area of car alignment	A person cooperating with the switching point department in the metro control center. Responsible for the correct parameters of all cars
Technical support	Department for solving technical problems related to the software system used
Fleet management	Checking vehicle alignment and steering system
Network management	Coordination of work and traffic intensity, and receiving reports in emergency situations
Transport assistant	Passenger information area and coordination with other control centers in the event of a failure

a day throughout the year. The center is equipped with huge video walls offering a good overview of the network and the current location of all trains. In the event of a failure, it allows for a quick and flexible response and coordinates the proper operation of the passenger information system at stations and means of transport.

The tasks of individual organizational units of the integrated metro management center are presented in Table 3.

The design of a joint bus and tram management center and a metro (*U-Bahn*) management center in Berlin aims to improve quality and safety as part of the integrated urban passenger transport system of the German capital. It enables the integration of public transport services within the city, as well as a common system of exchange of information and technical and operational standards of services provided between individual, organizational units of the carrier.

Conclusions

A metropolis such as Berlin could not function efficiently without a complex and highly efficient urban passenger transport system. However, the requirements for the transportation system are constantly changing. Therefore, the demand for management improvement solutions and security in Berlin is very high. This is due to the need to increase the efficiency of the transport system and the need to improve safety. The design and implementation of new solutions for public transport in Berlin is based on greater cooperation between the private sector, non-governmental organizations, and research and development units, both domestic

and foreign. However, improving the regional system in terms of improving security depends on all its participants, thus accounting for the significant social aspects. The implementation of improved or new solutions must be conducted in such a way as to encourage the potential user to accept the changes made, without a significant deterioration of travel conditions.

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