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INFORMATION SYSTEMS FOR PASSENGERS IN RAILWAY PASSENGER TRANSPORT IN THE SLOVAK REPUBLIC

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Abstract

The article analyses on-board passenger information systems used in railway passenger transport in the Slovak Republic. The aim of the paper is to identify and characterise the technological solutions implemented in railway vehicles and to assess their functional characteristics, level of integration and role in providing travel information during the journey. The analysis focuses on information systems installed directly in railway vehicles, which provide operational information to passengers throughout the entire trip. Several on-board information systems currently used in Slovak rolling stock are examined in terms of their architecture, types of provided information and ability to respond to operational changes and extraordinary situations. The results show that the current environment of on-board passenger information systems in Slovakia is technologically heterogeneous due to differences in rolling stock modernisation and the involvement of multiple system suppliers. Modern systems provide dynamic passenger information and higher integration capabilities, while older solutions offer more limited functionalities. The study also highlights the importance of interoperability and further integration of passenger information systems within the digital railway environment.

Keywords: passenger information systems, railway passenger transport, on-board information systems, digitalisation of railways, interoperability

1 Introduction

The quality and availability of information provided to passengers represent one of the key factors influencing the attractiveness, reliability and overall perception of railway passenger transport. In modern transport systems, information is no longer considered only as a supplementary service, but as an essential component of transport quality, directly affecting passenger comfort, orientation, and confidence during travel. The increasing complexity of railway operations, combined with higher expectations of passengers, places growing demands on information systems capable of delivering accurate, timely and comprehensible information [1, 2]. A specific and highly important category within passenger information services is represented by on-board information systems, i.e. information systems installed directly in railway vehicles. Unlike station-based or online information platforms, on-board systems accompany the passenger throughout the entire journey and play a crucial role especially during train movement, intermediate stops, operational changes or extraordinary situations. These systems typically provide journey-related information, in some cases including real-time updates about the train route, next stations, delays, connections, safety instructions and other operational messages, using visual and acoustic channels [1, 3]. In the Slovak Republic, on-board passenger information systems have undergone significant development in recent decades, reflecting both technological progress and gradual modernization of rolling stock.

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As a result, several different on-board information systems are currently deployed in railway vehicles in the Slovak Republic. These systems differ in their architecture, functional scope, level of integration with vehicle subsystems and ability to process dynamic operational data. The coexistence of multiple on-board information systems is largely influenced by the heterogeneity of rolling stock, different stages of vehicle modernization and the involvement of various system suppliers [4]. From a broader European perspective, the development of passenger information systems is strongly influenced by interoperability requirements and regulatory frameworks. In particular, the Telematics Applications for Passenger Services Technical Specifications for Interoperability (TAP TSI) defines requirements related to the provision, structure and exchange of passenger-related information. Although TAP TSI primarily addresses system interoperability and data exchange between railway actors, its principles indirectly affect also on-board information systems, especially regarding data consistency, accuracy and accessibility [5, 6].

This paper focuses on the analysis of on-board information systems used in railway passenger transport in the Slovak Republic. The main objective is to identify and characterise the information systems currently deployed in railway vehicles, analyse their functional properties and assess their role within the overall passenger information environment. The analysis is based primarily on data obtained from a bachelor thesis focused on passenger information systems in Slovakia, complemented by relevant scientific literature and European regulatory documents. By examining specific on-board information system solutions, the paper aims to contribute to a better understanding of current practises, challenges and future development directions in the field of passenger information systems in railway transport [4, 5, 7].

2 Literature review

In railway passenger transport, information provision plays a particularly important role due to the complexity of operations, the length of journeys and the need to manage passenger expectations during planned and unplanned events [1, 2]. Early conceptual approaches to passenger information systems emphasised their role in supporting passenger orientation and decision-making. Olivková [1] defines passenger information systems as integrated technical solutions designed to provide passengers with relevant transport-related information before and during the journey, using a combination of visual and acoustic communication channels. According to this perspective, the quality of information is determined not only by its content, but also by its clarity, timeliness and accessibility to different passenger groups. Gašparík and Čamaj [7] place passenger information systems within a broader framework of information and communication technologies in railway transport. They highlight the increasing integration of information systems with operational and vehicle subsystems, enabling the transition from static information provision to dynamic, real-time passenger information. Their work underlines that modern railway information systems must be capable of processing operational data and transforming them into passenger-oriented messages without delay or loss of accuracy. Several studies focus on the relationship between information quality and operational reliability. Greiner [8] points out that passenger information is strongly dependent on data flows between operational planning systems, traffic management and vehicle-based systems. Disruptions or inconsistencies in these data flows directly affect the reliability of information delivered to passengers, particularly in the case of delays, rerouting or extraordinary operational situations. This finding is especially relevant for on-board information systems, which rely on continuous updates during train movement [8]. The assessment of passenger information quality is closely linked to broader evaluations of transport service quality. Gašparík et al. [9] propose methodological approaches for assessing the quality of railway connections, where the availability and accuracy of information constitute an important qualitative criterion.

Although their methodology is primarily network-oriented, the underlying principles are applicable to on-board information systems, as passenger perceive information quality as an integral part of the overall travel experience. From a technological perspective, the evolution of passenger information systems is associated with increasing system complexity and integration. Bezák [10] discusses initial analyses for next-generation railway information systems, emphasising modular architectures, interoperability and scalability. These characteristics are particularly important for on-board systems, which must operate reliably in varying operational conditions and interface with both vehicle subsystems and external data sources.

Recent studies also highlight that increasing digitalisation of railway transport significantly influences the development of advanced information systems. Modern railway systems increasingly rely on interconnected digital infrastructures, real-time data processing and advanced communication technologies that enable the provision of context-aware services and improved operational management. In this context, intelligent transportation systems and other ICT-based solutions play an important role in enhancing the efficiency, safety and sustainability of railway operations [11]. Furthermore, the deployment of technologies such as the Internet of Things, high-speed communication networks and data-driven applications enables the collection and analysis of large volumes of operational and passenger-related data, which can support the development of more advanced and personalised passenger information services [12].

Recent research also reflects the impact of extraordinary situations on passenger information requirements. Bulková and Čamaj [3] analyse innovative procedures for equipping passengers with information during crisis conditions, highlighting the importance of adaptability, redundancy and clear communication. Their findings confirm that on-board information systems play a critical role in maintaining passenger confidence when standard operational patterns are disrupted. At the European level, the development of passenger information systems is influenced by interoperability requirements defined in the TAP TSI regulation. The Telematics Applications for Passenger Services Technical Specification for Interoperability (TAP TSI) establishes rules for the structure, exchange and consistency of passenger-related data across railway systems [5, 6]. Although TAP TSI primarily addresses system-to-system communication, its principles influence the functional design of passenger information systems, including on-board solutions, by promoting standardized data models and reliable information exchange. Complementary developments discussed by OTIF further underline the growing importance of harmonised telematics solutions within the European railway systems.

Overall, the reviewed literature demonstrates that passenger information systems are no longer isolated technical tools but form part of an interconnected information ecosystem. On-board passenger information systems represent a critical interface between complex railway operations and passenger perception of service quality. The literature provides a solid conceptual foundation for analysing specific On-board information system solutions used in the Slovak Republic, which is addressed in the subsequent sections of this paper.

3 Methodology

The study is designed as qualitative descriptive-analytical research focused on the analysis of on-board passenger information systems used in railway passenger transport in the Slovak Republic [4]. The methodological approach aims to describe the current state of implemented systems, analyse their functional characteristics and assess their role within the passenger information environment, rather than to perform quantitative performance evaluation. The primary data source for the analysis is a bachelor thesis focused on passenger information systems in railway passenger transport in Slovakia, which provides a detailed overview of system architectures, functional properties and deployment across different types of rolling stock.

This source is complemented by relevant scientific literature addressing passenger information systems, railway information technologies and service quality, as well as by European regulatory and interoperability documents [4, 5, 7].
The scope of the analysis is limited to on-board passenger information systems installed directly in railway vehicles. Station-based information systems, online platforms and mobile applications are not included in the analysis, except where necessary to explain data interfaces or information flows affecting on-board systems. The analysed systems include the following solution currently used in the Slovak Republic: UNITRACK Piredi, R&G, OAIS, MSV, IDIS, BUSE, AMiT, 4SKY and ALCASYS [4]. The analytical framework is based on a comparison of on-board information systems according to selected qualitative criteria derived from literature and regulatory requirements. These criteria include system architecture, types of provided information, methods of data acquisition, support for real-time operation, adaptability to operational changes and extraordinary situations, and compliance with interoperability principles [3, 7, 10]. The research methods applied in the study include document analysis, content analysis and comparative analysis. Document analysis was used to examine technical descriptions and system documentation available in the bachelor thesis. Content analysis was applied to scientific literature and regulatory documents to identify key functional and quality requirements for passenger information systems. Comparative analysis was then employed to evaluate similarities and differences among the analysed on-board information systems. The main limitation of the study lies in the reliance on secondary data sources and the absence of direct access to internal technical documentation of system suppliers. However, this limitation does not significantly affect the validity of the analysis, as the objective of the study is to provide a systematic overview and qualitative assessment rather than a detailed technical evaluation of individual system implementations.

4 Results

This chapter presents the results of the analysis focused on on-board passenger information systems used in railway passenger transport in the Slovak Republic. The results are based primarily on the findings of the bachelor thesis and supported by relevant literature and regulatory documents. The analysis aims to describe the current structure of on-board information systems, their functional characteristics and level of technological maturity, as well as to identify key differences between individual solutions deployed in railway vehicles. Particular attention is paid to the ability of these systems to provide accurate, accessible and timely information to passengers during regular operation and extraordinary situations [4, 5, 7].

4.1 Overview of on-board passenger Information systems in Slovakia

Railway passenger transport in the Slovak Republic currently employs a heterogeneous set of on-board passenger information systems installed in railway vehicles. This heterogeneity reflects differences in rolling stock age, vehicle modernisation process and the involvement of multiple system suppliers over time. As a result, several technically and functionally distinct information systems coexist within the national railway passenger fleet [4]. Despite their diversity, all analysed systems share a common objective: to provide passengers with essential travel-related information during the journey. Typical functionalities include visual and acoustic announcements of stations, display of route and destination information, indication of delays, and transmission of operational messages. However, the scope, technical implementation and level of integration with vehicle and operational subsystems differ significantly among individual solutions [4].

4.2 UNITRACK piredi on-board information system

The UNITRACK Piredi system represents one of the on-board passenger information solutions deployed in Slovak railway vehicles, primarily in modernised rolling stock. The system is designed as a modular solution integrating visual display units and audio announcement components [4]. UNITRACK Piredi enables automatic announcement of stations based on predefined route data, while also allowing manual intervention by train staff in case of operational changes. Information is typically displayed on interior screens, presenting data such as train destination, next stop and intermediate stations. The system supports multilingual content, which contribute to improved passenger accessibility, particularly on international routes [4]. From a functional perspective, UNITRACK Piredi demonstrates a relatively high level of automation, however, its effectiveness is strongly dependent on the accuracy of input data and correct system configuration. The system primarily operates as a vehicle-based solution with limited direct integration into external operational information platforms [4].

4.3 R&G on-board information system

The R&G on-board information system is implemented mainly in selected types of passenger coaches and multiple units. The system provides basic visual and acoustic passenger information typical for earlier on-board information solutions [4]. R&G systems are typically characterised by a simpler technical architecture compared to newer integrated platforms. Station announcements and route information are often based on predefined datasets uploaded to the vehicle prior to operation. While this approach ensures reliability under stable operational conditions, it limits the system's ability to respond dynamically to unplanned changes such as rerouting or delays [4]. As a result, the R&G system relies more heavily on manual control by train personnel when extraordinary situations occur. These characteristic highlights the trade-off between system simplicity and operational flexibility [4].

4.4 OAIS and MSV systems

The OAIS and MSV information systems represent earlier generations of on-board passenger information solutions used in older or partially modernised railway vehicles. These systems primarily provide basic static information and pre-recorded announcements [4]. Their functionality is generally limited to station announcements and simple route displays, with minimal support for real-time operational updates. Data input is often manual, and system adaptability to operational changes is constrained [4]. Although these systems no longer meet contemporary expectations for passenger information services, they continue to play a role in maintaining a minimum standard of information provision in vehicles that have not yet undergone comprehensive modernisation [4].

4.5 IDIS, BUSE and AMiT systems

The IDIS, BUSE and AmiT systems represent more advanced on-board passenger information solutions commonly deployed in modern public transport vehicles and adapted for railway applications. These systems offer enhanced functionality, including dynamic content management, graphical route visualisation and improved audio quality [4]. These systems are typically capable of integrating data from vehicle subsystems such as GPS or odometry, enabling more accurate station announcements and synchronisation with train movement. Their modular architecture allows for scalability and functional extensions, including support for accessibility features such as visual contrast optimisation and acoustic announcements for visually impaired passengers [4].

Among these solutions, AmiT system is notable for its higher level of configurability and integration potential, while BUSE systems are recognised for their widespread use and proven operational reliability [4].

4.6 4SKY and ALCASYS systems

The 4SKY and ALCASYS systems represent specialised on-board information solutions designed with a focus on integration and advanced data processing. These systems are typically deployed in newer rolling stock or pilot projects [4]. Their architecture supports a higher degree of interoperability with vehicle control systems and, in some cases, external data sources. This enables more flexible management of passenger information, including real-time updates and synchronisation with operational events [4]. However, due to their limited deployment, the overall impact of these systems on the national passenger information environment remains constrained. Their presence nonetheless indicates a trend toward more integrated and intelligent on-board information solutions [4].

4.7 Comparative assessment of on-board information systems

The comparative analysis of on-board passenger information systems used in the Slovak Republic reveals significant differences in functionality, adaptability and integration capabilities. Older systems such as OAIS and MSV provide basic information services but lack flexibility and real-time responsiveness. In contrast, newer systems such as UNITRACK Piredi, AmiT and 4Sky offer more advanced features and improved passenger experience. A common challenge identified across multiple systems is limited integration with central operational data sources. This limitation reduces the ability of on-board systems to reflect real-time operational changes accurately, particularly during extraordinary situations. Consequently, passenger information quality often depends on manual intervention by train staff. Overall, the result indicates that while the current on-board information system landscape in Slovakia ensures a basic level of passenger information provision, further integration and standardisation are required to fully meet contemporary passenger expectations and European interoperability principles [3, 4]. The following table summarises the main functional characteristics of the analysed on-board passenger information systems and highlights differences in their level of integration, adaptability and real-time information capability.

Table 1 Comparative characteristics of on-board systems used in Slovakia

System	Type of Information	Real-time Capability	Integration Level	Adaptability to Operational Changes
UNITRACK Piredi	Visual and audio passenger information	Partial	Medium	Medium
R&G	Basic visual and audio information	Limited	Low	Low
OAIS	Static announcements	No	Low	Very limited
MSV	Static announcements	No	Low	Very limited
IDIS	Dynamic passenger information	Partial	Medium	Medium
BUSE	Visual and acoustic passenger information	Partial	Medium	Medium
AMiT	Advanced dynamic information	Yes	High	High
4SKY	Integrated information solution	Yes	High	High
ALCASYS	Advanced integrated system	Yes	High	High

5 Discussion

The results of the analysis indicate that on-board passenger information systems used in railway passenger transport in the Slovak Republic form a technologically diverse and functionally heterogeneous environment. This situation reflects the long-term development of rolling stock, varying levels of vehicle modernisation and the involvement of multiple system suppliers. While such diversity allows for gradual technological innovation, it simultaneously introduces challenges related to system unification, interoperability and maintenance [3, 4]. One of the key findings is the variability in the functional scope of individual systems. Modern solutions, such as AmiT, BUSE or 4Sky, typically support dynamic data processing, real-time updates and integration with vehicle control systems. These capabilities significantly improve the reliability and timeliness of passenger information, especially in the case of operational changes or extraordinary situations. In contrast, older or less integrated systems primarily rely on static data and predefined announcements, which limits their ability to respond flexibly to real-time operational conditions.

From the passenger perspective, the quality of information provision is strongly influenced not only by the technical parameters of the system, but also by the consistency of presented information. The coexistence of multiple systems across the vehicle fleet may lead to differences in displayed content, user interface design and information detail, which can negatively affect passenger orientation and perceived service quality. This finding corresponds with conclusions presented in literature, which emphasise clarity, accuracy and uniformity as key attributes of effective passenger information systems. The analysis also highlights the growing importance of interoperability and compliance with European regulatory frameworks, particularly the Technical Specification for Interoperability relating to telematics applications for passenger services (TAP TSI) [5, 6]. Although on-board systems primarily operate at the vehicle level, their effectiveness increasingly depends on reliable data exchange with external systems, including timetable databases and operational management platforms. Systems capable of integrating standardized data formats and supporting interoperability principles are therefore better positioned for future development. Another important aspect concerns accessibility. Modern passenger information systems increasingly incorporate features supporting passengers with reduced mobility, visual or hearing impairments, such as synchronised visual and acoustic announcements or adjustable display formats. However, the implementation of accessibility features is not uniform across all analysed systems, indicating potential for further improvement in this area [1, 2].

Overall, the discussion confirms that while on-board passenger information systems in Slovakia have undergone significant technological progress, their development remains uneven. Future efforts should focus on harmonisation of functional standards, increased use of real-time data, and stronger alignment with European interoperability requirements. Such measures would contribute not only to improved operational efficiency, but also to enhanced passenger satisfaction and attractiveness of railway transport.

6 Conclusion

This article analysed on-board passenger information systems used in railway passenger transport in the Slovak Republic, with a particular focus on their functional characteristics, technological diversity and role in the provision of travel-related information to passengers. The analysis was based primarily on the findings of a bachelor thesis and supported by relevant scientific literature and European regulatory documents. The results confirmed that the current environment of on-board passenger information systems in Slovakia is characterised by the coexistence of multiple system solutions supplied by different manufacturers.

This situation reflects the historical development and gradual modernisation of rolling stock, but also leads to differences in system functionality, level of integration and passenger experience. While modern systems provide dynamic, real-time information and better adaptability to operational changes, older solutions remain limited in terms of flexibility and interoperability. The discussion highlighted that the effectiveness of passenger information systems is determined not only by technological capabilities, but also by the consistency, accessibility and reliability of the information provided. Increasing importance is placed on compliance with European interoperability requirements, particularly the Technical Specification for Interoperability relating to telematics applications for passenger services (TAP TSI), which creates a framework for standardised data exchange and unified passenger information services across Europe. Future development should focus on stronger system integration, wider use of real-time operational data and gradual harmonisation of information systems across the rolling stock fleet. Alignment with European interoperability principles represents an opportunity to improve the quality of passenger information, strengthen passenger orientation during travel and increase the overall attractiveness of railway passenger transport. In conclusion, on-board passenger information systems represent a key component of modern railway services. Their systematic development and integration contribute directly to passenger comfort, service transparency and the competitiveness of rail transport within the public transport system [4, 5].

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