Chapter 10
Challenges of Improving the Railway Passenger Information System in the Republic of Croatia

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1 Introduction

The ability to provide information and transport services anytime and anywhere makes the rail network more efficient and easier for end users. Real-time and accurate information is an essential item in informing passengers. The basis for obtaining this information is a stable and comprehensive passenger information system that uses a specific architecture to deliver the service. This system can do real-time transmission of information and data, for example, on the timetable from different sources, their connection into one whole, and providing through various interfaces. The system includes updated information related to any timetable change and timetable changes combined with timetable data and delivered to the information systems. The passenger information system relies on multimedia network technology in which the central computer provides information services to passengers using screens at stations or stops and in vehicles.

Elements of the railway network architecture enable computing capacity and telecommunications to collect, transmit, and process data related to stakeholders' management and information. From the management point of view, the passenger information system is divided into the source of information, central management level, management level in stations and on the train, and control equipment at stations and on the train.

This chapter will present the functionalities of currently available information and communication (IC) solutions and services that enable informing passengers in rail traffic in the European Union (EU). The analysis will include passenger

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information systems in the EU countries with the highest realized passenger traffic in the last year, measuring it in billions of passengers transported. Furthermore, these systems will be compared with the Republic of Croatia's (Croatia) passenger information systems. Based on the comparison and analysis of the current state of IC infrastructure, the chapter presents an overview of the possibilities of improving the passenger information system in Croatia.

2 Overview of the Current Passenger Information Systems in the EU

The railway system can be divided into structural area subsystems and functional area subsystems. The structural area subsystem includes infrastructure, energy, monitoring, control and signaling, control orders, and signaling in the vehicle and the vehicle fleet. Furthermore, the functional area subsystem includes traffic management, maintenance, and telematics applications for passenger and telematics services [1]. The passenger information system is a solution for providing relevant real-time information to passengers. It includes a passenger information system, passenger information screens, surveillance, and physical address. It is responsible for the automatic or manually programmed provision of visual and audio data to passengers at stations and stops. Passengers have access to the system through various channels, such as Internet-connected devices, computers, and mobile devices [2].

Mobile application-based passenger information systems are rapidly gaining ground due to the increased penetration of smartphone use. It is most common in passengers who use public transport [3]. Namely, passengers prefer to use data available on mobile devices rather than data displayed on screens at stations or through a public address system [4]. It is necessary to improve the quality of rail passenger transport services so that it reflects customer requirements and optimal use of public resources [5]. Apart from providing passenger information to end user, it is essential to know what real-time information passengers want and what agencies provide—information demand and supply side [6]. Research on existing and future passenger information concepts [7] has shown that innovative and new passenger information technologies represent a great benefit for providers of information services by increasing users' flow in stations. Providing passengers with accurate real-time information can lead to shortening waiting time and decreasing overall travel time due to changes in path choice and increased use of public transport and satisfaction with transit services [8]. The development of IC in the transport sector has resulted in services focusing on customers and their needs by changing passenger transport's previous perception [9]. With the developed technology and accurate information, available passengers can replan their path if any disturbances and disruptions on the network [10]. Modern and efficient railway infrastructure is a prerequisite for the development of rail transport [11]. The application of modern methods and IT tools in railway transport requires additional infrastructure equipment with many technical elements related to data collection, processing, and distribution [12]. Previous research has identified that current railway network modernization projects in the Republic of Croatia mostly include traffic management systems and solutions based on IC infrastructure [13].

By the EU Commission Regulation [14], each station manager must provide train departure data at railway stations to the end user. According to the Regulation, the telematics application subsystem consists of two elements: a passenger transport application and a freight application. Passenger transport applications further include systems for providing information to passengers before and during the journey, reservation and payment systems, baggage management, and the management of train connections and other modes of transport. The Regulation is based on the Technical Specifications for Interoperability (TSI) in Directive 2001/16/EC of the European Parliament and of the Council of March 19, 2001 on the trans-European interoperability conventional rail system, which details the provision of passenger information and the implementation of the passenger information system. The TSI aims to establish procedures and interfaces among all stakeholders to provide relevant information and issue tickets to passengers via currently available technologies [15]. The railway carrier is obliged to provide information from its timetable to other railway undertakings and third parties. All relevant information and timetable data must be accurate and up-to-date, and available to other railway undertakings and third parties within the next 12 months after they expire and become invalid. According to the EU Regulation, the basic guidelines for developing TSIs and their harmonization with European standards are defined. In 2020, the Croatian Parliament passed a law that is important for harmonizing information and the railway system [16].

A 2020 Eurostat survey on the impact of rail passenger transport at the EU level shows that the largest number of passengers in 2018 was carried in Germany (2,880,558,000), the United Kingdom (1,783,232,000), and France (1,246,804,000) [17]. For this reason, passenger information systems have been analyzed in the area of railway administrations of these countries. The railway system in these countries is much more complicated, so modern IC technology is integrated into all subsystems in order to maintain a functional and efficient system. In many EU countries, such an approach in the processes of modernization and introduction of modern communication solutions and services in the railway system has enabled the efficient, reliable, and safe operation of the system.

The current passenger information systems on the rail network in Germany, the United Kingdom, and France, which are developed according to the TSI guidelines and the EU Commission's Regulation, can be divided into passenger information systems before and during the trip. Passenger information systems before the trip include information via the website and mobile applications. During the trip, passenger information systems refer to audio and visual information via screens in the stations themselves or at the stops.

The German railway network infrastructure (DB Netz AG) is managed by the German Railways (Deutsche Bahn AG). It manages 33,300 [km] of the railway network, 5400 stations, and stops. The passenger information system used at stops and stations is fully developed in the environment of Cloud Computing technology [18]. Siemens solutions are one of the most represented on the railway network in Germany. Information provided to users at stations and stops is available in video and audio format. In addition to visual systems, the passenger information system also uses voice information. For this purpose, a fully automatic sound system "Voice over IP" is used, which projects voice announcements. Route number, destination station, and connecting transit are announced on tact, while delays, cancellations, closed doors, or route changes are announced as needed. General announcements regarding the ban on smoking and unattended luggage are also published regularly. An essential feature of this passenger information system is the ability to manually operate the entire system to provide important information to passengers in an emergency.

The UK rail network is managed by Network Rail Infrastructure Ltd. and has a network of 32,186 [km] of the track. The system for informing passengers at stations and stops includes the CIS—user information subsystem and OIS—operational information subsystem. CIS LED/LCD screens are located at the entrances to stations and/or platforms and provide departure/arrival information. The CIS subsystem also allows communication with arriving trains. OIS screens provide additional contextual or general information (for example, informing passengers about planned works) and possibly additional information during traffic jams. The solution represented on the UK railway network is the Infotec information system and is based on modern communication technologies, which enables the processing of all relevant data and real-time information to passengers. The technologies used by the system are Cloud Computing (Amazon AWS), IoT, 3G, 4G, and GPRS [19].

The railway network in France is managed by the SNCF group (Réseau) and consists of a network of 30,000 [km] of the track, of which 2600 [km] refers to high-speed rail [20]. Televic Rail's solution is used in vehicles, while Teleste, Alstom, and Thales group solutions are used at stops and stations. The Thales group's solution consists of signaling, video surveillance in vehicles and at stations, and a passenger information system. It is based on Cloud Computing technology, Big Data, and artificial intelligence. The services being developed in this environment provide passengers with information via video, audio, the multimedia system at stations and stops, and mobile devices. Elements of the IC system architecture are sensors, GPS devices, network components (routers, LAN, and WiFi), Cloud Computing, and more.

3 Comparison of the Passenger Information System in Croatia with the EU

The passenger information systems applied in the countries involved in the analysis of work are the best example of the implementation of passenger information practices in railway transport. To position the passenger information system's possibilities and the level of passenger information availability in Croatia to the EU, a comparison of this system's features with the previously analyzed systems will be presented.

On the rail network of the infrastructure manager in Croatia, HŽ Infrastructure (HŽI), out of a total of 545 stations and stops in Croatia, only 256 are equipped to provide visual information for passengers. Of the 124 stations equipped with the listed equipment required to provide information, six stations also provide dynamic screens for displaying information to passengers. There are 60% of stations and stops with the possibility of providing visual information to passengers, with only about 1.4% of them having dynamic screens [21].

The service of informing passengers at stations and stops is provided via loudspeakers or visually via fixed bulletin boards displaying the all-day timetable, i.e., screens with information on the time and place of train arrival and departure, train delays, possible change of transport route, and other necessary information related to rail traffic. Data on railway lines exist in digital form on the passenger transport operator's website and the mobile application.

Most stations and stops have a passenger information system consisting of several subsystems [22]:

- Classic fixed timetable
- Boards (led screens)
- Clock subsystems
- Loudspeaker subsystems
- Ups (uninterruptible power supply)
- Communication equipment that allows it

Analog clock screens located at stations and stops are composed of SMD (Surface-Mount Device) LED light modules designed to display various alphanumeric messages in multiple lines at rest. Each side of this screen consists of a display part (LED screen), a processor assembly, a power supply module, a communication interface, a light sensor, and lighting and switching assemblies. The information is created in a control center that sends it to the processor assembly, where it is processed and displayed on an LED screen. The communication interface is optically separate and connects the information screen and the control computer. The lighting and switching assemblies' sensors illuminate the mechanical clock and the inscription on display.

The clock subsystem consists of a master clock developed in modular technology, a two-wire transmission system (enables independent installation of auxiliary clocks without maintenance and a remotely synchronized computer system) MOBAWNT software program. The loudspeaker subsystem consists of a digital output module, a power amplifier, a universal interface module, a digital telephone exchange/digital key module, and a converter. The UPS subsystem is designed to prevent interruptions and impacts on computers and valuable electronic equipment. Communication equipment in stations are numerous and can be divided into the following elements: media converters, relay modules, power relay modules, input modules, smart web input/output Ethernet module, interface converter, various connectors, data cable shielding, and industrial server serial devices over a TCP/IP-based Ethernet network.

Table 10.1 Comparison of passenger information systems during the trip

	DB	NRN	SNCF	HŽI
Visual informing	+	+	+	+
Voice informing	+	+	+	+
Dynamic screens	+	+	+	+
Touch screens	+	+	+	–
Type of screens	TFT-LCD	LED	TFT	LED
Pointer direction	+	+	+	–
Diagnostic feature built into the screen	+	–	–	–
Time and date display on the screen	+	+	+	+
Display of train arrival/departure on the screen	+	+	+	+
Promotional content on screens	+	+	+	–
Adapted for disabled people	–	–	+	–

Table 10.2 Comparison of passenger information systems before the trip websites

	DB	National rail	SNCF	HŽPP
Availability on more languages	+	–	+	+
Adaptation for the visually impaired persons	+	–	+	–
Enabled direct purchase of tickets through the website	+	–	–	+
Multiple ticket payment methods enabled	+	+	+	+
Obligation to register and register when buying tickets	+	+	+	–
Seat reservation enabled	+	+	–	–
Travel planner	+	+	+	+
Benefit overview	+	+	+	+
Available information related to bicycle and pet transport services	–	+	+	+
Timetable display	+	+	+	+
Information about timetable changes	+	+	+	+
Passenger rights information	+	+	+	+
Canceling a ride or changing the ticket directly on the page available	+	–	–	–

The technology used and how information is displayed to passengers at stations and stops in the analyzed countries differ. Table 10.1 shows the main differences between passenger information systems during the trip.

According to a comparison of the passenger information system features during the trip, the systems used in Germany and France provide the most opportunities for informing passengers. On the other hand, informing passengers in Croatia is limited only to the necessary information, such as displaying time and date and departure time by visual or audio means. It should be noted that the above information is not available to passengers in all stations and that LED screens are in a limited number of large stations.

Table 10.2 shows the differences between the services offered through websites in the analyzed countries. Comparing the possibilities of informing passengers via

Table 10.3 Comparison of mobile applications of passenger information systems before trip

	DB navigator	National rail	SNCF app	HŽPP planer
Availability in multiple languages	+	–	+	+
Availability for devices on Android, IoS, and Windows phone platforms	+	+	–	–
One application that contains all the services	+	+	–	–
Enabled ticket purchase directly through the application	+	–	–	–
More ways to pay for tickets	+	+	+	–
Possibility to book a ticket	+	–	–	–
Possibility to reserve a seat	+	–	–	–
Travel planner	+	+	+	+
Offline map display and traffic information	–	–	+	+
Driving time schedule	+	+	+	+
Notices related to timetable changes	+	+	+	+
Additional offers	+	+	+	+
Adaptation for people with visual and hearing impairments	–	–	+	–

websites among the considered infrastructure managers, it is evident that DB provides the broadest range of services to passengers. In Croatia, the possibility of booking a seat, canceling, or exchanging tickets and registration when buying tickets is not available and is directly related to the passenger carrier. These shortcomings are not justified, given that there is still only one passenger transport operator in Croatia. In other countries, there are many more due to the liberalization of the passenger transport market.

The mobile application for informing passengers HŽPP Planer, among other things, offers the possibility of calculating the price of a ticket (with discounts, if the passenger is entitled to them), tracking the GPS position of trains, travel details, and the similar. Table 10.3 shows the essential characteristics of the analyzed applications.

According to the parameters listed in Table 10.3, it can be concluded that the mobile application for passenger information DB Navigator satisfies the broadest range of parameters considered.

4 Guidelines for the Improvement of the Passenger Information System in the Railway Transport of the Republic of Croatia

In 2019, a survey was conducted regarding the quality of railway passenger service in Croatia. Among other service elements, information availability was the focus of mentioned research. The survey results show that “information availability regarding service cancellation" was insufficient by 50% of users. "Available information regarding timetable changes" is rated insufficient by more than 35% of the users. Other elements regarding information availability were rated better [23].

According to the EU Regulation, the basic guidelines for developing TSIs and their harmonization with European standards are defined. The modernization of the passenger information system's objectives is based on the laws mentioned above and EU Regulations. The goals of modernization are

- Improving and maintaining the quality of railway transport services
- Ensuring compatibility with existing subsystems
- Compatibility of high-speed railway systems and conventional railway systems depending on the category of lines
- A railway system accessible to all regardless of the degree of disability
- Improving economic efficiency
- Mobility of system users
- Increasing the competitiveness of the Croatian railway measure
- User information

An IC architecture is needed to deliver accurate, secure, relevant, and real-time information to end users. Figure 10.1 shows a proposal for such an architecture. It can be seen that the passenger information system is part of the structure of the operational management and traffic control center. In this proposal, the data center is equipped with IoT sensor systems to monitor and control all parts of the system whose possibility of application in the railway system is the subject of research in [11]. It is necessary to pay attention to the possibility of cyber threats such as DDoS (Distributed Denial of Service) attacks on the system [24–26]. In such a structure, the current development direction is taken into account, i.e., integrated passenger transport projects [27].

In such a complex system, three subsystems listed and described in Table 10.4 participate in creating and delivering information to end users on the railway network. Currently, there is only one passenger transport service provider (HŽPP) in Croatia. However, this chapter's proposal enables any passenger carrier's connection for a specific category of users. Each of these subsystems can be modernized. For this chapter, the authors focused on the modernization of the infrastructure subsystem (HŽI).

$$S(R) = f\{S_{\mathrm{I}} ? S_{\mathrm{PTR}} ? S_{\mathrm{IT}}\}, \tag{10.1}$$

where

S_{I}—infrastructure subsystem
S_{PTR}—passenger transport by rail subsystem
S_{IT}—integrated transport subsystem

A communication network and a security concept must be used to exchange data to enable any network transmission. The information exchange architecture favors

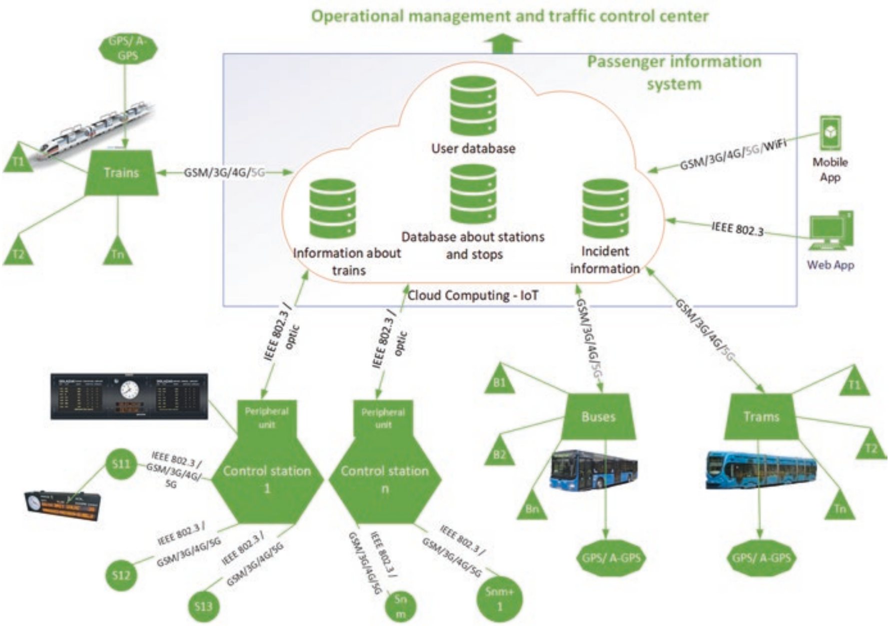

Fig. 10.1 Proposal of IC architecture for information delivery [28]

Table 10.4 Subsystems that are part of a system for delivering information to passengers on the railway network

Subsystem	Subsystem parts	Acronym
S_I	HŽI	$S_{HŽI}$
S_{PTR}	HŽPP	$S_{HŽPP}$
	Passenger transport operator 1	S_{PTO1}
	Passenger transport operator n	S_{PTOn}
S_{IT}	ZET	S_{ZET}
	Operator 1	S_{O1}
	Operator n	S_{On}

peer-to-peer interaction between all participants while guaranteeing the interoperable railway community's overall integrity and consistency by providing a full range of centralized services. The railway system's interoperability is based on a typical "information exchange architecture" known and adopted by all participants, thus encouraging the reduction of barriers for new participants, especially service users. The central data container is first accessed to access the meta information, for example, to verify the security data. Peer-to-peer communication then takes place between the participants involved. In order to manage other modes of transport, the following standards apply to the provision of information and the exchange of information with other modes of transport:

- For the exchange of timetable information between the railway carrier and other modes of transport: standard EN 12896 ("Transmodel") and EN TC 278 WI 00278207 ("IFOPT identification of fixed facilities in public transport")
- For the exchange of specific timetable data, XML technical standards, and Transmodel-based protocols, in particular EN 15531, ("SIRI"), for the exchange of actual timetables and EN TC 278 WI 00278207 ("IFOPT") data exchange standards "Stop/station"
- For the exchange of price data (this standard is still an open point)

The authors analyzed the current state of the infrastructure for receiving equipment and all relevant information needed for the transfer and information of passengers to define the possibility of improving the passenger information system at stations and stops by modernizing the current passenger information system. Also, phases of introducing the system for official places with the most significant number of dispatched passengers are proposed.

4.1 Information Needed to Inform Passengers

The information needed to inform passengers needs to be viewed from several different interactions between the relevant stakeholders:

- Between mobile units (vehicles) and central system units (servers)
- Between information screens at stations/stops and central system units
- Between the central units of the system and the vehicles and information screens at the stations/stops
- Between central and peripheral units

Data related to current train status, traffic regime on the routes of individual lines, driving time, distance traveled, the vehicle's status, drivers, lines, timetable, passengers, and driving units are exchanged between the vehicle and the server. Information screens at stops/terminals and servers exchange data such as the time until the arrival of an individual vehicle at the stop, the status of the information screen at the stop, the possibility of combining different modes of transport, traffic conditions.

Central system units, vehicles, and information screens at stops exchange data of different trip planners, different text and/or voice notifications and traffic information intended for drivers, traffic staff or passengers, and georeferenced information of all system users (driving/transport units, information screens at stops, other vehicles, etc.) according to the transport system, individual line, individual vehicle unit, and individual information display. They also exchange necessary information when changing routes (length, number, and arrangement of stopping points), driving time (turnover/half-turn/stopping at stops, standing at terminals, time of day, types of days), sequence, frequency, capacity, type and sort of vehicle, traffic area/zones, and information on changing routes intended for passengers, in vehicles and at stops, and on various web (mobile) applications.

Central and peripheral units interact with each other regarding the exchange of timetable data and various timetable elements (line, stops, planned/actual departures-arrivals per stop, individual journeys, driving duration, driving/transport units), staff data/workers, vehicles, line routes, stops/terminals, timetables, and all other information of interest.

4.2 The Existing State of Infrastructure for Receiving Equipment

The chapter presents an in-depth analysis of available data by HŽI related to certain official places' IC infrastructure equipment (Table 10.5). At some official places in Croatia, there are complete passenger information systems manufactured by EXOR 2002, 2009, 2011, 2014, ETC digitalpro, and Elektrokem. The system elements in the form of clocks and loudspeakers are placed in places where complete systems are not located. The existence of cable ducts is also present at specific locations and access points important for connecting an official location, such as a DuoTrack cable. In addition to the above, there is an STA or STKA cable (signal telecommunication cable with aluminum sheath and coaxial pairs) and a TD-TF cable (copper conductors) on the railway network. The table below is essential for understanding the current state of the infrastructure. It can be seen that only larger official places,

Table 10.5 Analysis of the current state of the IC infrastructure for several official places

Official place name	Status	Main station	Existing PIS	Cable canalization	Connection with official places (rail cable)	Electro energetic cable
M102 Zagreb GK-Dugo Selo						
Zagreb Glavni Kolodvor	Main station		YES/ EXOR/2002	YES	YES/STKA	YES
Maksimir	Station	Zagreb Borongaj	NO	NO	YES/TD	YES
Zagreb Borongaj	Main station		NO	YES	YES/STKA	YES
Trnava	Station	Zagreb Borongaj	NO	YES	YES/TD	YES
Čulinec	Station	Zagreb Borongaj	NO	NO	YES/STKA	YES
Sesvete	Main station		NO	NO	YES/STKA	YES
Sesvetski Kraljevec	Station	Sesvete	NO	NO	YES/STKA	YES
Dugo Selo	Main station		NO	YES	YES/STKA	YES

such as Zagreb Glavni Kolodvor, have an existing complete passenger information system, while smaller official places do not have any passenger information systems.

Optical backbones are the basis for future modernization in providing real-time passenger information services and other upgrades of the IC system. The modernization of the IC system began in 2015, and to this day, the old technological system has mainly been replaced by a new one. Telecommunication devices have been partially modernized on the Croatian corridors (former corridors X, Vb, Vc, and branch Vb1). This refers to installing an optical cable, the SDH backbone, the replacement of the ŽAT exchange with a new digital one, and the construction of a new IP/GBE data transmission network.

4.3 Stages of Introduction of the Passenger Information System

For this chapter, identifying phases of development and improvement of the passenger information system were performed. The authors analyzed the first ten official places that dispatched the largest number of passengers in 2019 in the Republic of Croatia. The met technical minimums in terms of construction and signal safety were also taken into account. The phases of introducing the passenger information system are based on the plans for the development and modernization of the railway infrastructure and the projects in progress. They are proposed according to the state of the IC infrastructure on the railway network in Croatia and according to supply and demand analysis. Table 10.6 shows whether the analyzed official places with their current information and communication infrastructure meet the technical characteristics to introduce the passenger information system. The condition for satisfaction is set if there is a cable sewer, access point, a railway conductor, and an electricity connection at the official place.

Phases 1 and 2 represent the implementation of existing projects under construction or planned to be implemented shortly. For certain official places, those that do not meet the minimum technical and technological requirements, the necessary measures for introducing a passenger information system are listed. Although this is a railway modernization plan, it is possible to include measures for equipping the passenger information system in the plans due to the adequate IC infrastructure.

After fulfilling all the technical preconditions, it is possible to start the phasing of introducing the information system at the stations and stops. Implementing the passenger information system should be carried out in phases, which enables certain parts of the project to be more efficiently implemented and the possibility of making the right decisions on further strategic directions for the modernization of the entire Croatia railway system.

Table 10.6 Review of the analysis of necessary measures for official stations that do not meet the requirements for the introduction of the passenger informing system

No.	Official place	Total dispatch	Telecommunication network meets the requirements	Implementation phase	Necessary measures
1	Zagreb GK	4,207,616	YES	1 and 2	
2	Dugo Selo	819,723	YES	1 and 2	
3	Sesvete	700,098	YES	1	
4	Zabok	603,106	YES	1	
5	Vrapče	480,937	BAD	3	Modernization of the telecommunications network
6	Zagreb ZK	453,791	YES	No data	
7	Varaždin	437,458	YES	1	
8	Gajnice	396,726	BAD	3	Connection of the official place with the rail cable
9	Osijek	393,803	YES	3	
10	Sl. Brod	386,148	YES	3	

4.4 Opportunities to Improve Passenger Information System in Croatia

Given that passengers today need to obtain specific information related to travel and the possibility of choosing such information, it is necessary to equip stations and stops with solutions that have touch screens to achieve interactivity with passengers. Promotional materials can also be placed on such screens while passengers are not using them, and they could be adapted for people with visual and hearing impairments. Improving the passenger information service at stations is possible by incorporating diagnostic features into the displays. In this way, the passenger operator could react promptly to any interference, which would raise the quality of information delivery.

The most significant current disadvantage is visible in providing information to people with visual and hearing impairments, as the screens at the stations are not adapted to these groups of users. The mentioned shortcoming is also visible when informing passengers before the trip, i.e., informing via the website and mobile applications. The information that the railway undertaking must provide to users with visual or hearing impairments must comply with the WCAG (Web Content Accessibility Guidelines) 2.1 guidelines. Also, the assistance reservation service provided by the railway undertaking should be based on modern communication solutions.

For the time being, the TAP-TSI is used to exchange data in rail transport. It is essential from an integrated passenger transport aspect (a combination of rail and other forms of public passenger transport), and it is essential to avoid duplicating travel data that may provide the passenger with inaccurate information. As a result, it could endanger the safety of passengers, especially if they are people with disabilities for whom the independent movement of the transport network can, in many cases, cause problems [29–31]. Therefore, it is essential to create a national access point to provide accurate and real-time information to passengers [32]. This point relies on a digital interface that provides relevant data and metadata from all transport service providers. In this sense, the provision of information is based on the CEN NeTEx CEN/TS 16614 data exchange standard based on the basic conceptual data exchange model Transmodel EN 12896: Version 2006 (public transport where railway transport is partly included). Combining existing public and private access points into one point would further increase the availability of accurate and real-time information to passengers and increase the level of customer satisfaction with the requested service.

Current ways of informing passengers in rail transport in Croatia face several challenges. As previously seen, it is necessary to modernize the way passengers are informed at stations and stops. By implementing the new information system, the challenges and problems listed in the previous section can be entirely or almost eliminated. Thus, it is needed to monitor modern IC solutions and services and within the defined TSI recommendations to implement optimal solutions on the railway network.

5 Conclusion

Advances in digital technology and the way data is used drastically, changing aspects of society, including industrial production, the private lives of individuals, and traffic in general. Thanks to it, travelers can more easily get all the necessary information related to travel planning. Travel planning is essential for passengers, with IC solutions and services playing a pivotal role. Thanks to the development of these solutions and services, passengers are provided with developed information systems.

Germany, the United Kingdom, and France are at the top of the EU regarding the number of passengers transported by rail per year. Their passenger information systems do not differ too much in the offer of services. On the other hand, currently available passenger information systems in Croatia are still not enviable. The modernization of IC equipment at stations and stops is indispensable regarding technological solutions developed daily. With the modernization of IC equipment, more satisfied passengers are expected to use the railway more often as a form of transport to go to work or school and as the primary form of transportation to more distant destinations.

According to the available data on the IC infrastructure's state on the railway network in Croatia, the passenger information system can be implemented according to the introduction phases and system upgrade measures. For construction requirements, it is necessary to satisfy all the prescribed articles that regulate arranging the station building and the station.

This chapter is the basis for further research and development of passenger information systems on the railway network in Croatia and its integration with other railway management subsystems such as ticket management adaptive for individual user groups. It also opens the possibility of comparing data with other passenger information systems in Eastern and Central Europe's neighboring countries. In addition to the above, future research will be based on the improvement of detected difficulties in the existing system to improve the information service to end users at the national level.

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