Chapter 29
Analysis of Available Information and Communication Solutions and Services for Railway Passenger Information in the EU

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29.1 Introduction

The ability to provide information and transport services anytime and anywhere makes the rail network more efficient and easier to use for end users. Real-time and accurate information is the most crucial 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 has the possibility of 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 that are 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 architecture on the railway network 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

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L. Knapčiková et al. (eds.), *5th EAI International Conference on Management of Manufacturing Systems*, EAI/Springer Innovations in Communication and Computing, https://doi.org/10.1007/978-3-030-67241-6_29

management level, the level of management in stations and on the train, and control equipment at stations and on the train.

This paper aims to 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 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 passenger information systems currently used in the Republic of Croatia (Croatia). Based on this, the most important recommendations for improving the existing passenger information system rail transport in Croatia will be summarized.

29.2 Literature Review

Digitization encompasses the processes by which organizations create some new value for their services [1]. According to [2], the combined cost of digitization for industry and society could exceed US$100 billion by 2025. Digital rail solutions in Europe are part of the Shift2Rail project, which provides a platform for innovation and research activities in this field [3]. Globally, the railway passenger information system segment is projected to be one of the most lucrative parts of the service market [4].

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 [4].

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 [5]. Namely, passengers prefer to use data available on mobile devices, rather than data displayed on screens at stations or through a public address system [6]. Through the railway operator's website or travel planning applications, passengers can be informed about the planned timetable, possible difficulties in the ordinary course of traffic in the event of line maintenance or other traffic disruptions.

Research on existing and future passenger information concepts [7] has shown that innovative and new passenger information technologies represent a great benefit not only for passengers by shortening their waiting time but also for providers of information services by increasing users' flow in stations. The development of IC in the transport sector has resulted in services focusing on customers and their needs by changing the previous perception of passenger transport. The most used services based on IC technologies in public transport are the subject of research in the paper [8].

The use of mobile devices has contributed to the healthy growth of e-commerce in the last year. It is important to note that mobile wallets and m-shops are becoming increasingly important in people's daily lives around the world. Mobile devices generate approximately 60% of the volume of all Internet traffic [9]. Thus, mobile applications of railway passenger operators are introducing or have already submitted the possibility of purchasing tickets through these applications. According to [10], the number of smartphone users in the world today exceeds three billion, and future forecasts refer to an additional increase of several hundred million in the next few years.

Given the above, an increasing number of travel planning applications are also available. Therefore, further development of transport services is expected that will be individually designed and tailored to end users. According to their characteristics, the research [11] grouped end users of train systems into four categories to obtain the requirements that innovative technologies must meet for end users to be satisfied.

However, there is not enough research on the possibility of providing information using screens at train stations that passengers use to obtain travel information. The last such study was conducted in 2014 in the United Kingdom and concluded that passengers prefer a conventional main information board while nonstandard boards can confuse them [12].

Passenger satisfaction with rail services is the subject of a European survey [13] published in 2018. The survey was conducted on a total of 25,537 respondents. Providing information during train travel, especially in case of delay, is satisfactory for 55% of respondents. Nearly three-quarters of respondents are satisfied with the provision of information on timetables and platforms. Forty-nine percent of respondents are satisfied with the availability of travel information displayed at the station. Providing quality information about timetables and platforms is very important for 69% of respondents, while for 68% of respondents, the ease of buying a ticket is essential. 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) [14].

Analysis of the current scientific and professional literature shows a lack of research topics that focus on informing passengers on the railway network based on up-to-date technologies. The same goes for research at the national level. In the last few years in Croatia, informing passengers on the railway network has been expanding. This paper presents the achieved level of IC solutions and passenger information services in Croatia and its comparison with the systems used by the countries with the largest number of passengers per year in the EU.

29.3 Currently Available Information and Communication Solutions and Services for Railway Passenger Information in the EU

Passenger information is one of the most critical services in all transport systems, including rail transport. Providing all the necessary information to passengers in the rail system directly affects their impression of the system's quality and the decision to reuse the said mode of transport.

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's subsystems are traffic management, maintenance, and telematics applications for passenger and telematics services [15].

By the EU Commission Regulation [16], each station manager must provide the user with train departure data at railway stations. 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 purpose of the TSI is to establish procedures and interfaces among all stakeholders to provide relevant information and issue tickets to passengers via currently available technologies [17].

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 Regulation of the EU Commission, 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.

29.3.1 Passenger Information System During the Trip

Generally, the architecture of the solution for providing services at stations consists of devices and technologies in the information center and at the stations. They are all connected via switches to the IP network. The information center located a passenger information system (central server, database, workstations, server

interface, video content server, and advertising server), a public address system (server, public address controller, workstation, and call station), and clock system (Network Time Protocol server, master clock, GPS, and workstation). The stations have screens, workstations, a server, public address controllers, a power amplifier, speakers, master, and auxiliary clocks. The timely joint interaction of all elements provides passengers with the necessary information at stations. All these elements create vast amounts of dynamic data, thus enabling communication between the subsystem at the station and the train from the departure point to the destination.

The need to obtain travel information during the trip is variable depending on the different parts of the station and between arriving and departing passengers. The essential requirement to get information is the same for all passengers. Still, the equipment for providing information, i.e., information carriers, differ in the number, design, and functionality they provide depending on the country's location. The types of information presented by information carriers can be divided into:

- Visual dynamic information
- Voice travel information and
- Interactive information.

Visual dynamic information is mainly used for real-time information related to the time of arrival/departure of the train and notifications about route changes and/or train delays. They are also used for promotional content or as a pointer when finding individual facilities at large stations. Screens that provide this type of information are located on the station's platforms and in the central information hub (waiting rooms) and are divided into internal and external. Voice travel information passengers are delivered via a loudspeaker system. They are used when notifying passengers of important messages (train delay, absence of train arrival, lost items, etc.). Interactive information on the main stations' unique platforms is designed to help people with hearing, vision, or cognitive impairments. However, people without impairment are also used, and the information is provided visually and audio-visually.

Deutsche Bahn (DB) uses internal and external TFT-LCD (thin film transistor—liquid-crystal display) visual information screens and audio speakers to inform passengers at its rail stations and platforms in Germany. This is part of the *DB Colibri* portfolio, which includes core products, applications, and maintenance solutions [18]. In addition to the possibility of providing information to passengers about routes and timetables, screens are also used to direct passengers to stations and platforms. At larger stations in Germany, touch screens have been installed to achieve interactivity. Indoor TFT-LCD screens are designed for public places where 24/7/365 display operation is required [19]. Travelers and visitors can use free Wi-Fi at 127 stations in Germany, making it even easier for them to obtain information [20].

The control centers for monitoring train traffic (timetable) in real time using the appropriate software solution (the Aramis program of the Thales program). A complete overhaul of the passenger information support system in the form of the development of the IRIS+ IC system is currently underway [21]. Also, testing of a

clock system whose data will be transmitted using LoRaWAN wireless technology is underway. This would allow real-time remote monitoring to identify and eliminate errors (displaying incorrect weather, switching off lighting, and damage caused by water) and improving passenger information [22].

The *National Rail Network* (NRN) uses LED (Light Emitting Diode) screens for dynamic visual information at stations in the United Kingdom, which provide information on the arrival/departure of trains and the main facilities' position at the station. Also, passengers have at their disposal a display of the timetable via a screen that is customized in such a way that filtered indexes are created. Shortcuts are provided to the most frequently searched destinations. In addition to LED screens, there are information kiosks at the main stations that display real-time data related to the arrival/departure of trains and platform numbers with diagrams and real-time statuses. These screens and kiosks' technical characteristics are adapted depending on whether it is an open or closed space. The screens differ only in dimensions (42 "for open spaces and 47" for indoor spaces), while their features are multi-touch interface, Ethernet, and WiFi, 1080 HD are enabled. Outdoor kiosks have tempered antireflective glass. The power supply is resistant to voltage, they have protection against vandalism, NEMA4 protection rating, while the indoor kiosk is characterized by being thin and suitable for all enclosed spaces [23].

Société nationale des chemins de fer français (SNCF) is a French national railway infrastructure provider that uses TFT flat screens equipped with antireflective glass at its main stations and the most frequent stops. With the arrival/departure times and line markings displayed at the screens, train logo and speech synthesis are also enabled. On the platform itself, the screens show the first incoming train, the list of stations to the destination, and at the very end, there are notifications. Speech synthesis is integrated into screens at regional stations, enabling the oral distribution of information in written form. Also, passengers are provided with free Wi-Fi access at the main stations, which gives passengers more available access to information from the mobile application or the operator's web page.

However, usage time is limited to 30 min. They are currently in the phase of gradual implementation of dynamic and light screens intended to facilitate the reading of the information provided on stations [24]. The clock system installed at the Persan–Beaumont station consists of a Profile TGV 950E clock model synchronized with the Sigma Master main clock. It is a wired time distribution system that transmits a complete-time message and is suitable for large clock networks. It uses an IRIG-B/ANFOR coded time receiver, whereby the time setting of the receiver is realized automatically after connecting to the clock line [25].

29.3.2 Passenger Information System Before the Trip

This way of informing passengers is to provide accurate real-time information to passengers before the start of the trip. Informing passengers via a website and a mobile application are ways of distributing this information.

Many railway undertakings are represented on the railway network in Germany, Great Britain, and France, and each of them has at least its website, if not a mobile application. Given their number, this paper analyzes passengers' possibilities by the websites and mobile applications of railway infrastructure providers in these countries.

29.3.3 Informing via Websites

The DB website is available in German, English, Czech, Danish, Spanish, French, Italian, and Dutch. It is adapted for people with visual impairments in a way that offers font size adjustment. Passengers can purchase a ticket directly on the site after registration and login to the system depending on the status (private or business user). When buying tickets, passengers are offered a wide choice of payment methods: credit cards, PayPal, SEPA direct debit cards, mobile banking, and PayDirect. Replacement or cancellation of the purchased reservation or ticket is also possible. The site provides information related to passengers' rights as well as a book of complaints and a display of all available services. It is possible to display the fleet (regional, intercity, international) and additional benefits offered by a train (Wi-Fi, sockets, seat size, meal offer, etc.). The website also contains information related to the mobile application [20].

The National Rail website for informing passengers is available in English only and is not adapted for the visually impaired persons. The services offered to passengers are related to searching for train departure times and selecting tickets, stations, travel destinations, and timetable changes. Ticket purchase is enabled directly on the page. It is unnecessary to register in the system beforehand, but the passenger can register as a guest. When buying tickets, passengers have the option of choosing a specific seat on the train and how to pick up a ticket. Two payment options are available: credit cards and PayPal. The traveler can get acquainted with his rights and get answers to the most frequently asked questions [26].

The French national railway infrastructure provider has a website available in three languages: French, English, and German. Unlike the previously analyzed websites, it is completely adapted for people with visual impairments (adjustment of font, contrast, animations, and line spacing). The purchase of tickets is not possible directly on the website, but the passenger is redirected to another website to perform the specified action. In doing so, he is provided with various payment methods. It is also possible to view all stations, travel duration, train type, timetable by the station, view by date, or train number. The amount of CO_2 emitted during a trip, and the choice of route to avoid during the trip are some of the exciting things that the website offers [27].

29.3.4 Informing via Mobile Applications

Mobile applications are one of the most widespread passenger information systems. The number of mobile applications for transport companies is continuously growing, and they provide many types of services. The advantage of mobile applications is the interaction with users, i.e., passengers. Since passengers provide certain information to the carrier when using mobile applications (most requested line, passenger departure and arrival station, most used services), the carrier can improve the current level of service it provides to passengers.

The DB Navigator mobile app is free and available for Android, IoS, and Windows Phone platforms. In addition to displaying timetables and travel planners, it is possible to check a specific train's delay via the application. If the passenger wants to find out information about a train, he can easily display the carrier's name, station, time platform, and transfer point of the selected train. Through the mobile application, it is possible to set various weather notifications related to driving. One of the options provided by the application is the use of another mode of traffic whereby passengers are redirected to other mobile applications or websites that offer the above.

National Rail, as well as DB Navigator, has a free app available for devices on Android, IoS, and Windows Phone platforms. Through the mobile application, it is possible to plan trips and buy tickets from all railway operators. In addition to the numerous opportunities it provides to passengers, information can also be obtained about the facilities located at individual stations and the services offered. Offline display of maps and information is not enabled. It is also possible to set alerts about individual lines as well as alarms about departure time. The option of combined transport (bicycle and train) is highlighted on the mobile application.

The SNCF mobile app is free and available in four languages: French, English, German, and Spanish. Offers offline map display as well as traffic information. Instant notifications and notifications related to individual train delays are enabled. As with the website, the reservation and purchase of tickets are not allowed with the mentioned mobile application. The traveler must use another application called OUI.sncf for the specified actions. In this application, it is possible to use voice search, making the mobile application adapted for people with visual impairments. The passenger is provided with information on the duration of the journey of a train and the benefits provided by the train (space for prams, access for passengers with disabilities, and room for changing children). The application also offers an overview of passenger trips and sending notifications of schedule changes.

29.4 Passenger Information System: Croatia Versus EU Best Practices

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 availability of passenger information in Croatia to the EU, a comparison of the features of this system with the previously analyzed systems will be presented.

29.4.1 The Comparison of the Passenger Information System Features

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 with the possibility of providing 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 [28].

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, as well as on the mobile application.

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

- Classic fixed timetable
- Boards (LED screens)
- Clock subsystems
- Loudspeaker subsystems
- UPS (uninterruptible power supply) and
- 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

Table 29.1 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	−	−	+	−

optically separate and connects the information screen and the control computer. The lighting and switching assemblies' sensors have the task of illuminating 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), and the 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. It filters out small fluctuations in utility lines and isolates equipment from significant interference by the service network's internal disconnection. It also provides uninterrupted power from its internal battery until the service line returns to a safe level or is discharged. Communication equipment in stations is 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.

The technology used and how information are displayed to passengers at stations and stops in the analyzed countries differs. Table 29.1 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 the display of 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.

Tickets can be purchased on the website of the currently only passenger transport service provider in Croatia, i.e., HŽ Putnički prijevoz (HŽPP). When buying, there

Table 29.2 Comparison of passenger information systems before the trip websites

	DB	National Rail	SNCF	HŽPP
Availability in 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	+	−	−	−

is a possibility of choosing with registration in the system or without registration, which facilitates purchase tickets for frequent users of the service. Still, it is not suitable for people with visual impairments. Credit and debit card payment methods are available. Passengers can get acquainted with their travel rights, existing tariffs, regulations/ordinances/instructions, transport documents, and access information on the HŽPP website. Also, information related to the services offered to them, traffic conditions, timetables from the current year is provided as an approach to the most common questions [29].

Table 29.2 shows the differences between the services offered through websites in the analyzed countries. It is evident that Croatia does not lag the leading countries in rail passenger transport in terms of display and availability of information on the website.

Comparing the possibilities of informing passengers via 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 is free and available in Croatian and English for devices on the Android platform. An application for the IoS platform is currently being developed. A timetable display is also possible without internet access. Among other things, the application 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. The possibility of warning information for the specified line is provided if there is a need. It is also

Table 29.3 Comparison of mobile applications of passenger information systems before the 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	−	−	+	−

possible to search by the desired point of view from which all the data about a train and the lines are visible. HŽPP Planner mobile application cannot purchase tickets, which is the biggest drawback of the application. For this reason, another HŽPP Karte mobile application is also in use, which enables the above. Table 29.3 shows the essential characteristics of the analyzed applications.

According to the parameters listed in Table 29.3, it can be concluded that the mobile application for passenger information DB Navigator satisfies the broadest range of parameters considered.

29.4.2 Opportunities to Improve Passenger Information System in Croatia

Based on the analysis of possible ways of informing passengers in rail transport, the countries with the largest number of passengers per year in the EU provide similar services and solutions for passenger information. For Croatia, which has a significantly smaller number of passengers than the analyzed countries, it is necessary to modernize the way of informing passengers at stations and stops if the railway network's competitiveness is to be increased. Thus, it is needed to monitor the development of modern IC solutions and services and within the defined TSI recommendations to implement optimal solutions on the railway network.

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., when 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.

By applying the passenger information system and a certain TSI and the modernization of communication equipment on railways in the Republic of Croatia, it is possible to achieve greater passenger interest in using this form of transport. The improvement of the passenger information system in Croatia should imply its harmonization with the integrated passenger transport systems, the introduction of which in the Republic of Croatia's territory is yet to follow. Better informing users according to personalized criteria or travel needs is achievable by establishing a multimodal national access point. This point relies on a digital interface that provides relevant data and metadata from all transport service providers. 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.

29.5 Conclusion

Advances in digital technology and the way data are used drastically changing aspects of society, including industrial production, the private lives of individuals but also 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.

Understanding and effective management of railway requirements, such as providing information to passengers, cannot be seen only in a functional subsystem of telematics applications. Only one of the integrated subsystems is listed, which

is interdependent with others and can only fulfill its role. For example, without the efficient maintenance of the railway infrastructure, the flow of railway traffic is disrupted, which leads to a decrease in the quality of the transport service, and thus to customer satisfaction.

Germany, the United Kingdom, and France are at the very 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 for the necessary going to work or school and as the primary form of transportation to more distant destinations.

An analysis of mobile applications available to passengers shows that mobile applications available in Croatia offer their users the least opportunities. One of the crucial things that are missing in the current system of informing passengers in Croatia is the greater inclusion of people with visual or hearing impairments, given that the current system is not adapted to this group of people. The most significant emphasis is placed on the publicly available set of open data of data providers, which would increase the availability of necessary, accurate, and real-time information provided to end users.

Above mentioned is one of the biggest obstacles to passenger information systems in Croatia. This paper is the basis for further research in passenger information systems on the railway network in Croatia and its integration with other subsystems of railway management such as ticket management adaptive for individual user groups. It also opens the possibility of comparing data with other passenger information systems in the neighboring countries of Eastern and Central Europe. 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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