LOGI – Scientific Journal on Transport and Logistics
Vol. 14 No. 1 2023 DOI: 10.2478/logi-2023-0017
© 2023 A. Pálková *et al.* This is an open access article licensed under the Creative Commons Attribution-NonCommercial-NoDerivs License (http://creativecommons.org/licenses/by-nc-nd/3.0/).

Proposal for Using IT Solutions in Public Passenger Transport in Slovak Republic to Reduce the Spread of COVID-19

Jaroslav Mašek[1], Adriana Pálková[1*], Peter Blaho[1], Štefánia Halajová[1], Simona Jursová[2] and Denis Šipuš[3]

[1]*University of Žilina, Department of Railway Transport, Univerzitná 8215/1, 01026 Žilina, Slovakia; E-mail: jaroslav.masek@uniza.sk, adriana.palkova@stud.uniza.sk, blaho.peter@zsr.sk, halajova@idsvychod.sk*
[2]*Technical University of Ostrava, ENET Centre, 17. Listopadu 2172/15, 708 00 Ostrava - Poruba, Czech Republic; E-mail: simona.jursova@vsb.cz*
[3]*University of Zagreb, Faculty of Transport and Traffic Sciences, Vukelićeva 4, 10000 Zagreb, Croatia; E-mail: denis.sipus@fpz.unizg.hr*

***Corresponding Author:** Adriana Pálková

Received: 26 January 2023; Revised: 28 January 2023; Accepted: 9 February 2023; Published: 19 May 2023

Abstract: The unexpected emergence of the viral disease COVID-19 has caused many changes in all areas of life. People suffered from the fear of contracting the disease, which resulted in the decrease in the use of public passenger transport services. People's uncertainty and frequently changing measures with a lack of information caused a shift of passengers from public passenger transport to individual transport. The analysis identified important criteria that passengers considered very important during the COVID-19 pandemic in relation to public transport. If these criteria are not met, passengers will not be willing to use public passenger transport and the use of individual transport will continue to grow. To ensure passenger satisfaction, new innovative software solutions have been analysed and then implemented into one specific solution. The proposed solution can meet the requirements of passengers, facilitate their travel using public passenger transport and provide them with regular information related to viral illnesses and important information and will ensure their satisfaction.

Keywords: COVID-19, public passenger transport, safety, IT systems

1. Introduction

Public passenger transport has become an essential part of human society. People´s demands are growing and responsible organizations operating within public passenger transport try to maintain transport performance and compete with private passenger transport to the maximum possible extent [1]. However, the unexpected emergence of COVID-19, which has spread rapidly across all countries

in the world, changed passenger habits and behaviour [2]. Passengers started to prefer individual car transport instead of public passenger transport in many cases, because they were afraid of infection. Measures taken by governments have caused a high decrease in demand for public passenger transport. The articles by [3,4] deal with this decrease during the pandemic, stating that the highest decrease was recorded during the first and second wave of the pandemic. The article by [5] states that when the COVID-19 pandemic ends, it will be very difficult to get passengers to start using public transport again and some new measures will have to be taken to achieve these goals. The article by [6] describes tools that could be used and implemented to improve public transport in the post-pandemic period. Despite the negative impacts of the virus, the authors of the paper [7] describe that COVID-19 could encourage passengers to use rail transport. Railway transport has been characterized as a mode of transport with lower spread of COVID-19 in comparison with other modes of transport. The article published by [8] describes three criteria that influence users' feelings and how the public perceives public passenger transport, specifically perceived risk, standard operation procedures, and information credibility. These criteria should be met especially during the pandemic situation. The article [9] presents the results of a survey whose results show that overcrowding in means of transport significantly affects passengers. COVID-19 has caused an increase in the cost of cleaning and protective equipment. On the other hand, fare revenues dramatically decreased, because of reduced transport performance [10].

Innovations and development in the IT sector can ensure and help responsible stakeholders to meet all listed criteria from users' points of view. The article by [11] mentions the mobile application, which offers many modern and user-friendly features for passengers. This mobile application provides passengers with all necessary information in one place. Also, the thesis by [12] deals with designing a mobile application, which should be used by passengers in public transport. This mobile application should help users traveling by public transport as much as possible, as it contains all necessary information in one place. The aforementioned software solutions can work with real-time data, which could be very helpful during the pandemic situation [13]. During the pandemic in the Slovak Republic, it was very difficult to follow the often-changing measures, because there was not one point with all actual information and measures related to public transport. This could be a key factor in passengers' choice of mode of transport, as the unstable situation made travelling by public transport uncertain. Passengers did not have information about the possibilities of using means of transport and stops. For this reason, they preferred to use private cars where they were sure that sufficient personal distance was kept, unlike when using public passenger transport [14]. The innovative software helps to keep sustainable and safe mobility and ensure quality public passenger transport [15,16].

The paper proposes functioning of the mobile application designed for public transport passengers. It also describes basic information about the application, advantages of the system, and the ways the system could help transport service providers and other entities. The article also describes the epidemic situation in the Slovak republic, with its effects for the whole society.

2. Impact of COVID-19 on Public Passenger Transport in Slovak Republic

COVID-19 has affected public passenger transport across the whole world. Transport performance has decreased dramatically and passengers started to prefer the use of private cars for commuting. Many users of public transport are still apprehensive about using public passenger transport [8]. Stakeholders involved in public passenger transport have had to implement preventive steps to maintain transport performance to keep passengers feeling secure. Despite efforts to maintain performance in public passenger transport, huge drops have been recorded [16]. Figure 1 shows the long-term development of rail, bus, and urban transport in the Slovak Republic. Already before the pandemic, public passenger transport was not developing positively, and the onset of the pandemic has led to an even greater decline in transport performance.

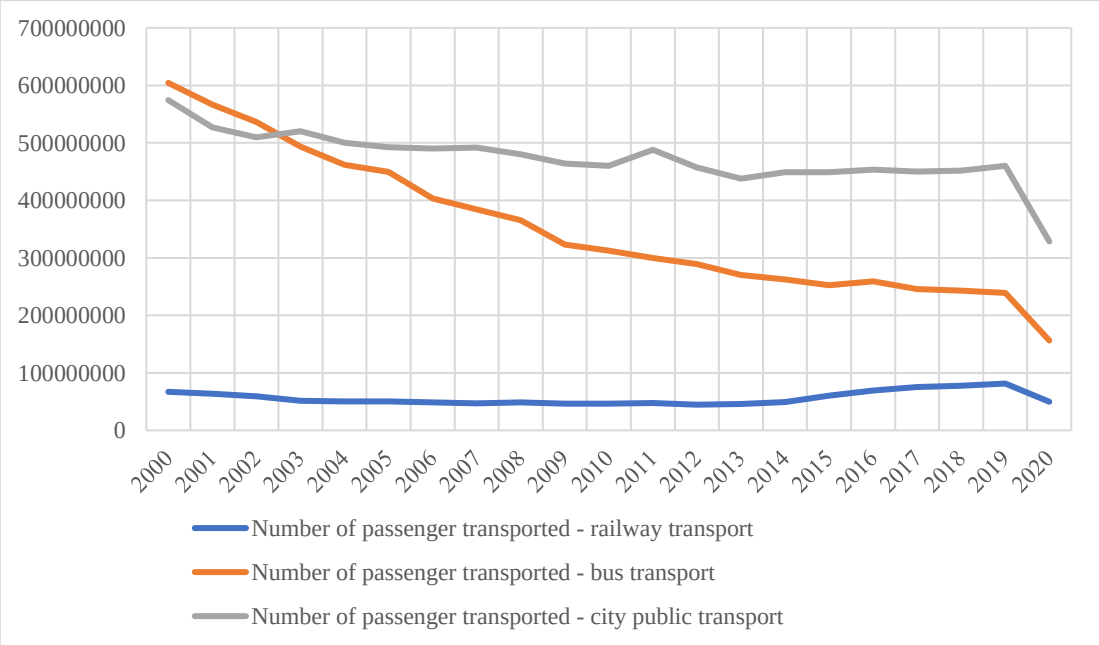

Fig. 1 Number of passengers transported by different modes of transport. Source: [3]

The development of public passenger transport during the pandemic was fluctuating. The largest decreases in transport performance were recorded from 15 March to 14 June, i.e., from the beginning of the COVID-19 pandemic to the end of the state of emergency. Subsequently, in the summer months until the 1st of October, when lockdown was reintroduced in the Slovak Republic, an increase in transport performance was recorded again. After the reintroduction of lockdown, transport performance dropped extremely to the end of 2020. This decline was due to the adopted measures,

such as closure of schools, curfews, working from home, etc. [3]. Figure 2 shows the development of mobility in the Slovak Republic in each month. The change in mobility was recorded from February 2020, and it was still growing. Then, from March, after the confirmation of the 1st positive case of COVID-19, mobility decreased significantly.

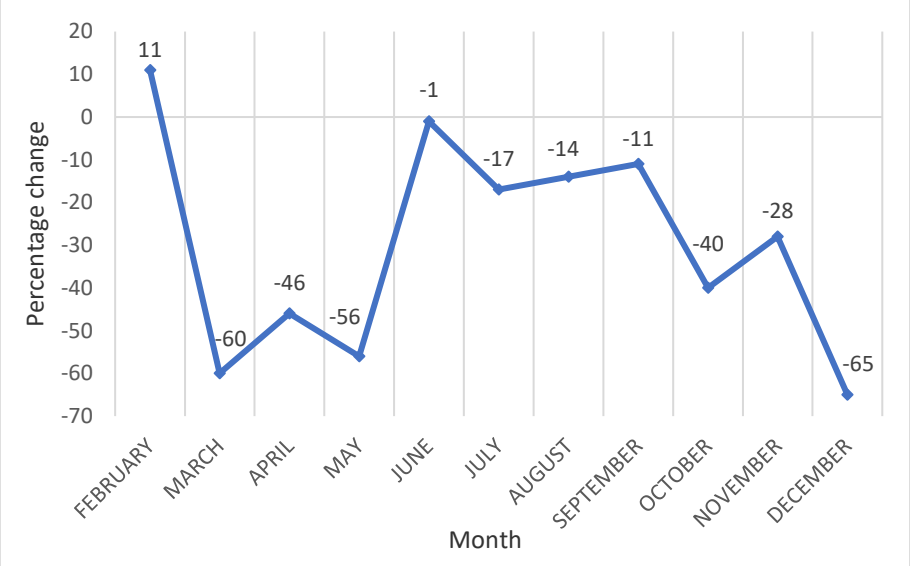

Fig. 2 Mobility changes in 2020. Source: [3]

The biggest decrease in transport performance was recorded in rail passenger transport. In the selected region of the Slovak Republic, this decrease was up to 48 % compared to 2019. Bus passenger transport in this region recorded a decrease in performance at the level of 40 %. The smallest decrease was recorded in individual car transport, amounting to 11 %. This trend in transport performance was caused by the fear of infection and the taken measures, with passengers preferring to use passenger cars for transport. Transport performance in this period is presented in Table 1.

Table 1 Comparison of transport performance. Source: authors

Transport mode	Performance (million passenger-kilometres)		Percentage change
	2019	2020	
Individual car	2,574	2,286	- 11.2
Bus	472	283	- 40.0
Railway	141	72	- 48.5

3. Data and Methods

For the purposes of this research, data and fact analysis were used to investigate and define passenger requirements for public passenger transport. The outputs and passenger expectations were identified based on a questionnaire that defined several criteria and indicators from the passengers' perspective that will help to increase the use of public passenger transport. Based on these criteria, suitable innovative software solutions were then analysed that could significantly increase the safety of public passenger transport. The selected software solutions were then combined into a single unit to create a user interface that supports passenger safety and public passenger transport in general.

Measures related to public passenger transport in Slovakia have affected all transport service providers, passengers, authorities, and other stakeholders. The most significant measures include restrictions on the provision of travel services abroad, regular disinfection of means of transport, the need to observe social distancing, and operating train and bus services in a weekend mode [17]. Despite regularly changing measures, passengers had no mobile app to inform them about new measures adopted in relation to public passenger transport. This may have been the reason for such a large drop in the number of passengers using public passenger transport.

Lockdowns, work from home and the threat of infection in public transport vehicles reduced mobility demand in many countries [18]. The survey [19] describes several measures that should be implemented in public passenger transport during the pandemic situation. Table 2 describes the main measures based on the results of the survey to improve security, comfort, and reliability, which is expected to increase the willingness of passengers to use public passenger transport even during the pandemic.

Table 2 Important indicators of public transport (based on passengers' opinions). Source: [19]

Measures	Explanation
To increase the cleanliness of the means of transport, bus and railway stops and related public places	Cleanliness and disinfection are one of the most important elements during a pandemic, because these methods can significantly reduce the spread of viruses
To monitor the peak and off-peak hours	Monitoring public passenger transport will ensure better planning. Based on the data collected, it is possible to reinforce some services by adding other vehicles in the line or by reducing their number or capacity if they are not sufficiently utilized. Such monitoring is particularly important for services where the capacity is utilized at maximum, as it is important to reinforce these services during a pandemic to ensure social distancing in vehicles.
To keep passengers informed	Passenger information is one of the most important elements of public passenger transport. High quality real-time information about transport means occupancy and stops, about delays, about current arrangements will provide passengers with a comfortable way of travelling. The best way to offer information to passengers is to create a mobile application that offers all the necessary features and which, among other things, will provide passengers with important information that will help them to choose the right travel solution, especially during a pandemic (for example: the passenger can see the occupancy of the connections - expected and real and based on this they can decide which connection to use)
To ensure contactless purchase of travel tickets	Passengers would prefer contactless purchase of travel tickets, which can be ensured by the proposed solution. This could encourage passengers to use public transport because it will make travelling more comfortable

All these measures shall ensure the satisfaction of public passenger transport users, increase their health protection, and reduce the spread of COVID-19 and other similar contagious diseases. The development of a single, comprehensive mobile app that will provide passengers with all the information they need on public passenger transport in one place can help to ensure that the criteria in the table are met.

4. Results and Discussion

The proposed mobile app for passengers' needs can increase the competitiveness and safety of public passenger transport during a pandemic. Based on the previous chapters, it was found that passengers prefer social distance, a larger personal zone, as well as limited personal contact and better information, which reduces the risk of transmission of infectious diseases, including COVID-19.

The proposed software solution will have several innovative features that shall enhance the quality, accessibility, information, and comfort of public passenger transport. Especially in the current situation, features are being developed that are particularly important in the combat against pandemics, especially in terms of their spread in closed channels. Figure 3 shows the components and possible features to be included in the mobile application (User Interface).

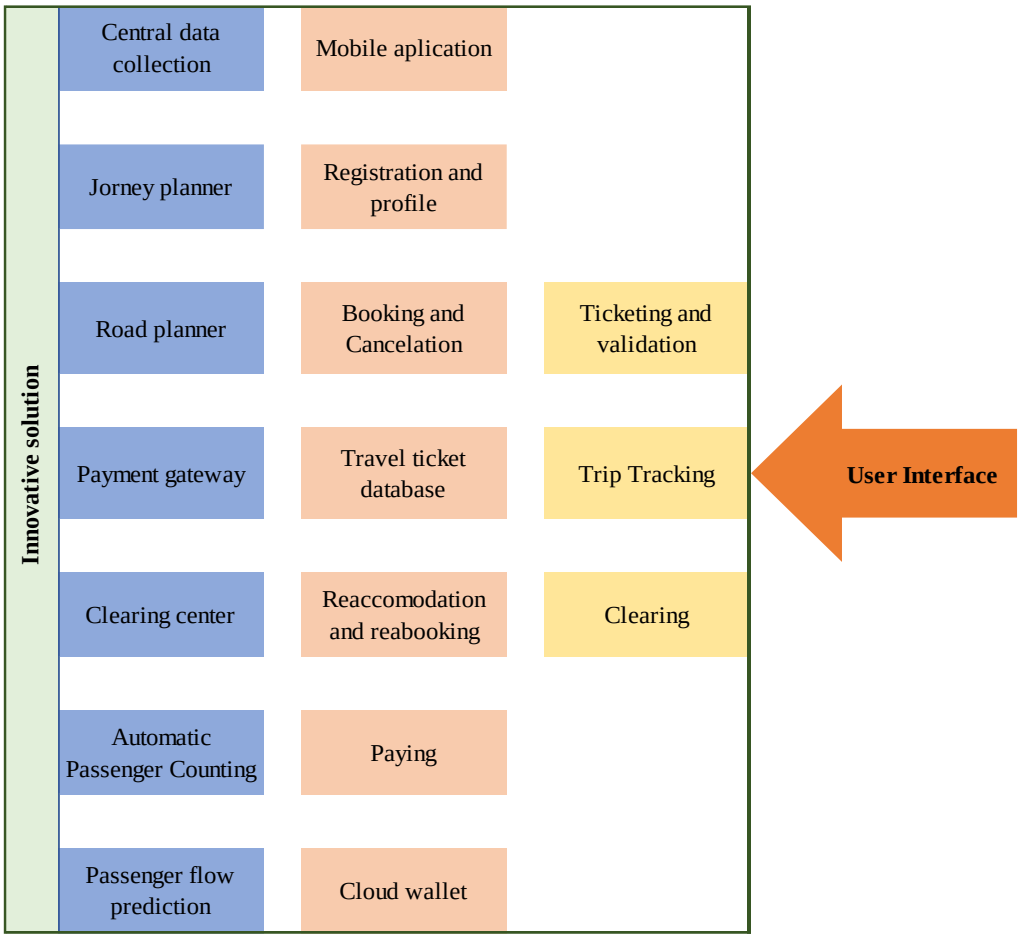

Fig. 3: Proposed software solution. Source: authors

Through the user interface (Mobile application), passengers will be able to create a profile and set their preferences (this feature will be provided by the Registration and profile service). It will also allow them to search for multimodal travel solution (using Journey planner and Road planner), to book the selected travel solution (by calling the Booking service) and pay for it (the Payment service connected to the Payment gateway will be used for this feature). After payment, the passenger will receive a ticket (using the Ticketing service); the ticket will then be stored on the Cloud wallet. Invalid tickets will be stored on a blacklist (this will limit the sharing of one ticket by multiple users), valid tickets on a whitelist (Travel ticket database is used for this feature).

Software solution will enable working with real time data [20]. After the passenger has selected, booked, and paid for the selected travel solution, in the event of a delay, the passenger will be informed about the delay (this will be ensured by Trip Tracking). In case the passenger misses a connection due to the delay, they will be offered the possibility to cancel all or a part of the travel solution (for this purpose, the Cancellation service will be used) and then a new travel solution will be offered to them (by using the Re-accommodation and Re-booking service).

However, not all features are designed for passengers. The proposed software solution also includes features useful for carriers and other stakeholders. Carriers must make the necessary data available (this data will be stored in a Central data collection folder). Also, the revenues for the services provided will be automatically recalculated (the Clearing function will be linked to the Clearing Centre) and each carrier will automatically receive the revenues. In addition, the solution includes a validation service, which will allow responsible persons to check passengers' travel documentation [21].

The overall attractiveness of the software solution is enhanced by the fact that it includes the implementation of innovative features such as Automatic Passenger Counting and Passenger Flow prediction. These two features can encourage passengers to use public passenger transport even during a pandemic [22].

Automatic Passenger Counting shows accuracy of approx. 99 %. Passenger counting is very important for all stakeholders in public passenger transport. It also helps in planning, management, and evaluation of public transport [23]. Finally, Automatic Passenger Counting in vehicles is also important for passengers, as confirmed during the COVID-19 pandemic. By implementing this feature in the software solution, it will be possible to increase passenger awareness. The users will receive real-time information about the number of passengers in all means of transport used within their journey. Such information will be sent in a simple way via the mobile application. The passenger can then decide whether or not to use the travel connection.

Passenger Flow Prediction offers many benefits for all stakeholders. This feature uses a model of deep learning and the results reflect actual conditions. The results are adjusted according to a day

of the week (weekdays or weekends), time, holidays, population structure, and many other indicators [24]. This feature will allow carriers to better plan the transport services overall and to show passengers, via the mobile app, the estimated occupancy of individual connections already during the selection of a travel solution. This way, passengers will be able to decide whether to use the travel solution before making a purchase [25].

These two features ensure that passengers are constantly informed about the occupancy of the means of transport [26]. This means that passengers do not have to worry about overcrowding during COVID-19, and the risk of disease transmission will be reduced by ensuring that vehicles are not overcrowded.

In addition to the database of timetables and fares, the central data collection will also include the COVID-19 measures that passengers must follow when using public passenger transport. Currently, measures adopted are not presented to passengers by the providers of transportation services in any way. Compliance with the adopted measures in public passenger transport will also be promoted, as passengers will be provided a clear overview of which measures are currently valid and up to date. It is thus very important that the software also creates a space where the measures are clearly presented.

5. Conclusion

The goal of the paper is to describe the status of public passenger transport during the pandemic situation and the ways to support using public transport during the pandemic situation. The paper describes innovative IT solutions that promote user-friendly public passenger transport in the Slovak Republic, which could help users with the decision-making processes and encourage them to decide for public passenger transport also during a pandemic. The paper also presents the ways how passengers could be informed about current measures adopted in public passenger transport. The proposed travel solution offers pre-diagnostic analysis and real-time data on vehicle occupancy, which can help passengers in their decision making. In addition, the solution also offers many other innovative features ranging from finding a travel solution to purchasing and cancelling the selected travel solution, e.g., in a case of a delay. Such a solution should be user-friendly and attractive so that it enables to shift the flow of passengers from individual car transport to public passenger transport, mainly by providing the users with all necessary information in one place, namely in a mobile application. The added value of this solution is also the possibility of reducing the spread of COVID-19 in traffic by limiting personal contact and by providing a clear picture of the current situation of vehicle utilization and current measures adopted.

Acknowledgments

This publication was created thanks to support under the Operational Program Integrated Infrastructure for the project: Identification and possibilities of implementation of new technological measures in transport to achieve safe mobility during a pandemic caused by COVID-19 (ITMS code: 313011AUX5), co-financed by the European Regional Development Fund.

References

[1] Štefancová, V., Nedeliaková, E. & López-Escolano, C. (2017). Connection of dynamic quality modeling and Total Service Management in Railway Transport Operation. Procedia Engineering 192, 834–839. DOI: 10.1016/j.proeng.2017.06.144.

[2] Gkiotsalitis, K. & Cats, O. (2020). Public transport planning adaption under the COVID-19 pandemic crisis: Literature review of research needs and directions. Transport Reviews 41(3), 374-392. DOI: 10.1080/01441647.2020.1857886.

[3] Konečný, V., Brídziková, M. & Senko, Š. (2021). Impact of covid-19 and anti-pandemic measures on the sustainability of demand in suburban bus transport. the case of the Slovak Republic. Sustainability 13(9), 4967. DOI: 10.3390/su13094967.

[4] Bulková, Z., Dedík, M., Štefancová, V. & Gašparík, J. (2022). Proposal of the systematic measures to support rail passenger transport during the pandemic period. In 26th International Scientific Conference Transport Means 2022, 5-7 October 2022 (pp. 378-383). Kaunas, Virtual conference. DOI: 10.5755/e01.2351-7034.2022.P1.

[5] Dedík, M., Zitrický, V., Valla, M., Gašparík, J. & Figlus, T. (2022). Optimization of timetables on the Bratislava–Žilina–Košice route in the period after the end of the COVID-19 pandemic. Sustainability 14(9), 5031. DOI: 10.3390/su14095031.

[6] Subbarao, S.V.S. & Kadali, R. (2022). Impact of COVID-19 pandemic lockdown on the public transportation system and strategic plans to improve PT ridership: a review. Innovative Infrastructure Solutions 7(1), 97. DOI:10.1007/s41062-021-00693-9.

[7] Tardivo, A., Carrillo Zanuy, A. & Sánchez Martín, C. (2021). Covid-19 impact on transport: A paper from the Railways' Systems Research Perspective. Transportation Research Record: Journal of the Transportation Research Board 2675(5), 367-378. DOI: 10.1177/0361198121990674.

[8] Sham, R., Xuen, C.K., Ting, L.Y. & Hye, M.N. (2022). Public transport, ridership and safe travelling environment during COVID-19 pandemic. Environment-Behaviour Proceedings Journal 7(19), 339–346. DOI:10.21834/ebpj.v7i19.3217.

[9] Aghabayk, K., Esmailpour, J. & Shiwakoti, N. (2021). Effects of COVID-19 on rail passengers' crowding perceptions. Transportation Research Part A: Policy and Practice 154, 186-202. DOI: 10.1016/j.tra.2021.10.011.

[10] Auad, R., Dalmeijer, K., Riley, C., Santanam, T., Trasatti, A., Van Hentenryck, P. & Zhang, H. (2021). Resiliency of on-demand Multimodal Transit Systems during a pandemic. Transportation Research Part C: Emerging Technologies 133, 103418. DOI: 0.1016/j.trc.2021.103418.

[11] Dolinayova, A., Masek, J., Kendra, M., Čamaj, J., Grandsart, D., Marlier, E., Colzani, P., Arena, M., Paragreen, J., Navaratnam, P., Brennan, M. & Paleta, T. (2018). Research of the passenger's preferences and requirements for the travel companion application. Journal of Advanced Transportation 2018, 8092147, DOI: 10.1155/2018/8092147.

[12] Pálková, A. (2022). Measures to support the introduction of an integrated transport system in the Banská Bystrica region. Diploma Thesis, University of Žilina, Žilina, Slovakia.

[13] Ceder, A. & Jiang, Y. (2020). Route guidance ranking procedures with human perception consideration for personalized public transport service. Transportation Research Part C: Emerging Technologies 118, 102667. DOI: 10.1016/j.trc.2020.102667.

[14] Lucchesi, S.T., Tavares, V.B., Rocha, M.K. & Larranaga, A.M. (2022). Public transport covid-19-safe: New barriers and policies to implement effective countermeasures under user's safety perspective. Sustainability 14(5), 2945. DOI: 10.3390/su14052945.

[15] Korfant, M. & Gogola, M. (2017). Possibilities of using traffic planning software in Bratislava. In 12th International Scientific Conference of Young Scientists on Sustainable, Modern and Safe Transport-Transcom 2017. 31 May – 2 June 2017 (pp. 433-438). High Tatras, Slovakia. DOI: 10.1016/j.proeng.2017.06.075.

[16] Stańczyk, T.L. & Hyb, L. (2019). Technological and organisational challenges for e-mobility. The Archives of Automotive Engineering – Archiwum Motoryzacji 84(2), 57-70. DOI: 10.14669/AM.VOL84.ART5.

[17] Klos-Adamkiewics, Z. & Gutowski, P. (2022). The Outbreak of COVID-19 Pandemic in Relation to Sense of Safety and Mobility Changes in Public Transport Using the Example of Warsaw. Sustainability 14(3), 1780. DOI: 10.3390/su14031780.

[18] Bratislava region (2020, August). Special measures in transport. Retrieved November 9, 2022, from https://bratislavskykraj.sk/mimoriadne-opatrenia-v-doprave/

[19] De Borger, B. & Proost, S. (2022). Covid-19 and Optimal Urban Transport policy. Transportation Research Part A: Policy and Practice 163, 20–42. DOI: 10.1016/j.tra.2022.06.012.

[20] Ďurneková, S. (2022). Customer requirements for public mass passenger transport in connection with the Covid-19 pandemic. Bachelor Thesis, University of Žilina, Žilina, Slovakia.

[21] Yang, Y., Yan, J., Guo, J., Kuang, Y., Yin, M., Wang, S. & Ma, C. (2021). Driving behavior analysis of city buses based on real-time GNSS traces and road information. Sensors 21(3), 687. DOI: 10.3390/s21030687.

[22] Zalar, D., Uspalyte-Vitkuniene, R., Rebolj, D. & Lep, M. (2018). A methodological framework for measuring the level of convenience of transport ticketing systems. Transport 33(4), 1005-1016. DOI: 10.3846/16484142.2017.1300783.

[23] Wang, P., Chen, X., Chen, J., Hua, M. & Pu, Z. (2021). A two-stage method for bus passenger load prediction using automatic passenger counting data. IET Intelligent Transport Systems 15(2), 248–260. DOI: 10.1049/itr2.12018.

[24] Siebert, M. & Ellenberger, D. (2019). Validation of automatic passenger counting: Introducing the t-test-induced equivalence test. Transportation 47(6), 3031–3045. DOI: 10.1007/s11116-019-09991-9.

[25] Liu, L. & Chen, R.-C. (2017). A novel passenger flow prediction model using Deep Learning Methods. Transportation Research Part C: Emerging Technologies 84, 74–91. DOI: 10.1016/j.trc.2017.08.001.

[26] Li, Y. & Ma, C. (2023). Short-time bus route passenger flow prediction based on a secondary decomposition integration method. Journal of Transportation Engineering, Part A: Systems 149(2), 04022132. DOI: 10.1061/jtepbs.teeng-7496.