Scientific Journal of Silesian University of Technology. Series Transport
Zeszyty Naukowe Politechniki Śląskiej. Seria Transport

Volume 112 **2021**

p-ISSN: 0209-3324

e-ISSN: 2450-1549

DOI: https://doi.org/10.20858/sjsutst.2021.112.5

Journal homepage: http://sjsutst.polsl.pl

Article citation information:
Gorzelanczyk, P., Seweryn, B. Analysis of telematics techniques in logistic transport management in cities. *Scientific Journal of Silesian University of Technology. Series Transport*. 2021, **112**, 63-73. ISSN: 0209-3324.
DOI: https://doi.org/10.20858/sjsutst.2021.112.5.

Piotr GORZELANCZYK[1], Bartlomiej SEWERYN[2]

ANALYSIS OF TELEMATICS TECHNIQUES IN LOGISTIC TRANSPORT MANAGEMENT IN CITIES

Summary. The rapid increase in the number of vehicles in cities and the intensity of their movement necessitates the use of appropriate transport management solutions. Various telematics techniques are used in logistics transport management in cities, which are the basis for the functioning of telematics systems. This article analyses selected telematics techniques used in logistics transport management in cities and presents the developed concept of changes in logistics transport management in the city of Piła, including the use of appropriate telematics techniques. The existing telematics system in the city of Piła and the proposed solutions were subjected to appropriate examination. This study aimed to verify the quality of the current state of the system and learn opinions on the proposed solutions that could be implemented in Piła, considering the effects that could be achieved as a result of improving the existing system. The survey method was used to obtain relevant information. The questionnaire developed, containing the elements assumed in this study, was addressed to respondents residing in Piła and its environs. The survey was conducted in December 2020 and January 2021.

Keywords: telematics systems, transport management, city of Piła

[1] Stanislaw Staszic University of Applied Sciences in Pila, Podchorazych 10 Street, 64-920 Pila, Poland. Email: piotr.gorzelanczyk@puss.pila.pl. ORCID: https://orcid.org/0000-0001-9662-400X
[2] Stanislaw Staszic University of Applied Sciences in Pila, Podchorazych 10 Street, 64-920 Pila, Poland. Email: bseweryn1@gmail.com. ORCID: https://orcid.org/ 0000-0001-5660-3589

1. INTRODUCTION

Telematics techniques used in logistics transport management in cities are becoming extremely important. During the increasing demand for various types of transport and easier access to means of transport, difficulties related to smooth movement increase. Huge amounts of vehicles cause congestion, especially in the centres of large cities. In addition, there is a limited number of parking spaces, which also affects this condition, as drivers searching for free parking spaces often drive vehicles around the city for a long time. This, of course, affects fuel consumption, and thus, the operating costs of vehicles and the amount of pollution they generate. Given this scenario, it is hard not to notice the sense of using telematics techniques in the construction and operation of telematics systems that significantly reduce the phenomenon of congestion, travel time and have a positive impact on the behaviour and safety of road users.

2. TELEMATIC SYSTEMS USED IN LOGISTIC TRANSPORT MANAGEMENT IN SELECTED CITIES

Telematics systems used in logistics transport management in cities are used not only abroad, but also in Poland. Of particular interest are those that meet the requirements of intelligent transport systems. Systems of this type used in Polish cities were analysed in the study [16]. This problem was similarly raised in the following publications [2, 11, 12, 14, 15, 19, 24].

One of such systems is the Integrated Traffic Management System TRISTAR used in the Tri-City. This system manages urban traffic using, among other systems: Road Traffic Control, Video Surveillance, Measurement of Meteorological Parameters, Monitoring and Supervision of Vehicle Traffic and Parking Information, as well as public transport using the systems: Information for Passengers of Public Transport and Traffic Management of Public Transport Vehicles [3, 9].

As part of this system, there are variable message boards with important information for road users, boards informing about the number of free parking spaces and boards at public transport stops. In this system, collective transport has been given priority in traffic lights at intersections [16].

Systems used in Szczecin are another example of such solutions. There is a Traffic Management System (TMS) consisting of a Traffic Management Centre and from the subsystems: Travel Information, Motion Detection or Mobile Information, as well as the Central System of Urban Transport Management (CUTMS), which includes, among other systems: Fleet Management, Dynamic Passenger Information, Video Monitoring in Vehicles, Counting Passenger Streams, Optimisation of Communication Network, Location and Monitoring of Technical Vehicles Serving "Winter Action" and Transport on Demand [1].

As part of TMS, variable content boards present complex messages, road signs and diagrams to road users, while variable content signs similarly present road signs and short information as well [16]. CUTMS includes, among others, passenger information boards at stops, an internet information system for mobile phones and multimedia information for passengers in vehicles [1].

Further deliberations on telematics in transport can be found in the following publications: [10, 13, 20-23].

3. TELEMATIC TECHNIQUES USED IN THE LOGISTICS TRANSPORT MANAGEMENT IN THE CITY OF PIŁA

The city's location on a national scale means that important intersections of communication routes occur in it. Roads from the north of the country to the south, to Poznań, Gorzów and further towards Germany, and from Szczecin to Bydgoszcz and Warsaw intersect here [4]. There are four categories of public roads in Piła: national roads, voivodship roads, poviat roads and commune roads [5]. One of the most important elements in the road infrastructure of the city of Piła is the beltway. In 2019, the city had about 73,139 inhabitants [6].

Piła is a dynamically developing centre. Due to its dynamic urbanisation, there is a visible increase in the number of vehicles moving on the streets, causing congestion on city streets, noise, and air quality. Appropriate traffic management in the city is, therefore, a challenge for local authorities to tackle, in particular, ensuring a smooth movement for residents, encouraging them to use public transport. In the context of the "smart city" concept, an intelligent and innovative city is also associated with intelligent and innovative urban transport.

Negative results of the increase in the number of passenger cars can be mitigated by efficient public transport, which uses intelligent solutions. The city of Piła is currently implementing a project of building and implementing a Dynamic Passenger Information System (DPIS) in the city. This system will use GPS modules installed in city buses, due to which it will be able to monitor their current position. The elements that make up this system include [18]: 45 double-sided electronic information boards, 5 info kiosks, DPIS on-board devices installed in 46 MZK Piła buses, Data Centre equipment and Traffic Control Centre in the depot, equipment for the position of an employee of municipal services located in the Municipal Guard headquarters, a wireless communication system, as well as a mobile application and a website presenting dynamic passenger information.

The essence of an intelligent city is the integration of its elements and the functions it offers. In line with this, a project was initiated to create an Integrated Interchange Centre in Piła (ITC). It will be located in the city centre by the VIVO gallery. This facility will be located near the train and bus stations, besides, many public transport lines connect at this point. ITC will be equipped with a bicycle shelter and roofed bus stands, illuminated and heated by solar energy. The establishment of ITC is to make it easier for residents and guests coming to the city to travel by various means of transport while respecting the natural environment. The key word for the implementation of this investment is "integrity", which is why public, suburban and transit bus timetables will be merged, allowing travellers to move smoothly. Interactive information kiosks and information boards connected with DPIS [7] will support the devices, thereby supporting the implementation of the assumed goals. A view of the planned Integrated Interchange Centre is presented in Figure 1.

The aforementioned solutions were preceded by the commissioning of the Video Monitoring Centre (VMC) in 2018, constituting the first stage of the construction of the Integrated City Management System (ICMS) [8].

As part of the second stage of the ICMS construction, a system integrating signals and information for analysis, processing and management will be built from the following subsystems: intelligent traffic control system and traffic lights, two-way communication with the "Traffic Engineer", Park & Ride and Bike & Ride buffer car parks and intelligent street lighting and squares. With such a system configuration, information about DPIS and ITC [8].

Fig. 1. View of the planned Integrated Interchange Centre
Source: [7]

4. THE CONCEPT OF CHANGES IN THE LOGISTICS TRANSPORT MANAGEMENT IN THE CITY OF SAW, CONSIDERING THE USE OF APPROPRIATE TELEMATIC TECHNIQUES

One of the solutions that could be implemented in Piła under this concept is the creation of a parking lot on Staszica Square. The location of this car park is shown in Figure 2.

Fig. 2. Parking location at Staszica Square in Piła
Source: authors' study based on [17]

Of course, this would not be a permanent solution as the square is for residents and not only a place where various mass events take place. However, the square is empty during most days of the year, providing a good base for parking in the city centre. Next to it is the town hall, close by is also a train and bus station, VIVO gallery, two large shopping points, and soon, the ITC. A square turned into a parking lot would operate for a specified period. The character of the square remains unchanged as it would perform its current function in the event of mass events. However, in the remaining period, it would be possible to park on the square. Such an opportunity to use the free space in such an attractive location would significantly reduce the problems associated with the lack of parking spaces in the city centre.

Another proposal associated with parking spaces would be the use of variable content signs informing about the number of free parking spaces. Such a solution could be in the centre of the city, informing about free parking spaces located in the car parks at ITC, VIVO gallery, Shopping Park and Plac Staszica. Visualisation of the use of variable content signs informing about the number of free parking spaces together with suggestions for the location of these signs is shown in Figures 3 and 4.

Fig. 3. Visualisation of the variable content sign indicating the number of free parking spaces - the sign is located on Staszica Square
Source: authors' study based on [17]

Fig. 4. Visualisation of the variable content sign indicating the number of free parking spaces - the sign is located at Zygmunta street
Source: authors' study based on [17]

The use of variable content signs indicating the number of free parking spaces would contribute to limiting the "circulation" of vehicles in the city by drivers to find a free parking space. This would reduce the number of congestion generated in the centre by drivers looking for a free parking space as they would receive information on which parking lot they will find one. In addition, this information would be transferred to mobile devices in the form of applications and would be on the website of the transport management system in Piła.

Appropriate system configuration would make it possible to use current and new solutions to implement Intelligent Motion Control. It would be based on video detectors already present in the city, located at intersections, monitoring and GPS transmitters located in public transport buses, from which the obtained data on the exact location of buses would be used not only to determine the exact time of their arrival at the stop but also would send signals to the nearest intersections to allow these buses run smoothly through the road junction. Undoubtedly, the use of such a solution would reduce travel time, which would increase the attractiveness of using public transport in the city.

By creating additional algorithms, one could get a traffic light control system that would adapt to the current road happenings in real-time. Thanks to such solutions, it would be possible to create the green wave, which consists of smoothly covering the road by maintaining a constant, prescribed speed. The system would optimise the capacity of intersections and strive to minimise the number of stops and the loss of time. It would analyse the situation at a given intersection on an ongoing basis and at the moment when the given entrance to the intersection would be more loaded, a green signal would be given to it, enabling "discharging" of the piston. This solution could be implemented on several streets in Piła.

The last interesting solution that could be used in the city is to install time displays at intersections, indicating the time left to change the light. The use of such a solution would improve the safety of road users.

5. RESEARCH CONCERNING EXISTING AND PROPOSED SOLUTIONS IN THE FIELD OF LOGISTIC TRANSPORT MANAGEMENT IN THE CITY OF PIŁA

The survey method was used to obtain relevant information. A survey questionnaire containing 17 questions was prepared, including closed questions regarding basic information about the respondent as well as other closed questions and one open question about the studied issues. These were mainly questions with 'yes' or 'no' answers and the scale of answers. A small-scale pilot study was made for the prepared questionnaire to verify the correctness of the questionnaire preparation. After minor modifications, the questionnaire was presented to individual respondents, asking for a written answer. It was directed to respondents residing in the city of Piła and its environs. The method of testing incidental communities was used to select respondents. The survey was conducted in December 2020 and January 2021. A total of 70 respondents participated in it. The study aimed to verify the quality of the current state of the system and learn about the respondents' opinions on the proposed solutions in the field of logistic transport management that could be implemented in Piła. The results of the survey were developed and presented on many charts.

Among the respondents participating in the survey, 52.9% were women and 47.1% were men. The respondents were divided into five age groups: under 18, 18-25, 26-35, 36-50 and over 50. The largest group consisted of people aged 18-25. The smallest group were people under 18 years of age. The distribution of respondents in individual age groups is shown in Figure 5.

Among the respondents participating in the survey, most live in Piła, the rest were people living in the vicinity of Piła. The distribution of respondents in terms of place of residence is shown in Figure 6.

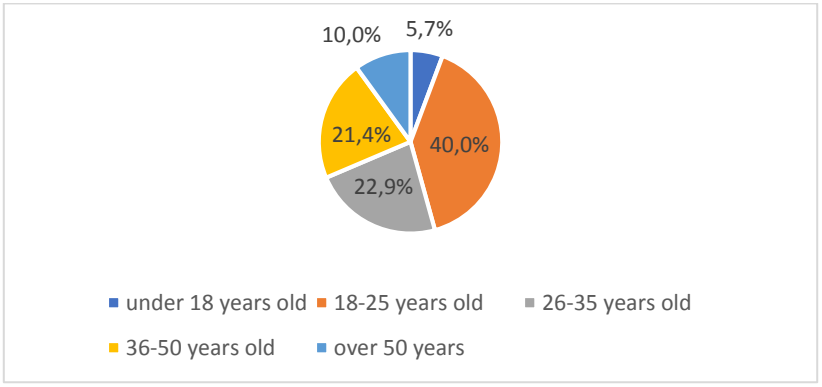

Fig. 5. Distribution of respondents in individual age groups
Source: authors' study

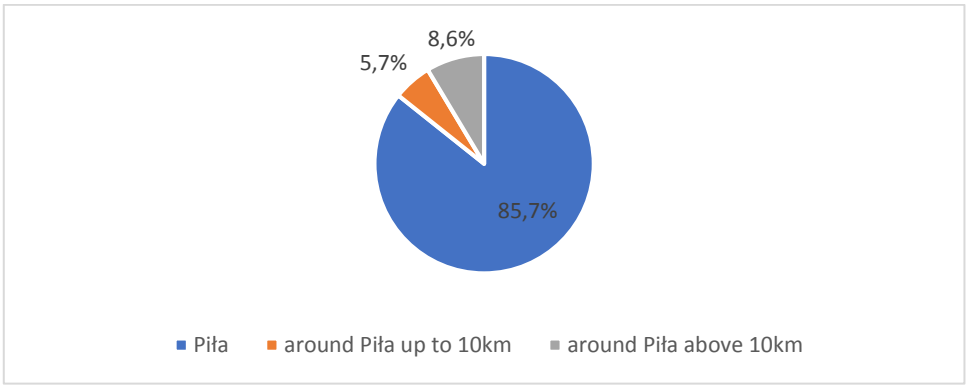

Fig. 6. Distribution of respondents in terms of place of residence
Source: authors' study

In answer to the question: What type of transport do you mainly use? most respondents said a passenger car. This shows that a significant proportion of them use their own means of transport. Public transport buses were another means of transport used by the respondents. The distribution of answers to this question is shown in Figure 7.

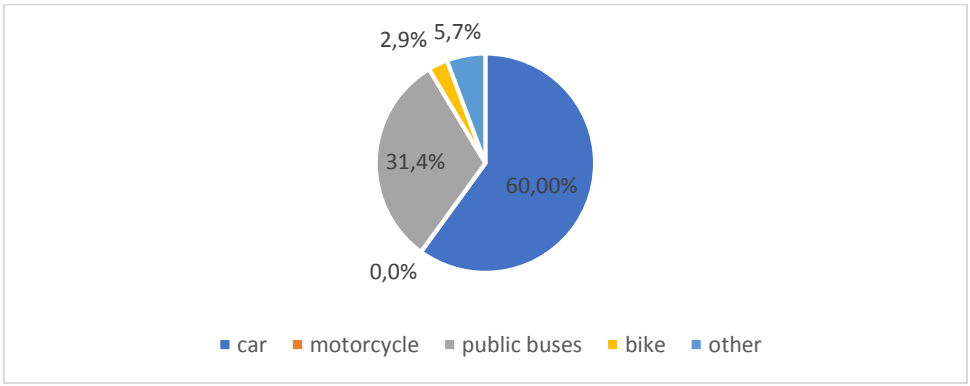

Fig. 7. Distribution of answers to the question:
What type of transport do you mainly use?
Source: authors' study

Since public transport plays an important role in ensuring the mobility of residents, the question was asked: Do you use public transport in Piła? The answers show that more than half of the respondents do not use public transport (52.9%).

Telematics solutions are closely related to road infrastructure, which is why the question was asked: How do you assess the current road infrastructure in Piła? Concerning this question, respondents had the opportunity to choose answers on a scale of 1 to 10, where 1 meant - weakly, while 10 - very good. Usually, the respondents indicated the answer 8. The distribution of answers to this question is shown in Figure 8.

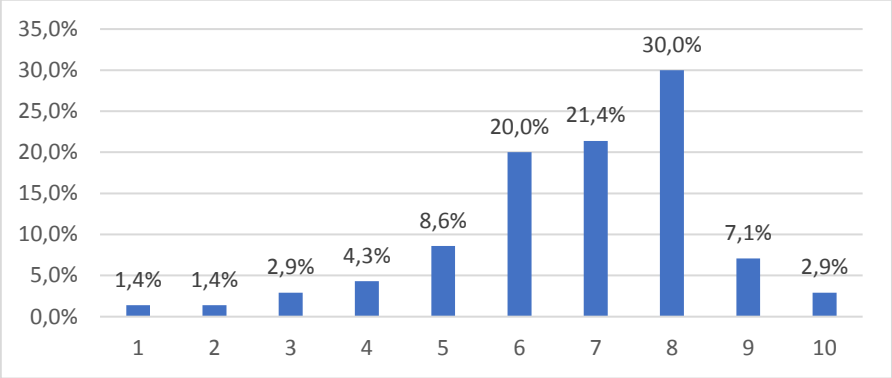

Fig. 8. Distribution of answers to the question:
How do you assess the current road infrastructure in Piła?
Source: authors' study

In answer to the next question: Do you think that the number of parking spaces in Piła is sufficient? most respondents stated that the number of parking spaces in Piła is too small (75.7%).

Considering the solutions that can be used in the city of Piła with the current infrastructure, the question was asked: Do you think that the creation of the Park & Ride solution at Staszica Square (Park & Ride - drivers leave their vehicles in designated places and then change to public transport) will reduce the problems associated with congestion in the city centre? The answers show that less than half of the respondents believe that this solution will reduce these problems (48.6%).

To the question: Do you think that the introduction of variable content signs indicating the number of free parking spaces will contribute to reducing the phenomenon of crowded roads in the city? The majority of the respondents responded positively (80%).

In connection with the DPIS introduced in the city for public transport and the proposed extension of its capabilities, the question was asked: Do you think that the introduction of intelligent traffic control (the use of video detection to improve the passage of emergency vehicles and public transport vehicles) will reduce congestion on roads in Piła? A majority of the respondents answered this question positively (87.1%).

Telematics solutions present a range of possibilities to be used to fluidise traffic, which is why the question was asked: Do you think that the introduction of a traffic light control system at successive intersections to maintain smooth driving (green wave) would be a good solution? The answers show that almost all the respondents believe that this would be a good solution (97.1%).

The question was also asked: How do you assess the degree of congestion in Piła? Regarding this question, the respondents had the opportunity to choose answers on a scale of 1 to 10, where 1 was low and 10 was high. Most of the answers ranged from 5 to 8. The distribution of answers to this question is shown in Figure 9.

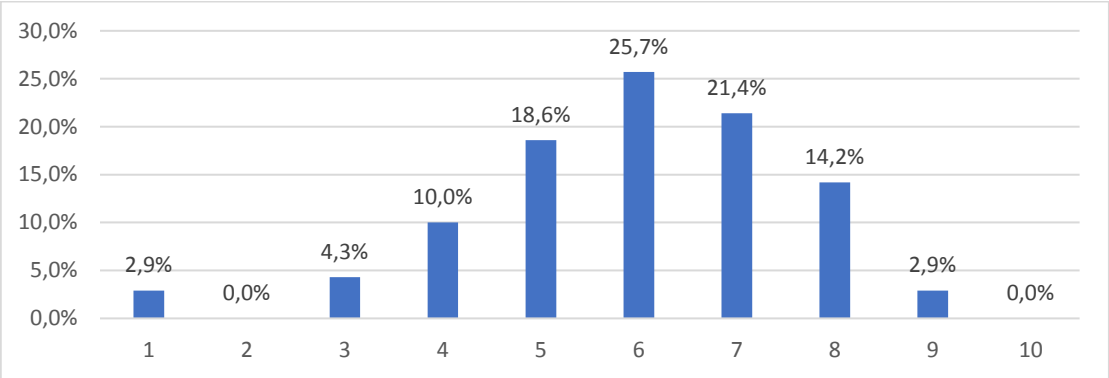

Fig. 9. Distribution of answers to the question:
How do you assess the degree of congestion in Piła?
Source: authors' study

An important aspect is the safety of road users, therefore, the question was asked: Do you think that the current road layout and infrastructure in Piła provides a sufficient level of safety for road users? The answers shows that the respondents have a different opinion on this topic (52.9%).

An interesting idea becoming an increasingly common solution is the introduction of time displays at intersections informing drivers of a change in light colour, hence the question was asked: Do you think that the introduction of time displays at intersections (indicates how much time left to change the light) will improve the level safety of road users? The answers show that most respondents believe that this solution will improve the level of safety of road users (90%).

Following sustainable development, an important element for the inhabitants of Piła is the natural environment, therefore, the question was asked: Do you think that the phenomenon of congested roads at peak times plays a significant role in the air quality in Piła? The answers show that a significant proportion of respondents believe that this phenomenon plays a significant role in the quality of air in the city (77.1%).

It is not possible to introduce changes without the proper actions of the local government, which aims to improve the road situation in the city, therefore, the question was asked: Do you think that the activities of the local government towards the proposed telematics solutions in Piła (DPIS, ITC) will contribute to improving the traffic situation in the city? Based on the answers, it can be stated that the majority of the respondents believe that the current activities of the local government in Piła will contribute to improving this situation (77.1%).

The last question was: Do you have any comments about current / proposed telematics solutions? It was an open question, to which respondents were to answer themselves, however, none of them indicated any comments on the current / proposed telematics solutions presented in the survey.

6. CONCLUSION

From the content presented in this article, it appears that various telematics techniques are used in logistic transport management in various cities. Aiming to obtain the best possible telematics system in the given city, it is necessary to verify the quality of the existing system and propose new solutions. Of course, it is desirable to include in this process, the recipients of the effects of such a system, that is, above all, the city's residents and other people who may have contact with this system to learn their opinions on this topic. This was done too. Accordingly, surveys were carried out and the results of these studies were presented in the article. On this basis, it can be concluded that a significant proportion of the respondents expressed positive opinions on most of the proposed solutions that will contribute to reducing the phenomenon of congestion, improving the safety of road users and improving the air quality in the city of Piła.

References

1. ACET. 2019. Innovation in public transport on the example of the Szczecin agglomeration. Available at: http://www.sitkszczecin.org.pl/images/dokumenty/materiały/2017/2017%20-%20Innowacyjność%20w%20transporcie%20publicznym%20na%20przykładzie%20aglomeracji%20szczecińskiej.pdf.
2. Audu Akeem A., Olufemi F. Iyiola, Ayobami A. Popoola, Bamiji M. Adeleye, Samuel Medayese, Choene Mosima, Nunyi Blamah. 2021. "The application of geographic information system as an intelligent system towards emergency responses in road traffic accident in Ibadan". *Journal of Transport and Supply Chain Management* 15(a546).
3. Biniasz D. 2016. "Rozwiązania telematyczne w transporcie miejskim: studium przypadku". *Autobusy : technika, eksploatacja, systemy transportowe* 17(6): 516-524. [In Polish: "Telematics solutions in urban transport: case study"].
4. City Piła. 2021. Available at: https://www.pila.pl/pl/nasze-miasto.html.
5. City Piła, 2021, Available at: http://www.pila.pl/files/file/prezentacja_drogi_inwestycje2012.pdf.
6. Pila in numbers. 2021. Available at: https://www.polskawliczbach.pl/Pila.
7. City Piła. 2021. "It will be easier to travel thanks to the new interchange center". Available at: https://www.pila.pl/pl/aktualnosci/bedzie-latwiej-podrozowac-dzieki-nowemu-centrum-przesiadkowemu.html.
8. City Piła. 2021. "New Video Monitoring Center in Piła". Available at: https://www.pila.pl/pl/aktualnosci/nowe-centrum-monitoringu-wizyjnego-w-pil.html.
9. GDIK. 2019. "Integrated traffic management system TRISTAR". Available at: http://www.gdik.gda.pl/42/inwestycje/zintegrowany_system_zarzadzania_ruchem_tristar.html.
10. Hossain E., G. Chow, V.C.M. Leung, R.D. McLeod, J. Mišić, V.W.S. Wong, O. Yang. 2010. "Vehicular telematics over heterogeneous wireless networks: A survey". *Computer Communications* 33(7): 775-793.
11. Jarašūniene Aldona. 2007. „Research into intelligent transport systems (ITS) technologies and efficiency". *Transport* 22(2): 61-67.

12. Klodawski Michel, Marianna Jacyna, Rostislav Vasek, Piotr Klimek, Roland Jachimowski, Emilian Szczepanski, Konrad Lewczuk. 2020. „Route Planning with Dynamic Information from the EPLOS System". *Tehnicki Glasnik-Technical Journal* 14(3): 332-337.
13. Lann J.D., A. Heino, D.D. Waard. 1997. "A simple procedure for the assessment of acceptance of advanced transport telematics". *Transportation Research Part C: Emerging Technologies* 5(1): 1-10.
14. Litwin M. 2003. "The role of Intelligent Transportation System (ITS) National Architecture and Standards - the Canadian Experience". In: *4th Scientific and Technical Conference. Communication problems of cities in the conditions of automotive congestion.* Poznań, Poland.
15. Luke Rose, Gert J. Heyns. 2014. "Reducing risky driver behaviour through the implementation of a driver risk management system". *Journal of Transport and Supply Chain Management* 8(1): a146.
16. Małecki K., S. Iwan. 2014. "The utilization of telematics as the determinant of the efficient urban freight transport management". *Logistics* 3.
17. Maps Google. 2021. Available at: https://www.google.com/maps/place/Pi%C5%82a/data=!4m2!3m1!1s0x4703e43e19ce785d:0x64dc72cbc93a28bd?sa=X&ved=2ahUKEwiLjdrMibLkAhUNmxQKHbbQDS0Q8gEwAHoECAoQAQ.
18. MZK. 2021. "Dynamic Passenger Information System in Piła". Available at: https://www.mzk.pila.pl/aktualnosci/256-system-dynamicznej-informacji-pasazerskiej-w-pile.html.
19. Neumann T. 2017. "Automotive and Telematics Transportation Systems". In: *2017 International Siberian Conference on Control and Communications (SIBCON)*. Astana, Kazakhstan.
20. Smart Cities and Communities - European Innovation Partnership, C(2012) 4701, European Commision.
21. Svítek M., Z. Votruba, T. Zelinka, V. Jirovský, M. Novák. 2013. *Transport Telematics - Systemic View*. WSEAS Press.
22. Svítek M., T. Zelinka, V. Jirovský, M. Jeřábek. 2012. "Advanced Approach to Intelligent Transport Systems Design". *International Journal Of Systems Applications, Engineering & Development* 6(1): 179-187.
23. Quddus M.A., L. Zhao, R.B. Noland. 2003. "A general map matching algorithm for transport telematics applications". *GPS Solutions* 7(3): 157-167.
24. Wydro K.B. 2008. *Telematic services and systems in transport*. Warsaw: Telecommunications Publishing and Telecommunications Techniques.

Received 18.04.2021; accepted in revised form 28.06.2021