SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2025
ORGANIZATION AND MANAGEMENT SERIES NO. 222

FROM VISION TO REALITY: WHAT SHAPES THE FUTURE OF AUTONOMOUS PUBLIC TRANSPORT IN BIAŁYSTOK

Natalia ZAZULKA

Bialystok University of Technology; natalia.zazulka@pb.edu.pl, ORCID: 0009-0004-0532-0879

Purpose: The purpose of this article is to analyze the possibility of implementing autonomous vehicles in Bialystok.
Design/methodology/approach: The first phase of study focused on a critical analysis of the literature and a case study on the example of Bialystok. Then a diagnostic survey method, supported by the CAWI (Computer Assisted Web Interview) technique, was used to obtain data from users of Bialystok's public transportation. In addition, a statistical analysis of the survey results was undertaken to identify correlations between respondents' answers
Findings: The study showed that there is a possibility for the implementation of autonomous buses in Bialystok. However, in order for the implementation to be effective, it is necessary to analyze and modernize the current urban infrastructure, as well as raise public awareness and education about autonomous vehicles.
Research limitations/implications: The study is based on a diagnostic survey method, while it would be interesting for future research to use more elaborate statistical methods to deepen the analysis, for example identifying the profiles of potential users of autonomous vehicles.
Practical implications: Autonomous buses can impact the positive perception of public transportation and improve the frequency of public transportation use, but requires an analysis of the current state and appropriate regulations.
Social implications: Successful implementation of autonomous buses in Bialystok can help improve the residents' quality of life, travel comfort and even change habits by choosing public transportation more often than cars.
Originality/value: The study presents an analysis of the current state of public transportation in Bialystok and verifies users' opinions on autonomous vehicles, offering value to researchers and practitioners planning to analyze the conditions for implementing sustainable and intelligent mobility in cities.
Keywords: urban transportation, autonomous buses, smart urban mobility, sustainable urban mobility.
Category of the paper: Research paper.

1. Introduction

The rapid development of technology observed in recent years has greatly affected many different areas of daily life, including public transportation (Gohar, Nencioni, 2021). One of the most popular trends in this sector is autonomy and sustainability, which are closely related to the concept of smart and sustainable urban mobility (Herdiansyah, 2023). The goal of both ideas is not only to improve transportation, but also to minimize negative environmental impacts and adapt the city's infrastructure primarily to the needs of residents, but also to the constantly changing standards of modern and smart cities (Mach, Skrzypek, 2019).

It is true that modern cities are changing at a rapid enough pace to keep up with new technologies and call themselves the smart cities of modern times. A key element of these transformations is the development of urban mobility, so as to effectively face the new challenges of urbanization of cities, minimizing congestion, improving safety and protecting the environment (Mouratidis, Serrano, 2021).

One of the technological developments that are contributing to the modernization of urban development strategies in the transportation field is autonomous vehicles. Focusing on public transportation vehicles, one increasingly hears about autonomous buses. These driverless vehicles, capable of driving themselves without a driver, have great potential to revolutionize the way cities get around (Banach, 2020). This is already seen in more than a dozen cities in Europe and around the world that decided to test this means of transportation, such as Helsinki, Oslo and Stockholm (Olivier Wyman Forum, 2023).

An interesting example of a place where autonomous buses could be implemented is Bialystok, a city located in the northeastern part of Poland, which is the capital of the Podlaskie Voivodeship. On the one hand, the city remains open to innovation, as evidenced by its investment in a Traffic Management System or expansion of its electric bus fleet (Oficjalny Portal Miasta Białystok, 2025). On the other hand, residents of Bialystok may have a variety of opinions on such innovative solutions as driverless buses. Before deciding on implementation, it's worth studying public opinion, as residents will be the daily users of autonomous buses if the city finally decides to implement. In addition, the implementation of autonomous buses could help eliminate a problem in Bialystok of a deficit of bus drivers and a lack of applicants for this position (Barometr Zawodów, 2025).

Therefore, the purpose of this article is to analyze the possibility of implementing autonomous buses in Bialystok. The study will analyze the current situation of Bialystok's public transportation, as well as the opinion of residents about autonomous vehicles. The results of the analysis will indicate what steps should be taken to effectively implement autonomous buses in public transportation in the city of Bialystok.

2. Literature review

2.1. Concept of sustainable and smart urban mobility

We can term urban mobility as any way in which people move around in cities for daily duties, travel and other social purposes (Kos et al., 2023). It is worth noting that there is a steady increase in the mobility of society, and consequently growing needs for efficient relocation. In an attempt to meet these expectations, such methods of relocation are increasingly popularized, such as: public transportation or the rental and sharing of cars, motor scooters, electric scooters, bicycles (Janczewski, Janczewska, 2022).

Looking at modern urban development and the evolution of urban society, urban mobility requires special attention when implemented in urban spaces. Given the growing awareness of the need to protect the environment and the desire to follow the latest technological trends among today's communities, these issues should be a priority in the urban mobility design process (Kos et al., 2023). Focusing on these two overarching values, two related concepts have emerged in the field of urban mobility: sustainable urban mobility and smart urban mobility (Herdiansyah, 2023).

The topic of sustainable mobility in the European arena was addressed as early as 1992 by the European Union in the "EU Green Paper." This entry was one of the first to address the ever-increasing environmental impact of transportation, which was the direct cause for the concept of sustainable mobility (European Commission, 2025). For that moment, the concept was about reducing the negative impact of transportation on the environment, improving energy efficiency and taking care of the public's quality of life. Most of these goals are still relevant, but the scope of sustainable mobility issues has expanded to include a greater focus on sustainable urban mobility. This focus has begun to draw attention to challenges such as the excessive number of vehicles in cities, high emissions and increased noise levels (Holden et al., 2019, Aladayleh et al., 2023).

When it comes to smart urban mobility, it is also a current topic, as it is one of the six dimensions of smart city functioning (Herdiansyah, 2023). The idea of smart cities is shaping today's cities, which are trying to respond to any problems related to urbanization, pollution, mobility, economy, quality of life of residents or effective management of (Goumir et al., 2023).

One of the attempts to make efficient use of urban infrastructure and improve the comfort of residents' daily travel is smart mobility. The concept of smart mobility focuses on the design of intelligent, but also sustainable transportation, based on the use of Information and Communicastions Technology (*ITC*) - including, among others, the Internet of Things (*IoT*), artificial intelligence or real-time analysis of large data sets (big data) (Augustyn, 2020).

2.2. Sustainable and smart urban mobility solutions

The guarantee of a high level of sustainable and intelligent urban mobility in road transport is continuous improvement. By improvement we should understand the implementation of modern transport systems, the use of environmentally friendly measures to reduce emissions of exhaust fumes and pollutants, as well as the popularization of the combination of various forms of transport. The literature highlights more than a dozen available solutions that promote the progress of urban mobility at the same time and are complementary to each other. They can be classified into public transportation, micromobility and Intelligent Transportation Systems (*ITS*) solutions. (Janczewski, Janczewska, 2019). A detailed division with example technologies is presented in figure 1.

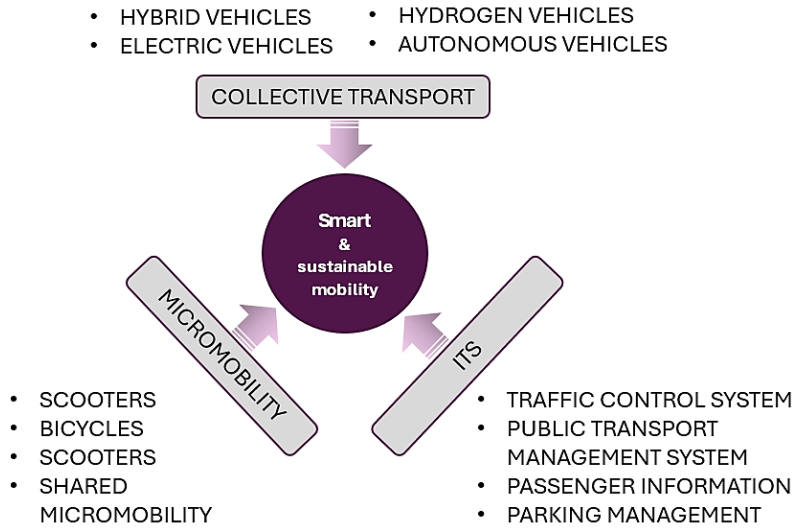

Figure 1. Classification of sustainable and smart urban mobility solutions.
Source: own elaboration.

The segment of solutions that the article particularly focuses on is public transportation. This group includes standard vehicles such as buses, streetcars, urban trains, subways (Nakamura, 2024). In the literature, most information can be found on the most common means of public transport - the bus (Jóźwiak, Guciewski, 2018).

More and more often hear about the modernization of classic buses, especially in cities implementing smart city concepts. One of the upgrades in the bus transportation industry is the introduction of autonomous buses, the kind that doesn't need the human driver's intervention to move (Banach, 2020).

Autonomous buses are a popular solution around the world, not only on public roads, but also in private areas such as universities and even cmenatres. As it turns out, the universities of Salford-Manchester, Gothenburg, Michigan and Adelaide have decided to test small autonomous shuttle buses in campus towns, which are used by the university community on a daily basis. (Navya, 2025). Of other interesting examples, self-driving shuttles were tested in 2021 in the Gdansk cemetery. Due to the high car traffic in the area, there was an initiative to

minimise the traffic, so autonomous buses were used to drive visitors along the main avenue of the cemetery (Trapeze, 2021).

These types of vehicles operate fully or partially without human supervision, which means they can autonomously perform such maneuvers for example accelerating, braking, turning and even reacting to obstacles on the road (Banach, 2020). This is possible by using artificial intelligence technology, navigation systems and rich equipment with various types of sensors placed on the vehicle. The more technologically advanced and better equipped a vehicle is, the higher level of autonomy it has (Scurt et al., 2021, Siderska et al., 2023). In order to correctly identify the environment and minimize human error, devices such as:

- video cameras - responsible for transmitting images,
- lidars (laser radars) - responsible for scanning the space around the vehicle,
- ultrasonic sensors - responsible for detecting obstacles over short distances,
- infrared sensors - responsible for detecting obstacles at long distances,
- microphones - responsible for detecting sounds around the vehicle.

Using the sum of the collected information from all sensors, it is possible to determine a complete picture of the traffic situation (Choromański et al., 2020). An example of sensor placement in an autonomous vehicle is shown in fig. 2.

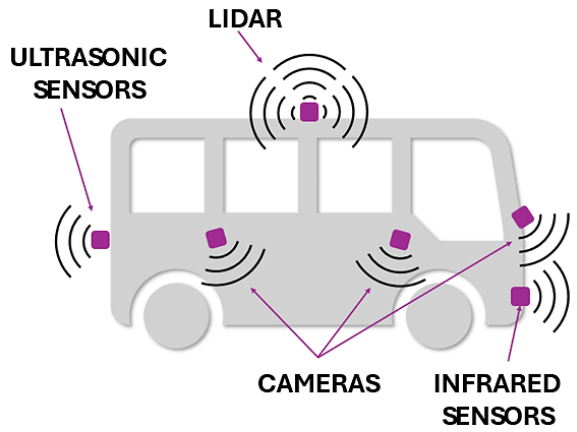

Figure 3. An example of the arrangement of basic sensors on autonomous vehicle.

Source: elaboration based on Choromański, Grabarek, Kozłowski, Czerepicki, Marczuk, 2020, p. 122.

2.3. Benefits and barriers to implementing autonomous vehicles

The implementation of autonomous vehicles is one of the newest steps being taken towards the development of public transportation and public transport. Like any novelty in the market, there are some benefits and barriers to implementation, which must be analyzed before implementing the technology on a larger scale (Olivier Wyman Forum, 2023).

There is no doubt that commercially available urban mobility solutions, including autonomous vehicles, offer numerous benefits for all users of transportation systems, such as drivers, pedestrians, passengers, public transportation, people with reduced mobility, but also institutions related to transportation management (Tomaszewska, 2022).

Conducting a review of the available literature and the research done, the benefits of implementing smart and sustainable solutions can be divided into three main categories:

- environmental benefits (environmental aspects),
- organizational benefits (economic aspects),
- social benefits (safety aspects, educational aspects, user comfort) (Tomaszewska, 2022).

The key benefits of implementing autonomous vehicles in public transport are primarily: reduced operating costs (due to the lack of need for physical drivers) (Kornaszewski et al., 2017), improving the quality of the environment (Tomaszewska, 2022), increase the safety of passengers and other road users (Crişan et al., 2021), as well as increasing the accessibility of public transport and more efficient traffic management in the city (Wach-Kloskowska, Rześny-Cieplińska, 2018). A detailed analysis of the benefits with specific categories is provided in table 1.

Table 1.
List of benefits of implementing urban mobility solutions

Benefit category	Range of benefits	Examples of benefits
Environmental benefits	**Environmental aspects**	- Reducing the harmful impact of urban transport on the environment. - Reducing exhaust and toxic emissions. - Reduction of fossil fuel consumption. - Reducing the loss of urban greenery.
Organizational benefits	**Economic aspects**	- Reduction in financial outlays for road resurfacing and repairs. - Reduction of operating costs. - Strengthening the city's budget.
Social benefits	**Safety aspects**	- Automated road safety inspection. - Quick response when a dangerous situation is detected (accident, collision, other danger). - Reduction of accidents and dangerous situations. - Reducing traffic congestion. - Optimal use of transport infrastructure potential. - Optimal use and capacity expansion of available road infrastructure.
	Educational aspects	- Encouraging the public to use environmentally friendly travel methods. - Promoting an environmentally responsible lifestyle. - Continuous improvement of urban mobility solutions.
	User comfort	- Improved mental comfort due to the ability to track the location of the transport in real time. - Save time with faster travel. - Improved quality of life due to reduced noise and lower emissions. - Improving travel comfort with the newest fleets. - Reducing stress, for example, in connection with the search for a parking space.

Source: elaboration based on Tomaszewska, 2022, pp. 345-346.

The risks, as well as the benefits associated with implementing autonomous vehicle solutions, can affect many levels of city operations and its stakeholders (Czupich et al., 2016). Possible difficulties most often arise at least from the structure of the city's finances, legal conditions, or public attitudes toward innovation and change (Hesse, 2008).

The fact is that the development, and subsequent implementation, of innovative projects and high-quality transportation services is an expensive process, especially in the early phases of the investment process. This is quite problematic given the public budgets of cities, which are often highly strained (Werland, Rudolph, 2019). Lack of adequate funding can also be a problem when it comes to infrastructure in need of renovation. Often the current transportation infrastructure in cities is not sufficient to adapt new technologies (Sadowski, Pasternak, 2014). The population, or potential users of autonomous vehicles, may also prove to be a challenge, mainly their beliefs and attitudes toward change. On the one hand, the current population is increasingly aware of the need to implement sustainability and ecological measures, and yet there are still concerns about the introduction of new technologies. Fear of change and resistance to adapting new solutions is a natural human reaction. In the face of such attitudes, there may be voices of opposition from residents, which will have to be faced by authorities wishing to follow the mobile development of their cities (Krawiec, Krawiec, 2019; Schachenhofer et al., 2023; Ejdys et al., 2024).

Therefore, it is possible to consider classifications of barriers to the implementation of autonomous vehicles distinguishing such types of barriers as financial, infrastructural, social and legal (Hesse, 2008). More examples of barriers considering the aforementioned division are presented in table 2.

Table 2.
List of barriers in the implementation of urban mobility solutions

Types of barriers	Examples of barriers
Financial barriers	- High investment costs - costly urban mobility technologies. - Burdened city budgets - no readiness to take on new investments. - Difficulties in raising funds for new technologies. - Unknown and lack of knowledge of all possible financing tools. - Lack of skills or sufficient experience in preparing grant applications.
Infrastructure barriers	- Complete lack of infrastructure necessary to implement modern technologies. - Current but insufficient urban infrastructure (unsuitable for adaptation of new technologies). - Lack of funds to renovate outdated infrastructure. - Difficulties in integrating new solutions with current systems. - Problems with spatial adaptation.
Social barriers	- Fear of change. - Resistance and negative public attitudes to change despite growing environmental awareness. - Lack of sufficient knowledge about new urban mobility technologies. - Lack of awareness of the benefits of adapting new technologies. - Lack of long-term experience in implementing sustainable and smart urban mobility solution. - Personal beliefs and biases.
Legal barriers	- Regulatory and legal barriers. - Difficulties in adapting regulations to new solutions. - Lack of synergy and harmonization between new and existing regulations.

Source: own elaboration.

2.4. Characteristic of the urban transport system in Bialystok

Bialystok is the administrative center of the Podlaskie Voivodeship and thus the largest city in northeastern Poland, even though it occupies only about 0.5% of the area of the entire voivodeship (102,13 km^2) (Bielawska et al., 2024).

The location of the city of Bialystok is very advantageous, as it is located at the intersection of major national and international transportation routes - primarily road, and in the future, railroads (Urząd Miejski w Białymstoku, *Diagnoza*…, 2021). The city also has many district and municipal roads, which have lengthened by 5.8% in five years since 2015. The situation is similar when it comes to the lengthening of streets that serve as the city's bypasses - these have increased by 25.5% over the same period under review (Urząd Miejski w Białymstoku, *Strategia*…, 2021). As a result of the city's progressive road infrasturcture, it is characterized by a radial-circuit system (Urząd Miejski w Białymstoku, *Diagnoza*…, 2021).

The urban transport system of Bialystok consists of such kinds of transport as public transport, bicycle and individual transport (Piórkowska, Szpilko, 2019). As it turns out, Bialystok is the only Polish city with a population of more than 250,000, and yet it has no alternative forms of public transportation other than bus transport (Public Transport Consulting Marcin Gromadzki, 2021).

Public transport organization in Bialystok is the responsibility of the Bialystok Public Transport Authority – in Poland is called Zarząd Białostockiej Komunikacji Miejskiej (BKM). This one, in turn, outsources the given transport tasks to three operators belonging to the municipal transport company, these are (Public Transport Consulting Marcin Gromadzki, 2021):

- Komunalne Przedsiębiorstwo Komunikacyjne sp. z o.o. (KPK).
- Komunalne Przedsiębiorstwo Komunikacji Miejskiej sp. z o.o. (KPKM).
- Komunalny Zakład Komunikacyjny w Białymstoku sp. z o.o. (KZK).

Thus, the transportation companies listed are only responsible for city bus service, which has a total of 56 lines, including (Komunikacja Białystok, 2025):

- 30 city lines (one- and two-digit designations),
- 17 suburban lines (designations 1xx),
- 3 municipal lines (designations 2xx),
- 6 night lines (designations from N1 to N6).

In terms of the fleet of public transport buses, it definitely stands out on the city's streets, as each vehicle has a distinctive white and green color scheme along with the BKM logo (Piórkowska, Szpilko, 2019). The current fleet of public transport buses, has a total of 267 buses, which are divided into two types: single-frame and double-frame (articulated). The number of vehicles of both types is quite equal, as there are 136 single-frame buses and 131 articulated buses (Zarząd Białostockiej Komunikacji Miejskiej, 2024). It is also worth noting that the vast majority (more than 95%) are low-floor buses, which allow for greater

comfort and safety of travel, especially for passengers with disabilities, parents with strollers, or the elderly (Piórkowska, Szpilko, 2019).

Equally optimistic is the fact that BKM is investing in environmentally friendly buses, although still not in large numbers. As of 2024, Bialystok's fleet consisted of 92 diesel buses meeting the latest Euro VI palin emission standard (including 6 hybrid buses) and 20 electric-powered buses. This represents 34% and 7% of the total fleet (Zarząd Białostockiej Komunikacji Miejskiej, 2024).

3. Methodology

The main objective of the study was to analyze the possibility of implementing autonomous buses in Bialystok.

The subject of autonomous buses is important, especially in light of the prevailing shortage of bus drivers in the region. As the research shows, there is a serious problem in the public transport sector in Bialystok County and the city of Bialystok, due to the very low number of people with the right qualifications. This is problematic because in this region of the Podlaskie Voivodeship the demand for specialized drivers is the greatest. The main reason for the deficit is the salary, working hours and the nature of the work, which is physically and mentally straining (Barometr Zawodów, 2025).

But it is still comforting to know that the city of Bialystok is open to change and following new technologies, as demonstrated by the moves made by local officials. The city's rulers are taking concrete steps to positively influence the development of Bialystok, including by planning a development strategy for the coming years. One of the goals of this plan is to introduce new forms of transportation by 2030, such as for example autonomous vehicles (Urząd Miejski w Białymstoku, *Strategia…,* 2021).

Therefore, the survey focused on finding out the opinions of Bialystok residents on the functioning of the current public transportation system and the possible implementation of autonomous buses. To verify this, a method of quantitative diagnostic survey was used, supported by the CAWI technique (Computer Assisted Web Interview). The technique is to conduct an interview by computer using a website (Strojna et al., 2022) – it was Google Forms ind this case. The link was share by social media, and feedback wac collected for 14 days.

The survey questionnaire consisted of 18 questions, appearing in several forms:

- Single-choice closed questions.
- Closed multiple-choice questions.
- Semi-open questions.
- Evaluation questions using Likert Scale.
- Matrix questions.

The opening questions were typically demographic questions, designed to collect information about the survey participants and to systematize information such as gender, age, education and type of connection to the city of Bialystok. Further questions focused on the frequency and purpose of travel on public buses, as well as the degree of satisfaction with current public transportation services in Bialystok. The next part of the survey was devoted to the issue of autonomous buses, where they were asked, among other things, about awareness of what autonomous vehicles are. Respondents had the opportunity to express their approval or disapproval of specific theses related to the implementation of autonomous buses, as well as to give their opinion on the appropriateness of implementing this solution in Bialystok.

The survey was directed primarily to residents of Bialystok and the nearby areas, and the condition for participation in the survey was to use Bialystok's public transportation at a minimum of once. The final group of respondents consisted of 103 people, including 55 women and 48 men.

4. Results

Apart from examining the typical characteristics of respondents, such as gender and age, it was decided to also pay attention to the respondents' education and type of connection to the city of Bialystok. Knowing the answers to these questions can help later understand the public's technical knowledge and general awareness of autonomous technologies and determine the strength of their relationship with Bialystok.

As for the educational level of the respondents, most of them (43%) have a high school education. On the other hand, slightly fewer, 40%, have higher education. The smallest percentage of people represents primary education, it is only 17%, or 18 respondents. This structure allows us to conclude that the majority of those who took part in the survey have completed secondary school (high school, technical school or vocational school) or are still pursuing undergraduate studies. However, it should be noted that a similar result is also represented by those who have already completed their university education and hold a bachelor's, engineer's, master's or doctoral degree.

Such results on the question of education are reflected in the answers to the question on the type of connection to the city of Bialystok. The majority of respondents (54%) declared that they live permanently in Bialystok. According to the level of education, the second most frequently chosen type of connection to the city was education, with nearly 36% of respondents indicating that they study in Bialystok. Just slightly fewer responded that they work in the Podlasie capital (32%). The least numerous group were those who declared that they do not live or study or work in Bialystok, but come to the city from time to time (12%). Importantly, the question was multiple choice, and the distribution of results is shown in figure 4.

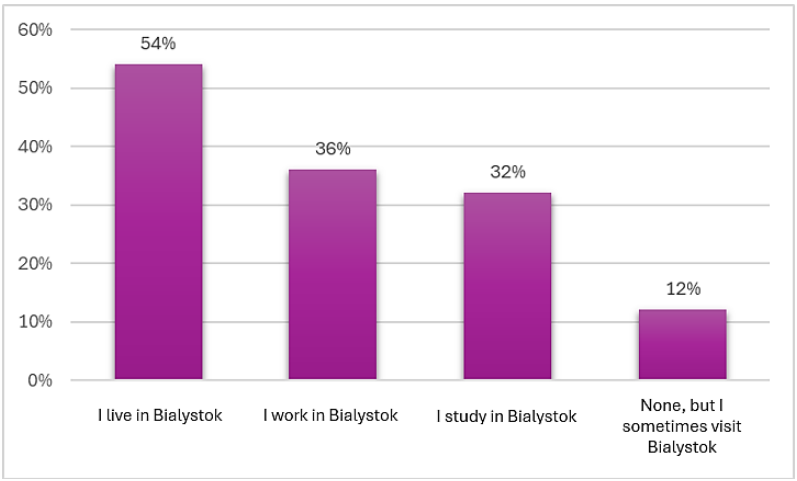

Figure 4. Respondents' answers to the question "What kind of connection do you have with the city of Bialystok?".

Source: own elaboration.

The next step was a series of questions examining the frequency of use of bus travel and respondents' attitudes toward the current way public transportation operates in Bialystok. First, respondents were asked how often they use public transportation. The responses were fairly balanced, although statistically the most common answer was "several times a month" chosen by 36 people (35%). In second place with a score of 27% was the answer "several times a week," and the last place on the podium was taken by the answer "several times a year," selected by 17.5% of respondents. It can be said that just as often as several times a year, public transportation is also used daily, with 16.5% of respondents declaring that they choose this mode of transportation every day. The least frequently chosen answer was "less than once a year" (4%), which means that each person participating in the survey travels by public transportation in Bialystok at least once a year. The distribution of responses is presented in figure 5.

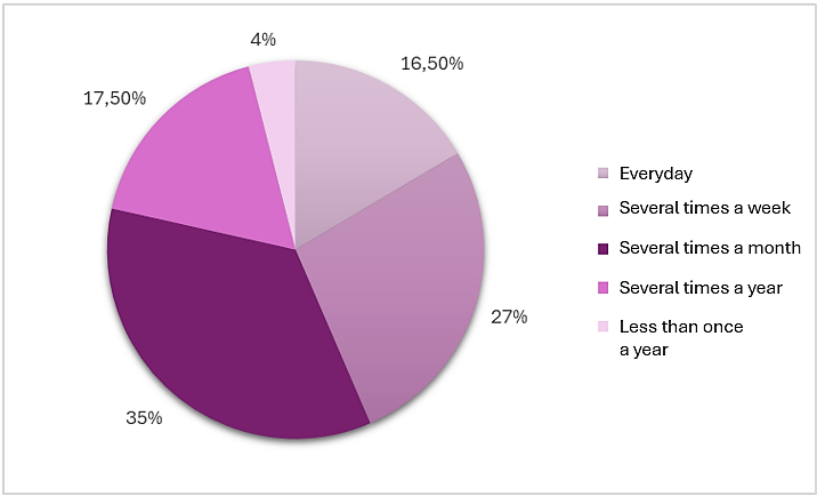

Figure 5. Respondents' answers to the question "How often do you use public transportation in Bialystok?".

Source: own elaboration.

As it turns out, respondents most often travel by public transportation in connection with the need to do things in the city, such as doing basic shopping, visiting a doctor, office or bank (42%). In second place were two responses that were equally indicated by 36% of respondents - this was to get to school or university, and to get to meetings with friends and family. Slightly fewer, 33%, also indicated commuting to work as one of the situations in which they choose to travel by bus. The fewest responses (11%) were for recreational purposes such as getting to the city beach or to a park. It turns out that young people, who are most likely still continuing their education, use public transportation almost as often as young adults attending work. Nevertheless, representatives of both of these numerous groups share one common purpose of travel, which was indicated most often - to run private errands in the city, which everyone confronts in their daily lives. The question allowed the choice of more than one answer, and detailed data is shown in figure 6.

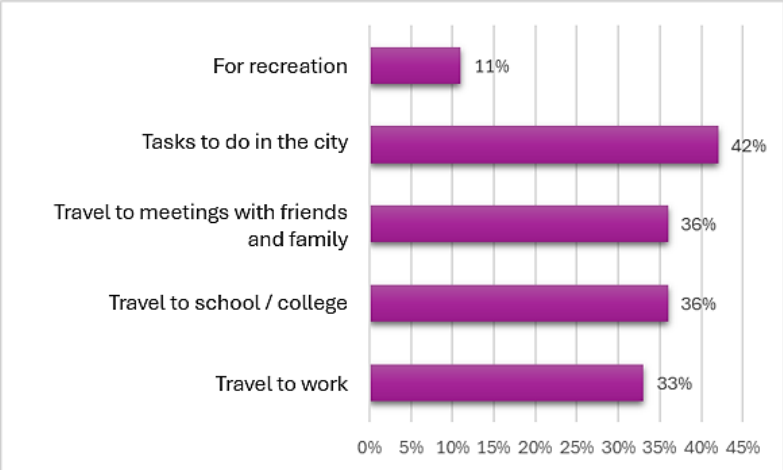

Figure 6. Respondents' answers to the question “In what situations do you most often use public bus travel?”.

Source: own elaboration.

Respondents were asked if perhaps there were other reasons for using city buses besides the specific situations indicated earlier. Only 8% responded that they were not guided by reasons other than those indicated above. The remaining responses, in turn, were quite diverse, as shown in figure 7.

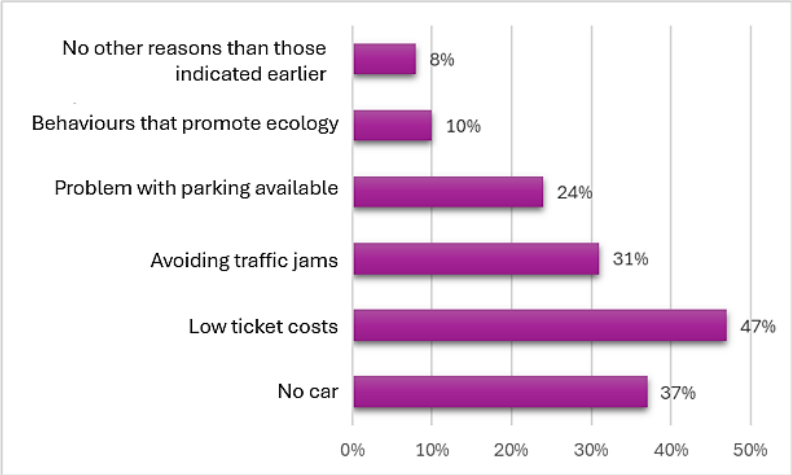

Figure 7. Respondents' answers to the question "What are your main reasons for using city public buses, other than the situations selected in the previous question?".

Source: own elaboration.

For the large majority, the most convincing reason for using public transportation is low ticket prices (47%). The current price list for public buses traveling in Bialystok is unchanged as of March 14, 2023, which passengers apparently appreciate.

The second most frequently cited reason is the lack of own car (37%) as a result of which travel by public transportation is necessary. Avoiding traffic congestion (31%) and the problem of finding a parking space (24%) were also relatively common responses. On the one hand, some respondents are somewhat forced to travel by public buses due to the lack of a private car, but still about 60% have a car, and there were nevertheless responses suggesting that public transportation works as a good alternative to car travel.

It may be worrying that only 10 respondents (about 10%) answered that they choose to travel by public transportation because they have an environmental awareness and need for eco-friendly behavior. This percentage of responses may be related to the low availability of green buses in the current BKM fleet. Of the 167 available buses, only 6 have hybrid power, the rest are powered by a classic diesel engine that emits pollutants into the atmosphere (Zarząd Białostockiej Komunikacji Miejskiej, 2025).

The final, and the key question closing this segment of the survey was "Are you satisfied with public transportation services in Bialystok?". The results are shown in figure 8.

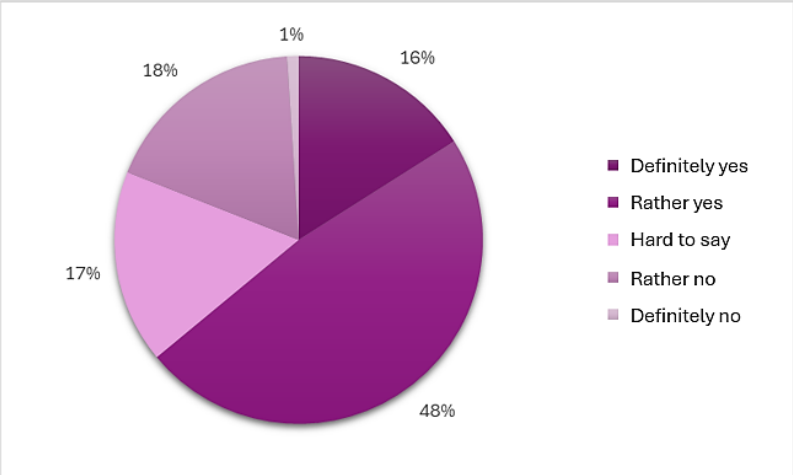

Figure 8. Respondents' answers to the question, "Are you satisfied with the public transportation services in Bialystok?"

Source: own elaboration.

The large majority of responses were positive, as 48% of respondents answered "rather yes" and 16% answered "definitely yes," for a total of 64%. Negative statements were made by 19% of respondents, marking "rather not" (18%) and definitely not (1%) in the survey. Nearly as many, with 17%, had trouble answering this question clearly and chose "hard to say". Without a doubt, the positive opinion of the majority and only 1 definite negative answer are reasons to be satisfied with the current operation of public transportation. However, it is worth thinking about how to change the opinions of the rest of the respondents, who are rather not satisfied with the services of Bialystok's public transportation or found it difficult to give a specific opinion on the subject.

The next questions in the survey already focused on the technological aspect, and were designed to examine respondents' attitudes toward autonomous vehicles. In this regard, the question was asked "Are you familiar with the concept of autonomous buses?" and its definition was included. More than half of the respondents answered yes (68%), while the rest announced that they were not familiar with the concept until now (32%).

In the following part of the survey, an attempt was made to determine the attitude of the public towards selected features of autonomous vehicles, such as travel safety, eco-friendly operation, and travel comfort.

So the first question was asked, "How far do you agree with the statement that autonomous buses can be a safer means of transportation than human-driven buses?". As it turns out, although there was a preponderance of affirmative answers - "definitely yes" (33%) and "rather yes" (23%), the second most frequently chosen answer was "hard to say" (30%). Therefore, it can be concluded that the public still remains distrustful of autonomous technologies and is not fully convinced of the safety of such a solution.

Next, the question was asked: "How far do you agree with the statement that autonomous buses are a greener alternative to traditional diesel buses?". A total of more than 80% of respondents said yes, and only 8% disagreed with the statement. Such a result may indicate that

even though the need for pro-environmental behavior is not the priority one when choosing to ride public transportation, public awareness of the benefits of green solutions is at a high level anyway.

However, the question of feeling comfortable on an autonomous bus is not as obvious as the aspect of the positive environmental impact of these vehicles. Respondents were asked "How much do you agree with the statement that you would feel comfortable traveling in an autonomous bus?". Although the majority of responses were still affirmative (72%), the overwhelming response was "rather yes" (50%), rather than "definitely yes" (22%).

The next step of the survey was to find out residents' opinions on the necessity of introducing autonomous buses in Bialystok and if they think that the current infrastructure is up to the modern technology.

The question was then asked, "Is it necessary to implement autonomous buses in Bialystok's public transportation?" It turns out that the public is unanimous on this question, as 42% answered "definitely yes" and "rather yes" 38%, giving a total of 80% support.

Despite the consensus on the need to implement autonomous buses in Bialystok, it appears that opinions are divided on the appropriate timing for the introduction of such vehicles in the city. Nearly 63% of respondents favored the introduction of the technology in the near future, with 35% voting for implementation as soon as possible, and 27% believing it should happen by 2030. Another 20% see such a possibility by 2040, and 16% even further in the future. Only 2% of respondents believe that autonomous buses should not be introduced to Bialystok at all. The results are presented in figure 9.

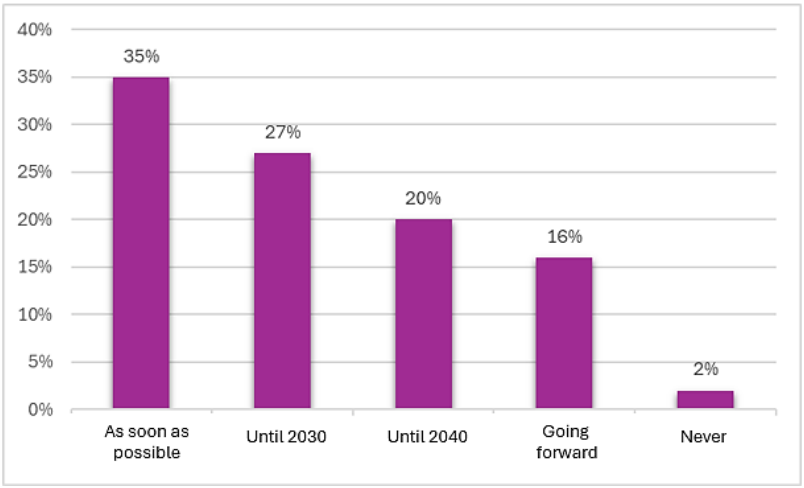

Figure 9. Respondents' answers to the question "How soon do you think autonomous buses should be implemented in Bialystok?".

Source: own elaboration.

While respondents recognize the city's potential to implement autonomous buses in the future, responses to the next question show that at the same time there is clear uncertainty about the actual readiness of the city's infrastructure for this project. Respondents were asked the question "Do you agree with the statement that Bialystok's infrastructure is ready for the

implementation of autonomous vehicles?". 42% of respondents answered "rather yes" and 29% answered "definitely yes," indicating that nearly half of the respondents believe that Bialystok is at least partially ready for the implementation of autonomous vehicles. However, the dominance of "rather yes" responses over the more certain "definitely yes" may suggest that there is some caution and incomplete conviction among the community about the readiness of Bialystok's infrastructure for modern technology. On the other hand, such responses may indicate people's high awareness that the implementation of autonomous vehicles requires diligent preparation, and that the current infrastructure, while at a good level, is not necessarily fully prepared for such advanced vehicles.

It also tried to study the public's attitude toward the technology, which some respondents were previously unfamiliar with. A positive finding of the survey is that, despite their low knowledge of the subject, the majority of respondents said they would be interested to try a ride on an autonomous bus if such means of transportation were available in Bialystok. Positive responses totaled 81%, with 36% saying "definitely yes" and 45% saying "rather yes". 15% of respondents marked "it is difficult to say," and only 4% said they would not even want to try such a ride. Detailed statistics are shown in figure 10.

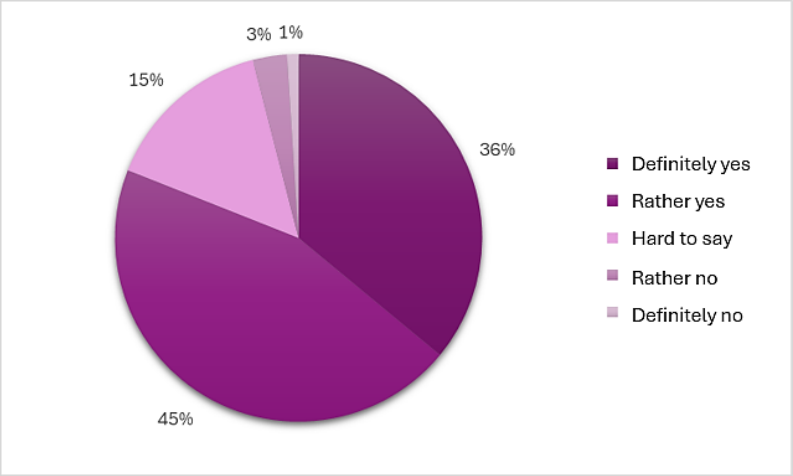

Figure 10. Respondents' answers to the question "Would you like to try a ride on an autonomous bus if it were available in Bialystok?".

Source: own elaboration.

The question was also asked, "Would the introduction of autonomous buses in Bialystok encourage you to use public transportation more often?" Nearly 37% of respondents said they would definitely use public transportation more often then, and 33% said this was probable. At the same time, about 19% of respondents felt that the presence of autonomous vehicles would not affect their frequency of riding public transportation, and nearly 9% had a difficult task to clearly define themselves.

It should be noted that a large number of respondents have had no direct contact with autonomous vehicles before, and some are also not convinced of the validity of introducing these vehicles into Bialystok's public transportation. It was therefore decided to confront the public with some ideas for taming the society with this technology.

The first question asked "Do you agree that public education about autonomous vehicles is key to their acceptance by the public?" Interestingly, this was the question with the highest agreement in the entire survey, as 92% were affirmative responses. 66% of respondents said they strongly agreed with the statement, while 26% "rather yes." As it turns out, effective educational campaigns are highly relevant to the public, and increased knowledge of how autonomous vehicles work could help eliminate fears and build confidence in the new technology among residents.

Respondents were also asked, "Do you agree with the statement that the government should support the development of autonomous technology in public transportation?". The responses indicate strong support, as 56% of respondents answered "definitely yes", and an additional 32% answered "rather yes", for a total of 88% support. It can be seen that respondents place high hopes on the role of the government in the implementation of autonomous buses in cities, and expect such support from them. Detailed results are presented in figure 11.

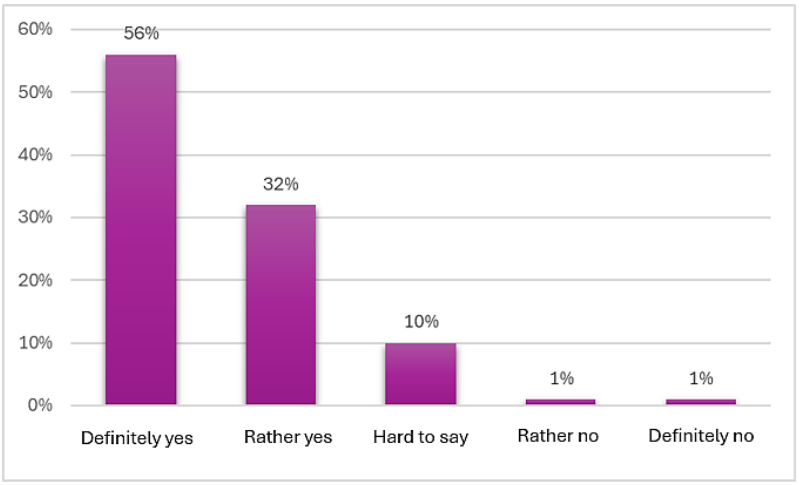

Figure 11. Respondents' answers to the question, "Do you agree with the statement that the government should support the development of autonomous technologies in public transportation?".

Source: own elaboration.

5. Discussion

The results of the survey indicate that the residents of Bialystok are positive about the solution of autonomous buses. Despite some uncertainty in front of the unknown technology, they still show interest and desire to learn about the functionality of driverless vehicles.

Respondents see several key advantages of autonomous vehicles in terms of safety, comfort and ecology, which is in line with the main benefit cateogories identified by Tomaszewska (2022). Respondents agreed that driverless buses could be a safer and more environmentally friendly alternative to traditional human-driven diesel buses (Crişan et al., 2021). Respondents also confirmed that these types of vehicles are a guarantee for more comfortable travel, although

with this question there were most unsure answers - “rather yes”. This may indicate the problem of the low level of education of the public about sustainable and intelligent mobility, which is reflected in a certain uncertainty about the solutions offered in this area (Krawiec et al., 2019; Schachenhofer et al., 2023).

Nevertheless, this attitude of the public towards new technologies is in favor of the plans contained in the City Development Strategy to 2030 published by the Urząd Miejski in Białystok (2021). Among other things, the strategy involves developing public transportation and investing in autonomous vehicles.

Unfortunately, despite respondents' frequent travel by public transportation on a daily basis, nearly half of them are unsure whether Bialystok's infrastructure is ready for the implementation of autonomous buses. As the literature review showed, this is a relatively common barrier to implementing autonomous vehicles in cities (Sadowski, Pasternak, 2014).

This is an aspect to look into, especially because the public would like to see such vehicles appear in Bialystok. Moreover, the respondents mostly admitted that driverless buses are needed in the city, and mostly declared that they would then probably use public transportation more often.

6. Conclusions

The study showed that there is a possibility for the implementation of autonomous buses in Bialystok. However, in order for successful implementation, it is necessary to analyze and modernize the current urban infrastrcuture and adapt it to driverless vehicles - for example, by reconstructing roads or tunnels built many years ago, which may not meet current mobility requirements. An excellent example and inspiration for Bialystok in this field could be the nearby Scandinavian countries, which especially in recent years, have stood out for their high standard of implementation of sustainable and intelligent urban mobility solutions.

Key to the successful implementation of the new technology in the city may also prove to be the education of the public, who themselves highlight such a need. The city's rulers could solve, for example, educational public campaigns, which in the era of the availability of numerous mass media are possible in many ways and could make a significant contribution to minimizing public distrust.

It can also be seen that respondents place high hopes on the role of the government in the implementation of autonomous buses in urban spaces, and expect such support from government. It is therefore worth finding out whether the state offers grants or programs to support the implementation of sustainable and intelligent urban mobility solutions.

Following the proposed recommendations may prove important in terms of sustaining residents' interest in autonomous buses and their positive attitude towards the technology. Certainly, social acceptance will be a welcome development if the city administration decides to implement driverless vehicles in the urban space of Bialystok.

References

1. Aladayleh, K.J., Al Qudah, S.M.A., Fuentes Bargues, J.L., Ferrer Gisbert, P. (2023). Global trends of the research on COVID-19 risks effect in sustainable facility management fields: a bibliometric analysis. *Engineering Management in Production and Services*, *Vol. 15(1)*, pp. 12-13. doi: 10.2478/emj-2023-000
2. Augustyn, A. (2020). *Zrównoważony rozwój miast w świetle idei smart city*. Białystok: Wydawnictwo Uniwersytetu w Białymstoku.
3. Banach, M. (202). *Od inteligentnego transportu do inteligentnych miast.* Warszawa: PWN.
4. *Barometr Zawodów 2025*. Retrieved from: https://barometrzawodow.pl/, 20.03.2025.
5. Bielawska, P., Wojnicz, K., Leśniewska, G., Walendzewicz, P., Leończuk, D. (2024). Zarządzanie transportem publicznym w trakcie trwania pandemii COVID-19 z punktu widzenia młodych mieszkańców Białegostoku. *Akademia Zarządzania*, *Vol. 8(2)*, pp. 189, doi: 10.24427/az-2024-0021
6. Choromański, W., Grabarek, I., Kozłowski, M., Czerepicki, A., Marczuk, K. (2020). *Pojazdy autonomiczne i systemy transportu autonomicznego*. Warszawa: PWN, p. 121.
7. Crişan, G.C., Pintea, C.M., Calinescu, A., Sitar, C.P., Pop, P.C. (2021). Secure travelling salesman problem with intelligent transport system features. *Logic Jorunal of the IGPL*, *Vol. 29(6)*, pp. 925-935, doi: 10.1093/jigpal/jzaa035
8. Czupich, M., Kola-Bezka, M., Ignasiak-Szulc, A. (2016). Czynniki i bariery wdrażania koncepcji smart city w Polsce. S*tudia Ekonomiczne. Zeszyty Naukowe Uniwersytetu Ekonomicznego w Katowicach*, *Vol. 276*, p. 226.
9. Data from Zarząd Białostockiej Komunikacji Miejskiej, 20.08.2024.
10. Ejdys, J., Strojny, P., Zazulka, N. (2024). Społeczna akceptacja rozwiązań inteligentnej mobilności miejskiej na przykładzie autonomicznych autobusów w Białymstoku. *Akademia Zarządzania*, *Vol. 8(4)*, p. 251, doi: 10.24427/az-2024-0072
11. European Commission. *Green Paper on the impact of Transport on the Environment. A Community strategy for 'sustainable mobility'.* Retrieved from: https://op.europa.eu/en/publication-detail/-/publication/98dc7e2c-6a66-483a-875e-87648c1d75c8/language-en, 4.04.2025.
12. Gohar, A., Nencioni, G. (2021). The role of 5G Technologies in a Smart City: The Case for Intelligent Transportation System. *Sustainability*, *Vol. 13(9)*, pp. 1, doi: 10.3390/su13095188

13. Goumiri, S., Yahiaoui, S., Djahel, S. (2023). Smart Mobility in Smart Cities: Emerging challenges, recent advances and future directions. *Journal of Intelligent Transportation Systems, Vol. 9*, p. 3, doi: 10.1080/15472450.2023.2245750
14. Herdiansyah, H. (2023). Smart city based on community empowerment, social capital, and public trust in urban areas. *Global Journal of Environmental Science and Management, Vol. 9(1)*, p. 116, doi: 10.22034/gjesm.2023.01.09
15. Hesse, M. (2008). *The City as a Terminal.* London: Routledge, pp. 75-80.
16. Holden, E., Gilpin, G., Branister, D. (2019). Sustainable Mobility at Thirty. *Sustainability, Vol. 11(7)*, p. 1965, doi: 10.3390/su11071965
17. Janczewski, J., Janczewska, D. (2019). Zrównoważony rozwój z perspektywy mikromobilności. *Zarządzanie Innowacyjne w Gospodarce i Biznesie*, *Vol. 2(29)*, p. 166, doi: 10.25312/2391-5129.29/2019_11jjdj
18. Janczewski, J., Janczewska, D. (2022). Zrównoważona mobilność miejska – dobre praktyki. *Zarządzanie Innowacyjne w Gospodarce i Biznesie*, *Vol. 33(2)*, p. 166, doi: 10.25312/2391-5129.33/2021_11jjdj
19. Jóźwiak, A., Guciewski, Ł. (2018). Wybrane aspekty ekologii w miejskim transporcie drogowym. *Prace naukowe Politechniki Warszawskiej*, *Vol. 10*, pp. 1-7, doi: 10.5604/01.3001.0014.4746
20. Komunikacja Białystok (2025). *Białostocka Komunikacja Miejska*. Retrieved from: https://www.komunikacja.bialystok.pl/, 28.03.2025.
21. Kornaszewski, M., Chrzan, M., Olczykowski, Z. (2017). Implementation of new solutions of Intelligent Transport Science in railway transport in Poland. *Communications in Computer and Information Science*, *Vol. 715*, pp. 282-292, doi: 10.1007/978-3-319-66251-0_23
22. Kos, B., Krawczyk G., Mercik A., Tomanek R. (2023). *Odporna mobilność miejska*, Katowice: Wydawnictwo Uniwersytetu Ekonomicznego w Katowicach.
23. Krawiec, S., Krawiec, K. (2019). Wdrażanie autobusów elektrycznych do publicznego transportu zbiorowego – teoria i praktyka. *Transport miejski i regionalny*, *Vol. 3*, p. 10.
24. Mach, B., Skrzypek, M. (2019). Możliwość oraz perspektywy wdrożenia autonomicznej komunikacji miejskiej w Polsce. *Journal of Trans Logistics*, *Vol. 5(1)*, pp. 11-12.
25. Mouratidis, K., Serrano, V.C. (2021). Autonomous buses: Intentions to use, passenger experiences, and suggestions for improvement. *Transportation research part F: traffic psychology and behaviour*, *Vol. 76*, pp. 321-322, doi: 10.1016/j.trf.2020.12.007
26. Nakamura, F. (2024). Role of public transport in supporting the urban cultural and creative functions. *IATSS Research*, *Vol. 48(3)*, pp. 343-344, doi: 10.1016/j.iatssr.2024.06.002
27. Navya (2025). *Use of Navya self-driving shuttles on campus*. Retrieved from: https://www.navya.tech/en/usecases/campus/
28. Oficjalny Portal Miasta Białystok, https://www.bialystok.pl/pl/dla_mieszkancow/fundusze_unijne/zrealizowane/okresprogramowania20142020/rozwoj-infrastruktury-transportu-miejskiego-w-bialymstoku.html, 4.02.2025.

29. Olivier Wyman Forum (2023). *Urban Mobility Readiness Index 2023 Report*. Retrieved from: https://www.oliverwymanforum.com/mobility/urban-mobility-readiness-index-2023.html
30. Piórkowska, P., Szpilko, D. (2019). Komunikacja miejska jako element systemu transportowego miasta Białystok – wyniki badań. *Akademia Zarządzania*, *Vol. 3(2)*, p. 107.
31. Public Transport Consulting Marcin Gromadzki (2021). *Analiz kosztów i korzyści związanych z wykorzystaniem przy świadczeniu usług komunikacji miejskiej autobusów zeroemisyjnych dla miasta Białystok,* p. 26.
32. Sadowski, A., Pasternak, Ł. (2014). Bariery i ograniczenia w logistyce miejskiej. *Studia Miejskie*, *Vol. 15*, p. 13.
33. Schachenhofer, L., Kummer, Y., Hirsch, P. (2023). An Analysis of Underused Urban Infrastructures: Usage Opportunities and Implementation Barriers for Sustainable Logistics. *Applied Sciences*, *Vol. 13*, p. 12, doi: 10.3390/app13137557
34. Scurt, F.B., Vesselenyi, T., Tarca, R.C., Beles, H., Dragomir, G. (2021). Autonomous vehicles: classification, technology and evolution. *IOP Conference Series: Materials Science and Engineering*, *Vol. 1169(1)*, doi: 0.1088/1757-899X/1169/1/012032
35. Siderska, J., Aunimo, L., Süße, T., von Stamm, J., Kedziora, D., Aini, S.N.B.M. (2023). Towards Intelligent Automation (IA): literature review on the evolution of Robotic Process Automation (RPA), its challenges, and future trends. *Engineering Management in Production and Services*, *Vol. 15(4)*, p. 91, doi: 10.2478/emj-2023-0030
36. Strojna, N., Zalecka, K., Ryciuk, U. (2022). Współdzielona mikromobilność w transporcie miejskim. *Akademia Zarządzania*, *Vol. 6(3)*, p. 372, doi: 10.24427/az-2022-0047
37. Tomaszewska, E.J. (2022). Korzyści wdrożenia inteligentnego systemu transportowego w mieście. *Akademia Zarządzania*, *Vol. 3*, p. 353, doi: 10.24427/az-2022-0046
38. Trapeze (2021). *Trapeze Supports Autonomous Bus Project for the Vulnerable*. Retrieved from: https://trapezegroup.co.uk/blog/autonomous-bus-project-for-the-vulnerable/
39. Urząd Miejski w Białymstoku (2021). *Strategia rozwoju miasta Białegostoku do 2030,* pp. 14-34.
40. Urząd Miejski w Białymstoku, Urząd Statystyczny w Białymstoku (2021). *Diagnoza sytuacji społecznej, gospodarczej i przestrzennej Miasta Białystok,* p. 11.
41. Wach-Kloskowska, M., Rześny-Cieplińska, J. (2018). Inteligentny i zrównoważony rozwój transportu jako element realizacji założeń koncepcji smart city – przykłady polskie i europejskie. *Studia Miejskie*, *Vol. 30*, pp. 102-103, doi: 10.25167/sm2018.030.07
42. Werland, S., Rudolph, F. (2019). *Funding and financing of Sustainable Urban Mobility Measures.* Brussels: Urban Mobility Observatory, p. 12.