JMFS
Journal of Management
and Financial Sciences

Volume XIX
•
Issue 59
pp. 63–80
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The potential of large Polish cities to implement the concept of Mobility-as-a-Service

Abstract

Modern cities face many challenges in the field of mobility, including congestion, environmental pollution, the increasing number of private cars, and suburbanization. Therefore, remedial measures are necessary. The aim of this study is to examine how public transport operates in selected Polish cities and to assess whether it is possible to implement the Mobility-as-a-Service concept there. This concept involves the full integration of transport services within a single digital interface. The study applied the Systematic Literature Review method in combination with the PRISMA methodology, as well as participant observation conducted in five cities belonging to the Union of Polish Metropolises. The results indicate an evolution in the definition of MaaS, from a broad understanding to more specific interpretations. It was observed that public transport in the selected large Polish cities is still characterized by a relatively low level of integration. The lack of inclusive solutions should also be emphasized. Therefore, action is needed in the areas of transport integration, the development of passenger information systems, and digitization.

Keywords: urban mobility, public transport, Mobility-as-a-Service
JEL Classification: R41, O18, L91

Introduction

Contemporary cities are developing rapidly. It is projected that by 2050, approximately 68% of the population will live in urban areas, 13 percentage points higher than today [United Nations, 2018]. Population growth is mainly associated with the process of suburbanization. Suburbanization can be defined as the uncontrolled spatial development of a city beyond its administrative boundaries, usually leading to the gradual depopulation of the city centre [Korwel-Lejkowska, 2021]. Demographic and spatial urban development pose numerous challenges for urban mobility. The number of private cars has increased, and they are becoming the primary mode of transport, particularly among people of middle age and suburban residents [Ramos et al., 2020]. A large number of cars results in traffic congestion, which increases emissions of air pollutants and lengthens travel times [Wen et al., 2019]. The increased use of private cars may stem from an underdeveloped public transport system that does not meet the needs and requirements of various groups of residents. The weakness of public transport is reflected in poor service quality, namely a lack of punctuality, the need to change vehicles, or inadequate onboard equipment [Agrawal et al., 2015]. These challenges result in a decline in the perceived quality of life among urban residents, who are unable to meet their needs fully.

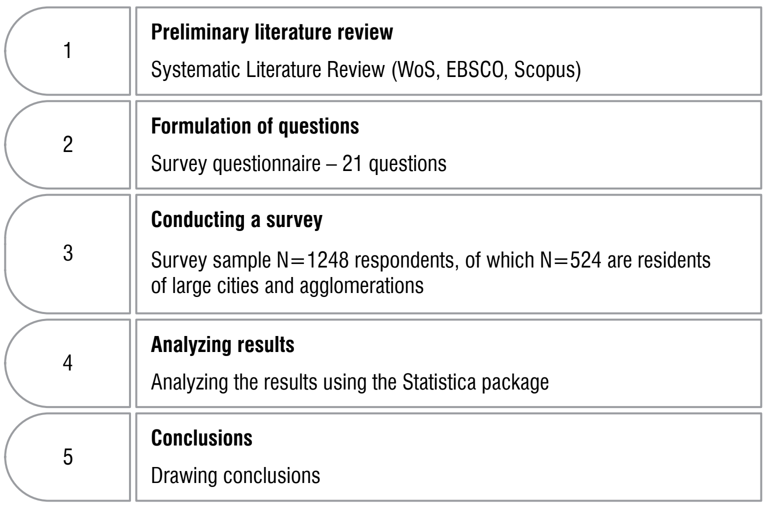
Therefore, city authorities must take remedial action, focusing primarily on the appropriate formulation of local transport strategies and policies. These measures should include shaping desirable and more sustainable transport behaviours. An example of a systemic approach to urban mobility challenges is the implementation of Mobility-as-a-Service (MaaS). This concept involves the full integration of transport services in the city within a single digital interface (application) that offers various functionalities such as ticket purchase, travel booking, real-time information, and journey planning [Makino et al., 2018]. Examples of MaaS implementation in cities such as Helsinki and Budapest demonstrate the effectiveness of the concept in transforming urban transport systems to be more user-friendly and sustainable. However, the concept is not currently implemented in Poland, and there is also a lack of comprehensive analyses of the possibilities for implementing MaaS in Polish cities, which constitutes a significant research gap. The main objective of the study is to identify how public transport functions in selected Polish cities and whether it is possible to implement the MaaS concept in these cities. This objective stems from two research questions: RQ1: How punctual are public transport connections in Polish cities, and how effectively do Intelligent Transport Systems (ITS) operate with respect to passenger information? RQ2: Which determinants and barriers to the implementation of MaaS can be identified in Polish cities?

Achieving the main objective required the use of qualitative methods. The study employed the Systematic Literature Review and participant observation in five Polish cities belonging to the Union of Polish Metropolises named after Paweł Adamowicz (UMP). The research procedure is discussed in detail in the *Methods* section. The results are then presented, and the article closes with the main conclusions.

Methodology

The aim of the study is to examine how public transport functions in selected Polish cities and whether it is possible to implement the MaaS concept in these cities. To achieve the main objective, two complementary research methods were employed: the Systematic Literature Review and participant observation. The research procedure is presented in Figure 1

Figure 1. Research procedure



Source: own elaboration.

In the first stage of the study, a preliminary literature review was conducted to identify research gaps, formulate research questions, and define the analytical objective. Desk research, a method widely used in social sciences, was employed to systematize knowledge on the topic and to delineate existing research gaps [Topolewski et al., 2023].

Table 1. Systematic Literature Review summary

Query	Database	*N* searches	*N* searches II	*N* after analysis of abstracts	Errors	*N* total
(“Mobility-as-a-Service” OR “MaaS”) AND (“concept” OR “idea” OR “definition”)	EBSCO	61	53	19	25	87
	Scopus	65	63	36		
	WoS	126	117	57		
(“Mobility-as-a-Service” OR “MaaS”) AND (“adoption” OR “implementation”) AND (“cit*” OR “urban area*”)	EBSCO	12	10	6	9	35
	Scopus	32	27	17		
	WoS	42	42	21		

Source: own elaboration.

In the second stage, an analysis of scientific literature was conducted using the Systematic Literature Review method with specified keywords and Boolean operators. This method entails a systematic and transparent search for scientific literature, its organization, and analysis in accordance with established criteria [Lame, 2019]. Two key research questions were formulated in the analysis (see Table 1).

We searched for scientific articles that were open access full texts, peer-reviewed, and in English. The search was restricted to manuscripts published between 2010 and 2025, as the MaaS concept was first introduced in 2014. Three publicly available scientific publication databases were queried: EBSCO, Scopus, and Web of Science, which are widely used in similar analyses. At this stage, 258 publications were found in Query 1 and 86 publications in Query 2. The publications were then catalogued in Mendeley. Nineteen publications in Query 1 and seven in Query 2 were excluded due to the unavailability of the full text or publication in a different language. Subsequently, the manuscripts were screened on the basis of their abstracts. The abstracts were assessed for alignment with the purpose of the analysis, and manuscripts that did not meet this criterion were rejected. Articles that did not refer to the MaaS concept directly were rejected, such as those that referred only to transport integration or focused on a single mode of transport. In addition, some abstracts contained the abbreviation 'MaaS' but it did not refer to the term 'Mobility-as-a-Service'. At this stage, a total of 121 publications in Query 1 and 35 in Query 2 were rejected. Finally, duplicate manuscripts were removed (25 and 35 duplicates, respectively). In total, 87 publications in Query 1 and 35 in Query 2 were included in the full text analysis.

The PRISMA methodology was used to analyze the full articles, which enables full reporting of the literature review results [Sarkis-Onofre et al., 2021]. For this purpose, a template was prepared in MS Excel, divided into two tabs corresponding to specific queries. This made it possible to identify and analyze numerous definitions of the MaaS concept and to identify barriers and determinants of its implementation, based on specific examples from the literature. The results of the review were summarized.

In stage 4, five participatory observations were conducted in cities belonging to the UMP (see Table 2), which allowed for an analysis of the functioning of the public transport system in the selected cities from the user's perspective. All observations were carried out in 2025. However, the limitation of this method is its subjectivity [Iacono et al., 2009]. To minimize this risk, assessment questionnaires were used for the observation, which were prepared online on the MS Forms platform. Two questionnaires were used: one concerning travel by public transport, the other assessing stops. This made the assessment more objective, as it was based on the same elements each time.

The journey evaluation questionnaire assessed punctuality, vehicle equipment with passenger information systems and user amenities, the possibility of purchasing and validating tickets, and the level of crowding. During the journey, punctuality was assessed, namely departure from the initial stop and arrival at the destination stop. In addition, the availability of electronic displays, the quality of on-board information (visual and voice), the consistency of the actual journey with forecasts and timetables, the correct functioning of the passenger information system, and the availability of digital channels used during the journey were verified. Three perspectives were adopted in the analysis of the results: passenger, operator, and a general perspective for the potential implementation of MaaS. The stop evaluation questionnaire concerned the location and type of the stop (shelter, pole), the availability of passenger information: timetables, real-time travel information, electronic displays, network maps, voice announcements, solutions to increase accessibility, and the display of messages about mobile channels and fare and zone rules.

Table 2. Summary of participant observations

City	Length of stay	Available public transportation	*N* evaluated journeys/ coordinated transfer	*N* evaluated stops	*N* journeys included/ coordinated transfer	*N* stops included
Bydgoszcz	20–22 July	• Bus • Tram	17/14	14	10	8
Lublin	26–29 July	• Bus • Trolleybus	26/25	16	10	8
Rzeszow	24–27 August	• Bus	26/24	18	10	8
Warsaw	31 August – 3 September	• Bus • Tram • Metro • Urban railway	27/24	19	10	8
Gdansk	14–16 September	• Bus • Tram • Urban railway	22/20	17	10	8

Source: own elaboration.

A large amount of data was collected, so a similar number of journeys and stops were selected for analysis to ensure the comparability of results. The results of the analyses are presented in the following section. In the descriptive part of the results, the analyzed cities are listed according to their rating in a given perspective, starting with those with the highest ratings and ending with those with the lowest ratings. This order allows for a transparent and consistent presentation of differences in the level of accessibility and the quality of infrastructure and information systems in the context of MaaS implementation.

Results

Mobility-as-a-Service concept

The MaaS concept is based on the integration of transport modes, fares, tickets, information, and transport policies [Maretić, Abramović, 2021]. However, its practical implementation requires a clear definition of the concept. In 2014, the first definition of MaaS was formulated, indicating that it is a comprehensive mobility service that includes trip planning, reservations, and ticket purchases for various modes of transport within schemes [Aba, Esztergár-Kiss, 2024a]. However, it was rather general and may now be outdated. Therefore, 69 definitions of MaaS were analyzed, 26% of which were original definitions. Based on the analysis, two approaches to defining this concept can be distinguished.

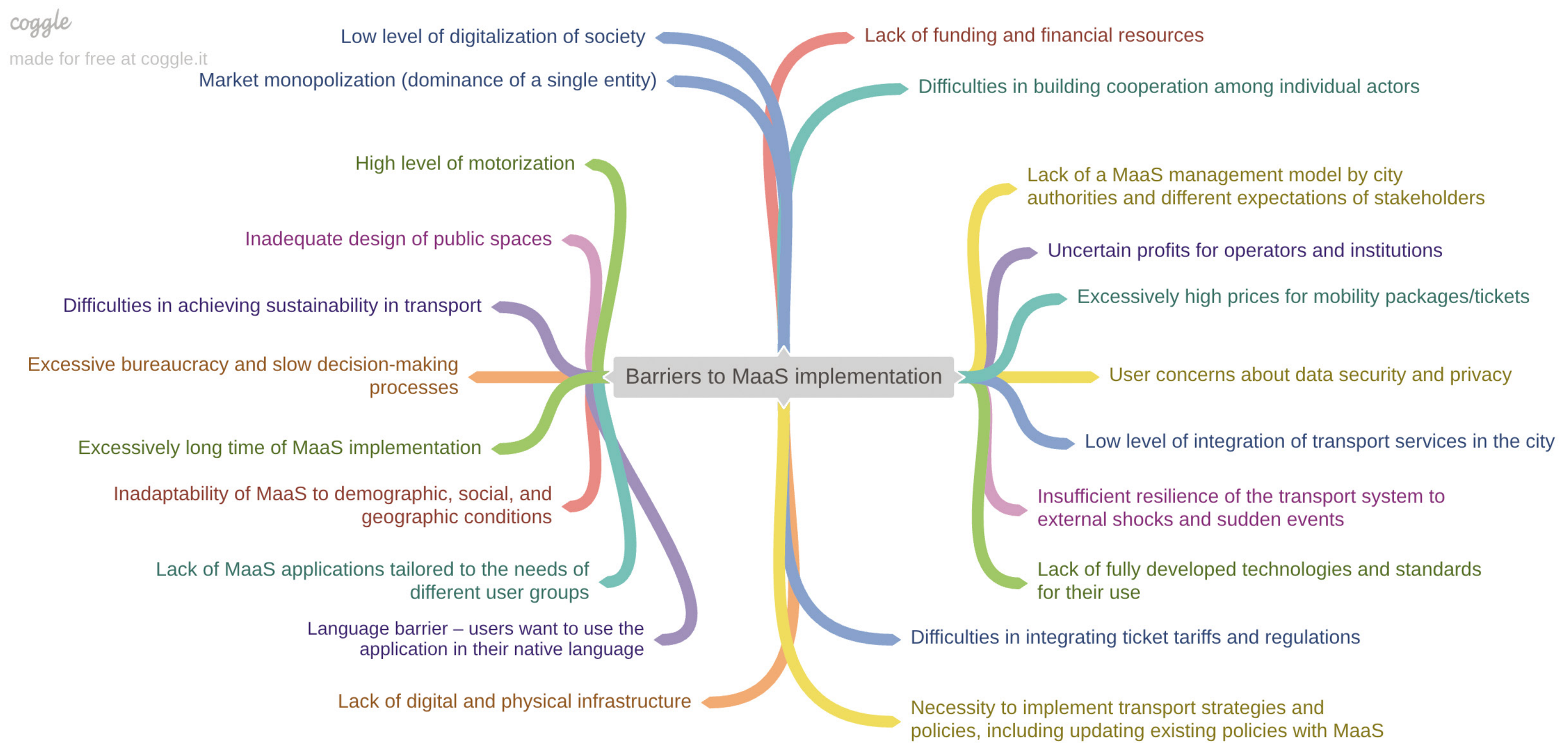
The first general definitions of MaaS were formulated between 2014 and 2016. Their authors emphasized the most important elements of the concept, including, above all, user orientation [Arias-Molinares, García-Palomares, 2020; Castellanos et al., 2022; Jang et al., 2020; Pangbourne et al., 2020]. This made it possible to outline the general framework of the concept, identify its main attributes, and emphasize the role of users. Nevertheless, the limitations of general definitions of MaaS can be identified. First, the aspect of sustainable development was overlooked [Karlsson et al., 2016; Lopez-Carreiro et al., 2023; Lyons et al., 2020]. No specific MaaS stakeholders were identified, either [Aba, Esztergár-Kiss, 2024b; Jang et al., 2020]. These definitions may also be outdated, as research on the MaaS concept is constantly evolving.

Between 2017 and 2025 more detailed definitions emerged, but they rarely attempted to provide a general conceptualization, focusing on specific attributes of MaaS instead. Thus, definitions were developed that emphasized the important role of stakeholders [Enoch, Potter, 2023; Łukasiewicz et al., 2023], the importance of the business model in the development of integrated transport services [Athanasopoulou et al., 2022], the aspect of sustainable development and the implementation of sustainable solutions in transport [Mulley et al., 2018; Musolino, 2022; Russo, Rindone, 2023]. These definitions have contributed to a better understanding of what MaaS is and what aspects need to be considered in order to implement this concept.

Based on an analysis of the MaaS definition, it was possible to identify all the attributes of this concept. These include: digital platforms and mobile applications, ticket payments, travel booking and planning, real-time information access, business models, sustainable development, infrastructure, stakeholders and actors, integration and multimodality, user orientation, and transport policies. Based on these attributes and an analysis of the definition of MaaS, an original definition of this concept was created, which reads as follows: MaaS is a service that integrates private, public, shared, and active mobility modes into a single digital interface, allowing users to plan their journeys based on real-time data, make reservations and payments, and access on-demand services to make their travel smoother and more tailored to their individual needs; the goal of MaaS is to realize sustainable transport policies based on an efficient business model, infrastructure development, and the cooperation of key stakeholders – public authorities, residents, users, transport operators, and digital service providers.

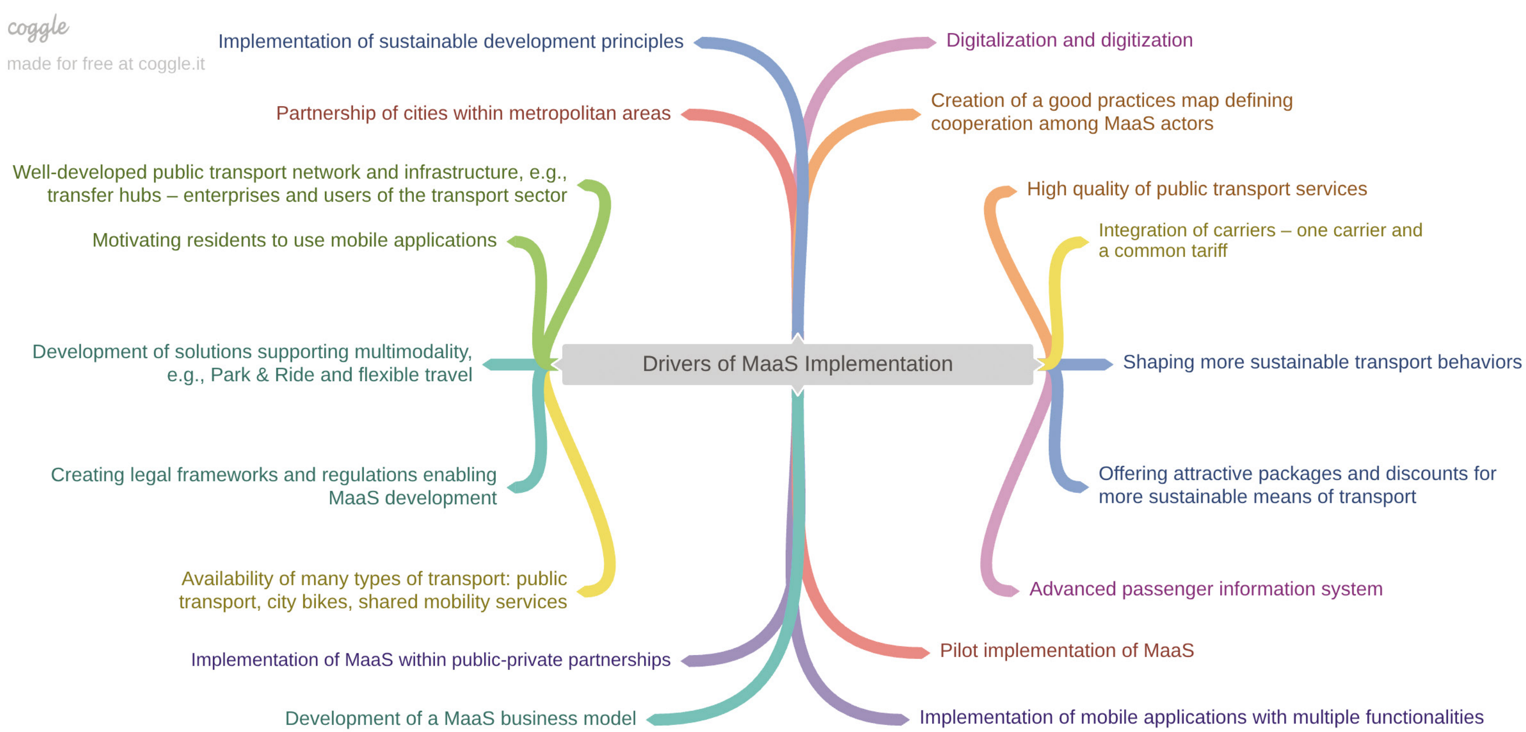
MaaS is a new mobility model based on users and modern technologies. Its practical implementation may encounter a number of barriers, which are presented in Figure 2.

Figure 2. Barriers to MaaS implementation



Source: own elaboration.

Figure 3. Drivers of MaaS implementation



Source: own elaboration.

MaaS relies on the use of mobile applications, which makes technological factors very important. Therefore, low levels of digital skills can slow down the process [Hasselwander, Bigotte, 2022]. The widespread use of new technologies also raises concerns about data security. Another category is organizational factors. To date, no effective business model has been developed for MaaS operators, and in many cities fragmented transport management makes it difficult to integrate operators and services [Ho, Tirachini, 2024]. Fares and information are also poorly integrated. Infrastructure factors constitute another important group. Another significant barrier is the underdeveloped physical and digital infrastructure [Mitropoulos et al., 2023], which usually means a lack of facilities for people with special needs. The policy and role of municipal authorities are of significant importance. Municipal institutions, considered key players in MaaS, struggle with slow decision-making processes and excessive bureaucracy [Mavrogenidou, Papagiannakis, 2024]. As a result, this may discourage operators and suppliers from cooperating. An important limitation is the lack of funding [Ho, Tirachini, 2024], which can be classified as economic factors.

The successful implementation of MaaS requires significant financial investment, public participation and stakeholder engagement, the implementation of modern technologies and a well-developed public transport system (see Figure 3).

The drivers of MaaS implementation include, among others, the implementation of sustainable development goals in the context of mobility, the promotion of sustainable transport, and the provision of multiple types of public, private, and shared transport [Filipe, Heath, 2023; Lopez-Carreiro et al., 2023]. These factors can be classified as organizational drivers. Actions within the framework of technological and political factors, such as digitization and the creation of transport policy, are also important [Milne et al., 2024]. The growing number of private cars in cities indicates the need to promote the use of public transport, which can be achieved by developing multimodal solutions, e.g. parking lots, transfer hubs, or flexible travel [Ceccato et al., 2023]. However, many authors emphasize the crucial importance of high-quality public transport, namely well-equipped vehicles and stops, availability of passenger information, easy transfers, punctuality and reliability [Ali et al., 2025; Coppola et al., 2025; Ko et al., 2022].

The practical implementation of MaaS is based on the existing public transport system, which is why it is necessary to ensure its high quality. Quality in transport manifests itself in several elements, but the analysis of the functioning of the public transport system in Polish cities focused on access to information and punctuality.

The functioning of public transport systems in Polish cities

The comparative assessment of stop infrastructure and MaaS implementation potential from the passenger perspective in the analyzed cities is presented in Table 3.

The results presented in Table 3 indicate clear differentiation in infrastructure quality and digital readiness among the examined cities. Based on an analysis of the results in terms of stop infrastructure and the potential for implementing MaaS from the perspective of passengers in the city, Bydgoszcz received the highest rating. The high level of dynamic information system availability, the presence of mobile channels, and clear fare and zone information facilitate greatly travel planning and execution; at the same time, they reduce the risk of errors, which the authors collectively refer to as information costs. Lublin, which ranks second, stands out for its high level of real-time data availability and the presence of mobile channels, which compensate for the lack of fare information. Gdansk, on the other hand, is characterized by well-developed stop information, which includes electronic displays. However, it should be noted that there are no timetable applications and limited visibility of solutions that increase accessibility. In Warsaw, there is a lack of a uniform standard for bus shelters, which may increase passenger uncertainty. The varied exposure of electronic displays can also be emphasized. Rzeszow, on the other hand, has an insufficient number of electronic displays and limited access to real-time data, which makes it more difficult to get around the city.

Table 3. Assessment of the stop infrastructure and MaaS implementation potential from the passenger perspective in selected cities

City	Key infrastructure strengths	Identified limitations	Impact on information costs and mobility	Qualitative assessment
Bydgoszcz	High availability of dynamic passenger information, well-developed mobile channels, and clear fare and zone information supporting travel planning	Limited integration with regional systems and incomplete visual standardization	Low information costs, high travel predictability, and strong ease of spatial orientation	Very high MaaS potential
Lublin	Wide availability of real-time data and functional mobile channels supporting travel decisions	Incomplete fare information at stops and limited consistency between information channels	Moderately low information costs and partial fare-related uncertainty	High MaaS potential
Gdansk	Well-developed stop information and the presence of electronic displays improving system readability	Lack of timetable applications linked to stops and limited visibility of accessibility-enhancing solutions	Moderately low information costs and good local orientation with incomplete digital journey continuity	High MaaS potential
Warsaw	Extensive stop network and partial availability of dynamic information	Lack of a uniform standard for stop infrastructure and uneven exposure of electronic displays	Variable but generally average information costs and periodic passenger uncertainty	Moderate MaaS potential
Rzeszow	Basic stop infrastructure ensuring a minimum level of static information	Insufficient number of electronic displays and limited access to real-time data	High information costs and reduced ease of navigation within the transport system	Low MaaS potential

Source: own elaboration.

Table 4 presents the systemic assessment of MaaS readiness, focusing on stop infrastructure maturity, data integration, and orchestration capacity from the operator's perspective.

The differentiation observed at the systemic level provides the foundation for analyzing passenger-level information quality and journey experience in the following section. From the operator's perspective, the assessment focuses on data maturity and stop standards, and their role in demand orchestration, fare integration, and quality control. Gdansk received the highest rating, as it has the most developed real-time information system. In addition, stops in this city are well equipped, including information on ticket purchasing applications and fares, thus enabling effective control of supply and demand management in the MaaS ecosystem. Bydgoszcz stands out with its mature mobile channels and clear fare and zone system, but the role of real-time information is limited. Lublin, on the other hand, offers electronic information systems at most stops, but there is a lack of consistent fare and integration information. As a result, this reduces the scale of orchestration. Warsaw is struggling with stratification of information standards between major transfer hubs and other stops, which hinders the uniform implementation of MaaS. Rzeszow, due to its inadequate infrastructure and weaker digital channels, is the least ready to take on the role of a leading operator within MaaS. In turn, in the systemic assessment, which focuses on a comprehensive evaluation of ITS systems at stops, Gdańsk occupies the strongest position. In this city, bus shelters are commonly equipped with QR codes for ticket purchases, clear fare information and current information, for example about route changes. Bydgoszcz ranks second, mainly due to the availability of mobile channels (apps) and simple information about zones. However, it should be emphasized that further standardization and integration of stops and transfer hubs are necessary. Lublin remains a city with well-developed digital information, but there is a noticeable lack of consistent fare and integration information, which may limit the full functionality of the system. Warsaw, despite its modern transfer hubs, does not have uniform standards in the area of public transport networks, which weakens integration. Rzeszow, on the other hand, should focus on expanding its infrastructure, such as information boards and mobile channels, in order to implement MaaS effectively.

Table 4. Comparative systemic and passenger-level assessment of MaaS readiness in selected cities

City	Positive systemic attributes	Digital integration and fare environment	Key systemic limitations	Qualitative assessment
Gdansk	Highly developed real-time information system and well-equipped stops with fare and ticketing information	Strong integration supported by QR codes, NFC, and clear fare access	Limited consistency of integration visibility across the network	Very high MaaS readiness
Bydgoszcz	Mature mobile channels and clear fare-zone structure supporting demand management	Functional mobile environment with partial integration	Limited real-time information and incomplete stop standardisation	High MaaS readiness
Lublin	Widespread electronic stop information and a developed digital information environment	Digital availability without full fare and integration coherence	Lack of consistent fare and integration information	Moderate MaaS readiness
Warsaw	Modern transfer hubs and partial system maturity	Uneven standardisation of stop infrastructure and integration	Stratification of information standards across the network	Moderate MaaS readiness
Rzeszow	Basic functional infrastructure and initial digital elements	Weak digital maturity and limited integration capacity	Insufficient infrastructure development	Low MaaS readiness

Source: own elaboration.

Table 5 presents the passenger-level assessment of MaaS readiness, focusing on the quality of information available during the journey and the continuity of digital travel support.

Table 5. Passenger-level assessment of on-board information quality and digital journey continuity in selected cities

City	On-board information quality	Digital travel channels during the journey	Passenger-level limitations	Qualitative assessment
Warsaw	Very high, real-time, clear visual and audio communication	Present but unevenly exposed	Lack of full digital journey continuity	Very high MaaS readiness
Gdansk	Very high, supported by modern passenger information systems, QR codes, and NFC	Well integrated with fare access	Limited visibility of integration across contexts	Very high MaaS readiness
Rzeszow	High quality delay communication and efficient information transfer	Limited digital channels	Weak digital ecosystem during travel	Moderate MaaS readiness
Lublin	Adequate displays and audible announcements with delayed updates	Wide range of digital tools	Reduced predictability of travel information	Moderate MaaS readiness
Bydgoszcz	Functionally correct on-board information	Lack of visible digital channels during the journey	Increased passenger information costs	Low MaaS readiness

Source: own elaboration.

Together, the systemic and passenger-level perspectives enable an integrated interpretation of MaaS readiness across the analyzed urban transport systems. A further element of the analysis is the assessment of the quality of information available during the journey. The elements assessed affect passenger comfort and transport operational efficiency. From the passenger's perspective, Warsaw stands out with the highest standard of information in the vehicle and the efficiency of the system during the journey. Displays, announcements and current messages are up to date and clearly audible, which significantly increases travel comfort. Gdansk is characterized by equally strong and well-developed on-board information and high availability of current data. These are supported by a modern passenger information system, QR codes and NFC tags that link to fare information or enable ticket purchases. In Rzeszow, the high quality of on-board information and the efficiency of the system can also be observed, especially in the transmission of information about delays. In Lublin, on the other hand, vehicles are equipped with displays and announcements are audible, but they are updated with a delay, which may reduce the predictability of travel. In Bydgoszcz, despite well-functioning on-board information, there are no visible digital channels during the journey, which increases the information cost for passengers.

Table 6 presents the operational and strategic dimension of MaaS readiness, integrating real-time controllability, digital journey continuity, and leadership capacity from the public transport operator's perspective.

The comparative structure shown in Table 6 synthesizes systemic, passenger-level, and operational findings, forming the basis for the final interpretation of MaaS leadership readiness across the analyzed urban transport systems. From this integrated perspective of a public transport operator that must take on the role of a potential MaaS leader, Warsaw provides the highest operational controllability thanks to the high efficiency of the system, high-quality on-board information and rapid updating of information based on current data. This enables a quick response to any disruptions. It is necessary to highlight better the digital channels available on board in order to fully close the digital user path, namely to provide the user with a smooth and complete experience from the first contact with the service to the achievement of the intended goal, without interruptions or difficulties at any stage of interaction. Gdansk offers very high-quality on-board information and access to delay data through an extensive ITS system. However, despite the use of a number of solutions, communication with passengers about the use of digital solutions should be improved. Rzeszow has a high-quality on-board system, although the shortage of digital channels should be emphasized. Lublin stands out with a wide range of digital tools available during the journey, which promotes better market communication, but its operational quality and intensity of current information remain weaker than those of the leaders. In Bydgoszcz, the lack of digital channels and the moderate quality of on-board information should be noted, which limit operational potential and may lead to increased information costs. The main challenges in the development of passenger information include: the development and exposure of digital channels during travel and the improvement of real-time data quality. These aspects remain key to effective integration and increased user satisfaction within MaaS.

Table 6. Operational controllability, digital journey closure, and strategic MaaS leadership capacity in selected cities

City	Operational controllability and real-time responsiveness	Digital journey closure and passenger communication	Key strategic limitations	Qualitative assessment
Warsaw	Very high system efficiency, rapid real-time information updates, and strong disruption response capacity	Digital channels present on board but insufficiently exposed to ensure full continuity of the user journey	Incomplete closure of the end-to-end digital passenger path	Very high MaaS readiness
Gdansk	High operational responsiveness supported by an extensive ITS environment and access to delay data	Well-developed information ecosystem requiring improved passenger communication about digital solutions	Limited effectiveness of digital solution visibility and user guidance	High MaaS readiness
Rzeszow	Stable and efficient on-board information transmission, including delay communication	Noticeable shortage of digital interaction channels during travel	Limited digital maturity reducing leadership capacity within MaaS	Moderate MaaS readiness
Lublin	Functional operational environment with available real-time and digital tools	Broad range of digital tools supporting communication during travel	Lower operational intensity and weaker real-time information quality than leading cities	Moderate MaaS readiness
Bydgoszcz	Moderate operational information performance and limited real-time responsiveness	Lack of visible digital channels during the journey	Increased passenger information costs and constrained operational leadership potential	Low MaaS readiness

Source: own elaboration.

Next, an assessment of the punctuality and stability of public transport was carried out based on the average absolute deviation of departure and arrival times. The analysis revealed clear differences in the level of predictability between the systems studied, which is important from the perspective of passengers, operators, and the development of MaaS.

Table 7. Punctuality metrics by city (10 connections per city; on-time departures, arrivals, and both; MAD = Mean Absolute Deviation, in minutes)

City	Number of connections	On-time departures [%]	On-time arrivals [%]	MAD – departures [min]	MAD – arrivals [min]	MAD – overall [min]
Warsaw	10	70	40	0.40	2.70	1.55
Gdansk	10	50	0	0.70	3.20	1.95
Lublin	10	60	0	0.90	3.50	2.20
Rzeszow	10	30	0	1.30	3.60	2.45
Bydgoszcz	10	30	20	2.10	3.10	2.60

Source: own elaboration.

Warsaw stands out with the highest temporal consistency, with minimal dispersion at the start of the journey (MAD=0.40 min) and the lowest at the end of the journey (MAD=2.70 min). This results in greater comfort when changing trains, more efficient traffic management, and less need to create time buffers. For passengers, this means greater comfort and predictability, and from the point of view of MaaS implementation, solid conditions for the integration of various transport services. Gdansk is characterized by moderate departure stability (MAD=0.70 min) with greater variability on arrival (MAD=3.20 min), which indicates a need to optimize traffic control, especially for trams. This is necessary to improve passenger comfort and network reliability. Lublin, despite rather punctual departures (MAD=0.90 min), struggles with early arrivals (MAD=3.50 min). This makes it difficult to synchronize transfers and requires more rigorous schedule control. In Rzeszow, there is a noticeable accumulation of delays from departure (MAD=1.30 min) to arrival (MAD=3.60 min). As a result, passenger uncertainty increases, and transport operators have to take several measures related to traffic control in the event of long delays. Bydgoszcz, with the highest spreads (MAD departure 2.10 min, arrival 3.10 min), generates considerable uncertainty as to travel time. This result indicates the need to stabilize departure points and respond efficiently to disruptions, which is key to the effective implementation of MaaS.

It should be noted that increasing MAD values indicate a greater need for buffering and advanced time management within the public transport system. Significant delays in public transport may be due to objective reasons such as traffic congestion or road accidents. However, they are a signal to passengers that the system is unreliable and unpredictable. As a result, passengers may choose to use private cars or taxis.

Summary

The MaaS concept can be defined as the full integration of all forms of mobility, from public transport and shared transport to active mobility. In addition, this concept allows users to purchase tickets, book journeys, and access real-time information through a single digital interface. The greatest potential for implementing the MaaS concept exists where high-quality public transport operates. The analysis focused on two key aspects: passenger information and punctuality.

In this context, Warsaw is the leader, thanks to the lowest time dispersion, a fairly good level of stop equipment, high-quality on-board information and efficient real-time data. An important aspect is the integration of fares between different modes of transport in the metropolitan area, which was not observed in the other cities surveyed. Gdansk, ranking just behind Warsaw, has a well-developed stop infrastructure and passenger information system, but needs to expand its digital channels at stops. Lublin and Bydgoszcz are characterized by advanced digitization and a clear fare system, but require further investment in consistent passenger information. Rzeszow remains the least prepared for MaaS implementation due to information infrastructure deficits and high time variability.

The gradual implementation of MaaS in Polish cities requires urgent action to standardize passenger information at stops to ensure user comfort. A low level of information can mislead users, cause difficulties in getting around, and even discourage travel. In turn, poor punctuality is observed in almost every city during rush hours. This requires action not only in the area of proper route management but also in the area of a coherent, sustainable transport policy that minimizes the use of private cars in everyday travel.

Cities should develop physical and digital infrastructure in a sustainable manner and implement a consistent fare policy. Only then will they have a chance to implement MaaS successfully. Overcoming technological, organizational, and financial barriers is essential for integrating operators and creating a safe, accessible mobility ecosystem. To this end, Polish city authorities can seek external funding from the European Union for activities related to the development of sustainable mobility: the purchase of alternative fuel vehicles, transport infrastructure renovations, and the creation of mobile applications. To some extent, such activities are already being undertaken, but it should be noted that they are fragmented. The lack of a systemic approach slows down the implementation of new solutions in urban transport, including the MaaS concept. Future research in this area should focus on business models that integrate dispersed systems and stakeholders. It is also necessary to study the social aspects of MaaS adoption, such as digital literacy and social acceptance, which will strengthen the effectiveness and scale of implementations in Polish cities.

The presented analysis is based on the use of qualitative methods: the Systematic Literature Review and participant observation. It should be emphasized that the use of the indicated methods allowed for an in-depth analysis of the possibilities of implementing MaaS in Polish cities, which constitutes a significant contribution to the development of research on sustainable mobility in Poland in general. In the future, this analysis may be expanded to include a practical approach, supported by quantitative research, for example surveys. This would allow us to learn about the perspectives of various stakeholder groups, as conflicting expectations and needs may be a factor hindering the implementation of MaaS in Polish cities.

Acknowledgement

This research was prepared within the framework of the research project PRELUDIUM 53, financed by the National Science Centre, Poland, under agreement no. UMO-2024/53/N/HS4/03130.

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