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SMART CITY INTEGRATED URBAN TRANSPORT SYSTEM OF TRI-CITY METROPOLITAN AREA

Abstract

The article focuses on two main forms of public transport in the Tri-City: collective transport and road traffic. The current status and proposals for changes are presented. It is also based on the best examples related to public transport according to the smart city concept. It shows in which direction the Tri-City Metropolitan Area is heading and methods of changing the habits of residents are also presented.

Keywords smart city, intelligent transport, smart mobility, public transport

Introduction

The term 'Smart City' in a literal translation from English is well known to everyone, however, in relation to the subject matter to which the following text is devoted, different definitions should be provided and an attempt should be made to create a new formula of the concept. Urbanization progress and its consequences are presently key problems for city authorities. Public services costs are rising. The concept of sustainable development is supported by modern technology, especially in terms of transport and telecommunication. (Jankowska, 2015, p. 1).

According to the Massachusetts Institute of Technology, a 'Smart City' is a concept defined as "intelligence contained in a combination of more and more effective digital telecommunications networks, omnipresent intelligence, sensors, tags, and software." This intelligence does not exist in isolation from other urban systems. There is a growing web of direct connections to the mechanical and electrical systems of buildings, household appliances, transportation systems, electrical grids, water supply and waste removal networks and systems that provide life safety and security of city residents" (Mitchell, 2007, p. 5). Within the meaning of this definition, a 'smart city'" is a complex concept, nonetheless, it is impossible

not to see the importance of the transport system whereof an integrated public transport system is a component. Nicos Komninos's theory is quoted to precisely define and describe the subject matter of our considerations. "The term 'intelligent city' describes a territory with four main characteristics (Komninos, 2008, p.136):

- 1) a creative population and developed knowledge-intensive activities or clusters of such activities;
- 2) embedded institutions and routines for cooperation in knowledge creation allowing to acquire, adapt, and advance knowledge and know-how;
- 3) a developed broadband infrastructure, digital spaces, e-services, and online knowledge management tools; and
- 4) a proven ability to innovate, manage and resolve problems that appear for the first time, since the capacity to innovate and to manage uncertainty are the critical factors for measuring intelligence.

The theory of Nicos Komninos emphasizes the role of the population in creating and developing a 'smart city'. The operation of an innovative technology depends on the thinking and knowledge of its users and administrators, namely, the society. The wording of the quoted definitions allows us to define a 'smart city' as a structure of closely interrelated organisms created to improve the life of the community. The organisms work independently, but in an integrated manner. The implemented innovations are determined by the needs perceived by the society of a given urban agglomeration, and their implementation is based on the technical, financial, human and natural capabilities.

1. Public transport in the Smart City concept

What is public transport? How should it be integrated and what steps should be taken to unify the system in the Tri-City urban agglomeration?

The municipal transport is a domain of management and it is difficult to clearly define the meaning of this term. In broad terms, it can be assumed that it is the need to move in an urbanized environment (Wyszomirski, 2007, p. 9). Smart city uses all information and communication technology in order to improve interactivity, infrastructure efficiency and public awareness (United Cities and Local Governments, 2018). Public transport in a 'smart city' organism requires us to take a comprehensive approach. Car users will want to develop the road network, smart management of the traffic lights system to move as fast as possible. The most important thing for cyclists will be extension of bicycle paths so that they should be safe and enable access to any place in the city, and advocates of collective transport will want the development of this means of transport so that it should be comfortable and easy to use.

The smart city develops in all these areas in a sustainable way so that the residents should feel comfortable in it. A challenge for people managing urban agglomerations is the falling number of residents. When looking at the Tri-City it is only in Gdansk that the population increases whereby there are more and more residents in the urban agglomeration year by year. There are more people in the urban area during the day and in the summer period which is the reason why the needs

to move are even greater. It is necessary to satisfy the needs of all stakeholders for the city to properly develop. Residents of the Tri-City – the core of the metropolis – take 41% of their journeys by passenger cars, the share of collective transport in the city trips in the Tri-City is 40%. The share of the passenger car in travels in the remaining Tri-City Metropolitan Area (OTM) is almost 49%, while public transport accounts for 10% only (Kołodziejski et al., 2015, p. 5). The urban web of connections in the Tri-City should be based on the Rapid Urban Railways (SKM and PKM), complemented by the bus, tram and trolleybus networks. The Rapid Urban Railways are the most important rail carrier in OMT. In 2013, the Rapid Urban Railways (SKM) transported 35.2 million passengers. In 2014, the connection to Tczew was restored and the frequency of trains on the Gdańsk Główny – Gdynia Cisowa section was increased to 7.5 minutes during the peak hours (Kołodziejski et al., 2015, p. 5). An important aspect is also taking care of the suburbs and the nearby smaller towns adjacent to the urban agglomeration. The OTM area comprises 30 municipalities. This is a very large area to integrate from the point of view of the public transport. Multiple problems may arise, such as a common tariff, multiple operators, the service frequency, as well as infrastructure development. To emphasize the size of the area Figure 1 shows the division of the Tri-City Metropolitan Area into: the metropolis centre, the metropolis functional area and the metropolis surroundings.

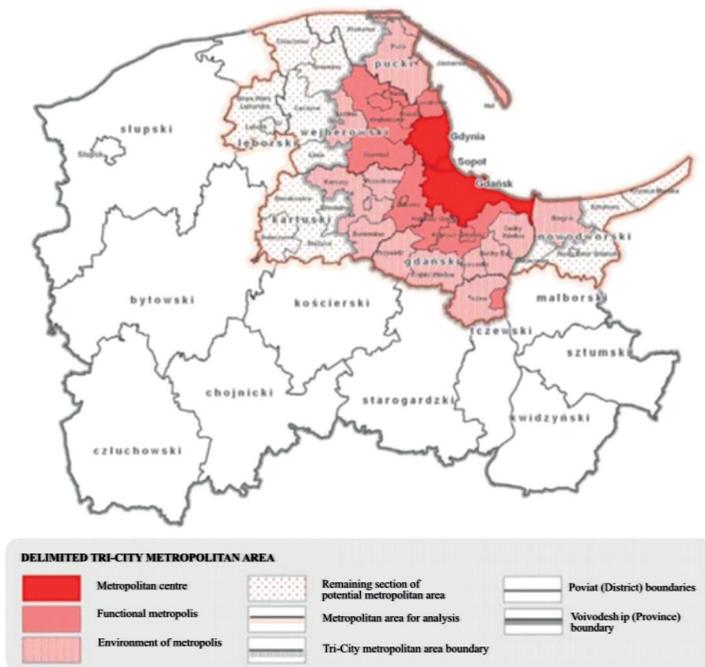


Figure 1. Delimited Tri-City Metropolitan Area in the administrative structure of Pomorskie Voivodeship

Source: (Auksztol, Matczak, Eds., 2011)

Figure 2 shows the structure of the methods of travelling in the core of the OTM area and outside it. The study that was carried out in 2014 illustrates how strongly the residents are linked with transport by car.

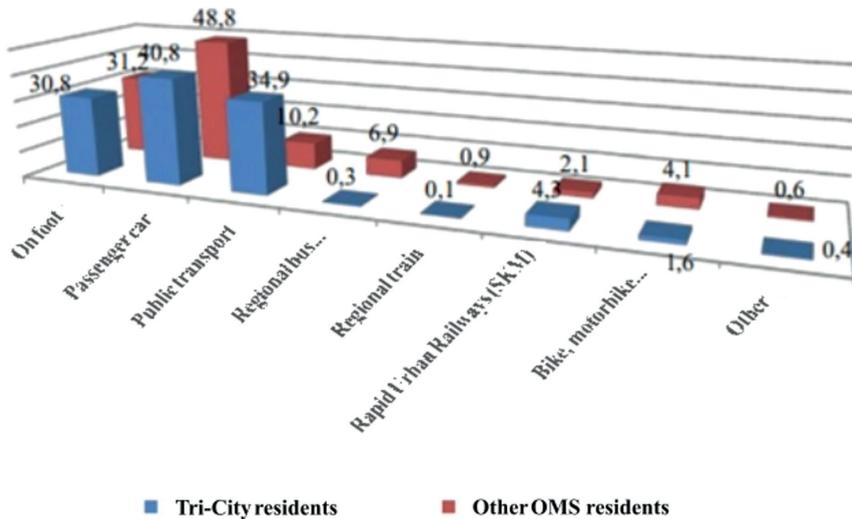


Figure 2. Methods of travelling by OMT residents in 2014 [%]

Source: (Kołodziejcki, Wyszomirski, Grzelec et al., 2015)

Collective transport has to meet several requirements to be competitive with the car. It should be modern, environmentally friendly, and most importantly, predictable. Collective transport operators should not be focused on maximizing profits but on optimizing the costs related to passenger service. Public transport is and should be common for people who are using it, unfortunately, this will not always mean profitability. The question should be asked whether it should be free of charge or subsidized in some part by users by applying a tariff. The most important thing is that the system of payment should be very simple for users, since owing to such a solution they will not feel any discomfort related to movement. The Tri-City can be presented as an example of a bad ticketing system. Due to the multitude of carriers and a very obscure tariff system, passengers may be confused, which means they will be giving up travelling by public transport. It is Warsaw that may serve as an example of a well-organized tariff system in Poland. It looks similarly to Copenhagen or New York. The Tri-City should integrate the tariff to enable easy transfer at the most important transport nodes in order to be able to use the potential of its urban transport system.

A solution for the Tri-City would be to integrate Gdańsk, Gdynia, Wejherowo, Rumia, Reda, Pruszcz Gdański, Tczew, Władysławowo, Puck, Kartusy, Kościerzyna, Jastarnia and Hel into one transport system. It should be based on the railway system that would be the backbone of transport. Since 2015 when the railway line connecting Gdańsk and Gdynia was opened being the first railway line in Poland built completely from scratch after the war, many residents have been able to reduce

the time needed to reach the centres of both cities. The greatest problem seen by passengers has been the lack of a unified ticket, hence, it should be changed as soon as possible for the urban agglomeration to become 'smart'. Thanks to the construction of many P&R car parks, the number of cars in the centres of the three cities has been reduced. Owing to this procedure, a section of the urban tissue should be returned to the residents. This may happen by limiting the traffic of cars through introducing special zones as well as by limiting the number of parking spaces. Such procedures will enable providing more green areas, bike paths and restaurant gardens.

It is known that the Tri-City has problems to drain stormwater, by limiting the vehicular traffic it is possible to create rain gardens, linear parks, pocket parks, which will serve residents as a place of rest or entertainment. An important aspect in relation to the public transport is its direct availability, railway stops are located at distances longer than two kilometres, this distance is too large for some residents to cover, therefore, transport is not popular for them. The railway network should be supplemented by trams, buses and trolleybuses, which may have much more densely arranged passenger collection points. As in any urban tissue, complementary lines should not only transport passengers to train stops, but also run lengthways to fill the gaps. In addition to the environmentally friendly fleet of vehicles, it should be considered how passengers from smaller towns or clusters of houses should be transported to larger interchanges. A very interesting trend is seen at this point – it is called Demand-Responsive Transport. It is an advanced, user-oriented form of public transport, characterized by flexible routing and scheduling of small/medium vehicles operating in a shared drive mode between pickup and drop-off points according to the needs of passengers, which responds to the needs of less urbanized places in urban agglomerations (McClean, Freeman, 2017, p. 4). The idea is that the need to move from the place of residence to the nearest public transport node is communicated and then used by an individual or a group of people. It is more profitable to use than maintaining a permanent bus line to a given area which is not used or is not used to a sufficient degree. This solution has been used in Poland since 2007 in Kraków in the form of a tele-bus. It should be remembered that this is only a complementation of the web of connections which allows limiting the exclusion of a section of an urban area from the transport network. When implementing an integrated public transport system, it is not only the public transport or tariff, the P&R system but also the possibility of travelling by bicycle that should be remembered.

In November 2018 the city bike system for the metropolitan area (MEVO) will be launched. At the beginning, it will use 30% of its capacity, however, as early as on 1 March 2019 the system is expected to be fully operational. Many questions and controversies related to the objectives of the project co-financed from the European Union Funds still remain to be answered and clarified as far as this mode of transport is concerned. The assumptions of MEVO were such that the metropolitan bicycle was to be partly free of charge and integrated with the public transport ticket, unfortunately delays in launching the latter have led to changes. The bicycle will not be free in part, and it will be possible to integrate it with the ticket only when the ticket is introduced in 2020. This is a very good move and a great

initiative, however, it is only in several years' time that we shall see how it has been programmed into the public transport system. The city bike is not the only thing as it is necessary to develop the infrastructure and make appropriate changes in the behaviour of residents. The systematically growing number of cycle paths as well as the improvement of the existing ones will make it possible to increase the safety of pedestrians and cyclists. It should be remembered that it is necessary to appropriately mark the paths as the traffic of two-wheeled vehicles should also be transparent. Even the most developed network of connections without proper marking will not be effective.

Young people should also be educated which type of behaviour is desirable and how to exercise caution in the best way. Creating contraflow lanes for bikes in Gdańsk as is the case in Kraków, as well as limiting the speed in the very centre down to 30 km/h as is the case in Katowice, the capital of Silesia, will make it possible to change the behaviour of drivers who often do not understand how an integrated public transport system should work. The global trend is to leave cars in the garage or in a P&R car park and to use the public transport to travel around the city. Many people say that this is inconvenient also complaining about the quality of the vehicles, for example, air conditioning is not switched on in the bus, tram or train although it is installed. Some drivers would like only public transport channels related to roads to be expanded. Unfortunately, it is worth paying attention to what the trend in the world is and which cities are becoming most smart, where we can use Seoul as an example where a river was given back to the city by taking a highway away, or New York which has succeeded to find 1.43 miles for a linear park in such a very populous place as Manhattan (Dybalski, 2013; Friends of High Line, 2018).

In 2014 the Tri-City launched the TRISTAR system, where the objectives were very ambitious, the design started as early as in 2009, unfortunately, the very rapid technological change that followed had not been foreseen, and in my opinion, unfortunately Qumak, the provider of the 'Tristar' portal with maps and road information has not managed to successfully implement the task. In the era when such applications as Google Maps, Jak dojadę [How I will get there] are available and enable quick checking which means of transport to use to move most efficiently, the car traffic management system in the Tri-City should be integrated with one or several of the mobile applications whereby recipients would be reached more efficiently.

An additional solution that is becoming more and more popular is car-pooling. While additional lanes are provided for buses and taxis, they should also be made available for cars travelling with a minimum of three people. Such solutions can reduce the number of cars travelling on the Tri-City roads as well as reduce the amounts of exhaust gases emitted to the atmosphere. The movement of individual vehicles in the very centre should be minimal, and therefore the number of parking sites should be limited. Limiting the role of cars in the city is not only a simple need resulting from the lack of space. It is also the necessity to provide residents with healthy and comfortable development.

The Warsaw Mobility Policy pursues, *inter alia*, reducing pollution and noise, unblocking the space previously occupied by cars for cultural and social purposes,

and last but not least, prosaic savings associated with the expenditures incurred for the development and maintenance of the existing road network. At this point the example of Szeroka Street in the historical centre of Gdansk can be given where the food service industry has been developing, however, the street is still accessible to cars, while restricting this place for pedestrians only could return space to its residents. The number of parking spaces available in the Tri-City is very large, hence, the number of cars is also increasing. A developed public transport network will make it possible to limit this number. A change of the habits of residents as well as influencing their decisions is a long-term process. The first thing to do to learn the methods of travelling would be to carry out research using state-of-the-art technologies that have been already partly implemented in the Tri-City and use the acquired knowledge in an appropriate way.

The theoretical basis for changing the process of behaviour is presented in the psychological model – MaxSem (Max Self – Regulation Model) (Szołtysek, 2011, p. 136). It uses the most important types of psychological models of changes of behaviour, including but not limited to the probability of accomplishing goals. It provides a temporary dimension of the change process referring to four key stages (Szołtysek, 2011, p. 136):

- Stage 1 – the initial state of awareness – where residents do not express the will to limit the use of individual means of transport;
- Stage 2 – mature state of awareness – it is a change of attitude where the thought of limiting the use of the car is allowed, residents become more and more aware;
- Stage 3 – preparation for change of behaviour and its implementation – people at this stage choose a specific strategy of behaviour that allows them to achieve the goal related to limiting the use of the car or they have occasionally tried other means of transport;
- Stage 4 – maintaining the behaviour change status – a desired stage where residents have adopted a new model of behaviour and perpetuated the acquired habits. The main force motivating a voluntary change of habits is acting for the protection of the environment. In this aspect, emotional processes and self-evaluation standards are extremely important for an internally motivated process.

Transport behaviours can be formed using various instruments. The most common of these include economic, administrative, legal, information and moral instruments (Grzywacz, Wojewódzka-Król, Rydzkowski, 2003, p. 41–42). It is possible to distinguish main phases related to this process (Szołtysek, 2011, p. 139):

Phase I – increasing the awareness of city users about the risks of using individual means of transport. This activity is intended to make people realize that each decision to move in this way is associated with a negative impact on the environment, degradation of the linear infrastructure, heavier congestion, which leads to decreasing attractiveness of the urban area. Moreover, it is important to be aware that every resident can contribute to the reduction of these consequences with his or her behaviour.

Phase II – providing the necessary information on alternative methods of movement. Such activity enables the acquisition of appropriate knowledge on environmentally friendly means of transport, analysis of the existing status,

searching for solutions, as well as evaluation of possible travel alternatives, e.g. in terms of time and travel costs.

Phase III – encouraging the use of newly acquired knowledge to change behaviour and perpetuate the changes (Pressl, Reiter, 2003, p. 10). Transport behaviour management consists in shaping the demand by changing the approach to passenger and freight transport as well as to the ways of moving, where the use of the means of transport more beneficial from the point of view of minimizing congestion and negative impact on the natural environment is preferred. The above presented pattern illustrates how important and time-consuming is to change the attitude of residents to the use of public transport. Works on this should be started from the youngest age, because these will be full-fledged users of the city in the future.

2. New transport solutions for the Tri-City

A smart city is a city which not only listens to its residents, but also communicates with them in a transparent way, which is why the IT system called TRISTAR which allows appropriate traffic management should be expanded and interactive smart boards showing the time of departure of the next bus, tram, trolleybus and in how many minutes it will arrive should be installed at all public transport stops, while only 73 of them have been provided so far (TRISTAR, 2018). It would seem that all users of public transport have smartphones or at least credit or debit cards, but it turns out that not everyone in Poland uses a bank account or a mobile phone allowing installation of applications. Therefore, the public transport has a data carrier in the form of a City Card which allows collecting data about users. Looking at faster and faster changing generations and their digitization and the possibility of introducing biometric identity cards (Poland Ministry of Digitalisation, 2018) on which we will be able to save data, a thesis can be confidently advanced that city cards will cease to exist in the near future. Innovative communication with residents should already be based on applications that can be easily installed on various types of media, starting from the phone, tablet, car disk, ending with the watch. Owing to such solutions, users of public transport will be able to accurately predict the time needed to move around the city. This will encourage them to leave their own cars in the garage. In addition to information about departures and the waiting time, a uniform ticket is required in the Tri-City to travel between cities and towns within the urban area (Kołodziejski et al., 2015, p. 106). The joint ticket project already exists and it is being implemented, passengers can expect that it will be introduced in the next decade. This will undoubtedly be a milestone in the creation of an integrated transport system.

Another aspect is to upgrade the rolling stock used by the Rapid Urban Railways (SKM) as well as limit breakdowns on the S1 line (Gdańsk-bound) and S2 (Gdynia-bound) to a minimum. The extent of the problem when one or both of these lines are unavailable for passengers and can be seen already now.

It should be remembered that 'smart' is not only modern technologies related to applications, traffic management or rolling stock upgrading, care should be also

taken of the comfort of waiting for trains, the walking routes around bus stops should also be optimized. The climate of the Tri-City is quite humid and windy, which is why shelters are often insufficient, and railway stops are poorly roofed or do not have any roofing at all (Kołodziejcki et al., 2015, p. 40–43). An example to be followed by the urban agglomeration should be the shelters built for the needs of PKM [Pomeranian Metropolitan Railways], where we can get into the train without getting wet during the rain. The next step is separation of bus lanes on the streets of Gdańsk, Gdynia and Sopot, which will reduce the waiting time at bus stops for passengers.

It should also be noted that buses, trolleybuses and trams should be very punctual, whereby the journey becomes predictable and it does not have to be planned well in advance. However, the greatest problem is the speed of travelling. As long as we are going to need disproportionately more time to travel from point A to B by public transport and the cost is too high, residents will choose their own cars. When the number of car parks in the city centre and near beaches is reduced, the popularity of public transport may increase. This is shown by the statistics. According to the report by Deloitte drivers in the Tri-City spend between 5–6 hours per month in traffic jams, which gives about 15–18 minutes per day (working week) (Deloitte, 2016). At this point, I shall present a brief case study comparing the time needed to travel the route from Gdańsk Niedźwiednik to the Alchemia Business Centre in the district of Gdańsk-Przymorze by public transport and by car. The time of travelling on this route by public transport (PKM, SKM) oscillates within 16–20 minutes depending on the frequency of trains, while using the car, we are able to travel this route in about 7 minutes with no congestion. When travelling in both directions, the estimated time needed to move without looking for a parking space is about 14.5 min and 16 min, extreme measurements being taken into account. If the search for a parking space is added, this time increases even up to 8 minutes, however, in the case of public transport, transfers from home to the stop as well as from the stop to the destination have not been taken into account and this can take up to 8–10 minutes in many cases (Jak Dojade, 2018). This example is not perfect and shows only one selected route, but it makes us realize that travelling by our own car will take us slightly less time than travelling by public transport which builds resistance in users to use the public transport. We should combat the conviction that we are able to save much more time when driving our own car. It is worth noting at this point that we have a chance to read a book or prepare ourselves for work when travelling by public transport.

Another aspect is integration of the metropolitan bicycle and the ease to use it. The research conducted by Uber in London shows that 30% of the transport activity during peak hours occurs in the suburbs and does not lead to the very centre of the city but to the nearest underground station where the passenger couples with the public transport network (Grobelny, Ed., 2017, p. 14–15).



Figure 3. Map of Uber connections in London
Source: (Grobelny, Ed., 2017)

When developing the MEVO system, civil servants should not forget about the suburban district (Metropolita area of Gdansk Gdynia Sopot, 2018) where reaching the nearest Rapid Railway (PKM) stop will be crucial. The road infrastructure should be developed on the outskirts of the city, and thus the construction of a metropolitan bypass road will allow the transit to be transferred to this road. During the holiday season this infrastructure will make it possible to relieve the Tri-City bypass road which is heavily jammed with traffic. This will also open up the Tri-City to visitors from cities like Słupsk. The beneficiaries of the new road will include also the adjacent municipalities whose road networks will be linked to this bypass. (General Directorate of Public Roads and Highways, 2018) The tourist economy of the region will also benefit from this solution, as it will enable better and faster movement across the entire Tri-City urban agglomeration, and even the entire Pomorskie Voivodeship.

There are many reflections on the situation in the public transport sector at the moment, doubtlessly we have the opportunity to observe many changes in the area of transport, it is a very popular and topical issue. It is easy to digress and propose solutions, however, as we can see that the greatest problem is in the correct implementation of the innovation. This article has focused largely on the Tri-City urban agglomeration, as it is an area of a specific transport tissue between the three major urban centres: Gdańsk Sopot-Gdynia (Jamroz et al., 2014, p. 19). A hybrid as well as administratively separate urban system is a curiosity similar to the Upper Silesia Industrial Area.

The 'smart city' slogans are in fashion and easy to catch. It should be remembered that this is not an unambiguous term and the complexity of this concept needs to be emphasized. An integrated public transport system in the light of the 'smart city' definition means literally saving time and convenience of travelling based on the needs of residents of a given area, as well as taking into account the percentage of people travelling to this place for tourist or business purposes. It is necessary to reconcile the tourism economy with the challenges faced by residents in their everyday travelling. An integrated public transport system in a 'smart city' is individual for each place, it is not possible to unify its meaning for everyone at once. Therefore, one should be careful in calling something 'smart'. The future, and at the same time a challenge for the Tri-City public transport system will be to create a joint transport plan based on one tariff in a given area. The plan should take into account land development plans, as rapidly developing cities create new housing estates which determines the development of the transport network in new centres that are not always included in the original plans. After all, it is the infrastructure that is one of the determinants of the economic development of an area. Do we really need 'smart transport'? From the point of view of the user, there is a need for an infrastructure that will meet the needs of residents regardless of the point where they start their travelling.

Conclusions

The greatest challenges faced by the administrators of the Tri-City Metropolitan Area have been illustrated above. The results of the research showing the habits of residents as well as the routes used by them to travel are also presented. It can be said that the three main cities of the metropolis are slowly seeking to transform their area into a smart one, however, it will be a slow process due to the high costs and the required change in the awareness of communities inhabiting them. It should be remembered that it is best to learn from other people's mistakes and adopt the best solutions that are available. Only one of the cities from the Bay of Gdansk region (Gdańsk) has been classified in the European Smart Cities (European Smart Cities, 2018). It is worth noting that a smart city is not only about the public transport, but also many other spheres of life. For the city to be 'smart' it is necessary to develop it a sustainable way, however, it is important to always implement the state-of-the-art solutions.

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