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Concept of A System for Integrated Ticketing and Tariffs for A Given Area in Poland

Damian Iwanowicz [1], Tomasz Szczuraszek [1]

[1] University of Science and Technology in Bydgoszcz, Poland

damian.iwanowicz@utp.edu.pl

Abstract. The article presents a proposal of a system for integrated ticketing and tariffs for a given area in Poland. This area is the Bydgoszcz-Toruń Metropolitan Area which is situated in Kujawsko-Pomorskie Voivodship, in the central part of Poland. Its area has 3.4 thousand km^2 and population equal to 838.6 thousand people. The concept is based on extensive research and analysis on potential development possibilities of public transport in the analysed area. The research on the current state included: rate of public transport means occupancy passengers and a survey among inhabitants concerning forms of transport they use, their preferences in the choice of transport means and assessment of the current system of ticketing and tariffs. Transport prognoses were analysed using results of simulation calculations carried out by means of prognostic transport models. These models were developed taking into consideration all real social-economic and transport conditionings of the area and for three development scenarios: optimistic, realistic (sustainable) and pessimistic (passive). Results of prognosis of the demand for public passenger transports show that in the most probable scenario (realistic), further drop in the number of passengers, carried by the public transport, will occur by 2030. Conclusions drawn from these analyses confirmed a necessity to take immediate actions to improve attractiveness of the transport system in the considered area, including implementation of modern solutions for integrated ticketing and tariffs. The proposed concept of integrated ticketing and tariffs of public transport is inspired by similar solutions implemented in other metropolitan areas of Poznań and Katowice in Poland and other agglomerations of Europe. The system involves using electronic tickets and paying from a 'virtual wallet' of the ticket user. The concept assumes integration of public transport in the two largest towns of the analysed region with train connections between these cities and regional passenger transports functioning on the territory of the entire area. An important element of the system is implementation of gradation of prices for single journeys (multi-change), depending on the length of the journey or e.g. range of a given transport corridor. The study presents characteristics of internal (inside transport means) and external infrastructure to be provided for the purpose of the system implementation. In the opinion of the authors, implementation of the system is expected to increase attractiveness of public transport services with simultaneous reduction in the number of journeys by individual transport means.

1. Introduction

The vision of the development of the European transport system as presented in key EU strategic planning documents has been described in such papers as [1, 2]. They mainly highlight the need for appropriate integrated political measures to be undertaken by individual EU Member States. The main objective of the European transport policy is to reduce the consumption of energy by the transport sector, to use modern infrastructure in a more efficient way and to limit harmful effects on the environment and

natural resources. Another preferred measure involves a new mass transportation model (applicable to passenger and freight traffic) using the most efficient means of transport, also in combination. The theme of the measure is to use individual transport only as the last stage of a journey (the final section of the route).

One of the main proposals is to make travelling more eco-friendly and supported by information technology to improve the quality of service and safety of the passengers. For a number of years, the EU transport policy has been advocating a close integration of transport systems, both internal (limited to cities, municipalities, districts, provinces, regions or the country) and external (linking them with other systems). It promotes the development, implementation and compliance with sustainable mobility and sustainable development of public transport as reasonable. The policymakers think it essential to optimise the solutions applied to the public transport system networks, integrated transport interchanges, parking areas for individual means of transport, passenger information systems, tariff systems etc.

One of the various actions which make travelling by public transport more appealing to passengers (as underlined in the EU strategic planning documents) is a comprehensive integration of this transport system in terms of time, space and tariffs, as well as with other transport systems (including private car and bicycle transport). The purpose of this article is to present a concept of an integrated tariff solution for a selected area of Poland, namely the Bydgoszcz-Toruń Metropolitan Area.

The Bydgoszcz-Toruń Metropolitan Area (Bydgosko-Toruński Obszar Metropolitarny, B-TOM) is situated in the north-central part of Poland and the centre of the Kujawsko-Pomorskie voivodeship. The social and economic situation of the voivodeship is average and typical as compared with the other regions of the country. The Bydgoszcz-Toruń Metropolitan Area comprises two large cities: Bydgoszcz (with a population of approx. 354,000) and Toruń (approx. 202,000), seven towns (with a total of ~79,000 residents) and twenty rural areas (~218,000 inhabitants). The B-TOM covers the area of 3,744 km2, of which the area of Bydgoszcz accounts for about 4.7%, Toruń about 3.1% and the other seven towns – about 2.1%. The rural areas take up nearly as much as 90.1% of the B-TOM. Bydgoszcz has the highest population density, exceeding 2,000 people per km^2, whereas the mean population density in the B-TOM is just about 480 people per km^2 [3, 4].

At present, two municipal transport systems operate within the B-TOM – one in Bydgoszcz and one in Toruń – and both comprise a tram and a bus subsystem. The city transport networks also include a few suburban lines. A suburban railway service has been launched to join the two cities (about 40 km) and complement their municipal transport systems. It incorporates transport hubs integrating the city and suburban systems (and an individual transport system in some cases). There are also intercity and regional public transport services and private (commercial) transport operators, joining the two metropolitan centres with each other and with satellite towns and places in the suburbs. Of course, there is also an interregional and international public transport subsystem available in Bydgoszcz and Toruń.

The numbers of trips per day undertaken by the residents of the B-TOM using different travel modes are provided below [5]:

- 1,317.9 thousand trips per day (54.8%) – by car, of which:
  - 1,010.0 thousand trips per day (42.0%) – as the driver,
  - 307.9 thousand trips per day (12.8%) – as a passenger,
- 360.2 thousand trips per day (15.0%) – by public transport,
- 240.0 thousand trips per day (9.9%) – by bicycle,
- 487.9 thousand trips per day (20.3%) – on foot.

If the trips are divided into just non-walking and non-cycling, the share of car-based trips is 78.5% (with 60.2% residents driving one and 18.3% travelling as passengers), whereas the remaining 21.5% were undertaken by means of public transport. The results of a study [5] confirm that in the recent years there has been a continuous decline in the number of passengers within the analysed area. This is consistent with a general downward trend in the number of public transport passengers in Poland [3, 4, 5].

For the purpose of the development of a public transport tariff integration project the following information was used:

1. The results of the simulations of transport needs, performed using transport models developed within the framework of a Norway Grants project concerning the study of the sustainable development of transport systems of the Bydgoszcz and Toruń Functional Area [5]. As many as 18 models were developed altogether, corresponding to:

- Three periods (the year 2015 – i.e. the existing situation providing reference for transport forecasts, the year 2020 and the year 2030 – forecast periods),
- Three scenarios of the economic development of the B-TOM and Poland: Optimistic (dynamic growth of the social and economic sector, a successful development of the road and rail infrastructure in the period, and a clear increase in the motorisation and mobility rates of the population), Stabilised (maintenance of present economic trends, mobility and motorisation rates, but a slower pace of the implementation of transport-related investment projects), and Passive (possible economic slump, the slowest pace of the implementation of transport investments and constant motorisation and mobility rates),
- Two intervals of transport operations (24 h on a typical weekday and the morning rush hours: 07:00-08:00).

The simulation models were developed using the German Visum software [6] based on two layers: the supply (available transport systems in the analysed area) and the demand (transport needs of the residents of the B-TOM and visitors), as well as mathematical procedures used to make the necessary calculations of mutual relationships between the layers.

2. The results of surveys conducted among the residents on their evaluation of the functioning of the public transport in the analysed area, including the existing fares and ticketing system. Around 6,000 people were surveyed in different residence areas in proportion to the population and the number of residents representing each group.

2. Elementary conditions for the development of public transport in the analysed area

Figure 1 presents the results of simulations made using the above-mentioned transport models. The results indicate projected changes in the transport needs of the residents of the analysed area of B-TOM in the years 2020 and 2030, with reference to the situation in 2015.

Both in the Optimistic and the Stabilised scenario the number of trips undertaken by car increased in the forecast years. This will certainly lead to an overall increase in the traffic volumes within the road network of the analysed metropolitan area. On the other hand, the Passive scenario assumes that the number of car-based trips will remain more or less stable, however their structure will noticeably change: there will be an increase in the number of trips undertaken by the residents as passengers, and a decrease in those undertaken as drivers, the reason of which is an expected decline in population and thus in the number of cars. This may lead to a decrease in the traffic volume, as well.

In the case of the public transport, an increase in the number of trips – by as much as 25.5% – can be expected only if the Optimistic scenario of economic development comes to reality. However, the authors believe that such a scenario is unlikely. In the other analysed cases, the number of trips undertaken by means of public transport will have fallen by 2030 by approx. 2.5% in the most likely scenario or – in the worst-case scenario – by nearly 13%. This is undoubtedly bad for the development of public transport in the analysed area.

It should be noted that the utilisation of public transport for travelling, as compared with cars, may slightly increase only in the Optimistic scenario: by about 0.2% in 2020 and about 1.2% in 2030. In the other cases it is expected to decrease, however by 2.1% at worst.

The results of the surveys [5, 23] show, among other things, that the expectations of bus passengers regarding the payment of fares are almost equally divided between the following three options (with about 33% of responses in each): ‘payment by card’, ‘ticket purchase on the bus’, and ‘season ticket

purchase on any day of the month'. The expectations and preferences of train passengers, on the other hand, were most often related to 'better accessibility of ticket counters' (34.2%) and 'more ticket machines' (26.3%), followed by 'longer opening hours of ticket counters' (10.5%) and the need to introduce 'a single, common ticket accepted by many operators' (7.9%). At the same time, the passengers rated the existing level of integration of the railway and bus transport systems at an average of 5.46 (on a scale of 1 to 10). This means that about a half of the passengers are not satisfied with the coordination of public transport services. In this respect, 'small' private bus operators were rated the lowest (2.68), which means that in that case there was no integration whatsoever with the other, 'big' public transport providers operating in the analysed area.

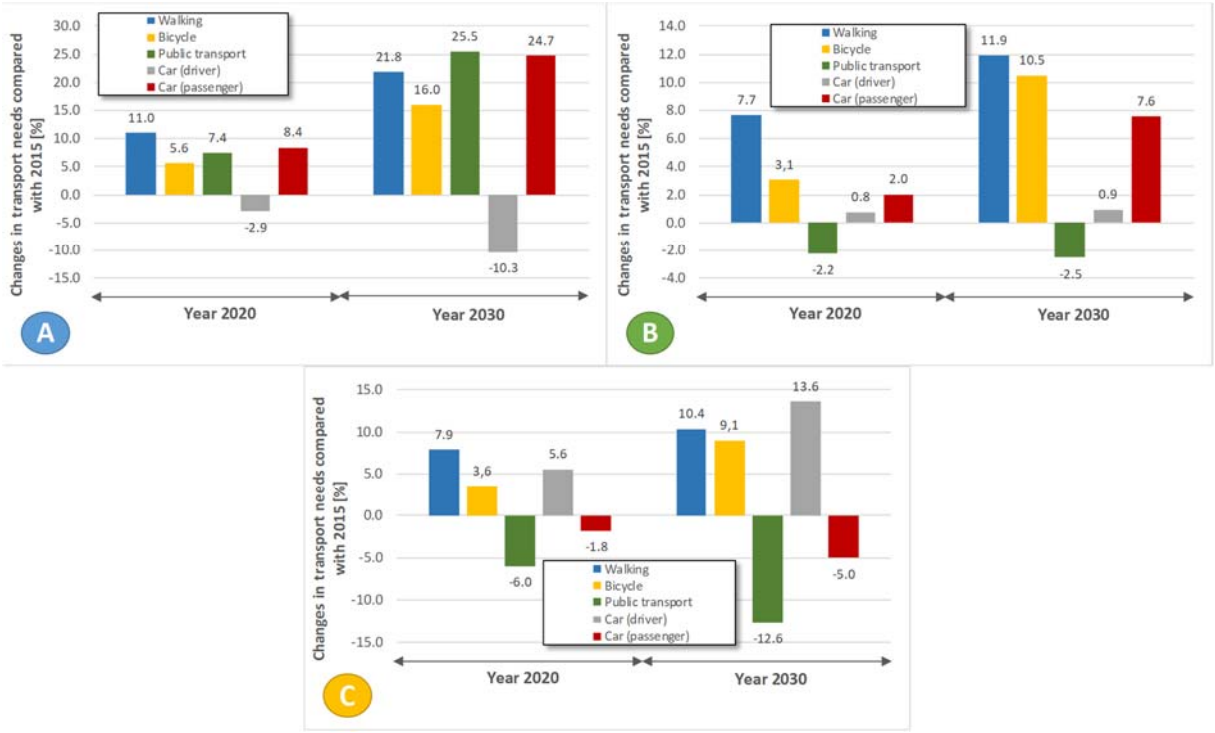

Figure 1. Projected changes in transport needs in the B-TOM in the forecast years of 2020 and 2030 as compared with 2015, assuming different scenarios of economic development (A – Optimistic, B – Stabilised and C – Passive). Source: own research [5]

3. Concept of an integrated ticketing system for the B-TOM

Considering the unfavourable conditions for the development of public transport in the analysed area, predicted in the most likely scenario of economic development for the Bydgoszcz-Toruń Metropolitan Area, and being aware of the difficulty in acquiring new and maintaining existing passengers, it is both vital and urgent to take measures to improve the appeal of this form of transport. Irrespective of upgrading and improving the standards of the vehicles used in urban and suburban public transport and of the related infrastructure, the authors believe that implementation of a modern tarrif integration system in the analysed metropolitan area is essential. A system like that would provide the residents with a broad choice of travel modes. It should be underlined again, that the development of an integrated ticketing system must be accompanied by work to ensure both temporal and spatial integration (e.g. construction of transport hubs at various levels, including parking areas).

The concept of such a system proposed in this article is based on the examples of the Poznań Electronic Agglomeration Card (PEKA) system e-wallet [7, 8] and the Silesian Card of Public Services (ŚKUP), containing tariffs based on distance and times and zones [9, 10]. The system to integrate regional and suburban public transport in the Pomorskie voivodship and the Bay of Gdansk metropolitan

area will be based on a similar principle [11]. Modern integrated ticketing systems using one electronic ticket for different travel modes have been already successfully implemented in other parts of the world, e.g. in Latvia [12], Greece [13], Slovenia [14], Slovakia [15], Portugal [16], Switzerland [17], and Italy [18]. According to the studies, and some other works [19-24], in most cases such implementation has contributed to an improvement of the appeal of public transport to residents. Still, much attention is drawn to certain material shortcomings of such services, for example varying levels of service within a region, relying on the available standard of ICT services, limited profitability after launch, or different problems connected with the implementation itself in relatively small areas of operation of public transport and a limited coverage of bus and train services.

The main objectives of the system are:

- To improve the appeal of public transport as compared with the use of private cars, also by the introduction of integrated ticketing and a common passenger information system in the whole area concerned;
- To satisfy the expectations of the B-TOM travellers, expressed in the surveys;
- To enable the residents to undertake a trip using just one ticket or a special reduced fare for the whole trip within a particular area;
- To reduce travel costs and to enhance the comfort of travel;
- To include a feature offering travellers the best price option regarding the trip (or a reduced fare for certain numbers of kilometres travelled, individual trips undertaken or the total travel time recorded);
- To use electronic chip cards in the form of e-tickets to pay the fare, and suitable card readers installed on vehicles used for carrying passengers within such an integrated public transport system in the whole metropolitan area. Electronic data storage devices used as the Electronic Ticket for the Metropolitan Area (BEOM) can be made available in a virtual form for smartphones equipped with a radio-frequency communication protocol called NFC (already common in mobile payment applications).

The proposed integration comprises three levels (or public transport systems): integration of urban and suburban transport services, including with suburban rail services, integration of urban transport systems with intercity and regional services, and integration of public transport systems with individual and private transport systems. The first level of integration is the priority and provides the basis for the others, so it must be implemented as the first step. The other two levels are considered as supplementary and they can be launched independently to support the basic level. The second and the third level of integration are both important for tariff integration. A general functional diagram of the Integrated Ticketing System (ZSTB) in the Bydgoszcz-Toruń Metropolitan Area is shown in Figure 2.

In the authors' opinion, the Voivodeship Transport Authority (WZT, established as part of the Transport Plan for the Kujawsko-Pomorskie Voivodeship) should coordinate the ZSTB system and to supervise the implementation of tasks related with voivodeship passenger traffic [23], as it already acts as the organiser and public administrator of regional public transport as an organisational unit subordinate to the Speaker of the Kujawsko-Pomorskie Voivodeship. The main responsibilities of the WZT should include the provision of appropriate funding for the ZSTB system, the specification of the pricelists and fares and the maintenance of the relevant database. These elements should be respected by other organisers of passenger transport within the ZSTB (i.e. the mayors of Bydgoszcz and Toruń, district administrators and other parties willing to participate in the system).

In order to implement integrated ticketing, all operators and carriers providing transport services within the framework of the ZSTB will have to be equipped with the required equipment (rented) – the ticket validator (BEOM card reader) – to charge the fare according to the route and distance travelled (based on the number of stops). The equipment should be entrusted in the care of the organisers of municipal and local public transport in Bydgoszcz and Toruń and the WZT. These three parties should sign an appropriate agreement regarding the integration of the public transport within the B-TOM. Settlements between individual public transport operators and private operators, as well, would be based

on the performance of their transport responsibilities (the number of vehicle- or train-kilometres performed and the revenues from the sale of tickets).

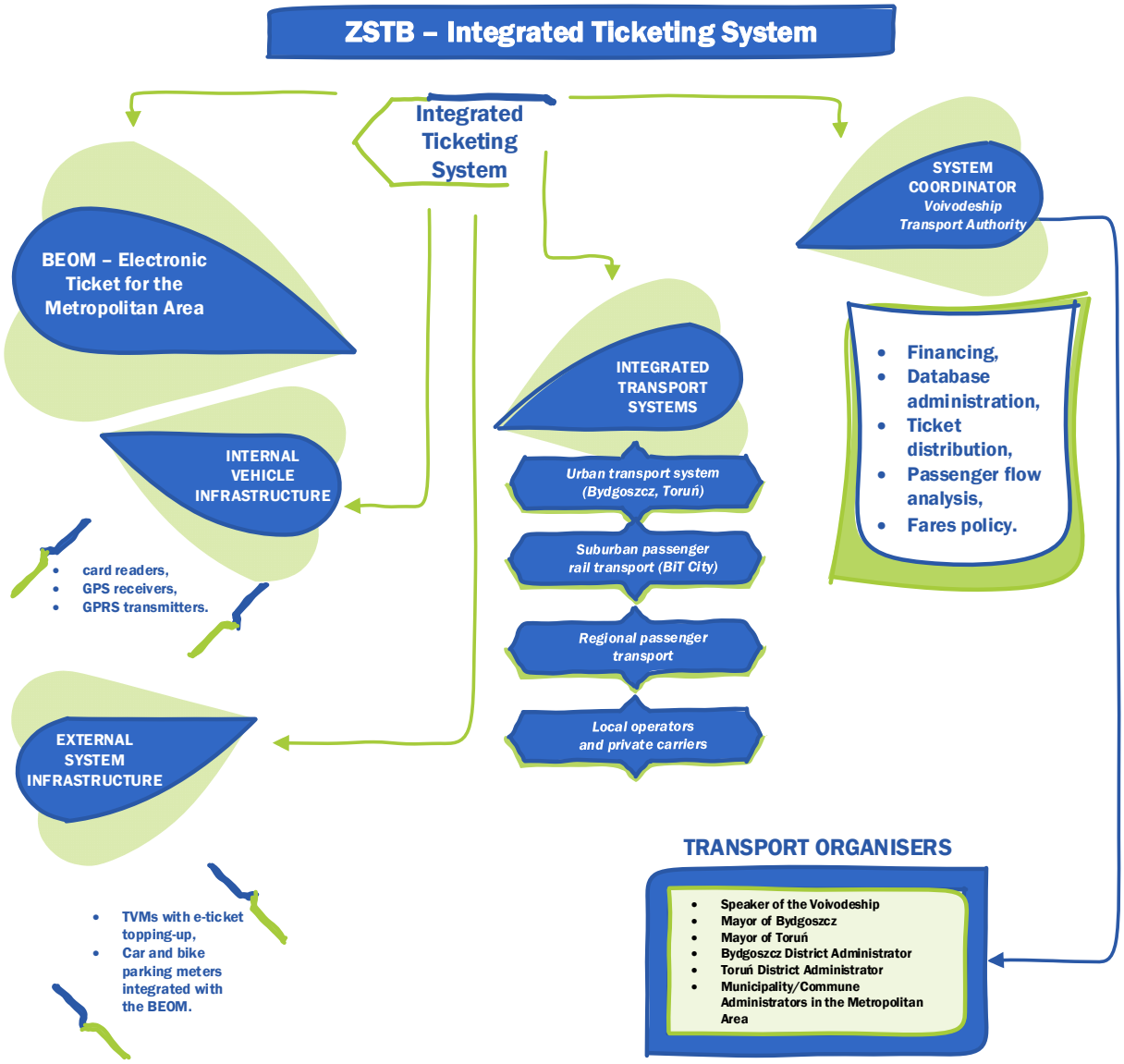

Figure 2. Block diagram of the functioning of the Integrated Ticketing System (ZSTB) in the Bydgosz-Toruń Metropolitan Area (B-TOM)

It is assumed that the clearing and settlement system should be supervised by the WZT. The prices of single (one-way) tickets, their grading and the prices of season tickets or passes should be adjusted to the appeal of the traffic corridor. The idea of grading the fares itself should take into account all three elements affecting the pricing (number of stops, kilometres and time) independently of one another, just as it does in the case of public transport services in the city, but offering the 'best price' option. Both the determination of the appeal of a traffic corridor within the metropolitan area and of the fares, as well as the distribution method of the tickets, are left to the decision of the organisers of public transport.

The data coded in the microchip of the e-ticket (BEOM) should be the basic personal details of the user, including their address of residence (temporary or permanent registration) or the location of their tax office used or filing annual tax returns (PIT forms). This kind of data will make it possible to determine the fundamental principle of separation of the three levels of fares for travelling by public

transport depending on the address of residence or their tax office. Obviously, the residents of the two major cities – Bydgoszcz and Toruń – will be privileged with the lowest fares. Higher rates should apply to the residents of the rest of the Metropolitan Area (mainly the neighbouring municipalities and communes of Bydgoszcz and Toruń), and the highest level of fares would have to be paid by people living in the other areas of the Kujawsko-Pomorskie voivodeship and by people who do not have the BEOM cards (including tourists). At the same time, the pricing of seasonal tickets (issued for a month, 3, 6 and 12 months) should be based on much lower fares than established for single tickets. It is also recommended to introduce free rides for children under 7 and schoolchildren under 14 using urban and suburban transport.

It is essential that passengers issued with a BEOM card validate it each time they get on and off the means of transport by holding the card (or their smartphone) against the reader installed on the vehicle. As a result, the public transport operator will have reliable and actual information on the passenger flows on the transport network. This will enable a better alignment of the services with the residents' current needs as regards public transport, and the application of the favourable solution which consists in the grading of fares depending on the number of stops passengers travel. This is another key aspect of the BEOM. In the case of visitors from outside the two cities, the information provided by the system will enable quick and efficient settlement of accounts for public transport services on the inter-municipal level (on the basis of the passenger flows through particular municipalities and communes). The mandatory logging of the BEOM card holders on vehicles must include those who use them as season tickets. For this type of users, separate card readers should be provided just to record them (passenger counting).

The concept of the Integrated Ticketing System (ZSTB) is based on the following principles as regards tariffs and fares:

1. The fare for a single trip (a single ticket) required of a person with the address of residence registered in the Metropolitan Area is subject to grading according to the distance travelled (the number of stops, kilometres or travel time); if the passenger does not validate the card when getting off the vehicle, the applicable full fare will be charged.
2. When undertaking a single trip with changes within the Metropolitan Area and the total travel time does not exceed 100 minutes, the fare is charged as for a single trip, unless the passenger changes vehicles more than 3 times.
3. When undertaking a single trip with changes as in Item 2), but using the suburban rail transport system – BiT City, the fare is increased by the price of a single suburban ticket, regardless of the stop where the trip begins or ends. Taking a BiT City train as part of the trip is not counted as a change.
4. The card reader installed on the vehicle provides the option to pay more than one fare (purchase more single tickets).
5. If the total fares charged off a single ticket within one day reach the value of a daily ticket, no further fares will be charged (except for the BiT City surcharge when taking a suburban train).
6. The validity of season tickets depends on the time of the first validation (holding it against the reader), not on the date of purchase.
7. If a passenger does not validate the season ticket on the vehicle, it will be considered as fare evasion (unauthorised travel).

Besides the solutions described above, it is necessary to implement new possibilities of tariff integration to support the management of public transport. This mainly concerns the introduction of such functionalities of the BEOM tickets which would integrate public transport with individual transport within the metropolitan area. To this end, the following solutions are proposed:

- Integration of a trip undertaken using any means of public transport (urban only) in the city of Bydgoszcz or Toruń, if the traveller leaves their car in a special Park&Ride car park, with a free-of-charge parking of the car for up to 12 hours from the time the BEOM ticket is validated

using a reader unit installed at the car park (applicable to the residents of both cities and other holders of the BEOM);

- Integration of a trip undertaken using any means of public transport on any routes organised by the mayors of Bydgoszcz and Toruń, if the traveller leaves a public bike in the area of the stop where they start their trip using public transport (Bike&Ride), with a free-of-charge use of the public bike;
- Exemption from the parking fee in B subzone of the Paid Parking Zone in Bydgoszcz and Toruń (or for entry to the B subzone), if the traveller uses a public bike or a means of public transport to continue the trip (i.e. validates their BEOM using the parking meter).

The above-listed propositions require integration of the BEOM system with the bike-sharing systems and the paid parking zones operated in the cities of Bydgoszcz and Torun, whereby the BEOM card will need to be validated each time at the car park and in the means of public transport. Such an integration of the BEOM system with the bike-sharing systems will also make it possible to rent a public bike using the card.

4. Conclusion

The present social and economic situation in the country, and also in the analysed area, are not favourable from the point of view of the potential for development of public transport systems. The coming years are predicted to bring about a further declining trend in the number of passengers using public transport, and a simultaneous increase in traffic generated by car-based transport. In the authors' opinion, considering the current and the projected conditions for the development of public transport, including the travel behaviour of the residents of the analysed area, it seems necessary to update and upgrade the tariff and ticketing system and make travelling by public transport more appealing to the residents through the introduction of the Electronic Ticket for the Metropolitan Area (BEOM). This measure, along other aspects which require improvement (e.g. the development of passenger information systems), should yield a positive evaluation of the functioning of the public transport system and upgrade its standards of the developed economies of Europe.

Based on a research of the technical capacities, it is estimated that the cost of operation of the Integrated Ticketing System (ZSTB) and the Electronic Ticket for the Metropolitan Area (BEOM), if the implementation comprises the urban transport systems of Bydgoszcz and Toruń, should not exceed €0.129 m a year or €0.065 m if the voivodship passenger transport system is included. The estimates take into account the necessary ITC equipment for the means of transport.

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