Irena NOWOTYŃSKA, Tomasz TRZEPIECIŃSKI

DETERMINANTS OF THE DEVELOPMENT OF PUBLIC TRANSPORT NETWORK

In the transport market, public transport is an important place for passenger transport. The proper functioning of collective urban transport in cities is becoming increasingly important in relation to the growing demands of travelers, whose satisfaction and content should be met. The paper presents the elements of the transport process and analysis of factors determining the demand for public transport services on the example of Rzeszów and neighboring municipalities. Ensuring sustainable development of public transport contributes, inter alia, to reducing emissions and is the most effective way of protecting the environment in the city.

INTRODUCTION

The modern city is a very complex structure that consists of many elements and is characterized by a large number of internal and external connections. There are some processes of quantitative and qualitative nature. It is in the interest of the authorities and people responsible for managing urban areas to learn about these changes and processes and, consequently, the ability to control them to some extent through a wide range of instruments. This way, one can more easily achieve the expected results and quickly eliminate the problems and threats that are emerging. The transport network, which is an integral part of the urban structure, plays a particularly important role. The share of road transport in passenger transport is about 75%. This is still a great value in spite of the declining trend observed in recent years. Still, a significant number of travelers, both within cities and in intercity, choose transport companies instead of individual transport. They speak for it: lower cost, faster arrival at peak traffic, no need to look for parking places in cities and an increase safety and comfort of bus travel.

Mobility in the city is considered as an important factor contributing to the rise and fall of unemployment, which has a huge impact on the sustainable development of the European Union [1]. Measures are being taken to make alternative ways to move around, such as walking, cycling, collective transport, with the option of optimizing travel for residents - by effectively linking different modes of transport. Public transport should be easily accessible to everyone, regardless of their physical fitness, age, caring (children, the elderly) and other characteristics.

Public transport is supported by the use of Intelligent Transport Systems (ITS) that provide better fleet management and additional passenger services. Using the ITS system can increase the throughput of road sections by 20-30% and this is of utmost importance, as the possibilities for road extensions in urban areas are very limited. Active management of urban transport infrastructure can also have a positive impact on safety and the environment. ITS could be applied primarily in the management of efficient interconnections between individual communication networks connecting urban and suburban areas.

In the National Transport Development Strategy until 2020 (with a vision to 2030) one of the objectives is to organize a smooth, locally-based movement of people within the city and facilitate the movement to and from outside [1]. Under this strategy, actions aimed at:

- promoting solutions for the integration of transport subsystems; the integration of different modes of transport, through the implementation of intermodal systems (interchanges, park and drive systems, etc.), common timetables, uniform tariff systems and a ticket valid for all modes of transport for all regional carriers;
- increasing the capacity of rail transport in agglomerations;
- promoting innovative technical solutions, e.g. by developing ITS systems that give priority to road transport by means of public transport;
- promotion of least polluting and energy efficient transport (electric, gas, hybrid, fuel cell, etc.).

The actions taken will be aimed at reducing transport congestion, in particular in urban areas, by:

- increasing the share of public transport in passenger transport;
- integration of urban transport (including suburban commuting);
- optimization and integration of urban transport and regional passenger transport systems;
- promoting walking and bicycle traffic;
- low emission zones in cities

Ensuring the ability of easy, fast journeys within a given center seems to be one of the key problems encountered by individuals and institutions that manage the city today. That is why it is important to carry out urban transport research and an analysis that can be used to plan the development and shaping of the modern city.

The aim of this study is to bring together issues related to transport, and, in particular public transport in Rzeszów and neighboring municipalities. Well-functioning, friendly passengers, public transport is important not only for social and economic reasons.

1. TRANSPORTATION PROCESS

The transport process is an organizational and technological sequence that integrates material and Intelligent Transport Systems procurement, production, distribution, operation and regulation with the phases of carriage, transshipment and storage. Its task is to ensure the efficient flow of physical goods from the moment of manufacture to their operation. This type of transport means that it handles not only the broadly defined supply of raw materials and the distribution of finished goods, but also the handling of returns, the servicing of operational processes and the collection and recycling of waste generated during the production process. The transport process is perceived as a series of related commercial, executive and organizational activities (Fig. 1) [2]. Implementing actions inclu-

de carrying out the carriage, i.e. carrying out the transport process, which includes such activities as cargo loading, carriage and unloading, while carrying out these activities requires direct involvement of the vehicle. Organizational tasks include preparation of transport documents or planning of the journey [3].

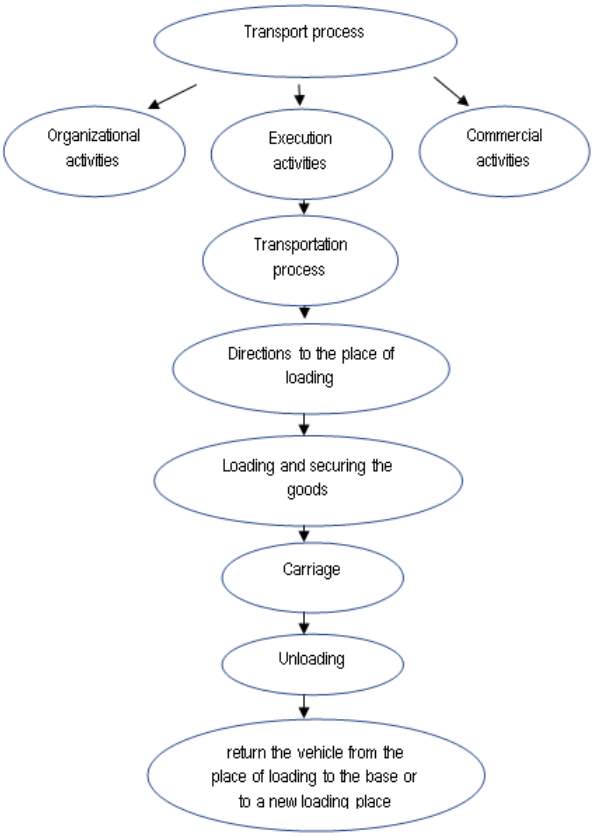

Fig. 1. *Elements of the transport process*

Transport is perceived as a service and transport services require appropriate transport infrastructure, means of transport, people, rules and regulations that together form the so-called transport system. The rules and regulations included in the transport system apply to the movement of persons and cargo from the points of dispatch, through the loading points to the collection points. These are principles of organizing the movement of loads and people in time and space [4].

The economy is characterized by a number of basic transport sectors such as road, rail, air or sea transport. In addition, pipelines, intermodal, multimodal, or combined transport can be distinguished [5]. Linking the activities of all modes of transport is referred to as a transport system that exists to meet transport needs. The importance and value of the work of people related to transport determines the effectiveness of the transport system in the process of meeting transport needs [6].

Optimal transport system:

- includes an ordered set of measures and activities for all modes of transport consisting of a transport system,
- contains the most relevant links with the national economy of the various transport sectors as well as inter-branch links,
- fully satisfies the quantitative and qualitative transport needs,
- minimizes social expenditure incurred to meet transport needs.

The transport system is very important for the flow of final products and materials between the supplier and the customer.

2. COLLECTIVE PUBLIC TRANSPORTATION

Public transport is a very important area of the economy. This transport is competitive to individual transport mainly due to travel costs but also for the benefit of the environment. Transport is an element connecting the city in a functional system. It depicts the urban center as a system of interdependencies that crosses its individual elements (Fig. 2). Any movement of loads and people that are carried out to satisfy the economic activities of a given region are considered as transport processes affecting the area of spatial planning, functions and urban development. At present the transport cannot be limited only to the transport function. With logistic concepts, it has to take over additional functions, while transport systems should have the optimum use of space, time, and transport capacity, with the optimum use of road infrastructure.

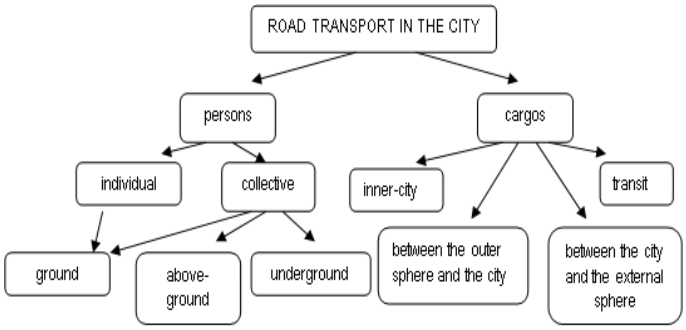

Fig. 2. *Transport division in the city*

Spatial development of the city takes place from the moment when the means of transport serving the transport needs achieve the limit of reach. In this respect urban space is limited by the practical possibilities of communication perceived as time lost on the journey, and time is a non-renewable resource. However, in the case of urban agglomeration the range of influence of the center is proportional to the attractiveness of the center and the efficiency of the means of used transport. Figure 3 shows the connections of urban transport with other functional elements of the city.

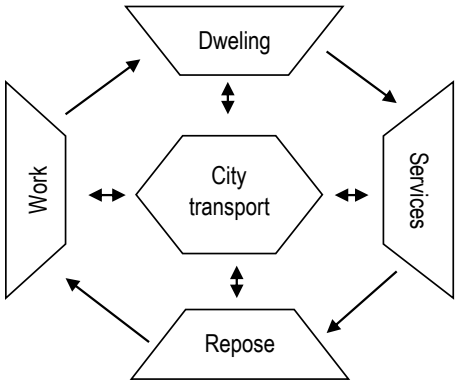

Fig. 3. *Connection of urban transport system with other elements of city functioning (on based [7])*

The urban transport shown in Figure 3 is an element that connects the city with a functional system. It depicts the urban center as a system of interdependencies between its individual elements. By integrating and combining all functions accomplished by the city, it simultaneously leads to a relative change in urban functions, as well as within systemic transformations. The functions performed by urban transport are the result of interdependence and links with the various factors of urban agglomeration.

The efficiency of the urban transport system plays an important role in shaping the socio-economic relations in a given area. The number of communication connections in the city is influenced by many different factors. Major areas include communication needs, spatial planning, work and science sites, population distribution in the city, as well as distribution of commercial and industrial functions.

Collective urban transport can be considered as efficient when it properly and fully satisfies the transport needs of its inhabitants while at the same time optimally utilizes technical means. In order to achieve such a state it must be ready both technically and organizationally and economically to provide comprehensive transport services. Urban transport readiness is its ability to remain in a state that enables it to perform specific tasks under given conditions, within a given time period assuming that the required technical measures are provided. PUBLIC TRANSPORTATION IN RZESZOW

The purpose of public transport in the area of the city of Rzeszów and municipalities which signed with the city of Rzeszow municipal agreements on the organization of public transport is the functioning and development of modern and environmentally-friendly public transport fulfilling the expectations of passengers - in such a way that a real alternative to travel made by own car passenger.

The location of Rzeszów at the intersection of so many transport corridors determines its development. Rzeszów is a center of national and international importance in the Podkarpackie Region and a vibrant economic center and regional academic center. It is assumed that the development of attractive and competitive public transport - by the creation of a Public Transport Management Center and coordination of services provided by carriers, taking into account the needs of disadvantaged areas. It is also assumed that there will be an improvement in road accessibility to places of business concentration - in particular to economic zones and places of special tourist interest.

The communication network in Rzeszów only covers bus lines. As of 31 December 2013, the total length of the Rzeszów municipal transport line was 588.6 km, while the length of the route was 242.4 km. The average operating speed was 16.2 km / h and the average speed was 23.2 km / h. As of 10 January 2014, the public transport network organized by the city of Rzeszów consisted of 46 bus lines (one special and three at night). Public road transport in Rzeszów is based on the street network of the city and suburban roads - with separate bays on the routes with the largest passenger flows. Within administrative boundaries of Rzeszów there are 307 bus stops [7].

Factors determining the demand for public transport services in Rzeszów and surrounding municipalities included in the plan are:

– the number of residents;
– age structure of the population;
– occupational and educational activity of the population, including the number of students and students;
– size and direction of migration

and derivative factors, such as the number of registered cars

As of 31 December 2012, Rzeszów Urban Transport served the area inhabited by about 220 thousand people. Changes in the number of inhabitants in Rzeszów and in the neighboring communes covered by the plan are shown in Figure 4 [1].

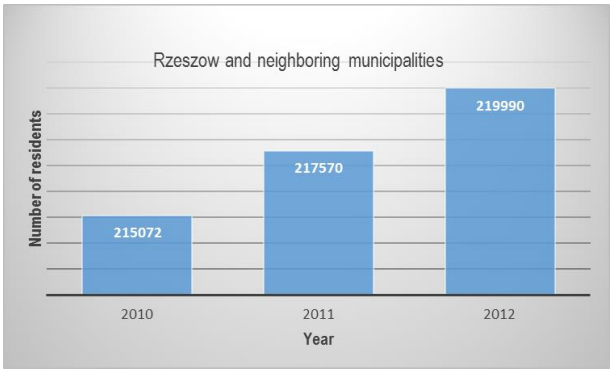

Fig. 4. *Change in the number of inhabitants of Rzeszów and municipalities serviced by Rzeszów municipal transport in 2010-2012 - Central Statistical Office data*

As shown in Figure 4, there a general stabilization of the population in 2010-2012 in the area serviced by Rzeszów municipal transport. The change in the population of Rzeszów resulted not only from demographic reasons, but also from territorial changes, including the inclusion of several towns in this area.

The structure of the population of Rzeszów and gminas, according to the criterion of professional activity, is presented in Figure 5. The data included in the figure illustrate the change in the structure of occupational activity of inhabitants of Rzeszów and gminas covered by the plan in recent years. In 2008-2012, the number of inhabitants in the pre-working age decreased (by 0.6%), the number of working-age residents increased slightly (by 2.0%), while the number of working-age residents increased significantly (by 13.8%) [7].

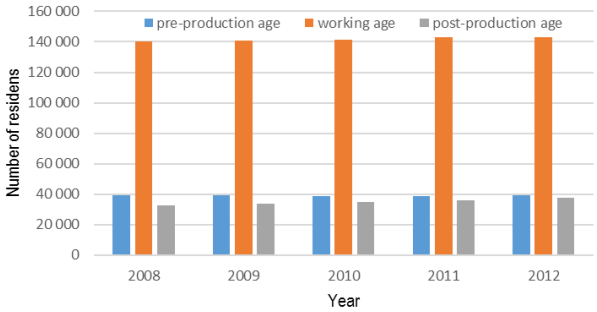

Fig. 5. *Structure of the population of Rzeszów and gminas covered by the plan in 2008-2012*

The demographic forecasts for Rzeszów and the gminas included in the plan drawn up by the Central Statistical Office (CSO) and presented in Figure 6, taking into account the different age groups, assume that these trends will be maintained and deepened by 2020 [1].

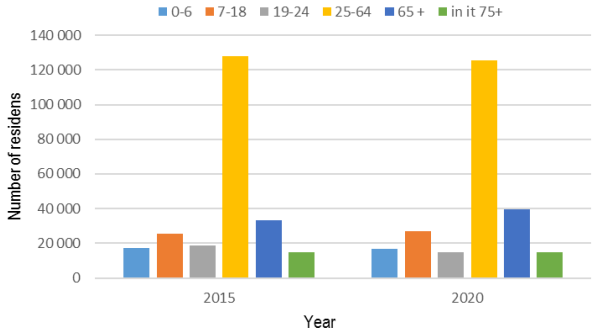

Fig. 6. *Estimated population of Rzeszów and communes covered by the plan in 2015-2020 - according to CSO data*

As a consequence of the anticipated changes in the demographic structure of the inhabitants of Rzeszów and the communes covered by the plan, the number of passengers buying normal tickets (full-paid) Rzeszów city transport should be reduced to 2020, and the number of people entitled to free journeys will increase by as much as 20% in relation to the number of people currently using these powers.

As of December 31, 2012 as many as 50% of the population were residents of the age who are entitled to reduced and unpaid travel. The demographic forecasts predict that in the years 2014-2020 the proportion of people aged 25-69 will decrease by between 3 and 5%, ie by the age group using public transport mostly from regular tickets, but by more than 20% purchasing rights on grounds of age. Attention is drawn to the potentially favorable size of the segment of people aged 25-64, which - as at 31 December 2012 - accounted for 58% of the inhabitants of Rzeszów. Most of the people in this segment do not have the right to travel and free of charge (exceptions are students of extramural studies, people with disabilities and their carers, etc.) [1].

As demonstrated by the results of marketing research on the preferences and behavior of the residents, this segment is made up mostly of people traveling by their own car. It is therefore a segment of the population with high demand for public transport, which can in part be transformed into effective demand, shaping the transport offer according to the preferences and expectations of these people.

In the last few years, the time structure of demand for public transport services has changed drastically. In Poland, the number and share of obligatory journeys by means of public transport decreased, as well as the change in the hours of their operation. The total reduction in the number of mandatory journeys was influenced by demographic and socio-occupational factors: demographic factors led to a decline in the number of students commuting to schools and a change in the employment structure.

There is also a shift of peak hours to commute to work. More and fewer people are employed in shift workplaces, starting around 6 pm, while employment in the service sector is increasing, with jobs starting between the hours of 8 and 10.

In the case of Rzeszów, there is still a clear morning traffic peak between 6.30-8.00, but already the number of passengers using public transport in the peak-to-peak period, between 8.00 and 12.30, commences on weekdays 68-77% of the number of passengers from the morning peak [1].

The figures for automotive indicators are also unfavorable for the demand for public transport services. In 2012, according to the GUS Local Data Bank, more than 103.6 thousand were registered. passenger cars. The car index was more than 569 cars per 1,000 inhabitants. The forecast of the automotive index prepared for Rzeszów assumes an increase in the number of passenger cars to 110.5 thousand. in 2015 and 117.7 thus - in 2020. This means an increase in the number of passenger cars in the subsequent years up to 2020 by 6.7 and 13.6%, respectively, 12, which means that the car index will reach 644 cars per 1,000 inhabitants by 2020. It is therefore important to introduce various types of incentives and priorities for public transport and well thought out restrictions for individual transport so that as many travelers as possible decide on the use of public transport 17].

CONCLUSIONS

The proper functioning of collective urban transport in cities is becoming increasingly important in relation to the growing demands of travelers, whose satisfaction and content should be met. The services proposed by urban transport should include such attractive features as will allow the passenger to opt out of using private cars. Collective transport and its functioning are important both for meeting individual needs (mobility needs) and for social life.

The presented analysis of factors determining the demand for public transport services in Rzeszów and neighboring municipalities showed in what directions should the development of public transport go to ensure its sustainable development. It can be implemented through actions that promote the maintenance of the current level and the development of public transport - by introducing public transport privileges (public transport) and prudently restricting the movement of individual vehicles, especially in the city center. Maintaining a high share of public transport in the number of motorized journeys in the city should have the greatest impact on the reduction of pollution emitted to the environment by vehicle traffic. Urban transport significantly reduces traffic to workplaces or to the city center, which directly translates into reduced emissions and is the most effective environmental protection in the city.

REFERENCES

1. www.rzeszow.pl/file/22094/Plan.pdf
2. Stajniak M., Hajdul M., Foltyński M.,. Krupa A, *Transport i spedycja*, *Instytut Logistyki i Magazynowania*, Poznań 2008.
3. Grzelakowski A.S., *Transport w logistyce a logistyka w transporcie, „Logistyka" 2009*, nr 2.
4. Liberadzki B., Mindur L., Uwarunkowania rozwoju systemu transportowego Polski, Wydawnictwo Instytutu Technologii Eksploatacji – PIB, Warszawa 2006, s. 517.
5. Coyle J.J., Bardi E.J., Langley C.J., Zarządzanie logistyczne…, s. 411.
6. Neider J., Transport międzynarodowy, PWE, Warszawa 2008.
7. Meyer B., *Systemy komunikacyjne w aglomeracjach*, *ZNUS nr 159, Prace Wydziału Transportu i Łączności* nr 7, US Szczecin 1995.

Determinanty rozwoju sieci publicznego transportu zbiorowego

Na rynku usług transportowych ważne miejsce w zakresie przewozu osób zajmuje publiczny transport zbiorowy. Właściwe funkcjonowanie zbiorowego transportu miejskiego w miastach nabiera obecnie dużego znaczenia względem rosnących wymagań ze strony podróżnych, których satysfakcja oraz zadowolenie powinny być zaspokojone. W pracy przedstawiono elementy procesu transportowego oraz analizę czynników determinujących popyt na usługi komunikacji miejskiej na przykładzie Rzeszowa i gmin ościennych. Zapewnienie zrównoważonego rozwoju publicznego transportu zbiorowego przyczynia się między innymi do obniżania emisji spalin i jest najbardziej efektywnym działaniem ochrony środowiska w mieście.

Authors:

Dr inż. **Irena Nowotyńska** – Rzeszow University of Technology, Department of Computer Engineering in Management, e-mail: i_nowot@prz.edu.pl

Dr hab. inż. **Tomasz Trzepieciński** – Rzeszow University of Technology, Department of Materials Forming and Processing, e-mail: tomtrz@prz.edu.pl