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The Concept of Construction of Agglomeration Railway System in the Upper Silesian Conurbation

ABSTRACT

An indispensable element in the development of urbanized areas of individual agglomerations is the change in the structure of transport systems in such a way as to meet their needs. Depending on the nature of the area, the use of infrastructure is strongly related to the mobility and transport preferences of its residents. In the case of the Upper Silesian Agglomeration, the agglomeration rail system is not developed in a way that corresponds to its potential. The article presents the concept of establishing a fast agglomeration railway as a complement to the existing transport systems in the Upper Silesian Agglomeration.

Keywords: urban rail lines, transport system, demand, transportation planning

1. Introduction

The role of railway transport as a means of urban public transport in Poland is currently minimally taken into account during the organization of transport by local governments and other organizational units. The exception is the capital city of Warsaw, which has significantly integrated the railway with other public transport modes, i.e. buses, trams and metro. An example is the possibility of traveling within the city on the basis of tickets issued by the Public Transport Authority by trains of “Szybka Kolej Miejska”, “Koleje Mazowieckie” or “Warszawska Kolej Dojazdowa” [Zarząd Transportu Miejskiego w Warszawie]. However, in addition to the tariff integration, there is also organizational integration. It allows improving the functioning of the public transport network within the city and agglomeration by coordinating the routes and timetables of individual lines on routes. This makes it possible to limit the competitiveness of public transport, which in principle should complement each other [Dydkowski, 2009, p. 304]. In the case of the Upper Silesian agglomeration, the regional rail system is ignored in tariff and organizational integration. The exceptions are legal regulations and agreements between public transport organizers enabling the use of rail and other public transport. An example of this is the “Orange Tariff”, which allows using transport lines organized by “MZK Tychy” and “Koleje Śląskie”. However, in the Upper Silesian Agglomeration there is no full integration enabling cooperation of all the public transport organizers. The creation of the Metropolis enabled the integration of three public transport organizers. These are “KZK GOP”, “MZKP Tarnowskie Góry” and “MZK Tychy” creating the Metropolitan Transport Authority. However, the potential of the railway lines that have their course in the agglomeration is still missing. Rail transport is effective not only for transporting people, but also for transporting goods [Macioszek, Staniek, Sierpiński, 2017, pp. 388–395, Macioszek, 2018, pp. 147–154, Koźlak, 2013, pp. 172–185, Bieda, 2010, pp. 183–195, Giedryś, Raczyński, 2014, pp. 30–32]. On the basis of the information collected from the surveys and the analysis of the number of journeys with selected transport routes, the article presents the possibility of using the railway in the agglomeration transport system. The aim of the article is to present the concept of the Agglomeration Railway Systems along with routes of transport lines and frequencies of trains.

2. Analysis of transport systems in the Upper Silesian Agglomeration

2.1. Area of the analysis

The analysis area includes cities and municipalities located in the Upper Silesian Agglomeration. In the characteristic way for this region of Poland, individual local government units

form a single entity showing the socio-economic impact between them. Depending on the sources, the number of cities in the agglomeration varies significantly. According to the Central Statistical Office, 19 cities are included in the Upper Silesian Agglomeration, and the number of inhabitants is over 2 million [Statistics Poland]. Table 1 shows the cities (together with the population) belonging to the agglomeration.

Table 1. Cities included in the Upper Silesian Agglomeration with their population [Statistics Poland]

| No. | City | Population [thous.] |
|-----|----------------------|---------------------|
| 1 | Katowice | 301,8 |
| 2 | Sosnowiec | 209,3 |
| 3 | Gliwice | 184,4 |
| 4 | Zabrze | 177,2 |
| 5 | Bytom | 172,3 |
| 6 | Ruda Śląska | 141,9 |
| 7 | Tychy | 128,6 |
| 8 | Dąbrowa Górnicza | 123,3 |
| 9 | Chorzów | 111,2 |
| 10 | Jaworzno | 94,3 |
| 11 | Mysłowice | 75,1 |
| 12 | Siemianowice Śląskie | 69,6 |
| 13 | Tarnowskie Góry | 60,9 |
| 14 | Piekary Śląskie | 54,2 |
| 15 | Będzin | 58,4 |
| 16 | Świętochłowice | 52,4 |
| 17 | Knurów | 39,3 |
| 18 | Mikołów | 39,6 |
| 19 | Czeladź | 33,6 |
| Σ | - | 2127,4 |

Source: Statistics Poland.

In Katowice, which is the seat of the Silesian Voivodship and the Metropolis, there are many offices of administrative, industrial, scientific and trade institutions. At the same time, the city is the largest urban area in terms of population in the agglomeration. It is also the main transport hub. All the regional railway lines start or have routes running through the main station located in the centre of the city of Katowice, which is also the main interchange point in the agglomeration. The population of the agglomeration cities served as one of the criteria for the selection of survey points. The research was carried out in the cities with a population of more than or equal to 100,000.

2.2. Status of railway passenger connections

In the Upper Silesian Agglomeration, railway passenger connections are carried out by “PKP Intercity”, “Przewozy Regionalne” and “Koleje Śląskie.” The last company is owned by the local government of the Silesian Voivodeship and implements all the connections in this area. “Przewozy Regionalne” performs inter-voivodeships connections, i.e. those whose routes cross the border of the voivodeship. “PKP Intercity” realizes long-distance connections. Table 2 shows the existing connections running through the main stations in the agglomeration.

Table 2. Rail lines of a chosen station in the Upper Silesian Agglomeration
[PKP Polskie Linie Kolejowe]

| City / Station | Rail company | Category of rail connection | Main destination |
|----------------|---------------------|-----------------------------|--|
| Katowice | PKP Intercity | EIP, EIC, IC, TLK | Warszawa, Kraków, Wrocław, Poznań, Gdańsk, Bielsko-Biała |
| | Przewozy Regionalne | REGIO | Kielce, Kraków, Rzeszów, Rybnik |
| | Koleje Śląskie | Osobowy | Bielsko-Biała, Bytom, Częstochowa, Gliwice, Lubliniec, Tychy |
| Gliwice | PKP Intercity | EIP, EIC, IC, TLK | Warszawa, Kraków, Wrocław, Poznań, Gdańsk |
| | Przewozy Regionalne | REGIO | Kędzierzyn-Koźle, Nysa, Opole |
| | Koleje Śląskie | Osobowy | Częstochowa, Katowice |
| Sosnowiec | PKP Intercity | EIP, EIC, IC, TLK | Warszawa, Wrocław, Poznań, Gdańsk |
| | Przewozy Regionalne | REGIO | Kielce |
| | Koleje Śląskie | Osobowy | Częstochowa, Gliwice, Częstochowa, Tychy |
| Bytom | PKP Intercity | IC, TLK | Poznań, Wrocław, Katowice |
| | Koleje Śląskie | Osobowy | Katowice, Lubliniec |
| Tychy | PKP Intercity | EIP, EIC, IC, TLK | Warszawa, Gdańsk, Katowice, Bielsko-Biała |
| | Koleje Śląskie | Osobowy | Bielsko-Biała, Katowice, Sosnowiec, Wiśła, Zwardoń |

Source: PKP Polskie Linie Kolejowe.

2.3. Public transport organizers

The organization of public transport plays an important role in the functioning of the Upper Silesian Agglomeration area. This task was entrusted to four organizers. These are “KZK GOP”, “MZK Tychy”, “MZKP Tarnowskie Góry” and “PKM Jaworzno”. “KZK GOP” is the largest organizer of public transport in the agglomeration. The “KZK GOP” organization system has been implemented in 25 communes, which are located in the central part of the agglomeration. The union is responsible for the operation of 29 tram lines and about 300 bus lines. “MZKP Tarnowskie Góry” is an administrative unit that organizes public collective transport in 10 communes located in the northern part of the agglomeration. On the basis of an agreement with “KZK GOP”, a common ticket tariff applies. “MZK Tychy” is the unit providing the organization of public transport mainly in the city of Tychy. However, “MZK Tychy” also operates in 16 other communes, which decided on an agreement related to the organization

of public transport in their area. The unit also organizes connection lines to communes that do not participate in the costs of their operation. Such communes are, for example, Katowice or Gliwice. The last organizer is “PKM Jaworzno”. It is the only administrative unit in the agglomeration that organizes and provides transport services at the same time. It operates mainly in the city of Jaworzno. However, the transport system of the city of Jaworzno includes public transport lines that run through the surrounding cities and communes. Among the listed organizers, full tariff integration functions only between “KZK GOP” and “MZKP Tarnowskie Góry”. The organizational tasks of these units will be taken over by the Metropolitan Transport Authority, which will associate all the communes included in the Metropolis. The exception is the city of Jaworzno, which gave up being a part of the metropolis.

3. Analysis of the passenger flow

3.1. Forecast number of trips

The forecast numbers of trips on designated connection routes is an important element determining the legitimacy of the building of the Fast Agglomeration Railway. The specified forecast allowed directional orientation of the travel destinations, resulting primarily from the central character of the city of Katowice, to which the forecast connection routes were designated. To make the forecasts, data on the number of journeys received from individual organizers of public transport, excluding railway companies, was used [KZK GOP, MZK Tychy, PKM Jaworzno]. The data refers to the period from 2010 to 2016. In 2017, no vehicle capacity tests were performed. The forecast connection routes have been selected on the basis of the relationship between the reference points and the occurrence of the connection by the railway line. If there is no infrastructure and railway connections between the selected reference points, forecast was not made. The point of reference is the area in which the stops and stations form a transfer node. Table 3 shows the matrix of the connections between selected cities for which the forecasts were made. The plus sign means the occurrence of direct connections between the cities.

Table 3. Matrix of connections between the chosen cities.

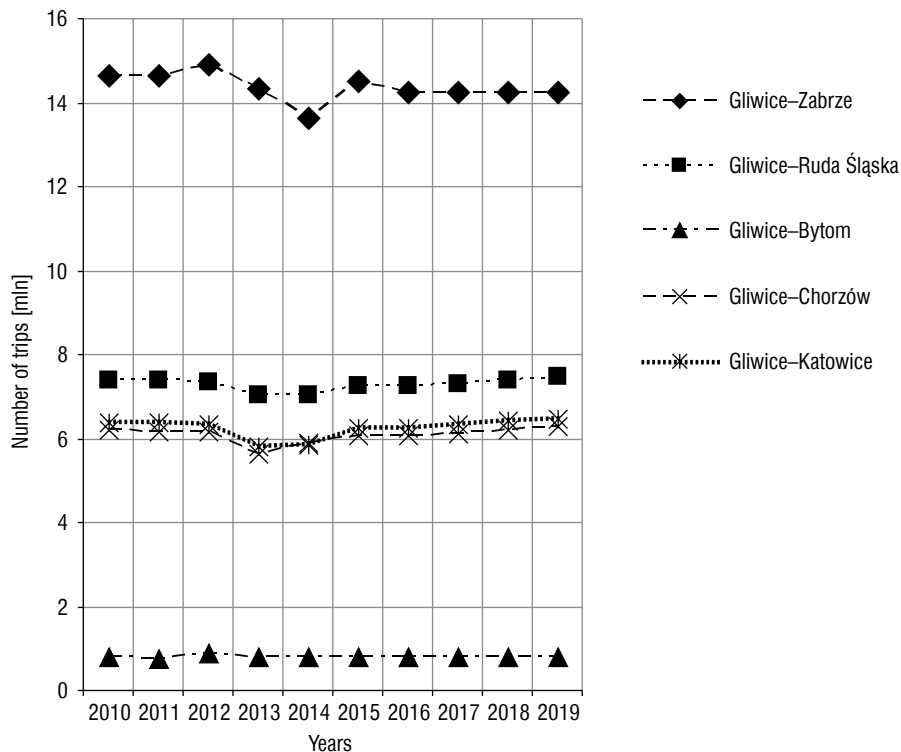
| from \ to | Gliwice | Zabrze | Ruda Śląska | Bytom | Chorzów | Katowice | Tychy | Sosnowiec | Dąbrowa Górnicza | Jaworzno |
|-------------|---------|--------|-------------|-------|---------|----------|-------|-----------|------------------|----------|
| Gliwice | - | + | + | + | + | + | - | + | + | - |
| Zabrze | + | - | + | - | + | + | - | + | + | - |
| Ruda Śląska | + | + | - | - | + | + | - | + | + | - |
| Bytom | + | - | - | - | + | + | - | - | - | - |
| Chorzów | + | + | + | + | - | + | - | + | + | - |
| Katowice | + | + | + | + | + | - | + | + | + | + |
| Tychy | - | - | - | - | - | + | - | + | - | - |

| from \ to | Gliwice | Zabrze | Ruda Śląska | Bytom | Chorzów | Katowice | Tychy | Sosnowiec | Dąbrowa Górnicza | Jaworzno |
|------------------|---------|--------|-------------|-------|---------|----------|-------|-----------|------------------|----------|
| Sosnowiec | + | + | + | - | + | + | + | - | + | - |
| Dąbrowa Górnicza | + | + | + | - | + | + | - | + | - | - |
| Jaworzno | - | - | - | - | - | + | - | - | - | - |

Source: KZK GOP, MZK Tychy, PKM Jaworzno.

For all these connections, forecasts of the number of journeys were made using the moving trend method. The method allows isolating the development trend of the forecast variable, which in this case is the number of journeys. The example of the city of Gliwice presents a graphical summary of the results obtained. Figure 1 shows the forecast numbers of trips for 2018 and 2019.

Figure 1. Diagram of the forecast number of trips for Gliwice.



Source: Lach, 2017.

The chart shows that the most journeys were made in the Gliwice – Zabrze connection. On the other hand, the smallest number of trips was recorded for the connection Gliwice – Bytom. A large number of journeys in the connections from Gliwice to Katowice, Zabrze, Ruda Śląska and Chorzów may indicate the necessity of establishing an integrated agglomeration system with other means of transport.

3.2. Survey research

Another important element in the analysis of the construct of the agglomeration rail is the survey research, which was carried out at selected points of the Upper Silesian Agglomeration. Similarly to work [Sierpiński, 2012, pp. 93–106], the main criterion for selecting individual measurement points was the number of inhabitants. In the survey research there were selected cities with a population of over 100,000. The next criterion was the number of passengers using individual public transport stops. The surveys were carried out in the spring of 2017. A total of 668 surveys were collected. A detailed description of the research is presented in [Lach, 2017]. Table 4 presents the list of measurement points in which the tests were carried out.

Table 4. Points of the survey research.

| City | Name of the measuring point | Date of measurement | Number of surveys |
|------------------|--|--|-------------------|
| Gliwice | Dworzec Kolejowy (platforms) | 21.03.2017 (od godziny 7:00, szczyt poranny) | 42 |
| | Plac Piastów | 21.03.2017 (od godziny 13:00, szczyt popołudniowy) | 30 |
| Zabrze | Dworzec Kolejowy | 22.03.2017 (od godziny 13:00, szczyt popołudniowy) | 23 |
| | Goethego (all platforms) | 22.03.2017 (od godziny 13:00, szczyt popołudniowy) | 30 |
| Ruda Śląska | Ruda Chebzie | 24.03.2017 (od godziny 7:00, szczyt poranny) | 21 |
| | Chebzie Pętla | 24.03.2017 (od godziny 13:00, szczyt popołudniowy) | 25 |
| Bytom | Dworzec Kolejowy | 29.03.2017 (od godziny 13:00, szczyt popołudniowy) | 20 |
| | Dworzec Autobusowy | 29.03.2017 (od godziny 13:00, szczyt popołudniowy) | 40 |
| | Plac Sikorskiego | 29.03.2017 (od godziny 13:00, szczyt popołudniowy) | 38 |
| Chorzów | Rynek | 4.04.2017 (od godziny 7:00, szczyt poranny) | 32 |
| | Chorzów Batory (kolejowy, autobusowy i tramwajowy) | 4.04.2017 (od godziny 13:00, szczyt popołudniowy) | 20 |
| Katowice | Rynek | 31.03.2017 (od godziny 7:00, szczyt poranny) | 42 |
| | Aleja Korfantego | 5.04.2017 (od godziny 13:00, szczyt popołudniowy) | 34 |
| | ul. Piotra Skargi | 5.04.2017 (od godziny 13:00, szczyt popołudniowy) | 32 |
| | Dworzec (podziemny dworzec autobusowy) | 7.04.2017 (od godziny 7:00, szczyt poranny) | 33 |
| | Dworzec (perony kolejowe) | 7.04.2017 (od godziny 13:00, szczyt popołudniowy) | 33 |
| | Plac Wolności | 12.04.2017 (od godziny 13:00, szczyt popołudniowy) | 34 |
| Tychy | Dworzec Komunikacji Miejskiej | 19.04.2017 (od godziny 13:00, szczyt popołudniowy) | 30 |
| | Dworzec kolejowy (perony kolejowe) | 21.04.2017 (od godziny 7:00, szczyt poranny) | 20 |
| Sosnowiec | Dworzec PKP (przystanki autobusowe i tramwajowe) | 26.04.2017 (od godziny 13:00, szczyt popołudniowy) | 25 |
| | Dworzec PKP (perony) | 28.04.2017 (od godziny 7:00, szczyt poranny) | 30 |
| Dąbrowa Górnicza | Centrum | 28.04.2017 (od godziny 13:00, szczyt popołudniowy) | 34 |
| - | - | Σ | 668 |

Source: Lach, 2017.

The main purpose of the survey was to collect information about the source and destination of the trip. The analysis does not include trips whose purpose was outside of the Upper Silesian Agglomeration. There were a total of 44 such journeys. That is, 93% of the respondents traveled within the agglomeration. Table 5 shows the number of trips in specific connections based on the surveys.

Table 5. Matrix of the number of trips from the survey research.

| | Gliwice | Zabrze | Ruda Śląska | Katowice | Sosnowiec | Bytom | Chorzów | Dąbrowa Górnicza | Jaworzno | Tychy |
|------------------|---------|--------|-------------|----------|-----------|-------|---------|------------------|----------|-------|
| Gliwice | 14 | 6 | 2 | 35 | 6 | 0 | 0 | 0 | 0 | 0 |
| Zabrze | 5 | 15 | 2 | 15 | 7 | 1 | 3 | 1 | 0 | 0 |
| Ruda Śląska | 5 | 2 | 10 | 18 | 5 | 4 | 0 | 2 | 0 | 0 |
| Katowice | 6 | 0 | 0 | 100 | 12 | 12 | 7 | 6 | 10 | 9 |
| Sosnowiec | 6 | 3 | 0 | 15 | 13 | 0 | 1 | 3 | 0 | 3 |
| Bytom | 0 | 6 | 7 | 21 | 5 | 25 | 12 | 0 | 0 | 0 |
| Chorzów | 8 | 5 | 0 | 21 | 4 | 2 | 7 | 0 | 0 | 0 |
| Dąbrowa Górnicza | 0 | 0 | 0 | 7 | 4 | 0 | 0 | 14 | 0 | 0 |
| Jaworzno | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tychy | 0 | 0 | 0 | 19 | 3 | 0 | 0 | 0 | 0 | 21 |

Source: Lach, 2017.

The analysis shows that a large number of trips had their destination in the city of Katowice. This confirms the fact of the leading role of this city. The obtained results were compared with the forecast numbers of trips. It was confirmed that the agglomeration railway lines should be delimited in such a way that their routes pass through the city of Katowice. It should be noted that a large part of the journeys were made within the administrative boundaries of individual cities. Most of such trips were registered in Katowice. However, such a figure may also be caused by a large number of measuring points located in its area.

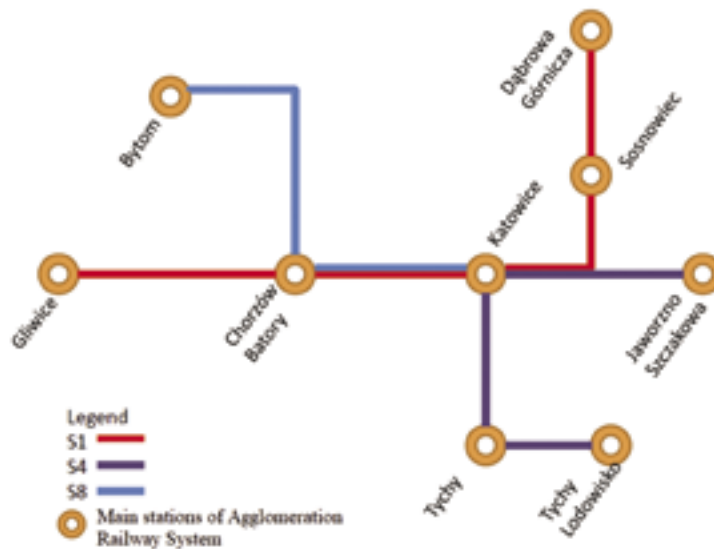
4. The concept of the Agglomeration Railway System in the Upper Silesian Conurbation

The concept of constructing of the Agglomeration Railway System in the Upper Silesian Conurbation was preceded by surveys verifying the transport preferences of its inhabitants. Based on the results of this research and the inventory of the existing Public Transport connections, individual connection lines of the agglomeration rail with the frequency of running trains have been prepared. Figure 2 presents the proposed scheme of connections of the agglomeration railway of the Upper Silesia conurbation.

The figure shows that the concept contains the idea of creating three connectionlines marked successively S1, S4 and S8. The line designations come from the previous numbering

of regional trains of the Koleje Śląskie company running on given routes. Table 6 presents proposals for frequency of running trains on individual lines.

Figure 2. Network of the Agglomeration Railway System.



Source: Lach, 2017.

Table 6. Frequencies of the Agglomeration Railway System trains.

| Name of line | Connection | Frequency of trains during rush hours | Frequency of trains without rush hours |
|--------------|-------------------------------|---------------------------------------|--|
| S1 | Gliwice – Sosnowiec | 30 min | 30 min |
| | Sosnowiec – Dąbrowa Górnicza | 30 min | 60 min |
| S4 | Tychy Lodowisko – Katowice | 30 min | 60 min |
| | Katowice – Jaworzno Szczakowa | 60 min | 60 min |
| S8 | Katowice – Bytom | 15 min | 30 min |

Source: Lach, 2017.

In connection with the possible introduction of trains from the Agglomeration Railway System, the routes of some regional trains of the Koleje Śląskie company must be changed or included in the said system.

5. Summary

The following conclusions were drawn on the basis of the analyses:

- the potential of the regional rail is not sufficiently used in the Upper Silesian Agglomeration;
- the tariff integration system should take into account all the public transport organizers;

- the forecast number of trips shows that there is a tendency of an increase in the number of passengers using public transport;
- to meet the growing number of passengers, the agglomeration rail system should be integrated with other organizers;
- the agglomeration railway should become the core of the agglomeration transport system;
- the agglomeration rail system may be a huge competition for individual transport, which in turn may lead to a reduction in the number of passenger cars in the agglomeration's road network;
- the results of the surveys carried out confirm the superior character of the city of Katowice throughout the Upper Silesian Agglomeration;
- in the further analysis there should be obtained more information about passenger journeys;
- continuous research of passenger flows in public transport vehicles help in immediate response to changes occurring in transport preferences of the residents;
- the proposed concept assumes the introduction of three main lines: S1 from Gliwice to Dąbrowa Górnicza with the frequency of 30 min, S4 from Tychy Lodowisko to Jaworzno Szczakowa with the frequency of 30 min, S8 from Katowice to Bytom with the frequency of 15 min. The given frequencies of operations apply only for rush hours.

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