Mariusz Korzeń
mgr inż.
absolwent Politechniki Wrocławskiej
Wydział Budownictwa Lądowego i Wodnego
mariuszkorzen9@gmail.com

Igor Gisterek
dr inż.
Katedra Dróg, Mostów, Kolei i Lotnisk
Wydział Budownictwa Lądowego i Wodnego
Politechnika Wrocławska
igor.gisterek@pwr.edu.pl

DOI: 10.35117/A_ENG_21_06_07_02

Create of the Agglomeration Railway in Wrocław with the use of new cross-city sections

Abstract: The paper is closely related to the article "Concept of the cross-city railway route in Wrocław to create the LRT system" (PK 2/2021, p. 6-10) [2] and is a continuation of the topic related to create of the Agglomeration Railway system in Wrocław with particular emphasis on city traffic service. The study focused on the creation of an efficiently functioning system, the key element of which is the cross-city section. It has been pointed out that the route of the cross-city section will be the main factor that will determine the level of use of railways in journeys within the city limits. Therefore, the current condition of the Wrocław Railway Junction was analyzed in terms of adapting it to the needs of LRT, focusing primarily on the best accessibility of travelers to system. Places where new stops should be created to increase the attractiveness of agglomeration transport have been indicated. In the following points, three variants of system are proposed depending on the route of the cross-city route. In the summary, the most advantageous variant was indicated and the use of hybrid sections (road-rail) was proposed as one of the solutions that could improve the transport network in the city in the near future.

Keywords: Agglomeration railway; Wrocław; Cross – city route

Introduction

Fast City Rail (LRT) is a very attractive means of transport in urbanized areas (mainly in agglomerations), the main task of which is to transport a large number of passengers on short distances compared to the long-distance rail in a relatively short time. It is often a faster and more convenient alternative to reaching the city center, mainly from peripheral directions. The core of each LRT system is the place where individual lines converge, which is the cross-city section or the central station. It is important that the movement along the diameter takes place in a collision-free manner with other means of transport, therefore its course should take place along a flyover, on the ground level (embankment/ditch), or in a tunnel. The very route of the cross-city route will largely determine the attractiveness of rail transport, especially within the city limits. Often the city center is the main destination because of the traffic generators in this area, mentioned in the article [2]. That is why it is so important that the route of the cross-city route is adjusted to the transport needs of the inhabitants as much as possible.

Currently, there are several high-speed urban rail networks in Poland, including in Warsaw, the Tri-City, and Łódź, which effectively carry out their task by transporting a large number of people from and to the center in a relatively short time. Unfortunately, the LRT

system has not been established in Wrocław so far, despite a well-developed railway junction. However, even when creating a network, the cross-sectional section may be a problem. Currently, this is the flyover leading to the Wrocław Główny station from the side of the Wrocław Grabiszyn branch point. The limited capacity on the flyover can cause many restrictions on the operation of trains. Already, a large volume of transport can be observed in this area, and the addition of additional LRT lines may completely paralyze the traffic in the diameter. Therefore, following the example of many Western cities, it is worth considering the creation of a new section of a cross-city route in Wrocław, thus giving the possibility of running LRT trains with a high volume of transport without limiting the capacity of the existing diameter. In addition to the issue of the new diameter, it is also necessary to analyze what changes should be introduced within the Wrocław Railway Junction (WWK) in order to increase direct access to the railway network.

Distance between stops

The number of potential passengers will depend on the availability of the network. The access of travelers to the network itself takes place via platforms. Therefore, as the number of stops on the network increases, the attractiveness of this mode of transport increases. At the same time, it should be borne in mind that each subsequent stop on the train extends the total travel time. Therefore, stops should be located where they are most needed. There is a tendency that the distances between stops vary depending on their distance from the center. The farther the stops are from the center, the greater the distance between them and vice versa. This relationship is closely related to the population density in the city. Due to the high population density in the city center, stops should be more densely distributed in order to be able to handle much larger flows of passengers than in the periphery. Analyzing the average distances between stops on the urban rail network, the study [3] concluded that:

- the distance between the stops in the center is in the range of 500 - 1000 m, although the most common value was approx. 800 m,
- the distance between stops in the suburbs of the city is in the range of 800 - 1500 m, although the most common value was approx. 1000 m,
- distances between stops in the agglomeration area depend on the location of the town along a given line, usually between 1500 and 2000 m.

It can be initially assumed that the distances between successive stops in the city center should not exceed 1000 m. This is of course dependent on many factors, e.g. the route of the line through a natural obstacle or the location of large interchange nodes. However, the stops should not be located too close to each other for the network to be effective and fulfill its basic task of fast passenger transport.

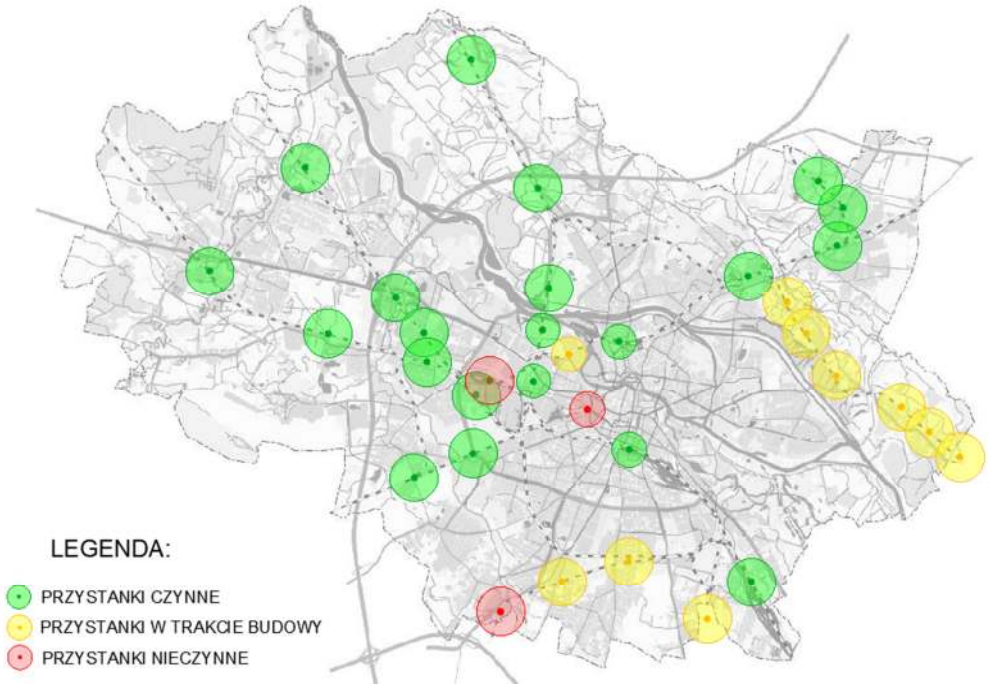
Adaptation of WWK to the needs of LRT in terms of accessibility to infrastructure

WWK consists of a dozen or so lines (including all slip roads and a goods bypass, which shows that the Wrocław agglomeration has a great potential to create the LRT system. However, modifications to the infrastructure should be introduced so that the node meets the requirements for agglomeration railways. the possibility of increasing the capacity of the route in the area of the existing cross-city route, which was discussed in the work [5]. This study focuses on the direct accessibility of travelers to the railway network, which can be expressed by the distance from the foot to the stop. walking distance to the S - Bahn stop These values are respectively:

- city center: 350 – 500 m,
- area outside the center: 400 – 700 m,
- city outskirts: 500 – 800 m.

On the basis of the above data, it is possible to define the city area with direct access to the railway network. Due to the size of Wrocław, only the first two zones of access to the stop have been adopted. Therefore, it was assumed that the value of 500 m in the center (Downtown, Old Town) was assumed, and 700 m in the rest of the city.

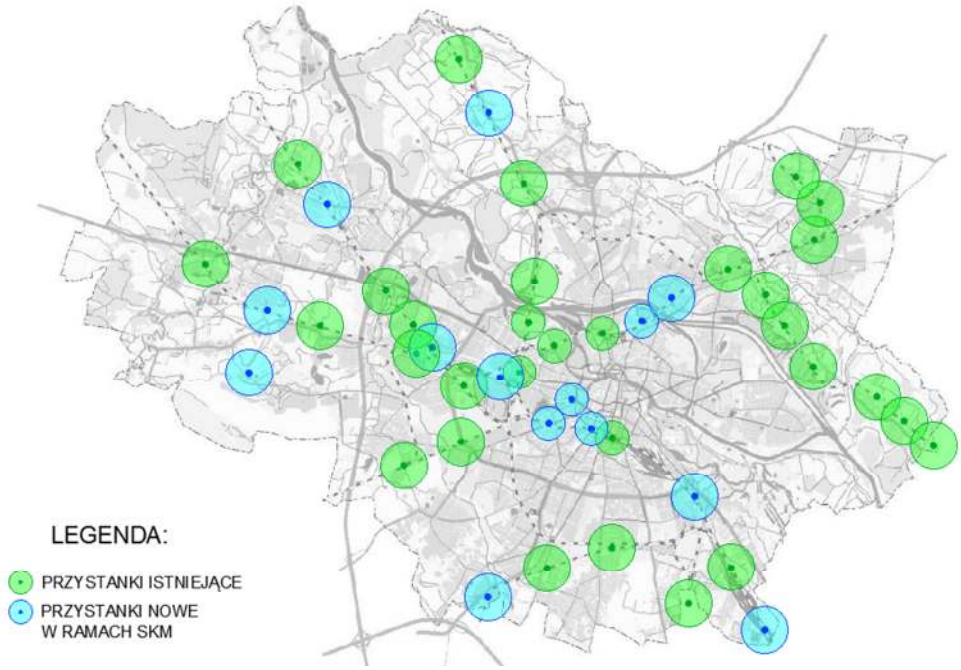
Figure **1** shows the current state of WWK in terms of the location of railway stops on the city map. Currently, there are 21 stops in operation, located mainly in the western and northern parts of the city. They are marked in green on the map. Currently, railway line No. 292 towards Jelcz Laskowice is being renovated and line No. 285 towards Świdnica via Sobótka is being renovated. Additionally, construction of new stops is underway, i.e. Wrocław Szczepin and Wrocław Iwiny. Stops under construction and put into operation in the near future are marked in yellow on the map. 3 railway stops (i.e.: Wrocław Świebodzki, Wrocław Klecina and Wrocław Gądów) marked in red on the map are not planned for operation in the near future. The circle marked the area of direct pedestrian access to the stop. Counting all the stops to be used on the network (yellow and green) there will be 31 of them in total. This is quite a large number considering the size of the city. However, the problem is the low number of stops within the city center. Due to the fact that WWK currently circles the city center, there are only 5 train stops in the city center, which is very few. In order to increase the attractiveness of rail transport, especially those planned under LRT, it is necessary to increase their number and place them in the vicinity of the current traffic generators. Moreover, the distances between stops are often greater than those recommended for agglomeration connections. Therefore, the number of stops should be increased while maintaining an appropriate distance between them. The number of new stops and the layout of the entire LRT network will depend on the number of new cross-section sections proposed. In addition, when designing the LRT system layout, city plans related to the construction of the railway line to the airport were also taken into account.



1. The current state of WWK in terms of the location of railway stops on the city map. Own work in the background [10]

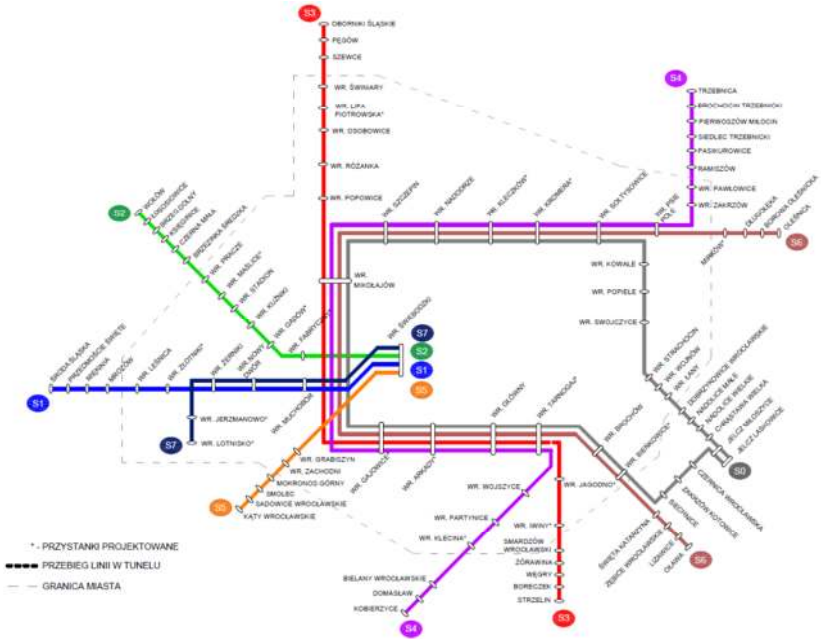
Option I of the LRT system without a new cross-city section

It is the most economical option as there is no need to build new routes. The existing railway flyover will become a section of the diameters on the network. The very limited capacity of the flyover may be a problem. Therefore, a necessary condition for launching the network in this variant is the extension of the flyover with an additional track, as described in [1, 5], and the restoration of the railway function of the Świebodzki Railway Station. It has been proposed to create 14 new stops, including 4 in the city center. The location of the new stops is shown in Figure **2**.



2. Arrangement of stops on the city map in variant I.
Own elaboration, based on [10]

With this information in hand, you can start building your network. The network layout was developed on the basis of the analysis of the existing examples described in [3] and on the basis of the earlier concepts of the Agglomeration Railway routes included, inter alia, in the book [4], the report [6] and in the article [9]. The main criterion when designing individual lines was to meet the transport needs of the residents of Wrocław and the agglomeration with an emphasis on servicing the center and adjusting the lines in terms of operating parameters (maximum speed, number of tracks, type of traction, etc.). It is also worth considering the directions of the city's development in terms of the creation of new housing estates and future business and service centers. In addition, each line should run through the city center, and at stops in the city center, it should be possible to travel to the largest possible part of the city. The proposed network diagram in Variant I is shown in Figure **3**.

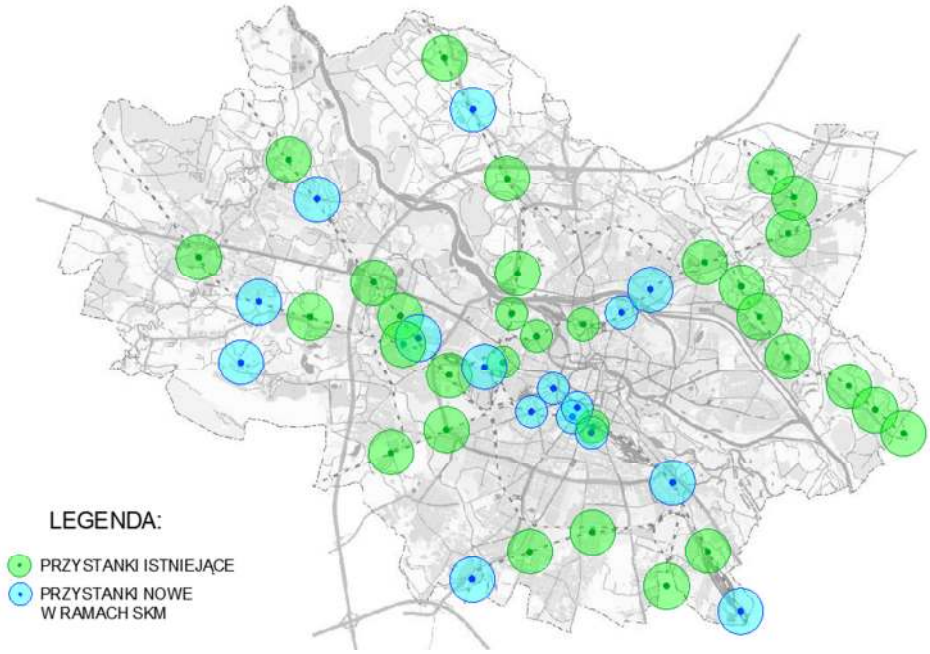


3. Scheme of the LRT system in variant I. Own elaboration

A total of 8 lines were proposed, including one perimeter line. Part of the line ends at the Wrocław Świebodzki station, so it will become a fairly important interchange junction, mainly for servicing the western part of the city and the agglomeration. The major disadvantage of this option is still the lack of direct access to the city center railway network. The necessity to change flights causes a decrease in the attractiveness of transport within the city limits and extends the travel time.

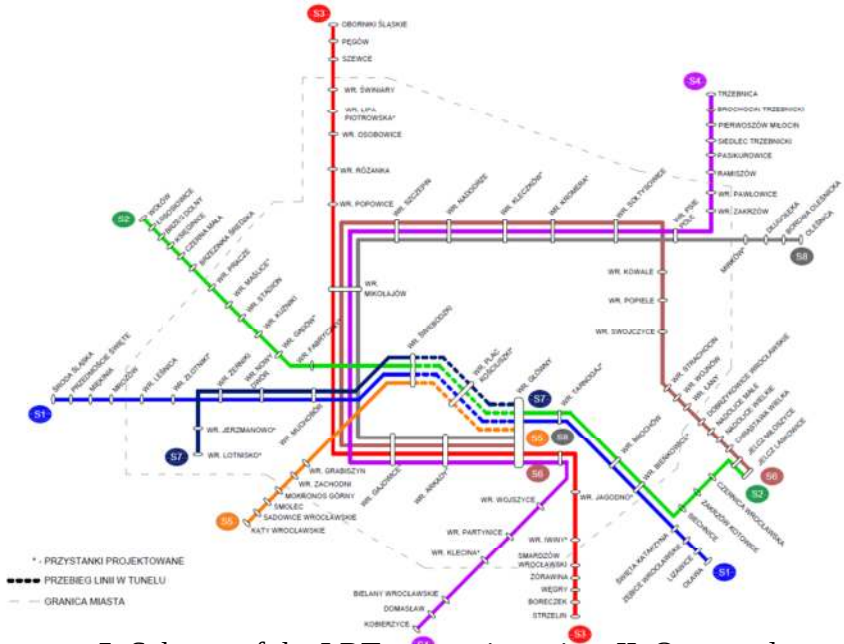
Variant II of the LRT system with the tunnel connecting the Świebodzki Railway Station and the Main Railway Station

The variant assumes the construction of a tunnel connecting the Świebodzki Railway Station and the Main Railway Station, thanks to which the Świebodzki Railway Station will become a transit station. The idea of creating a route connecting both stations with a similar course was described in the article [7]. In this variant, it would also be necessary to use the existing railway flyover and consider the need to extend the flyover with an additional track to maintain the required diameter capacity. The new route will protect the capacity in the area of the center in case of problems with maintaining the flow of traffic on the flyover. 16 new stops were proposed, including 6 in the city center. The location of the new stops is shown in Figure **4**.



4. Arrangement of stops on the city map in variant II.
Own work based on [10]

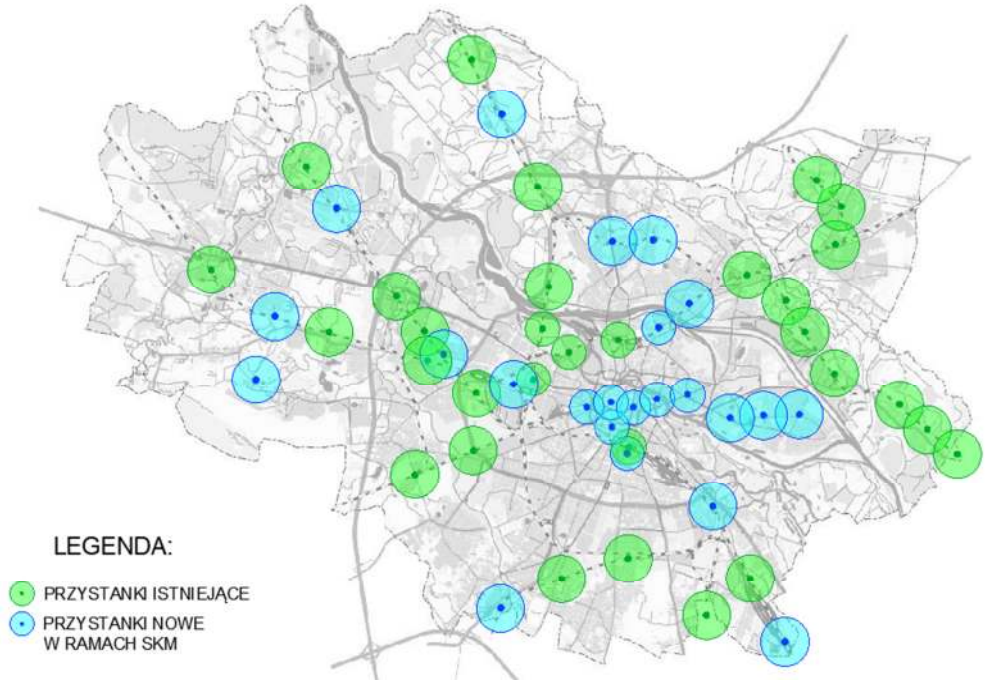
The LRT system diagram in variant II was developed on similar principles as in Option I. The proposed diagram of the network is shown in Figure **5**, which consists of 8 lines, similarly to variant I. Thanks to the construction of the new route, it was possible to extend the routes ending in variant I at the Świebodzki Railway Station. As a result, there are more options for laying the line, thus increasing the transport offer and the attractiveness of rail transport. The newly designed tunnel section is marked with a dashed line. All lines run through the Wrocław Główny station, although changing between the lines may be difficult due to the passage of trains on two levels. Unfortunately, the construction of the new route will not significantly increase direct access to the city center railway network. Therefore, it would be necessary to adjust the communication system of public transport (bus, tram) in terms of the shortest travel time to LRT stops, with particular emphasis on access to the Main Railway Station.



5. Scheme of the LRT system in variant II. Own study

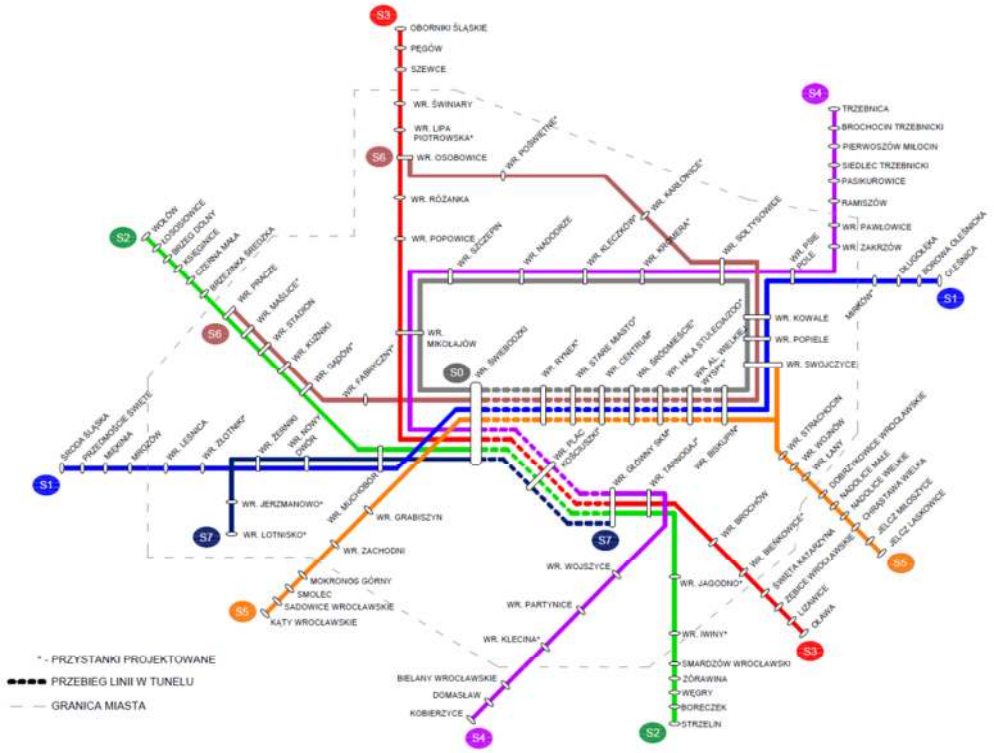
Variant III of the LRT system with two new cross-city routes

This is the most extensive variant. It provides for the construction of two new cross-section sections in the tunnel. Their detailed course is described in article [2] and work [3]. As in option II, it was proposed to create a link between the Świebodzki Railway Station and the Main Railway Station. Additionally, a tunnel under the city center has been proposed, which will significantly increase the capacity in this area. There is also no need to run the line on the railway flyover, assuming that it will be used only for regional and long-distance connections. A total of 23 new stops were proposed, including 8 in the center. Their distribution on the city plan is shown in Figure **6**.



6. Arrangement of stops on the city map in variant III.
Own work based on [10]

On this basis, the network diagram shown in Figure **7** was developed. As in variants I and II, there are 8 lines in total, including one perimeter line. The newly designed sections in the tunnel are marked with a dashed line. All lines pass through the Wrocław Świebodzki station. Therefore, the area of Orląt Lwowskich Square will become the most important and best-connected place in the city, from which it will be possible to travel to virtually every part of Wrocław without changing. The advantage of this option is that there is no need to change trains to travel to the city center, which is especially important for people traveling within the city limits. Unfortunately, it is also the most expensive of the proposed variants. The construction of the tunnel, especially the longer one, is currently beyond the city's capabilities. Therefore, the implementation of such a costly investment would be possible only in cooperation with PKP PLK and co-financing from the European Union, as is the case with the construction of a cross-city tunnel in Łódź. Difficult soil and water conditions within the city may prove to be an additional problem, which may make construction impossible or increase the already high construction costs.



7. Scheme of the LRT system in variant III. Own study

Summary and conclusions

In October 2019, PLK signed contracts with contractors for feasibility studies for the Wrocław Railway Junction, as well as the railway line on the Św. Katarzyna - Wr. Muchobór and Wr. Świebodzki [12]. The detailed scope of the study is included in the Description of the Subject of the Contract [11]. On the basis of the study, plans for the development of railways after 2020 will be determined. restoration of the railway function of Świebodzki Station and its reconstruction to a transit station, as well as the construction of a railway line leading to the airport. The quoted document shows the interest in improving the transport network in the region and in the agglomeration itself. This is a good prognosis for the construction of an efficiently operating agglomeration railway network in Wrocław in the coming years.

In connection with the above, it is worth considering the possibility of creating the LRT system in Wroclaw. The study proposes three variants of the network, depending on the route of the cross-city route. Additionally, in order to increase the accessibility to the network within the city, it was proposed to locate new stops with an appropriate distance between them. Variant I, due to the limitations of the use of the railway flyover, may result in large restrictions in the running of trains, and thus the LRT may be ineffective. The most feasible variant is variant II with the construction of a tunnel connecting the Świebodzki Railway Station and the Main Railway Station. Unfortunately, this solution still forces people traveling to the city center to transfer and it will also be necessary to use the railway flyover. Therefore, the creation of the LRT system in variant II will mean that the new means of transport will be focused mainly on servicing the agglomeration rather than the city itself. Therefore, it would be a much better solution to set up a network in Option III, but the high implementation costs currently prevent this goal.

In that case, it is worth considering whether there is a possible solution that will allow for the creation of a new cross-city route with a high collision-free route without the need to build expensive sections in the tunnel. One of such solutions may be the introduction of hybrid vehicles that could move on both the rail network and the road network with their appropriate adaptation. In addition, thanks to this solution, it will be possible to route routes

more freely, and thus it will be possible to adapt the network to the transport needs of residents. The strength of this solution is the elimination of transfers, which significantly increases the attractiveness of this means of transport. In the area of the city center, it will be possible to create collision-free routes at the ground level, e.g. in a ditch using the city moat or partially in a tunnel to increase the collision-free passage. It is quite an innovative solution and requires a lot of research related to the adaptation of the infrastructure and the vehicles themselves. However, this does not change the fact that the idea of using hybrid vehicles in public transport should be analyzed in more detail as one of the solutions that may contribute to the improvement of the quality of travel in urban agglomerations.

Source materials

[1] Gisterek I.: Projekt dobudowy czwartego toru na estakadzie kolejowej we Wrocławiu wraz z identyfikacją zagadnień podtorzowych. Przegląd Komunikacyjny 11/2012, s. 19-22.
[2] Korzeń M.: *Koncepcja kolejowej trasy średnicowej we Wrocławiu w celu uruchomienia sieci SKM*. Przegląd Komunikacyjny 2/2021, s. 6-10.
[3] Korzeń M. „*Koncepcja tunelu dla SKM we Wrocławiu*". Praca dyplomowa magisterska, opiekun I. Gisterek, Politechnika Wrocławska, 2021 r.
[4] Kruszyna M.: *Koleje miejskie i regionalne w Polsce*, Monografia, Łódź Księży Młyn Dom Wydawniczy 2018.
[5] Kruszyna M., Makuch J.: *Koncepcja rozbudowy estakady kolejowej w centralnej części WWK*. XIII Konferencja Naukowo – Techniczna „INFRASZYN", Zakopane 9 – 10.06.2021 r.
[6] Kruszyna M., Makuch J., Popiołek A., Gasz K.: *Koncepcja rozwoju pasażerskiego transportu kolejowego w Aglomeracji Wrocławskiej poprzez uruchomienie Wrocławskiej Kolei Aglomeracyjnej*. Raporty Wydziału Budownictwa Lądowego i Wodnego Politechniki Wrocławskiej. Raport SPR nr 32/2017.
[7] Kruszyna M.: *Propozycja wprowadzenia odcinków podziemnych w transporcie zbiorowym Wrocławia*. Transport Miejski i Regionalny, 12/2015, s. 3 - 6.
[8] Light Rail in Germany, VDV 2000, red. G. Girnau, A. Müller – Hellmann, F. Blennemann
[9] Makuch J.: *Działania niezbędne dla uruchomienia atrakcyjnego systemu kolei aglomeracyjnej na przykładzie Wrocławia*. XI Konferencja Naukowo – Techniczna „INFRASZYN", Zakopane 18 – 20.04.2018r.
[10] Podkład mapowy - System Informacji przestrzennej Wrocławia, https://geoportal.wroclaw.pl/
[11] Opis Przedmiotu Zamówienia dla przetargu nieograniczonego na wykonanie dokumentacji przedprojektowej w ramach projektu: „Wstępne Studium Wykonalności dla Wrocławskiego Węzła Kolejowego wraz z opracowaniem Studium Wykonalności C-E 59 – odcinek Święta Katarzyna – Wrocław Brochów – Wrocław Muchobór/Wrocław Kuźniki". Zadanie I: „Wstępne Studium Wykonalności Wrocławskiego Węzła Kolejowego" (WSW WrWK). PLK 2019.
[12] Strona internetowa: https://www.rynek-kolejowy.pl/mobile/plk-podpisala-umowy-na-studia-rozbudowy-wroclawskiego-wezla-kolejowego-93840.html