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RAPID AGGLOMERATION LIGHT RAIL SYSTEM AS A RESPONSE TO SPATIAL PLANNING IN THE CRACOW METROPOLITAN AREA: TYPOLOGY OF TRAIN STOPS

Summary. This article presents the concept of division and assigns the railway stops, which are part of the rapid agglomeration light (RAL) rail system within the Cracow Metropolitan Area (CMA), in relation to two criteria. We can see considerable variation in the functions of the railway stops, even if they are located in the same metropolitan area. In this article, a review of the policy and planning document concerning the RAL has been conducted.

Keywords: rapid agglomeration light rail system; sustainable urban development; transport systems; urban planning.

1. INTRODUCTION

Polish cities are changing their image and character as a result of economic growth and the expectations of their residents. When looking at the development of Cracow, one can form the impression that it replicates the mistakes of other European cities from the times when they were also experiencing economic growth. Improved access to the car, as well as the growth of the automotive industry, has led to the fact that the mobility of people in the cities is expanding. Making additional trips, apart from commuting to work or study

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centres, is easier, because a car facilitates access to places of service, entertainment and recreation, which are often located at a considerable distance from the car owner's home. The availability of a car, especially for urban residents, is extremely important, because the distance between home and work forces them to use this means of transport. At the same time, the availability of a car makes it easier to live outside a big city. However, this contributes to the effect known as "urban sprawl", which is accompanied by an increase in the number of cars on the inlet roads. This effect has a negative impact on the functioning of the city, as well as distorts its profile and degrades the spatial order. This leads to problems related to the management and development of spatial structure, resulting in the lowering of the quality of life of city residents. The most effective, indeed only, means of transport is rail, which, in the form of the agglomeration railway network, can use the existing infrastructure to provide quick access to chosen destinations (rail is not exposed to the effects of automotive congestion), as well as generate the environment around train stops, such that cities and towns develop in those places located along the train route. However, above all, it is imperative that the agglomeration railway stops are found within the network that is accessible to residents, thereby enabling them to fulfil a full range of activities. Therefore, the environment around train stops and how they are serviced must develop.

The RAL (SKA, in Polish) rail system offers Cracow the chance to develop as a metropolitan centre (in terms of the economy, science, its universities and culture), as well as provides an opportunity for the residents of townships within the agglomeration to increase their standard of living in a balanced way: namely, living in quiet towns and working in a big city.

This article is the first step in the author's assessment of the development of the railway stops' surrounding. The proper development of those stops could increase their attractiveness and effectively respond to passenger demand, as well as deal with the agglomeration railway system's financial issues.

2. FUNCTION OF STOPS WITHIN THE RAL RAIL SYSTEM IN THE CMA

Residents of cities located within the agglomeration and working in Cracow would like to commute to work much faster and in more comfortable conditions. The offer of the urban rail network would meet these demands. However, for that system to be fully operational and influence an increase in the share of journeys made by rail, it is important to ensure good transport accessibility to RAL bus stops, while the form of spatial planning around these stops should increase the attractiveness of their use. In turn, it is noticeable that both the availability of different means of transport and the environment of these stops are unattractive, such that they discourage people from using this public transport option in their daily travels.

The main problems in the planning process are concerned with underestimating the role of the bus stops and railway stations in a rational reconstruction of the CMA in terms of sustainable mobility of its residents. What is noteworthy is the significant lack of communication in conducting planning activities related to transport and spatial structure of the city, and of the agglomeration more widely, particularly in terms of the rail system. Of note, railway stations and RAL stops, along with their surroundings, are real and potential sites that make up the so-called urban nodes in the transport category.

An urban node in the category of transport is an element in the spatial structure of an agglomeration, which allows for free and efficient journeys between home-work-home and eliminates unnecessary trips, while ensuring a high quality of public space and

the environment. At the same time, its form and degree of development contribute to creating behaviours of residents in the spirit of sustainable mobility and reduces automotive congestion on the road networks of the city and within the entire agglomeration. Therefore, we should strive to improve the accessibility of RAL stops by different means of transport, such as public and bicycle transport options, while taking into account pedestrian and car access ways (i.e., park and ride systems). At the same time, efforts should be made to develop the surroundings of railway stations, so that the types of buildings erected around them encourage residents to travel using this means of transport because they provide various types of functions (service, office, residential). The presence of these forms of functional buildings around a train station will help to increase passenger capacity and, in turn, the efficiency of the service offered in the area by RAL. The surroundings around RAL sites represent an attractive offer for the private sector (e.g., office buildings, shops), given that the price of land around railway areas is quite low. Regeneration of the surroundings of stops/stations can help to increase the value of the land located in their vicinity, which will further improve the efficiency of the RAL. Currently, there is a huge gap in the planning process with regard to the surroundings of stops and railway stations as interchange nodes. Therefore, it is necessary to better integrate transport system planning with the functional and spatial structure of the city, including improving the quality of public spaces, which have transport-related aspects. Such actions may affect the strengthening of passenger potential (including rail transport), while reducing car congestion on the agglomeration road network.

3. FUNCTION OF STOPS ALONG THE RAL RAIL SYSTEM IN THE CMA

A very important factor in the development of the RAL rail system in the CMA is the presence of this issue in planning documents. The lack of reference to the potential form of development in these studies can impede the implementation of this project. On the other hand, it is essential to pursue scientific research into the significance of the presence of such a system in the spatial structure of a large area (in this case, the metropolitan area).

The regional context regarding the development of the RAL rail system is extremely significant, since the functioning of this form of transport is very closely related to the spatial structure of the region. Urban rail is mainly dedicated to journeys made from municipalities located within the metropolitan area to the core of the city, which represents its centre of gravity in economic terms. The direction of the development of the CMA has been extensively discussed in the *Urban Development Plan for the Malopolska Province* [8]. In this document, the CMA was described as a functional region, the centre of which is a big city (Cracow), while the rest comprises neighbouring settlement units, which are interconnected with the metropolis by different interactions. The CMA's limit was determined by the criterion of so-called "functional commuting to work". Thus, at the stage of the delimitation of the metropolitan area, an important factor was the impact of transportation. The document notes that the border of the area was determined by the spatial extent of the mutual arrangement of the labour and housing markets. Linking these two areas of activity by an efficient transport system, then, gives an important context. The document entitled *Development Strategy of the Malopolska Province for 2011-2020* [9] notes the important role of the development of the CMA, particularly in terms of places of residence and work. The document clarifies strategic objectives, including those relating to transport infrastructure. For this purpose, high external and internal transport accessibility of the region was assumed, which was to be competitive and coherent in terms of economic and spatial

planning. Particular attention was to be paid to improving the internal accessibility of the region, where the development of integrated transport within the Cracow agglomeration was to take place based on the RAL rail network, as well as the pre-metro/metro and fast tram networks.

Another document that more broadly deals with transport issues in the regions is the *Strategy of Transport Development in the Malopolska Province for 2010-2030* [7]. The primary objective of the development of rail transport in Malopolska is the development of infrastructure in order to increase the share of this means of transport in the public transport framework and increase the transport availability in the regions of Malopolska. The document also defines intermediate targets for the development of the railway system in the Malopolska region, including improving the accessibility of the railway in relation to the infrastructure of other means of transport, in particular, road and air transportation, in order to provide a modern connection to the Balice airport and bus termini. This provision, though a little enigmatic, suggests that it is appropriate to improve the availability of RAL stops in relation to different means of transport (including the improvement of the public transport services). For the authors of the document, its direct purpose concerns the modernization of the existing railway lines in order to offer better services to the regional passenger traffic, as well as adapt the infrastructure to meet the needs of persons with reduced mobility (reconstruction of railway stations) and increase the frequency of regional and agglomeration trains.

The *Plan for the Sustainable Development of Public Transport in the Malopolska Province* [6] draws attention to the important role of the railway system in transport services for residents of the province. This, in turn, will be done by removing most of the traffic from the roads. This objective can be achieved, for example, by increasing the availability of railway stations through their greater density on the railway lines, as well as the organization of access to railway stops with coordinated timetables and the construction of interchange nodes, parking lots at railway stops. A series of public transport service standards was also defined, including those relating to rail, such as pedestrian access roads to platforms, "park and ride" (P&R) spaces, "kiss and ride" places etc. That said, this study lacks detailed guidance concerning the forms and functions in developing the surroundings of the train stops. Locally, there are numerous documents that ought to include issues related to the development of the city or municipality in combination with a railway system. One such document is the *Study of Conditions and Directions of Spatial Development in the City of Cracow* [10]. In terms of external transport, the document lists rail as the primary means of transport. In terms of the rail connections for Cracow and the Cracow agglomeration, a new element in the transport system, which will be RAL rail, is to be introduced. This issue is addressed very widely in the aforementioned document. As part of the tasks, and in order to improve the accessibility of Cracow, it is planned to build new stops (apart from the already existing ones that have been modernized) and construct more P&R spaces.

At the same time, interchange parking lots and bicycle racks are to be available at each RAL stop. It is also possible that RAL transport will be provided on other railway lines, which are already active in Cracow. At the same time, it is planned that bus and microbus transport will service those municipalities that are not supported by rail. At the same time, agglomeration lines will end before the border of the downtown area in termini that will allow changes to rail or tram. Therefore, the question of connecting rail with bus transportation or the microbus system is addressed. That said, the place where these two systems are connected will likely not be made in the downtown and city areas, but on the train stops located outside of the city and in the outskirts. Regarding internal connections, rail constitutes an important addition to the tram system and the planned metro (or its variant). In the document, we can

see that the interchange nodes of the agglomeration rail and metro are important factors in the development of urban investments, due to the significant transport potential of these means. Therefore, in their vicinity, it is important to increase the intensity of land use. Unfortunately, nothing is said about the function of these areas, which is a very important issue.

The *Integrated Development Plan of the Public Transport for Cracow for 2007-2013* [15] broadly refers to the development of RAL. For example, it assumes a travel time of 25 min within Cracow and 45 min when commuting to Cracow from a location within the area of CMA; the expansion of the main railway station is also mentioned. Regarding the interchange nodes, P&R parking facilities are mentioned, but only at the Wieliczka, Batowice and Swoszowice stops. At the same time, the document puts an emphasis on the crucial role of the P&R spaces at railway stops. In the document, we can see a number of recommendations regarding the implementation of the RAL system, such as increasing the role of spatial planning of the surroundings of railway lines, the lack of interest from investors as to the location of the investment, exploiting the potential of the railway line, and the consideration of additional train stops in existing housing estates (Sidzina, Skotniki and Kobierzyn). The document also draws attention to the transport links of the planned stops within the public transport (mainly tram) network.

In the document *Transport Policy for the City of Cracow for 2007-2015* [11], a number of ways regarding the development of the city and the agglomeration of Cracow (and its surroundings) in a sustainable way is presented. This includes striving for consistency across all transport systems, such that local (urban and suburban), regional, national and continental networks are within reach of residents, with special attention being paid to the development of relations between regional and metropolitan areas, including the use of existing railway lines, as well as the integration of a spatial and functional urban transport subsystem with other subsystems (including interchange parking spaces for cars and enabling the use of the means of public transport to carry bicycles) and stimulating the development of the city within the areas that are well serviced by public transport and in direct vicinity to train stops (railway, tram).

Among the local and strategic planning documents of the municipalities located along the rail corridors, local area development plans and the main development strategies stand out. Unfortunately, the analysis of these documents [1]-[5], [12]-[14] pointed to the underestimation of the role of the means of transport in connection with the centre of the agglomeration. While some documents indicated a significant potential for the suburban railway network connected with Cracow, the surroundings and the servicing of stops are hardly addressed. Meanwhile, these elements are crucial to the success of the RAL project.

Summarizing the documents at the regional level, we could state that the development of the railway system in the CMA was important to the authorities of the province. Each document emphasizes the role of spatial development of Malopolska and the need to improve the accessibility of this area by a railway system. However, in the analysed documents, there are significant deficiencies. There is no mention of the issues related to the necessity of developing the surroundings of the stops/railway stations in order to increase passenger potential and the efficiency of the respective means of transport. What is also missing is a clear message regarding the improvement of the availability of train stops, as well as the development of road infrastructure (P&R facilities), public transport (lines serving railway station), and bicycle (parking lots, racks) and pedestrian infrastructure (convenient access routes). It seems that, in the above documents, the issues of the development of rail in the Cracow agglomeration are treated in a very general way, without providing the tools for

the implementation of sustainable development of the CMA in terms of transport and spatial planning.

At the local level, the matter of RAL is addressed in a slightly different way. Documents for the city of Cracow widely address the issues of the development of the urban light rail and its benefits, although they should indicate more detailed solutions. Municipalities belonging to the CMA treat this subject either to a smaller extent or not at all. Most often, the matters related to railway connections between the municipality and Cracow are neglected or they concern statements about the need to improve the connection of the municipality with transport (mainly by road, although sometimes by rail). The fact that no importance is given to the development of the railway system in the context of regional connections indicates that there is no understanding of this problem, while the chances resulting from such actions are poor.

4. TYPOLOGY OF TRAIN STOPS IN THE CMA

Train stations within the RAL system are crucial, given that, when properly developed, they can significantly affect the increase of the passenger potential and therefore change the modal split in terms of travel options within the agglomeration. These points as urban nodes may increase the efficiency of railway connections. However, given that such railway stops attract potential rail passengers (because they are attractive), they must be developed in terms of the land around them and the availability of train stops in relation to other means of transport, which, while ensuring a change from a train, offer access to the railway from remote areas of the agglomeration. These urban nodes become an inseparable part of the whole system of the RAL rail network, while their environment can contribute to the network's success or failure. In many planning documents, what seems to be ignored is the issue of the quality of the surroundings of the railway station, while the only component of success in its operation is the range and frequency of trains.

In general, the RAL rail network exceeds, by far, the boundaries of the CMA. This is particularly evident in the northern direction (the last stop on this line is located in Sędziszów) and towards the east (the last stop is Tarnów). Such an extension of service coverage of the RAL takes into account the real extent of commuting within the Cracow agglomeration [16]. This article will analyse all the railway stops that are function or are planned to function within the RAL system:

- SKA 1: Trzebinia-Kraków Główny-Tarnów
- SKA 2: Sędziszów-Miechów-Kraków Główny-Skawina
- SKA 3: MPL Balice-Kraków Główny-Wieliczka Kopalnia

It should be noted that, in the connection to the west, it also includes the area of influence of the Upper Silesian agglomeration. Planning a common rail system for both the Cracow agglomeration and the Upper Silesian agglomeration should be the subject of broader consideration, because these two areas have a high potential for development, not only economic, but also related to the residential function. Only an efficient transport system will allow for any modern development involving cooperation between Cracow and Katowice (towards the creation of an area called Krakowice), allowing the residents of these two agglomerations to freely choose the place of their work and their home. In the future, it might be reasonable to consider lengthening the route in the direction of Katowice, with a joint involvement of administrative bodies to activate train stops functioning in the system.

The attractiveness of the railway station in the RAL system may be dependent on the fulfilment of criteria (aspects) regarding the evaluation of such a stop, depending on the type of a stop. Therefore, it is important to define the criteria by which urban nodes (analysed stops) will be allocated to certain types. Two criteria (aspects), namely, structural and functional, were referred to in the author's paper.

The structural criterion takes into account the location of bus stops in the CMA area. This criterion provides for the classification of a bus stop to one of the following areas:

I - area of the city centre (CCA)
II - downtown area (DA)
III - residential area in the city (RA)
IV - area of suburbia (SuA)
V - area of small- and medium-sized cities within the CMA (SCA)
VI - area of exurbia (EuA)

The I area represents the centre of the city. Although the reach of the centre according to the document *Study of Conditions and Directions of Spatial Development of the City of Cracow* [5] is much greater in terms of the type of a stop, the structural criterion is only met by the main railway station (located in the city, which is the centre of the agglomeration; in this case, Cracow). The II area is downtown, but any stops that qualify for this type of area are partially located in the centre of the impact of the area.

In the second area, there are four RAL stops: Prądnicka, Grzegórzecka, Zabłocie and Krzemionki. The III area comprises areas where there are housing estates, most often with high intensity. Some of these stops are located in downtown Cracow (delimitation according to the study document), and some are in typical residential areas, even though they are still effectively considered as part of the downtown area.

The III area also includes bus stops that are located in the vicinity of major traffic generators, such as a shopping centre (Bonarka) or religious spaces (John Paul II Centre). All stops located in area III will mainly support travel in the city traffic. However, because of the presence of traffic generators, they can also be considered a destination for residents of the Cracow agglomeration (mainly in order to make purchases, but also for work-related motivations to a lesser extent). In area III, 13 RAL stops were qualified: Łokietka, Głowackiego, Bronowice, Żabiniec, Prądnik Biały, Prądnik Czerwony, Piastów, Płaszów, Podmiłów, Bieżanów, Bonarka, Łagiewniki and Centrum Jana Pawła II.

The IV areas are located around the border of the city, which is the centre of the agglomeration; the so-called suburbia. These house settlement units that functionally connect with the city, both on the administrative border of the city and outside its jurisdiction. These areas are strongly associated with the city centre in terms of functional and spatial matters. The predominant function of the structures in this area is single-family housing of low intensity, although it is concentrated in a relatively small area. Although the primary role of railway stations located in the area will be to offer source routes for journeys to the city centre, the stops can also service destinations if a stop is a traffic generator associated with workplaces (e.g., the Krzyzowka stop). In area IV, there are 14 stops of this kind: Złocień, Bieżanów Drożdżyska, Bieżanów Autostrada, Swoszowice, Kliny, Opatkowice, Sidzina, Mydlniki, Uniwersytet Rolniczy, Zakliki z Mydlnik, Krzyżówka/Olszanica, Balice MPL, Mydlniki z Wapiennik and Tarnów Mościce.

The V area includes small- and medium-sized towns located in the CMA. Train stations operating in the RAL system will, in this case, offer source routes for journeys to the centre of the agglomeration. Thirteen rail stops qualify as this type of stop: Skawina, Wieliczka Rynek,

Krzeszowice, Trzebinia, Słomniki Miasto, Miechów, Sędziszów, Bochnia, Brzeska, Zabierzów, Podbory Skawińskie, Wieliczka and Słomniki.

In the VI area, there are stops that do not qualify to serve areas IV and V, but are instead characterized by extensive building structures and a very low population density, i.e., exurbia. These stops are located at a considerable distance from the major centres of settlement and will be the source of trips to the centre of the agglomeration, which may include changes to other means of transport. Twenty-nine rail stops qualified as this type of stop: Wieliczka Bogucice, Węgrzce Wielkie, Podłęże, Staniątki, Szarów, Kłaj, Stanisławice, Cikowice, Rzezawa, Jasień Brzeski, Sterkowiec, Biadoliny, Bogumiłowice, Kraków Business Park, Rudawa, Wola Filipowska, Dulowa, Zastów, Baranówka, Łuczyce, Goszcza, Niedźwiedź, Smroków, Szczepanowice, Kamieńczyce, Dziadówki, Tunel, Kozłów and Klimontów.

The structural criterion takes into account the function of urban nodes, which is the role that they perform in the CMA. In the analysed stops, there are five such functions and they are:

I - the main nodes (MN)
II - nodal places, i.e., commercial centres (CcN)
III - nodal places, i.e., centres, housing estates (HcN)
IV - nodal places, i.e., multifunctional centres (McN)
V - other nodal places (ON)

The first type of stops selected for this criterion is the MN, performing the basic function in servicing the residents of the agglomeration and having the greatest importance in ensuring metropolitan connections. In this group, there are the main railway stations in large cities. In the context of the RAL, these functions are performed by the main railway station in Cracow and Tarnow Central station.

The second type of stop, around which land development has a commercial and service function, involves nodal places that have the role of CcN. The surroundings around such a stop can develop in the direction of office, service or sports functions etc. Such stops are important traffic generators, which should be well served by various types of transport, including RAL, creating a fully integrated interchange node. Four RAL stops qualified as this type of stop: Bonarka, Krzyżówka/Olszanica, Balice MPL and Zabierzów Business Park.

The third type of stop in the functional criterion is a nodal place performing the function of a housing estate. Spatial planning around such a stop comprises, and should resemble, residential buildings of medium and high intensity. Of course, in such an area, there should be additional functions, including service points (to ensure daily shopping is facilitated) and leisure venues (recreational parks, playgrounds etc.). However, this form should not be overwhelming in relation to the housing function. Nineteen RAL stops qualified for this type of stop: Łokietka, Głowackiego, Żabieniec, Prądnik Biały, Prądnik Czerwony, Piastów, Bieżanów, Łagiewniki, Złocień, Bieżanów Drożdżyska, Kliny, Sidzina, Mydlniki, Mydlniki z Wapiennik, Zabierzów, Podbory Skawińskie, Wieliczka, Słomniki and Tarnów Mościce.

Another type of a stop is a nodal place of a multifunctional centre type. The surroundings for this type of stop are varied and include housing, service, office and recreational functions. In addition to the stops within the city of Cracow, these stops can be found in small- and medium-sized towns of the CMA. Nineteen stops qualified for this type of stop: Prądnicka, Grzegórzecka, Zabłocie, Krzemionki, Bronowice, Płaszów, Podmiłów, Centrum Jana Pawła II, Uniwersytet Rolniczy, Zakliki z Mydlnik, Skawina, Wieliczka Rynek, Krzeszowice, Trzebinia, Słomniki Miasto, Miechów, Sędziszów, Bochnia and Brzesko.

The last type of stop in the functional criterion is a stop that, as a node, performs a different function to those mentioned above. Most often, this function is only focused on the possibility of providing a change onto urban rail from other means of transport. This does not mean that this type of stop performs a minor role in the RAL. On the contrary, it allows for journeys to be continued that were started by car from small- and medium-sized towns (also villages), which are not well serviced by other means of transport. There are many such town in the CMA. Therefore, an extremely important role in increasing the attractiveness of such a stop will be to develop the surroundings of such an interchange stop, with good accessibility by car as well as efficient interchange to rail. The following 31 locations qualified as stops that have the function of an interchange: Bieżanów Autostrada, Swoszowice, Opatkowice, Wieliczka Bogucice, Węgrzce Wielkie, Podłęże, Staniątki, Szarów, Kłaj, Stanisławice, Citkowice, Rzezawa, Jasień Brzeski, Sterkowiec, Biadoliny, Bogumiłowice, Rudawa, Wola Filipowska, Dulowa, Zastów, Baranówka, Łuczyce, Goszcza, Niedźwiedź, Smroków, Szczepanowice, Kamieńczyce, Dziadówki, Tunel, Kozłów and Klimontów.

An important element in the typology of stops is that they meet the requirements for completeness and lack of a disconnection. This means that each of the analysed stops must be simultaneously assigned to structural and functional criteria. Further work on this issue should seek to define the criteria characterizing the surroundings of railway stations, which will help increase the passenger potential of rail. If the railway stations do not fulfil these criteria, such knowledge will help to indicate those places in the railway network where quick improvement actions need to be undertaken.

5. CONCLUSION

Regarding the efficient redevelopment of the Cracow functional area, the main problems in the planning process involve a limited awareness of the huge role played by the railway stops in the context of urban sustainable transport. The lack of an integrated planning process in relation to land use and transportation is highly visible and ignites debate. The proposed method allows for city planners to make a plan concerning actual railway stops, which should be developed in the first stage, as well infrastructure elements that should be implemented.

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