

Strategy of Traffic Planning for new Developments together with Rail Track Public Transport - Experiences from Bratislava

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Abstract: The contribution deals with the development plans and possibilities of the Bratislava's northwest expansion, in area Bory – which with its size of approximately 817 hectares is owned by two major developers as well as the development of south-east part of Bratislava, in an area called Domové role. The contribution describes variants of possible integrated rail transport system extension, as it is classified as the cordial system of public transport by the Bratislava strategic documentation. The traffic service proposal deals with the new traffic infrastructure on given future and realized locations and generates input for the traffic model, which determines the proposal's necessity and effectiveness. Along with the urban tram with a narrow gauge of 1000 mm defined in urban planning documentation, the northwest area service is considered by the introduced standard gauge (1435 mm) tram-train track connected to the international railway link. This track is intended to be a part of the integrated suburban public transport system aiming to access the satellite town Stupava inside the Bratislava's city agglomeration. The south-east extension is proposed with urban tram narrow gauge of 1000 mm as well as in a standard gauge of 1435 mm, with the connection to existing tram track from the city centre to the most urbanized part of a city – Petržalka. The routing of a new track involves the construction of the bridge over the river Danube, which can be used also for pedestrians and the cyclists. The new track can be an important fast connection between the southeast and southern part of a city where is the most populated area of Bratislava and also the University campus is located. The connection like this, between these two parts of a city, is currently missing. We show solutions and measurements which should be followed by the area of urbanization in order to achieve sustainable development and sustainable mobility.

Keywords: Bratislava, Urban planning, Public transport, Tram-Train, Transport analysis, Integrated transport

I. INTRODUCTION

Everycity's development is subjected to urban planning documentation. Bratislava was not able to regulate its own development in a level of the smart city over the period of last decade. The impact of the developers is immense. And the city is not prepared. Such undirected expansion caused unrestrained build-out without a vision, without continual traffic service solutions in relation to the region within the agglomeration. Today the problem of every new investment is, that the investor wants to multiply the value of his real estate with minimal expenses. Furthermore, each new investment affects the existing urban area, where other people live for decades and they think of their environment very conservatively. The city should stand on the inhabitant's side and regulate the development. It should be pleasant for the people to remain, eventually to constantly return work, services, and amusement, because the city is worth living in. The city position in this issue must consist of systematic

regulation of build-out in order to reach the contemporary modern conception of forming so-called „smart cities“ – sustainable living and sustainable mobility. Each new investment, large or small, should have the solution for people's mobility system. The first level of the solution is correct saturation of various functions in a given area. The new city center of Bratislava is such a deal. The second level is traffic planning as a whole, not just to design the connection of an object to the road system, but to integrate the site into the supply – demand system of the city. In terms of the city development in Bratislava, a tram is defined as a carrying system of transport connection. This article deals with the current state analysis with introduction of strategic solution of area service by rail track public transport system.

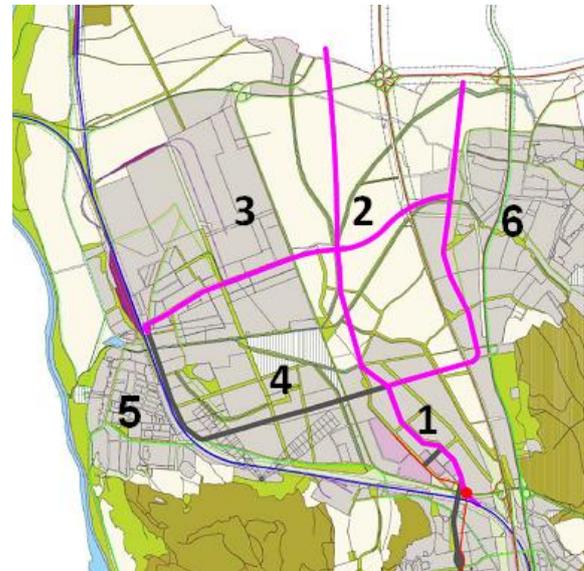


Fig. 1 City of Bratislava with solved areas [11],

Nord-Western Area (1) = Bory and CENTROP,
South-Eastern Area (2) = Domove Role and Malé Palenisko

II. NORD-WESTERN AREA OF BRATISLAVA

2.1 Area analysis

The given area is located in the southern part of Záhorie lowland between the massif of Devínska Kobyla and slopes of Lesser Carpathians. It lies within the city limits of Bratislava the capital of The Slovak Republic. The airline distance between area's southern edge and the city center is approximately 9 km. The area is delimited from the south by the road II/505 and parallel railway ŽSR 110, connecting Bratislava with Vienna and Brno, by the road II/505 along with Volkswagen car factory employing approximately 12 500 people from the east. The western edge consists of the motorway D2 connecting Bratislava with Brno and Prague and the northern limit is the D4 motorway, the future "zero bypass" of Bratislava.

Mentioned area is composed of two main parts – Bory and

CENTROP. Bory with the area of approximately 245 hectares represents the southern section between the road II/505 and Lamač creek[3]. CENTROP is located in the northern part from Lamač creek to the D4 motorway. Its area within the delimited area is approximately 570 hectares[4]. In the future, these two areas have to offer the housing, free time as well as the services and industry. All these together will be creating a new supply and demand for the transportation. First, transport-planning solutions in these areas were connected with the automotive industry, which was dealing with cca 12 500 new employees. This was before the new shopping center Bory-Mall was built. The opening of this shopping center leads to new constructions, which in the final, count with cca 59 000 inhabitants and over 15 000 new employees. In terms of transport, however, this areas will have a character oriented to the city center as well as other eastern and southern parts of the city. In most cases, the source and the target will not be in this area.

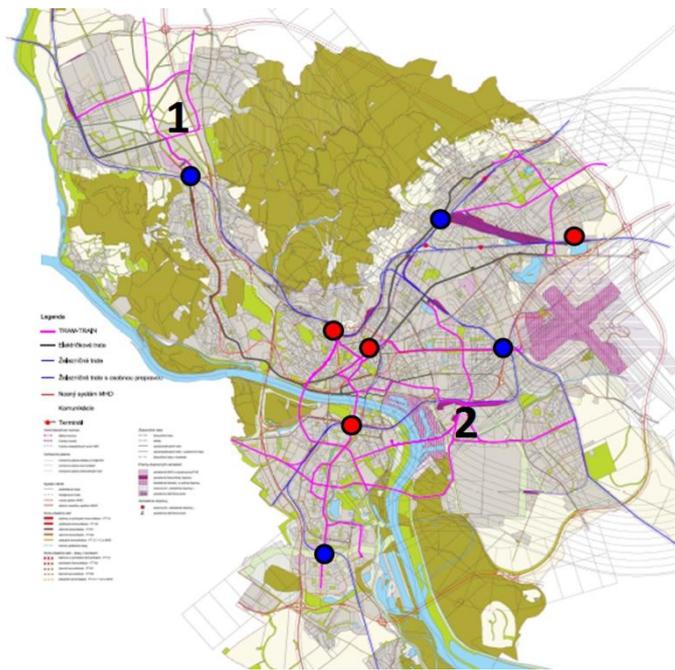


Fig. 2 Solved Nord-western area[11],

Bory (1), CENTROP (2), Automotive factory VW (3), Area "Pod Bančegovicami" (4), district Devínska Nová Ves (5), district Záhorská Bystrica (6)

2.2 Urban planning documentation of the city

Modal split of transportation is defining the achievement of transport objectives, which is not only for the city center's relations but also for its other development axes in the east and southern parts of the city. Its mainly focused on the system of public transportation as it is defined in the urban planning documentation of the city of Bratislava. In accordance to the valid urban planning documentation (UPD) the Bory area is meant for the build of services, offices, and retail (UPD code 201 – 165,6 ha) and mixed land use of services and residential zones (UPD code 501 – 41,0 ha). The northern part – CENTROP – is according to the UPD classified as agricultural land yet. The developer of Bory has already started with the urbanization. The shopping center Bory Mall and a part of the commercial zone Bory Retail, holding up to 20 large capacity business operations, were built there. In the southern part – Bory – the developer already finished some of the build-outs. The condition for further expansion was the establishment of a communication system servicing Bory Mall and Bory Retail zone[2]. The road II/505 was expanded to the four-lane road.

Twelve roundabouts were constructed in the area, four of them at intersections on the road II/505. Unfortunately, nowadays, after few traffic surveys and traffic analysis we already know, the improvement of the infrastructure for individual car traffic will not be a solution.

The most important thing in this area is the rail transport system as a carrying transport system which is marked in the Master Transport plan of Bratislava as well as in the urban planning documentation (UPD). The documents solve the operation on the new transport infrastructure at current and future areas of construction and create inputs for the transport model that determines the requirements and efficiency of the planning. The public transport operation of this area count with a Bratislava's city tram with a gauge of 1000 mm which is currently marked in UPD[5], as well as a newly designed tram-train track with a conventional rail gauge of 1435 mm. Tram-train is a type of rail vehicle that is capable of running on city tram rails as well as on railway infrastructure shared with conventional trains. The operation of these vehicles could allow connecting the newly designed tram-train track with existing international railway line ŽSR 110.

2.3 Transport analysis of Nord-western area

The mobility is an essential requirement for the effective functioning of the urbanized area. Individual mobility, i.e. people commuting to work, school, for services, or to a place of leisure, is an important element of personal freedom and belongs to the fundamental human rights. On the other hand, continually increasing traffic volumes is a source of environmental pressures and the loss of quality of life and, therefore, there is a necessity to look for the optimal solution for sustainable transport in relation to the quality of the environment. Mobility management is primarily a demand-oriented approach aimed at influencing the traffic patterns and behaviour of the users of transport. It is therefore important for the coordination of transport systems with the rules of modal split, as well as using the tools of the organization and the progressive traffic management. [9] The setting of the transport model for a territory being solved will be assessed in the light of a number of scenarios of:

- time intervals in 5-year levels with a view to + 20 years
- alternatives of the transport infrastructure, in which it remains invariable design of the road network (as shown in Figure 3), and scenarios will be considered to keep the rail track lines of public transport.

A clear advantage of creating the transport model is the fact that there is a sufficient range of transport surveys according the Volkswagen investment throughout the area, carried out between 2013 and 2015, [7]. Besidesthere is a detailed analysis of the transport model, which as used in our case, and which is appliedto its own proposal for transport – urban infrastructure. It can be stated that the land was detailed deeply of 35 new zones. The rural – outside transport will also be addressed in detail in the project, and its results are documented [8]. From these documents there will be created a new OD (origin-destination) matrix of transport relations, which was analysed following the urban planning studies [8] and it was created a particular view of the spatial arrangement and functional use of the territory, which still does not have any supporting documentation. This solution is designed to present the idea to the system solutions for transport infrastructure, which can also give an answer to the progressive urbanization of the area in the time frame of + 20 years.

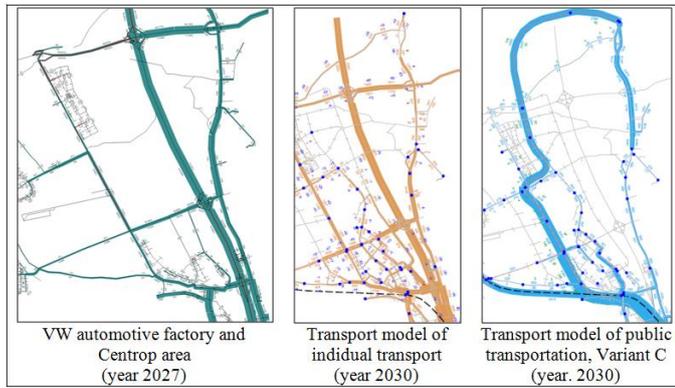


Fig. 3 Examples of the transport models

2.4 Proposal of the rail transport service in the area

The key solution is to design the guidance of the rail track routes, which are broken down into:

1. urban track – tramway line with a gauge of 1000 mm
2. suburb track tram-train with a normal gauge of 1435 mm, which is connected to the international railway track ŽSR 110 from Vienna and Brno in the direction to the center of Bratislava, to the Main Station.

For the purpose of connection was to design the new Integrated Personal Transportation Terminal (TIOP), which is located at Lamačská Brána, near the Bratislava district Lamač, on the existing railway line 110. At the TIOP would be located also a regional bus station, which offers the fast and comfortable transfer between the trains and buses to other parts of the region. All these together create new opportunities for expanding the integrated rail transport. The service quality of the territory is designed to integrate the suburban railway, which will serve for quick connection to the city centre and to the other satellite cities in other directions. In addition, it will allow a high-value connection with satellite town of Stupava on the north side of agglomeration. This town has been developing very quickly in recent years. It has currently has 12 500 inhabitants already and the upcoming projects declared in a time horizon of 10 years increase up to 25 000 inhabitants.



Fig. 4 Alternatives of routing new railway lines in area of Bory

The strategy of the sub-urban rail has its significant justification in terms of the development of the city of Bratislava, which is enormously developing more in its agglomeration than in its own territory. Just in terms of simple principles of geography and urban development it is possible to declare a demand of the suburban rail public transport, which however must have a clear city corporate function. Therefore, it was addressed already in the past, where there were some tracks of tram-train, examples which can be seen in several cities in Europe. Bratislava in terms of its own development should not be an exception, because of its

internal city area together with its agglomeration cannot be ensured by conventional rail transport only.

To investigate the area public transport as deep as possible[9], the tram-train tracks are designed in three variants which are interchangeable. In Figure 4 is a scheme of variants, which are connected to the railway infrastructure, of course, according to the principles of international rules, which must be a flyover in a collision link. In the southern part of the territory there is a terminal TIOP, by which the rail, tram-train, tramway line, and suburban bus transport will be served. All variants are designed according to the Slovak technical standards with a design speed of 80 km/h. By potential impossibility the design speed is reduced to 50 km/h with local restrictions exceptionally to 15 km/h.

Based on the analysis of all scenarios, we have created a design system for railroad public transport in the area. It was created in accordance with the general requirements and regulations for designing rail tracks. In the transport model, we examined the relevance and effectiveness of the design of the transport service in the mentioned area. Based on the technical solutions, the following assumptions [6] have been defined:

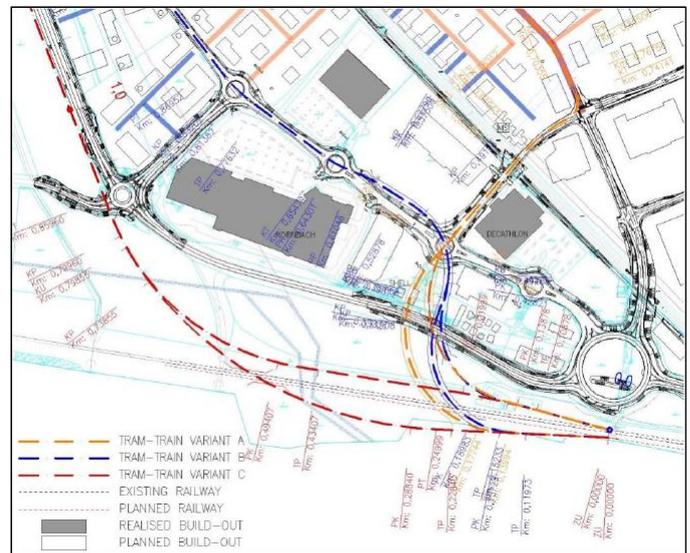


Fig. 5 Tram-train connection to the railway network

1. Create a fast and direct connection between rail track ŽSR 110, and agglomeration Stupava, via solved area,

- Design speed of 80 km.h-1,
- Direct route guidance,
- Preference at junctions,
- Secure of railroad crossings
- Rail track security systems, in urban area design for speed of 80 km.h-1, in rural area of 120 km.h-1,
- Distance between the stops cca 1000 m
- Pedestrian accessibility of stops cca 600 m;
- The Realization of integrated terminal TIOP in Lamač

2. To create a separate public transport system with a gradient to TIOP

- Establishment of local tramways with possible operation of tram-train vehicles
- The platforms of minimal length of 120 m.
- To solve the problem with the different elevations of platforms on conventional tracks of ŽSR and tram lines
- To establish integrated stops, with the smallest transfer distances between the tram-trains and regional buses
- To rebuild the railway no.110 in the section from

Bratislava, the main station to turnout in Devinska Nova Ves, which divides railway to Vienna and to Brno - existing two tracks have to be replaced with three tracks over the whole length.

3. Using the benefits of tram-trains,

- In a built-up urban area, it is a city-forming element
- In urban area possibility of using the existing tram stops
- In rural area possibilities to use all advantages of existing railway tracks – opportunity to increase the design speed to 120 km.h-1;

III. SOUTH-EASTERN AREA OF BRATISLAVA

3.1 Area analysis

The new planned development area Malé Pálenisko - Domové Role is located in the south-eastern part of Bratislava in the district of Ružinov. The area is delimited from the north by the railway ŽSR 132 which leads from Bratislava, Main station, via Bratislava UNS freight station, through the Port Bridge to the direction of Hungarian city Hegyeshalom. The southern edge consists of street Slovnaftská. The eastern edge consists of 1st class road I/63 from Bratislava to satellite town Šamorín. Western outline of the area is bordered by the river Danube and with the shipping port. The airline distance between area's northern edge and the city center is approximately 5 km. Mentioned area is composed of two main parts – Malé Pálenisko and Domové Role, which are divided by train track to Slovnaft refinery. At present, it is a non-built-up area with a planned large residential development. The largest construction is expected with a launching of the new expressway R7 [12] - currently the only one connection between this area and the largest district of Bratislava - Petržalka. It is a bridge, namely the Port Bridge, which is 460 m long 29.4 m wide, four-lane bridge, with a two track railway and pedestrian paths. This bridge is already on the capacity limit, on the level of service class E-F. Level E means, the capacity was fulfilled, and the average waiting time is from 70 to 100 seconds, level F means, the demand is higher than the capacity, and average waiting time is more than 100 seconds. That's why the construction at the new development area is planned together with a new city bridge, which would be built mainly for pedestrians, cyclists and the tram transport. The design is also connected with a future planned development of the residential unit in a district of Petržalka, with the possible new development area of Malé Pálenisko and Domové Role. In terms of transport, these areas will have a character-oriented mainly to the city centre.

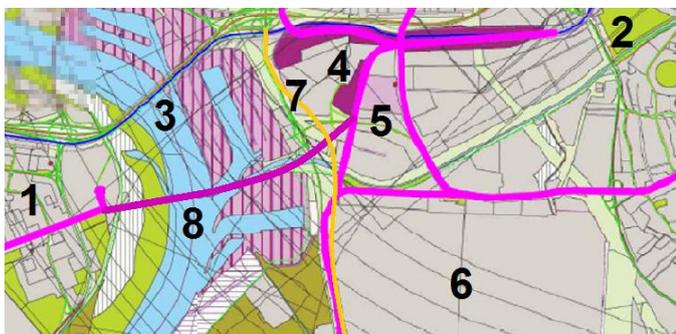


Fig. 6 Solved South-eastern area[11],

District of Petržalka (1), District of Ružinov (2), Existing Port Bridge (3), New district of Malé Pálenisko (4), New district of Domove Role (5), Refinery Slovnaft (6), Currently constructed expressway R7 (7), proposal routing of a new bridge (7)

3.2 Urban planning documentation of the city

Master transport plan of Bratislava [1] designs the extension of the tram network to the wider area of Petržalka. In the current state, the first phase of the tram-line is built. It consists of a double-track line from Štúrova Street; via Šafárikovo Square and the Old Bridge to tram stop Jungmannova. Track gauge was built dual, 1000 and 1435 mm. The track has a width of 7.0 m at an axle track distance of 3.1 m. The tram ride is performed on an electrified track with a speed limit of max. 50 km / h. The second part of the route will continue from the already built track from the Jungmannova stop over the undeveloped area to the Janíkov dvor site, where the development project South City is growing. The new planned proposal focuses on the construction of a new tram line with a connection to the existing first phase of the tram line, and it provides the northeastern connection of the tram network with the city centre as well as the design of a new bridge in Bratislava [10]. The tram line, as it is proposed, is not defined in the urban planning documentation of the city of Bratislava yet.

For Malé Pálenisko area the town planning analysis was created, which main purpose was to verify the new development plans of owners and investors interested in land use. The study sets the areas, which could be necessary for the development of the shipping port of Bratislava, and the principles of functional use and spatial arrangement on the other area of the solved territory.

3.3 Transport analysis of South-eastern area

The purpose of traffic planning in the concerned area is providing the development activities and transport services. Traffic planning can be divided into three basic stages, which are the analysis of the current state, the prediction of further transport relations and the design of a transport system solution. The transport model should present the actual traffic situation as accurately as possible based on established and known patterns. Included transport analysis, the traffic volume of the existing sections of roads and bridges as well as the routing of traffic in the current area. The model was based on the demographic data of the affected districts - Ružinov and Petržalka. For the most realistic view, there was a model used, which includes the whole of Bratislava. From these analyses, a new OD (origin-destination) matrix of transport relations will be created. It was analyzed following the urban planning studies. There is no supporting documentation, so it can give us a particular view of the spatial arrangement and functional use of the area. The analysis was made for the current state as well as for the state after the new city bridge between districts Petržalka and Ružinov will be built.

From the results of the transport model, it is obvious that the proposed city bridge will have an impact on the redistribution of traffic in the mentioned area. There was a decrease in the traffic density of the Port Bridge. The total reduction in traffic volume is 35%, representing approx. 15 000 cars.

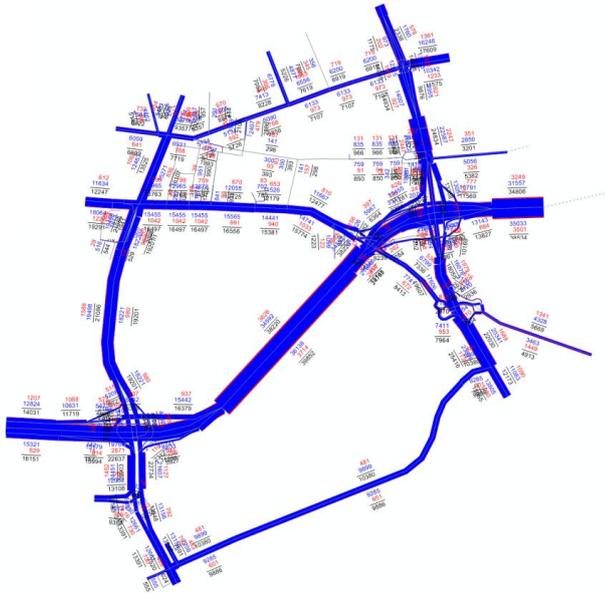


Fig. 7 Example of the transport model
Showing the traffic volume on three bridges, in the middle the existing Port Bridge and below the newly designed city bridge is shown

3.4 Proposal of the rail transport service in the South-eastern area

The newly design bridge connects two banks of the Danube river, where the city districts Petržalka and Ružinov on the other side are situated. It will contribute to reducing the access time between these two city districts. The bridge expands the road network and tram network in Bratislava, because the bridge is designed as a combined bridge with a four-lane road, two track tram lines, the cycle and pedestrian paths. The total width of the bridge is 30 m. The proposed city bridge route crosses the R7 expressway. The City Bridge was designed in order to solve the internal traffic relations, not to transitor for other city's external traffic relations. Transittraffic is addressed by the design and construction of the D4 motorway [12], which is designed to be connected to the R7 expressway. For this reason, it is recommended that the city bridge is not connected with expressway R7. The proposed city bridge will be part of the rail carrying transport system in Bratislava.

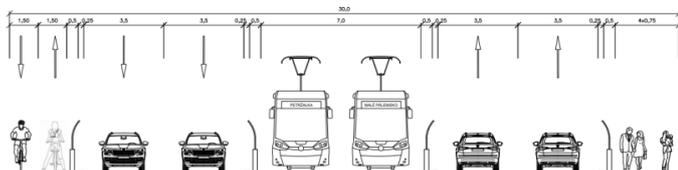


Fig. 8 The cross-section of the newly design city bridge

Based on the analysis and in accordance with the general requirements and regulations for designing rail tracks, we have created a proposal for public transport in the area, which will be operated by trams. The proposal includes the extension of the public transport system in the Petržalka district, where it would be connected to the currently existing tram line.

This existing tram line was realized with a track in a dual gauge, 1000 and 1435 mm. Therefore, the newly proposed track could be implemented at a 1435 mm gauge with the possibility of using the Tram-Train system. It will make full use of the potential of the already existing dual gauge on the

tram track from Štúrova Street to Petržalka with the using of tram-train vehicles. In further expansion it would be possible, to continue as a conventional train, from Domove-Role, via UNS Prievoz - freight train station, to other railway radials of the city. All these together create new opportunities for expanding the integrated rail transport, mainly in southern direction.

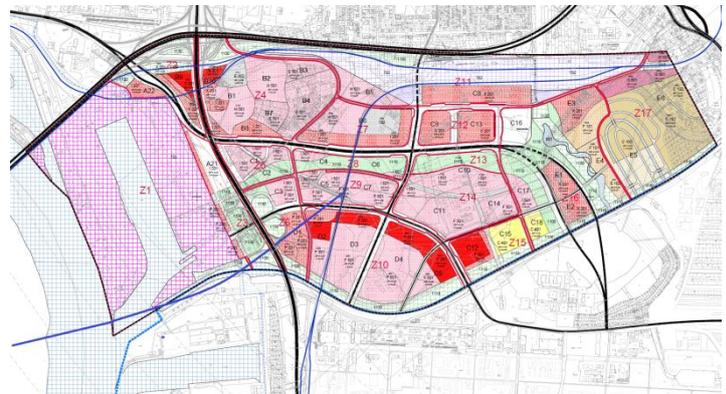


Fig. 9 The wider relations of South-eastern area, together with tram track, over the city bridge, connected to existing railway from Slovnaft raffinery to UNS Freight station.

Based on the technical solutions, the following assumptions have been defined:

1. The newly designed city bridge,
 - Width of the bridge is 30 m
 - 4 lane road, with the lane width of 3,5 m
 - double track tram line, with total width of 7 m
 - 2 Cycle paths of width 1,5 m
 - Sidewalk of the total width of 3 m.
 - Without connection to expressway R7
 - Mainly provide the internal traffic relations
2. Ceate a tram track from Petržalka to new district Male Palenisko,
 - Connect to the existing tram track from Štúrova street to Petržalka
 - Design speed of 50 km.h-1,
 - Preference at junctions,
 - 7 stops in each direction.
 - Distance between the stops cca 300 - 500 m, according to the pedestrian availability isochrones
 - Sidewalks along the tram-track, especially in streets Haanova and Polereckeho.
 - Triangle turn-out, which will allow turning to the eastern and western side of Petržalka
3. Opportunities for further expansion,
 - Using tram-train vehicles in gauge 1435 mm
 - Connect the existing tram track to the railway station in Petržalka, with a usage of tram-train vehicles
 - Possible connection from Male Palenisko via UNS Prievoz freight train station to a conventional railway network
 - Possible connection to all railway radials.

CONCLUSIONS

The area of the BORY and CENTROP lying in the north-western development direction of the city of Bratislava is one of the most potential developing territory in Central Europe. To create a sustainable vision for the future of the built-up area is

from the first phase of the project, it is necessary to solve problems with the transport serviceability. As far as the Nord-west development area is concerned, the Tram-train, or similarly a capacitive and fast public transport system must be a condition for the development of the area. In the framework of these arrangements the corridors for the future transport network of the territory are determined. For optimal service of the area, we preliminarily recommend the Variant C to be elaborated in details. It has sufficient offset from the urban tram, it achieves the speed of 80 km/h in the whole route and serves the territories on both sides of the road II/505 along with Volkswagen automotive factory. The next steps of the work must be directed by comprehensive tools for the development of this great area.

In South-eastern area of Bratislava is the situation different, because the carrying rail transport system is not written in the LMP here. As well as in Nord-western area, we have planned development here, which will cause the growing demand for the public transport. For this reason, the proposal to solve the interconnection between these two parts by rail is significant. The proposed southeastern variant tram-track will contribute to the area of Bratislava – Petržalka – by building a carrying rail system. This proposal does not interfere with the planning activities that are written in LMP. Therefore, we recommend keeping a space reserve in the mentioned areas, for the future implementation of the carrying rail system. From the point of view of the modal split in these two mentioned development areas, rail transport should be the basic attribute of the integration of transport systems for the sustainable development of mobility, which significantly influences the quality of urban life.

Abbreviations

LMP = Land Master Plan
UPD = Urban planning documentation
TIOP = Integrated Personal Transportation Terminal

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