

Tram track layout options in the area of Danube riverbank – Pribinova – Karadžičova in Bratislava

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Abstract—

The Master Transport Plan (MTP) of Bratislava has proposed a variety of new tram track layouts in developed areas. The article in question describes technical options of a tram track layout near a new development Nová Vydrica on the Danube waterfront, starting at the SNP Bridge and then through Ľ. Štúra square –Fajnorovo waterfront – Pribinova street – Karadžičova street. This article analyses existing documentation and the work process description of the track layout optimization. The carrying PT system lines must be optimized, in order to design: the change of traffic organization that begins under the SNP Bridge, within the way out of Hviezdoslavovo square to the Danube promenade and a connection of the western tram transport radial line towards the new city center formed by Eurovea complex, Sky Park, Twin City and the area of new bus station Mlynské nivy. The tramway line study ends on the Karadžičova Street at the CBC business complex.

Keywords: public transport, tramway, tram track, urban area, pedestrian promenade.

I. SUBJECT MATTER AND PURPOSE OF THE DESIGNED SOLUTION

Current development of Bratislava focuses mainly on a waterfront area where a new complex of several functions, which will represent not only residential but also social functions, is being built. It is area of former PKO centre (Park of Culture and Leisure, now River Park) and the new city districts Zuckermanel and Vydrica, which ends at SNP bridge with connection to the historic city centre. The new city centre is being created on the other side of the Danube riverbank, also from the the riverbank between Old Bridge Apollo Bridge, starting with the Eurovea complex, the New Slovak National Theatre and subsequently the area delimited around Landererova street – Dostojevského rad – Mlynské nivy – Košická street, where the set of almost 20 high rises

with the entire complex of diverse urban and larger urban functions, is being created.

Urban road traffic in this area is at the limit of saturated traffic flow and therefore regular traffic congestions occur in rush hours of an average working day. If Bratislava won't strategically prepare construction of new tramway tracks which, according to the Land Master Plan (LMP) are part of carrying PT system, then any new activity would trigger a collapse. The entire waterfront area and the new city centre cannot be planned without this public transport system.

The area around the designed tramway line SNP Bridge - Ľ. Štúr square – Pribinova street – Karadžičova street – Mlynské nivy must be analysed, in order to do traffic planning, which would benefit the area affected by the rapid development of urban and larger urban functions accompanied by the high population increase. Capacitive tramway transport in this zone will provide increased comfort for passengers that are traveling or will travel from western parts of the city. A continuity of the tramway tracks to the north parts of the city are anticipated in the outlook. The designed route must be evaluated by feasibility study, which would assess and compare variants in terms of technical and socio-economic feasibility, including environmental impacts. Within the technical solution itself, a pedestrian and cyclist routes should be designed.

Addressed area begins at the junction near the SNP Bridge, where the development Nová Vydrica is located. The fundamental solution to this part of area is expected to be the change in function and service of the space under the SNP Bridge. The second impact on the required change of the area service, in terms of functional utilization of area, is the building process of new office and residential city centre zones "Chalupkova" and Eurovea 2 in city districts Old City and Ružinov. It is the renovation of the former industrial brownfield Apollo, Nivy and areas near former Winter Port. The urbanization of this area will require new traffic demands and will bring along the issue of public transport and dynamic car transport planning in this part of the city.

The goal of this article is to describe the work completion in the solution of area analysis and technical design of new tram transport line in the built-up area of the new city centre and adjacent the Danube riverbank. The tramway track will address the transport service of this urbanized area. The capacitive track transport within the area is uniquely designed to increase travel comfort of passengers. This tramway track was also designed by the Master Transport Plan (MTP) of Bratislava [1.] as an alternative route, which was not the subject of the direct assignment but should be taken into account and have to be verified by feasibility study. This article submits the first step, which is the review of possible technical designs.

any new tram track in Bratislava, except the last opened line in a south radial direction into the city district of Petržalka: section Štúrova street – the Old Bridge – Jungmanova street which length is 2,4 km and it is operating since July 2016 [5.].

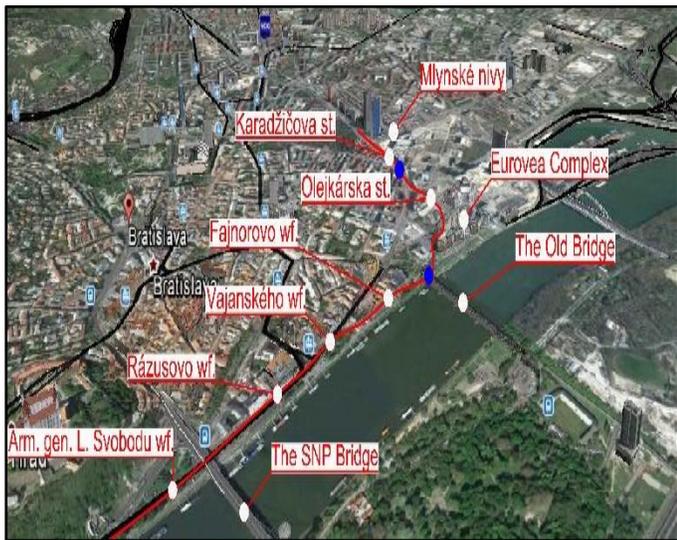


Figure 1 The designed tram track in the riverbank area

II. CURRENT STATE OF PUBLIC TRANSPORT IN BRATISLAVA

Traffic into the city and within the city is formed by the network of roads and rail tracks. Urban public transport is provided by a network of tramway, trolleybus and bus lines. Tramway transport (TT) is the carrying PT system, enhanced by complementary trolleybus and bus lines. TT runs on rail network of 1000 mm gauge.

The length of the tramway track network in Bratislava is 42 km double-track, it has 155 stops and nearly three quarters are operated on an own segregated body. It consists of 9 lines, which are established as radial urban routes. The network in the city is currently consisting of five radial routes, which are connected to a central circuit in the city centre, along the route of L. Svoboda waterfront – Rázusovo waterfront – Vajanského waterfront – Šafárikovo square – Štúrova street – SNP Square – Kapucínska Street – Tunnel. According to MTP the public transport tramway network is not in optimal condition and it recommends the development of new tramway network in the city, in addition to the improvement of the old tracks maintenance and condition. Over the past 40 years there were no investments in

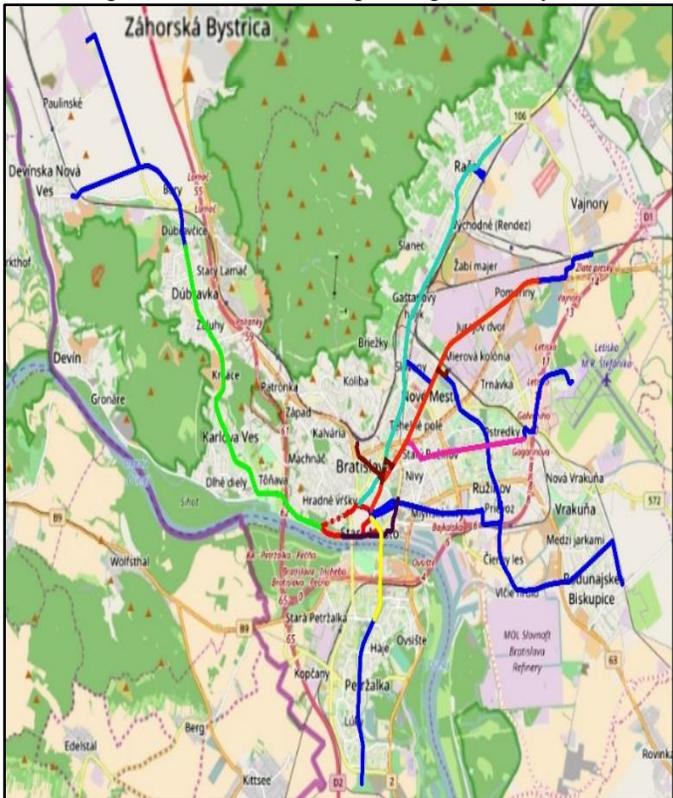


Figure 2 The tram track network in Bratislava
 Source: *openstreetmap.org*

III. AREA AROUND THE SNP BRIDGE

The aim of this design is to create and assess transport service in the area around the SNP Bridge, delimited by the area of Rázusovo waterfront, arm. gen. L. Svoboda waterfront and their connection to the bridge. The requirement of architects for this area with public transport function was to create a node, which is not limited by road transport only but is used as pedestrian transport node too. The original historic pedestrian routes from Rybné square and Hviezdoslavovo square as well as Židovská Street and Pánska street must be restored. These are the rules for urban changes. The principle of transport changes is to:

- cancel the final bus station under the SNP Bridge,
- remove the connection branch which begins at the Danube hotel and connects to Staromestská street and design it in a different position,
- design a new position of tram and bus stops under the SNP Bridge,
- design a new transport service concept of the area with respect to the main pedestrian route from Hviezdoslavovo square., which opens into Danube promenade,

- design a new connection positions on municipal streets for four sections – branches of the SNP Bridge whose design depends on the vertical and horizontal alignment of remaining branches.

The riverbank is designed in the single category urban street MZ 20,5 (according the design standard for urban roads and streets) for the whole section, but outer edge of carriageway lines are excluded due to the cramped conditions. The cross-section through PT stops and the waterfront is in the Figure 4. Removal of the left turning lane to the bus station and to the connection branch created a space for the new position and arrangement of public transport stops, enabling their vertical connection with the SNP Bridge by a system of elevators shown in the Figure 3 and 4. This design increases safety and comfort of pedestrians or physically disabled people when moving through the area. We have created the pedestrian transport node with access to the historic centre, the promenade and also to the developments of Zuckermandel and Vydrica, just by adding a pedestrian crossing at junction of L. Svoboda waterfront and the connection branch to the bridge.

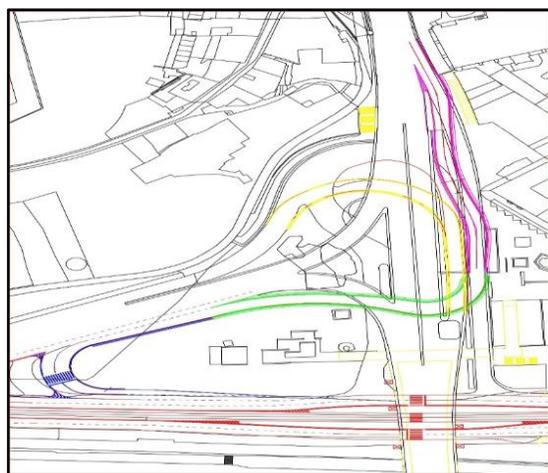


Figure 3 Designed situation

(red – Riverbank, blue – V01, green – V02, orange – V03, magenta – V04)

Because of restoration and connection of historical pedestrian routes, we have created a new horizontal and

vertical alignment for branches which connect the waterfront with the bridge and Staromestská street, by relocating the connection branch that begins at the Danube hotel and connects to Staromestská street, this way we have completely removed road traffic from the extension of Hviezdoslavovo nám. and Rybné nám. Cancellation of the bus station under the SNP Bridge gave us space to shorten the exit branch from the bridge by one third and lay it out one column group sooner. This design creates a completely new area for pedestrians, connecting Židovská Street, Rybné square and Pánska Street and realigning the branch connecting to Staromestská street. The expanded connection between Rybné nám. and Hviezdoslavovo square, have created prerequisite for the removal of the massive structure of this branch and its replacement with more suitable, space efficient column design. Designed parameters are in table 1.

Table 1 – Designed parameters of branches V01,V02,V03,V04

Branch	Length	Lane width	Hard shoulder width	Max. longitudinal gradient	Min. longitudinal gradient	Number of horizontal curves	Number of vertical curves	Crossfall
V01	97,44	3,5 m	2,0 m	3,84 %	0,55 %	1	2	2,0 %
V02	115,0	3,5 m	2,0 m	6,30 %	3,84 %	2	3	
V03	113,0	3,5 m	2,0 m	8,50 %	1,73 %	1	1	
V04	148,5	3,5 m	2,0 m	8,50 %	1,21 %	3	3	

IV. SECTION LUDOVÍT ŠTÚR SQ. — FAJNOROVO WATERFRONT – THE OLD BRIDGE

MTP describes this whole section as a connection to south radial route respectively as an alternative layout from Šafarikovo sq. – Pribinova Street – Landererova street – to the junction Karadžičova – Mlynské nivy, where it connects to its route [1.]. The track continues down the Karadžičova street to Křižna, through the future station Filiálka connecting to Jarošova street and the southern radial route (area of the city district Rača). This track extension from Mlynské nivy is not the subject of our analysis. The first element of design is the triangle on L.Štúr sq., which must be designed as double-track

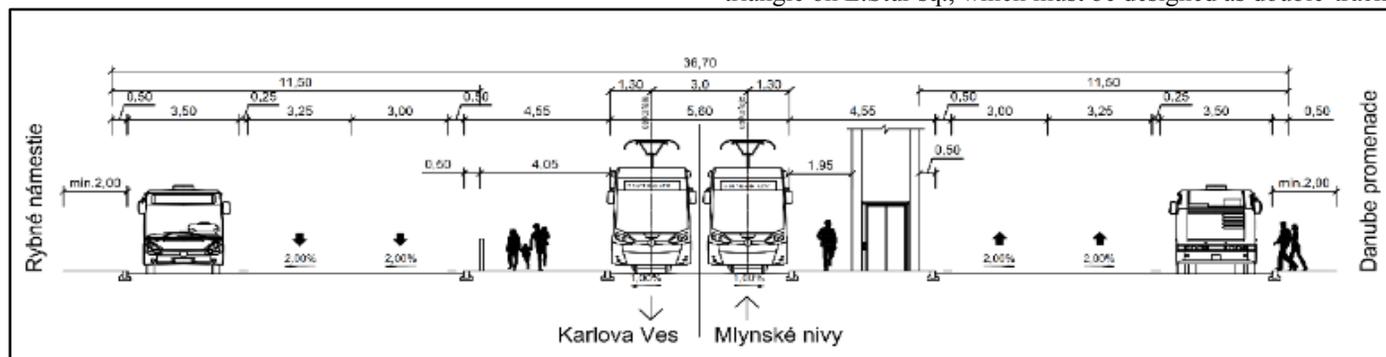


Figure 4 Cross section under the SNP Bridge

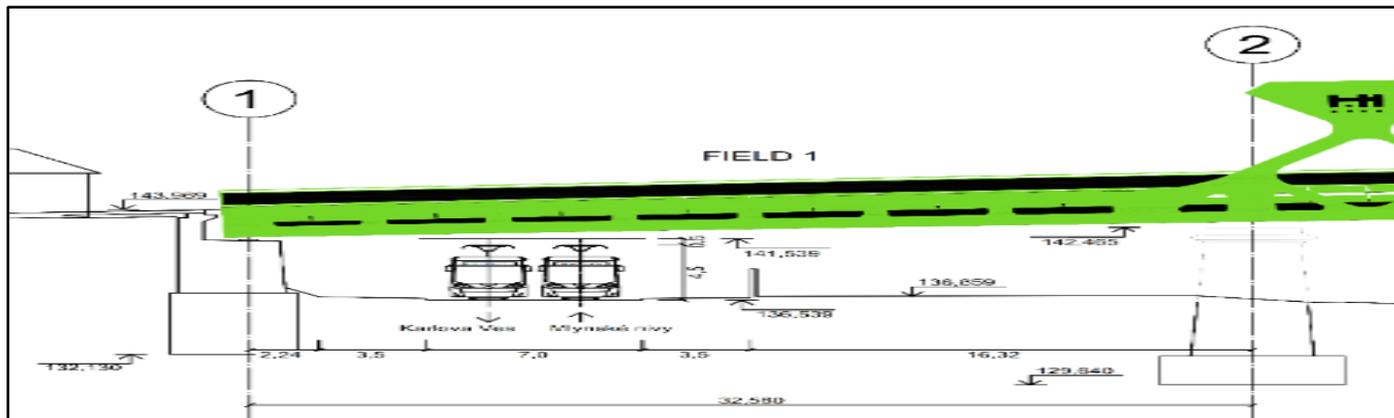


Figure 5 Cross section under the Old Bridge

in all directions. Its route layout (Figure 6) starts at E.Štúr sq. at the current rail intersection from Rázususovo waterfront to Vajanského waterfront and continues towards Slovak National Museum, where it turns to Fajnorovo waterfront, using two contra directional curves.



Figure 6 The triangle on E. Štúr square and track along Fajnorovo waterfront

The track is designed between the current historical build-up area and flood protection wall towards Gondova street. Transverse arrangement design is in Figure 8. Characteristic properties are: the width arrangement without curbs and the sidewalk on the build-up area side. It will only be allowed to drive on the rail track by transport service. Parallel parking will be cancelled. It is proposed to relocate the promenade behind the flood protection wall. The problem of the longitudinal alignment is at the interchange with the Old Bridge, mainly because of the need to keep the clearing cross-section of the double track tram route under the Old Bridge (Figure 5). The design is to place the track even deeper under the original terrain level. The vertical alignment in this place must meet the conditions given by standards namely: maximal longitudinal gradient of the track and required vertical curves. Given that the track is placed near the bank of Danube river, two main safety measures must be designed. The track structure must be protected from the power water by flood protection wall and the underpass must be dewatered. A two-way stop is designed in the location of parking lot on Gondová street.

V. Section starý most – eurovea – olejkárska

The track begins under the Old Bridge and is designed to change direction using the levorotatory curve between the building of Eurovea and Ministry of Interior of the Slovak Republic. The track interferes with the parking lot of ministry and a two-way stop is designed in front of the main entrance to Eurovea. From there, two layout variants of tram routes were studied. First variant route is designed along Krupková street where it connects to Dostojevský rad. Second variant goes along Eurovea, up the streets Pribinova and Olejkárska back to Dostojevsky rad. We recommend the second variant due to insufficient transverse width at Dostojevsky rad opening to the ram area of Landererova junction. The track at Pribinova Street,

is designed on the boulevard along the street edges because of the entrance/exit of Eurovea parking garage. The crossing of tram track direction on Krupkova street is designed outside the junction in the direction towards the Slovak National Theatre. The principle of tram track design along the edges of street is kept also on Olejkarska, which must be designed four-lane in its the entire length. The transverse arrangement is shown on the Figure 9.

The track continues through the signal controlled junction Landererova where the principle of design along the street edges ends. A two-way stop is designed in front of the ZSE building. The tram track is placed to the right side of the street along Karadžičova Street on its own body towards the intersection with Mlynské nivy, where it intersects with proposed tram track Kamenné sq. – Dunajská – Mlynské Nivy – intersection of Bajkalská street and Mlynské nivy [4.], prospectively to the Slovnaft. A problematic aspect of the junction will be the layout of designed tram track due to current Twin City Tower project where the street boundary line of Karadžičova street wasn't kept and the object literally interferes with the street area and thus creates a problem in terms of transverse arrangement.

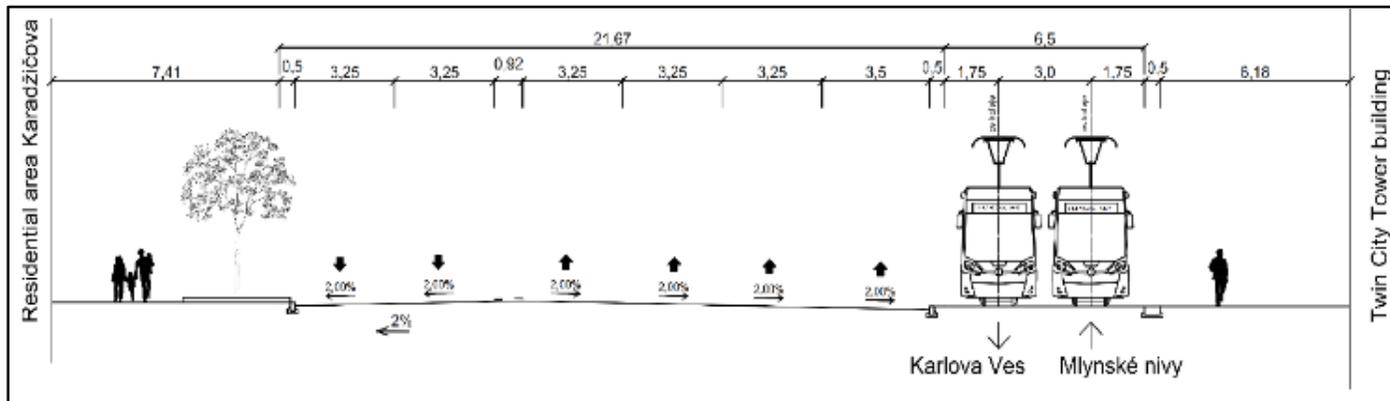


Figure 7 Cross section along Karadžičova Street

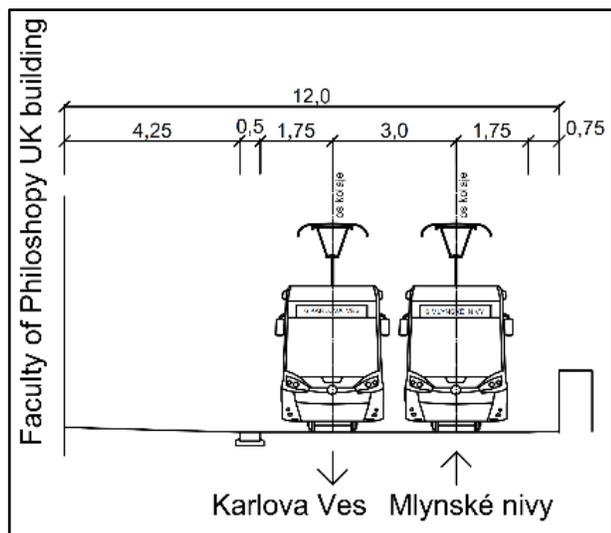


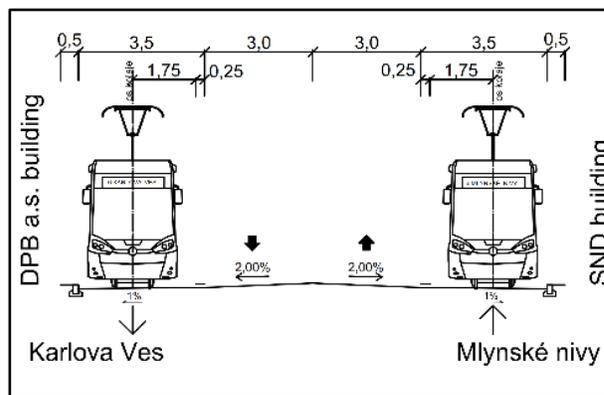
Figure 8 Cross sections on Fajnorovo waterfront

VI. SECTION KARADŽIČOVA – MLYNSKÉ NIVY

The track continues through the signal controlled junction Landererova where the principle of design along the street edges ends. A two-way stop is designed in front of the ZSE building. The tram track is placed to the right side of the street along Karadžičova street on its own body towards the intersection with Mlynské nivy, where it intersects with proposed tram track Kamenné sq. – Dunajská – Mlynské Nivy – intersection of Bajkalská street and Mlynské nivy [4.], prospectively to the Slovnaft. A problematic aspect of the junction will be the layout of designed tram track due to current Twin City Tower project where the street boundary line of Karadžičova street wasn't kept and the object literally interferes with the street area and thus creates a problem in terms of transverse arrangement.

The design ends at the tram stop behind the junction, near the VÚB building where a transition of trams to opposite direction will be secured. Prospectively, the continuation of this track towards Filiálka and southern radial route is taken into account. Given the continuation of track and lack of space

for the turning bay, only the double rail crossover can be designed.



9 Cross sections along Olejkárska street

CONCLUSION

The solution of this technical study confirmed the possibility of resolving the traffic area and defined the main points of the subject and the advance of the proposed tram line led on the Fajnorovom waterfront. The design is a part of a comprehensive solution of the territory and the need to ensure its compatibility with the other parts, especially the building of architectural solutions. Transformation of the territory around the SNP Bridge as a sustainable transport point as a public transport terminal with pedestrian main route from old city towards promenade on the Danube waterfront, together with the proposed tram line has brought two important nodes in Bratislava, and the SNP bridge and New city centre Mlynske nivy.

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