Modelling of Capacity and Public Transport Modal Split for New City Centre in Bratislava

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Abstract. The article describes the detailed traffic modelling in new city centre, which is actually widely discussed by public and experts. The core of the problem is lying on the municipality, which put on the table a final decision about the change the modal split for public transport development. The north part of new city centre, which is under construction the suburb bus station. The solutions of new tram routes are taken into account. Results of traffic studies show, that how could be this change re-define the current traffic behaviour and create for the new area new functional interest and certainly the new quality of relationships of the territory. The system solution is the new public transport service for this area with which will be created by a capacitive new tramway network. The transport model has the importance of these empirical experiences for practice and final decision making. The city of Bratislava had a very detailed and defined layout of the Master Transport Plan and is a big impact to change on the side of developers. The question is why they have not complied with it and the answer would be found, because exact scenarios can show the disproportion for each details of organization of traffic flows, public transport lines with results of measurable sustainable mobility together with accessibility.

1. Introduction

The new city centre of Bratislava, Capital of Slovakia, is under a huge development boom, which takes the area from the Danube river bank on the south and on the edge of the Old City from west, where is risen up a new down town of the city. On the north part will be a new bus station. Deployment of this new city centre has a possibility to move toward east. The base situation is shown on Figure 1. The territory specified will have more than 20 high-rises with different function and there will be more than 20 000 new parking spaces together will app. 2 mil. m² of new activities. The city position in this issue must consist of systematic regulation of build-out in order to reach contemporary modern conception of forming so called „smart cities“– sustainable living and sustainable mobility. Nowadays, the reality is that, we have saturated flows on the street network around the contact area. In this area a new bus station will be built, which will influence an existing public transport network created by city bus and trolleybus network. For the changing the modal split toward better using the public transport (PT), there is a complex of technical studies to realize around the centre a new tramway lines connecting the operated tramway network in Bratislava.

The article is about the methods of complex traffic flows and capacity analysis and results of traffic model which will be used not only for the prognosis scenarios of dynamic traffic flows but for...
changing the modal split for the public transport. There is under construction the new bus station and begins to reflect on the new tram routes. The management of the city is before a decision making how will be start the changing the modal split towards the public transport, especially to serve the area with tramway lines. Couple of results of technical studies with its recommendations and possible professional discussion put inside this area a philosophy of modern nonconventional elevated automatic public transport system as well. The appraisal of saturated traffic flows, new traffic form investment and the bus station together with a huge city PT lines covering by bus and trolleybus lines create a methodology of traffic modelling. The aim is improving the operation of the territory with designing the new tramway lines as a form of sustainable mobility. If it will be a possible rule how to define a real smart city application is the answer of the future couple of years.

Some tools for decision making and steps for realization will be shown. The main issue is to change the modal split for PT. There are identifying opportunities to improve the attractiveness of public transport, together with suburban bus service (SBS), thus providing for its precedence over individual car traffic in the city of Bratislava (Figure 2) and its agglomeration in the Bratislava region. The solution is shown how is possible to be a part of the integrated public transport services possibility to operate regular all days’ mobility problems in the city and not only to cover the rush hours. This article is an overview of 4 years work of traffic engineers and planners to keep clear systematic approach and solutions with developers and municipality administration.

2. Development of the new City Centre in Bratislava

Every city’s development is subjected to the urban planning documentation. Bratislava has a valid Land use master plan (LMP) and Transport master plan (TMP) according to the Building act. What is a truth, the city was not able to direct systematically its own development over the period of last 2 decades. Such undirected expansion was caused unrestrained build-out without a vision, without continual traffic service solution in relation with the region within the agglomeration. In detailed was this problem described in [1]. The answer for systematic rules of urban development with an orientation for solid accessibility for the land development should be clear by measurability of the sustainable development/transport together with clear rule what the smart deal in the city is really. High density developments in city central area have high potential. The right planning tools and strategies need to be used to maximise the chances and minimise the risks.
The traffic service proposal deals with the existing traffic infrastructure on given future and realized app., more than 2 mil. m² functional areas. These ones generate input for the traffic planning, which will define new traffic volumes in many scenarios to find a functional solution of traffic organization and control. Particular variants of the tramway lines in given area are proposed to be the primary tool for future “sustainable mobility”. Road network for cars shouldn’t be significantly further developed since only marginal gains of the capacity in term of moved people are possible. A car-based strategy cannot succeed in satisfying the mobility needs of a dense city. Optimization of the network needs to be oriented to the improvement of the capacity of the system in term of moved people and not moved vehicles. A public transport based multimodal approach needs to be promoted. The efficiency circulation of bus and tram traffic needs to be guaranteed independently from possible congestions of the private car road network (segredated lanes, smart traffic lights, etc.). A systematic prioritization of the public transport needs to be pushed at city scale.

3. Modal split in Bratislava as a high priority of tramway development

Passenger transport - mobility is an essential prerequisite for the efficient functioning of a city economy and its agglomeration. Public transport (PT) in developed countries plays a primary role in promoting the development of society. It is included in all passenger transport oriented documents that highlight the need and necessity to direct the movement of people from their sources to the goals of their activities using PT [1]. Last couple of year is modern to use in urban area the solid “accessibility” with short trips and with not too many transfers using modal split. Passenger transport, i.e. people commuting to work, schools, offices, healthy facilities and places of other services or leisure time activities, is an important element of fulfilling the efficiency of society in both economic and social terms. We are witnessing steadily increasing volumes of passenger transport, which are based on the current trend of the life of city dwellers and their backgrounds. Passenger transport through constantly rising values of the use of individual transport is a source of environmental burden and reduction of quality of life, and therefore we must seek an optimal solution for sustainable transport in relation to the quality of service using the strong orientation to the public transport.

![Modal split: PT : Car](image)

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Figure 3. Scheme of evaluated tramway lines for new City Centre in Bratislava

The main problem not only in the Capital of Slovakia Bratislava but completely in Slovakia is the destruction of public transport supporting from state level. Another reason is that while in the building act is not provided a demand for the coordination need of the implementation of public transport service. It should be defined as a accessibility in land - urban plan. On the other hand, in Slovakia at the end of the 90s, definitely lifted the subsidy for public transport from the level of the state, and it transferred the responsibility of the regions or the towns, without a state subsidy policy. The collapse of the system of quality public transport from the 80s of the last century with the promotion of the false freedom of the use of individual transport has for a cause a comprehensive change of modal split in transport. It was in the mid 90-ties in the level of more than 80% in favour of public transport and only 20% was personal car usage. Currently in the Capital of Bratislava has reached the degradation under 50% in favour of public transport. In Bratislava is a modal split 44% by public transport compared to 56 % of the personal car in the year 2018. On average in Slovakia a decrease reached a
level of 55-60% of the public transport to 45-40% of the car, which radically increasing in favour of personal car usage. It can be expected that more than 50% of the modal split takes the cars to 5-8 years in Slovakia. An example of the degradation of the modal split in Bratislava is shown in figure 3.

4. Multimodal approach for the new city centre

The road network around the new City Centre area is already overloaded. The detailed analysis was published in [1-3]. The potential additional car traffic generated from the planned 20,000 parking slots is basically not compatible with the capacity of an urban network. The road network was defined for the future traffic organization as a stabilized and not to widening with additional traffic lanes. The capacity problem should be solved/tackled with a **multimodal approach**, were the prioritization of **high capacity public transport** should come in the first place [12]. The modal split (% of trips on cars, PT and other means of transport) is sensitive to the quality of the public transport in the solved area. Both origin/destination (O/D) and through traffic are influenced from the quality of the PT. The references from several studies [8-10] consider the realization of a new tram lines around the City Centre as basis for the estimation traffic demand as a basic load of the network. The **development of the PT/tram network should be regarded as an integral part of the mobility strategy** [12]. The effect of different tram solutions need to be modelled in additional scenarios and systematically assessed for assessment of measurable accessibility of the area together with coherent PT tramway service in direct connection to the other part of the city using the existing tramway lines.

The methodology used for the assessment of the modal shift is still not clear. The effect of new tramway lines and or high quality Bus – Trolleybus corridors on the car traffic streets needs to be studied at three levels [12]:

- O/D traffic, local scale: assessment of the potential considering the local specific catchment areas (about 300 m around the stops).
- O/D traffic, larger scale: improvement of the PT network for the trips with origin or destination in new City Centre.
- Through traffic, larger scale: improvement of the PT network as attractive alternative for the cars through-traffic.

The attractiveness of the public transport depends strongly on reliability of the service, which needs to be independent from possible traffic jams. The evaluation of the different scenarios/solutions is focused on the assessment of the level of service (LoS) of the cars traffic. According of [1, 3] the traffic flows in present situation are in level of service D-F. The public transport is not included in the assessment process. In first step the role of expert point of view was to show the big disadvantages of car traffic, which was clearly presented. For next steps, this would be a role of the Municipality of the City of Bratislava need to be compared different solutions according to an integrated evaluation of the multimodal traffic quality. The detailed capacity evaluation of one tramway line on traffic lights junctions was done [13]. The evaluation method should include e.g. the delay at junctions of PT vehicles (bus, tram). The assessment process should return Quality Levels with regard to capacity/delay of people not vehicles [12].

5. Tramway public transport around the new city centre as a need for smart solution

The requirement of tramway lines development in new city centre of Bratislava was designed in principles of work chain: strategy – system – technical solution. From the urbanization point of view for the city with tramway lines were defined these steps [6]:

1. Tramway lines and their elements of city composition.
2. Tramway lines bands to the other kinds of PT – in our case of the new city centre is the Bus Station and other kinds of urban PT – buses and trolleybuses.
3. Stops, nodes of tramway and PT terminals – public areas.

The new – studied tram lines are completely according the strategic rules defined in MTP and/or LMP. The details about the strategy of the tramways are published in [6]. The strategy of the tram lines
development around the new downtown of Bratislava (see figure 2) shows the clear definition how covers and influence the tramway operation the quality of service around the city centre. This logically shows that the tramway reinitiates further urbanization of the new centre together outside of the developed land. The advance it the connection to the existing radial tram lines, so the new urban area will be completely bind with the city.

Only one possibility to be sustainable and smart for this part of the city is working hard on changing of modal split with advance for PT. For the new city centre were studied three tramway lines. According to the complex public transport services there were defined these base items:

1. The operation of existing public transport lines using buses and trolleybuses in the area in and around the new centre will be in operation to keep the modal split;
2. Tramway lines will be the new carrying system of public transport in the solved area created by 4 tangential tracks (see the Fig. 2);
3. Tramway tracks will be led in the main traffic area of the streets but horizontally separated from road lanes. The sections in pedestrian zones will be in the middle of the street, and the other, where the tram tracks are designed on the side (left or right) from the dynamic traffic. Special section will be on the northern part of the City centre where the tram track will be both side in the PT lanes.

![Figure 4. Tramway lines for new City Centre in Bratislava](image)

5.1. Tramway line Dunajská Street – Mlynské nivy

This tramway line (on figure 4 – green line) is defined by the TMP of the City of Bratislava (see the figure 4). The systematic work for preparing the design was shown in [8]. The tram line is placed close to the new Terminal Bus Station [7]. The study is solved in double-track solutions. The proposed line with its stops, however, must be primarily assessed by traffic flows of passengers through a comprehensive transport model in/out of bus station and toward the functions of the city centre in terms of architectural and construction designs with individual details of this area, which can be subject to restrictive conditions.

In [12] was mentioned, that the realisation of this new radial tram line connecting the old city centre to the eastern sector of the city across the Mlynské nivy – which is the part of the new city centre - has a high potential because of:
• It serves a strong high demand radial corridor with further growing possibility
• It connects directly the high demand PT node/Central Bus station (most frequented PT stop in the city)
• It connects directly the new shopping Mall and a big part of the Twin City and Sky Park investment areas of the new city centre.

It can replace several existing bus lines with possible saving of resources due to higher capacity/less vehicles. This could be evaluated in detailed multimodal PT model scenario.

5.2. Tramway line Fajnorovo nábr. – Karadžičova Street

The tramway route layout was presented in [8] (on figure 4 violet line) starts at L.Štúr square at the current tramway intersection from Rázusovo waterfront to Vajanského waterfront and continues towards Slovak National Museum, where it turns to Fajnorovo waterfront, using two contra directional curves. 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. From the Old Bridge goes the track along Eurovea, up the streets Príbinova and Olejkárská back to Dostoyevsky St. The track at Príbinova 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 Olejkárska Street is designed outside the junction in the direction towards the Slovak National Theatre. The track continues through the signal controlled junction Landéřova 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 to the intersection with Mlynské nivy, where it intersects with proposed tram track Kamenné sq. – Dunajská – Mlynské nivy – intersection of Bajkalská street and Mlynské nivy (written above). The second advance of this line that technically is design also the possible connection directly from the Old Bridge from southern city borough Petržalka [10].

5.3. Tramway line Pribinova – Košická Street

This tramway line (on figure 4 – full red line) was designed by the developer according to [10]. Interesting deal is that the idea comes from private sector and they would like to finance this project. On the Fig. 3 with red line is the complete new line which will be connected near the Old Bridge and will be in the back side of the new Promenade Eurovea shopping mall on Pribinova street. The line will continue on the right side of the Apollo Bridge on Košická street and will continue on the all length of this street. On the northern part will be connected to the existing tramway axis in Ružinov borough. Optional added track is an arm along the Prístavna street to the Port Bridge.

The study [12] says that the considered tram line has a good catchment area within the Eurovea/Panorama city area but:
• The line is with regard to the high density areas Twin City and Sky Park investment rather peripheral but directly serves the Danube promenade.
• The routing along the east part of the Košická is on the “wrong side” of the road from the City centre point of view, the line doesn’t have place for the tram track on the inner part of the city centre, only on the other – outside of the street.
• The combination of short radial (Pribinova) and rather long tangential (Košická) doesn’t seem to be strong enough for a 1st priority new tram line from the priority of constructions of the all tramway tracks. Our notice is fulfilling the idea that this line has an advance to connect the eastern city borough Ružinov via new city centre with southern Petržalka borough across the existing Old Bridge.
6. Traffic modelling of the new city centre area

The traffic model was creating from the origin TMP model. The new model for the city centre was completely recalculated because of many logical mistakes which were presented in [14]. The system work of the traffic-engineering deal included from the performance of long term surveys, up to creation of a traffic model for the territory of the new city centre of Bratislava [4, 6]. The analysed area was set out through the streets: Mlynské nivy – Košická – Landererova – Dostojevského rad – Karadžičova (Figure 2). The result of the traffic model published in [14] is based on the extensive urban area analysis, which will serve for the progressive loading of defined transport network investments prepared on the area of the new city centre. In the model was added 72 now zones which represents all entry/exit of the garages (on figure 5 – blue rectangles). Nowadays each investment is tested in the traffic model (42 new buildings). The aim is to show the high of the new traffic volumes from each investment and to know the partial percentage from all amounts of traffic flows on the street network. The scenarios gradually put a strain on the trail of the individual investments on which is considered the critical way of traffic saturation on junctions. To this situation will be implemented the individual sections of tramway tracks on the territory for a new down town.

Figure 5. Traffic model output – scenario perspective of 2024, AM peak hour

7. Conclusions

The planned new administrative-residential-leisure zone in centre of Bratislava will be significantly changing the modal split of this area and its traffic volumes. Only the PT with tramway lines can afford a higher quality of service for this new area of interest with adequate capacity. For the city decision making is necessary to fill up these main issues:

- To analyse of modal split in favour of the tramway system in many scenarios to show the real need for accessibility and changing the modal split toward the PT
- To demonstrate a sufficient volume of passengers in the design of all three tramway rail tracks around the new city centre
- To keep the smart solutions with measurable sustainable mobility for this new created area to resolve the basic relations of pedestrian flows and its routings with sufficient capacity in urban traffic patterns – not to evaluate cars but people – pedestrians and/or travellers.
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