Biljana ARANDJELOVIĆ

Belgrade metro studies

The subway system is an indispensable part of every modern metropolis. Building a subway is no longer a matter of prestige but a necessity, a consequence of the traffic revolution worldwide. This paper shows four metro studies with specific reference to the Belgrade subway and problems that occurred. The first one was conducted in 1946 by the famous Serbian architect Nikola Dobrovic. This document is indeed the first written record discussing the subway issue in Belgrade. The next study dates back to 1968. This project was the first major study on the possibility of a subway. The third and biggest, this subway study was completed in 1982 and contained a major and comprehensive subway project. This project was officially accepted and enacted by the city government. The fourth project in circulation with regard to the subway is the light city railway project. It came out due to the consequences of the decision that a classical subway was not necessary in Belgrade, so that a replacement for the classical subway system was to be undertaken. The light city railway project was adopted as a part of the General Urban Plan for Belgrade by the year 2021.

Key words: Belgrade metro, subway system, light railway, public transport

1 Introduction

The city of Belgrade was for a long period of time a borderline post between the Austrian and the Ottoman Empires. As such, it has been attacked and burnt to the ground on numerous occasions. The population fluctuated as different conquerors replaced one another. Its favorable geographical position influenced how Belgrade would become a major crossroads, even back in those times. When Belgrade was finally taken over by the Serbs, by a decision of the authorities it became the capital of the new young state, which resulted in the immigration of a new population, who came from the interior of the country. An increase in population numbers continued, so in the course of the 20th century, the city grew several times over. However, the changes in the population numbers were not followed on an equal basis by changes in the urban structure and street network system: their position and composition was the same as it had been in the times in which the city had far fewer residents. The increase in the population was not followed by the development of street networks; therefore the traffic chaos that ensued on the streets was an inevitable result.

Before World War Two, research had stressed the danger of traffic network overloading, and a few decades later this was no longer the prediction for the future of Belgrade, but rather its grim reality. The city was attracting more and more people from the provincial parts the country, who immigrated in order to find a better life and more opportunities for work, while the street space was shrinking due to the growing number of individual motor vehicles, which jammed the traffic on the streets of Belgrade. The modernization of the city, which also included the acceptance of global individual motor vehicle transportation tendencies, resulted in the overloading of the traffic network. There was a severe disparity between the number of private vehicles and the traffic network itself.

The expansion of the city to the left of the Sava River bank was not followed by an appropriate road network reconstruction. This process was followed by the building of new suburban districts and with an unexpected growth of individual motorization numbers, which caused traffic chaos. Traffic chaos caused low speeds on the roads, combined with low comfort in the traffic system itself and also with inappropriate lines. The mono-centric city structure, its radial character of the road network and the poor traffic base of the central zone, resulted in forming numerous bus and trolleybus stops with convoluted line changes. This caused traffic intersections.

The most difficult task is to try to ensure an efficient traffic flow, within cities with rich history and with an inherited traffic network, which must allow for unhindered traffic along all major arteries. Belgrade is a good example of a city that developed quickly, whose number of inhabitants grew rapidly due to many circumstances. Its traffic situation long ago reached such levels where something should have been done to allow traffic to proceed unimpeded.

The mistakes regarding this issue were made long ago. Just after World War Two, the most eminent Serbian experts, including the well-known architect and urban planner Nikola Dobrovic, warned of the danger of traffic chaos in Belgrade. Unfortunately for the city, these experts' warnings were not heeded, the number of citizens soared and the streets hit their maximum capacity within a very short period of time. Throughout history, we have witnessed numerous events and disputes between experts and politicians, some of whom were also experts/politicians. The 1980s project can with justification be called the only true, detailed and comprehensive Belgrade subway project. The commencement of the construction work was certain and then, due to suspicious political circumstances the project was halted and never to be realized. A lot of resources and the work of a team of highly trained experts were invested in the classical metro project (Arandjelovic, 2008).

Nowadays, in the 21st century, Belgrade has been experiencing a traffic implosion, even though certain experts pointed toward this outcome as early as the first half of the 20th century. There are four studies related to the subway problem in Belgrade in the past.

2 Metro systems around the world

The first metro systems appeared before the introduction of individual motorization. In this respect, London is the most notable, as it was the first metro system and was constructed in 1863, as a result of the attempts to use the classic railway for inner city needs. At the turn of the 19th century, in the times when electrical engineering was becoming more popular, the first cities to introduce metros were Budapest in 1896, Paris in 1900 and Berlin in 1902. Since then, a great number of cities around the world, not just metropolises but also cities with a population of less than one million inhabitants installed metro systems. Since 1975, the number of cities with metro systems increased rapidly and in the review of the International Union of Public Transport, more than 90 cities now have metro systems (mainly European cities) and also there are a great number of cities intensively preparing to construction more subway systems (around 22). Metro systems are appropriate for cities with more than 800,000 inhabitants, with a minimum of 4 million passengers annually per 1 km of line, along the corridors where more than 15,000 passengers are expected within the first phase (Maletin, 1993).

Table 1: The review of world subways at the end of the 20th century.

City	Year of Construction	Length of line (km)	Number of stations	Track width (m)	Speed (km/h)	Length of developed lines	Number of developed stations
Amsterdam	1977	18.0	20	1.435	32.0	/	19
Berlin	1902	134.5	159	1.435	31.0	/	/
Bucharest	1979	57.8	39	1.435	38.0	11.0	10
Rome	1955	25.5	33	1.435	32.0	11.5	14
Hamburg	1912	95.7	84	1.435	32.0	2.4	3
Helsinki	1982	14.0	10	1.524	43.0	2.8	3
Hong Kong	1982	38.6	37	1.435	33.0	5.0	1
Lisbon	1959	16.15	24	1.435	28.0	6.72	9
London	1863	392.0	248	1.435	33.0	/	/
Madrid	1919	112.6	117	1.445	21.7	8.8	10
Milan	1964	55.9	66	1.435	30.0	12.7	17
Moscow	1935	251.8	148	1.520	41.3	22.4	10
Munich	1971	62.6	66	1.435	34.0	18.0	18
Beijing	1971	40.1	29	1.435	38.0	12.0	/
Stockholm	1950	110.0	99	1.435	40.0	/	/
Washington	1976	112.0	64	1.435	56.0	8.5	3
Vienna	1976	41.0	49	1.435	33.2	/	/

Source: Schleife (1992).

3 The present situation of public transportation in Belgrade

The main traffic problems in Belgrade today, defined in the General Plan 2021 are (Urban Planning Institute of Belgrade, 2003):

- Mono-centric development with a high concentration of jobs in the central zone and the dispersion of main residential zones toward the city outskirts, which have increased the intensity of traffic at radial directions and an increasingly difficulty in supplying the central zones.
- Lack of public transportation along the most loaded corridors, unresolved problem of Belgrade railway junction.
- Neglecting the fundamental motivation for the building of a new junction: removing of entire infrastructure from the Sava Amphitheater.
- Technical underdevelopment and reduced security.
- Interfering of local traffic with the flow of transit and goods transportation at the most critical junctions of the street system.

As indicated by the General Plan 2021, the mobility growth is 2.5 and 2.7 travels by one citizen per day. Because of this, the total number of travels in 2021 will reach approximately 3.6 million of travels per day. During peak rush hour periods, the load would be 8–9% of the total daily traffic, so that in the period of the highest rush hour traffic load, the number of travels would be round 300,000 travels per hour. Public transportation annually transports around 550 million passengers, with 500 yearly rides by each citizen. In all, the number of transported passengers is classified as follows: approximately 75% of people are transported by bus, approximately 22% by tram and trolleybus, and approximately 3% by railway. There are 125 lines within the public transportation system, with

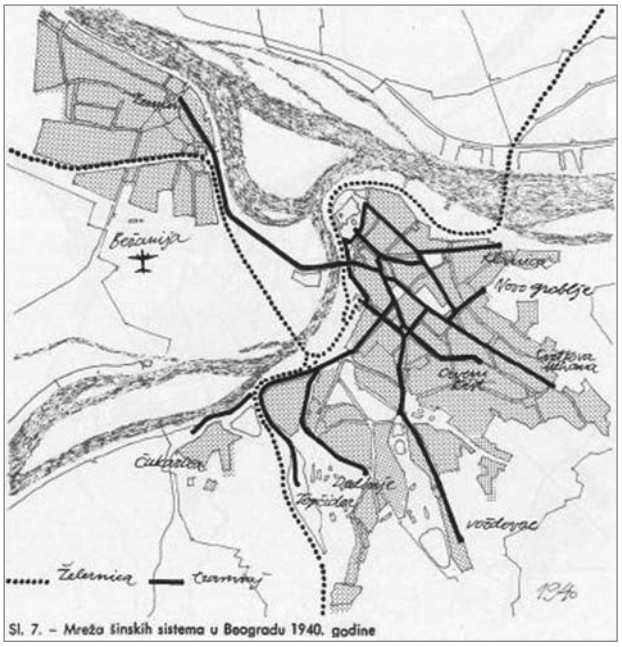

Figure 1: The rail systems network in Belgrade in 1940 (source: Belgrade Development and Reconstruction Agency, 1982).

2,363 stations. Altogether there are approximately 750 vehicles: 130 trams, 88 trolleybuses and 536 buses.

Also, the statistics taken from the General plan 2021, states that the number of cars registered in the period 1990–2001 in the territory of the city of Belgrade (16 city municipalities) was in the range of 308,000–319,000 cars. The motorization ratio in 2000 reached a limit of 200 vehicles/1,000 citizens. In 10 city municipalities the motorization ratio reached 210 vehicles/1,000 citizens. In case of any further increases in the number of cars, the road network would not be capable of accepting them. From the 617 km of the basic street network, approximately 67% are one way streets. The average speed in the central zone is 12–18 km/h, which on some routes causes a time increase of 45% with respect to the total time of travel.

4 Belgrade metro studies

4.1 The Nikola Dobrovic study – 1946

The first subway study was produced in 1946 by the famous Serbian architect, Nikola Dobrovic. It was his idea that Belgrade needed a subway. This document was later quoted a number of times, and is indeed the first written record discussing the subway issue in Belgrade.

Dobrovic concluded that out of all the cities of (now former) Yugoslavia, only Belgrade had the need and the right conditions for the installment of an underground railway system, i.e. a subway, whether as a single line or even an entire network. He also stated that the population was increasing, which was contrary to the desires of the city authorities, and that the terrain configuration and its geological composition were already suggesting where the future underground lines would be placed and how they would gradually be constructed. With the properties of the terrain in mind, it was clear that a ground network was possible, only in the lowland areas, i.e. in what is now New Belgrade (Dobrovic, 1958).

Table 2: An analysis of the travel situation in Belgrade from 1932 to 1939.

Year	Number of citizens	Total number of travels	Number of travels per citizens
1932	292,000	47,967,731	164
1933	306,000	47,075,709	156
1934	321,000	46,603,500	145
1935	335,000	49,656,968	148
1936	346,000	55,709,426	161
1937	365,000	60,349,120	166
1938	380,000	64,413,871	170
1939	399,000	73,415,765	184

Source: Dobrovic (1958).

4.2 Belgrade metro study by Savo Janjic – 1968

The second study dates back to 1968 and this is a project conferred upon by the "Institute for Studies and Architecture of the Community of the Yugoslav Railroads", led by the engineer, Sava Janjic. This project was the first major study on the possibility of constructing a subway system. Work on the study took six years to complete, from 1962 to 1968. Its goal was to stress the traffic problems with regard to Belgrade and tender a plan for three lines of the subway network in Belgrade (Janjic, 1968).

In the period between 1957 and 1961, the number of cars quadrupled. The total number of vehicle increases in the same period was 3.2 times. Janjic concluded that around 10 citizens per each vehicle were expected by 1973. If this rate continued, approximately 5 citizens per each vehicle could be expected by 1980. By this, the average rates of developed countries would be reached.

In this study it was noticed that by comparing the possible road capacity with the forecasted loads expected up to 1970, the new bridge on the Sava River was at a critical spot, as the capacity of the bridge is 1,400 vehicles per hour and the expected load was 1,630 vehicles per hour. This was not the only problematic part, as there were many areas with a similar situation. For example, another critical spot was at Vuk's Monument – The School of Law locality, with a capacity of 1,400 vehicles per hour and a predicted load of 1,690 vehicles per hour (Janjic, 1968).

Table 3: Forecast of the number of passengers on public transport.

Year	The number of citizens	Presumed ride number on public transport (annually) citizens	The forecasted number of passengers
1962	630,000	421	265,000,000
1965	684,000	427	292,000,000
1970	815,000	450	367,000,000
1972	870,000	458	398,000,000
1975	945,000	470	444,000,000
1980	1,060,000	485	514,000,000
1985	1,145,000	496	560,000,000

Source: Janjic (1968).

Sava Janjic compared in his study the average ride number on public transportation in Belgrade with the average ride number in other cities with the metro system, and concluded that the number of rides in Belgrade was much greater than in other cities at the moment of metro construction. Belgrade had during the time of the study, more travels per citizen than some larger cities.

4.3 The metro project from the 1980s

The third and the biggest subway study, was completed in 1982 and contained a major, comprehensive subway project. This project was officially accepted and verified by the city council. The task of developing a project for the metro system was given to the Directorate for Building and Reconstruction of

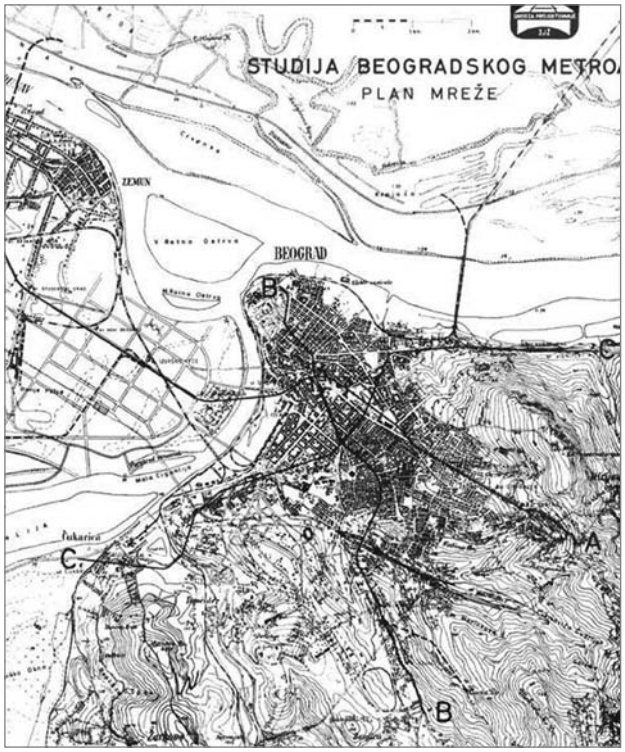

Figure 2: The metro network plan (source: Janjic, 1968).

Belgrade, which also assumed the responsibility of gathering the expert team who would realize this project. At the end of 1972, and at the beginning of 1973, the Directorate formed the "Sector for metro and underground works" and made an agreement with Energo-project (a Belgrade firm) on 27 October 1972 and also with the Institute for urban development (15 February 1973) to co-operate and to develop a project for a future metro system. The City Assembly accepted all the information and analyses gathered by the project team in the course of its session, which was held on 20 December 1973. On 26 April 1974, the contract for the project inception was signed between the City Council and the Direction for City Development and Reconstruction. The project for the Belgrade metro was formulated, but after a political decision in 1982, all further works were halted (Belgrade Development and Reconstruction Agency, 1982).

4.3.1 The first metro phase

Special attention during the Feasibility Study has been paid to the first stage of the metro building. Based on specific analyses and various revisions, the first metro stage has suggested two lines connecting the new and old Belgrade, and also serving the city center (14.2 km with 18 stations and a technical base). The suggested metro network includes the uninterrupted Belgrade conurbation territory expending 10 km from the city center to its environs. The metro network would be supplemented with a fast bus network on special lines, in order to serve urban areas within walking distance from the metro stations. In the city centre itself, three intersection spots would be formed (two connected with the regional metro) in order to allow a fast and effective flow of traffic, forming huge pedestrian zones (Knez Mihailova, Trg Republike, Terazije, Slavija). The first metro stages would be functionalized with metro compositions (6 vehicles) within each 3 minutes, transporting 25,600 passengers/hour/direction, with speeds of up to 34 km/h (Belgrade Development and Reconstruction Agency, 1982).

In contrast to many other cities, Belgrade has the advantage that with the integration of the first metro line into traffic, many positive effects would be seen. First of all, the main aim of all important activities is that they are planned to be within walking distance from all stations. The first stage immediately assumes the role of a basic transport system within the city. The lines of the already existing tram network, with all the necessary improvements would serve as a transport system to the suburb metro stations, together with buses and trolleybuses. The transportation lines of the existing public transport system do not need to pass through the most heavily, loaded parts of the center, so that the positive effects would be noticed quickly. It is estimated that the travel time on public transport would decrease from the present day figures by 20–25%. The first stage of the metro, together with the supply lines of the tram, bus and trolleybus will overlap with the main fluxes within the city (2/3 of all local travels in Belgrade have the city centre itself as their main aim) and 6 metro stations from the first stage form the ultimate and lasting traffic base in the direction of Kalemegdan-Slavija, thereby improving the quality of life in the city center and returning important spaces to pedestrians and the opening up of public green spaces. In essence, with a metro system, Belgrade would be a real modern center. With a few exceptions, most public transport lines are radial with their terminus in the city center. The city structure is mono-centric so that the traffic network has a radial characteristic. At the same time, the weak traffic base of the central zone does not allow for the introduction of more diametric lines, which results in the need for passengers to change lines regularly (Belgrade Development and Reconstruction Agency, 1982).

A growth in the mobility rate (22.32%) was noticed due to the result of income increases and the rapid growth of mobility grades. It was possible to predict the mobility growth rate until 2000 through research, as given in Table 4.

Table 4: The number of travels and mobility rates until the year 2000.

Year	Mobility growth rates	Number of travels a day
1960	1.00	630,000
1975	1.60	1,700,000
1985	2.25	3,400,000
2000	3.00	6,000,000

Source: Belgrade Development and Reconstruction Agency (1982).

4.4 The light metro project

The fourth project that was adopted as a solution to the traffic chaos in Belgrade, the light city railway, part of the General Plan 2021 was already to have been developed in part. The construction was planned to begin in 2005, and a part of the section was already to be opened for traffic.

Expectedly, the light subway project aroused a major polemic with respect to those within the profession and also among non-professionals, dividing the experts and citizens into two factions. Where one group supports the opinion that without a real subway Belgrade simply has no future, so that there is no system that can replace the subway and ensure the normal functioning of traffic flows. The other group advocates the theory that Belgrade does not need the subway, that the load in the most critical parts of the town does not require a full subway be constructed, that the subway system is a luxury which Belgrade cannot afford, and finally, that the "21st century tramway", as the light railway system is locally called will be enough for the needs of the people of Belgrade (Belgrade Land Development Public Agency, 2003).

5 Conclusion

Subways are constituent parts of modern civilization. Keeping in mind the fact that in the world today we have quite a few major cities with subways and that numerous new subways are currently under construction, one may conclude that the number of people using the subway on a daily basis is not to be neglected nor overlooked. In modern metropolises, life without the subway would be unimaginable, because this system facilitates communication, makes much more space available to the average citizen and offers more opportunities with regard to the selection of jobs and places of residence. The metropolis and the subway are two inseparable terms. Building a Metro system is very expensive (Beara, 1998). However, investment in a Metro pays off in the long run and with high revenues from passengers, the running costs per passenger-kilometer are lower than any other mode of transport. In the large cities of the world there is no alternative to the Metro as a means of public transport.

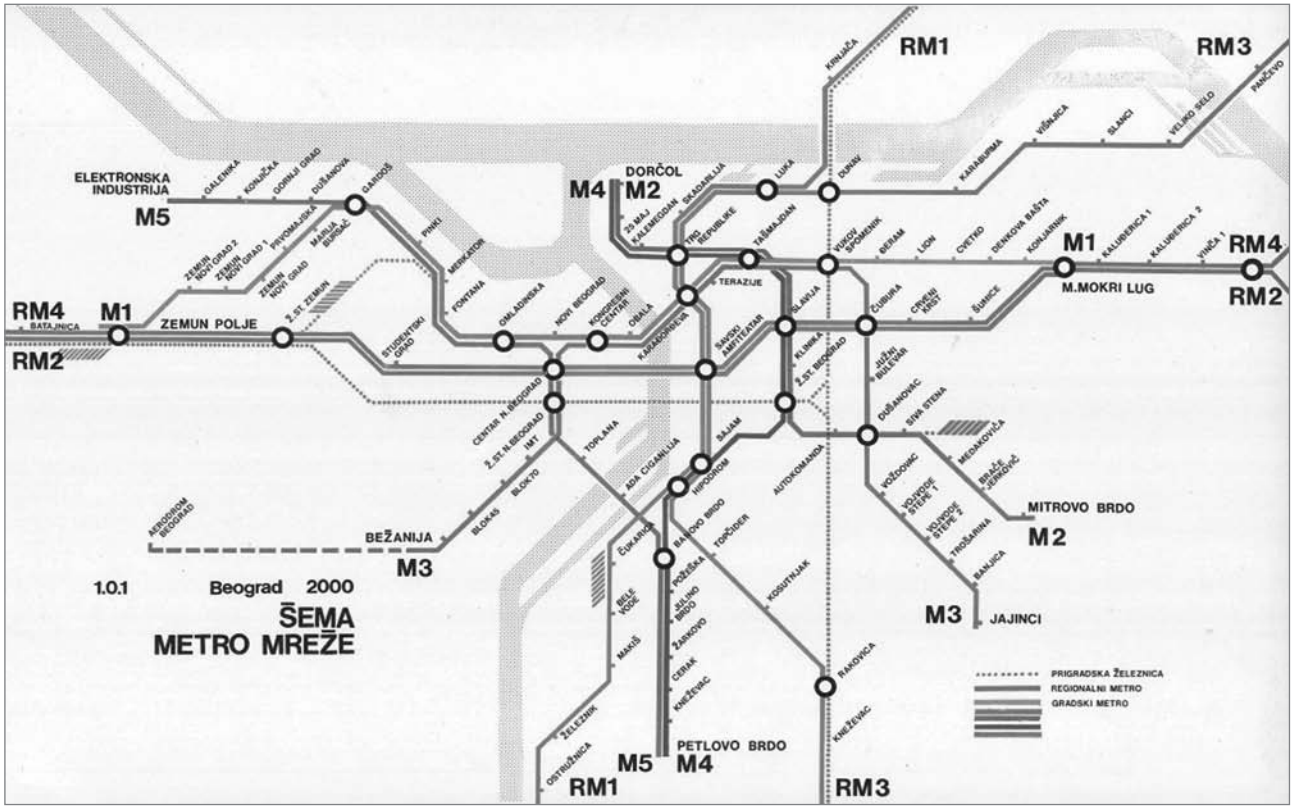

Figure 3: Metro Belgrade (source: Belgrade Development and Reconstruction Agency, 1982).

The study of the suitability of the classical subway has provided accurate financial calculations. The classical subway project is now over 30 years old. However, a new analysis of the project was conducted in the year 2000, with the same team of experts from the original project. They adapted the project to fit the current conditions, changed the dinar to the equivalent value in euro, and thus made the economic predictions transparent. The study stresses that the greatest financial expenses should be expected in the initial phase, because it requires the most complicated work, which need more extensive resources than the subsequent stages. This means that every phase to follow would cost less and would be completed in a shorter time period. It was then estimated that an 80–90 million dollars of a yearly investment, after the 2005 exchange rate, would amount to the yearly construction of the network spanning 2.5–3.9 km. The study with specific reference to the suitability of a light railway also shows the financial facts, where the total financial resources required for the first line of light railway amounts to 349–386 million euros within a six-year period. (Nenadovic, 1996)

With the information we have from both studies, one can conclude that financial resources in comparing both projects should not be the decisive factor in choosing the system. The effect of the two is simply incomparable, and if one also considers the financial aspect, which has in the past made decision makers opt for the so-called light railway, one can see that the claim is fully ungrounded because the financial difference is almost negligible.

Research completed by 1975, which included analysis of experiences from abroad and a detailed check up of the spatial and physical characteristics of Belgrade's urbanization and traffic infrastructure in the city, undeniably suggested that, in terms of Belgrade, the dilemma of the "light" or "heavy" railroad transportation is objectively ungrounded, because the two systems exhibit fully different conceptual grounds, functional characteristics, and transportation capacities. The ultimate theoretical capacity of "light railway transportation", if it is granted independent lines and a normal rail width of 1.435 m, reaches 20,000 passengers/hour/direction, which is not enough even for present-day requirements of principal Belgrade corridors. This means there are no reserves needed for future growth. In essence, "light railroad transportation" is but a technologically updated classical tramway with certain limitations as it requires independent line tracks, on the ground, occupying organized traffic network corridors, not only in terms of their transversal profile but also in terms of the pace and spatial organization of the crossroads. The capacity of a light railroad is 20,000 travelers/hour/direction, while the capacity of the classical subway of up to 45,000 travelers/hour/direction. Due to the physical nature of the city structure, "light railway transportation" is formed as an independent system which will use both ground and/or underground level, then "light" and "heavy" railway transportation become totally equal in principal construction expenses (Maletin, 1993: 18–17).

Without the wish to delve into political disputes following the events around the metro system, which was supposed to sustainably solve the traffic problem in Belgrade, one may conclude that the failure to implement this project has been a great loss for Belgrade.
The second solution to this problem, originally presented as a replacement for the classical metro system, was the light metro system, a "21st century tramway". Without too many details regarding this solution, currently favored in Belgrade's 2021 General Plan, one can conclude that history is repeating itself, for who knows how long. A project accepted does not mean a project implemented.

Belgrade, too, has preconditions in order to become a full-fledged metropolis and to sort out its traffic chaos, which can be witnessed on the streets every day. What needs to be revitalized is the only real metro project, conducted in the eighties. This project needs to become relevant again. Belgrade's streets need to be relieved of the problems associated with overcrowded traffic, through the construction of an underground railway system. The traffic problem cannot be solved by the construction of a light rail system, which supported by some experts, because it will be physically impossible to add specific traffic profiles on to the current traffic network, inherited from the past. This would be a mere fast tramway, and no such system can solve the traffic problem, even if it were the most advanced and were able to travel at the speed of light.

The solution to Belgrade's street chaos is to be found only in the construction of an underground railway system, which would take on the bulk of passengers, thus reducing the traffic congestion and allowing the city to start breathing freely again. The classical metro system would make Belgrade one of the global metropolises (Maletin, 1992). A city with such a good geographical position cannot and must not allow that bad assessment of those responsible to further worsen the present situation.

Therefore, we are witnesses to the time in which the fate of this city will be decided. Without a functional traffic system, there is no functional city! Something should indeed be learned from the mistakes of the past.

Dr. Biljana Arandjelovic, Assistant Professor
University of Nis, Faculty of Civil Engineering and Architecture, Nis, Serbia
E-mail: bilja@vtkom.net

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