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Metro or Light Rail: Belgrade Transport Proposals

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1 ABSTRACT

An architectural discourse on urban railroad transport systems in European context is presented in this paper. Metro and light rail systems are briefly compared and international practice discussed. As a case study, the proposals of metro and light rail transport in Belgrade are concisely reviewed and the budget crucial role is recognized. Five attached figures are specially completed for this paper.

2 INTRODUCTION

European towns have a variety of urban forms, spatial structures and transport systems. The transport in the towns is complex because of the multitude of origins and destinations, and the amount of traffic. The transport problems take place when transport systems cannot satisfy numerous requirements of urban mobility. Typical urban problems are traffic congestion, parking difficulties, land consumption, public space reduction, environmental impacts, energy consumption and public transport inadequacy.

Urban railroad transport, which is influenced by continuous technological innovations, serves urban and suburban areas and plays a dominant role in many European towns. There are various types of rail systems with rail vehicles running on electricity. Rail systems classification and subdivision into types is not easy, because type characteristics often overlap. Terminology of rail systems is not uniform also. Between the "*metro*" and the "*tram*", which are two main types, there is the "*light rail*", which is a relatively new system resembling to tram although with many characteristics of a metro.

Few proposals of metropolitan system in Belgrade, called "Belgrade Metro", span from the time after the Second World War, to the first decade of the New Millennium. Recent proposal is light rail system in Belgrade, called "Belgrade Light Metro". All these proposals consider various Belgrade transport aspects, such as demand, network, speed, capacity, frequency, operation, maintenance and investment.

Railroads are town infrastructure regulating elements which provide mutual connections and relations among different urban districts. New metro or light rail system design and construction, where architects devoted to urbanism participation is compulsory, gives an opportunity for the town transformation. This chance for new urban development of Belgrade, conveniently located on two river banks, is important locally and regionally and should not be missed.

3 URBAN RAIL TRANSPORT

3.1 Urban infrastructure

Infrastructure study is complex because many interrelated phenomena have to be analyzed. Infrastructural buildings, which can be traced since antique times, follow towns' spatial development and human civilization progress (Korica 2008). Rise of infrastructural systems started with antique roads and canals for transport of people and goods. Modern infrastructure systems, besides transport of people and goods, also provide transport of energy and information.

Urban infrastructure, as a basis of urban functions, increases town development potentialities and everyday life qualities. Nevertheless, classification of infrastructure is not unique and can be done in a few ways. Infrastructure consists of *technical* infrastructure (roads, water supplies, sewers, electric lines, telecommunications, heating systems, and so on), and *social* infrastructure (kindergartens, schools, hospitals, social institutions, et cetera).

Technical infrastructure systems of interest in urban planning are: *transport* systems (which utilize land as medium, water, and air), *water* systems, *energy* systems and *telecommunication* systems (Korica 2008:37). *Transport systems*, particularly these with roads or railroads infrastructure, are very important in space

planning and urban design. Corridors of roads or railroads, with tunnels, bridges and different buildings change environment.

The cost of infrastructure, such as roads or railroads, is high and compounds a principal part of the total cost of transport system. Built infrastructure maintenance is expensive too. The state usually finances infrastructure construction because of its high investment costs.

3.2 Transport

Transport (transportation, transit, traffic) represents an essential aspect of urban life. Mobility is fundamental to economic and social urban activities (Rodrigue et al. 2009). Each movement, independent of its nature, has an origin, perhaps intermediate locations, and a destination. Nowadays traveling is a part of everyday life.

Transport systems, composed of network and nodes, are coupled to distinct urban functions. There is a connection between mobility and life quality. Good design and advanced materials can improve transportation systems and create more sustainable urban environment. Increasing demands of urban population are raising complex transport issues.

3.3 Influence of transport

An analysis of urban development through history, as Mumford (1961) presented in his influential masterpiece "The City in History", shows that means of conveying of passengers and cargo have an important function in founding, shaping, and growing of towns. Transport influences town location, appearance and size. Regional and local transport system transforms both urban form and urban structure.

Locations of many European towns correspond to trading routes intersections and goods transloading points. Typical town locations are: harbor on seashore (Rotterdam), river crossing (Paris), port on river bank (Budapest), rivers confluence (Belgrade), mining district (Ruhr), hilltop (Prague), resort (Nice), and so on.

Easy access by different transport means increases the growth of town. Effective mobility within town affects diversification of urban functions. For example, the tunnel in Buda followed by the chain bridge over the Danube enabled residential, commercial, and industrial development in Pest. The unification of Buda and Pest into Budapest was the consequence of better mobility, economic growth and residents increase.

In the 19th century, world population increased and urbanization process started. The invention of railway, having capacity, speed and comfort, caused enlargement of towns and expansion of street networks. In a short time, narrow medieval streets of old European towns were encircled by broad new boulevards.

3.4 Public transport

At the beginning of the 20th century, numerous technical inventions in mechanical and electrical engineering enable development of public transport along streets and rail tracks in European towns (Vuchic 2007).

Public transport (mass transit) is a common passenger transportation system, with fixed routes and scheduled service. Main urban public transport vehicles are bus (motorbus, autobus), trolleybus, tram (tramway), and urban train.

Rail transport allows high capacity on short or long distance, but requires construction of tracks and suitable stations. Urban rail transport main types are: *metro*, *trams*, and recently *light rail*. Rail vehicles use less urban surface area than private cars (Maletin 2009).

Urban passenger majority travels mostly between their homes and work places. Public transport is safe and offers mobility for all. It has to provide quality service and to fulfill sustainable mobility requirements (UITP 2011).

After the Second World War private cars started to create congestion and to disorganize rail transport operations in streets. Large towns began to utilize rail technology for high-speed services on lines with fully separated rights-of-way.

3.5 Metro

Public enterprise "Serbian Railways", successor of the first Serbian railway line Belgrade-Nis opened in 1884, is a member of the International Association of Public Transport (UITP - Union International des

Transports Public), founded in 1885. This Association defines *metro* as "a tracked, electrically driven local means of transport, which has an integral, continuous track bed of its own"(UITP 2011). Nevertheless, the extended definition of metro is adopted in this paper and given hereunder.

Metro (metropolitan, underground, subway), called *rapid transit* also, is urban public transport electric railway system with large capacity and frequent service and completely independent from other traffic. In this definition, it should be noticed, *metro attributes* are speed, independence, urban, public, electric, capacity, and frequency. In large town, metro may be only in central parts and with frequent stations, while a *suburban railway* reaches peripheral districts.

Metro system is everywhere considered as public transport *backbone*, because of its speed, capacity, and frequency. In fact, metro has capability to transport speedily and frequently a large number of people over short distances, using minimal area of the town surface (UITP 2011). In addition, metros can be easily integrated with other public transport by interchange stations.

In many capitals and large cities around the world, metro is a major public transport and it serves millions of passengers per day (Beara 1998). Famous are pioneer metros in European cities, such as metro in London (opened in 1863), Budapest (1896), Paris (1900), Berlin (1902), Madrid (1919), and Moscow (1935).

Metro lines are regularly placed below street level in underground tunnels. Parts of metro lines can be above the ground on elevated bridges. Two metro construction methods are *tunneling*, first used in London, and street *excavating*, first used in Budapest. Luxurious metro stations in Moscow have demonstrated economical and technical achievements of the Soviet Union. During the World War II, metro tunnels in London were used as shelters.

Metro trains are electric and driven by drivers. Older systems use direct current (DC). Trains commonly have steel wheels running over two steel rails. Two innovations, used in the Paris Metro, are driverless train operation and rubber tires. Metro has small energy consumption and space occupancy (UITP 2011). From Europe to America and Asia, there are different designs of metro systems.

Developing and operating of metro system is a complex task. Metro system construction is very expensive and lasts many years. Maintenance of metro system is costly too. The country or town government investment and ownership are standard these days. Regardless of the high investment cost and long construction time, metro is an optimal public transport mode for a town with population of over a million, what is a traditional benchmark for start of building a metro system in a town.

In our time, metro systems exist in 175 towns in 49 countries of the world. Out of these, 75 metro systems, covering a track length of about 3500 km, are in Europe. Among them, 62 metros belong to the European Union member countries (the EU-27) and 13 metros are outside the EU-27 (WMD 2011). Germany has 19 metro systems, France 7, Italy 7, Spain 6, Russia 6, UK 3, Belgium 3, and so forth.

Some of the European metros belong to the top ten in terms of: *annual passenger rides* (Moscow 3.2 billion, Paris 1.2, London 0.88), *number of stations* (Paris 369 stations, London 275, Berlin 254, Munich 229, Madrid 190, Moscow 165), *length of metro lines* (London 415 km, Moscow 265, Madrid 226, Paris 212, Berlin 146) (WMD 2011). According to consumer surveys (GMT 2011), four European metros (the London Underground, the Paris Métropolitaine, and the metros in Moscow and Madrid) belong to the top ten metro systems in the World.

Approximately 77 per cent of the existing metro length in Europe lies in Western Europe, in view of the fact that Central and Eastern European countries primarily invested in their tramway systems expansion. Further, there are big differences in metro characteristics across different countries (GMT 2011).

Metro planning, designing, evaluating and constructing is extremely complex urban and transport venture (Beara 1998). Detailed feasibility study with anticipation and objective evaluating of metro routes and stations is necessary for making a decision. Worldwide practical experience should be used.

3.6 Light rail

Trams, or tramways, are electric vehicles that run on rails in streets. They have larger capacity than buses, but they are less flexible vehicles, that must follow rails and electric wires. Developed with the advent of electricity at the beginning of the 20th century, trams become very popular and in a short time, almost every

big town in Europe has trams. After the World War II, trams are slowly removed from many towns in favor of cars (Vuchic 2007).

Some towns cannot find money for a metro system. Decision makers decide to keep trams and modernize them. The strategy is to free the trams from streets congestion, expecting that for a small part of metro costs the town will get a big part of metro performance. Compromise principle is, it may be said, "to get 80% of the performance attributes of metro for 20% of its costs" (UITP 2011).

These pioneering towns successfully improved quality of trams' service at reasonable costs and they activated exceptional interest. During the last two decades, many cities introduced urban light rail systems running on street level with low-floor vehicles allowing easy use without high platforms (Vuchic 2007).

Light rail, called *light rail transit* also, is "a tracked, electrically driven local means of transport, which can be developed step by step from a modern tramway to a means of transport running in tunnels or above ground level. Every development stage can be a final stage in itself. It should however permit further development to the next higher stage". (ERRAC 2004). This broad definition contains a wide variety of situations, from conventional tram, to tram-train system (like Cologne-Bonn in 1980s). In this definition, *light rail attributes* are: track, local, electric, development stages.

In other words, light rail is a modern development of a tram, with increased speed, step-free access and track segregated of other traffic as much as possible. Light rail can be developed in stages from traditional tramway systems or designed and built as completely new systems. The former strategy is encouraged in Central and Eeastern Europe, and the latter mostly in Western Europe (ERRAC 2004).

The term "light rail transit" covers those systems which role and performance lie between a conventional tram running on the main street at one extreme and an urban heavy rail or metro at the other. Light rail systems are thus flexible and expandable. Capacity of light rail depends on vehicle type and varies between 170 and 350 passengers (UITP 2011).

Light rail system is successful transport mode, proponents declare, because of its speed, capacity, regularity, reliability, accessibility, comfort, safety, adaptability, phased development, moderate cost, and contribution to a positive image of a town (UITP 2011).

Today, there are about 400 light rail systems in operation worldwide, roughly 60 more under construction and above 200 in plans. Europe has 170 light rail systems in operation and nearly 100 more in construction or planning (LRTA 2011).

4 BELGRADE TRANSPORT PROPOSALS

4.1 Location of Belgrade

Belgrade (Beograd) is the capital of Serbia and its administrative, economic, educational and cultural center. With nearly 2 million inhabitants, Belgrade represents a market attractive to investors.

Founded at the confluence of two rivers, the Sava and the Danube, Belgrade occupies the central position in Southeast Europe. Therefore, Belgrade is an important transportation and commercial centre of the Balkan Peninsula since ancient times. The Danube River is a sailing route, which connects Belgrade with many European towns.

The *Pan-European* corridors, likewise the *Trans-European* corridors in Western Europe, are main transport routes in Central and Eastern Europe and they require investment over the next decade. There are proposals to unite these two corridors into an integral system. The corridors differently encompass road, rail and waterway routes.

Contemporary Belgrade is a junction of the Pan-European corridors No. 10 and No. 7. For that reason, Belgrade has strategic position and it is the main communication and logistic center in the region.

4.2 Public transport in Belgrade

In the 19th century Turks departured (1867) and Serbia acquired full independence (1878). Since that time, Belgrade has developed by means of urban plans. As the capital and the main crossroad, Belgrade was always attractive to newcomers from the region and its population was increasing permanently.

Master plan, as strategic projection, defines a town spatial development and, besides other, determines transportation corridors and capacities. After the World War II, Belgrade developed on the base of master plans adopted in years: 1950, 1972 ("Belgrade 2000"), 1985, 2003 ("Belgrade 2021").

Public transport in Belgrade, after the first horse tram (in 1892), started in the 20th century with initial traffic lines (electric tram 1904, motor bus 1925, trolley bus 1947). Modern Belgrade public transport system has lines networks of buses, trolley buses and trams.

Unfortunately, Belgrade transport infrastructure cannot satisfy demands of its inhabitants. Street network of Belgrade has low capacity and the number of vehicles in the streets increases drastically. In rush hours, consequently, there is enormous traffic jam in the streets. Shortage of parking spaces and lack of garages bring on illegal parking on pavements and disturbance of pedestrians, above all children. Streets and pavements are often in the state of a real traffic chaos.

During the past decades, *different proposals* were substituting each other in Belgrade, starting from *metro* (in 1958, 1968, 1976, and 1982) (Beara 1998, Arandjelovic 2009), to *light rail* (2006) (BMP 2003, ABLCB 2008). In addition, different terms are used for light rail (modernized tram, pre-metro, Belgrade light metro).

Novel five figures (Fig. 1 to Fig. 5) are completed for this paper, with the objective to enable convenient comparison among four different metro proposals (Fig. 1 to Fig. 4) and light rail proposal (Fig. 5). In these figures, the same aerial map of Belgrade is used as a base. Applying existing data (Dobrovic 1958, Janic 1968, BDBR 1976, Maletin 1993, ABLCB 2008), five different proposals are presented, i.e. the rail lines of each proposal are drawn. Networks, directions and lengths of lines can be easily visually compared by five presented figures.

Fig. 1: Belgrade metro line – 1958 proposal

4.3 Belgrade metro proposals

Professor Dobrovic, prominent architect and urban planner of New Belgrade, made *proposal* of Belgrade metro (Fig. 1) in his monograph on urbanism technique and traffic (Dobrovic 1958). He promoted a line which links the town centre (terminus: Kalemgdan) to district Vracar (terminus: Cubura).

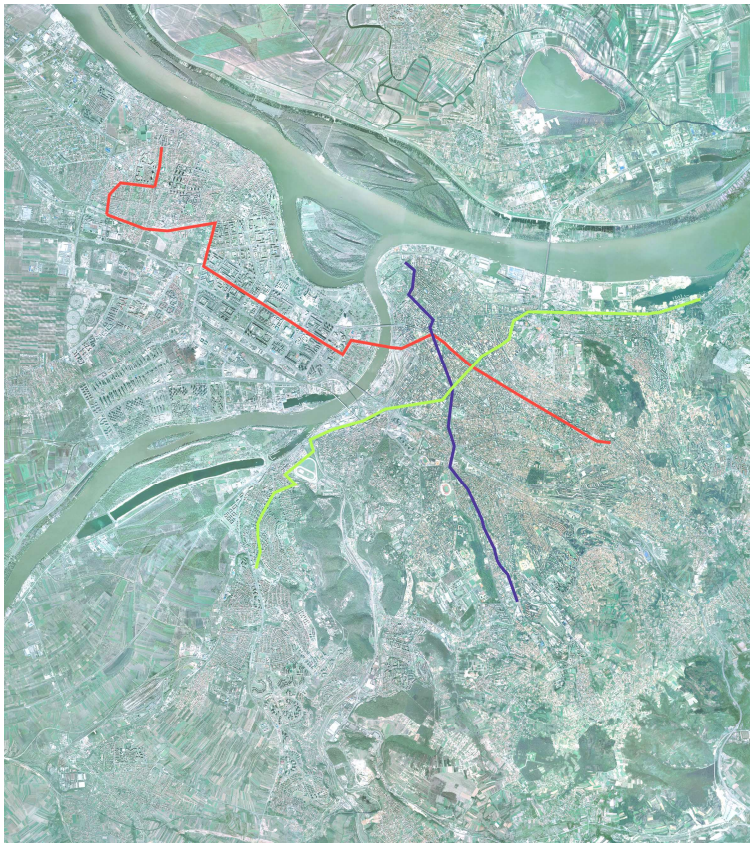

Fig. 2: Belgrade metro lines – 1968 proposal

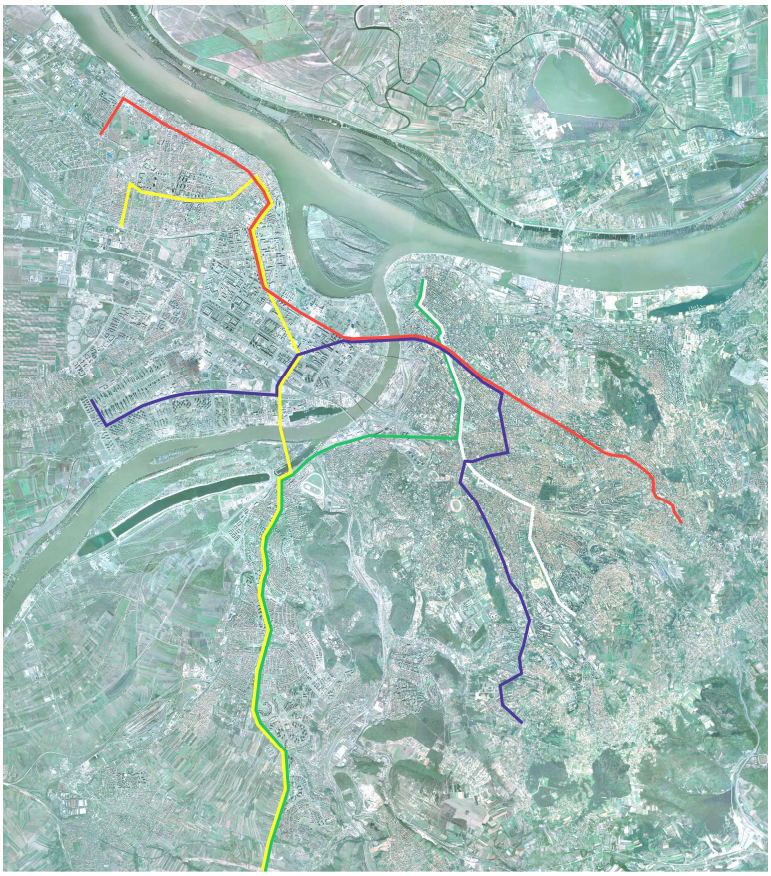

Fig. 3: Belgrade metro lines – 1976 proposal

Fig. 4: Belgrade metro lines – 1982 proposal

Fig. 5: Belgrade light rail lines – 2006 proposal

The overloaded bridges and certain spots of the town caused analysis. New *proposal* of Belgrade metro (Fig. 2) is given in the study for the Yugoslav Railways (Janjic 1968). This study, started in 1962 and was completed in 1968, proposed metro network with three lines, (denoted A, B, C), with total length of 33 km and 35 stations. The line A links Zemun to Zvezdara, the line B links Kalemegdan to Banjica, and the line C study links Cukarica to Visnjica. Unfortunately, economic and political situation in Yugoslavia that time halted the study continuation through a detail design.

In a relatively short time, the *Directorate of Buildings and Reconstruction of Belgrade* (BDBR) formed an expert team, led by architect B. Jovin. This team gave an important *proposal* of Belgrade metro (Fig. 3) in the study on rapid public urban transport (BDBR 1976). Metro has five lines (M1 to M5) and large network to be constructed in two phases. The first phase has two lines, the line M1 links Zemun Centar to Vuk's Monument, and the line M2 links Dorcol to Autokomanda. These lines, together with bus, trolley bus and tram network, would immensely improve the life quality and provide additional green and pedestrian spaces.

In the BDBR study few feasible lines variants are developed also. Metro proposal (Fig. 4) given in 1982 has two central lines. The expert team studies started in 1972, but a political decision stopped the further work in 1982.

The metro system makes possible a better future development of Belgrade (Maletin 1993). In 1995, the revision of the study (BDBR 1976) was done, but economic and political matters did not allow investment in metro construction (ABLCB 2008).

4.4 Belgrade light rail proposals

During the 1990s, which started with the split of Yugoslavia and ended with the bombardment of Serbia in 1999 by the NATO, the economic crisis and shortage of possible financing postponed further studies of Belgrade metro. After the democratic changes in 2000, extensive feasibility study on *light rail* (LR) transport in Belgrade commenced with updated input parameters and objective to resolve traffic problems (ABLCB 2008). This study received a positive review and was the base of the master plan until year 2021.

Belgrade Master Plan to 2021 (BMP-2021), adopted in 2003, proposes three public rail transport types: urban railway, light rail, and trams. It defines light rail as "massive rail system (LRT)" (BMP 2003:985). The BMP-2021 proposes seven construction phases of LRT, first phases 1 to 3, and later phases 4 to 7.

Belgrade light rail transport system (Fig. 5), proposed in 2006, has three lines. Line 1 links Zemun and New Belgrade on the left bank of the Sava River to the town centre and Zvezdara. Line 2 is on the right bank of the Sava River and links the town centre to Topcider. Line 3 links New Belgrade to Banovo Brdo. The light rail system is compatible with the existing tram and suburban rail network. The initial Line 1 proposal is later improved with more details (ABCLB 2008).

The BMP-2021 provokes long, intense and permanent discussions between *metro proponents*, and *light rail proponents*. Metro proponents are simultaneously *light rail opponents*, who light rail call: "21st century tram". There are many critics on the BMP-2021 light rail proposal. Light rail opponents declare the low cost is prevalent argument for light rail promotion, and that metro system is the only long-term public transport solution. On the other hand, light rail proponents state that the cost is crucial for Belgrade, and that light rail is, in terms of maximum number of passengers per hour, adequate solutions in the next two decades.

Belgrade urban train, (called: BG Voz) was opened in 2010 as the first phase of metro and includes underground stations that were built for metro earlier.

5 CONCLUSIONS

Architects of the 21st century face a challenge of modernizing urban infrastructure that supports civilization. Infrastructure problems are particularly acute in over populated urban areas. Architect is associated with diverse issues and activities. Because of that, architect's role in infrastructure designs is complex.

Participation of architects devoted to urbanism is compulsory in the design of metro or light rail. New rail transport system is an opportunity for urban area transformation. Railroads, as town infrastructure regulating elements, provide mutual connections and relations among different urban districts.

In European towns, from the point of view of architects, metros enable dense developments instead of urban sprawls. Metro lines are independent of existing street networks. That makes useful change of urban structures and functions possible. Thus, poorly planned towns can be improved.

Sustainable urban infrastructure planning demands not only an efficient systems approach, but also project management methods application. Public transport in towns must be coordinated with other urban functions. Increase of cars instead public transport improvement is not convenient.

Present economic recession seriously affects all businesses activities and tends to cut urban rail transport construction. European industrial countries experience is extremely useful to countries in transition.

Belgrade is one of the last European capitals with population over a million inhabitants that still has no metro or light rail transport system. The time of wars passed and the time of transition current should not be an excuse for no action.

Long history of dispute on metro versus light rail in Belgrade enlightens both transport systems. Program of stable financing is necessary for a successful construction of quality transport system.

If metro or light rail construction opens a chance for modern urban development of Belgrade, this excellent chance should not be missed.

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