Preliminary results of studying optimal LRT network in the City of Zagreb

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Abstract

The first results are being presented regarding the multidisciplinary research study of LRT (Light Rail Transit) system, based on three studies and the adopted General Urban Plan in the period from 1999 to 2008. The priority so-called "ZG cross" has been specially analyzed, with line A in the West-East direction and with line B in the North-South direction, with two versions of the gauge (1000mm and 1435mm) and with several possibilities of connections with relevant tram and suburban railway system through the Park&Ride locations. The problem of the so-called "ZG ring" has been discussed as well, based on the past studies regarding improved connections of the new, bigger urban and suburban agglomerations.

Keywords: LRT, multidisciplinary research study, ZG cross, ZG ring.

1 Introduction

Zagreb today has near to 800,000 citizens and about 500,000 passenger cars, which along with the vehicles from close and more remote environment contribute to the creation of huge traffic loads. Apart from the classical forms of public transit (trams, buses, suburban rail) Zagreb is threatened by a high share of individual traffic, which results in high road network loads and extreme traffic issues at all levels.

For efficient solutions of the traffic issues, and especially public transit, systemic research and progressive improvements in all segments are necessary. It is estimated that the municipal administration has not yet considered seriously the entire scope of the problem, and therefore there are no adequate preparations for efficient solutions. Certain sector analyses and study researches are still sporadic, without continuity and commitment by the authorized services.

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The paper proposes the introduction of a new under- and above-ground rail system at LRT level as the solution to the current traffic situation.

2 Condition of traffic and traffic solutions in the City of Zagreb

The conditions of traffic infrastructure (rail and road network) in the City of Zagreb are not at a satisfactory level, and do not contribute to the required standards regarding capacity and safety. Certain positive shifts occurred following the Traffic Study of the City of Zagreb (MVA, 1999), 2003 General Urban Plan and Program platform of the under- and above-ground rail system in the City of Zagreb (FPZ, 2006).

A network of ZET tram and bus lines was formed in accordance with the principle of their segregated space operation whereby the area of tram operation is concentrated in the downtown area, and the bus subsystem operation area includes the suburban areas of the city. The contact points of two complementary subsystems are tram-bus terminals at which the passengers continue their trips by changing from vehicles of one subsystem to another.

The terminals with the highest exchange of passengers on the network of lines are the final eastern and western points of tramlines, and the main railway station [1]. Very high passenger exchanges at these points indicate that the existing organization of tram transport does not recognize the wishes of a large number of passengers who do not end their trips at these terminals but continue their trip further from these terminals towards the centre of the city or some other city destinations.

Critical points in the traffic system of Zagreb include:

- overloaded sections on the road network,
- overloaded intersections,
- lack of parking capacities,
- overloaded lines of public transit.

Since 1999 no new classical passenger counts of sets of lines or individual lines as part of the tram subsystem have been carried out, whereas in the bus subsystem a number of individual passenger counts on lines have been carried out in order to optimize their offer.

In the same period, for identical objective, a number of visual estimates of the number of passengers onboard vehicles passing through selected stops were made, with assessors stationary positioned at these stops. This method is rather unreliable since the accuracy of estimate depends on the qualification and level of the concentration of assessors.

Based on the comparison of available data for identical sections of line networks it may be concluded that during the past period there have been no significant changes in the volumes of traffic flows as part of the bus subsystem, and the passenger flows in the peak direction constantly increase towards the peripheral parts of the network of bus lines, via the network of tram lines to central parts of the city where these are the largest. Already based on this fact it may be concluded that the central part of the City of Zagreb is the destination of the majority of passengers from the area served by ZET (city transport agency).

Consequently, the main directions of commuting passengers in the morning peak period and in the peak direction may be recognized. The most loaded route is from the extreme West towards the centre of the city (from 1008-4141 PAX/h), from the East towards the centre of the city (from 1036 to 2987 PAX/h) and from the South towards the centre (about 7000 PAX/h divided into 3 transversals North-South) [1].

Unlike the bus subsystem, the difference regarding directions of vehicle movements on the network of lines is not as pronounced in the tram subsystem. On the bus lines, however, as a rule, there is a large difference between the number of passengers who travel in the morning period in the peak direction towards the centre of the city from the number of passengers who travel in the opposite direction.

Analyzing the traffic routes, the strongest passenger flow in tram traffic is realized on the Dubrava – Črnomerec route (eastern and western peripheries of the city), which is very significant since also a very transport-efficient suburban rail on the Savski Marof – Dugo Selo relation operates along this route at a parallel distance [2]. It is obvious that in spite of the proven advantages of railway the position of its corridor cannot satisfy the existing travelling wishes of the passengers who reside outside the gravitation scope of its stops, northwards from the railway line.

On the network of tramlines in the centre of the city in the morning peak period the running speeds between 12 and 16km/h are reached, and on the section of the bus lines network in urban parts of the centre of the city the speeds range between 15 and 25km/h. On the sections of tram network where the rail line is located at a separate body, higher running speeds of tram vehicles are achieved, between 20–25km/h. The extremely low travelling speeds on individual sections of tram network and bus network of lines which are realized in the peak traffic load on the main approaches to the centre of the city, which takes about 60 minutes, are even lower and on certain sections range below 10km/h [1].

The main reasons for low travelling speeds of public transit vehicles include the large number of vehicles of individual transport on the roads and their movement along lanes reserved for the public transit vehicles, a large number of signal-controlled intersections and, in certain cases, the relatively short distances between stops. What additionally contributes to the resistance of tram vehicle operation is sometimes the poor condition of rail lines which on some line segments allow speeds of tram vehicles limited to minimal values of 5 or 10km/h.

3 Proposal of LRT Lines

The basic urban and traffic documents of the City of Zagreb define the basic so-called Zagreb cross. This proposal elaborates the mentioned cross (lines A and B), and proposes new lines for the connection of the centre of the city with the airport (line C) and the ring line around the city (line D).

3.1 The basic network of lines A and B

Among several studied lines and networks of the so-called light rail system, few actually valid lines have been determined. Out of four previously studied varieties, two with modifications have been selected for final procedures of design and cost-efficiency control. With certain simplifications in further elaborations, the varieties with two modalities of rail gauge (1000mm and 1435mm) can be studied. The indicated system with group of lines A – West/East (Savska Opatovina – Borongaj and Prečko – Dubec) and line B – North/South (Mihaljevac – Buzin) represent the better studied "PNTS cross" in the domain of their routes.

The set of lines A in the West – East direction is composed of the main line A1 from Savska Opatovina (Osredek) / Španska in the West to Borongaj in the East, and line A2 from Prečko (West) to Dubrava (East). The joint section of lines A in the central part is planned as underground route [2].

At the extreme western point of line A1 the plan includes also a depot of this line. At the point of the second stop a possibility of physical contact with suburban railway line and road across the Sava River is planned. In the narrow part of the city the route is planned with an underground section in the length of about 1.93km, and to the connection with the rail at Borongaj stop the route goes above ground. Layout and elevation design elements of the route are planned for the lighter system ($R_h \geq 20$m, $s \leq 7\%$), i.e. for the case of selecting the normal track gauge $R_h \geq 200$m, $s \leq 3\%$. Line A1 has 23 stops, which on 14,416m of route yields an average spacing of 655 metres. In case of realization of the system according to the tracks variant of normal width, the line connections to the railway network are planned: at Osredek 1,595m and at Borongaj 933m. The Traffic Study plans for this line by the year 2010 the highest load of 3,825 passengers per direction, with largest boarding of 770 passengers/h and disembarking of 1,380 passengers/h at the stop [2].

Line A2 starts in the western part of the city in the district of Prečko and ends in Dubec / eastern Dubrava in the East of the City. A depot with a workshop (replacement for the existing one) is planned in Prečko, and the existing depot with final stop (turning bay) in Dubec will be kept as well. The Prečko – Dubec route is mostly set on the existing tram route, and in one part connects to line A1 and proceed for the most part together. In continuation the route would be guided along the tramline to Dubec and the possible contact with the railway line of normal gauge. Within the forecast period 2010, line A2 will have maximal load of 2,160 passengers/h in one direction, and at certain stops the highest boarding of 625 passengers/h. Line A2 contains 30 stops, which on 17,372m of the route yields an average spacing of 579 metres [2].

The carried out research in the Traffic study MVA and Program platform (FPZ, 2006) has determined the priority of lines A1 and A2 compared to line B because of the intensity of travelling and thus receive priority in the development of the project.

Lines A1 and A2 would be realized in three phases. The first phase would see the realization of the joint section in the total length of 2,587.85 metres for the most part underground. The second phase would see the construction of the

surface section in the length of 2,926 metres and two depots. If variant 2 were selected, this phase would also see the conversion of the narrow gauge into the normal gauge of the existing gauges. In the third phase the remaining surface sections in the western part of the city would be constructed.

Line B on the route from the North to the South stretches from Dolje to the end of Dugave. From Dolje the line goes southwards at ground level, descends underground at Degenova Street, passes below the Ban Josip Jelačić Square, and near the Main Railway Station is directed more eastwards and passes below the Grada Vukovara Street and Kruge, and exits above ground before the Sava River. The line then passes across the Sava River over the bridge and continues at level through the districts of New Zagreb.

A part of the line south of the Sava River is planned as above-ground over the viaduct in the length of about 2181m after the bridge across the Sava River in the length of about 500m.

Line B is of total length of 12,389.95m and has 17 stops with a depot in Dugave.

Line B would be realized in two phases. In the first phase, the underground section to the bridge over the Sava River and the surface sections north of the entry into the underground would be realized.

The second phase would see the construction of the bridge over the Sava River in the length of 345m and the viaduct from the Sava Bridge in the total length of 2,340.90m. This phase would see the construction of the remaining surface sections in the south and the vehicle depot [2].

3.2 Proposal of network expansion (lines C and D)

The extension of the light rail system (LRT) should be considered in order to enable more uniform connections of many agglomerations and new centres with new facilities. These are primarily centres or facilities along the city periphery, which need to be connected with the centre and among themselves in an optimal way because of the distance from the rail network or because of the slowness of the tram transport.

Line C connects the Kvaternik Square in the centre of the city and the airport, i.e. the city of Velika Gorica. The route to the bridge over the Sava River is almost unambiguously defined, both in the aboveground route and its cross section. In the area from the point of crossing with the Zagreb bypass and in the airport zone and Velika Gorica an underground section in the length of 6.3km is planned.

In the traffic, technical and technological sense, line C is more oriented towards the light rail system and lower axle load. The entire track of line C is 16,794m long and accommodates 16 stops, with average inter-stop distance of about 1050m [2].

The causality and purpose of studying line D can be explained through two infrastructure modalities: through a set of particular sections / sublines with clearly defined functions of connecting the centres, and as final ring-subsystem with the primary objective of serving and integrating the peripheral parts of the City of Zagreb.

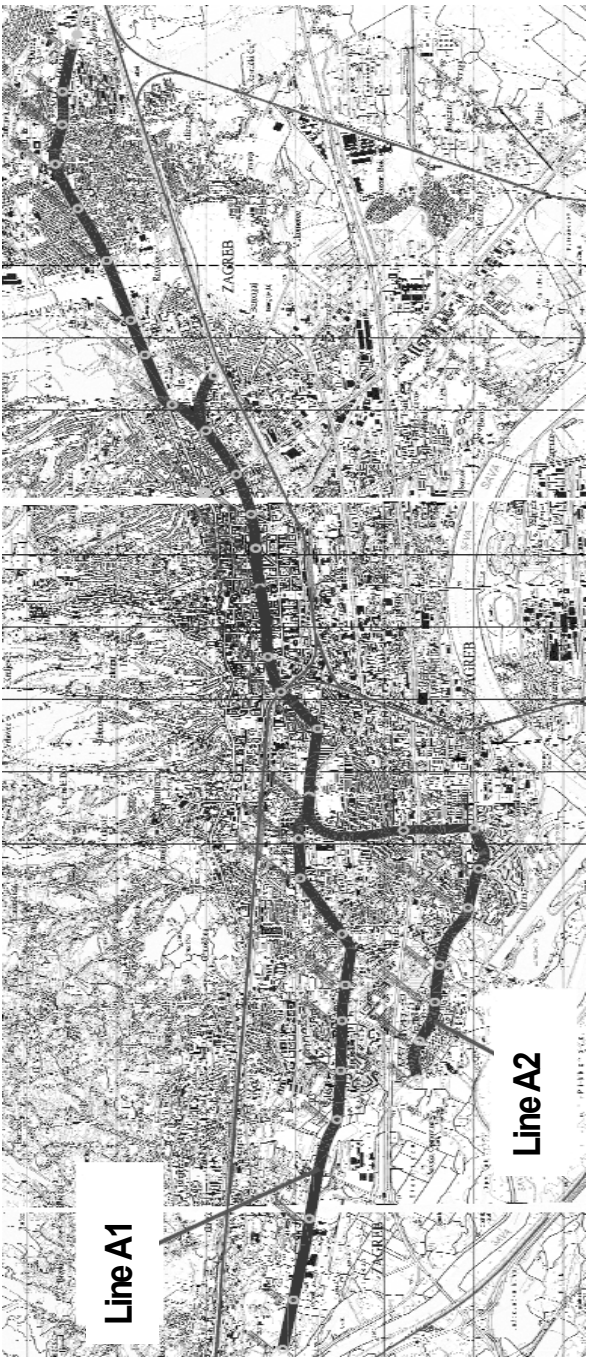

Figure 1: LRT lines A1 and A2.

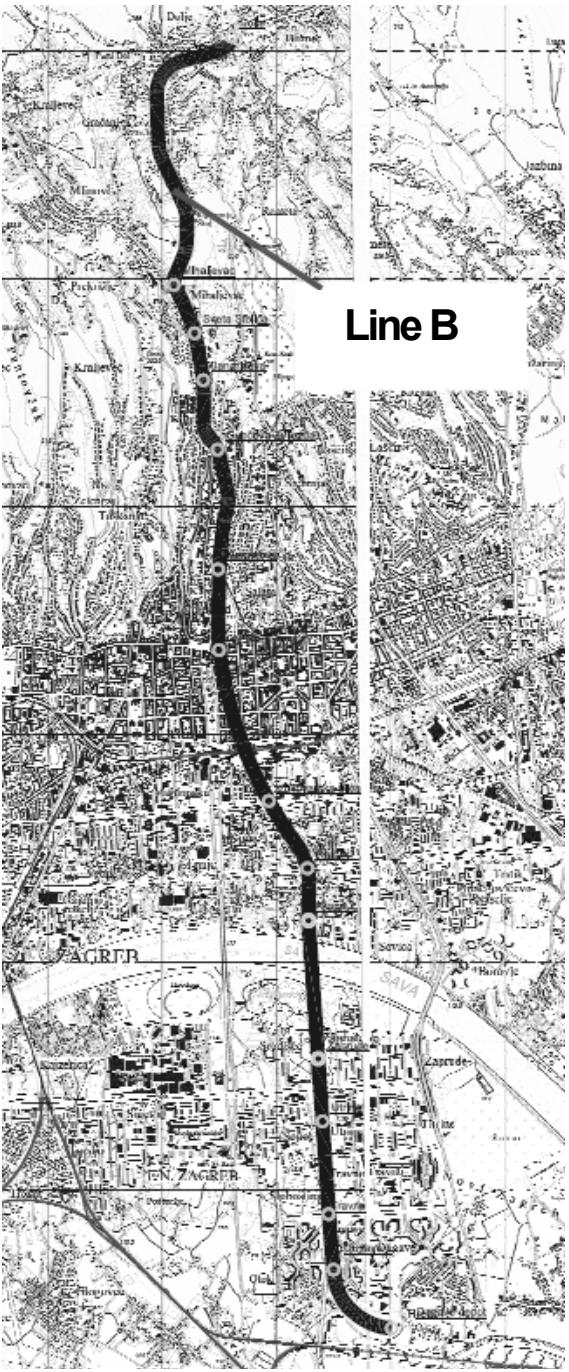

Figure 2: LRT line B [2].

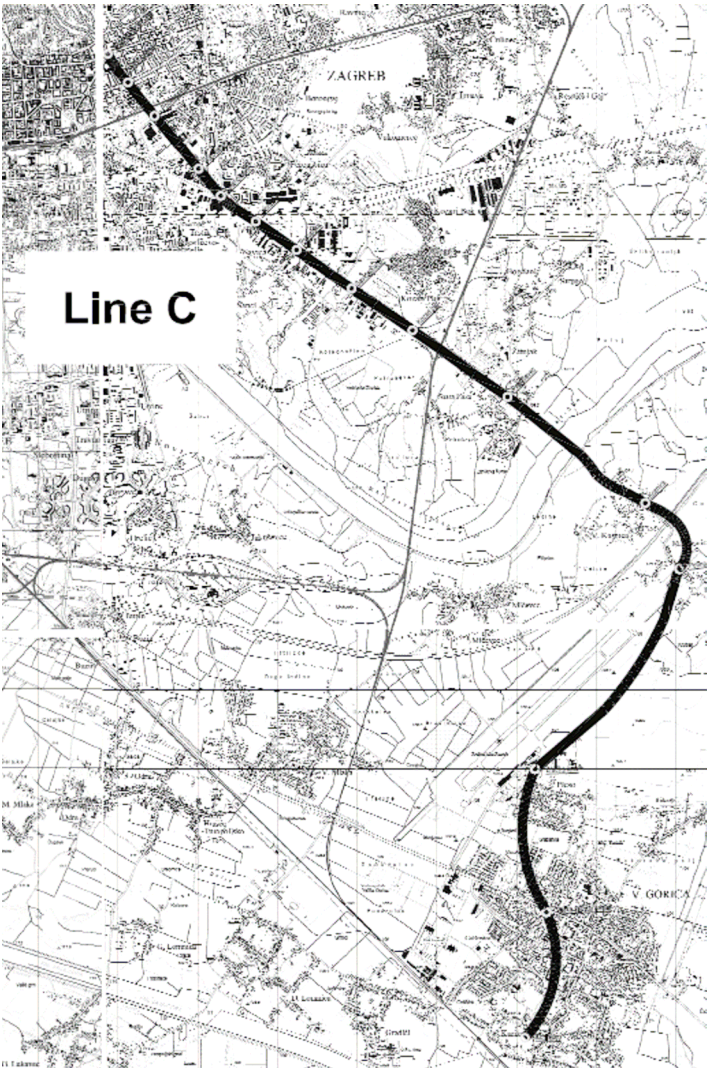

Figure 3: LRT line C [2].

The initiative to extend the light rail system is multiple:

- adaptation of the traffic infrastructure for the basic trapezoid shape and further city development (with longer baseline in the North and a shorter one in the South);
- fastest integration of the North and the South with several transversal connections;
- the possibility of phase realization of single sections, as well as of closed subsystems.

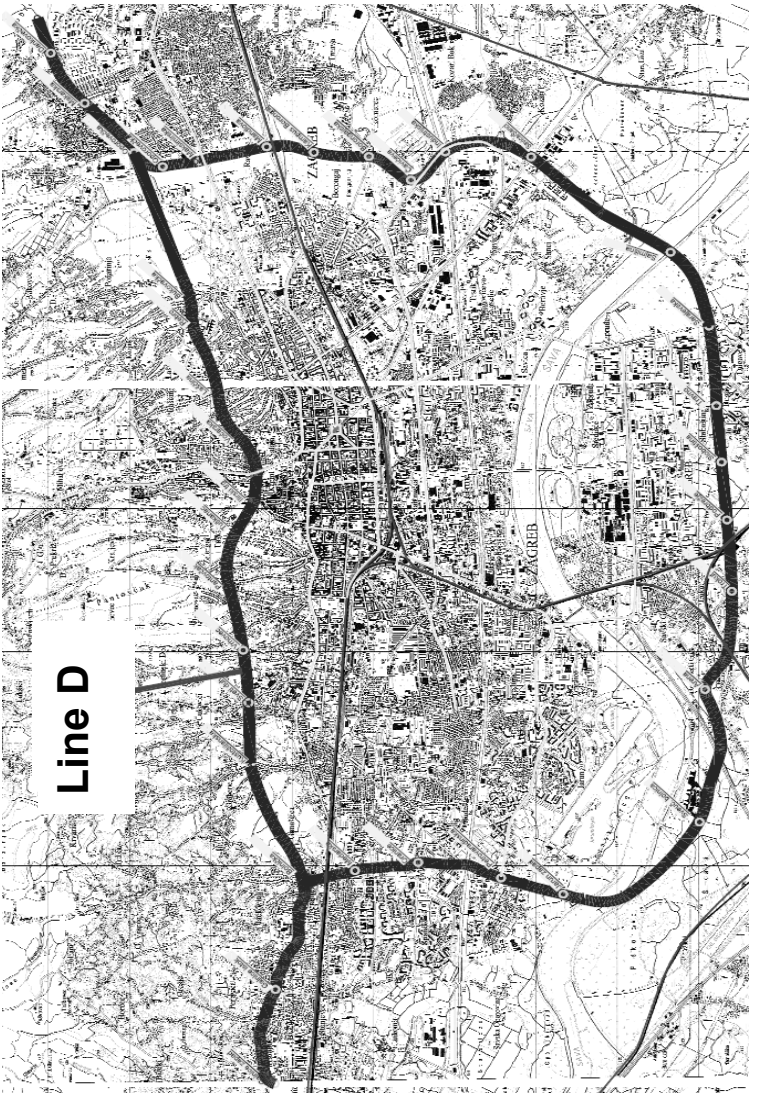

Figure 4: LRT line D [2].

The power plant functional component of the line determines this line eventually in the most part as a two-part system:

a) northern subline (D_s) (depot Gajnice – depot Dubrava North);
b) southern three-sided semi-ring (D_j) in the final form at the connection: Vrapče - KB Dubrava) [2].

Regarding the possible dynamics in the realization, the whole should be considered regarding traffic and functional sections i.e. development phases. Therefore, two phases with sub-phases are proposed. The zero phase includes the so-called internal ring, with the northern side from line A and with preparations for extension to the northern tangent. The first phase would be realized in two sub-phases through the construction of the eastern and western transversals. The northern underground tangent would be realized in the second phase.

Generally, along the entire route (ΣL = 36,642m) the greater part of the line passes underground (Lp = 22,512m, 61.4%), and a minor part (Ln = 14,130 m, 38.6%) is planned as aboveground route. The southern route D_j is 20,630.08m long and has 23 stops at average inter-distance of 982m, and the northern route D_s is 16,011.85m long and has 18 stops with average inter-distance of 889 metres. The integral complex of line D has a route in the length of 37,300 metres and 41 stops with average inter-distance of 956 metres [2].

4 Proposal of direct research

The results of previous research of the light rail system (MVA-1999, GUP-2003, FPZ-2006) refer primarily to the basic and already verified "PNTS cross", i.e. lines A and B. Certain evaluations and recommendations refer to a lesser extent also to wider areas of the routes / corridors of lines C and D, as a certain expansion established basic networks over a longer period of time. Further research should encompass the overall problems of public rail transport (tram, light rail system suburban and urban rail). The elaboration of single systems may be done, however, parallel to the general space and traffic concept and modelling. With the aim of approaching the realization of lines A and B in the direct phase it is necessary to develop the preliminary design of both rail modalities (1000 and 1435mm), the study of environmental impact, risk analysis for single route sections, the elaborate of the existing installations, feasibility study, study of urban traffic reorganization per construction phases, elaborate situations on property and legal relations (for the construction on plots of different owners), and to prepare the documentation for the location permit.

It is necessary to prepare also the operationalization of organizing and managing the Project (so-called Department / Board for LRT Project Implementation), and later also the founding of the municipal company for further development and construction of this traffic system network.

For the additional lines C and D, it is necessary to primarily determine the level of actual needs of the mentioned lines per certain segments or as a whole. This is to be determined using the traffic modelling in correlation with other systems and the city development, and in re-considering the traffic and urban requirements as part of the elaboration of GUP and other documents.

5 Conclusion

The carried out research in the urban and traffic elaborate of the City of Zagreb has confirmed the need of introduction and capacity sufficiency of advanced underground and aboveground rail system at LRT level for radical improvement of the public urban transit. Direct and indirect benefits of this rational system will be reflected in acceleration of the traffic flows and increase in the number of public urban transit users, and in reducing the congestion of the urban space by individual automobile traffic. The quality of living will be improved because of the shorter travel times and because of the reduction of adverse impact on the environment. In the new zones along the lines, the value of land and real assets will be raised, alleviating the load on the central part of the city. The detailed explanation of the proposals of direct research will give incentive to political structures to accelerate further processes of the construction of underground and aboveground rail system in the City of Zagreb.

References

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