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DESIGN CONCEPT AND FINANCING OF THE LIGHT RAIL ZAGREB PROJECT

SUMMARY

The expansion of individual traffic in the city of Zagreb has reached the level where it requires fast development of a light rail system as a major component of public transportation. Different variants have been analysed leading to a solution of light rail system consisting of two lines in directions north-south and east-west. The analysis shows advantages of development of a narrow gauge track of 1000 mm width and a connection to an existing tramway network. The lines consist of sections located underground, on the surface and elevated with more major structures such as tunnels, stations, bridge crossing of Sava river, viaducts and ramps. The financing and construction of the system should be developed continuously in steps during the time.

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1. INTRODUCTION AND ENVIRONMENTAL DEMANDS

The City of Zagreb reached, when passing over to the 21st century, a population of approximately 800 000 inhabitants. The urban development of the city followed the design standards defining the dimension of the traffic flows through the city. The present standards determined, to a greater extent, the traffic parameters and capacities so that an intensive development of the individual transport during the last 20 years, surpassed all expectations and plans. At the same time the public transport did not develop much nor did it follow the City. In accordance with the development of the traffic necessities, various documents were worked out trying to find, during the previous decade, the solution for the traffic city problems; the "Traffic Study" from 1999 and the new "General Urbanistic Plan" (GUP) from the year 2003, presented new solutions for the traffic problem in the city itself and suggested the development of a light city railway (LGŽ) as one of the traffic solutions on the public transport improvement level.

2. INTRODUCTION AND ENVIRONMENTAL DEMANDS

In this sense, except the basic light rail scheme, presented with the GUP 2003, other line variants were also developed and analyzed. The line networks taken into consideration shows two main lines in two basic directions following the concept of the city development as well as the main directions of the daily city traffic: they extend in the east-west and north-south directions (see Abb. 1). A total of 4 variants concerning these lines were taken into consideration, covering implementation of the light rail in the existing tramway network or connecting to railway lines passing through Zagreb.



Abb. 1: One of the variants leading the rails of the light city railway (LGŽ) of the City of Zagreb.

The lines followed, in the most part, the principles concerning the setting into "traffic flow centre" which also favours the layout of lines with mild horizontal curves enabling thus the development of larger average daily traffic speeds. In longitudinal sections the lines were placed above ground, on the ground level or underground (Abb.2). The subterranean parts are limited, in the first place, on the central parts of the city centre where there is an evident lack of space for on the surface.

Parts of the lines on the ground level are extending in directions where, owing to the urbanization and lack of space it was not necessary to go underground, while the space on the surface level gives a minimum of possibility to proceed on a necessary daily traffic speed (presumed average daily traffic speed of 25-30 km/h).

Parts of the lines above the ground level were conducted on viaducts in places where there was not enough room for such objects and where there exists the potential to, by erecting a line, increase the speed of the LGŽ traffic which, as is the case in the underground sections as well, is separated from all other forms of traffic losing thus its speed.

Hydro-geological profiles developed for the presumed lines in the basic directions - east-west and north-south used the database from the Zagreb area GIS system.

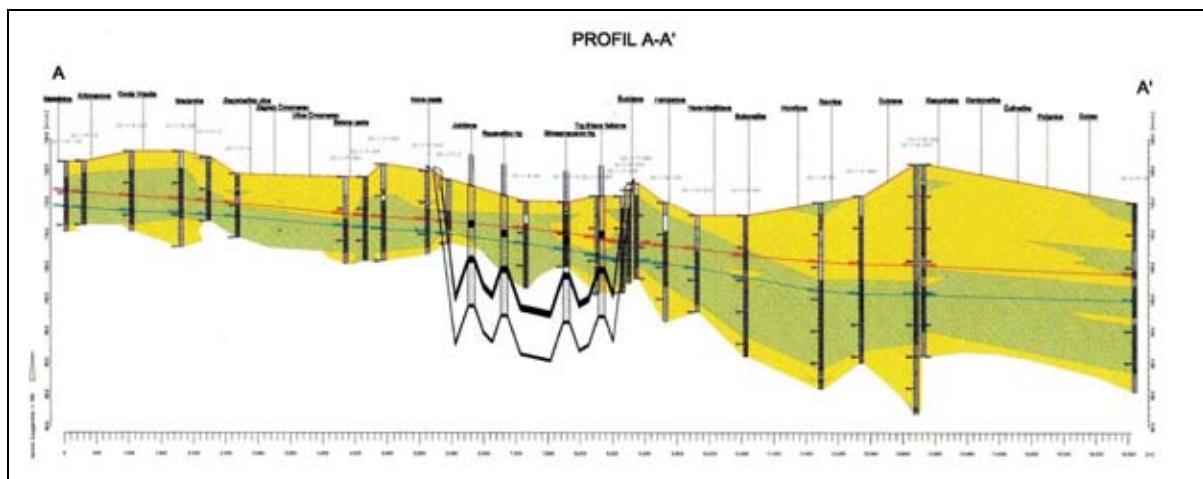


Abb. 2: Vertical hydro-geological section in the direction of the LGŽ west-east line in the variant 1.

2. STRUCTURE ON THE LIGHT RAIL LINES

Light rail stations are set up in accordance with customary criteria and in accordance with the zones where the passengers tend to gather, according to the usual distances with the light rail system and according to the habits of the passengers who have been using certain stations for years. The gravitation zones have been established in accordance with the area attracted by a station and they may be of a narrow (400, and 5 minutes walk) or of wider type (600 m and 7.5 minutes walk). The usual distance between the stations with the light-rail system is 500-800 m and this was also taken here into consideration: the distances used were in the range of 350-800 m, with certain exceptions.

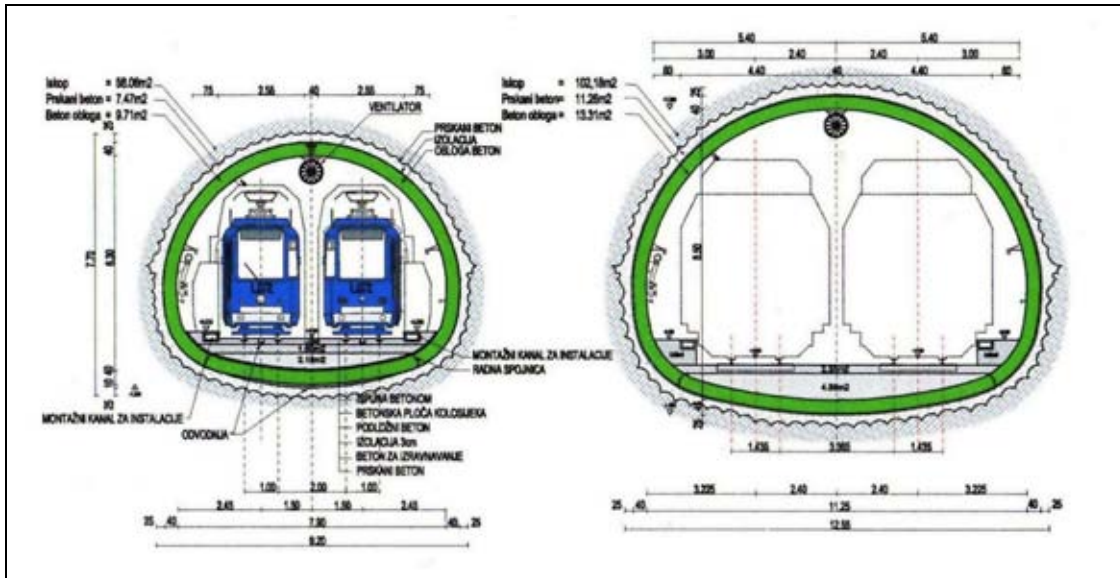


Abb. 3: Typical cross-sections of tunnels with the narrow (1.0 m) and railway gauge track (1.435m).

The stations foreseen on the light rail lines are either underground or aboveground. In order to reach the underground ones, it will be necessary to go deep down till the level where it is possible to conduct the further alignment underground. The favourable geological layers of predominantly clay lay at the depth of 15-20 m in Zagreb.

The underground sections are based on the size of the track gauge : whether to use single or double tubes, narrow or regular railway track gauge was the main factor in the estimation of variants (Abb. 3).

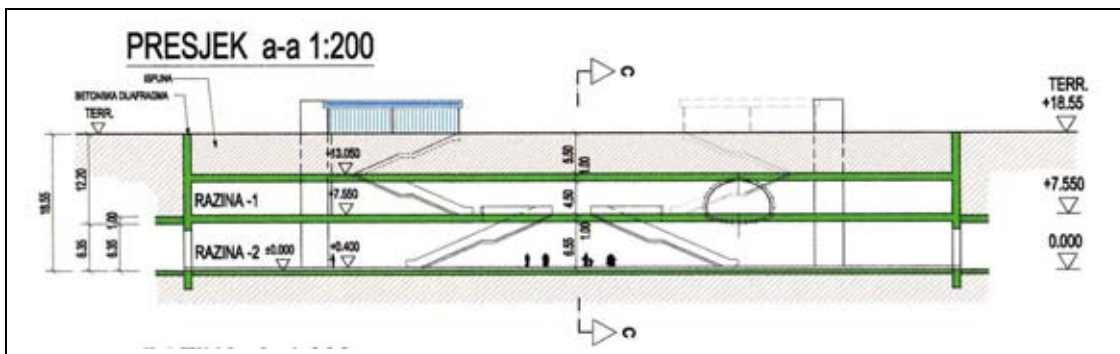


Abb. 4: Typical underground station executed by the "top-down" method: Trg bana Jelačića.

The structural and economical analysis indicators were more in favour of the variant with the narrower rail as, owing to the quantity of works and its price. According to the Abb. 3 it is clearly visible that only the execution of the tunnel profile for a double light rail tube with a narrow rail has 58 m², while, in case of a full railway section it is nearly double so large and amounts to 102 m². The construction of the tunnel section is not questionable and is executable with the

application of the usual tunnelling methods in urban areas based on the NATM or TBM method [Kolić D., Kolić V., 1999].

The further more major part of the lines are bridges for the crossing of the Sava river and viaducts for the conducting of the above ground alignment. The bridge over the Sava river will be conceived not only as the necessary crossing for the light rail line, but also as one of the main city bridges in use of regular daily traffic (Abb.5). From the economical point of view one bridge crossing on this location is 4-5 times cheaper solution in a comparison with the tunnel crossing [Kolić D., Gulyas L.,2001].

The tunnel sections are foreseen to lead to the underground stations, executed by some of the mining methods [Kolić D., Gulyas L.,2001] or by excavations from the surface. The desire regarding the decrease of costs is directed towards the stations executed by the "top-down" method (Abb. 4) where the works are executed from the surface interrupting thus the normal life and traffic in the vicinity only for a short time [Kolić D., Matoš S., Krasić D.,2004]. At the same time such structures are most acceptable from the economical point of view as well.

From the traffic point of view, the vertical alignment will be conducted low, a fact which will facilitate the approach to the bridge as well as the road ramps and the light rail ramps should approach the bridge from the north, exits from the underground. The bridge cross-section should have expected width of carrying at least 2 light rail lines and 6 motor vehicle tracks and pedestrians' paths (Abb.6)

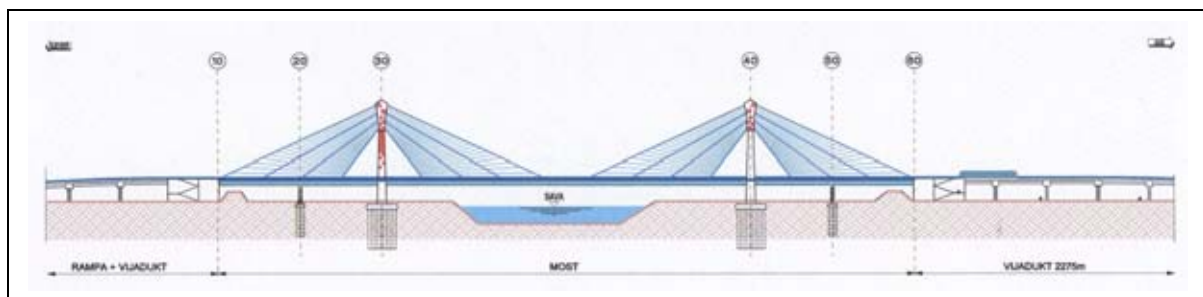


Abb. 5: View of the bridge over Save river in the direction Avenue of BR Deutschland.

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When the line will be above the ground level it will stay on the viaducts , conceived as simple prefabricated structure, made of pre-executed prestressed elements and may be effectively, quickly and acceptably constructed on locations where there is enough space and where its influence on the environment is not too big.

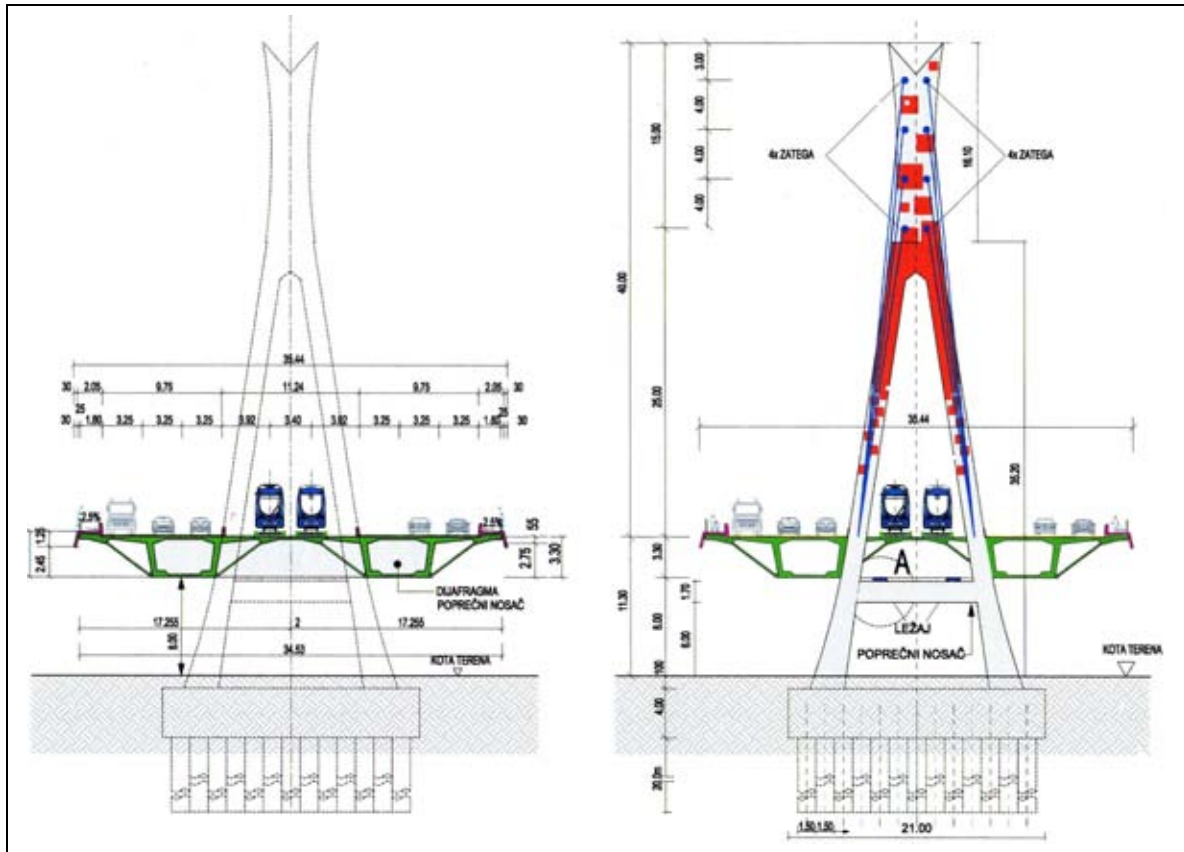


Abb. 6: Cross sections of the bridge crossing Save with the view of the bridge pylon.

3. PPP AS THE WAY OF FINANCING OF THE LIGHT RAIL ZAGREB PROJECT

The construction of the LGŽ system is one of the largest projects not only for an urban environment of the size as the city of Zagreb but also for the whole region and the Republic of Croatia as a whole. The funds necessary for the realization of such a system are not unambiguously presentable as we speak here of a project executable in phases and for a longer time period.

The evaluation, in accordance with the present price level is such that the two basic lines in the direction east-west and north-south, with the belonging vehicles and equipment are 500-600 million EUR. Owing to such an extraordinary high amount, this project will be developed in phases and its feasibility will be in a row of direct and indirect consequences having its result in the everyday life and work of this environment such as [Kolić D., Kolić V., (1999) and Kolić D., Matoš S., Kراسić D.,(2004)]

- a) improvement of the city flows, decrease of noise, decrease of the pollution by motor vehicles
- b) increase of the real estate prices on the direction of lines, additional construction and investment
- c) increase of the traffic safety, opening of the pedestrian zones, lesser number of accidents
- d) continuous construction of the system as the starter for the development of the

environment; opening of new jobs.

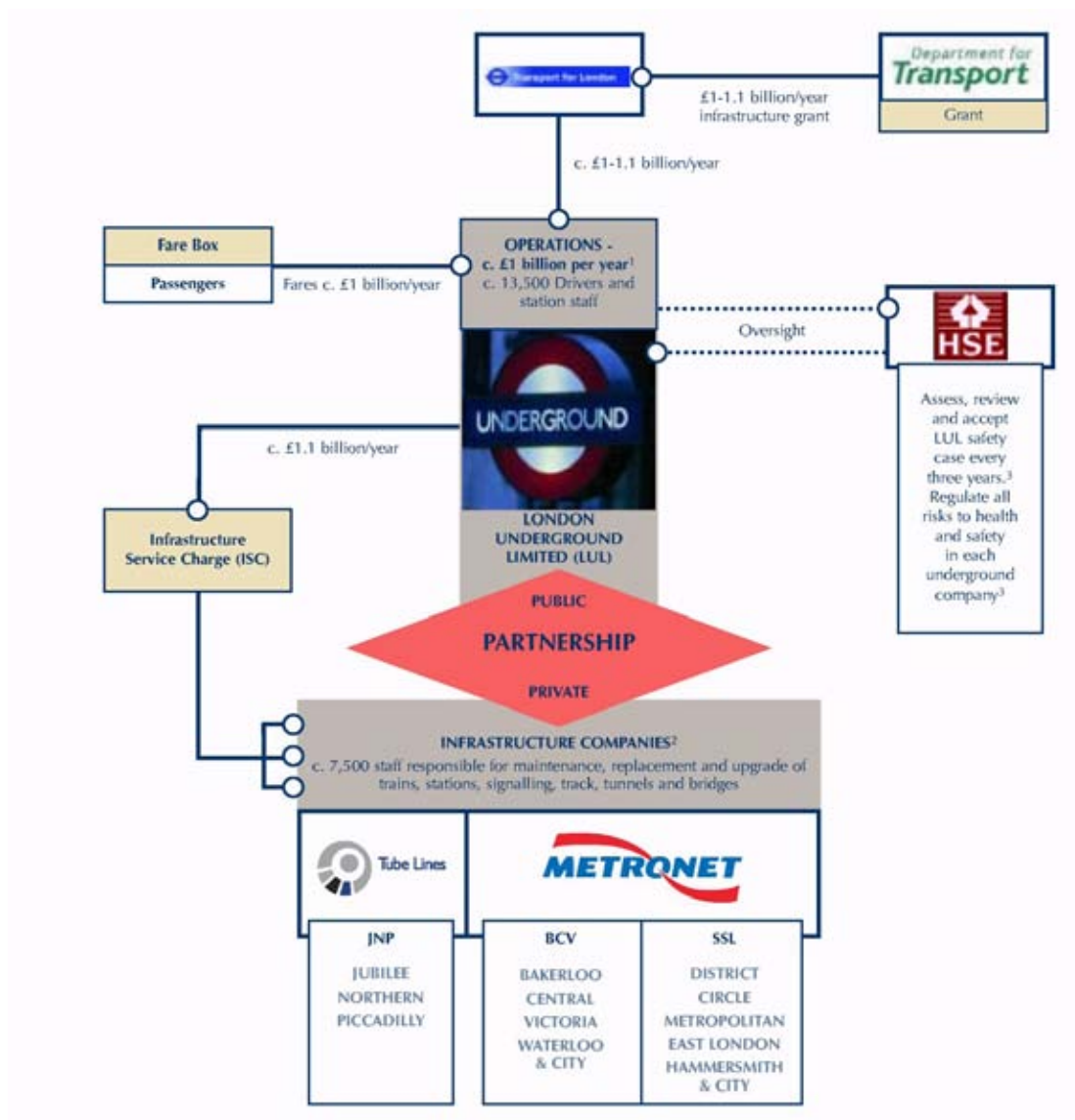


Abb. 7: London Underground PPP structure [8].

To enable the execution of PPP projects, many European and non-European countries enacted PPP guidelines [Abadie, R. and Howcraft, A.A, (2004) and Commission of European Communities (2004)], by which they provide legislative frameworks or by which they direct and encourage the execution of such facilities. PPP projects can be very diverse. Since the terminology and nomenclature are not unambiguously defined, different terms and denominations are used in practice. The most common contractual forms of the PPP are BOT (Build, Operate, Transfer) and PFI (Private Finance Initiative), according to which a private entrepreneur with his own means builds, maintains and manages a project, and in the end returns it to the public government [Marenjak, S., Skendrovic V. & Cengija, J. (2005), and Vukmir, B., Skendrovic, V.,(1999)].The next graph emphasise the possibility of applying PPP/PFI model of financing to the LIGHT RAIL ZAGREB PROJECT, on example of London Underground PFI project [National Audit Office(2004)].

The lack of recent legislation development was also the biggest problem and obstacle in wider implementation of PPP models in Croatia. Although the Croatia has become candidate country for acceptance to the EU and is at this moment in the phase of screening, process of adjustment of national PPP legislation to standards in EU, which is still ongoing.

The Croatian government has publicly declared that the question of defining legislation on PPP is of strategically important issues to the country. The need for rising standards in public sector and closing the gap between the EU countries and Croatia has led to recognising PPP and speeding up the procedures in forming the national legislative developments on PPP's. Croatian government has formed a PPP Working Group to solve the problems and create the legislation so that the PPP model could be fully exploited and the process and rules for PPP models would be strictly defined.

In order to enable more wider contracting of PPP projects in the Republic of Croatia based on PPP principles, on the recommendation of the Working Group for defining the rules and procedures, as well as monitoring the PPP projects development, the Croatian Government introduced and issued The Guidelines to Croatian PPP projects.

4. CONCLUSIONS

According to the executed variants and its analysis it can be evaluated that the development of the light rail system in the city could mean a very significant step towards the final solution of the public city transport. The construction of a transport is recommended, based on narrow tracks with a distance not larger than 1000 mm, connecting to the existing tramway net.

Two basic lines are suggested for the execution on the directions east-west and north-south. The lines are executed in sections either in the level, or underground or are conducted above the ground and with its development an average daily travelling speed of 25-30 km/h must be reached. The section construction is foreseen in phases, although parts of the lines may be executed, if the funds are provided for, independently or at the same time.

The financing of such and infrastructural mega-project is possible from several sources and in several forms (public funds, from own sources, using the conventional way by a credit, by the way of concessions or with private financing). The participation of the whole city, region and the Republic will be necessary.

With Croatian Government PPP guidelines on applying the public-private partnership it is recognized that the approach to the usage of possibilities of full capacity, it offers, and also the maximizing the interaction and cooperation between the private and public sector.

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