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SOME SOLUTIONS FOR THE ZAGREB RAILWAY TRAFFIC JUNCTION

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Abstract

The City of Zagreb is a large traffic junction, since it is at the gateway of large European traffic routes. It is the beginning and end destination of numerous travels being presently undertaken through five motorway routes or 15 railway lines coming onto the city area.
The Zagreb railway junction includes 15 existing railway lines including the connecting sections, total length 192,6 km. All are categorized as lines on international significance, since they all run in the Pan-European traffic corridors X., $X._A$ and $V._B$ or along the lines connecting to these corridors. The largest ecological problem in the area of the Zagreb railway junction is the cargo traffic, which passes through the city center.
Based on the analysis of the *Spatial–Traffic Study results of the road and railway traffic in the wider Zagreb City area*, the paper presents a proposal of the new solution for the Zagreb railway junction, based on a modern concept postulates, which would satisfy the medium and long term requirements of the traffic demand and supply in the wider Zagreb City area, along with a high quality level of services and an economically effective concept.

Keywords: Zagreb, traffic, traffic network, railway, traffic model, feasibility.

1 Introduction

Zagreb, as the largest ant most significant traffic junction in Croatia represents the starting point and end destination of the majority of road and railway traffic routes, where the existing traffic network has to be redefined and mutual coordination of the road and railway traffic planned, as well as town and suburban and long-distance traffic coming in or going out of the city of Zagreb.
The complexity of this traffic problem is solved today mostly through individual traffic and spatial studies, the subject being a railway traffic junction in the city area or high speed city roads, which are seen as the solution to the transit traffic generated by the existing or future motorway in the immediate vicinity of town. In this sense, the mutual influence of long distance traffic and town and suburban traffic needs to be better coordinated, i.e. the main city road and railway network needs to be redefined in the context of the present and future traffic demands of the wider Zagreb city area.
In order to find the solutions to the above given questions, a group of Investors, (relevant institutions in Zagreb and the Company managing the traffic infrastructure having influence on the suburban and city road network), initiated a comprehensive Traffic and Spatial Study of the road and railway traffic in the wider Zagreb City area.
The Study was based on collecting and analyzing relevant traffic and technical documentation on individual traffic systems in the wider Zagreb City area (road, railway, air traffic). The analysis of the spatial planning documents tried to determine possible discrepancies or inconsistencies in individual traffic segments.

The proposed implementation of the planned integrated traffic system included the following time periods: Stage 1 up to the year 2012, Stage 2 from the year 2013 to 2018 and Stage 3 from 2019 to 2030. The Study proposed some solutions for the long distance cargo and passenger railway traffic and suburban railway lines as solution to the town and suburban traffic. It was proposed that a light city railway or a metro be introduced as supplement and extension of the present railway traffic in the city area, as well as extended tram traffic.
Solutions of the future traffic network are based on the results of the planned traffic model. The traffic part of the Study systematically dealt with available data regarding present traffic load with additional measurements and surveys. Based on the statistical data, forecasts of future traffic loads were given and traffic routes defined for the planned period for road, railway, long distance, local and city public transport as well as public and private transport. A traffic model was prepared which in the first stage presented the actual present condition in the existing traffic network, and the second stage presented some technical solutions on the future integrated traffic network.

2 Proposed solution for the new Zagreb Railway junction

2.1 Structure of the future railway network in the city area

The future traffic network includes the wider Zagreb city and county area, also including the long-distance road and railway traffic, as well as town and suburban individual passenger and public transport. This paper presents and outline of the solution for the railway traffic only, while the planned road network is presented in the papers of other authors (due to the extensive subject matter).
The analyses in the Study were done for long-distance railway traffic, town and suburban traffic as well as for public transport.
The long-distance railway traffic is analyzed in the Study through the new corridors of the west bypass railway line as part of the Corridor x, and through the west ring of the bypass railway line toward the east where the Corridor Vb separates toward the northeast, toward Hungary and Corridor x continuing toward southeast. This is the corridor of the bypass railway line for cargo traffic which would in the future be displaced from the city center, also displacing the marshalling yard further to the west of town.
The long-distance passenger traffic would keep the present railway line route but with grade separation in the town area; in the part from Borongaj o the West railway terminal (and possibly even further to the west toward Jankomir). This concept requires change and rehabilitation of the Main Railway terminal and its functional incorporation and unification with the Main Bus terminal. The town and suburban railway traffic would be realized along with the long-distance passenger traffic railway line (as a four track railway line), this being executed in the part between Savski Marof and Zaprešić on the west, to Dugo Selo to the east, and also as a four track line toward Horvati, here connecting to the existing line - the two track line – toward Jastrebarsko and Karlovac. Toward southeast, the town railway line would connect Velika Gorica, with a suburban two rack line in continuation toward Sisak.

2.2 Position of the railway junction in its surroundings

Enhanced and quick development of Zagreb and the increased need for travel and transport of passengers and cargo in its wider area imposes big demands on the transportation systems within the framework of realistic spatial limitations, and these demands are harder to be met every day. This causes bigger and bigger traffic infrastructure jams every day and an even lower speed of public and private transport. Therefore new technical and technological solutions for he overall traffic system must be found, which would satisfy the new social and economic needs of the city.

Zagreb has become a Croatian and Central-European center through its geographic position and historical role. It is a significant political, cultural, scientific, tourist and economic center within the Central European area. It has approximately 900.000 inhabitants, with suburbs over one million. All this caused Zagreb to become the starting point and end destination of significant passenger and cargo traffic, which in turn requires a high quality transport infrastructure and efficient traffic organization in the narrow and wider area of influence. Railway lines and railway terminals which are a part of the Zagreb railway junction have a significant role in this.

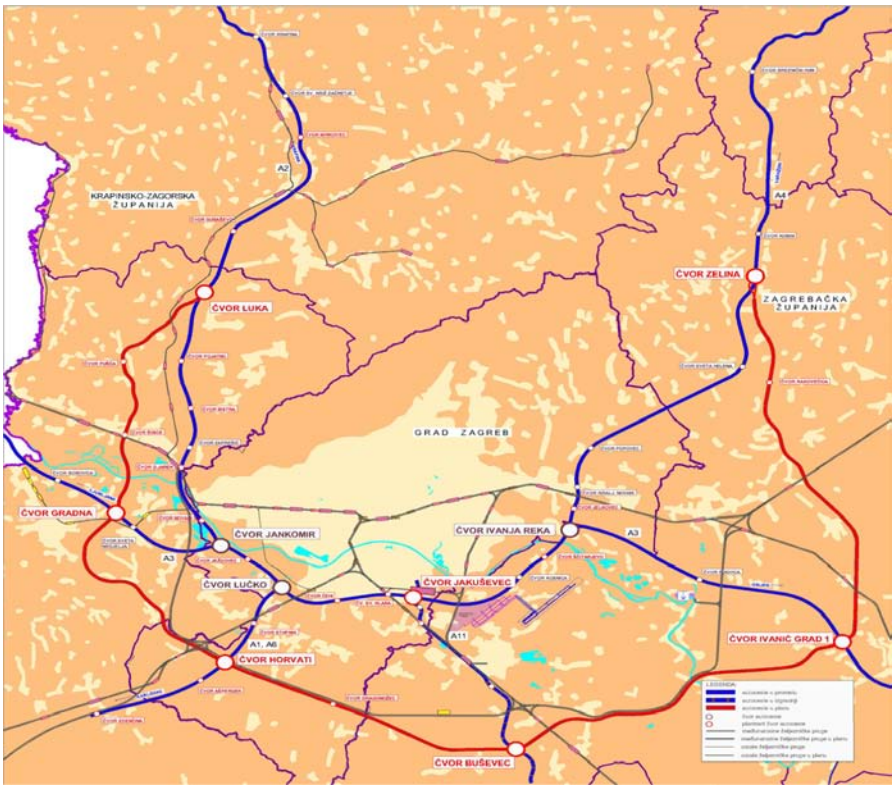

Figure 1 The present and future planed motorway and railway network in the wider Zagreb City area

The area of the Zagreb railway junction is surrounded by Zagreb city and county area. The junction itself is at the crossroads of two main Pan-European traffic corridors (corridors V_B and X), thus defining its role in the international and national transportation routes, in the Zagreb city area as well as in the County area and wider.

Construction of the Zagreb railway junction starts with the construction of the railway line Zidani Most-Zagreb-Sisak, in the year 1862. Soon after the construction of the first railway line, the railway line Zagreb-Karlovac was constructed in 1865, and railway line Zagreb-Dugo Selo in the year 1870. After the construction of these railway lines, the outlines of the Zagreb railway junction start to appear, which actually stay unchanged for nearly one century. Therefore, in the Zagreb junction area all main Croatian railway lines interconnect. These are: Botovo-Koprivnica-Zagreb-Rijeka and Savski Marof-Zagreb-Vinkovci-Tovarnik.

The Pan-European transport Corridor X, runs from Salzburg through Zagreb and Belgrade to Sofia and Athens. Significance of this corridor within the European parameters is high because it connects the west and northwest parts with the east and southeast areas. For Croatia,

as a north European and a Panonian Danube region country, this international traffic corridor bears a great significance since it enables a multi directional connection with the Central and West European countries, i.e. the East and the Southeast European areas.

The Pan-European transport Corridor Xa runs from Graz, Maribor and Krapina to Zagreb. This corridor connects in Graz with the Trans-European transport network (TEN), which, among other, covers complete area of Austria and South Germany. On its south branch, in Zagreb, the corridor X_A connects with the Corridor x which in turn connects the West and Southeast Europe. Thus, this system of corridors becomes a part of the transcontinental axis running from the North to the Aegean Sea and Bosporus.

Corridor V_B is a branch of the Pan-European corridor v, running from Lvov, Budapest, Ljubljana and Trieste to Venice. In Uzgorod, corridor V.a branches from corridor v and runs from Košica to Bratislava. Corridor Vb separates in Budapest and runs through Zagreb to Rijeka, as well as corridor V.c which runs through Osijek and Sarajevo to Ploče. Because of its specific and very favorable geographic position, this corridor offers Croatian the possibility to actively participate and join the European global and regional integrations (Alpe-Adria, the Mediterranean – Danube Region, Central-European Initiative, Adriatic-Ionian Initiative etc.), all of which favorably influences the new conceptual integrations and revalorization of the area as a whole. Except their international significance, these corridors also have a very important role in the concept of the global transport system of the wider Zagreb area (Figure 2).

Soon after commissioning of the Zagreb Marshalling yard (1978.), the second railway line was constructed between Zagreb Marshalling yard and Sesvete. This gave the Zagreb railway junction its present appearance (Figure 3).

The Zagreb railway junction is situated between the areas marked by the Railway terminals of Dugo Selo, Velika Gorica, Hrvatski Leskovac and Zaprešić.

The Zagreb railway junction encompasses over 15 railway lines including connecting and access lines, with a total length of 192,6 km. All these lines are categorized into the category of internationally significant lines because they are within the Pan-European transport corridors X., X_A, and V_B or within the connecting lines to these corridors.

There are 14 railway terminals within the Zagreb railway junction intended for cargo traffic and 8 railway terminals as well as 10 stations for passenger traffic.

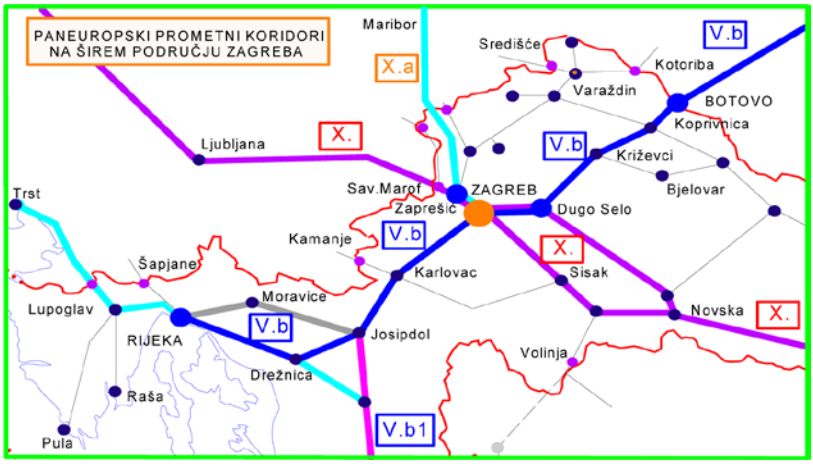

Figure 2 Schematic diagram of the Pan-European transport corridors

Most significant railway terminals are:

- Zagreb Main railway terminal – central point for passenger traffic
- Zagreb Marshalling yard – technological center for cargo traffic
- Zagreb West Terminal – passenger and cargo traffic,
- Zagreb East Terminal – railway cargo terminal
- Zagreb Borongaj (former marshalling year) – possible location of the future technical passenger terminal.

Over 13 million passengers pass through the Zagreb railway junction, 80% of which is town, suburban and local traffic (expected planned increase of 12 % /year), and 13 million net tons of cargo (expected planned increase of 4-10 % /year).

Analysis of the distribution of traffic flows per individual types of transport and per individual lines, shows the following situation:

- Most intense international, intercity and town-suburban transport is on the railway line sections Dugo Selo – Sesvete – Zagreb Main Terminal (app. 6,5 million passengers/year),
- The second line regarding passenger traffic intensity is the line Zagreb Main terminal – Zaprešić, with approximately 4,0 million passengers/year,
- The railway line Zagreb Main Terminal – Sisak, with 1,5 million, and Zagreb Main Terminal – Karlovac, with approximately 1,0 million passengers take the third and fourth place respectively.

Figure 3 Present condition of Zagreb Railway junction

The present infrastructure can not take this traffic load and traffic increase any more, and this was the main reason for he review of the Zagreb Railway junction as a whole, followed by the review of the railway infrastructure.

Objective review of the traffic and technological criteria for the new conceptual solution of the Zagreb railway junction was done in the Study, through the analysis of several important factors:

The criterion of technological and technical functionality – this was certainly one of the most significant criteria, which includes all traffic demand requirements of the respective region, and the technical and technological capacities of each individual traffic system,

The criterion of international standards – for construction of new and reconstruction of existing major European railway lines, the standards which these lines must satisfy are defined in the Agreement AGC and AGTC,

Rationality criterion – this criterion includes finding a rational technical and technological solution which would be realistically possible and economically feasible (maximum use of existing capacities),
Criterion of spatially acceptable design – all newly designed routes and the ones to be rehabilitated had to be well spatially designed and incorporated into the surrounding area,
Safety of the traffic system criterion – the railway has always been significantly safer transport means than the road traffic system, which is visible in the statistics showing a higher level of passenger safety. The high safety standards conditionally defend the type and scope of investments into the railway construction and reconstruction of railway junctions.
Criterion of environmental safety –it is well known that modern railways are a less environmental pollutant that the road traffic. Within the context of this criterion, it should be noted that noise, as an environmentally unwanted factor, is three times lower in railway compositions than the noise produced by road traffic,
Criterion of staged construction – large railway junctions, as e.g. the Zagreb junction, can not be completely built in one stage, so a solution for staged construction had to be found.

3 New spatial and traffic solution for the network and the junction

The new conceptual solution of the Zagreb railway junction (Figure 4) must ensure three main traffic functions which would satisfy the short-term, medium-term and long-term needs of traffic supply and demand in the wider Zagreb city area, along with high quality of services and an economically feasible concept. These functions are:

- To fulfill the needs of international transiting traffic on the Pan-European corridors (x and Vb)
- To fulfill the needs of regional railway traffic at the level of Croatia
- To fulfill the needs of public city and suburban traffic of Zagreb.

The first conceptual postulate for the new Zagreb Railway junction is to separate the passenger and cargo traffic on the main corridors and for this, to build new bypass railway lines for cargo traffic. This separation of passenger and cargo traffic would increase the quality level of passenger and cargo transport, and the near city center would be free of noise produced by cargo trains as well as free of marshalling yards which occupy valuable town area.
The second conceptual postulate is to separate the long-distance and the town or suburban transport on the lines with most traffic load, in a way to built separate lines and stations for town and suburban traffic. This primarily refers to the railway line Zaprešić - Zagreb Main Terminal – Dugo Selo, which is a line with extremely high traffic load, long-distance and suburban traffic. This separation would significantly increase the level of efficiency and quality of both types of transport.
The third conceptual postulate refers to the optimum coordination of railway transport with other types of transport, e.g. road, air and inland waterway transport. In this sense, the new conceptual solution includes an interface of all types of transport at every passenger and cargo terminal, depending on the availability of transport types.
Zagreb Main terminal is the key passenger transport structure or point in Zagreb Railway junction. In the new conceptual solution, the Zagreb Main terminal keeps its position as center of international, intercity and suburban passenger traffic. In accordance with the construction and modernization of railway lines passing through Zagreb Main Terminal, the town and suburban traffic is separated on the main east-west line from the long-distance traffic. This primarily refers to the receiving and dispatching lines and platforms (Figure 4).
Zagreb West Terminal in the new solution of the railway junction, this terminal keeps its function of passenger town and suburban traffic terminal and a place where other types of town transport also interconnect. (tram, town railway etc).
Technical passenger terminal (TPT) Zagreb is the place where all passenger coaches and wagons and motor trains are cleaned and washed and where all other activities required for

maintenance and preparation of passenger trains for safe travel are undertaken. The railway terminal in Borongaj (ZAGREB) was a very good location for TPT.

Zagreb Marshalling yard is the main center of cargo transport in the Zagreb Railway junction. Its capacity was intended for 4.500 wagons daily, which is more than the current needs. Construction of a new marshalling yard is planned (displacement) on the future southern bypass line, near Turopolje. In this case, the present marshalling yard would be reconstructed to serve the technological needs of the new intermodal logistic center to be constructed in the immediate vicinity and to serve the needs of the industrial lines in the wider Zagreb area.

Figure 4 Schematic diagram of the "new" railway junction Zagreb

New railway cargo terminal is planned as part of the new intermodal logistic center. With this, there would no longer be any need for the Zagreb East Railway cargo terminal of the Zagreb West Terminal, which would actually fee valuable surfaces for more vital town needs.

Intermodal logistic center Zagreb, will have an important international and regional role. This is due to the fact that Zagreb is situated at the crossroads of important Pan-European and regional traffic corridors. The location of the logistic center is planned in the free area south of the dispatch center of the Zagreb Marshalling yard, which is very well covered with railway and road infrastructure.

4 Conclusions

The concept of railway traffic in Zagreb is based on the following principles:

- Separate cargo and passenger transport on the main transport corridors passing through the town, by means of displacing lines and terminals intended for cargo traffic as much as possible from the city area.
- Separate long-distance and town and suburban traffic on the lines with greatest traffic loads which pass through the central parts of the city, by means of constructing separate lines, terminals and stations for town and suburban traffic,
- Reconstruct existing stations and terminals and construct new ones for passenger traffic, with all required urban infrastructure,
- Keep the starting point and end destination cargo transport terminals concentrated in one area as much as possible by means of constructing a new intermodal logistic center, which would consolidate all segments of cargo transport,

- Concentrate the facilities for maintenance at one location in Vukomerec,
- Introduce the system of remote control of transport and modern signaling and safety equipment on all lines and terminals of the Zagreb junction.

In order to achieve the set forth concept, new railway facilities must be constructed and old ones reconstructed in the wider Zagreb city area.

During preparation of the conceptual solution for the new Zagreb railway junction, cost effectiveness and rationality of construction were one of the main ideas. This at the same time means that the existing structures and infrastructure has been maximally incorporated into the new concept and that the new solutions are coordinated with the realistic possibilities and requirements in time and space.

Construction of new and reconstruction of existing railway structures in the wider Zagreb city area, which would have to be completed by the year 2030, offers a new modern transport system which would be effectively incorporated into the city transport structure and which would satisfy the long-term needs of Zagreb and the Zagreb County, but also the needs of the transiting traffic, which is very important for Croatia as a whole.

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