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OUTLINE OF THE SPATIAL-TRAFFIC STUDY OF THE ROAD AND RAILWAY TRAFFIC SYSTEM IN THE WIDER ZAGREB CITY AREA

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Abstract

All larger towns and cities represent a starting point and end destination for numerous traffic streams, which significantly influence the traffic conditions in the cities themselves. The City of Zagreb is the starting point and end destination of numerous travel destinations being realized presently through five incoming motorway routes. The peripheral, south route (motorway) is actually in the service of the city traffic and most of its traffic load is the city traffic, making the traffic distribution very difficult from those motorways. The railway traffic in the Zagreb railway junction has at its disposal 15 existing railway lines, including the connecting sections, with a total length of 192,6km, all in the international railway category. Therefore, the solution to the numerous accumulated traffic problems should be sought in a comprehensive traffic analysis of the wider Zagreb City area, with a rough definition of the spatial-traffic premises for establishment of an integrated traffic – technological system which would be the basis for further planning and development. Research was undertaken and analyses made as part of the Spatial-Traffic Study of the road and railway traffic in wider Zagreb. The City of Zagreb is to be used as an example for presenting an outline of a methodological approach and the results of the spatial-traffic study which was supposed to provide a solution for all the more prominent traffic problems generated by the newly-constructed motorway network just outside of Zagreb. A traffic model was made on the basis of gathered statistical data on the population and data on the present traffic load. Analysis of the traffic situation on the network resulted in several variants of an integrated traffic network solution. Some new and some reconstructed road and railway corridors are proposed, as well as new public transport models and solutions to the bicycle, pedestrian and passive traffic.

Keywords: Zagreb traffic network, road and railway traffic, traffic model, VISUM

1 Introduction

Zagreb, as the most important and the largest traffic junction in the Republic of Croatia, represents the starting point and end destination of most of the road and railway traffic streams, which requires a response by way of redefining the existing network and planning coordination between the road and the railway traffic, i.e. between the inner city traffic as much as the suburban one, as well as the remote traffic coming into Zagreb and going out of it. The complexity of traffic issues tried to be solved by individual traffic or spatial studies, whether it was the railway junction in the inner city area, or express city roads which were aimed at solving the through traffic generated by the existing and future motorways just outside of Zagreb. In that regard this spatial-traffic study was aimed to coordinate the mutual influence between the remote traffic and the inner city and suburban traffic, i.e. redefine the Zagreb's main road and railway network in the context of the existing and future traffic requirements of the wider Zagreb area. A group of investors and infrastructural systems administrators consi-

sting of: Croatian Motorways, The City of Zagreb, Zagreb County, Croatian Railways, Croatian Roads and Ministry of Sea, Tourism, Transport and Regional Development have put into motion the development of a spatial-traffic study of the road and railway traffic system of the wider Zagreb area [1], upon recognising the necessity of comprehensively solving the traffic issue in the wider Zagreb area. This paper will give an outline of the methodological approach to the traffic issue and of the results of such a method.
The study was based on collecting and analysing relevant traffic and technical documents dealing with the traffic systems (road, railway, air traffic) in the wider Zagreb area. Upon analysing the regional planning documents, possible deviations and disproportions in certain segments were being established. Basic methodological prerequisites were provided and investigation system specified.

2 Transport forecasting and capacity estimate

The part of the study pertaining to traffic systematically processed the available data on the current network traffic load, in addition to conducting additional measurements (surveys). The forecast for the future traffic load was provided based on statistical indicators, and the traffic streams were established within the planning period, with regards to road and railway traffic, remote, local suburban and inner city traffic, public and private transport. A traffic model was constructed; the first step was to present the current condition on the already built traffic network by using this model, and the second step was to verify the proposed technical solutions on the future network of a comprehensive traffic system. In the study development stages, the public transport model was constructed separately from the model for the remaining traffic network. In the end those two models were integrated into a unified traffic model for all systems.

3 The purpose and aim of the study

The Spatial-Traffic Study had as a goal the creation of a comprehensive traffic network of roads, railway traffic, air and river traffic, which would include public and private transport in the wider Zagreb city and Zagreb County area. The Study began with an analysis of a global traffic network of motorways, express roads, state roads, as well as county and local roads which, as one nears Zagreb, bring upon a great traffic load by distributing it onto the network of inner city roads of various categories. Within the railway traffic system framework, the solutions for the remote freight and passenger traffic ensued, where the suburban railway was proposed in the inner city and suburban areas. The rail traffic system would be supplemented by a light metro system in the city area, as well as with the existing and extended tram transport. The traffic system would be supplemented by air traffic through the Pleso Airport which will inevitably be extended, and by river traffic through the proposed Rugvica river port. The solution for the future traffic network was based on the traffic model. In that respect the traffic model of the existing traffic network in the wider Zagreb area was set up, based on the existing and measured data on traffic and population that generates travel in this traffic network, as well as the future one.

4 Traffic model

The traffic model was used for modelling the current condition of the traffic system and for projecting a future one. Models were used to identify traffic issues in the current and future conditions of the traffic system. Movements and development of traffic issues were monitored, with the possibility of offering alternative solutions, along with testing the effects of proposed solutions, and selecting the option presenting the most positive effects (Fig. 1) [3].

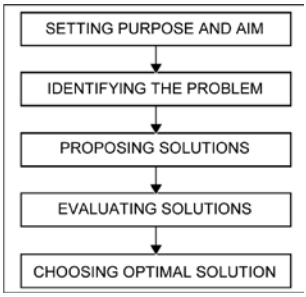

Figure 1 Flow chart of the traffic planning procedure

Under *traffic issues* we mean the insufficient level of service the traffic system has to offer, as well as insufficient capacity, or traffic jams. The traffic model in this study includes a large number of methods and modes of transportation, such as private and public transport, which is further divided into passenger transport by passenger cars and public transport buses, trams and trains, and into transportation of cargo by trucks. The entire traffic model was made with the help of the German programme package VISUM [4].

The first stage in making a traffic model was data collecting. The existing data were used such as permanent and occasional traffic counts on the road [5], and passenger counts in the public inner city and railway transport, as well as the data from the previous studies [6], [7], [8] and projects developed for the same area of intervention as this traffic study. Statistical data were also used [9], [10], necessary for generating trips. Of the existing statistical data in the Zagreb area, data on tourists in hotels were processed, as were those on visitors to Zagreb's sights, data on students in elementary and secondary schools, data on kindergarten children, theatre attendance, pupils' and students' dormitories, census records divided into age groups, employed population, jobs and education institutions.

Data collection was carried out through field investigation works (traffic surveys, traffic counts, and measuring traffic stream speeds). Traffic survey was carried out on two occasions, in the summer and autumn of 2007, over four-day periods between 6 a.m. and 7 p.m. in the summer, and 7 a.m. and 7 p.m. in the autumn. The area where the survey was conducted included 17 locations, in two directions, in the wider Zagreb area. Manual traffic count was conducted simultaneously with the survey, as an integral part of the comprehensive traffic field investigations. Counting was carried out by differentiating between eight types of vehicles. The conducted surveys were entered into a computer and two databases were created: the traffic survey database and the traffic count database, which was then ensued by a comprehensive processing of all databases (Fig. 2). The measuring of traffic stream speeds was carried out on all major roads in the wider Zagreb area, as well as in the city itself. These data were necessary for model calibration. The model intervention area (Fig. 3) was the City of Zagreb with two neighbouring counties: the Krapina-Zagorje County and the Zagreb County. Traffic zones were formed inside this area defined by boundaries and the zone centroid. The zone centroid is a point within the traffic zone boundaries representing the very centre of traffic activities and it usually constitutes the largest town. Furthermore, the traffic zones consist of attributes used for generating trips. Zagreb has been modelled on the level of statistical units specified by the city's department of statistics, and there are 511 of them, whereas the neighbouring two counties have been modelled on the level of municipalities, 66 of them in total. There are also six outer zones representing important traffic corridors enabling traffic connection between our intervention area and the surrounding areas. Road and railway networks have been presented in the model as a system of nodes and links in the network (Fig. 3). The attributes of the links are capacity [11], speed and time of travel, and the length of the connection. The attributes of the nodes are turning options at the intersection. More than 5700km of the existing network and over 3600 nodes in the network have been included. All the nodes and

links are placed in actual geographic coordinates and are georeferenced by their attributes. As for public transport, lines of public inner city transport have been modelled for trams, buses and trains. Stops have also been modelled. The total length of the lines is over 3300km, with over 1400 stops modelled.

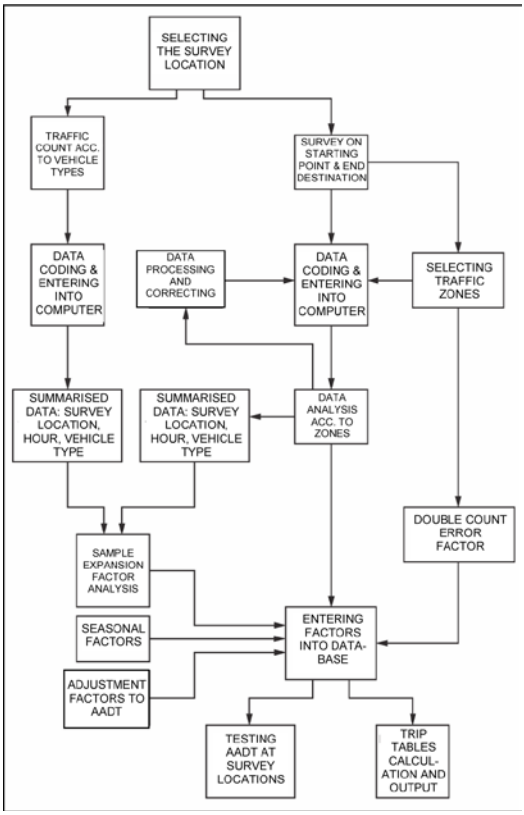

Figure 2 Flow chart of the study data processing

Trips have been modelled according to the standard four-step model [12, 13] consisting of the following stages: trip generation, trip distribution, mode-choice analysis and route assignment.

Trip generation or creation is divided into forming and attracting trips. The variables of trip formation included in this study are the population divided into various social groups such as: the employed, the unemployed, population attending educational institutions, etc. The variables of trip attraction are determined by the purpose of given areas, dividing them into residential, commercial, educational and other purposes. Distribution or division of trips into traffic zones was performed in accordance with the gravitation model. The mode-choice analysis is a classification into trip methods (modes), which are in this study divided into private and public trips. The trip modes are divided into private trips or passenger car trips, and public trips by buses, trams or trains. Routes are assigned simultaneously for all modes of transport.

After the first assignment, the procedure is not finished; rather, the traffic load intensity calibration of the known data from the traffic count still needs to be performed. The result of the assignment and calibration is a traffic load of the existing traffic network in the basal, i.e. initial year 2007.

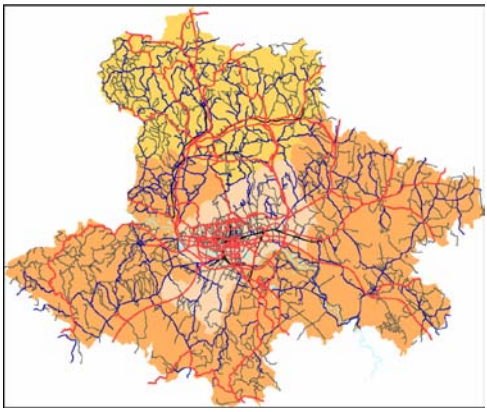

Figure 3 An outline of the intervention area with traffic zones and the network model

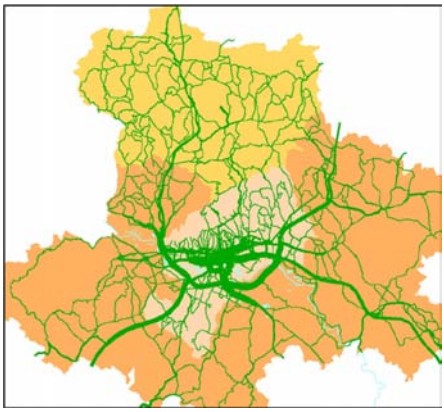

Figure 4 Outline of the road network traffic load

The existing traffic network load was attained per network links, expressed by the number of transportation vehicles, the so-called average annual daily traffic (AADT) (Fig. 4) or by the average daily number of passengers in public transport. In the model, the loads were attained per each network link and route direction. In public transport the traffic intensities were modelled according to the abovementioned modes of transport, i.e. public buses, trams and HŽ trains (Fig. 5).

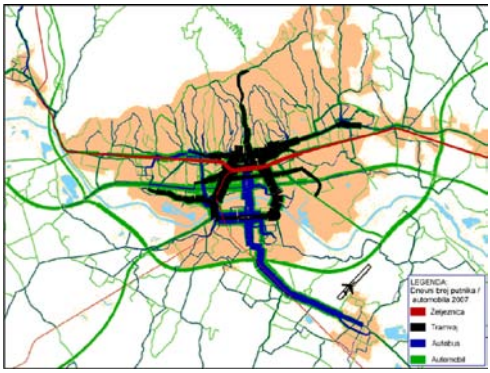

Figure 5 Outline of a multimodal traffic load of the wider Zagreb area

5 Redefining the traffic network of the wider Zagreb area

The planned traffic network will include the wider area of the City of Zagreb and the Zagreb County, and will contain the network of remote road and railway traffic, as well as inner city and suburban private and public transport.

5.1 Remote traffic

As already mentioned, Zagreb is the starting point and end destination for many trips taken over five motorway routes. All of them begin or end at the perimeter south motorway, the existing Zagreb bypass. Motorway A1, as well as the Motorway A6, via Lučko junction, connects Zagreb with Split, as well as with Rijeka in the other direction. Motorway A3, via Jankomir junction, connects Zagreb with Bregana and further on with Ljubljana. The Zagreb bypass stretches from Jankomir to the Ivanja Reka junction and from Ivanja Reka the Motorway A3 continues on towards Slavonia and further on towards Bajakovo border crossing. Motorway A2 connects Zagreb with Krapina via Jankomir junction and further on via Macelj border crossing with Slovenia in the direction of Maribor. Motorway A4, via Ivanja Reka junction, connects Zagreb with Varaždin and further on, via Goričan border crossing, with Hungary. All these motorways have already been built and are a part of the existing traffic network system of the wider Zagreb area. Motorway A11 is under construction and will connect the City of Zagreb, via Jakuševec junction, with Velika Gorica and further on with Sisak. All these motorways end at the Zagreb bypass, and generate its large traffic load.
In the wider Zagreb city and Zagreb county areas the road traffic in the traffic network has been represented by the existing Zagreb bypass, new motorway bypass corridors, state roads, express roads, as well as county and more significant local roads. In the study two options were considered for the existing bypass, one with the current width, and the other with increased capacity by way of constructing another lane for each direction of the current pavement. Two new corridors for the Zagreb motorway bypass were also considered, south and north of Zagreb. The new corridors would provide a continuous through passage for the remote traffic, without stopping at toll stations in Lučko, Ivanja Reka, Zaprešić or Sveta Helena, as is the case today. In the study the remote railway traffic was proposed with new corridors, as the west bypass railway tracks (relocation of the X corridor) and the south bypass ring, as joint relocation of the X corridor and the Vb corridor. It is the bypass railway line corridor for the freight traffic, which would in the future be relocated from the centre of Zagreb, by dislocating the existing marshalling yard south of the city. The new freight railway line would run through the joint south corridor along with the motorway bypass as much as possible. The remote passenger railway traffic would keep the current line route, along with its extension and grade separation in the city area, from Borongaj to the west railway station (possibly further to the west to Jankomir). Such a concept would require a modification of the existing main railway station and its functional integration with the existing bus station.

5.2 Inner city and suburban traffic

Inner city and suburban railway traffic would be realised along the remote passenger traffic route (four-rail tracks), i.e. from Savski Marof and Zaprešić in the west to Dugo Selo in the east, then to the south by four-rail tracks towards Horvati, as well as along the existing rail route, as a two-rail tracks towards Jastrebarsko and Karlovac. In the southeast direction the inner city railway would connect Velika Gorica, with the suburban two-rail tracks to Sisak. Private road traffic in the Zagreb area in the proposed traffic network would rely on the newly-designed route of the north tangent, as the express inner city road, which was offered in the study as an option in some of its segments. The north tangent would, as far as traffic is concerned, be connected through new vertical roads onto the existing inner city roads in the east and

west part, and onto the newly-designed extensions of the main city arteries. The following has also been proposed in the new traffic network: grade separation and extension of the Ljubljanska / Zagrebačka / Slavonska Avenues, partial grade separation of Vukovarska Street, Dubrovnik Avenue, Većeslav Holjevac Avenue, extension of Šarengradska Street along the tracks, parallel with Savska Street, a new bridge across Sava at location near Bundek and extension towards Draškovićeva Street, extension of Sarajevska Street with the connection to Motorway A11 for Sisak, which would have as a goal the realisation of favourable traffic effects in the future traffic model.

5.3 Public inner city transport

The analysis of the comprehensive traffic network has considered the public inner city transport in view of the existing and extended tram network, bus lines, mainly based on the existing lines, and possible introduction of additional lines in combination with other aspects of public transport, wherever the need for it should arise in the proposed traffic system. One of the tasks of a traffic study is expressed through the need for extending the public transport supply by introducing a light metro, a part of the traffic system which would increase transport capacity in the public transport segment by grade separation of the track system (underground and aboveground), with possible significant impact on reducing the traffic load generated by private transport. The light rail, realised through the planned stages, would connect east and west, north and south, with a possible ring inside the city, and connection with the airport across Domovinski Bridge, as well as Velika Gorica.

5.4 Airport and river port

The study proposes the extension of the airport by way of constructing a new runway, which would raise the safety level of the Zagreb Airport to a European level, and separate military from civilian facilities. The river port Rugvica upon Sava, east of Zagreb, was also included in the traffic analysis within the study, which would be connected to the wider Zagreb area traffic network system via railway and motorway.

6 Conclusion

The current traffic situation in the wider Zagreb area is very complex. The solution to the traffic issues has been considered through a comprehensive traffic analysis of the wider Zagreb city and Zagreb county area, as well as the neighbouring counties inside the impact zone, along with establishing general traffic and spatial requirements for setting up an integrated technical traffic system upon which its further planning and development would be based. The traffic model of the current condition was developed based on the existing data on traffic and statistical data on population. The statistical data have been processed and supplemented for a more precise development of a traffic model based on the planned network of public and private transport, road and railway traffic, and with airport and river port being integrated into that system. The improvement of the transport supply is expected upon implementation of a new motorway ring around Zagreb, upon transition of the existing Zagreb bypass into the inner city road system, upon grade separation and extension of the main city avenues, the expansion towards east and west, implementation of the north tangent, and upon realisation of new road connections towards north and south, with new bridges over the Sava river. As for the public transport supply, inner city and suburban railway will be included into the traffic system, and implementation in stages of a light city rail will be established as an unhindered, grade-separated corridor. The study has established traffic and economic viability of constructing certain segments of the traffic network, keeping in mind the integrated approach to the traffic network of the wider Zagreb area.

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