Title: Using EMME/2 in environmental studies in the Czech Republic

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1. Introduction

This paper presents the partial results of 1-year taking experience with EMME/2 in the Transport Research Centre, Czech Republic. The modeling involves 2 urban areas representing the big city Brno and smaller town, Zlin (the home town of worldwide known shoemaker Tomas Bata). The main purpose is modeling of current and future environmental impacts, with main focus on air pollution from transport.

2. Brno city model

The large, multimodal model of Brno is currently in progress. Brno is the 2nd biggest city in the Czech Republic after Prague, with approximately 400 000 inhabitants. Now the model contains 1 auto mode, 2 auxiliary auto, 4 transit and 2 auxiliary transit modes. Model contains 8 basic types of transit vehicles: 2 bus, 2 trolleybus and 4 tramway types.

2.1 Model network and used functions

The model network contains 199 centroids, 1814 regular nodes, about 6000 links, 113 intersections and 57 transit lines. The centroids represent specific zones created by an overlapping of the zones of traffic research and urban zones. With a help of node user data, the numbers of individual urbanistic zones are described in each centroid. Only 1 scenario is done up to now.

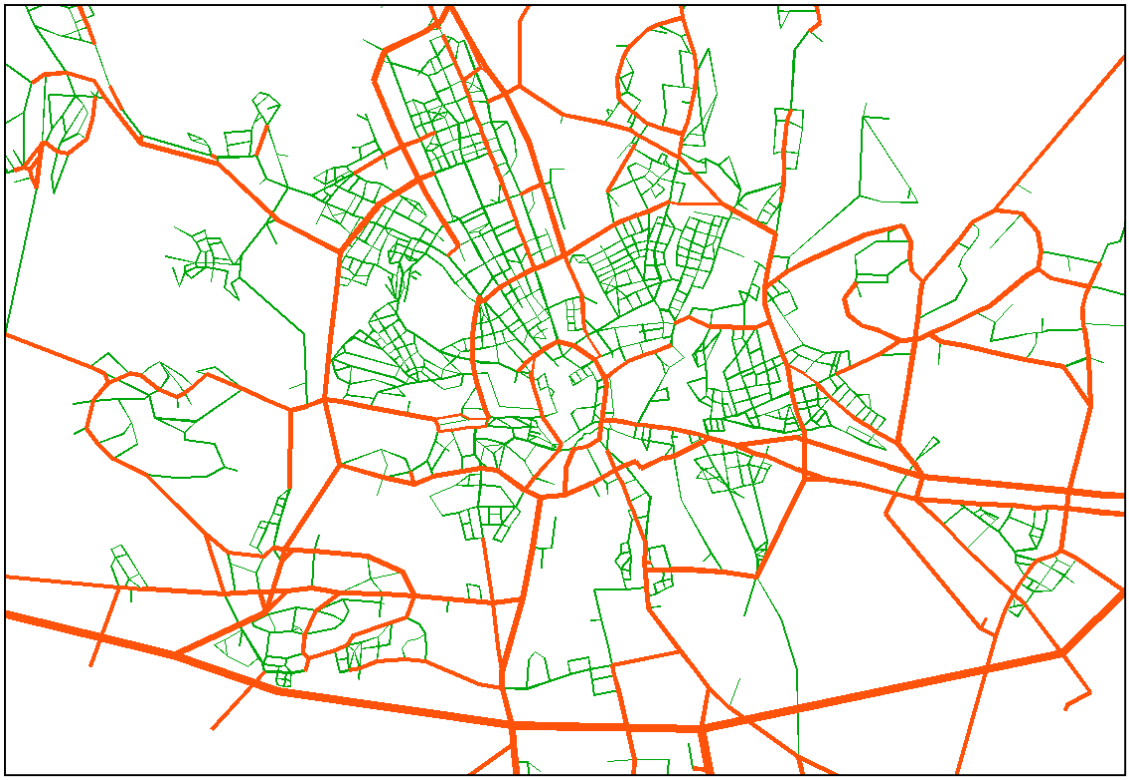
The nodes coordinations are in the S-JTSK projection, which is widely used in Central Europe. The coordination unit is a meter (or 10 or 100-metres - it is possible to recalculate by one command in network calculator - module 2.41) what enables automatic calculation of link length in meters and consequent calculation of travel time in minutes with a help of volume delay function (VDF).

The links are classified with the help of link type. The link type corresponds approximately to free flow speed, which is input as user link data 1 (ul1) as in Table 1.

Table 1. Link type and free flow speed

Road type	Link type	ul 1 (speed in km/h)
motorways D1 (Brno - Prague) and D2 (Brno - Bratislava, Slovak Republic)	11	110
express roads (R52)	10	100
1st class roads outside the city	8	80
Big City Circle (outer)	6 - 8	60 - 80
Small City Circle (inner)	5 - 6	50 - 60
linear roads from/to center - main	5	50
linear roads from/to center - minor	4	40
local main roads	3 - 4	30 - 40
local adjoining roads	2 - 3	20 - 30
pedestrian links	1	----

Fig. 1 The Brno model network (red – main roads, green – local roads)



The parameter of ul1 does not always correspond to the link type. This parameter is included to volume delay function. For the VDF we use BPR function with estimated link capacity per lane, depending on link type. The number of lanes is used in VDF function as well.

The 113 intersections are also the part of the model network. The Brno model contains two turn penalty functions, but very simple. There are only 2 levels of the supposed delay expressed in minutes. These functions are still not depended on an assigned volume of a turn.

The transit Brno model network involves 57 public transport lines in Brno. The 13 tramway lines ensure the main public transport service. Each of them passes through a circle that is situated tightly at the historical city center. The tramway delays occur permanently in city center because of the traffic density and sharing the road with cars. There are no special measures for the tram preference. This delay is taken into account in transit time functions (ttf). There are 2 transit time functions: the function of ft1 calculates a segment transit time from a length and speed and the function of ft2 (used in city center and in 1 city district called "Zidenice") calculated the delayed time with a help of a constant.

For the connection of outer districts to city center and between each other, the network of 11 trolleybus and 33 bus lines is developed in Brno. All these lines are incorporated in model. The variables are: default speed, headway (from the timetables) and segment attributes - dwelling time and layover. A dwelling time was estimated according to the character of transit stops. Layovers were input in the end stops and vary from 5 to 10 minutes. Node labels were used for abbreviations of transit stops names.

Fig. 2. The model network of tramway lines in Brno, transit stops are displayed

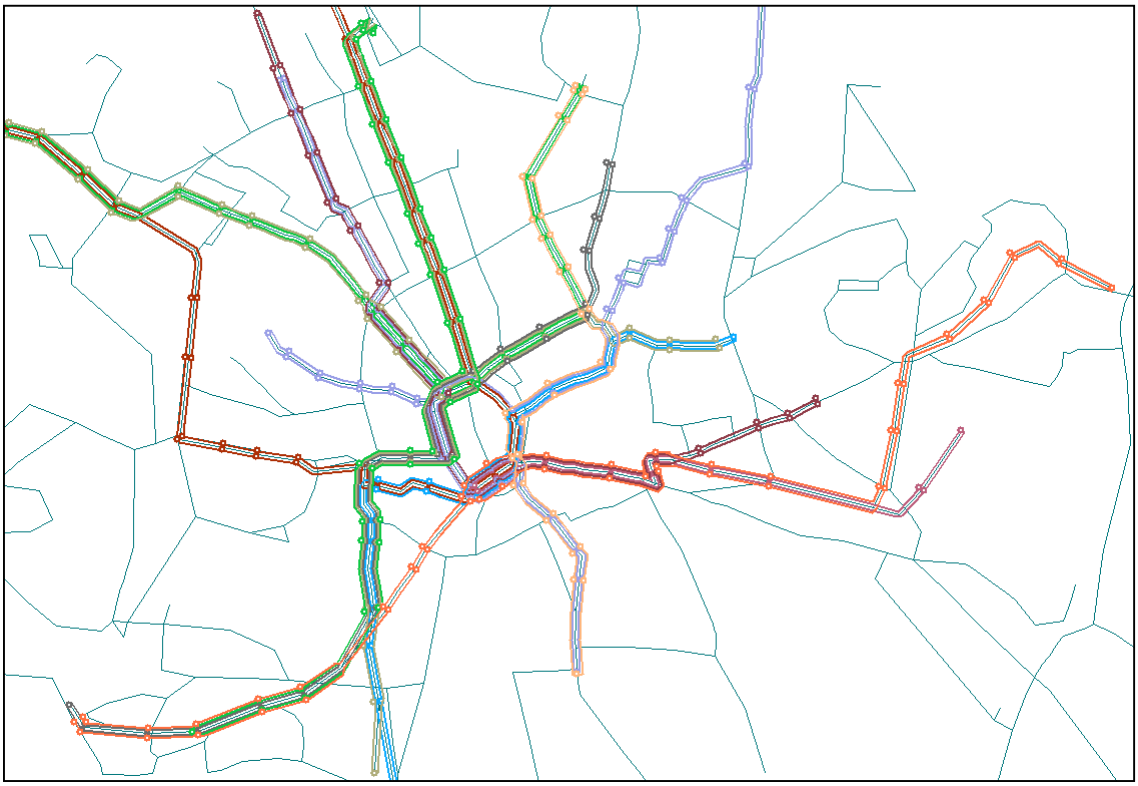
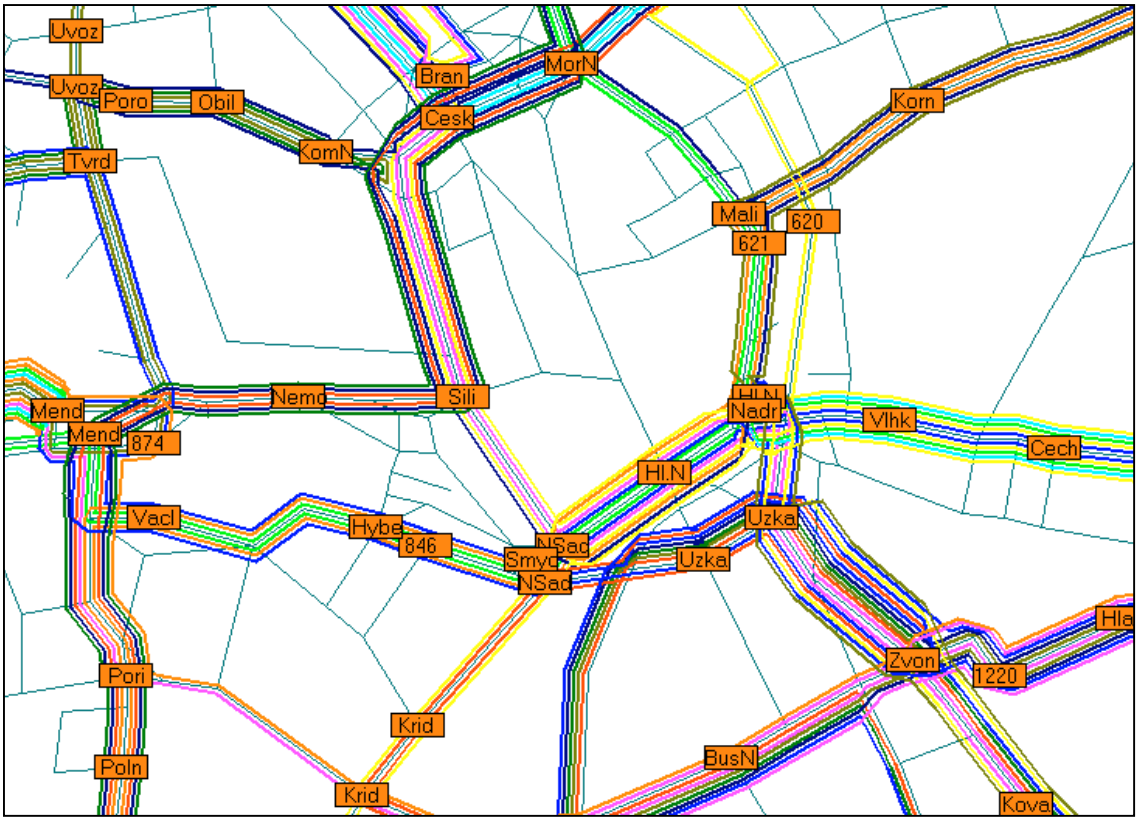


Fig. 3. A screen view of the central transit lines with node labels - transit stop names.



2.2 Car transport modeling and calculation of nitrogen oxides (NOx) emissions

In the car transport modeling we continued in the model done in old Czech modeling software called "Auto". The original demand matrix of car transport has been created from traffic research, with the help of the last directional traffic census made in 1997 in Brno. This matrix had to be completely modified in order to obtain the batch input format usable in EMME/2. Next modification of this matrix was done by updating of number of inhabitants and jobs in individual zones, population dynamics (No. of trips per day) and modal split. Also the new centroids have been added to the places where new trips start and end (new shopping centers). The standard equilibrium auto assignment was then performed. Assigned volumes are stored in an extra attribute.

Fig. 4 The results of auto assignment

Fig. 5 The NO_X emissions in Brno model network (grams per meter)

From this attribute, the emission factors of NOx and consequently NOx emissions per link were calculated. The emission factors used in the Czech Republic depend on vehicle speed. Various factors were put in like extra attribute depending on the ul2 attribute (real flow speed). The resulted link - related emissions of NOx are calculated by network calculator and stored in ul3 attribute.

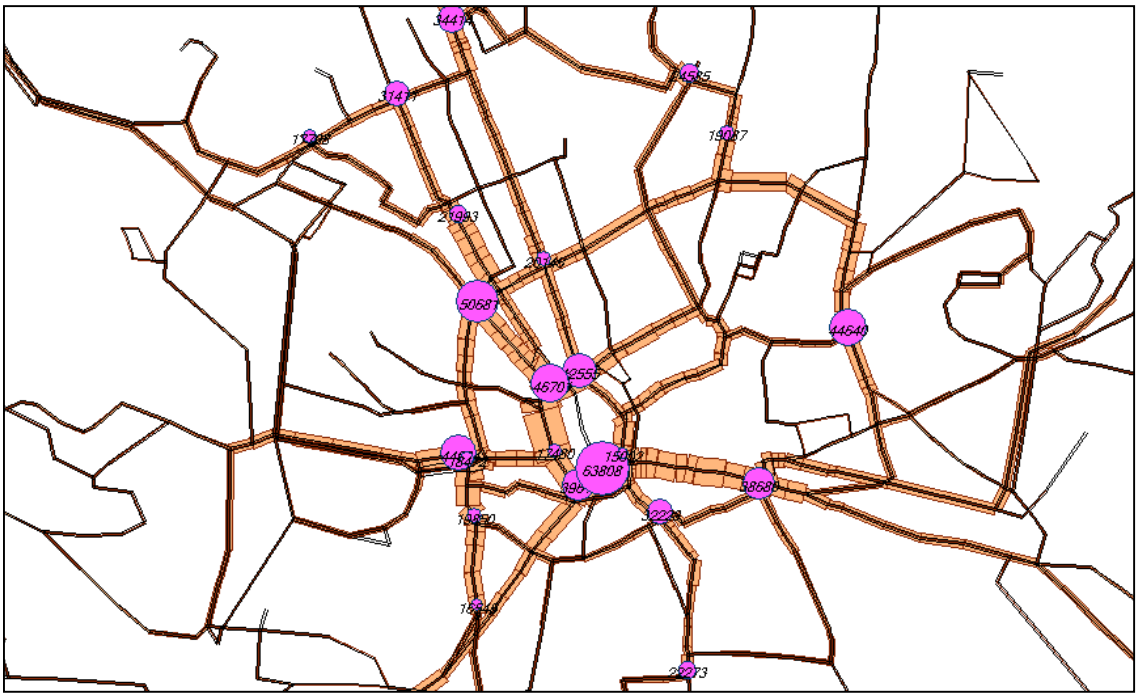
2.3 Public transport modeling

The evaluation of impact of several measures, such as "Park and Ride", on the traffic flows and air quality is planned. That's why the transit modeling is being done. The transit full matrix was calculated with the help of data on inhabitants, population dynamics and matrix balancing.

The modal split between auto and transit is 45:55 in Brno city. This ratio is an average and differs very much: from about 30:70 (in some zones in city center) to about 80:20 in suburbs. There are luxurious houses in suburbs where the high society lives. Transit matrix was calculated by a balancing of mo and md matrixes. Entries to/from model area doesn't contain any transit lines. Their production/attraction was set to zero value with the help of zone groups.

The fixed demand transit assignment has been used for the obtaining of the transit volumes in individual lines and segments. When the pedestrian transit time has a bigger weight (value = 1.3) the results are better. It was found during the calibration process. People in Brno probably perceive pedestrian time longer than it is. The other times (in-vehicle, boarding and waiting times) had no weight in Brno model, respectively their weights = 1.

Fig. 6 The latest results of fixed demand transit assignment



2.4 Verification of the results

In the case of car transport, the results of National Traffic Census are available in Brno city but only for the motorways and 1st class roads. These results were compared with assigned volumes. The model input parameters - free flow speed (parameter ul1), delays in individual intersections and the variables of the functions (volume-delay and turn-penalty) - had to be changed and assignment repeated many times. Now it is still not possible to say that the model is calibrated perfectly, but the results are different maximally on 20 % (in links with known traffic intensity).

In the case of public transport, some data about boarding and alighting in Central Railway Station and in surrounding were available. As for car transport modeling, the assignment had to be performed many times, after modification of parameters, in order to achieve more exact values. Also the speed of auxiliary transit had to be corrected.

3. Zlin town model

3.1 Traffic prediction

The goal of the traffic and emission modeling in Zlin town was different than the case of Brno city. The town shape is very extended in east - west direction and one big avenue with heavy traffic burden and a lot of congestions is the horizontal hub of the town. The situation is even worse because many houses are situated close to this noisy and dusty road. That is why the city authorities plan to build new roads, for relocation of the traffic from the central part.

The immediate purpose of the modeling was to predict the changes in traffic, which should come with the construction of new roads. The model does not involve public transport until now, even though the public transport is well developed in this town. The 2 scenarios are done: present state and predicted state of impact of 2 planned roads on the traffic and following on air quality. This model contains now 42 centroids, 175 regular nodes and 592 links and 4 intersections. The zones are housing estates and entries to the area. The nodes and centroids are in the S-JTSK coordinate system (like in Brno city).

Fig. 7 Assigned volumes in Scenario 1 - present state

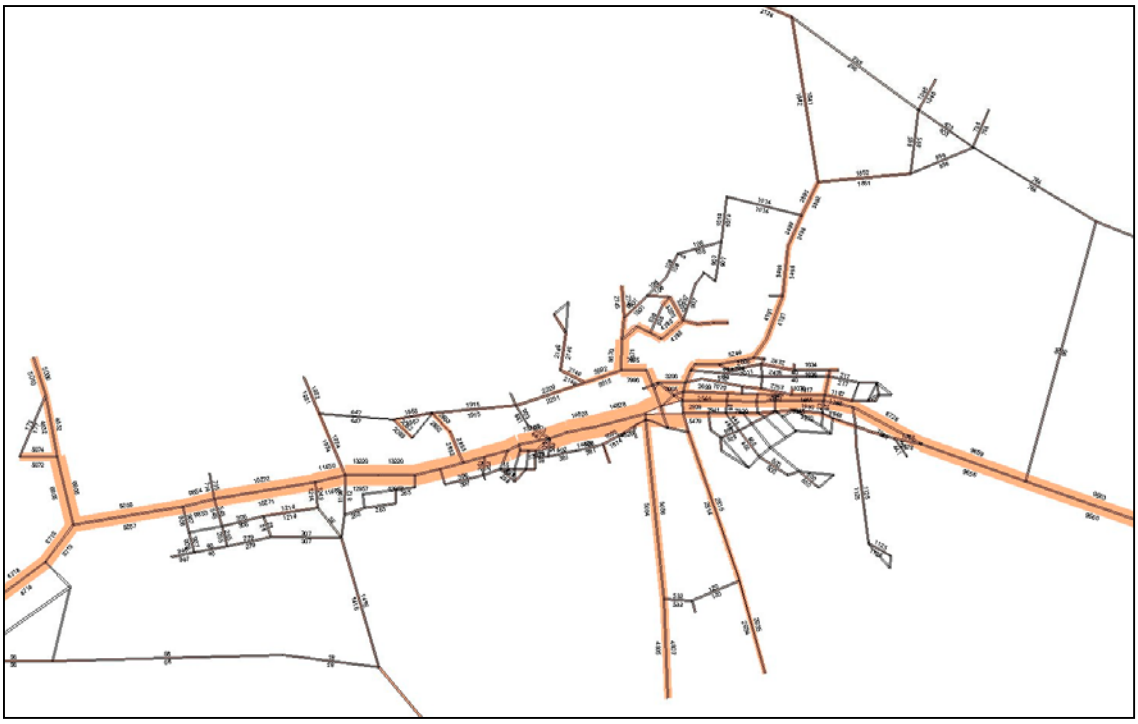
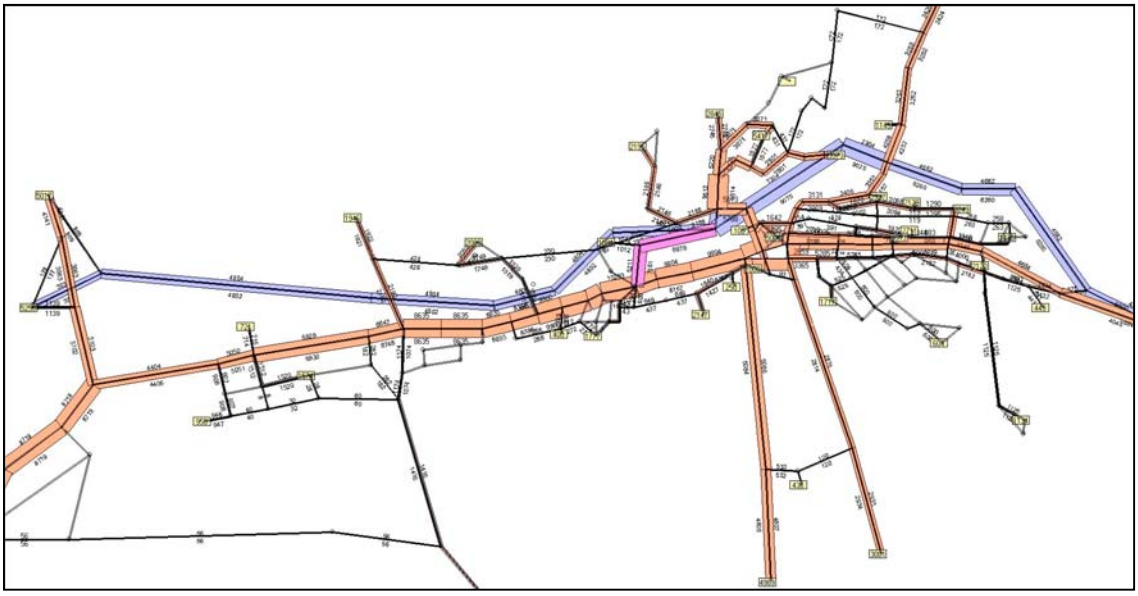


Fig. 8 Assigned volumes in Scenario 2 - efficiency of 2 planned roads: express road "Right Shore" and connection "Prstenska".



The matrix used for the auto assignment is a total of the internal and external trips. The internal matrix was found out by demand modeling, the external one by traffic research (observations).

3.2 Emissions of carbon dioxide

The traffic volumes in both scenarios were used for the calculation of carbon dioxide (CO_2) emissions from transport. For the emission calculation, the share of light and heavy duty vehicles and buses had to be estimated. According to the data from National traffic census, the share is between 5-7 % on main road and only about 1-2 % in local road. The share of buses has been estimated according to public transport timetables. As is displayed in Table 2, the day-to-day emission of carbon dioxide in Zlin town exceeds 216 tons per a day.

Table 2: Daily emission of carbon dioxide from transport in the Zlin town.

Transport mode	**Daily emission of CO_2 [tonnes]**
passenger cars	147,2
light duty vehicles	22,4
heavy duty vehicles	35,0
buses	11,4
t o t a l	**216,1**

Conclusions

The modeling should be an important part of environmental impact assessment especially in Brno city, where many transport constructions and measures have been planning and implementing. The key actions in Brno are: planned shift of Central Railway Station, finalization of the Big City Circle, building of parking houses and its best location, Park and Ride system, etc. Just the optimal location of parking houses and points for Park and Ride - this is the challenge for our traffic modeling. The model should help to evaluate all possible scenarios and optimal strategy. For the prediction of future impact we need to have the multimodal model of present transport in Brno as accurate as possible. More scenarios for Brno model are planned. In addition, more advanced modeling procedures like using the generalized costs, multiclass assignment and variable demand auto assignment are planned as well.

Concerning the Zlin town, the new roads seem to be very useful in order to divert the traffic from city center. The addition of the model on public transport (urban railway, trolleybuses, buses) is planned.