CETRA[2018]

5th International Conference on Road and Rail Infrastructure

17–19 May 2018, Zadar, Croatia

Road and Rail Infrastructure V

Stjepan Lakušić – EDITOR

IRF GLOBAL

FEHRL

Organizer
University of Zagreb
Faculty of Civil Engineering
Department of Transportation

CETRA[2018]
5th International Conference on Road and Rail Infrastructure
17–19 May 2018, Zadar, Croatia

TITLE
Road and Rail Infrastructure V, Proceedings of the Conference CETRA 2018

EDITED BY
Stjepan Lakušić

ISSN
1848-9850

ISBN
978-953-8168-25-3

DOI
10.5592/CO/CETRA.2018

PUBLISHED BY
Department of Transportation
Faculty of Civil Engineering
University of Zagreb
Kačićeva 26, 10000 Zagreb, Croatia

DESIGN, LAYOUT & COVER PAGE
minimum d.o.o.
Marko Uremović · Matej Korlaet

PRINTED IN ZAGREB, CROATIA BY
“Tiskara Zelina”, May 2018

COPIES
500

Zagreb, May 2018.

Proceedings of the
5th International Conference on Road and Rail Infrastructures – CETRA 2018
17–19 May 2018, Zadar, Croatia

Road and Rail Infrastructure V

EDITOR
Stjepan Lakušić
Department of Transportation
Faculty of Civil Engineering
University of Zagreb
Zagreb, Croatia

CETRA[2018]
5th International Conference on Road and Rail Infrastructure
17–19 May 2018, Zadar, Croatia

ORGANISATION

CHAIRMEN

Prof. **Stjepan Lakušić**, University of Zagreb, Faculty of Civil Engineering
Prof. emer. **Željko Korlaet**, University of Zagreb, Faculty of Civil Engineering

ORGANIZING COMMITTEE

Prof. Stjepan Lakušić
Prof. emer. Željko Korlaet
Prof. Vesna Dragčević
Prof. Tatjana Rukavina
Assist. Prof. Ivica Stančerić
Assist. Prof. Maja Ahac
Assist. Prof. Saša Ahac
Assist. Prof. Ivo Haladin
Assist. Prof. Josipa Domitrović
Tamara Džambas
Viktorija Grgić
Šime Bezina
Katarina Vranešić
Željko Stepan
Prof. Rudolf Eger
Prof. Kenneth Gavin
Prof. Janusz Madejski
Prof. Nencho Nenov
Prof. Andrei Petriaev
Prof. Otto Plašek
Assist. Prof. Andreas Schoebel
Prof. Adam Szeląg
Brendan Halleman

INTERNATIONAL ACADEMIC SCIENTIFIC COMMITTEE

Stjepan Lakušić, University of Zagreb, president
Borna Abramović, University of Zagreb
Maja Ahac, University of Zagreb
Saša Ahac, University of Zagreb
Darko Babić, University of Zagreb
Danijela Barić, University of Zagreb
Davor Brčić, University of Zagreb
Domagoj Damjanović, University of Zagreb
Sanja Dimter, J. J. Strossmayer University of Osijek
Aleksandra Deluka Tibljaš, University of Rijeka
Josipa Domitrović, University of Zagreb
Vesna Dragčević, University of Zagreb
Rudolf Eger, RheinMain Univ. of App. Sciences, Wiesbaden
Adelino Ferreira, University of Coimbra
Makoto Fujiu, Kanazawa University
Laszlo Gaspar, Széchenyi István University in Győr
Kenneth Gavin, Delft University of Technology
Nenad Gucunski, Rutgers University
Ivo Haladin, University of Zagreb
Staša Jovanović, University of Novi Sad
Lajos Kisgyörgy, Budapest Univ. of Tech. and Economics
Anastasia Konon, St. Petersburg State Transport Univ.
Željko Korlaet, University of Zagreb
Meho Saša Kovačević, University of Zagreb
Zoran Krakutovski, Ss. Cyril and Methodius Univ. in Skopje
Dirk Lauwers, Ghent University
Janusz Madejski, Silesian University of Technology
Goran Mladenović, University of Belgrade
Tomislav Josip Mlinarić, University of Zagreb
Nencho Nenov, University of Transport in Sofia
Mladen Nikšić, University of Zagreb
Andrei Petriaev, St. Petersburg State Transport University
Otto Plašek, Brno University of Technology
Mauricio Pradena, University of Concepcion
Carmen Racanel, Tech. Univ. of Civil Eng. Bucharest
Tatjana Rukavina, University of Zagreb
Andreas Schoebel, Vienna University of Technology
Ivica Stančerić, University of Zagreb
Adam Szeląg, Warsaw University of Technology
Marjan Tušar, National Institute of Chemistry, Ljubljana
Audrius Vaitkus, Vilnius Gediminas Technical University
Andrei Zaitsev, Russian University of transport, Moscow

CETRA[2018] 17–19 May 2018, Zadar, Croatia
5th International Conference on Road and Rail Infrastructure

USING OF THE EVA MODEL IN THE CZECH REPUBLIC

Vít Janoš, Milan Kříž
Czech Technical University, Faculty of Transportation Sciences, Czech Republic

Abstract

The most of transport models which are used for the strategic planning of the infrastructure are macroscopic models. These models are based on principles of transport demand and supply. The macroscopic transport models are very important tool for strategic planning of the traffic infrastructure. The set of these models is divided into many types. The EVA model is one of the most used transport models in Germany. The characteristic property of the EVA model is the joint destination and mode choice, which allows accurate description of particular possibilities. The question was how this type would behave in the conditions of the Czech Republic. This paper describes the principles of the EVA model and shows its use for the Jeseník District which was chosen as a testing area. Then the impacts of two infrastructure projects are evaluated. The transport model was made in the software package VISUM and for the preparing of the supply in the public transport the software FBS was used. The main contribution of the article is to describe the use of EVA model in a new environment – in transport planning in the Czech Republic – on the basis of application in Jesenik district. This approach is in transport modeling in the Czech Republic used very narrow – remain traditional methods based on comprehensive quantitative load of infrastructure. This approach does not allow an optimal selection of infrastructure adjustments based on actual and expected traffic flows. Authors have shown, that the method of use of available data and testing at an assembly EVA model leads also in the Czech environment to interesting and really applicable results.

Keywords: EVA, transport model, FBS, VISUM, Czech Republic

1 Introduction

The most of transport models which are used for the strategic planning of the infrastructure are macroscopic models. These models are based on principles of transport demand and supply. The term transport supply represents all of items which can have influence on someone´s decision of their trips. These items are mostly models of transport networks (road, rail etc.) and schedules of public transport. The term transport demand covers the creation and the formation of all particular trips.

The most known type of these models is the four-stage transport model [1]. The matter of this model is sequence of four steps (see figure 1): trip generation, distribution, modal split, assignment.

The process begins usually with the supply model where the networks and the zoning system are defined. Many data important for the transport demand (level of population, number of jobs, educational facilities etc.) are then collected for each zone. The first step of the demand modelling is the trip generation where the numbers of trips generated and attracted by each zone are estimated. The next step is the distribution. All trips from each zone are distributed to the set of possible destinations. The third stage (modal split) covers the choice of the mode for each trip. The last step represents the assignment of the trips by each mode to their corresponding networks.

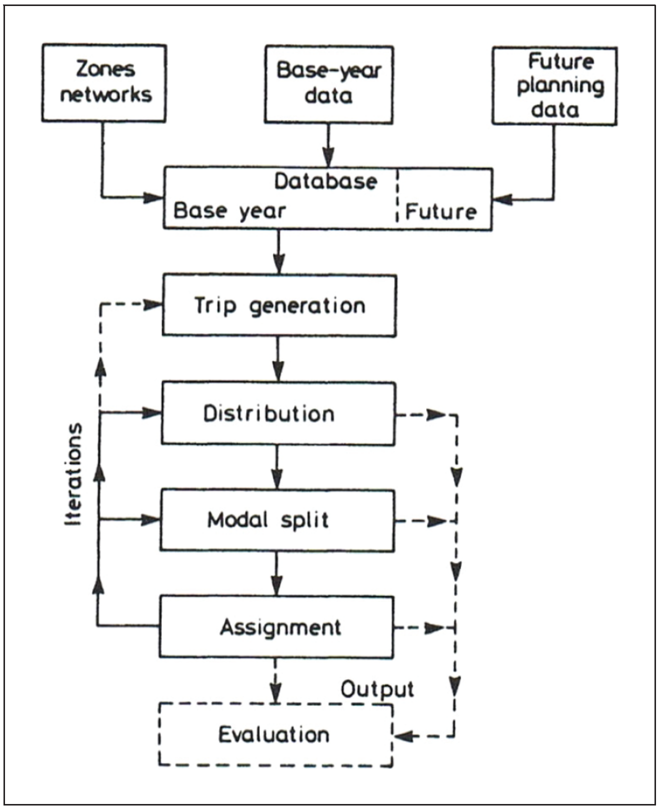

Figure 1 The classic four-stage transport model [1]

The transport EVA model (the name of the model originates from the German terms of the first three stages of the classic transport model: Erzeugung – Verteilung – Aufteilung) is based on the four-stage transport model. The most important character of this model is connection of the distribution and the modal split into one joint step. But the structure of this model has several other characteristics which relate to all first three stages of the transport models.
The model was developed by prof. Lohse at Dresden University of Technology. Lohse developed the core of the model in the early 1970s, but it was not published at this time. The model was first presented in 1977 [2].
However it was completely published in 1997 [3]. In 1997 also the first software for calculating the EVA model was created. Later the software was incorporated into the software package VISUM and is supplied as a facultative module of this software package [4]. The model was first described in English in [5].
One of the most serious general problems of the transport models is the fact, that the transport models are mostly developed for a certain region or town under specific conditions and requirements. Therefore such models are used in their original area and aren´t transferred to other areas.
The target of this article is to transfer the EVA model into the context of the Czech Republic and to show how this type of the transport models can be used in the new conditions.
The present paper describes first the principles of the EVA model with connection to the case study of the transport model of the Jeseník District [6]. The second part discusses more deeply the model of the Jeseník District and the third part deals with the evaluation of impacts of new infrastructure projects in the model.

2 Methodology

As mentioned, the core of the model is in the first three steps of the transport demand modelling, however the whole algorithm of the EVA model contains other common step used in the transport modelling (see Figure 2).

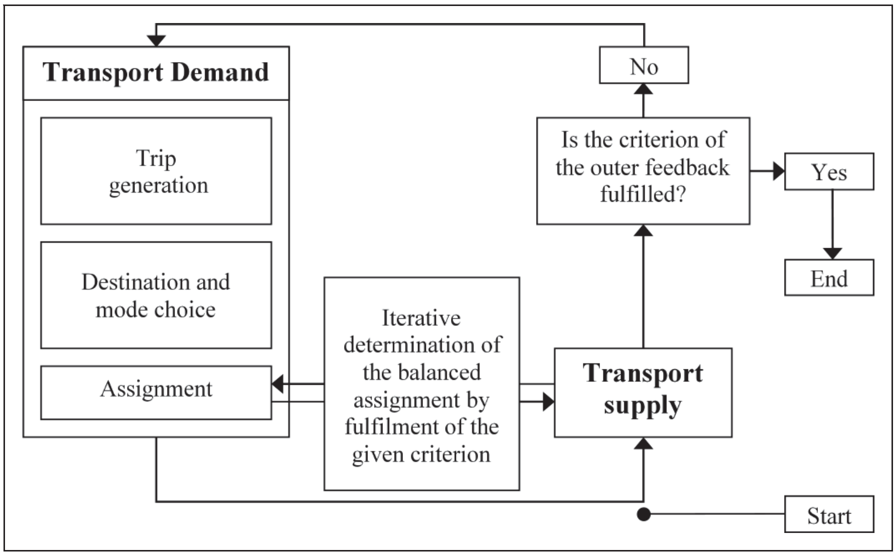

Figure 2 Algorithm of the EVA model [5]

At the beginning (after the network modelling and the zoning system) the set of all trips is disaggregated into activity-purpose pairs at origin and destination. In the model of the Jeseník District was used a common distribution into 13 pairs (see Table 1).

Table 1 Used activity-purpose pairs in the transport model of Jeseník District

To activity / From activity	H	W	P	E	S	O
Home (H)	–	HW(1)	HP(1)	HE(1)	HS(1)	HO(1)
Work (W)	WH(2)	–	WO(1)			
Preschool (P)	PH(2)	OW(2)	OO(3)			
Education (E)	EH(2)					
Shopping (S)	SH(2)					
Other (O)	OH(2)					

These pairs are divided into three groups, with regard to the location of so called home activity – it can be home (first priority) or work (second priority). These groups are:

- Type 1: Origin is home activity.
- Type 2: Destination is home activity.
- Type 3: Neither origin nor destination are home activity.

Each activity-purpose pair is associated with the only set of travellers. For example in the model of the Jeseník District the pair HS is associated with the group of schoolchildren at primary and secondary schools. So all trips HS in the model are related to this set of travellers. At the home end of a trip is the trip production and at non-home end is the trip attraction. For example by the pair EH trip production is the destination and trip attraction is the origin. At the attraction side there are two possibilities for solving the trip generation:

- Hard constraints: They are used if the trip attraction is calculated only from zone characteristics and is independent of mutual relations between zones at the attraction side. Trip attractions are calculated already in the trip generation and are in the next steps constant. This is used for obligatory activities such as work or school.
- Soft and elastic constraints: They are used if the trip attraction depends also on mutual relations between zones at the attraction side. Only potentials of trip attractions are calculated in the trip generation and the final attractions are determined in the next step. This is used for non-obligatory activities such as shopping.

Trip production for each pair in each zone e can be derived as:

$$H_e = \sum_p SV_p \cdot BP_{ep} \tag{1}$$

With:
H_e – trip production in zone e;
SV_p – production rate for person group p;
BP_{ep} – number of persons of group p in zone e;
For trip attraction see [3] or [5] (in English).

After the trip generation the joint destination and mode choice comes. The first part of this step is the weighting of costs. From the supply model are skimmed values of all required costs for each relation from zone i to zone j. One value of generalized costs w is determined from the values of particular costs for each relation and this value is transformed with special weighting function to valuation probability BW_{ijk} which represents conditional probability that the trip from zone i to zone j with mode k is executed with regard to the generalized costs. There are many types of functions which can be used. In the transport model of the Jeseník District so called EVA1-function with parameters E, F and G was used:

$$BW_{ijk} = \frac{1}{\left(1 + w_{ijk}\right)^{\phi(w_{ijk})}} ; \phi\left(w_{ijk}\right) = \frac{E}{1 + \exp(F - G \cdot w_{ijk})} \tag{2}$$

The problem of this non-linear transformation is that the parameters have to be adjusted for each activity pair and mode manually in the calibration. After calculating the probabilities we solve the tri-linear system of equations. In the case of hard constraints the system has the form:

$$v_{ijk} = BW_{ijk} \cdot fq_i \cdot fz_j \cdot fa_k \tag{3}$$

$$Q_i = \sum_j \sum_k v_{ijk} \tag{4}$$

$$Z_j = \sum_i \sum_k v_{ijk} \tag{5}$$

$$A_k = \sum_i \sum_j v_{ijk} \tag{6}$$

With:
fq_i, fz_j, fa_k – balancing factors at the origin, destination and mode side;
Q_i – number of trips at the origin side in zone i;
Z_j – number of trips at the destination side in zone j;
A_k – number of trip by mode k;

By forecasting the balancing factors fa_k remain constant and the system is only bi-linear:

$$v_{ijk} = BW_{ijk} \cdot fq_i \cdot fz_j \cdot C_k \tag{7}$$

$$Q_i = \sum_j \sum_k v_{ijk} \tag{8}$$

$$Z_j = \sum_i \sum_k v_{ijk} \tag{9}$$

The last step of the model is the assignment. In the EVA model one can use any algorithm for assignment. The whole calculation is carrying out until the outer feedback is fulfilled (see Figure 2). The complete model with many variations is described in [3].

3 The Model of the Jeseník District

In the case study the passenger transport model of the Jeseník District was created, calibrated and validated. For creating of the model the software package VISUM 12.0 from the company PTV was used. The zoning system was based on the system of basic residential units (základní sídelní jednotka) which is used by the Czech Statistical Office (CSO). The model consist of 113 such zones. The highest population of one zone was 2411 inhabitants. This model thus follows recommendations, that the zones should be not larger than about 9000 inhabitants [7]. Following data were collected for each zone: population, number of employed people, number of children between 0 and 5 years, number of schoolchildren who attend primary or secondary school, number of employees, number of employees in the tertiary sector, capacity of preschools, capacity of primary and secondary schools, sales area in the grocery. Not all data were found out directly, some had to be derived from other data.
In the model there were used four modes: passenger car, public transport, bicycle, walking. In the supply model all roads and all lines of the public transport were included. The parameters describing the transport behaviour were used partly from the Census 2001 in the Czech Republic and partly from the SrV 2008 [8] and adjusted for the Jeseník District. The only kind of costs which was skimmed was the journey time. The parameters of EVA1-functions were calibrated so that the mean journey time in the model and the mean journey time in the Jeseník District were the same. This was done for the activity pairs HW and HS and modes Passenger car and Public transport, the other parameters of the other EVA1-Functions were adjusted adequately. The validation of the model was carried out as a comparison between cross-section data in the model and from the National traffic census 2010 (Celostátní sčítání dopravy 2010) [9]. The results of validation are in Figure 3.

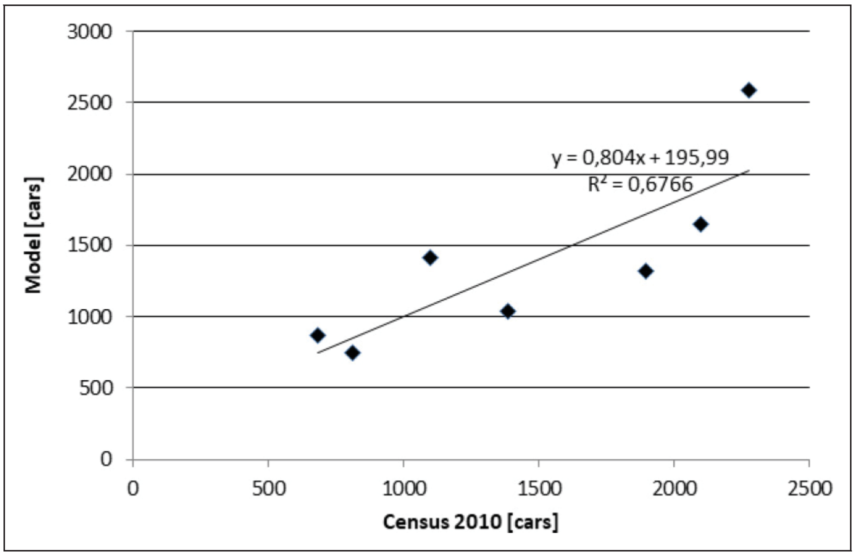

Figure 3 Comparison: Model – National Traffic Census 2010

The model was compiled according to the algorithm shown in Figure 2. At the beginning the network and the zoning system were made. Then all three steps of the transport demand were carried out and the criterion of the feedback between the supply and the demand was fulfilled. Certain outputs from the created model were compared with data in the real transport system of the Jeseník District and the parameters of EVA1-Functions were so adjusted, that the behaviour of the model responds to the reality. At the end the validation valued the quality of the model.

4 Evaluation of impacts of new infrastructure projects

With the calibrated and validated model one can evaluate impacts which some new infrastructure project can have. For the model two complex infrastructure changes were chosen. The first was in the road traffic and the second in the public transport. In the road traffic there was a complex of three new short sections on the main road between the towns Jeseník and Javorník. In the public transport the study Determination of the Priorities of the Development of the Fundamental Railway Network (Stanovení priorit rozvoje páteřní železniční sítě) [10] was used. In this study the complex of adjustments of the whole Czech railway net was suggested and the new supply in the form of netgraph was made. For this work the software package FBS was used. The part of netgraph which is related to the Jeseník District was used for the new supply in the mode public transport (see Figure 4). There wasn´t any change in other parts of the model (e.g. structural data in the zones).

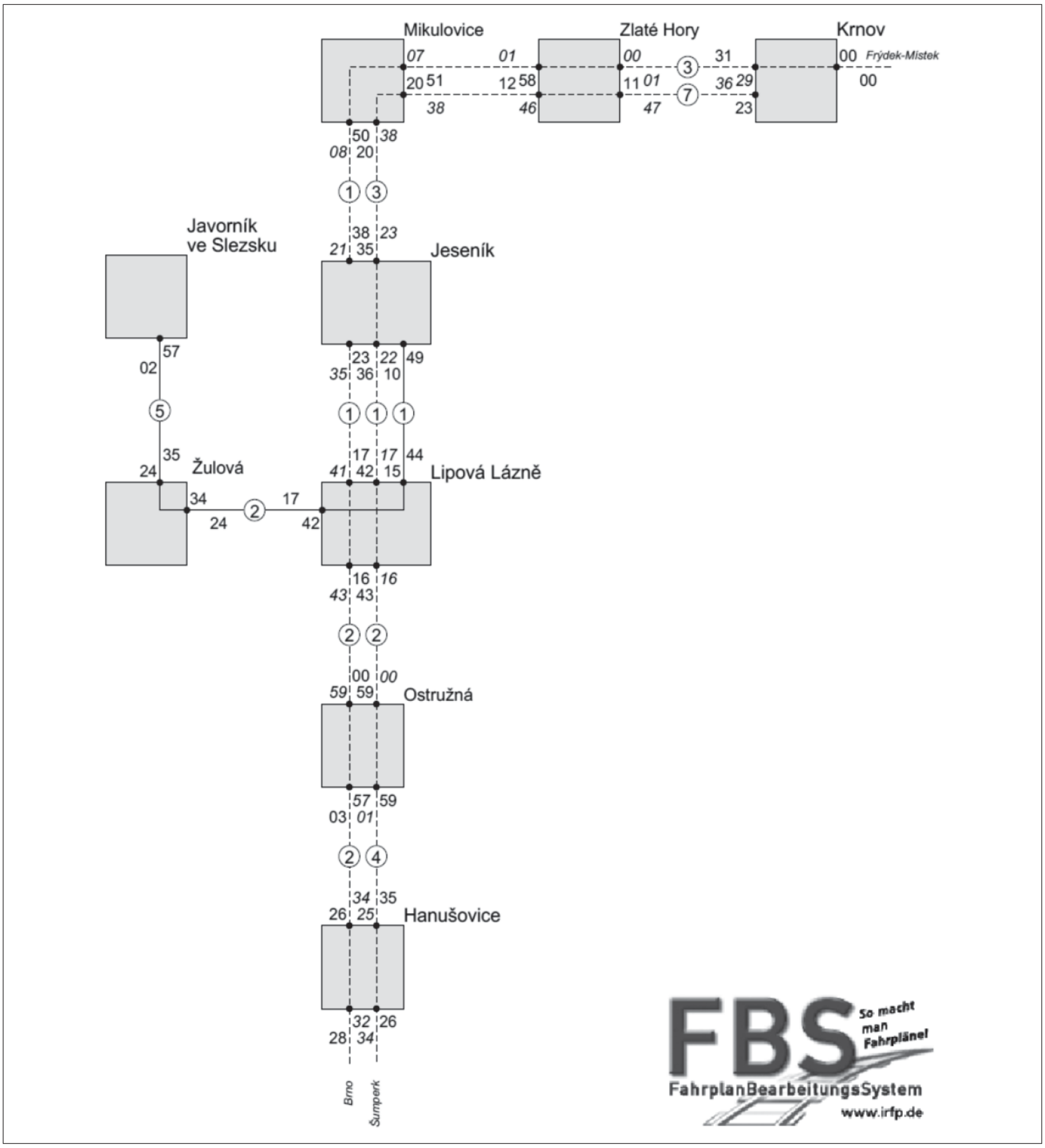

Figure 4 The new supply in the Public transport [10]

Four scenarios were proposed on the basis of the two possible infrastructure changes:

- Scenario 00: Neither of the transport modes is altered. The supply remains the same. The model doesn´t change itself.
- Scenario 0R: There is the change in the road network. The supply in the public transport remains the same.
- Scenario P0: There is the change in the public transport. The road network remains the same.
- Scenario PR: Both transport modes are altered. The supply is new in both transport modes.

For each scenario the model was derived from the calibrated model (with saved factors fa_k). Every of these models were calculated again with the same parameters of EVA1-Functions and factors fa_k, but with the new supply model. On the model we can evaluate many various results. One of the most interesting quantities in the transport modelling is the global modal split of all trips in the model. This quantity can be evaluated relatively or absolutely (in numbers of trips of the particular modes). For the relative values of the modal split in the particular scenarios see Table 1, for the absolute changes in the modes passenger car and public transport see Figure 5. The number of all trips (of all modes) in the model is 118 497 (for all scenarios).

Table 2 Modal split of the particular scenarios

Scenario		00	0R	PR	P0
Modal Split	**Walkin**	68,2 %	68,0 %	67,9 %	68,0 %
	Bicycle	5,9 %	5,9 %	5,9 %	5,9 %
	Passenger car	11,9 %	12,3 %	12,2 %	11,8 %
	Public transport	13,9 %	13,7 %	14,1 %	14,3 %

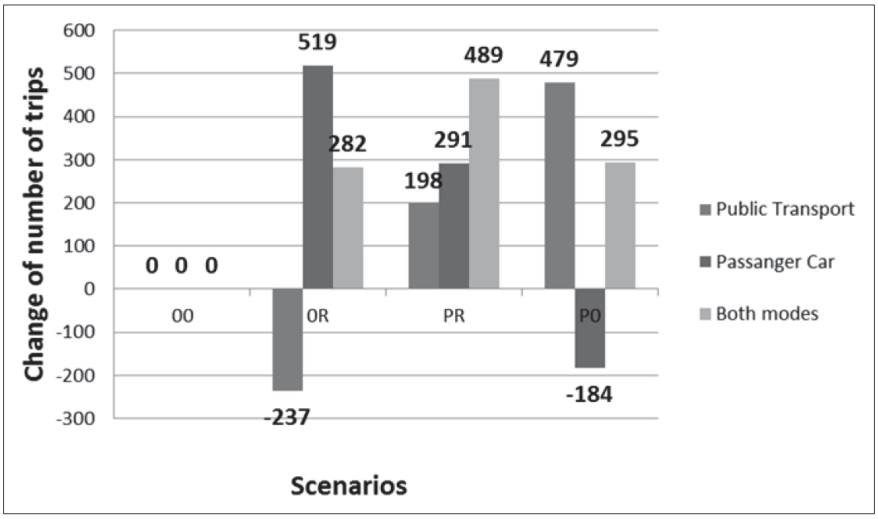

Figure 5 Absolute changes in the modes passenger car and public transport

5 Conclusions

The issue of transport modelling, as support for transport planning, in the Czech Republic is very complicated. As already mentioned, in the Czech Republic, there is no direct data collection for transportation modelling. The information of passenger flows is currently available mainly from the CSO data – data on the number of permanent residents in the municipalities and their local areas, information about regular commuting. Further information is available from carriers – information about the load-factor, number of boarding and alighting passengers at each stops, shortly will be provided the origin-destination matrices. For more information on the origins and destinations relate mainly to number of employment opportunities (data from major employers) and regular commuting school children – these data are used in abundance in the case of larger optimization of timetables in the region. Available CSO data are not broken down by mode of transport attributable to a specific origin-destination, because this is the information about the total passenger flows – across all modes of transport. On the contrary, data from carriers are related only to a particular type of service and thus have explanatory power only for passengers who already use the public transport. For a description of all passenger flows in the region across all transport modes can only be used the theoretical transport models. Thus established passenger flows can be followed on the basis of the availability of origins and destinations of share assigned to each mode of transport – theoretically calculated passenger flows thus assign theoretical modal split. It shows how important is the role of public transport in a whole transport system where there is generally a high demand for transport and the passenger flows which makes it suitable to be targeted and at the same time, in which relations there is a most unused potential for public transport. Contemporary, no region today has processed quality transport model [11], because the benefits of high-quality and comprehensive transport modelling in the Czech area are still not fully appreciated. What is missing, is a quality travel surveys, surveys on the transport behaviour and sensitivity of users to parameters of public transport offer. Finally, it is difficult, often impossible, to group the time incommensurable data needed for the transport model setting. For the purpose of transport planning are so often used incremental theoretical gravity models of passenger flows in the region. The output of these models is the proportional comparison of significance of passenger flows, often associated with the theoretical calculation of the modal split. The planning of the new infrastructure projects is very important, but difficult process. The use of the transport models is very helpful for the identification of many possible impacts of these projects. There are many various transport models in the praxis. The characteristic property of the EVA model is the joint destination and mode choice, which allows accurate description of particular possibilities.

References

[1] Ortúzar, J. D., Willumsen, L.G.: Modelling Transport, John Wiley & Sons Ltd, 586 p., 2011.

[2] Lohse, D.: Berechnung von Personenverkehrsströmen. Wissenschaft und Technik im Straßenwesen (in German), 1977.

[3] Lohse, D., Bachner, G., Dugge, B., Teichert, H.: Ermittlung von Verkehrsströmen mit n-linearen Gleichungssystemen unter Beachtung von Nebenbedingungen einschließlich Parameterschätzung. Schriftenreihe des Instituts für Verkehrsplanung und Straßenverkehr (in German), 1997.

[4] PTV AG: VISUM 12: Fundamentals, 2011.

[5] Vrtic, M., Fröhlich, P., Schüssler, N., Axhausen, K.W., Lohse, D., Schiller, C., Teichert, H.: Two-dimensionally constrained disaggregate trip generation, distribution and mode choice model: Theory and application for a Swiss national model, Transportation Research Part A: Policy and Practice 41(9), 857–873, 2007.

[6] Kříž, M.: Vzájemný vztah mezi VD a ID při dopravní obsluze území, Ms Thesis. Czech Technical University in Prague, Prague, 2012.

[7] Ušpalytė-Vitkūnienė, R., Grigonis, V., Paliulis, G.: The extent of influence of O–D matrix on the results of public transport modeling, Transport 27(2): pp. 165–170, 2012.

[8] TU Dresden: TUD – Forschungsprojekt 'Mobilität in Städten – SrV' – Ergebnisse des SrV 2008 (in German), 2009.

[9] ŘSD ČR: Prezentace výsledků sčítání dopravy 2010, available from Internet: http://scitani2010.rsd.cz/pages/informations/default.aspx (in Czech), 2011.

[10] IKP: Stanovení priorit rozvoje páteřní železniční sítě, IKP Consulting Engineers, s.r.o., 2011.

[11] Janoš, V., Baudyš, K.: Transport Planning of Public Services, European Transport Congress, Prague, 2013.