CETRA 2014

3rd International Conference on Road and Rail Infrastructure
28–30 April 2014, Split, Croatia

Road and Rail Infrastructure III

Stjepan Lakušić – EDITOR

Organizer
University of Zagreb
Faculty of Civil Engineering
Department of Transportation

CETRA 2014
3rd International Conference on Road and Rail Infrastructure
28–30 April 2014, Split, Croatia

TITLE
Road and Rail Infrastructure III, Proceedings of the Conference CETRA 2014

EDITED BY
Stjepan Lakušić

ISSN
1848-9850

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”, April 2014

COPIES
400

Zagreb, April 2014.

Proceedings of the
3rd International Conference on Road and Rail Infrastructures – CETRA 2014
28–30 April 2014, Split, Croatia

Road and Rail Infrastructure III

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

ORGANISATION

CHAIRMEN

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

ORGANIZING COMMITTEE

Prof. Stjepan Lakušić
Prof. Željko Korlaet
Prof. Vesna Dragčević
Prof. Tatjana Rukavina
Assist. Prof. Ivica Stančerić
dr. Maja Ahac
Ivo Haladin
dr. Saša Ahac
Josipa Domitrović
Tamara Džambas

All members of CETRA 2014 Conference Organizing Committee are professors and assistants of the Department of Transportation, Faculty of Civil Engineering at University of Zagreb.

INTERNATIONAL ACADEMIC SCIENTIFIC COMMITTEE

Prof. Vesna Dragčević, University of Zagreb
Prof. Isfendiyar Egeli, Izmir Institute of Technology
Prof. Rudolf Eger, RheinMain University
Prof. Ešref Gačanin, Univeristy of Sarajevo
Prof. Nenad Gucunski, Rutgers University
Prof. Libor Izvolt, University of Zilina
Prof. Lajos Kisgyörgy, Budapest University of Technology and Economics
Prof. Željko Korlaet, University of Zagreb
Prof. Zoran Krakutovski, University of Skopje
Prof. Stjepan Lakušić, University of Zagreb
Prof. Dirk Lauwers, Ghent University
Prof. Zili Li, Delft University of Technology
Prof. Janusz Madejski, Silesian University of Technology
Prof. Goran Mladenović, University of Belgrade
Prof. Otto Plašek, Brno University of Technology
Prof. Vassilios A. Profillidis, Democritus University of Thrace
Prof. Carmen Racanel, Technical University of Civil Engineering Bucharest
Prof. Tatjana Rukavina, University of Zagreb
Prof. Andreas Schoebel, Vienna University of Technology
Prof. Mirjana Tomičić-Torlaković, University of Belgrade
Prof. Audrius Vaitkus, Vilnius Gediminas Technical University
Prof. Nencho Nenov, University of Transport in Sofia
Prof. Marijan Žura, University of Ljubljana

CETRA2014 28–30 April 2014, Split, Croatia
3rd International Conference on Road and Rail Infrastructure

COMPARISON BETWEEN MODELLED AND MEASURED TRAVELLING TIME IN URBAN ROUNDABOUTS

Irena Ištoka Otković[1], Martina Zagvozda[1], Matjaž Šraml[2]
1 University of Osijek, Faculty of Civil Engineering Osijek, Croatia
2 University of Maribor, Faculty of Civil Engineering Maribor, Slovenia

Abstract

For the analysis of the existing and planned segments of the traffic system, a traffic modelling is used, and the choice of models depends on temporal and spatial limits of a model and the context of application of modelling results. Functioning of a traffic system is under the influence of variable human behaviour. Researches show that the behaviour of a driver is, among other things, territorially and culturally conditioned. Accordingly, there is no universally applicable model, so the adjustment of modelling to local characteristics of traffic system and its users is a necessary prerequisite for the use of any traffic model. The success of modelling of urban traffic networks and its segments is interrelated with successful modelling of critical network segments. According to a number of criteria, the most critical point of every traffic system is the intersection. The simulation models are very useful tool for the analysis of existing critical network segments and prediction of traffic conditions on existing and planned intersections. However, it is questionable whether they can be expected to give realistic modelling results that can be applied in the methodology, analysis and design of intersections in local conditions. Within this paper, a special attention has been paid to the microsimulation modelling of urban roundabouts. Accuracy of modelling results has been established by the comparison of travelling times between measuring points gathered in calibrated and uncalibrated VISSIM microsimulation models and the ones gathered in the field.

Keywords: travel time, microsimulations, VISSIM, roundabouts

1 Introduction

Development of mathematical, mathematical-empirical and simulation models of the traffic system was generated by the need to analyse the impact of the planned facilities and measures, as realistically as possible. Modelling as an analytical tool started to evolve in the forties of the last century. A great acceleration of development of mathematical modelling came about the same time as the rapid computerization and possibilities of solving great systems of equations in real time.

The application of various simulation models needs to be considered within the temporal and spatial scope. Specific simulation models are developed for certain types of traffic analysis and are intended for decision makings which differ in temporal and spatial coordinates. Macroscopic traffic models treat traffic flow as a kind of flow which behaves in accordance with continuum properties. Mesoscopic models incorporate the modelling of individual vehicles movements, where the operating characteristic, such as delays, is modelled in accordance with macroscopic modelling principles through the relationship between speed and density of traffic flow.

A closed driver-vehicle-environment cybernetic system, based on the feed-back relationship in reality, is the most similar with simulation models at the microsimulation level. Today's microsimulation models are able to model the stochastic nature of traffic flow at the multi-modal level: car – truck – bus/tram – cyclist- pedestrian, through a detailed movement modelling of each entity.
Modelling of roundabouts by simulation tool has its own specificities that can lead to significant discrepancies between modelled and measured data [1]. The microsimulation models are unquestionably a very useful tool for the analysis of existing critical network segments and prediction of traffic conditions on existing and planned intersections. However, it is questionable whether they can be expected to give realistic modelling results that can be applied in the methodology, analysis and design of roundabouts in local conditions. The best insight into the reality of the modelling results is provided by a comparison of modelled and measured traffic indicators.

2 VISSIM

VISSIM is a stochastic, discrete, micro-simulated model designed for traffic analyses. It started to develop in Germany at the University of Karlsruhe in the early '70s of the last century. VISSIM traffic model, which enables a detailed analysis and a large number of iterations in real time, is based on testing of various traffic scenarios. It includes empirical and measured data of each examined component of a modelled system and their interactions. Modelling results of each scenario are comparable. They focus on the analysis of alternative solutions, short-term traffic planning or optimization of particular elements of objects and/or evaluation of specific traffic regulation.
The simulation system of the VISSIM model contains two major program components. The first is the model of traffic distribution, and the other is the model of traffic signalization. Every second the main program detects the phase of traffic light signals and based on this data updates a traffic image (second by second, vehicle by vehicle). The stochastic nature of the model lies in the dynamic behaviour of system entities, it is in the function of gathering data from the environment and it is not fully determined by the earlier phase of the simulation.
The difference between VISSIM and other microsimulation models lies in the structure of the network model. Most microsimulation models are based on the node-connector structure, and VISSIM network model is structured on the basis of connectors and links. According to the logic of this kind of a structure, a vehicle that has come to the end of a connector changes the lane (link) and chooses the one that will take it to the desired destination as quickly as possible. The innovative structure allows modelling of complex intersections which reflect a realistic traffic situation. For the longitudinal vehicle movement the model implements the sub-model of psycho-physical modelling of car-following behaviour, and for lateral movement there is the sub-model based on the defined rules of acceptable time gap for changing lanes in vehicle moving [2].
Dynamic elements include the following information: size and structure of traffic flow, location of decision on the route choice, traffic volume distribution, traffic regulation, priority rule, etc. Dynamic elements of the network can be partially adopted from other programs in the form of an OD matrix, data on traffic regulation, main and secondary traffic flows, which shortens the time of framing the network model. Vehicles in the network are defined by the parameters of maximum and desired acceleration and deceleration, speed and desired speed distribution.
The development of computer graphics tools has opened up great opportunities for creating a high-quality three-dimensional presentation of the modelled part of the network or facility. Graphic animation has the ability to change views and perspectives [3]. Graphic presentation and animation are very important tools that help decision makers and wider public visualize and understand specific transport solutions.

3 Measured and modelled travelling time

To check the applicability of the microsimulation tool on roundabouts in local conditions, the two Osijek's single-lane roundabouts were chosen. The first selected roundabout was Vinkovačka–Drinska roundabout, the four-approach intersection of the primary urban network and the second location was a four-approach Kirova-Opatijska roundabout (Figure 1).

Figure 1 Two single-lane roundabouts in Osijek

VISSIM has developed, and it is continuously developing, a significant number of traffic parameters that can be analysed in traffic modelling, from operational features and economic indicators to environmental impact parameters (noise and air pollution). Measurability in the field was the main criterion for the selection of travelling time as indicator of operational characteristics that will be used as output simulation value of the observed intersection model. Model calibration is the adaptation of a model to local specificities. According to the Highway Capacity Manual, calibration is the process of comparing model parameters with actual data obtained by counting and measuring at a local network [4]. The aim is to reduce the discrepancy between output results of a simulation model and data obtained by measurements and observations in the field. Model validation is evaluation of calibration model efficiency by comparing modelled and measured traffic parameters. VISSIM microsimulation model calibration in local conditions is done by application of neural networks [5]. Identification of influential parameters, the range of their values and optimization of the influencing parameters and their values by some of optimization tools are an integral part of calibration process [6,7,8].
Review of results of counting traffic in the field and the procedure for creating a layout for microsimulation modelling is available in the references [9].
Travelling time for the measured sections for both intersections are measured and compared to the modelled travelling time for the same stream with calibrated and non-calibrated (default) values of model input parameters. The measured values of the observed traffic indicator – mean value of measured travelling time between measurement points are shown in Table 1. Comparison between average value of measured and modelled travelling time is shown in the Table 1.

Table 1 Measured and modelled mean value of travelling time (s)

	Rounadbout 1			**Rounadbout 2**
	1st measurement	**2nd measurement**	**3rd measurement**	**4th measurement**
Measured value	21,8	19,9	18,1	13,3
Default model	20,3	20,3	17,6	13,1
Calibrated model	21,4	19,8	17,6	13,1

For the analysis of travelling time, measuring points were selected in a way that they include one left-turn traffic stream for both observed intersections. VISSIM has the ability to analyse the travelling time of each vehicle in the examined traffic stream between measuring points. At the same time the number of vehicles generated by the model is not necessarily equal to the number of vehicles counted, because the model strictly holds the default traffic distribution and not the traffic load entered into the model. Comparison of each specific measured and modelled travelling time for every vehicle that passed between measuring points for the first measurement (roundabout 1) is shown in Figure 2. In Figure 2 it can be seen that calibrated model provides better matching with measured individual travelling time of observed traffic stream for first intersection.

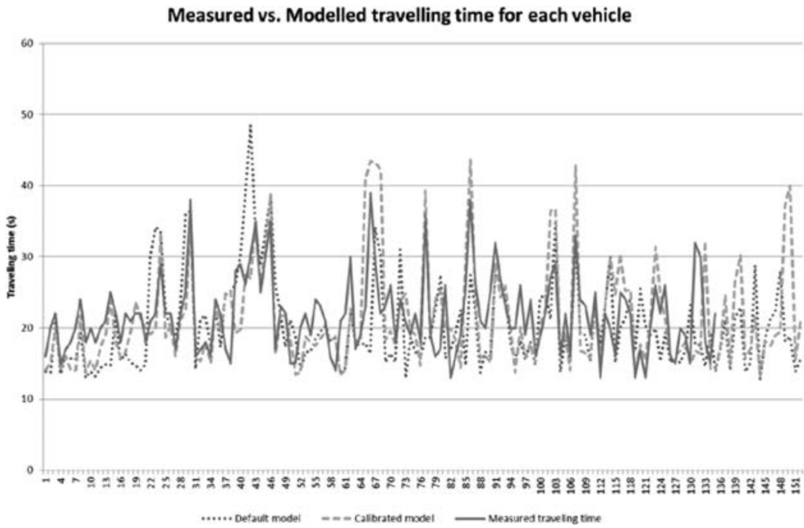

Figure 2 Comparison of modeled and measured traveling time for each vehicle of observed traffic stream (roundabout 1)

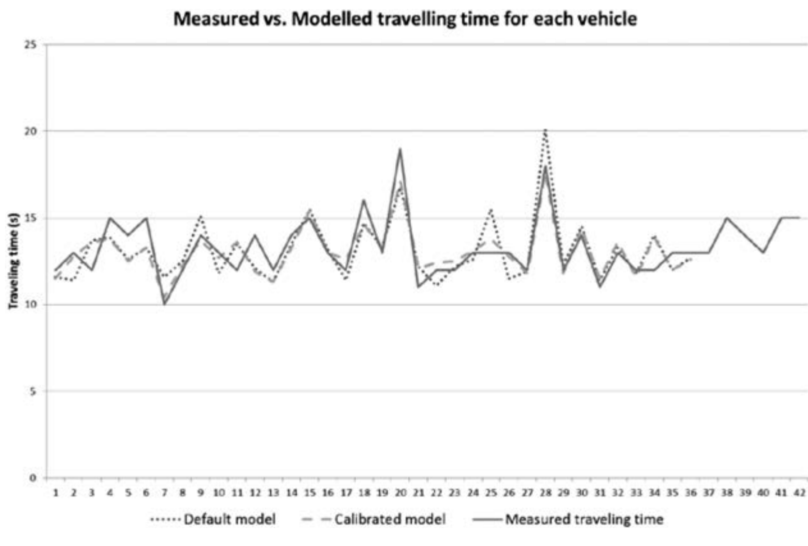

Figure 3 Comparison of modeled and measured traveling time for each vehicle of observed traffic stream (roundabout 2)

In conditions of low traffic load both calibrated and default model provide the same mean travelling time, and even analysis of travelling time of each individual vehicle in traffic stream does not show significant differences, as shown in figure 3.

4 Discussion

A basic insight into the reality of modelling results is obtained by comparison of mean values of traffic indicators acquired from modelling and measuring in the field. For a certain type of traffic analysis, such as selection of type of intersection in early stages of designing, comparison of alternative solutions for an intersection, optimization of intersection shaping elements and analysis of different traffic scenarios, that sort of modelling results is applicable.

Comparison of the mean travelling time obtained from calibrated and uncalibrated models with results obtained from the measuring in the field, clearly shows, as expected, that the calibrated model provides more realistic results, although the differences are not significant. In the first set of measured data, the difference between the travelling time and the modelling results of the calibrated model is 1.8%, and the uncalibrated model has given 6.9% shorter travelling time. In the second set of measured data, the difference between the measured travelling time and the one obtained from the calibrated model is 0.5%, and the uncalibrated model has provided 2% longer travelling time. In case of a low traffic load, both calibrated and uncalibrated model give the same travelling time. In the third set of measured data, the difference between the measured and the modelled travel time is 2.8%, and in the fourth it is 1.5%. In all of the examined cases, calibrated model reaches results which differ from the measured ones by less than 5%, and those are considered to be realistic modelling results [2,6].

Most of the model input parameters, chosen for optimization in the process of calibration [5,8] belong to the set of parameters that reflect behaviour of a driver in local conditions. The fourth set of measured data is made at the other urban roundabout with the idea to check if the calibrated model is applicable only to the roundabout at which the calibration is done or it can be applied to all one lane roundabouts in the examined traffic network. Unfortunately, both models – calibrated and uncalibrated – gave the same results of modelling of travelling time, so the initial hypothesis must be checked by analysing a new set of measured data and additional traffic indicators that are measurable in real traffic conditions, as well as the car-following parameters (mean and maximum length at the entrance to the intersection and the number of vehicles stopping at the examined entrance), delays, etc.

For more detailed and more sensitive analysis, such as traffic safety modelling on the micro-simulation level, identification of potential critical points according to traffic safety criteria, modelling of noise and air pollution, fuel consumption, etc. the mean values of traffic indicators are too rough and are usually not applicable. The advantage of microsimulation models is the fact that they model the movement of each entity separately and that they model the interactions of those entities through defined rules of priority and modelled response time which is variable. For such analysis, not only spatial, but also temporal distribution of traffic is important, so the additional calibration should be done by changing the value of a random number generator (input model parameter – random seed). Thus, the modelled temporal traffic distribution is approaching the real temporal traffic distribution, which has an additional impact on the reality of modelling results.

5 Conclusion

To make a certain traffic model applicable in analysis of a particular traffic network and its users, it needs to undergo calibration and verification processes so that it can model the actual traffic system with sufficient reliability. After the required reality of simulation models of the actual traffic system is achieved, they can be used for simulation of expected traffic growth, economic analysis and some other modelling parameters of the future traffic system and infrastructure.
Accuracy of modelling results is established by the comparison of values of traffic indicators gathered from modelling and the ones gathered in the field. Comparison of travelling times between measuring points in selected urban roundabouts shows that the calibrated model gives results that differ from the measured values of the travelling time by less than 5%, and such modelling results are considered to be realistic.
In order to check the applicability of the calibrated VISSIM microsimulation model to some other one lane roundabout in the examined urban traffic network, it is necessary to introduce additional parameters in the traffic analysis, such as the parameters of car-following, delays, etc. At the other examined roundabout, both models (calibrated and uncalibrated) gave the same modelled travel time between measuring points, which differs from the measured one for only 1.5%.

References

[1] Trueblood, M. & Dale, J.: Simulating Roundabouts with VISSIM, 2nd Urban Street Symposium, Anaheim, 2003.

[2] Kim, S.J.: Simultaneous calibration of a microscopic traffic simulation model and od matrix, Ph dissertation, Texas A&M University, 2006.

[3] Tonndorf, J. M. & Vorotovic, V.: Visualisation of Traffic Behaviour Using Computer Simulation Models, Journal of Maps, Vol. 2007, pp.135-148, 2007.

[4] Highway Capacity Manual 2000, Transportation Research Board, National Research Council, Washington D.C.

[5] Ištoka Otković, I., Tollazzi, T. & Šraml, M.: Calibration of microsimulation traffic model using neural network approach, Expert systems with applications, 40, pp. 5965-5974, 2013.

[6] Park, B., Won, J. & Yun, I.: Application of microscopic simulation model calibration and validation procedure: a case study of coordinated actuated signal system, Journal of Transportation Research Record, TRB, National Research Council, Washington D.C., pp. 113-122, 2006.

[7] Park, B. & Qi, H.: Development and Evaluation of Simulation Model Calibration Procedure, 84th Annual Meeting, Transportation Research Board, Washington D.C., 2005.

[8] Ištoka Otković, I., Tollazzi, T. & Šraml, M.: Analysis of the influence of car-following input parameters on the modelled travelling time, Tehnički vjesnik, 5 ; pp. 919-925, 2013.

[9] Ištoka Otković, I.: Using neural networks in the process of calibrating the microsimulation models in the analysis and design of roundabouts in urban areas,Ph dissertation, University of Maribor, 2011.