TRANSPORT PROBLEMS 2013
PROBLEMY TRANSPORTU Volume 8 Issue 2

MATSim; VISUM; traffic modelling; transport simulation;
4-stage models; agent-based system

Bartłomiej PIĄTKOWSKI*, Michał MACIEJEWSKI
Poznan University of Technology
Piotrowo 3, 60-965 Poznan, Poland
**Corresponding author*. E-mail: bartlomiej.piatkowski@doctorate.put.poznan.pl

COMPARISON OF TRAFFIC ASSIGNMENT IN VISUM AND TRANSPORT SIMULATION IN MATSIM

Summary. The paper presents a comparison of different approaches to traffic modelling and forecasting in VISUM and MATSim. The comparison was based on three indicators: link volumes, average travel time and distance. For this purpose, a virtual city with a road network and an OD matrix describing travel demands were created. Next the input data were created to both systems. The equilibrium and the dynamic stochastic assignment algorithms were used in VISUM while in MATSim a multi-agent approach was used for planning and a queue-based flow model for simulation. The comparison showed that although the overall results obtained in both systems were convergent, the detailed distribution of traffic was different. In VISUM the static assignment algorithm resulted in increased traffic flow on links located near to the connectors, while the dynamic one assigned traffic more uniformly, matching the MATSim's results.

PORÓWNANIE ALGORYTMÓW ROZKŁADU RUCHU W SYSTEMACH VISUM I MATSIM

Streszczenie. W artykule przedstawiono porównanie różnych podejść do modelowania i prognozowania ruchu wykorzystywanych w systemach VISUM i MATSim za pomocą takich wskaźników, jak liczba pojazdów na odcinkach, średni czas oraz średnia długość podróży. W tym celu stworzono wirtualne miasto z siecią drogową oraz macierz OD, określającą popyt na podróże. Następnie przygotowano dane wejściowe do obu systemów. W systemie VISUM wykorzystano algorytmy statycznej równowagi i stochastycznego rozkładu dynamicznego, natomiast w MATSim wykorzystano podejście wieloagentowe do planowania oraz model kolejkowy do symulacji ruchu. Porównanie wskazało, że choć wyniki ogólne otrzymane w obu systemach były zbieżne, to szczegółowy rozkład ruchu był inny. W systemie VISUM przy statycznym algorytmie rozkładu ruchu zwiększone było natężenie na odcinkach w pobliżu konektorów, podczas gdy algorytm dynamiczny rozdzielił ruch bardziej równomiernie, dorównując wynikom w systemie MATSim.

1. INTRODUCTION

To model and forecast the impact of transport system components (e.g., road infrastructure, transport services, travellers) on the overall transport performance, planners and engineers responsible for transport may use different existing models. One of the best known example is the 4-stage model [1, 8], a representation of trip-based approach to transportation modelling. This model can predict traffic flows between zones in the long term with trips aggregation. On the other hand, there are different approaches to travel demand modelling based on activities, in which trips are the derivative of the activities and all trips are disaggregated with an accuracy of a single traveller. The aim of the paper is to provide a comparison of the approaches to the traffic assignments used in two different systems VISUM and MATSim. In VISUM, a representative of the 4-step approach, the equilibrium and dynamic stochastic assignments were chosen. While in MATSim, an agent-based transport simulator was used, based on a simplified multi-agent model. With the same network and input data we compared the results of assignments by various indicators such as link volumes, average travel time and average trip distance.

2. THEORETICAL BACKGROUND

2.1. VISUM

VISUM [5] is a transportation planning system that allows for traffic modelling according to the 4-step approach [1, 2]. It offers a broad range of traffic assignment procedures for private transport. One of the assignment procedures chosen for the comparison was the static user equilibrium called the equilibrium assignment. This is one of the most popular assignments used by many transportation application. The procedure distributes the demand according to Wardrop's first principle [10]. The equilibrium assignment calculates the initial solution based on incremental assignment, which divides the demand proportionally over the number of iteration steps defined by a user. After that the system searches for alternative routes with lower impedance. If a new route is found for a given connection, the system will shift vehicles to the new one. That has an immediate effect on the impedance of network objects therefore VISUM must then recalculate network state. The procedure terminates if a state of balance has been reached, which means that there are no more vehicles to be shifted between routes.

Another VISUM's procedure used in the comparison was the Dynamic stochastic assignment, a dynamic stochastic user assignment. Firstly, the procedure calculates initial impedance of the network when it is unloaded. Next, the system starts external iteration of searching for connections between all origin and destination pairs. After the shortest route is found, the system is trying to find other alternative routes. Then their impedance factors are calculated. After that internal iteration starts, where the traffic is assigned to routes in accordance with a given discrete choice model. As traffic is being assigned, the system is constantly updating the impedances for all the routes according to the current volumes on links [5]. With this approach the system chooses different routes based on the time-dependent traffic flow parameters. In contrast to the static assignment, this method considers the overload effects in the network.

2.2. MATSim

MATSim [3, 6] is an agent-based system for transport simulation with the primary focus on transport planning. It allows for disaggregate activity-based modelling that consists of 3 main phases run iteratively: planning, simulation (also called network loading) and scoring presented in Fig. 1. The first phase (the planning phase) is used to create (first iteration) or modify (subsequent iterations) the agent daily plans, each consisting of activities and legs connecting the locations of subsequent activities. Next, during the simulation phase, all planned legs (along with activities) are executed by means of a queue-based traffic flow simulator. Within this simulation links are represented as FIFO queues with a set of parameters, among them: length, free-flow speed, flow capacity and storage capacity. The result of simulation is a set of events documenting changes in the state of any object (not only the agents) having been simulated. During the third phase (the scoring phase) the plans are evaluated against their actual execution (recorded in event logs). The obtained scoring is then used for choosing and modifying plans in the planning phase in the next iteration. The simulation ends after a termination criteria, based on a measure of the system relaxation, is met.

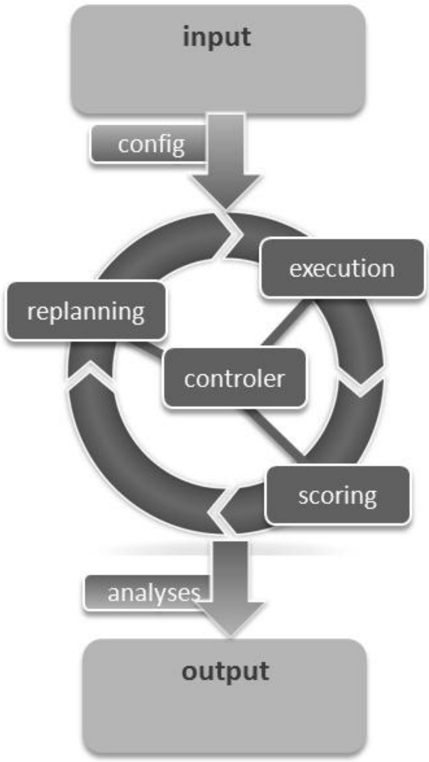

Fig. 1. MATSim's iteration approach [6]
Rys. 1. Iteracyjne podejście w MATSim [6]

3. MODEL CREATION

3.1. Network (supply)

The comparison was carried out for a virtual small-size city with a road network (presented in Fig. 2) based on the topology of Mielec, a city in South-Eastern Poland. The network model was first implemented in VISUM and then converted into the MATSim format file. It consists of 214 nodes and 610 links divided into three types: main roads (1-lane links, flow capacity 900veh/h, free-flow speed 60km/h), bulk roads (1-lane links, flow capacity 600veh/h, free-flow speed 45km/h), and local roads (1-lane links, flow capacity 300veh/h, free-flow speed 30km/h). Besides the urban network, external roads were modeled to allow for inbound, outbound and transit traffic. The whole study area was divided into 13 zones, each one having homogeneous land use. Nine of them represented city districts while the rest –external areas (sources and destinations of non-intra-urban traffic).

3.2. Demand

The city population was assumed to be around 60'000. The demand for private car transport was created in the form of an OD matrix, consisting of 4405 trips (per hour) that represent a typical afternoon rush hour traffic pattern. The demand was then doubled for a two-hour period where the first hour was treated as a warm-up. One should note that using OD matrices is not the default approach in MATSim where each agent has its own daily activity chain. However, the trip-base approach was used intentionally – the aim was to obtain precise and unbiased comparison of the assignment algorithms in VISUM and the queue simulation (with re-routing during the re-planning phase) in MATSim for exactly the same transport demand. In case of MATSim this led to the situation where each agent had exactly one trip (in other words, each trip of the OD matrix was performed by one agent). Furthermore, to keep a constant rate of the in-flow traffic, agents were only allowed to re-plan their routes while the departure times were kept unchanged.

Fig. 2. Road network of virtual city
Rys. 2. Sieć drogowa wirtualnego miasta

Despite the unification of both models, some differences still existed. For instance, in case of VISUM trips started and ended in zone centroids, which were connected to the network via connectors; the distribution of traffic between connectors within each zone depends on their weights for each OD pair. On the other hand, in MATSim trips originated and ended at links that were closest to a given activity location (generated randomly within a given origin or destination zone, see Fig. 3).

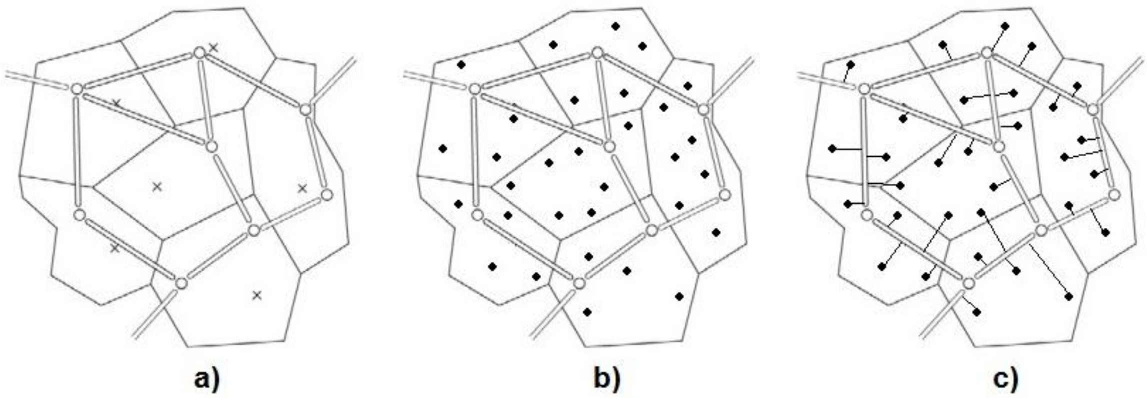

Fig. 3. Algorithm of agents generation, based on [9]: a) given network consisting links and nodes with defined zones, b) random generated agents, c) assignment of the agents to the nearest links
Rys. 3. Algorytm generowania agentów [9]: a) dostępna sieć drogowa zawierająca odcinki i węzły oraz zdefiniowane rejony komunikacyjne, b) losowo wygenerowani agenci, c) przypisanie agentom najbliższych odcinków

4. RESULTS COMPARISON

The main difference is that in MATSim each agent is simulated individually while VISUM aggregates vehicles into one stream. Looking at Fig. 4 one can see dots representing agents (dark grey dots represent agents stuck in congestion or trying to enter the network). In contrast to that, Fig. 5 shows just flows along links.

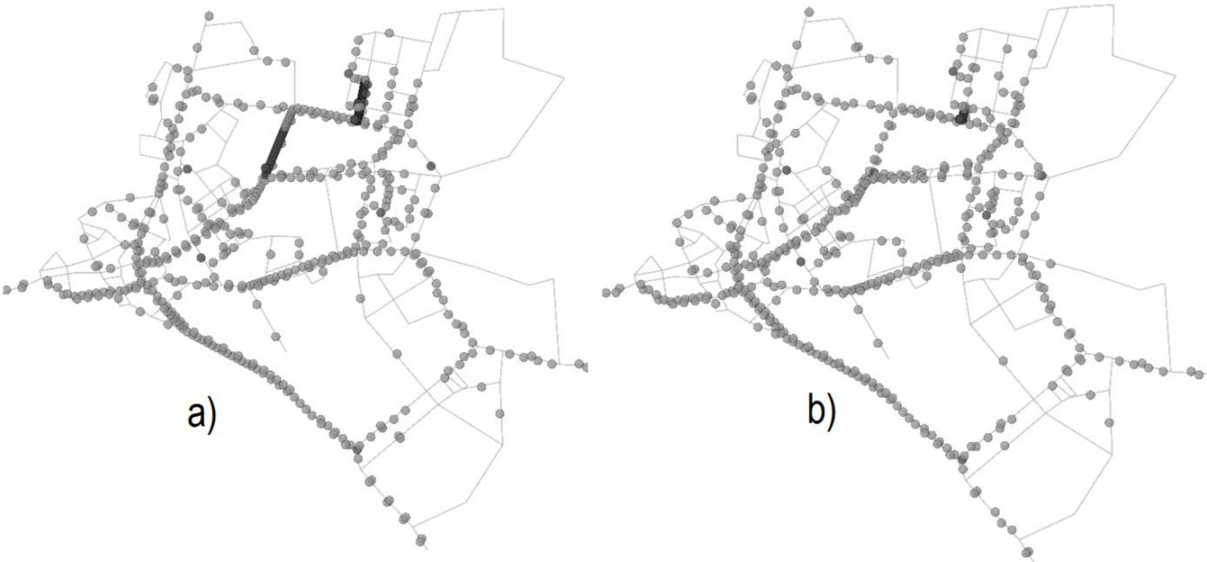

Fig. 4. Link Volumes in MATSim: a) at iteration 0, b) at iteration 20
Rys. 4. Natężenia pojazdów na odcinkach w MATSim: a) podczas 0 iteracji, b) podczas 20 iteracji

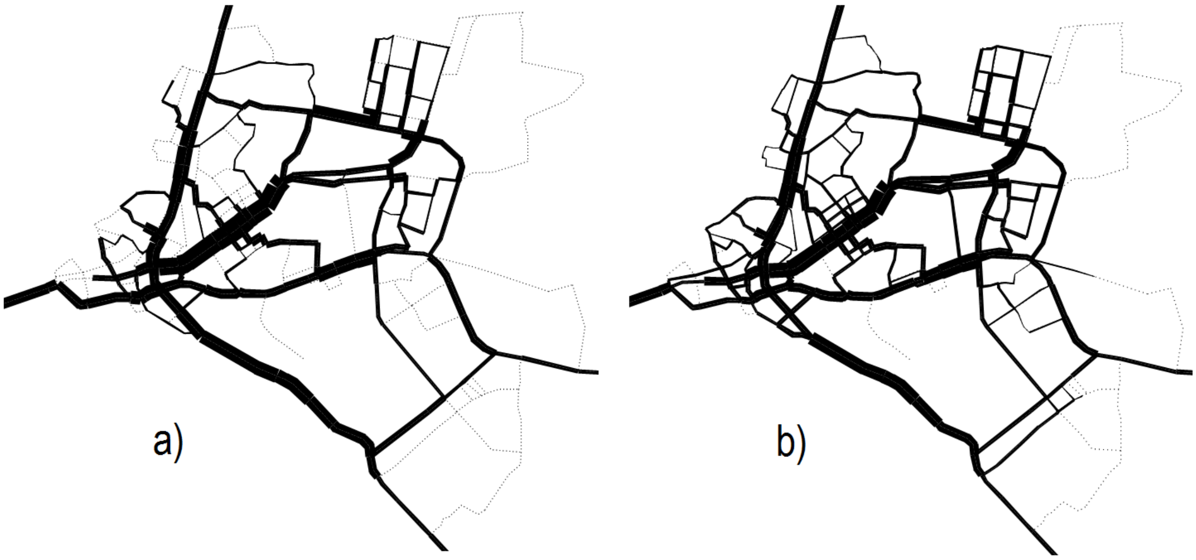

Fig. 5. Link Volumes in VISUM after using: a) static assignment procedure, b) dynamic assignment procedure. The links on which the traffic has not been reported are indicated by a dotted line
Rys. 5. Natężenia pojazdów na odcinkach w VISUM po użyciu: a) procedury statycznego przypisania, b) procedury dynamicznego przypisania. Odcinki, na których nie zanotowano pojazdów, przedstawiono linią przerywaną

Fig. 4 illustrates the effects of learning from iteration to iteration. After 20 iterations agents were more likely to choose a less congested faster but sometimes further route than at the initial iteration. Fig. 5 shows the difference between the static and dynamic assignments in VISUM. Links on which the traffic was not reported are indicated with a dotted line. In case of the static assignment (equilibrium assignment) traffic was distributed over the main links. However, the results for the dynamic stochastic assignment were more similar to those obtained in MATSim, i.e. flows are distributed more equally over the whole network.

Fig. 6 and 7 compare the result of simulation in MATSim and the static assignment in VISUM. Traffic in VISUM was concentrated on high-capacity links whilst agents in MATSim were trying to avoid congested links and were more likely to choose alternative routes. It is particularly noticeable on Fig. 7, which zooms into the low-volume links.

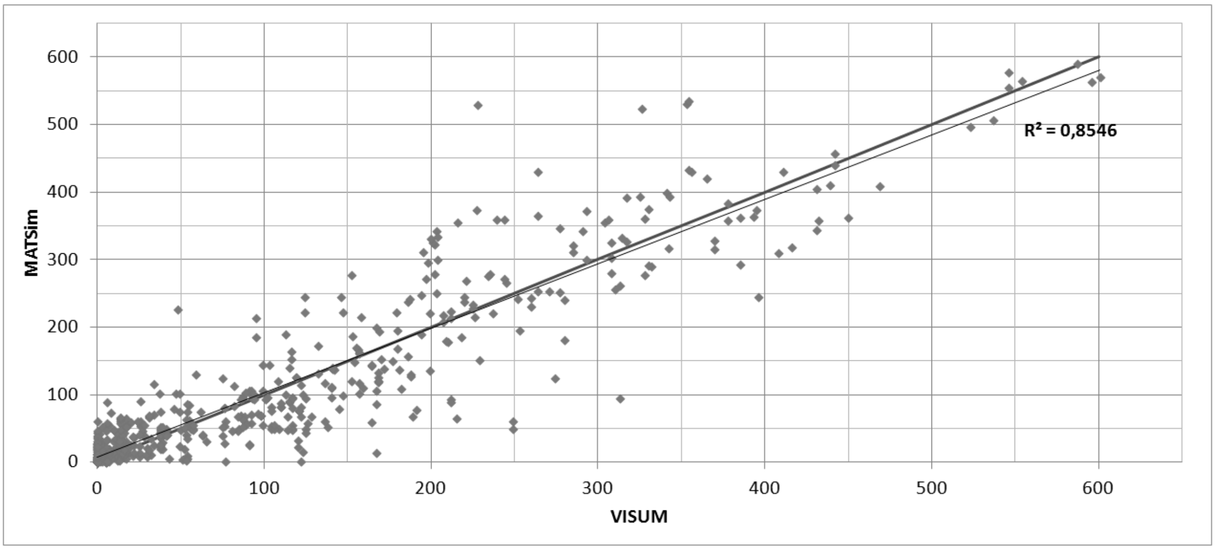

Fig. 6. Comparison of link volumes in VISUM (equilibrium assignment) and MATSim

Rys. 6. Porównanie natężeń pojazdów na poszczególnych odcinkach pomiędzy VISUM (statyczny rozkład) a MATSim

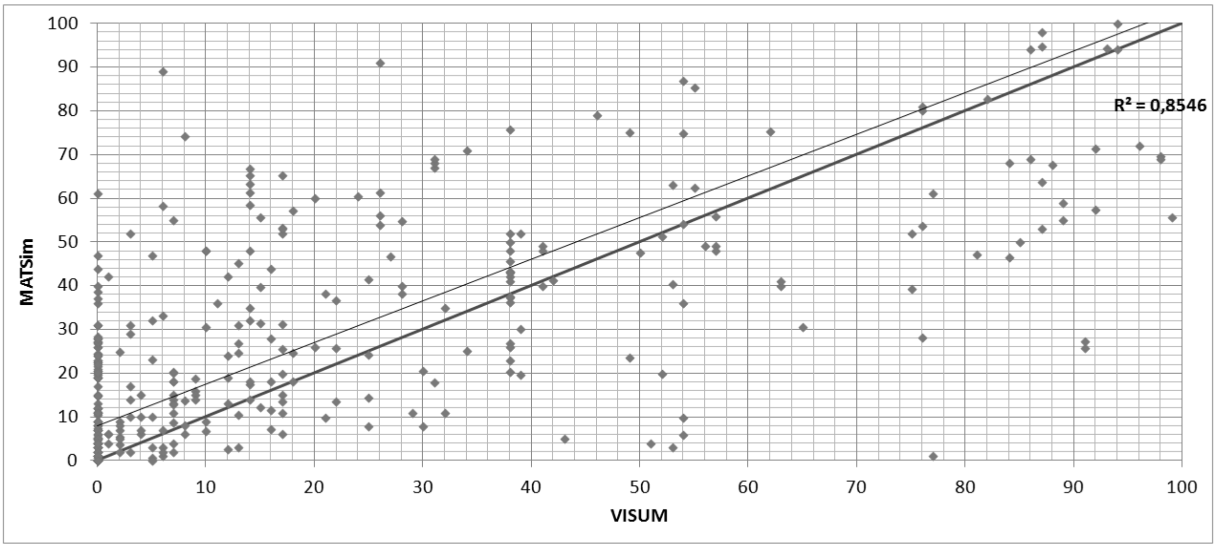

Fig. 7. Zoom in of comparsion of link volumes in VISUM (equilibrium assignment) and MATSim

Rys. 7. Powiększenie porównania natężeń pojazdów na poszczególnych odcinkach pomiędzy VISUM (statyczny rozkład) a MATSim

Fig. 8 and 9 illustrate the difference in the results between MATSim and the dynamic stochastic assignment in VISUM. However one can see that the dynamic stochastic assignment distributed vehicles more evenly on the low-volume links.

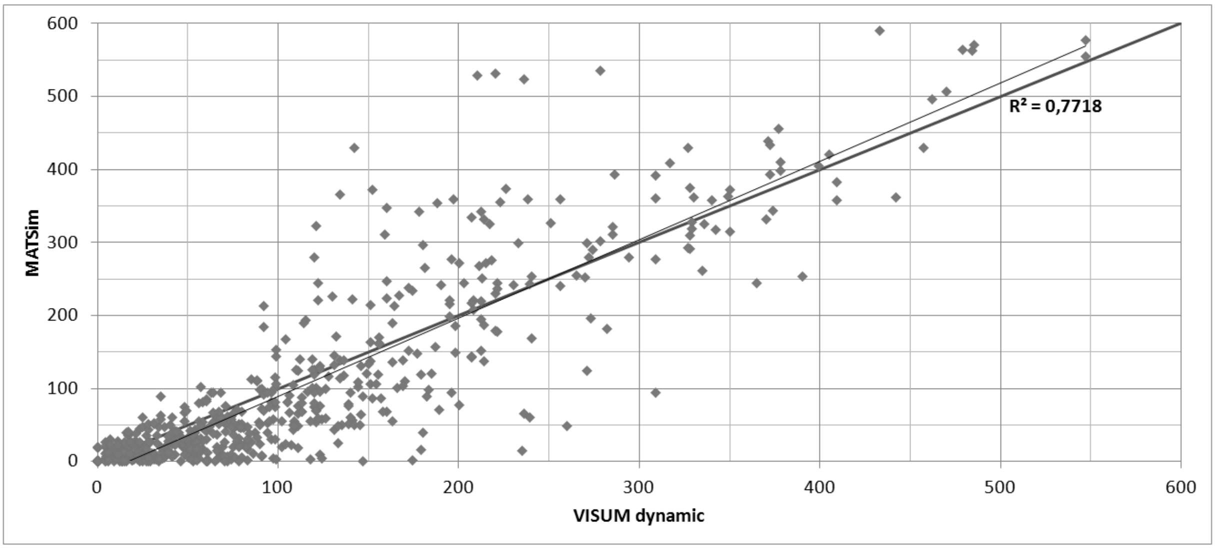

Fig. 8. Comparison of link volumes in VISUM (dynamic stochastic assignment) and MATSim
Rys. 8. Porównanie natężeń pojazdów na poszczególnych odcinkach pomiędzy VISUM (dynamiczny rozkład) a MATSim

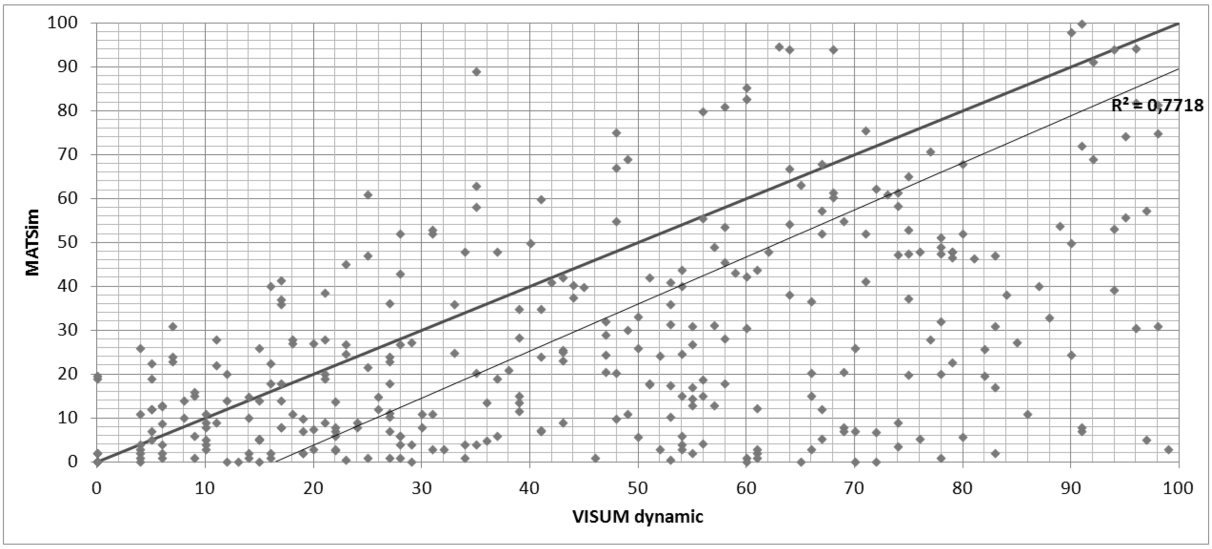

Fig. 9. Zoom in of comparison of link volumes in VISUM (dynamic stochastic assignment) and MATSim
Rys. 9. Powiększenie porównania natężeń pojazdów na poszczególnych odcinkach pomiędzy VISUM (dynamiczny rozkład) a MATSim

As the static (equilibrium) assignment in VISUM does not consider the link capacity constraints, all trips are loaded into the network mostly along the main roads, often resulting in the oversaturation of the flow (i.e., volume higher than the capacity). In case of the dynamic assignment in VISUM more diverse routes were chosen (since this is a stochastic assignment and therefore some routes are not the shortest). On the other hand, in MATSim agents choose the shortest routes based on the travel time estimates, which are based on the previous iteration (simulation). Moreover, it is not possible for the link volume to exceed the corresponding link capacity.

Concerning the average trip time, it was 09:00 (min:sec) in the static assignment, 09:56 in the dynamic assignment. In case of the MATSim simulation, average trip time decreased from iteration to iteration from 08:43 in iteration 0, to 07:53 in iteration 10, and finally to 07:43 in iteration 20.

Comparing precisely the average trip distances between VISUM and MATSim is difficult because these statistics are calculated differently in both systems. In MATSim trip starts at a link closest to the previous activity location, while in VISUM they start in zone centroids and then traverse connectors before entering the proper network. In MATSim the average trip distance was 5.602 km, while in the static assignment in VISUM– 6.58 (5.2191[1]) km and for the dynamic assignment 7.04 (5.675[2]) km. These statistics prove that the static assignment resulted in shortest paths, whereas in MATSim and the dynamic assignment traffic was more evenly distributed over the network.

5. CONCLUSION

In this study three approaches to traffic distribution from two systems MATSim and VISUM were compared. The comparison was focused on replanning (only re-routing) and traffic simulation in MATSim and two traffic assignments in VISUM. The results obtained in MATSim will have shorter travel times because network was almost free of congestions. Agents who got stuck in jams in one iteration, changed their routes in the following ones. Therefore, despite the increase in the distance, the travel times decreased, which can be seen in the results. The dynamic assignment procedure in VISUM, however, used a stochastic route choice, which had negative effect on the average travel distance and travel times, as some routes may not have been optimal. In contrast to that, the static assignment procedure in VISUM allocated traffic to high-volume links. To conclude, both MATSim and the dynamic assignment procedure gave similar and plausible results, while the static assignment procedure performed worse.

Bibliography

1. Hall, R. *Handbook of Transportation Science*. USA: Kulwer Academic Publishers. 2003.
2. Maerivoet, S. & De Moor, B. *Transportation Planning and Traffic Flow Models*. Submitted in Cornell University Library. 2005.
3. Balmer, M. & Rieser, M. & Meister, K. & Charypar, D. & Lefebvre, N. & Nagel, K. MATSim- T: Architecture and Simulation Times. In: Bazzan, A. L. C. & Klügl F. [eds.] *Multi- Agent Systems for Traffic and Transportation Engineering*. Information Science Reference. Hershey. 2008. P. 57-78.
4. Jovicic, G. *Activity based travel demand modelling – a literature study.* 2001. Note 8. Denmarks TransportForskning.
5. *VISUM 11.5 User manual. PTV Vison.* Karlsruhe: PTV AG. 2011.
6. *MATSim website*. Available at: www.matsim.org.
7. Fourie, P.J. Agent- based transport simulation versus equilibrium assignment for private vehicle traffic in Gauteng. In: *Proceedings of the 29th Southem African Transport Conference "SATC 2010"*. Pretoria. 16-19 August 2010.
8. Gao, W. & Balmer, M. & Miller, E.J. Comparisons between MATSim and EMME/2 on the Greater Toronto and Hamilton Area Network. In: *Proceedings of TRB 89th Annual Meeting*. Washington, D.C. January 10-14 2010.
9. Rieser, M. & Nagel, K. & Beuck, U. & Balmer, M. & Rümenapp J. Truly agent- oriented coupling of an activity- based demand generation with a multi- agent traffic simulation. *Transportation Research Record*. 2007. No 2021. P. 10-17.
10. Wardrop, J.G. Some theoretical aspects of road traffic research. In: *Proceedings of the Institute of Civil Engineers*. 1952. Part II. Vol. 1. P. 325-362.

Received 22.08.2011; accepted in revised form 23.04.2013

[1] Without connectors
[2] Without connectors