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THE SIMULATION ANALYSIS OF THE IMPACT OF INDUCED TRIPS ONTO TRANSPORTATION NETWORK

Introduction

Dynamic development of city substances, observed especially during last decades has strong influence on functional aspects of street network. New living areas, shopping malls or industrial areas are significant traffic generators which imply changes into functioning both public and private transport. Very often existing street network, especially in historical cities, is not prepared for high level of traffic. Those problems refer also to districts which are placed outside the downtown – in the suburbs. Many housing estates are connected with street network through few streets with low technical parameters. It effects on increasing lost time of passengers and drivers, increase operating costs, influence on modal split and decrease level of life in cities. In reply to increasing number of building investments and displacement of travel origins and destinations, city authority are planning and implementing infrastructure investments and heading for modernization and development of public transport system. Those investments usually not follow demands and assumptions of sustainable development policy and results of them can be quantified in proper designing documentation (e.g. feasibility study). However it is necessary to take into consideration strong influence of new infrastructure investments on travel behaviours of inhabitants, especially their mobility. Thanks to the improvements, traffic conditions can generate new trips which were abandoned in previous situation. It is also important to ponder opposite situation: decreasing of street network capacity and connected with it reduced number of trips (e.g. as a result of temporary road works).

1. Induced traffic

Induced traffic forecasting is based on assumption, that increasing supply (caused by development of street network) imply on level of demand. It is the result of time savings generated by increased capacity of connections in the city. When new transportation facility is constructed there can be observed changes in travel behaviour occurring in response to travel time savings which occur after investment. Generated travel time savings (or losses) are perceived as reason of reducing (increasing) travel cost, which imply on number of travels in four ways:

– New trips – trips which were not realized in previous situation due to either high level of congestion or not acceptable travel times by public transport (PT) means.

– Longer trips – reallocation of trip destinations caused by new possibilities of travelling.

– Changes in modal split – as a result of travel time changes for different transport modes.

– Reduced trips – due to impediments in traffic, there is possible that some trips will be abandoned due to e.g. constrained capacity.

In traditional four-step approach induced travelling is omitted: within first step – trip generation – travel time factor is not taken into consideration and this stage is not sensitive to implemented infrastructural changes. However in early 70' on Dresden University it was developed approach which required travel time as an influence factor for trip generation. Nevertheless this model is currently not used. During second step – trip distribution – it is possible to obtain longer trips in comparison to previous situation. Modal split – as a third step – defines relationship between possible modes of transport and has no impact on induced travel. However this stage is affected by changes in travel times and it is possible, that new car trips occurs as the result of passenger shift from PT to private vehicles. Nevertheless it is not induced traffic. In the last stage – traffic assignment – new trips are not generated, but it is only possible to estimate changes in ridership (vehicle – kilometres or vehicle – hours) which is the result of previous steps application.

Because classical approach does not take into consideration induced trips, there was introduced elasticity factor, which defines relationship between new (additional) trips and implemented infrastructural investments. Elasticity values of -0,5 is interpreted to mean, that 10% decrease in travel time will generate 5% increase in traffic. However it is not a constant value – generated traffic has dynamic character: as induced travel occurs, travel speed decrease, and demand for new travel correspondingly diminishes.

2. Questionnaire survey

To investigate the influence of traffic limitations on induced traffic it was conducted questionnaire survey among inhabitants. As a testing ground it was chosen area of two significant living districts in Krakow (Poland), which were affected by refurbishment activities carried on part of internal bypass road. The street was closed for 6 months, and it was the reason of significant impediments in travelling to the city centre – no left turns for private vehicles in the direction of city centre and considerably limitations in PT service. The assumptions were, that ensuing traffic impede could imply changes in travel behaviours of inhabitants in surrounding districts which results in resignation of non-obligatory trips or reallocation of trip destination. To verify how mentioned impediments could affect the possible travel behaviour changes, it was decided to conduct poll survey among inhabitants on PT stops and on parking lots situated inside the affected living districts. In the result it was obtained 326 questionnaires (194 among PT users and 132 among car drivers and passengers).

Among all respondents over 57% were travelling to the city centre every day and 18% 1-2 times a week. The purpose of the trip was mainly work (51%) and school (24%) other purposes have rather scarce share because the questions refers to working day.

Next question refers to transport modes which were used before and after occurred impediments. It will help to estimate influence of changes on modal split.

In the result of traffic restrictions connected with street refurbishment. The share of private cars travelling through affected link has decreased from 35% to 28% - it is not a significant value, but with regard of aversion of drivers not to their cars, it seemed to be important signal that it is possible to influence on private transport share in modal split. Much more decrease can be observed in bus trips. In this case the difference in situations before and after is greater than 12%. The most significant changes affects share of trams – growth with 18% it can be explained, that drivers and bus passengers have changed their modes for the tram.

According to the respondents' answers, main reason of changing mode of transport was shorter travel time in new mode (pointed by 49% of inhabitants) and comfort connection (pointed by 32%).

The most important question refers to trip resignation and its frequency. Over 65% of the respondents have not resigned from their trips to the city centre, but group of users resigning every day or 3 to 4 times a week give 12% of total.

3. Modelling of induced traffic

Main goal of the survey was to model response of the street network on implemented impediments taking into consideration induced traffic. Proposed approach was based rather on reduced travel (due to traffic constrains) than additional one.

The idea of the procedure is to define number of rejected trips based on poll survey and then in simulation model of the city evaluate its impact on ridership. For this purposed it was used simulation model of the Krakow defined in VISUM software. The model is based on results of Comprehensive Travel Study (conducted in Krakow in 2003) and is embedded in traditional four step approach:

I. Trip generation: according to obtained results of Comprehensive Travel Study (CTS), it was possible to define relationship between generated trips and spatial development (described as number of inhabitants, working places etc.) for different purposes of the trip.

II. Trip distribution: the result of this stage is the O-D matrix (origin – destination) showing spatial distribution of generated trips in the city.

III. Modal split: according to results of mobility survey, there was possible to define modal split model for Krakow.

IV. Assignment: it was defined street network model of Krakow (in Visum software), and after applying assignment procedure (Stochastic assignment) it was possible to define traffic volume at links.

Presented procedure was treated as iteration process, repeated several times to obtain better values of relevance (calibration process was based on comparison traffic counts and modelled traffic volumes on selected links in the network – 142 count locations in the city). Moreover it was used calibration procedure in Visum – TFlowFuzzy, which in general, affects both trips generation and OD matrix values.

For the modified OD matrices it was applied assignment analysis in VISUM. In the software it is possible to obtain chosen parameters, which state the base for comparison of scenarios: average speed in the network and ridership (veh.-km).

In the case of average speed in the network in the case of whole city, there can be found minor changes – values are almost the same in comparison with existing situation, especially for reduced matrix. However in the refurbishment influence area, it can be noticed decrease with 6,9% for scenario with constant demand. When matrix is modified, number of trips in the area is smaller than in previous situation, the decrease of average speed is much smaller – 2,5%.

For value of ridership (defined in vehicle-hours) in the whole city, major growth can be seen for scenario with constant demand. In this case modelled impediments affect travel time and the total value of vehicle-hours growth with 1,5% in comparison with existing situation. When demand is reduced, values of ridership are on the same level.

The tendency of changes in ridership in smaller area is different – even for reduced demand, ridership has higher (with 6,3%) value in comparison with scenario before traffic impediments. When constant demand scenario is taken into consideration, it can be noticed significant growth exceeded 17,7%. Considerable increase of ridership is the result of capacity limitations and reorganization of traffic scheme in the refurbishment area.

In presented approach, impact of investment (impediments) was defined not for affected corridor, but for extended area, where traffic limitations have their footprint. Broader analysis define changes in ridership for all vehicles travelling within chosen area, so it can be assumed, that it is possible to define elasticity factor for tested infrastructural changes. Using share of abandoned trips estimated according to questionnaire survey (4,4%) and defined changes in ridership (6,3%), for analysed situation elasticity rate is equal to -0,69.

Conclusions

Induced demand can be treated as new trips generated by improvements of traffic conditions (as a result of new infrastructural investments) but also as reduced trips due to occurred impediments. It must be emphasized, that reduced trips have usual temporary character arouse from e.g. refurbishment activities which affects trip conditions. In both cases estimation of elasticity factor is very difficult and requires poll survey and time savings evaluations (direct measurement or modelling).

Using simulation tools and results of poll survey, it was defined elasticity rate, which in this case refers to reduced demand. The procedure of elasticity rate estimation differs from traditional approach, but it is necessary to emphasize, that proposed way have pilot character and requires further verification.

When comparing simulation results, it is worth to highlight similar values of ridership in basic scenario and reduced demand scenario. It can be put the thesis forward, that street network is in continuous equilibrium state, and implemented infrastructural changes has no significant impact on traffic conditions. Verification of it will be deeply analysed by author in his further work