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The Analysis of Travellers Behaviour in the Upper Silesian Conurbation

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Abstract

Based on the traffic model developed by the authors for the major part of the area of the future Silesia Metropolis (in Poland), the change directions of the public and individual transportation tendencies in the coming few decades are discussed in the paper. The model is relevant to ca. 85% of the analysed area (Silesia Metropolis). All of the twelve cities included in the modelling are the core of the future Silesia Metropolis, i.e. lie within the trans-European corridors or within the direct catchment areas thereof. The basic principles that underlay route choice behaviour of individual travellers (ca. 2 million) in this area, were developed by authors from Silesian University of Technology, Faculty of Transport, Department of Traffic Engineering.

1. The Specifics of the Transportation Systems of Silesia Metropolis

Future Silesia Metropolis[1] will be a communal union of the cities of the Silesian Voivodship located on the territory of the Republic of Poland. The territory of the

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[1] Currently a project of transforming the Upper Silesian Metropolitan Union into a dynamically developing metropolitan entity 'Silesia Metropolis' is underway. Silesia Metropolis is assumed to be capable to effectively compete with other metropolitan centres in Poland and in Europe. Currently the Union is constituted of 14 cities (with city-county status) located within the Silesian-Dabrowa

future metropolis (acronym: SM area) is to a large extent identical with the territory of the former Upper Silesian Industrial District. The metropolis, for which the traffic model has been developed, is a unique urban entity on the territory of Poland. It is inhabited by almost 2.6 million people and together with the neighbouring Rybnik conurbation by over 3.2 million inhabitants [10]. The SM area lies at the crossing of two trans-European transportation corridors: III Dresden-Kiev and VI Gdansk – Bratislava (Fig. 1).

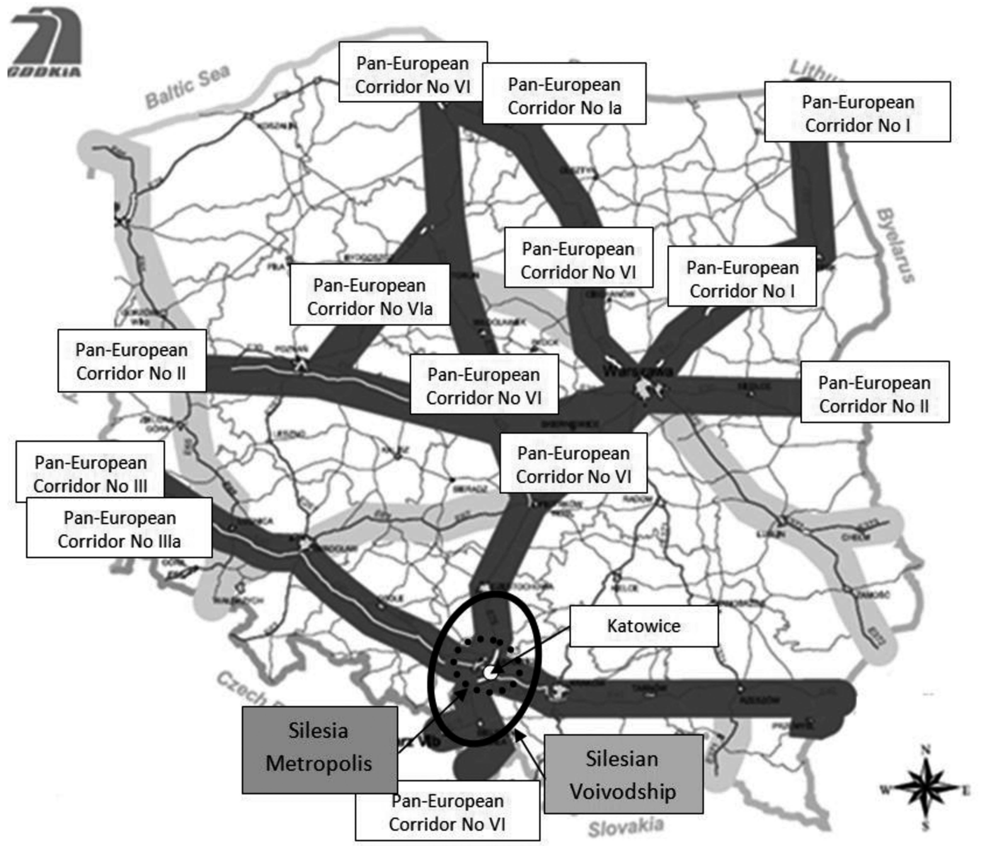

Fig. 1. The Silesia Metropolis location with reference to the Pan-European corridors
Source: [46]

The area between the cities located at the boundaries of the area (Fig. 1) is more than 60 kilometres long (longitudinally) and 90 kilometres wide (along the meridian). The area has a very dense transportation network with permanent congestion occurring in the central of each of 13 city areas (Fig. 2). The specificity

conurbation: Bytom, Chorzów, Dąbrowa Górnicza, Gliwice, Jaworzno, Katowice, Mysłowice, Piekary Śląskie, Ruda Śląska, Siemianowice Śląskie, Sosnowiec, Świętochłowice, Zabrze and Tychy.

of the modelled area is even higher due to the fact of several dozen cities being adjacent to each other (polycentric metropolis). This fact multiplies the complexity of the analyses of traffic flows in this highly non-typical area. The analysed area does not have an ATCS system (Advanced Traffic Control Systems). Intelligent transport systems (ITS) are the margins of technical equipment of control systems. Also

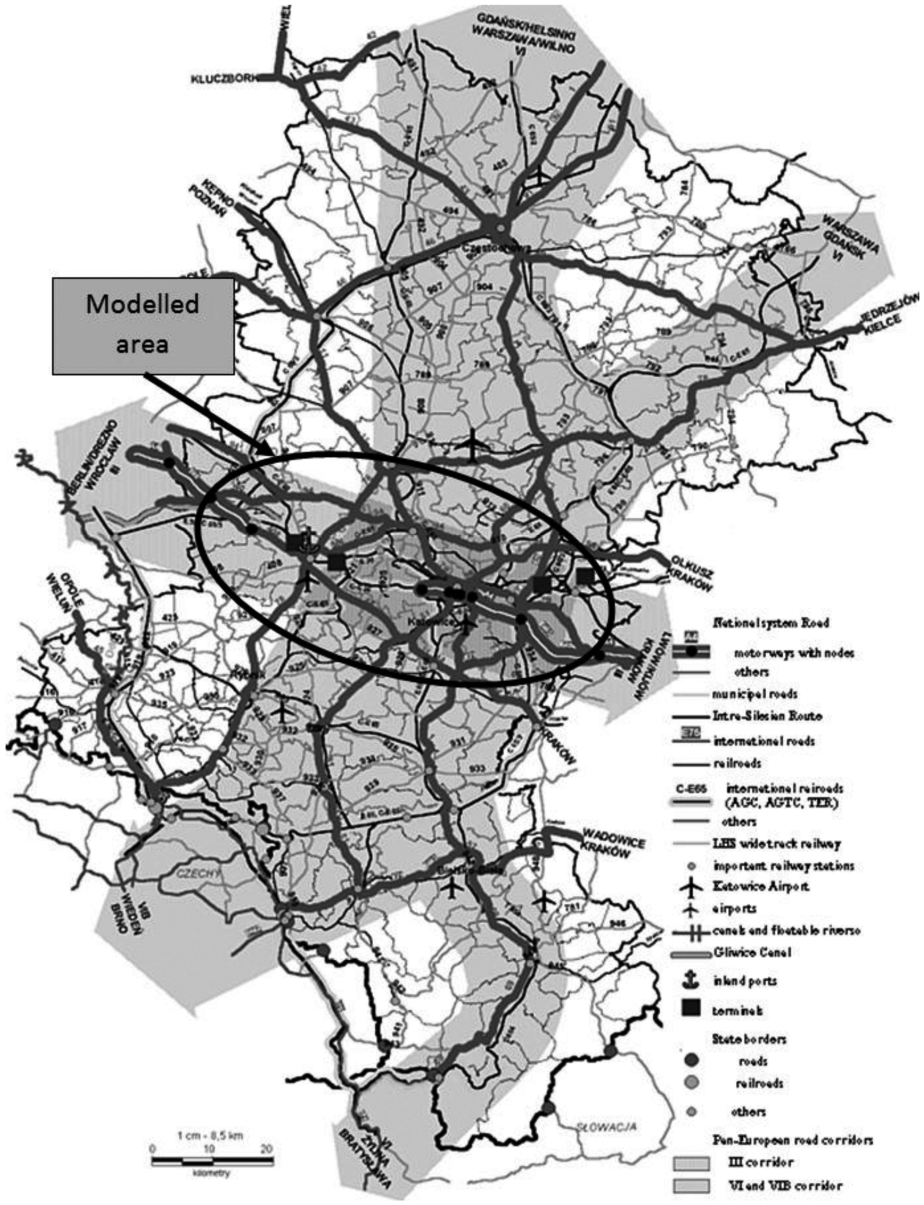

Fig. 2. The transportation system of the Silesian Voivodship
Source: [31]

average number of intersections equipped with traffic lights is only about 20% in major cities compared to 50%. The largest city in the region (Katowice) has a population of over 300,000 inhabitants. The number of registered passenger cars is 230,000. Length of the road network of more than 600 kilometres. Most of the cities in the area have similar parameters of transportation network.

The scale of transportation policy related problems of this area and in particular of those concerning the structuring of the transportation offer in public transportation, road traffic management and the implementation of the area traffic control systems, can only be compared with the largest European conurbations or metropolis: Paris, Moscow, London, Berlin and the Ruhr. As far as Poland is concerned the scale of the problems is comparable only with that of Warsaw (population ca. 1.8 million) area while its complexity is incomparable to any other in Poland.

2. The Essence of Traffic Modelling in Dense Transportation Networks

The topic of structuring the transportation policy over a number of diversified areas with various proposed service models, of operational quality improvement, trends and indicators is widely reported in the literature due to its complexity and multidimensional character [2], [5], [19],[44], [47], [48]. One of the most important topics allowing the right selection of a transportation system development model is the traffic model. Proper modelling in the road-street network requires applying a four-level (stage) traffic model (4SM, FSM) composed of the following stages [24], [25], [27], [28] (Fig. 3):

– Stage 1 – trip generation,
– Stage 2 – trip spatial distribution,
– Stage 3 – mode choice/modal split,
– Stage 4 – traffic assignment (route choice).

The traffic model obtained as a result of the analyses performed should reflect as accurately as possible the real conditions of the transportation system in the researched area. The main objectives of the construction of every traffic model are:

– obtaining the information on the traveller behaviour of the inhabitants of the researched area and its vicinity;
– collection of data on traffic flows in individual and public transportation;
– determination of the preferences and rating of the transportation system by the inhabitants;
– building the traffic models for public and individual transportation as for the current state.

The basic relation between activity patterns and the transportation system is a major concern for traffic modelling procedures. The construction of FSM (four step traffic model) are based on four elementary procedures: trip generation procedure,

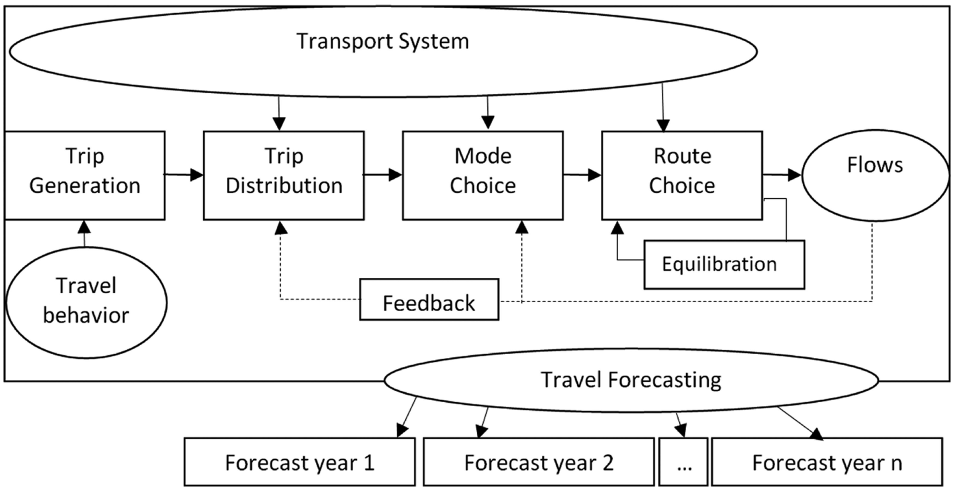

Fig. 3. Definition of the four step traffic model
Source: [24]

trip distribution, mode choice (modal split) and trip assignment [1], [3], [13], [23], [25], [37], [45]. First step in the FSM modelling process is a basic trip generation procedure. Generation procedure assumes that the person activity in each particular zone directly results in the numbers of trips between each of these. First step in FSM concerns the determination two sets of values what are called productions and attractions (or generations and absorptions). A trip end/start that is produced in a origin zone is called a production (generation). A trip end/start that is attracted to a destination zone is called an attraction (absorption). Each particular zone of the transportation network can be characterised (determined) in this way with the use only of two variables parameters (numbers): production and attraction. The rules for whether a trip end is maybe called a attraction or production is simply based on two particular cases. A home-based (HB) trip is generated (produced) at the home and absorbed (attracted) to the non-home (NH) end. Production and attraction terminology rules directly regardless of the direction of travel. A non-home trip is generated at the origin of the trip (non-home) and attracted to the destination of the trip (also non-home, there is no home in transportation process). The own research study [19] include set of equations (assigned to motivation) is used to obtain the number of trips generated by and absorbed to each area zone. These equation are based on area (in each zone) residential, employment, clients and many more characteristics (with NUTS- Nomenclature of Units for Territorial Statistics or GUS – Central Statistical Polish Office specification) [15][14]. These estimates rely on the actual or projected employment and others parameters in the zone to estimate how many workers, students, pupils and clients it attracts. The more shoppers, pupils, students, employment a zone has, the more shopping, education, work trips it attracts. This is analogous to the law of gravitational attraction in physics. A home-based trip, regardless to other start/end of trip are: home-based work (HBW), home-based-school (HBS), home-based other (HBO). (see: Fig. 11.) [23], [24], [45].

In step two, the whole number of generated and absorbed trip (productions and attractions) for all defined zones in the transportation network are geographically spread into complete trips, from an "generator" zone to a "absorbent" zone. For example, the school trip ends generated by a zone in Katowice Ligota suburban area, are matched with the school trip ends absorbed by other any zones throughout the SM region. When example trip ends are linked to create complete trips (from point to point at this area). The trip ends spread may occur within the same zone (inner zone trip), or between zones that are some distance apart, such as a zone in Gliwice and a zone in Dabrowa Górnicza, outer zone trips (40 kilometres) or adjacent zones (e.g. Katowice Ligota, Katowice Brynów, 2 kilometres). The same "ends" spread procedure is consequently used to linked all of the trip ends generated in SM area or absorbent to various zones in the analysed SM area into particular trips. The final result of step two is then the construction of a origin-destination matrix (OD). In such an OD, an element $[od]_{ij}$ denotes the whole number of trips departing from origin zone O_i (trip generator) and arriving in destination zone D_j (trip absorbent) [24]. In the SM area case, the same kind of travel impedance functions are used in combination with an adjusted gravity model. For more information the reader is referred to [19] since the entire development includes nearly 1000 pages.

The third step of the FSM modelling process is known as mode choice (AKA modal split). The mode choice in work [19] sub model includes motorized person and pedestrian trips. The model includes all auto modes (ride i-person in one car) and three transit modes (tramway, mode of interest in the work [19]), public bus, heavy rail). Simply say OD table obtained from step two, is now divided over the supported transportation modes in all SM area (main public transport operators: KZK GOP, PKM Tychy, PKP PR, Koleje Śląskie, Tramwaje Śląskie and many others).

The four and last step known as trip assignment is to determine the routes travellers choose to reach their destinations with chosen mode and finally path (travellers behaviour). In this work not only motorized person trips are assigned. OD matrix includes all trips made by pedestrian, car and public transport.

The current model was built on the basis of statistical data from over 20 000 traveller behaviour survey.

The traffic model developed in the Department of Traffic Engineering of the Faculty of Transportation of the Silesian Technical University may be used not only by the institutions responsible for transportation management but also by a range of commercial companies. It also can be useful for the road system analysis and management projects and for the decision making process concerning the public transportation planning. It allows as well forecasting and analyzing the traffic in the context of the transportation system development planning and design. This traffic model was built for the base year 2008 (and provided with the update data for 2009) taking into account the traffic forecasts for years 2013, 2018, 2023, 2028, 2033, 2038 and 2043 (five years horizon intervals). Forecasts for the model exclude structural investment in transport infrastructure planned for the forecast horizons in SM area (all know changes). Also model contains detailed economic and demographic forecasts produced by social research labs [19]. This makes this model original for the target SM area and similar agglomerations and metropolis (polycentric).

Nowadays most modern citizens in SM area have a completely different behaviour than their former counterparts at the end of the 20th century. In 1989, Poland has undergone a political transformation from a socialist to a capitalist economy. Recognising these very radical changes in the development (suburbanisation process, generators and absorbent allocations, unemployment etc.) approach the integration of an activity system from a completely different perspective. In our model demographic changes, shifts of the economic activities and much more other characteristics (including traffic) was taken into account (some kind of land-use models) [32].

The activities in SM area (polycentric metropolis) related to working, educational, living, recreation and other appear to occur at substantially different spatial locations (ca. 1000 square kilometres). Furthermore, most urban zones in these area are composed of unique generators and absorbents allocations (dense networks), among other things leading to the geographical aspect of a zones gets more important. In this aspect conducted research work in the field land-use models based on the characteristics of the survey [19]. Discussion of these issues beyond the scope of this article.

3. Traffic Model for the Purposes of Forecasting the Traveller Behaviour in Silesia Metropolis

In order to build the traffic model for the future Silesia Metropolis the data on the relocations of inhabitants as well as the socio-demographic data were taken into account. The data included the statistical information concerning the traffic generators in the analysed area, and the traffic generation and absorption equations were defined for the previously distinguished several hundred transportation zones [19]. The next step was building the traffic model for the area, according to the presented previously FSM methodology. The following operations were performed in a sequence: travel generation in the analysed SM area, traffic distribution between the attraction locations and productions, travel distribution between the means of transportation (modal split), travel relations selection taking into account the qualitative and spatial features of the modelled road network (classical approach) [30]. The modelled road network on SM area as for the current state is shown in Figure 4.

The next stage of building of the network model concerned the distribution of travel between the means of transportation. For this purpose a distinction was made between pedestrian and other travel, according to the predefined criteria. In the next

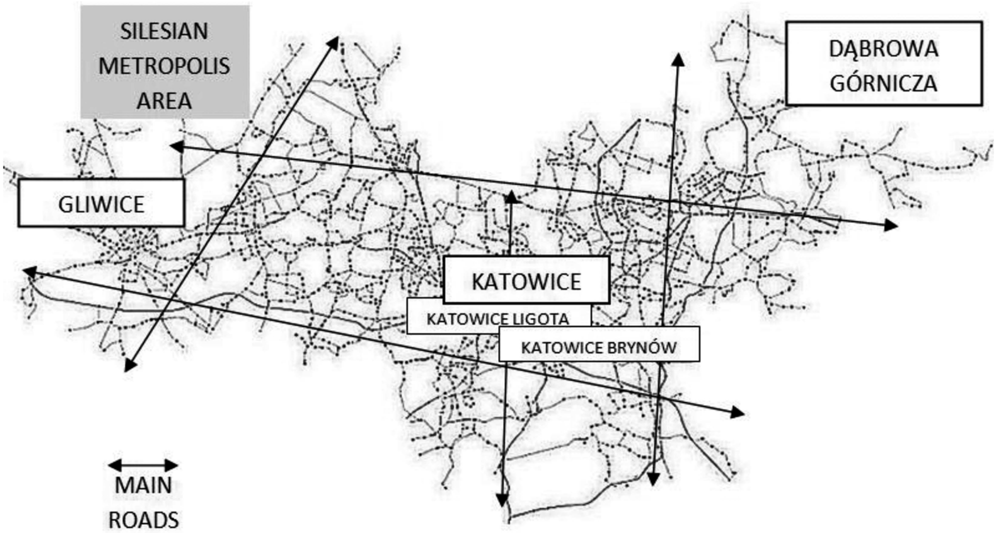

Fig. 4. Modelled transportation network
Source: [19]

step, the other travel (non-pedestrian) was subdivided according to the criterion of utilized means of transportation (both public and individual). The travel by public transportation was then subdivided into travel by train (not LTR), bus and tramway. The division into pedestrian and non-pedestrian travel was performed according to the formula [6], [19]:

$$U_{NP_{ij}}(t_{ij}) = a + b\frac{\exp(c \cdot (t_{ij} - d)}{e + \exp(c \cdot (t_{ij} - d)} \tag{1}$$

where:

$U_{NP_{ij}}(t_{ij})$ – the share of non-pedestrian travel between areas: i, j [−],

a, b, c, d, e – model parameters [-],

t_{ij} – time matrix of inter zone travel [h].

The values of the parameters *a, b, c, d, e* were calculated by comparing the modelled function (1) with the representative sample data as provided in (real traveller behaviour, sample over 3.200 pedestrian trip) [35]. The match of the empirical data and the model function (1) was performed using least squares method. The determined values of the parameters correspond to the best fit match of the empirical function of non-pedestrian travel to the chosen modelled data. The number of non-pedestrian travel calculated in this way was then subdivided into the travel utilising public and non-public transportation, using the following equation, For more information the reader is referred to [19].

$$U_{KI} = W_m \times W_g \times W_w \times W_n/(100 \times W_p) \tag{2}$$

where:

U_{KI} – the share of travel using individual transportation in the non-pedestrian travel [-],

W_m – the motoring index (number of vehicles per 1000 inhabitants), chosen according to [10], [35],

W_g – technical availability index (0.95 %), [%],

W_w – passenger car selection index (1.25 [-]), [-],

W_n – passenger car fill-up index [-], selected as per [7],

W_p – employed traveller index [-], selected as per [10].

The passenger car fill-up index W_n was assumed to be 1.25 [7], [19]. A decreasing tendency for this parameter over the past few years should be noted: 20 years ago the value of the index was 11% higher than today. The assumption as to the value of this parameter has consequences in the subdivision of travel between individual and public transportation and further in the activities planned within the transportation policy for the analysed region. The number of travels by public transportation can be automatically derived as a complement of the percentage of travel by individual transportation to 100%. The subdivision of travel into pedestrian and non-pedestrian was performed with the following passenger motivation categories included:

– home-work-home (HWH) or home-based work (HBW),
– home-school-home (HSH) or home-based school (HBS),
– home-other-home (HOH) or home-based other (HBO),
– non-home related (NH).

The calculated mean share values for pedestrian and non-pedestrian travel per individual motivation categories are shown in Table 1 and in Figure 5. For more information the reader is referred to [19].

Table 1

Mean share values for pedestrian and non-pedestrian travel per individual motivation

Motivation / **Travel**	**HWH**	**HSH**	**HOH**	**NH**	**General mean values**
1	2	3	4	5	6
Pedestrian	0.156300	0.483000	0.391500	0.09600	0.160950
Non pedestrian	0.843700	0.517000	0.608500	0.90400	0.718300
By transportation:					
individual	0.533918	0.145500	0.523044	0.69265	0.473778
public	0.466082	0.854500	0.476955	0.30734	0.526219

Source: [19].

The research of the Department of Traffic Engineering [19], [20] indicates a slight domination of the travel using the public transportation in non-pedestrian travel (Table 1 column 6). However, the traffic forecasts assuming the further growth of the motoring index show the emerging domination of individual transportation over the travel using public means of transportation.

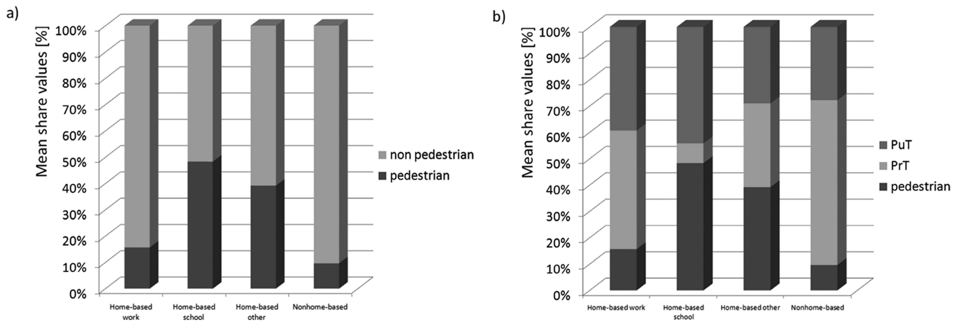

Fig. 5. Mean share values per individual motivation
Source: Own research based on [6], [19]

The performed analyses prove that non-pedestrian travel dominates in the area concerned. The pedestrian travel share is considerably high for the motivation categories HSH and HOH, in accordance with previous observations and expectations. In the HSH category the travellers usually have limited access to the individual means of transportation (due to economic conditions) while the HOH type travel is most often performed over a small distance, hence again the preference of pedestrian travel. For more information the reader is referred to [19].

Figure 6 shows the shares of non-pedestrian travel calculated according to the model (1), taking into account the travel duration and the motivations. As opposed to other used models, the used variable was not travel distance but travel duration. Such an approach allows incorporating the travel duration in the traffic model as an important qualitative factor dependent on the parameters of the modelled transportation network. The travelled distance, in turn, apart from the cases of traffic reorganisation, is a constant parameter. In infrastructural projects the time gain is one of the main measures that help deciding about the project launch. Also, the described approach allows in the future the development of dynamic traffic models with the characteristics variable in time. In such cases, the traffic models could potentially be directly implemented in the area traffic control systems.

The inhabitant mobility index is defined as the number of travels per inhabitant per day. Figure 7 shows the inhabitant mobility index values per individual travel motivations. Average mobility, taking into account the travels within and outside the analysed area, both in pedestrian and non-pedestrian categories, was 1.84 travels/day. From the model it stems that the highest mobility is characteristic of the professionally active people and the travellers with HOH motivation (Fig. 7). The lowest mobility is that of the students, pupils and people travelling with NH motivation.

Figure 8 shows the mobility index of the inhabitants of future Silesia Metropolis compared to the index values for other European countries. One may note that the mobility of the inhabitants of the future metropolis is lower than that of the so-called 'old Union' citizens. This fact results from a number of factors, mainly of the motoring levels and the professional activity levels and economic conditions.

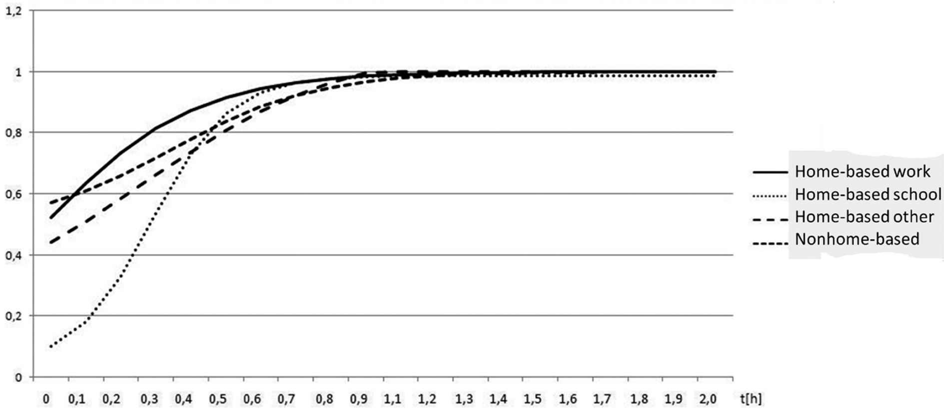

Fig. 6. The non-pedestrian traffic share. *Unp* – non-pedestrian travel share [-]
Source: Own research based on: [6], [19]

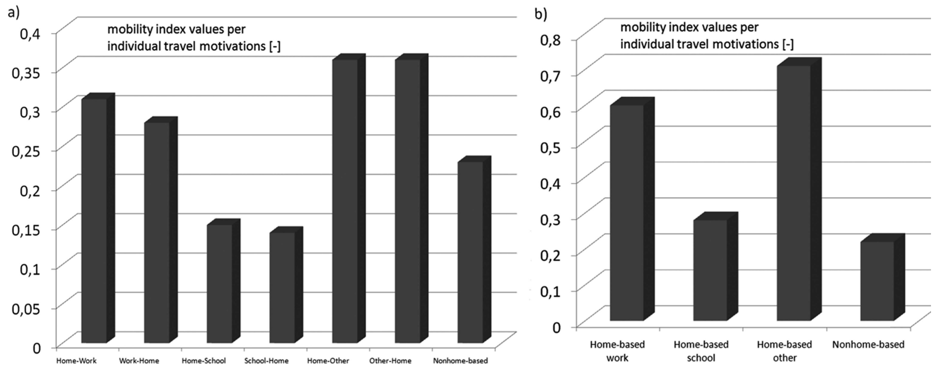

Fig. 7. The inhabitant's mobility index per travel motivations (a) separately (b) aggregated
Source: Own research based on: [6], [19]

However, the differences in the number of travels in the individual countries are also related to the mean travelled distance and the mean travel time, as shown in Figure 9. While the average travel duration (48 minutes in the analysed area) is not much different from the respective values for the EU countries, the average travel distance is much smaller than in Europe.

Figure 11 shows average mobility as calculated using the selected national traffic models (selected models from calculated in past ten years in Poland) and the model derived for the Silesia Metropolis (for more information the reader is referred to [19]). The mobility of the inhabitants of the analysed region is similar to those of other Polish cities (Leszno, Olsztyn, Zgierz, Łódź). The conclusion is that the location of the conurbation at the crossing of two trans-European transportation

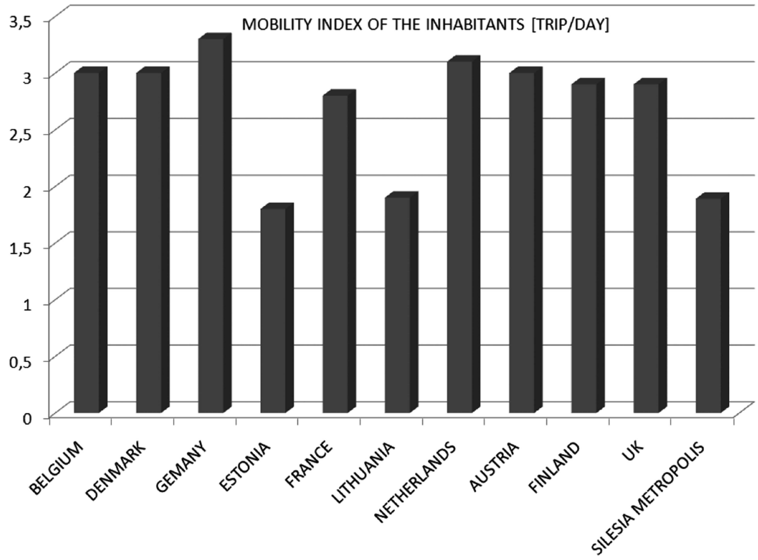

Fig. 8. Mobility index of the inhabitants of Silesia Metropolis compared with other EU countries
Source: Based on [9]

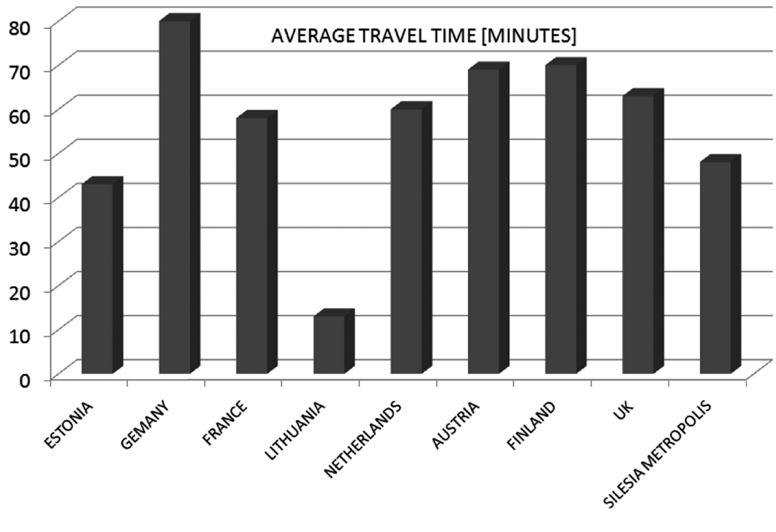

Fig. 9. Travel parameters for selected European countries average travel time
Source: Based on [9], [19]

corridors has little effect on the average mobility of its citizens, which requires further investigation.

The traffic variability patterns in highly congested areas are reflected also in the analysed region. In the area of the future Metropolis, the morning and afternoon traffic peak values tend to equalize and spread into uniform distributions in a day

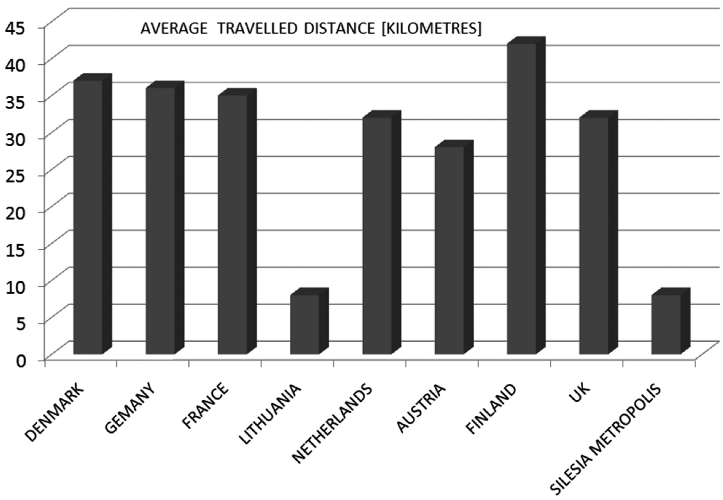

Fig. 10. Travel parameters for selected European countries average travelled distance
Source: Based on [9], [19]

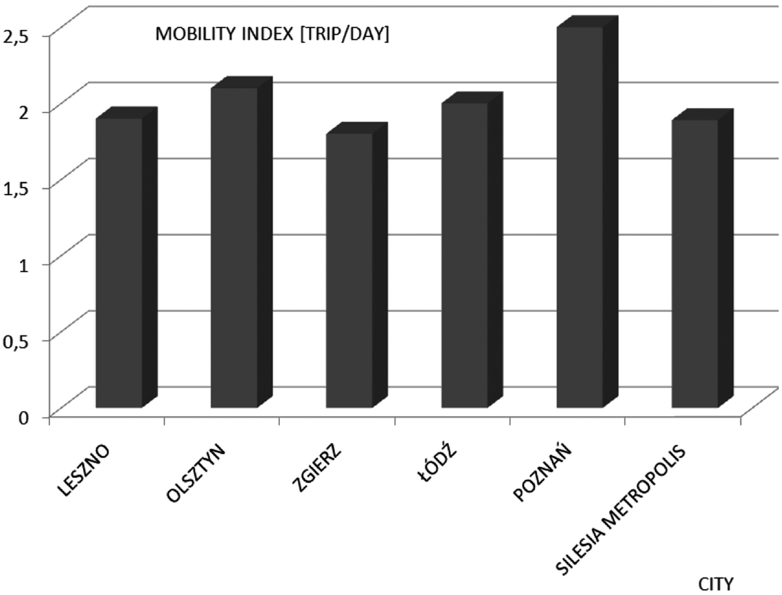

Fig. 11. The mobility of the inhabitants of Silesia Metropolis compared with other Polish cities
Source: Own research based on models [11], [12], [19], [36], [42]

(in congested zones). As shown in Figure 12 the volume in the morning peak were higher than those of the afternoon peak (mainly due to HSH). At the same time, as expected, the morning peak duration is shorter (7 till 9 AM) while the afternoon peak is extended in time and covers the hours from 12 noon till 5:30 PM. As expected, for an area with high congestion, in the period between traffic peaks the traffic is uniform and the volume is at the level of above 50% daily average. Further increase in the congestion will result in more reduction of the differences between the morning and afternoon peaks. As per the individual motivations the tendency for the share of travel in the morning peak to increase is even more visible in case of the motivation HWH and HSH.

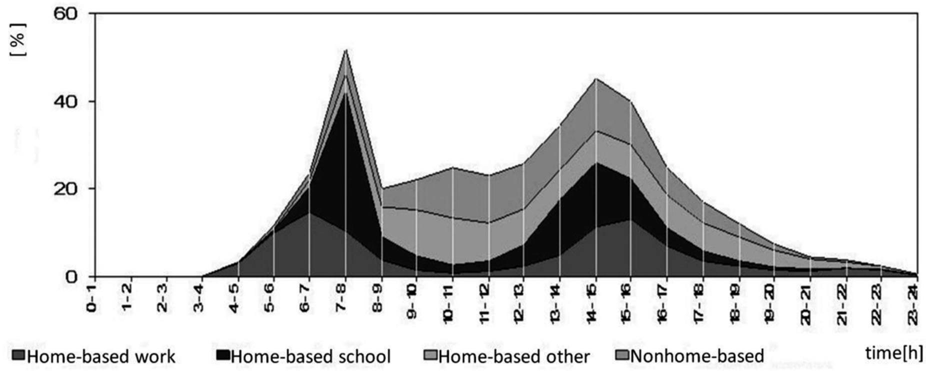

Fig. 12. Distribution of traffic in the future Silesia Metropolis, per individual travel motivations
Source: Own research based on [19]

Based on the data obtained from the traffic models, the shares of travel by individual means of transportation in public transportation were determined. Assuming the daily traffic (utilizing bus as the means of transportation) as 100%, the other traffic shares were calculated as: tramway: 24.14% and train: 7.33%. For more information the reader is referred to [19].

4. Traffic Forecasts for Silesia Metropolis

The existing transportation tendencies are illustrated by the forecasts calculated for the years 2013-2043 according to the cycles proposed in [30]. The forecasts were prepared with 2008 taken as reference year (partly 2009), in 5 scenarios. The base scenario (W0) assumed no investment and no changes to the existing road, tramway or train network. In the other scenarios (W1–W4) the investments planned for the coming years were taken into account (probability of delivering the investment and the year of completion). Figure 13 illustrates average tendencies for the traffic volumes in the area modelled. The reductions are presented separately for public and individual transportation.

The reductions were averaged across individual scenarios due to the continuous reduction in traffic volume over the forecasting period (in all socio-economic and industrial scenarios). The analysis took into account both planned investment projects as well as infrastructure reduction activities such as tramway lines shut downs. The

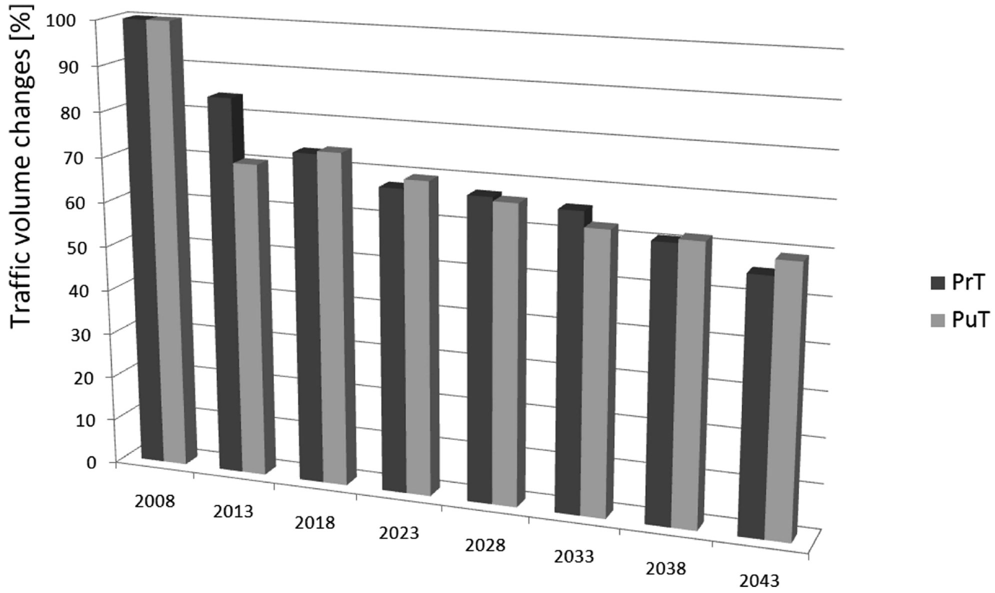

Fig. 13. Traffic volume changes in the analysed region, forecast years: 2008–2043
Source: Own research based on [6], [19]

general tendency both in public and individual transportation is decreasing, due to the dramatic demographic forecast for years 2013-2043 [18], [34]. The reader interested in the details of individual scenarios W1–W4, refer to the [19].

It may be expected that this spectacular decrease will be accompanied by a further increase of the motoring index as well as by the increase in mobility of the citizens in the area. The data of the Local Authority Analyses System (SAS) indicate the number of vehicles per 1000 inhabitants as 400 (in 2009, over 420 in 2012). The value is by ca. 20% lower than in Germany, however as indicated in [10] the index value for Poland does not have to be directly correlated with the income of the population. Similarly, the mobility in Poland is by 35%÷40% lower than in more developed EU countries (the so-called 'old EU'). The 26% decrease in the passenger transportation volumes (traffic forecast in [19]) in non-pedestrian transportation should be to some degree compensated by the increase of the motoring index and the increase of the mobility of the inhabitants.

5. Future Research

In the next few years, we illustrate how all change social, economical, and cultural activities with the upcoming field of activity-based transportation planning may be obtained. At present at The Silesian University of Technology, Faculty of Transport, Department of Traffic Engineering develop work is carried out to identify traveller behaviour with the usage GSM and GPS technology. Modern technologies, such as GSM, WiFi, CVC, OBU and GPS create new realistic in close horizon opportunities of reaching the ultimate goal of sustainable transportation. This is achieved, among others, by provision of the information on the relocations and moves across e.g. GSM networks (location update procedure, RSS fingerprint etc.). The GSM technology (often also supported by aGPS technology) allows locating the individual vehicles of the urban public and individual transportation currently being on the route. It allows, among other [39]:

- to determine the main traffic flows in the city (from the perspective of relocations); it can therefore support the urban public transportation at selected routes, for example by increasing the frequency of operation (appropriate changes in the timetable),
- to identify the routes in the network which have not been considered so far as appropriate to open new public transportation lines (based on 3D space trip distribution),
- to estimate the particularly high intensity of relocations on specific routes (source-destination relations) at specific times; this allows to make the operation of the urban public transportation more efficient.

Central to our work was the obtain 3D space-time paths of all (or close to all population) individuals' activity and traveller behaviour [43].

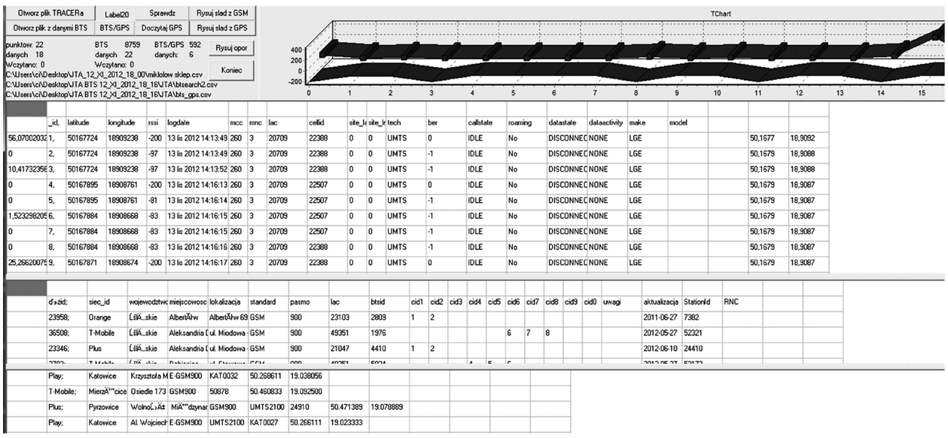

Fig. 14. Own software for estimation traveller behaviours via GSM and GPS
Source: Own research

6. Conclusions and Final Comments

Based on the traffic model developed by the current authors and on the discussion provided, the following conclusions can be drawn:

– The values of the motoring index and of the citizens' mobility index in the analysed area are lower than in other European countries (respectively 400-500 vehicles per 1000 inhabitants and 1.8 to 3.0).

– As the values of the motoring factor and of the inhabitants mobility factor in the analysed area are forecast to further grow, these changes are likely to at least balance off the decreasing tendencies of the traffic volumes in the analysed area in the coming years.

– The traffic congestion problem in the city centres of the future Metropolis remains still unresolved. Katowice has a route characterized by the largest movement in the whole country over 150 000 vehicles on the road at day. Traffic congestion often cover an area in Katowice of 25-30 square kilometres.

– One of the solutions to the problem, alongside with the development and upgrading of the transportation infrastructure is the development and implementation of an integrated advanced area traffic control system (ATCS). This area is one of the last large areas in Poland without such a system. The concepts of such a system for the future metropolis were described in [22], [49]. At the moment, the ITS system is prepared for the study area. Overall, a significant part of the area of analysis is equipped with outdated traffic control systems.

– The analysed area has a well developed rail transportation system. This fact is not reflected in the shares in the transportation volumes of the individual means of transportation. The 5% share (of all passengers) of railway transportation in all of passenger runs does not reflect the potential of this means of transportation, similarly as it is in the case of tramways (where the share in passenger transportation is at the level of 18%). At the moment the tramway network is constantly growing and modernized thanks to a grant of the European Union. Amount of project is ca. 220 million €. It needs to be stressed that the number of transportation runs by individual transportation will limit the development of volumes in public transportation. A solution to the problem could be the introduction on the territory of the Silesia Metropolis a policy supporting the sustainable development in the area of metropolitan transportation system. This can be achieved for example by increasing the attractiveness of public transportation, by convincing the travellers to resign from using private transportation means (such as private cars) and switching to public transportation or bicycles [16], [17]. Traveller behaviour should become the main axis of the activities in the field of transportation policy in selected area.

– Currently planned Park&Ride type systems (e.g. in Katowice Bogucice) should be complemented by the solutions ensuring higher priority for the public transportation. This can be achieved by applying the right instruments of the transportation policy as well as by technological solutions (priority signalling for public transportation, bus lanes etc.) At present the easiest solution would certainly be the implementation of legal and organizational restrictions aimed at the reduction of the individual transportation volumes.

– Ex post forecast errors statistics will be used in future to assess the accuracy of predicting as the results of comparisons of past predictions have already known the true values of the projected size (respectively in horizon years).

– Further economic development of the region generates the need for regular studies aimed at updating the current traffic model.

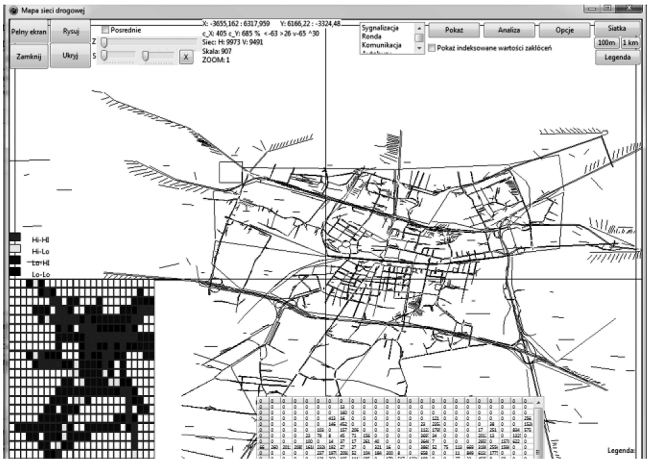

Fig. 15. Micro simulation model for Katowice
Source: Own research [21]

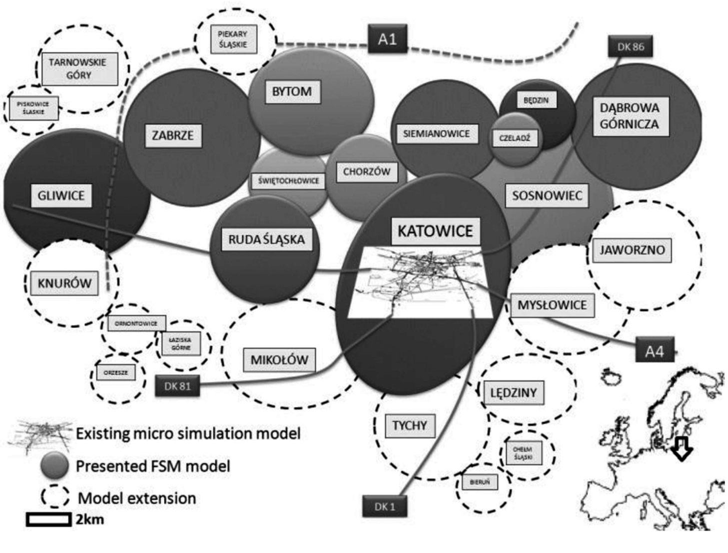

Fig. 16. SUT FSM and micro simulation model for SM area
Source: Own research [21]

This above conclusion is all important in view of the dedication in 2013 of two key infrastructural linear investment: A1 motorway (from north to south) and S69 expressway (from NE-SW). It should be expected that both of these investments have a significant change in the traffic picture of the SM area. It should be expected that dynamics of changes in the OD regional matrix will continue to grow with each passing year. In addition, the Silesian University of Technology, Faculty of Transport, Department of Traffic Engineering had software: an accurate model of traffic micro simulation largest city in the region Katowice, which is a one of key node in Polish transportation network (Fig. 15), [21].

FSM model presented in this paper are produced for all 12 cities in the SM area. The plan is to implement 11 micro simulation models for each of these cities (Katowice has a model). This approach will create a two-layer structure of the hybrid macro-micro transportation network simulation (Fig. 16). This division allows mutual calibration and validation of the both models at the flows and streams level. The idea is to allow the efficient management of the SM area transportation network.

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