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METHODOLOGICAL ASPECTS OF MICROSCOPIC MODEL APPLICATION AS A PART OF DECISION SUPPORT SYSTEM

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At present the microscopic models are used in decision support system (DSS) for urban transportation system (UTS) planning and development less frequently than macroscopic models. The main reason of that is complexity of microscopic model (MM) creation, actualization and application. Also its application entails the additional requirements to the data: the range of data is wider and they require additional attention to their relevance, credibility and quality. The analysis of information sources demonstrated the lack of recommendations for mentioned problems solving. In this paper the methodological aspects of MM application as a part of the model-driven DSS are considered. The attention is paid on the requirements formulation to the data needed for microscopic model application; the supporting of data credibility needed for the microscopic model application as a part of the DSS; the general procedure of the decision making on the base of the microscopic model.

Keywords: microscopic modelling, decision support system, credibility of decision, calibration and validation

Introduction

Planning and management of UTS structure should have a comprehensive systematic nature at all levels of decision making: beginning from the development of the regulatory framework and strategy of the city development, the long-term development plan for the UTS and ending by the operational management, and monitoring of the current situation. Usually, according to the UTS planning and development the mixed-type of decision making is used. The implementation of this approach requires the use of modern technology and modelling, use of various kinds of data and information [1, 2]. It requires continuous monitoring of UTS state, data collection, processing and analysis; playback scenarios of development and estimation of possible solutions. This style of management is complex and requires information support. That's why the implementation of information support in decision making process involves the decision support system development (DSS). Considering the mixed-type of decision making application the DSS should support the simulation models application for the current scenario of UTS functioning analysis, for the prediction of future state of UTS without changing, for different scenario analysis for UTS fragments functioning improvement. The experience review of DSS application for UTS development planning showed that usually the macroscopic modelling approach is used [3-6]. Despite the fact that microscopic models application gives more opportunities in detailed and comprehensive analysis it is used in DSS less frequently. The main reason of that is complexity of MM creation, actualization and application. Also its application entails the additional requirements to the data: the range of data is wider and they require additional attention to their relevance, credibility and quality. The analysis of information sources demonstrated the lack of recommendations for solving of the mentioned problems.

The methodology of MM application as a part of the model-driven DSS was proposed by the author in the doctoral thesis. In particular the attention was paid to the problem of data obsolescence in the DSS databases and necessary of its actualization. In the paper is presented some results of research: the put forwarded requirements to the data and some methodological aspects of the models application as a part of DSS from the point of view of data actualization.

1. Requirements to the Data Needed for MM Application as a Part of DSS and Procedures that should be Supported by DSS

Considering the MM application as a part of DSS it is necessary to define the requirements to the data that is needed for MM creation, calibration and application. The data has been given special attention, because the data quality is the cornerstone of the quality of model. The adequacy of decisions depends on the validity of simulation results. Relevant and correct data is needed for model formalization, calibration and validation, so that we can have meaningful and credible simulation results.

First of all, it is necessary to define the data and information that should be stored in the DSS data bases and knowledge bases. The list of data depends on the structure of UTS MM that includes the model of the transportation network and its infrastructure, the model of public transport network, the microscopic model of drivers' behaviour, the model of traffic routing, the model for assessment of the impact on the environment, the model of the demand on transportation of inhabitants that used the public transport and private vehicles. So the following groups of data and information are used:

- Data about road network geometry, its properties and attributes, the parameters of intersection functioning;
- Information about the public motor vehicle fleet, public transport lines and schedule;
- Information about private vehicles, cargo and pedestrians traffic flows: properties, structure, OD-matrices, information on traffic allocation to routes at the crossroads (in case of static routing);
- Information about the demand for transportation/movements and the proposed possibility of routing to the destination point (in case of dynamic routing).

Also, the following data are needed for the calibration and validation procedures that are the important stages of MM creation and using:

- Aggregated data: the characteristics of queues (mean and maximum value of queuing delay, average and maximum value of queue length), the journey time (measured average value of journey time of vehicles from one UTS point to another), the density of traffic flow on the network fragments, the amount of traffic on certain fragments of the transportation network;
- Disaggregated data: the car following trajectory, the vehicles speed trajectory.

Secondly, considering the aspects of data collecting, preparing, storing and using in DSS the requirements to it are necessary to formulate: the data should satisfy the homogeneity, relevancy, and actuality requirements. Since it is not possible to employ rough measurements for modelling directly – processing and analysis of measured data in parallel with the modelling process is required. From this point of view, DSS should provide the relevant procedures of data processing and analysis.

The typical problems working with data: the data missing, outliers, data heterogeneity. To eliminate the problem of data missing, the DSS should provide for well-known statistical techniques for replacing the missing observations by the mean values estimation, by the regression model's predicted values, etc. Any outliers in the data may lead to biased estimations of the average values and wrong conclusions. The outliers may be due to operator errors made during the data entry, those made when fixing the results of surveys and monitoring the system, and due to technical hardware failures. In the DSS, special partially automated procedures should be provided for preliminary statistical analysis needed to distinguish outliers (graphical analysis, tests) and exclude them.

The special attention should be paid to the data homogeneity. The following may be determined as the causes for heterogeneity of data samples:

- time shift during the data collection,
- violation of a unique data collection methodology by the survey process participants,
- UTS behaviour changing during the data collection;
- Data using form different databases and information sources.

In order to reduce the possibility of non-uniform sampling of numerical values of the system parameters, the following recommendations were formulated:

- According the data collection:
  - the start and the end of data collection should be harmonized with all participants of the data collection process;
  - use a common methodology and educate the participants of data collection process,
  - when planning data collection it is necessary to take into account possible changes in the organization of traffic flow on the specific fragment of the transportation network. Data collection should not be conducted if a repair work, temporary change of traffic light cycle or organization of various events is scheduled;
- According the different databases using: to check the samples homogeneity before organizing them into one sample.

The relevant procedures should be provided in DSS.

2. Requirements to the Model-Driven DSS Based on UTS MM Using

The main tasks of DSS are the following:

- provision of storing and access to the data required for UTS planning and control tasks;
- knowledge storing in knowledge bases and providing access to it;

- models storing in the model repositories and organizing access to them;
- ensuring the user interface to provide for data input by users;
- ensuring manipulation with the models and data;
- presentation of the output results in graphic and textual forms or in the form of generalized reports.

DSS usage means the inclusion of partial automation into the working with model, so it is necessary to provide automated access to data at different stages of the process. If MM is used as a constituent part of DSS, it is well to bear in mind that DSS should support the processes of preliminary project planning (modelling of UTS section), organization of additional data collection, UTS section model development, MM aggregated and disaggregated sensitivity analysis, its calibration and validation, estimation of measures of performance and goodness of fit, planning and execution of a number of experiments. The procedures of data collection, statistics pre-processing and processing; assessment of models running and measurement of efficiency, carrying out comparative analysis; data and simulation results representation in a user-friendly format should be automated.

A separate task is the arrangement of processing and storage of data necessary at all stages of model implementation. Data can be stored in decentralized databases of data owners or in DSS centralized databases. In case of decentralized storage, DSS should have access to the repositories of external databases for the extraction of relevant data and support of either the relevant format of data or procedures for data conversion into the relevant format. Moreover, the timely data updating procedures should be established in DSS in case of actual UTS changing. Also, DSS should support the procedures of data collection and pre-processing as well as data transition to the databases. The DSS should support the procedures of adding the new UTS data without changing or deleting the old ones, data conversion to the accepted format and data processing (deleting outliers, imputation of missing data, sample reduction, sample fusion, homogeneity analysis, etc.). In view of the fact that storage of time-changing information and data is needed, the databases must be temporal. The architecture of DSS data management subsystem that is responsible for the working with data is presented on Figure 1.

Moreover, DSS should include the knowledge bases that should contain not only normative and reference documents but also methods and methodological instructive regulations for application of models with necessary data under specific conditions. Development of such instructive regulations is a separate task, since an analyst facing the problem of selecting one or another way of assessing parameters or analysing a situation often spends a lot of time to select the appropriate tool for analysis (a model, a method, an approach).

DSS should provide an API-interface with external application systems; alternatively, it should include separate modules enabling one to perform the following procedures:

1. Statistical manipulation and analysis of data (both obtained from a real system and results of modelling and experiments), – as well as forecasting;
2. Modelling of UTS at macro- or microscopic level, the economic, demographic, and social situation in the city; modelling the ecological state, etc.;
3. Aggregated and disaggregated sensitivity analysis;
4. Calibration of UTS models, OD-matrices and preference functions when selecting routes, mode of transport, etc.;
5. Validation of models and analysis of scenarios.

A separate task of vital importance is the creation of a model management subsystem for organizing storage of models, working with them, and providing for their support. In particular, this subsystem should include a repository of different types of models: algorithm-based models, statistic-based models, linear programming models, graphical models, quantitative models, and qualitative models, and UTS simulation models. The last one includes the macroscopic and microscopic models of UTS fragments. As regards working with MM, it is necessary to provide the models interaction with databases. This problem has to be solved by database management subsystem module which is assigned the task of unloading the necessary data from databases, preparing it for transmission to the model and direct transmission. Also, this module is responsible for getting the data from the results of the sensitivity analysis and calibration procedures application, and the results of simulation and storing them in the appropriate databases. The scheme of data flows occurring in this case is presented on Figure 2.

The problem of data obsolescence is quite relevant. Taking into account that MM is based on the data needed for frequent actualization, the DSS should support the appropriate procedures. Usually the data actualization is based on the costly UTS surveys that should be regularly performed by governing bodies. The alternative approach is the using of the special procedures for data actualization based on historical data, with partial data collection on the real system.

On the basis of formulated additional requirements to the data and DSS working with MM it was developed the methodology of MM application as a part of DSS.

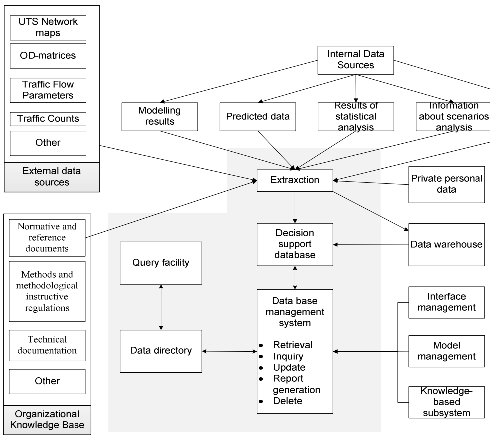

Figure 1. Scheme of data management subsystem in DSS

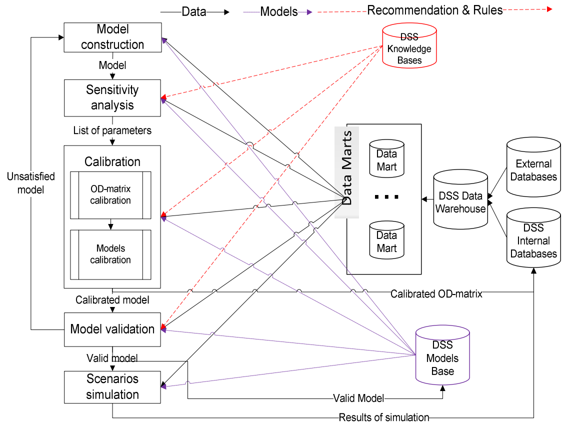

Figure 2. Scheme of data flow at various stages of working with model

3. Methodology of Decision-Making Support on the Basis of UTS MM Repositories

The model-driven DSS based on MM should support the decision-making process according the development plan for UTS (Fig. 3). DSS should help users to select the criteria for UTS functioning evaluation, provide access to the documentary standards referring to the methodology and procedures of UTS survey implementation, sensitivity analysis, and the application of calibration and validation procedures. Also it should support the database connectivity interface, procedures and special models for data evaluation, model relevance and data updating; the experimentation using the MM; processing simulation results and prediction of UTS traffic state development in the future under the old conditions of its functioning, and taking into account the planning modification. The prediction is necessary to implement not only the considered UTS fragment, but also the neighbouring ones since it is necessary to provide a well-balanced vision of UTS planning for improving the system level of service over the whole transportation network rather than a separate fragment only. The latter frequently impairs the use of microscopic simulation, as only one fragment of the model is normally considered.

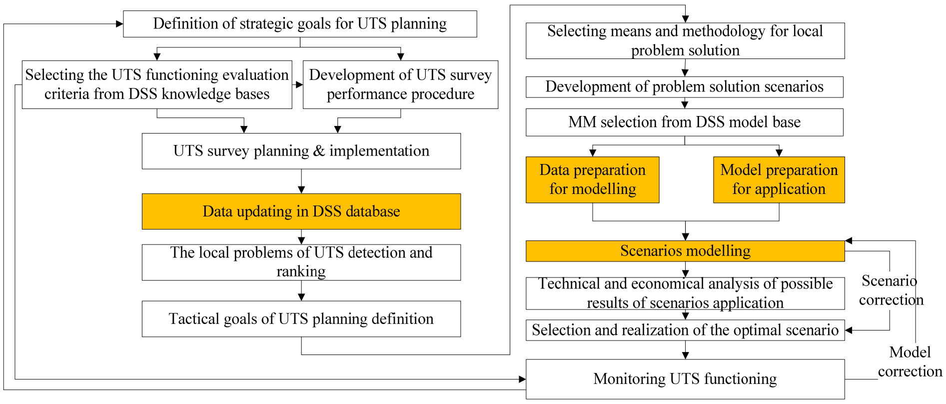

Figure 3. Model-driven DSS application in the frame of development plan for UTS

The proposed methodology focuses on the issues of data updating and preparation for modelling, consideration of model preparation and simulation scenarios including the analysis of the influence of new solution implementation on the neighbouring fragments of the network. The procedure of MM application as a part of model-driven DSS for decision-making support should include the steps presented on Figure 4 (developed by the author; procedures are marked by yellow).

The proposed methodology includes the procedures that can be considered as instructions, describing the processes of MM creation, calibration and validation as well as data actualization using the regression models (RM) and macroscopic models. The methodology also supports the procedures for analysing the new solutions impact on the neighbouring fragments of UTS.

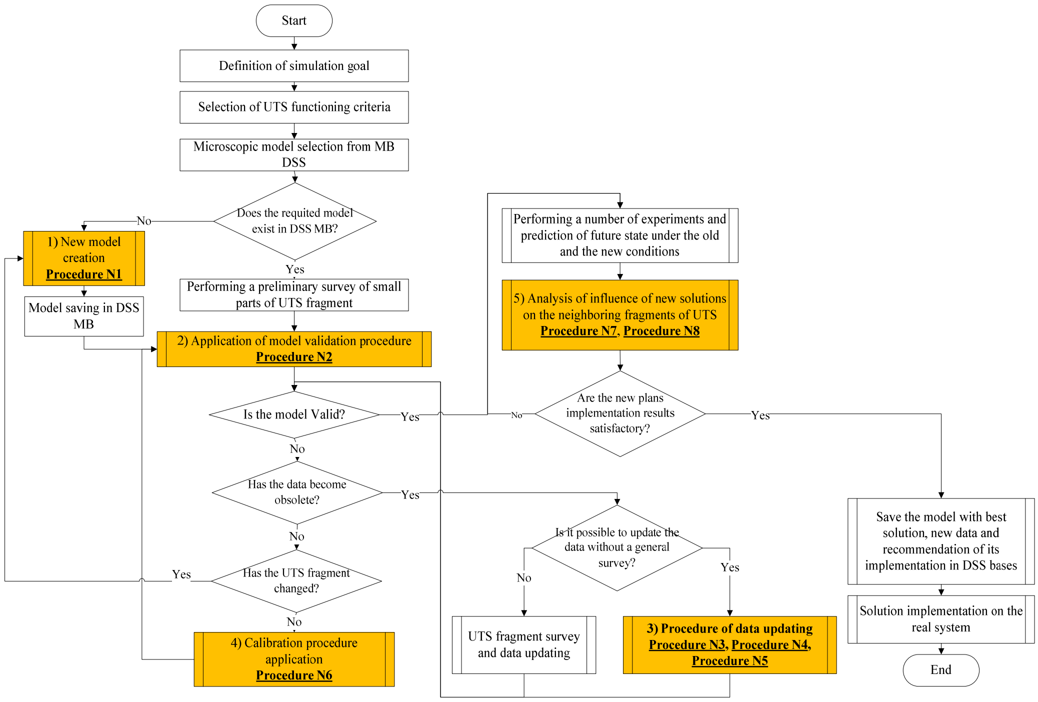

Figure 4. Scheme of MM application as a part of model-driven DSS for decision-making supporting

Eight procedures have been developed:

1. MM creation;
2. MM validation;
3. RM creation (the system was surveyed at the time moment t_i) for data updating;
4. RM application for data actualization at the moment t_{i+n}, n=1..k of simulation model j, created at the moment t_i;
5. Macroscopic model application for data actualization;
6. MM calibration;
7. Obtaining data for analysis of new solutions' influence on the neighbouring fragments of UTS (the case of two intersections located at the same level (road)).
8. Obtaining data for analysis of new solutions' influence on the neighbouring fragments of UTS (the case of two intersections located at different levels (roads)).

The following procedures will be considered more detailed in the paper:

- data actualization using the macroscopic models and regression models,
- analysing the new solutions impact on the neighbouring fragments of UTS.

3.1. Problem of data obsolescence and proposed ideas for its actualization

Considering the idea of MM application as a part of DSS, a separate storage for UTS fragments models (Fig. 5) should be arranged in DSS model bases, while the relevant data needed for simulation and decision-making – in DSS databases.

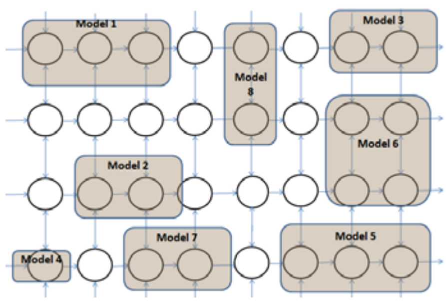

Figure 5. Set of several UTS fragments' MM that could be available for engineers and researchers

There are two cases that are typical to solving the problem of UTS planning on the basis of DSS and that are related to the need of data updating:

Case 1: the problem statement

It is necessary to carry out a repeated investigation of UTS fragment on the basis of the previously created MM. This model is stored in the DSS model base. *The problem:* it is necessary to carry out the additional expensive and time-consuming UTS survey for the data updating.

Case 2: the problem statement

Let us have a model $M_i(t_p)$ for some fragment *i* of UTS created/updated at the time t_p. The goal of the investigation is to increase the throughput capacity of UTS fragment. To achieve the goal, several scenarios of its reconstruction are considered. It is necessary to analyse the influence of throughput capacity of UTS fragment *i* on the other fragments lying at the same distance from the considered one. Let us denote the other fragments as *j*, $j = i \pm k$, where k – is a number of crossroads located between crossroad *i* and *j*, *k=2..n* (Fig.5). It is necessary to simulate the new output traffic volumes from UTS fragment *i* and to estimate the influence of this traffic flow volume on the level of congestion of the other UTS fragment *j* using the corresponding simulation model (Fig. 6). *The problem*: without the implementation of new solutions on the real UTS fragments *i*, we can't get any information on the new traffic flows with regard to UTS fragment *j*.

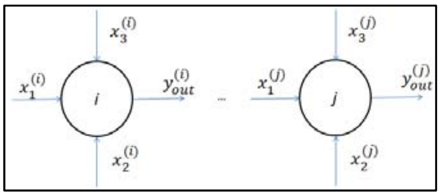

Figure 6. Output traffic flow $y_{out}^{(i)}$ of crossroad i has influence on the crossroad j input traffic flow $x_1^{(j)}$

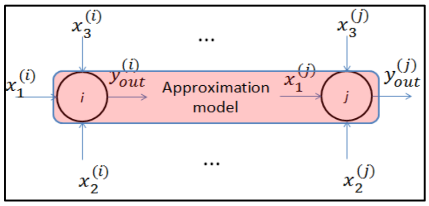

Figure 7. Illustration of the idea of RM application for the dependence between traffic volumes approximation

The traditional solution of the highlighted problem is either expensive (Case 1), or doesn't exist at all (Case 2). It is useful to find a way of reducing the number of additional surveys and costs. There were proposed by the author two ideas for the problem of data actualization solving:

- through the use of regression model as a tool for the dependence approximation of traffic flows of different UTS fragments (Fig.7);
- through the use of a macroscopic model of the UTS [7].

The idea about regression model application is briefly described in the paper.

The idea of regression model application

It was proposed the hypothesis in the research according the possibility of regression models application as a means of dependence approximation between traffic flows volumes of two crossroads located at a distance on the one street (Fig. 8) and on the others streets (Fig. 9). The first one can be used for the problem of case N1 solving, the second one – for the case N2.

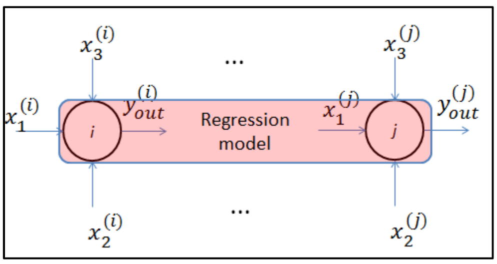

Figure 8. RM application for the dependence approximation

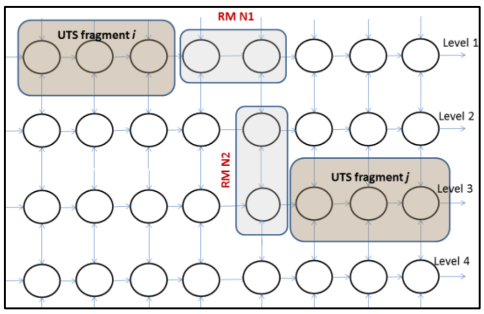

Figure 9. Two-stage application of RMs for the prediction of UTS fragment j input traffic flow volume

There were conducted 6 numerical experiments for the proposed hypothesis testing, and the positive results were obtained.

On the basis of the proposed ideas and experimentally obtained results the procedures of RM and macroscopic model application for data absence and actualization in the frame of methodology were developed.

3.2. Procedures for data actualization on the basis of RM and macroscopic models

The RM application as a part of DSS involves the application of several procedures that should be supported by DSS: regression model creation and RM application for data actualization at the moment t_{i+n}, *n=1..k* of simulation model j, created at the moment t_i. All the procedures mentioned below are involved in the methodology of MM application as a part of DSS (Fig. 4).

Procedure N3: regression model creation (the system was surveyed at the time moment t_i)

The algorithm of RM creation for data actualization is presented on Figure 10.

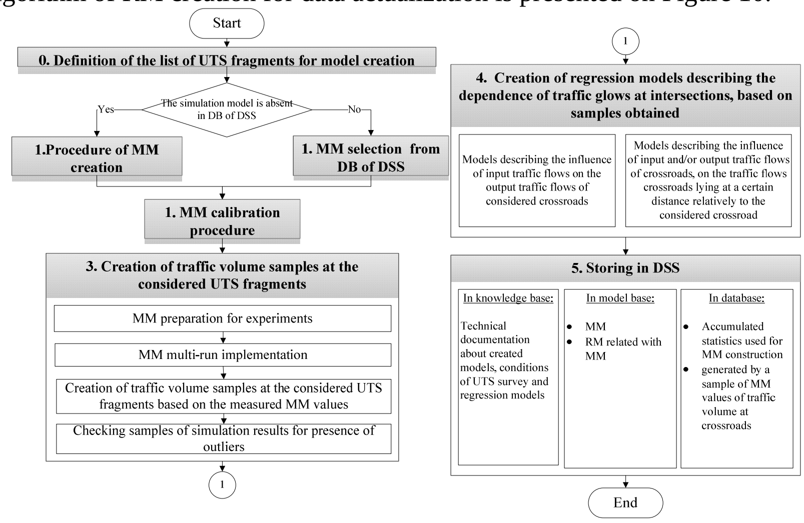

Figure 10. Procedure of RM creation for data actualization

It includes the following steps:

1. If the MM of the considered UTS fragment is missing:
   a. Collecting crossroads-describing data:
      - Traffic volumes, their distribution at crossroads by the directions; traffic light signal groups functioning schedule;
      - Schedule of public transport;
      - Geometrical characteristics of road network;
      - Aggregated characteristics of traffic within the transport network fragments (queue length, queue time, etc.).
   b. Storing the collected data in the DSS database;
   c. Creating the MM of considered crossroads based on the collected data;
   d. Calibrating the MM;
   e. Saving the calibrated model in the DSS model base.
2. Applying the calibration procedure to the selected MM.
3. Creating samples of the traffic volume values obtained at the considered fragments of UTS for the subsequent RM creation on the basis of MM selected from the DSS model base and data from DSS database. For that purpose, the following steps should be taken:
   1.1. MM preparation for experiments:
      a. setting up the total number of model runs, the simulation time, the model "warming-up" time and the time intervals of data collection, the conditions of data collection (aggregated during the selected time interval);
      b. selecting the traffic characteristics measured on the model (traffic volume at the input and output of crossroads – the total volume during the selected time interval);
      c. setting up the seed of random number generators as a random value.
   1.2. Carrying out multiple runs of the model;

1.3. Creating traffic volume samples at considered fragments of UTS on the basis of values measured on the model;
1.4. Analysing samples of simulation results: checking a sample for presence of outlying observations and excluding them.

2. Creating the following RM describing the dependence of traffic flows at the intersections based on the obtained samples:
   a. Models describing the influence of input traffic flows on the output traffic flow of considered crossroads;
   b. Models describing the influence on crossroad output of the input and/or output traffic flows of crossroads lying at a certain distance with regard to the considered one.

To put in effect the 4th step, the following is necessary:

- Selecting the interesting crossroad or group of crossroads (depending on the tested hypothesis);
- Determination of the dependent variable and the number of independent variables forming the dependent variable's value. As a dependent variable, either the volume of output traffic flows at the crossroad or an aggregated value of the volume of the input traffic flows at the crossroad may be taken. Independent variables are traffic volumes of UTS fragments which, due to their location, form the traffic flow volumes of the dependent variable.
- Analysing the RM creation, the quality of the model, and the requirements to residuals. Conducting the RM quality analysis based on:
  - General quality coefficients of RM (coefficient of determination of R-square, adjusted R-square, F-test, Standard Error of Estimation (SEE)).
  - Analysis of signs of RM independent variables coefficients (they must not contradict to the nature of the traffic flows-rendered impact on the corresponding value of the output traffic flow); analysing the significance of individual factors' influence on the output traffic flow formation.
  - Analysis of confidence and tolerance intervals for the dependent variable.

  If the RM quality is inconsistent with the specified requirements – various means to improve the model should be applied (changing RM the introduction of independent of non-linearity factors, etc.).

3. Storing in DSS:
   3.1. In knowledge and model bases:
      a. MM of a fragment of the transport network and the information about the conditions and date of construction of models, modelling objectives, conditions and date of data collection, and responsible persons;
      b. regression models and the information on specific data, simulation models, and specific conditions of the data collection.
      c. In knowledge bases – to save technical documentation about created models, conditions of UTS survey and regression models.
   3.2. In databases:
      a. accumulated statistics that was used for the model construction. It is necessary to fix the relationship of that data with MM wherein it was used, including the date and conditions of the data collection, as well as technical documentation describing the data collection method and the network survey project implementation
      b. A sample of the traffic volume at crossroads generated by MM, with the information on the specific data collected with regard to specific parts of transportation network, the conditions under which the experiment was implemented, the experiment date and time, and the reference to the technical documentation describing the conditions of the experiment.

Procedure N4: data actualization at the moment t_{i+n}, *n=1..k* of simulation model j, created at the moment t_i

The algorithm of the data actualization procedure using the RM presented on Figure 11 and consisting of the following steps:

1. Conducting a trial measurement of traffic volume on the respective UTS fragment. By using confidence intervals – comparing the distribution of traffic flows at the crossroads by routes with the historical data. If the distribution of traffic at intersections is not different from the historical data –

one should pass over to the next step, otherwise the application of this method is impractical due to a change in traffic distribution over the network, which entails the necessity of re-examination and a new regression model creation.

2. The comparative analysis of the similarity of traffic volume on intersections obtained during the preliminary UTS survey with the application of available historical data, using:
   a. The confidence interval: based on the previously accumulated data obtained as a result of simulation, the confidence interval is estimated and affiliation of the measured volume mean values to the confidence interval is analysed;
   b. Applying tests of homogeneity, performing analysis of variance or regression models in order to substitute the new traffic values based on the available models of examined fragments of the transport network, and to generate the traffic volume samples. Comparing the sample to the samples obtained in the previous studies by applying the homogeneity tests (Mann-Whitney test, Kolmogorov-Smirnov test, Chi-square), analysis of variance, and regression models.
   c. In case of a statistically significant difference between the data at different time intervals of system monitoring – applying the data actualization procedure (passing over to step 3).
3. Evaluation of the new values of traffic volume on unexplored parts of UTS fragments:
   a. To get the existing regression models created based on previous data,
   b. To substitute the new values of traffic for certain fragments of the network,
   c. Using the regression models to predict new values of traffic volume for the other fragments of UTS where the new value was not obtained.

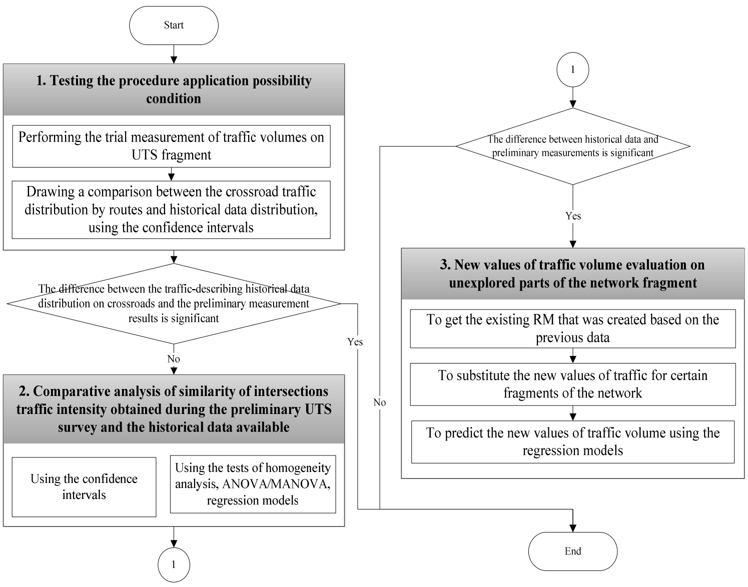

Figure 11. Data actualization procedure based on partially collected data and RM

Limitation of this procedure application: this procedure is meant to be applied under the conditions of MM use with the static routing. On condition of dynamic routing, OD-matrices and the models of decision-making according the route selection must be calibrated. For the calibration of OD-matrix and decision-making models, traffic information with regard to certain fragments of the network is needed. The more data from different network segments, the better. The OD-matrix calibration algorithm runs using the collected data.

Procedure N5: data actualization using the macroscopic model

The scheme of macroscopic model application procedure is presented on Figure 12, but the detailed description includes the following steps:

1. Implementation of a set of MM N1 running under the proposed UTS fragment functioning conditions.
2. Estimation of the new aggregated values of the traffic using the obtained simulation results: volume of traffic on the different fragments of UTS, travel times, speed of traffic, and queues characteristics.

3. Running the MM and updating the OD-matrix for the MM, taking into account the collected characteristics of traffic and applying the procedure of OD-matrix calibration.
4. Importing the data of MM N1 to the macroscopic model using the built-in software tools.
5. Running the macroscopic model with the new OD-matrix and obtaining the new values of traffic flows at all UTS.
6. On the basis of macroscopic modelling results – obtaining the updated values of traffic flows and crossroad traffic distribution by itineraries for the input points of MM N2.
7. Updating the MM N2.
8. Exercising a set of runs of MM N2, and obtaining the aggregated characteristics of traffic.
9. If some problems with traffic state on the fragment N2 of UTS are identified – considering different scenarios of problem solution at micro-level. Obtaining the new values of traffic characteristics and making the import to the macroscopic model.
10. To make the steps N4-N7 for the MM N1. If it will be necessary to repeat the procedure several times while will not be find the convergence state.

The proposed procedure may also be used for updating of several microscopic models if UTS survey on some fragments of UTS is conducted.

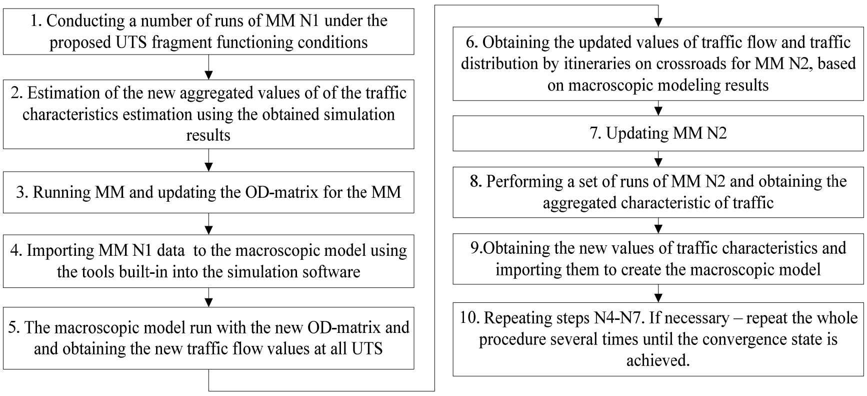

Figure 12. Procedure of macroscopic model application for MM data actualization

3.3. Procedures for data acquisition for analysing the influence of new solutions upon the neighbouring fragments of UTS

The procedure is meant for modelling the traffic data for the MM *j* on the updated values of the traffic model *i*. Two procedures of a regression model application have been proposed:

Procedure N7: Data acquisition for analysing the influence of new solutions on the neighbouring fragments of UTS (with two crossroads located at the same level (road))

The algorithm of RM application for data acquisition is presented on Figure 13 and consists of the following steps:

1. Taking from DSS an updated MM of a fragment of UTS *i* and the values of the input traffic by performing multiple runs, and getting a sample of values of the output flows. The number of runs should match the number of observations (of) other traffic flows forming the junction *j*.
2. Taking regression model from the base models of DSS, correlating the traffic volumes of *i-th* modified UTS fragment with the traffic volumes of *j-th* fragment of the transport network, which are at the same level.
3. Setting the simulated data describing the output flow volumes of *i-th* fragments of UTS to the regression model and estimating the prediction of the value of input traffic volumes for the *j-th* fragments of UTS.
4. Using the sample of predicted values as an input data on new volume of traffic flows for MM of *j-th* fragment of UTS.
5. Running the simulation model of *j-th* fragment of UTS and estimating the new traffic flow characteristics of *j-th* fragments under the new condition of functioning of *i-th* fragments of UTS.

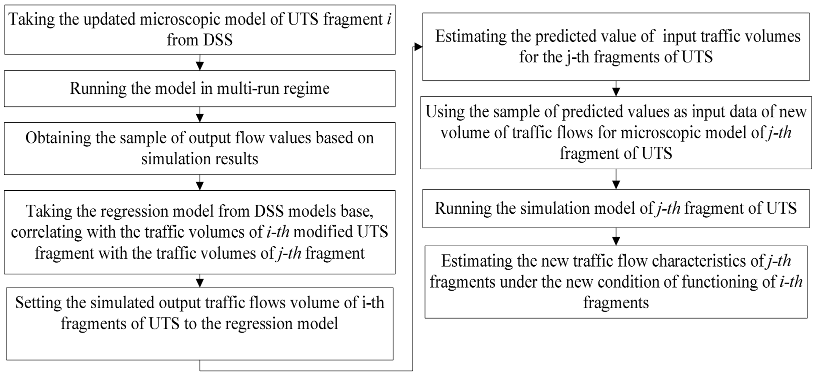

Figure 13. Data actualization procedure for j-th MM based on changed i-th MM data
(two crossroads located at the same level (road))

Procedure N8: Data acquisition for analysing the influence of new solutions on the neighbouring fragments of UTS (with the crossroads located at different levels)

The algorithm of RM application for data acquisition is presented on Figure 14 and consists of the following steps:

1. Getting an updated MM of a fragment of the transport network *i*, the values of the input traffic through multiple model runs to sample values of the output stream. The number of runs of the model should correspond to the number of observations of other traffic flows forming the junction *j*.
2. Taking the RM from the DSS model base, with step-by-step correlation of the *i*-th and *j*-th fragments of the network (Fig. 10).
3. Substitution of the simulated values of the output flow of the model *i* into the RM N1 and estimating the prediction of the values of output traffic volume.
4. Using the estimated values of traffic volume obtained by the RM N1 as the values of the independent variable of RM N2 and obtaining the estimation of the values of output traffic.
5. Using as input data the estimated values of traffic volume for the MM *j* obtained by the second RM
6. Running the MM of *j*-th fragment of UTS and estimating the new traffic flow characteristics of *j*-th fragments under the new condition of functioning of *i*-th fragments of UTS.

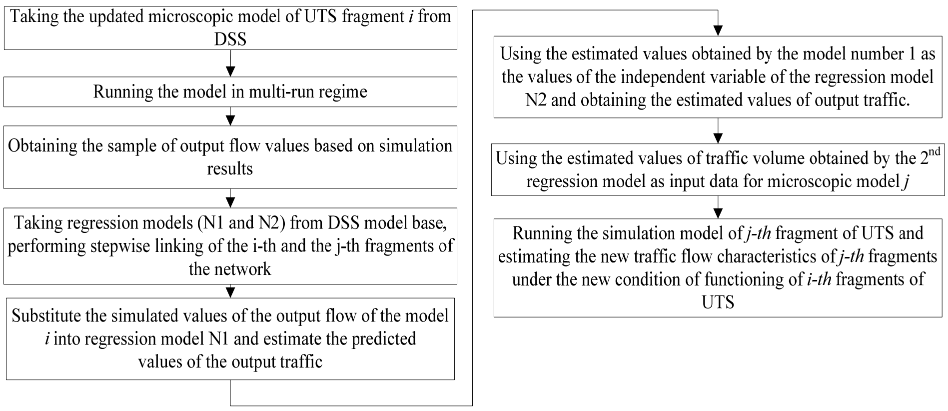

Figure 14. Procedure for data actualization for j-th MM based on the updated values of traffic of i-th MM
(two intersections are located at different levels (road))

4. Conclusions

In the paper were considered some methodological aspects of UTS MM application as a part of DSS. The proposed methodology includes the procedures of MM creation, calibration and validation; data actualization and new obtaining using the regression and macroscopic models. The last two groups of procedures were considered in the paper more detailed as well as the formulated requirements to the data and DSS architecture, and ideas of RM application as means of data actualization and new obtaining. The proposed methodology is aimed at suggesting a set of procedures for the provision of a credible decision-making according to the UTS planning based on model-driven DSS application using the microscopic models. The proposed methodology is designed to help:

- the engineer who makes the decision according to the UTS planning and management on the basis of MM simulation results;
- DSS developers to organize interaction between all components of DSS needed for MM application as an investigation tool.

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