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INTEGRATION OF AIMSUN NG AND ALMO: A SOFTWARE PLATFORM TO ASSIST ADVANCED TRAFFIC MANAGEMENT DECISIONS

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SUMMARY

The experience gained in developing software platforms to assist traffic managers in designing, evaluating and operating advanced traffic management strategies, led to a system architecture including, among others, three main components: A Real-time data collection subsystem that gathers the data provided by the traffic detectors, filters and stores them, and makes them available to other subsystems; a diagnosis module that analyzes the current data in the framework of the perspective historical information available, makes a diagnosis of the current situation on the road network of concern, makes a short term forecast of the expected conditions in the network in a do-nothing scenario, and proposes traffic management strategies to alleviate or solve the identified problem arising in a part of the network, the so called problem network; a Decision Support Module that makes the recommendations to the operator and provides him/her the suitable tools to help in the decision making process of selecting the most suitably strategy, and/or learn from the experience and generate new strategies. The decision support module also helps the decision maker in off-line processes to define and pre-test potential alternative policies. Systems based on this approach have been implemented and tested in some projects, in the last examples the implementation has been based on two new software platforms AIMSUN NG and ALMO, purposely designed and developed to fulfil these objectives. This paper describes the platforms and how they have been integrated. The integration is illustrated with examples from real projects in which they have been used.

ASSISTANCE OF ADVANCED TRAFFIC MANAGEMENT DECISIONS

Based on experiences from regional traffic management developments in the last 10 years, within the research project WAYflow [6] the Intermodal Strategy Manager ISM has been specified and

developed as prototype. The ISM supports the cross-responsibility definition and activation of traffic management strategies and has been utilized and validated in the range of the WAYflow field trials.

Within traffic management, problem situations whose effects cannot be mastered by only one traffic management partner are of special interest. In this case, the corresponding cross-responsibility and intermodal strategies consist of measures from various partners, which need to be co-ordinated. Improved co-operation and communication between the decentralized organized departments is one goal of the regional traffic management. This is needed to reduce the effects of regionally significant traffic hold-ups or to prevent congestion within a traffic network entirely. The individual technical and organizational constraints of all partners are taken into consideration. It enables the management of intermodal strategies and the communication between the parties concerned within the traffic management. The ISM supports the planning of new strategies, starting with their impact assessment and coordination up to their implementation as well as the optimizing of existing strategies. The advantages of the ISM as a part of the regional traffic management are obvious:

- ➔ It is unnecessary to build up an overall traffic centre and to hand over responsibility from the partners. Each partner is still responsible for his area and keeps the ability to influence the his own measures.
- ➔ The ISM development is system independent and allows each partner to decide how and when to conceive their own automatic Strategy Manager.
- ➔ The internet based communication is technically easy to implement and requires very little technical or financial effort from the partners.
- ➔ The amount of data exchanged is small as no bulk data needs to be transferred.
- ➔ There is no need for a common digital map with an integrated geo-referencing scheme

Above all the common strategies incorporate the regional and temporal diversion of traffic as well as the diversion from road traffic to public transport. The respective measures contain not only the traffic control, such as variable message signs, but also the distribution of information about the current traffic situation to the road users.

The strategies are defined in detail and authorised by the participating partners with respect to underlying problems (e.g. an accident, congestion at a section or major events). With the ISM, these strategies can be analysed and optimised regarding the various interactions with other relevant disturbing factors. If a problem arises it is possible to react at very short notice due to the predefined strategies. The ISM supports the automatic selection of the corresponding strategies and the verification of the predefined conditions. If the conditions are appropriate the strategy will be activated.
In complex network situations, the quality of the strategy application depends from the accuracy and acceptance of the strategy definition. For that reason, a Scenario Analysis Module is needed for the definition, validation and optimization of the network control and the support for the decision making process within the traffic management. As a result from earlier research projects and pilot applications, this requires a Traffic Management Data Warehouse. While the Scenario Analysis Module supports the traffic manager to study, to define, verify and optimize the traffic management strategies, to evaluate the expected impacts of the strategies and to determine the triggers to activate strategies according to prevailing traffic conditions, the Data Warehouse is the instance providing real world data. Basing on a Traffic Data Analysis, statistical representative sets of traffic pattern are provided for calibration and validation of the scenario analysis tool. Further on, historic incident messages as well messages on specific events or road work situations are provided for the definition of realistic scenarios.

Systems supporting scenario analysis and data warehousing/data analysis have been implemented and tested in some projects (see [1], [4], [6]). In the last examples the implementation has been based on two new software platforms AIMSUN NG and ALMO, purposely designed and developed to fulfil these objectives. This paper describes the platforms and how they have been integrated. The integration is illustrated with examples from real projects in which they have been used.

AIMSUN NG AND ALMO

AIMSUN NG

AIMSUN NG uses AIMSUN [7] microscopic traffic simulation model to redo real traffic situations in a virtual environment. AIMSUN NG is a new graphic software platform that embeds the microscopic traffic simulator AIMSUN, [7], and interfaces other traffic and transport analysis tools, as for example the transport planning software EMME/2, providing the analyst with a friendly user interface to perform the above described operations.

The AIMSUN NG approach is based on the concept of scenario analysis [2], [3]. A scenario is a specific virtual reality in the microscopic simulation environment, analysing a traffic problem in the relevant sub-network of a in a traffic network. The analysis network normally covers next to the problem the area in which possible traffic control measures can be managed. The analysis network is the so-called problem network.

The model input reproduces to a great degree of accuracy the traffic demand in the problem network for the time period for which the traffic problem has been identified, as well as the current operational conditions in the road network (i.e. current traffic control at signalized intersections, reductions of capacity at specific parts of the network by road works, incidents, and so on). The analysis of the scenario consists on a set of simulation experiments whose purpose is to help the traffic manager to develop and evaluate the impacts of the single actions or combination of actions, consisting of situation related measures (i.e. re-routings and/or speed control using Variable message Panels (VMS), changes in control, an so on), with the objective of alleviating or eliminating the traffic problem identified. This concept of action composed by the various situation-related measures is called a strategy. The evaluation of alternative scenarios, i.e. models of the same problem network with alternative traffic management strategies, is based on the comparison of the values of performance indexes measuring saturation levels, quality of service, total travel time, average delays, average queue lengths or total vehicle-kilometres travelled.

AIMSUN NG [3] is based on a combination of an AIMSUN microscopic traffic simulation model and a transport planning model of the traffic network, providing the analyst with the tools for adapting the traffic demand matrix, building the specific scenarios for the problem-networks where the traffic problems have been identified, and evaluating the expected impacts of the analysed measures. Three auxiliary tools assist AIMSUN NG operation:

- ➔ AIMSUN NG Software-Develoment Kid: The Generic Environment for Traffic Analysis and Modelling, its associated graphic editor that supports the network edition, visualisation tols as wellas open software interfaces to integrate plug-ins.
- ➔ AIMSUN, the microscopic traffic simulator providing the dynamic traffic models for the evaluation of the traffic management strategies, interactively activated from AIMSUN NG.
- ➔ An OD-tool providing the macroscopic traffic models for traffic assignment, OD matrix adjustment as wellas the genaration of the traversal matrix for the problem network under study.

The main objective of AIMSUN NG is to allow the fast and convenient manipulation of input data to create simulation scenarios and to present result data in a compressible way. It has two main components:

- ➔ the simulation experiment specification
- ➔ the result analysis.

The simulation experiment specification includes: The set-up of a Problem Network (either the network of the whole area or a sub-network); the creation, modification and adjustment of O/D matrices (global

for the whole area as well as local or traversal for the sub-networks); the addition of traffic management policies and their triggers and the simulator tuning (see Fig. 1).

The result analysis includes: the output data presentation and the comparative study of the performance of a solution, either with previous solutions or with real data. Since a problem can have different solutions and since these solutions cannot be obvious, the user can define several experiments combining different policies until he/she finds the best option. During this experimentation the user can reuse previous solutions and add new ones. Then the user can compare the performance of the new solution with either real data or other solutions. These two components can be used iteratively until a satisfactory solution is found. These components provide the support for the generation, evaluation and optimisation of traffic management strategies.

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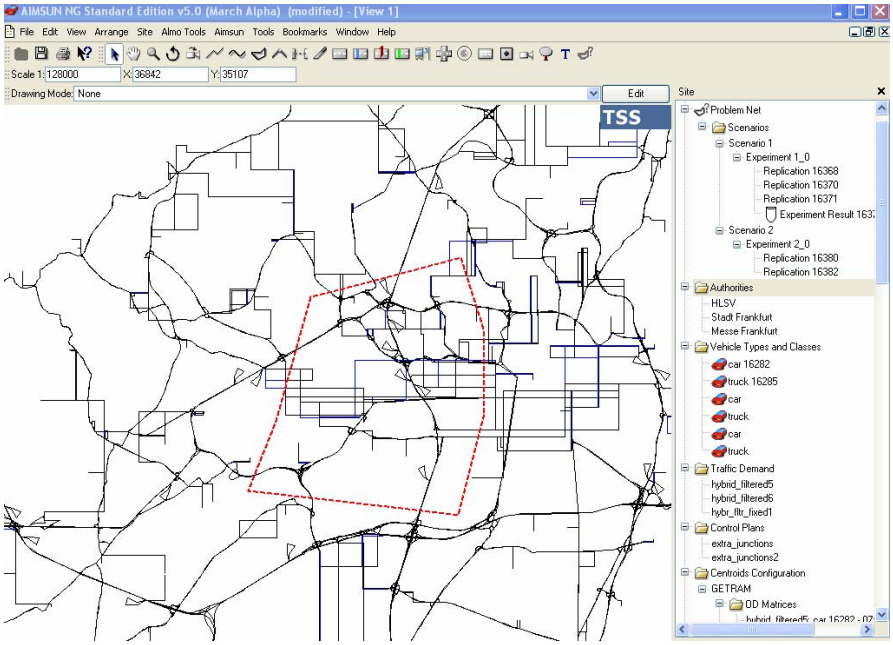

Fig. 1: Scenario definition and problem area

Once the Problem Network has been defined the operator activates the extraction of the sub-network model for the Problem Network, this is the first step in the process of generating the scenario to be analysed and the automatic production of the AIMSUN microscopic simulation model to analyse the scenario and assess the potential impact of the proposed traffic management strategies to alleviate the identified traffic problem. Once the model for the Problem network has been created, AIMSUN NG components provide the support for the following main tasks:

- ➔ Strategy generation, evaluation and optimisation
- ➔ Generation and adjustment of the local (traversal) OD-matrix describing the local traffic patterns,
- ➔ Generation of context-dependent simulated raw data (e.g. “travel times during an special event”)

Within these tasks, strategy-related scenario analysis is the main task, containing

- ➔ Scenario analysis of official, predefined strategies to optimise trigger conditions and deactivation conditions (and, by this, to define the road sections that are relevant to monitor trigger and deactivation conditions).
- ➔ Scenario analysis to generate new strategies or to optimise strategies that have been defined in earlier experiments.
- ➔ These strategies are the basis for the management discussions to define new, additional strategies.

After the definition of the simulation scenario (see Fig. 2) the corresponding AIMSUN simulation model is ready to work. The evaluation process is done conducting a set of simulation experiments that the operator can activate from the Scenario Analysis Module GUI. A simulation experiment is characterized by the combination of: Simulation modelling parameters, selection of a route choice model, a set of threshold values for the strategy triggers. The comparative analysis of the simulation results for the set of simulation experiments provide the answers to questions like: When strategy X should be activated to optimise its impact, Which are the most suitable values for the strategy triggers?, Which would be the expected effects of the strategy in terms of the level of service indices?

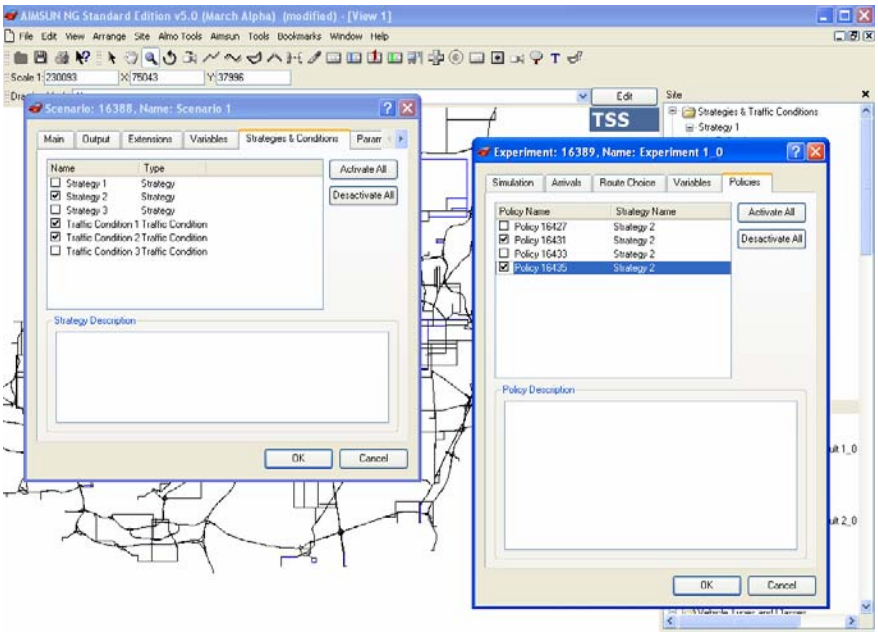

Fig. 2: Scenario, strategy and policy

The results of a simulation experiment can be visualized in colour scales an easy interpretation. The operator can identify conflicts and bottlenecks at a glance. The results analysis in Scenario Analysis Module includes a rich and powerful set of graphic tools to visualize time evolution of traffic variables or measures of efficiency, compare scenarios, and so on, with the purpose of providing the operator with a easy to use decision support tool.

ALMO

For parameterisation of traffic control models, it is important to generate knowledge bases as reliable parameters for online-operation. For that goal as well as for evaluation purposes, a comfortable access to historical data is necessary. This goal can be achieved by the realisation of a conceptual data warehouse. It has to support traffic management and traffic engineers with all context related information required. High quality and scale of the underlying data base is required, i.e. the data

warehouse should include a substantial data basis and exists beside and, what is more, in addition to the existing operative data bases of traffic control centres. Data analysis methods can be applied to the content of the data warehouse to generate knowledge basis. These include typical traffic pattern (see 3) parameters of congestion or typical road capacities. In addition, these data can be itemised according to timeframe, location, traffic influencing events as well as further dimension like weather.

For a micro-simulation based traffic management decision support like the AIMSUN NG, a comfortable access to historic traffic data documenting interesting historic traffic situations, in combination with certain traffic data analysis methods is important.

Within the ALMO-Office tool family for traffic data analysis (see [8]), ALMO CONTENT is a specialised instance of the described data warehouse approach to be an integrated tool in the AIMSUN NG. ALMO CONTENT is a structured and geographically referenced traffic data-tool, merging different data assets which manage among other things traffic data, traffic messages, weather data or event calendars. By means of an intelligent filter it is possible to restore the data asset pertaining to a special traffic situation. Basing on Traffic Data Analysis operations, statistical representative sets of traffic pattern are provided for calibration and validation of the simulator. Further on, historic incident messages as well as messages on specific events or road work situations are provided for the definition of realistic scenarios. So, ALMO CONTENT is an optimized traffic-data infrastructure for AIMSUN NG providing data situations with respect to time, location and traffic situation.

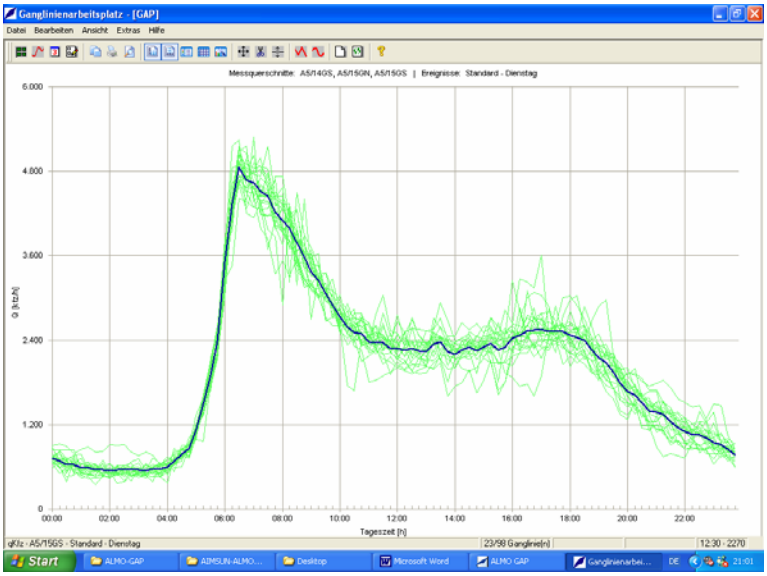

Fig. 3: Classification of “typical” classes within ALMO

For the integration with the AIMSUN NG, a semi-static interface is implemented to provide ALMO CONTENT- based real-world data, including volume data, context data like incident messages, road work situations and specific events and detector-ID and referencing information (see 4) for AIMSUN NG scenario analysis.

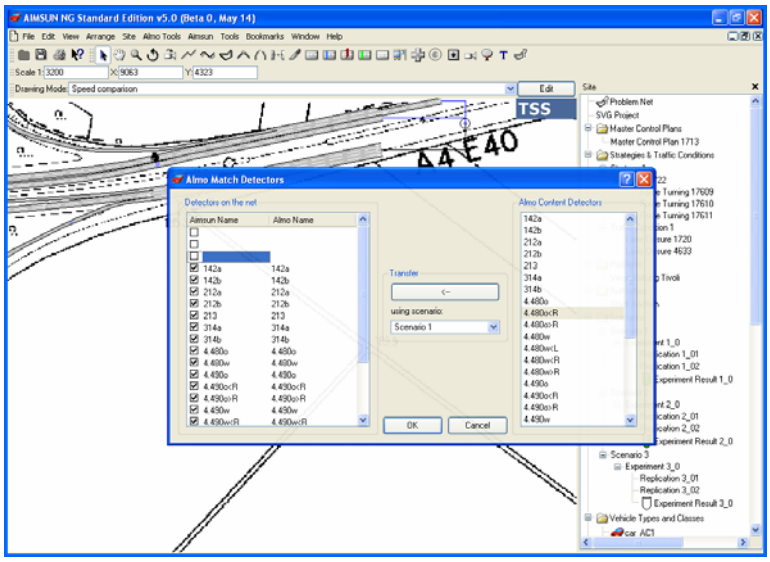

Fig. 4: Allocation of real-world detector locations to virtual simulation detectors

ALMO CONTENT so is integrated in the AIMSUN NG environment. The real-word data can be seen via the AIMSUN NG user interface (see Fig. 5) and while a scenario analysis is under study of the traffic expert, it is possible to select context-specific data situations that are relevant for the study under consideration. The user selects the specific kind of analysis and output format, including

- ➔ define traffic situation and parameter for pattern generation and export
- ➔ generate calibration data for list of detectors and corresponding traffic situation
- ➔ generate validation data for list of detectors, corresponding simulated data and corresponding situation.

As result of the ordered analysed data, the ALMO CONTENT exports the required data to the required interface format.

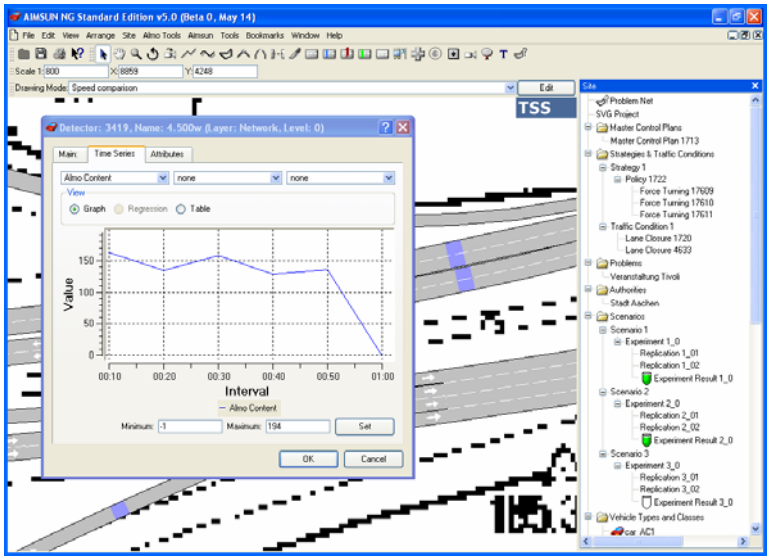

Fig. 5: ALMO CONTENT integrated in the AIMSUN NG integrated traffic planning environment

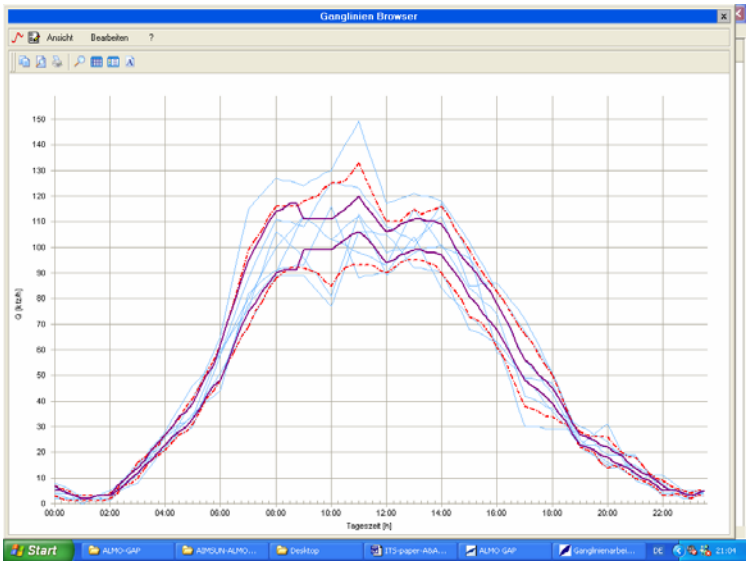

Fig. 6: Comparison of simulated data with the statistical bandwidth of real-world data

Another important functionality of ALMO CONTENT is the „benchmarking service" to compare simulated data with representative real world data for predefined situations. The results are benchmarking characteristics like mean square error of the two time series as well as the visualisation of the time series in question, as shown in Fig. 6.

INTEGRATED SOFTWARE PLATFORM FOR TRAFFIC MANAGEMENT ASSISTANCE

By the integration of the conceptual data warehouse ALMO CONTENT into the simulation tool AIMSUN NG, a powerful tool for dealing tasks within the field of traffic management design and evaluation is provided to the user (see Fig. 7). Hereby it is possible to use data from the existing traffic-data infrastructure of the real world for the calibration and validation of simulation-based scenarios computation.

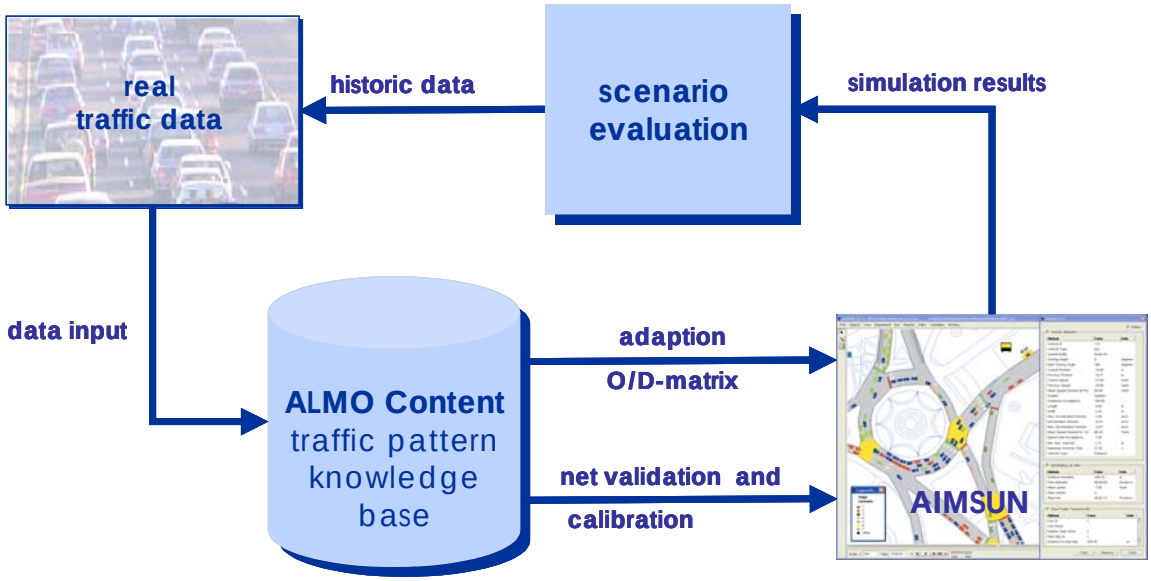

Fig. 7: Integration scheme of AIMSUN NG and ALMO CONTENT

By means of this comfortable Scenarios Analysis System

- ➔ new traffic management measures can be defined and evaluated
- ➔ existing traffic management measures may be verified and optimised
- ➔ impact assessments can be done for the measures or its variations
- ➔ activation conditions can be optimized
- ➔ the effects of road work, events etc. can be examined preliminarily.

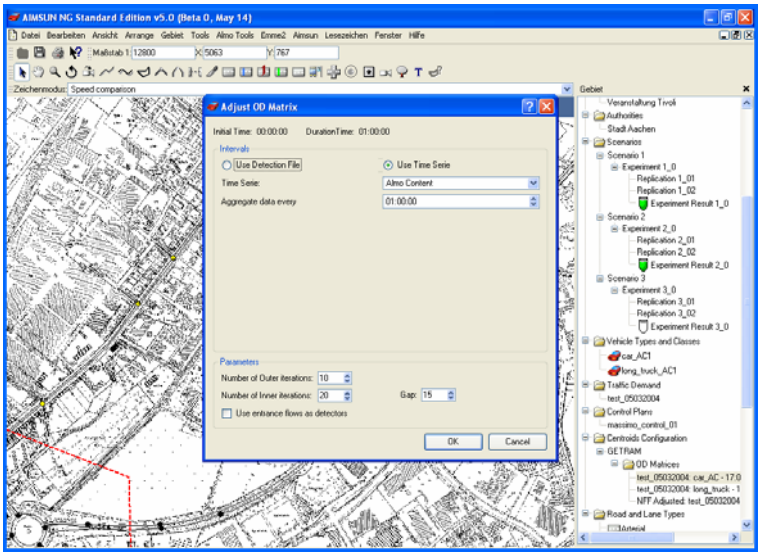

Fig. 8: Import of ALMO real world data to start calibration of the OD-matrices

The main tasks of AIMSUN NG to assist traffic management planning are to define strategies, generate interactively a problem area covering at least the problem net and generate the traffic situation to be examined. For that reason, real world data are loaded from ALMO CONTENT (see Fig. 8,9) and the basic OD-matrix is adapted. This generates the reference scenario, i.e. represents the real world traffic situation in the virtual environment of the simulator and gives the starting point for traffic management assistance.

Next steps are to define the Problem and to define some policy. This defines the scenarios that now can be examined, modifies and optimised. A scenario is characterized by:

- ➔ The Road Network within the defining window
- ➔ The specific OD matrix selected from the OD Database linked to the Problem Network, corresponding to the traffic patterns for which the scenario will be simulated.
- ➔ The specific traffic management strategy presumed suitable for solving or alleviated the identified traffic problem, whose impacts are going to be evaluated by simulation

The traffic management strategy is characterized by:

- ➔ A Network operational scheme, that is, a configuration defined for instance by specific blocked lanes by road networks, temporarily banned turnings, etc.
- ➔ A specific traffic policy, i.e. a set of specific messages for the corresponding VMS panels with the associated actions (information, rerouting, Park and Ride recommendations, etc.), ramp metering on specific ramps, etc.

Triggers whose threshold values, defined in terms of the selected indices of performance to measure the level of service, activate the operation of the strategies.

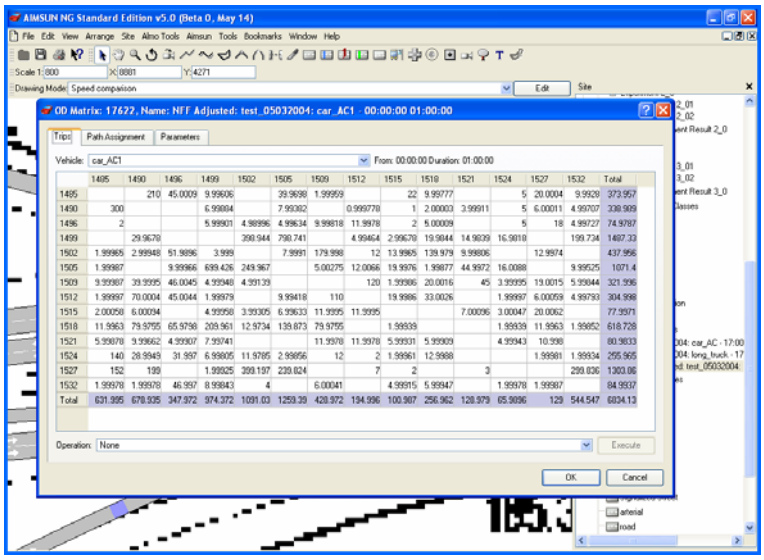

Fig. 9: Adapted OD-Matrix after calibration with ALMO real world data

AIMSUN NG supports powerful features to evaluate the results of scenario analysis. Some of them are shown in Figures 10 and 11.

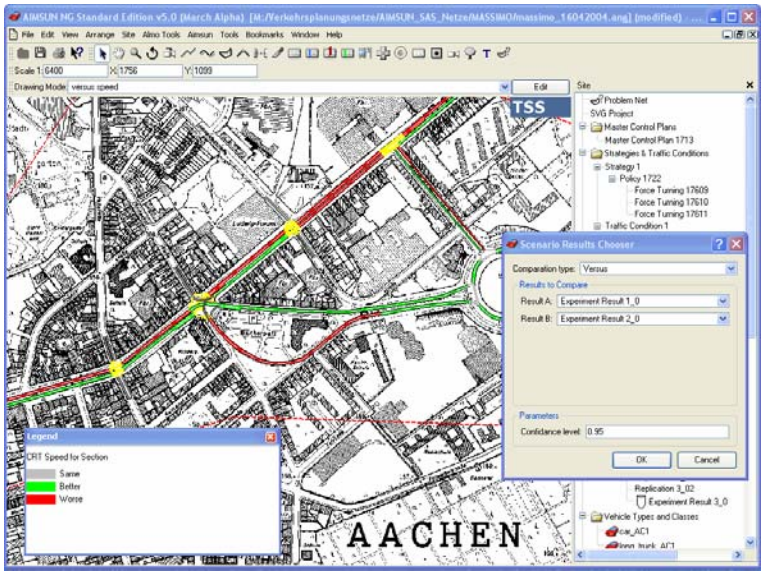

Fig. 10: Graphical comparison of two scenarios

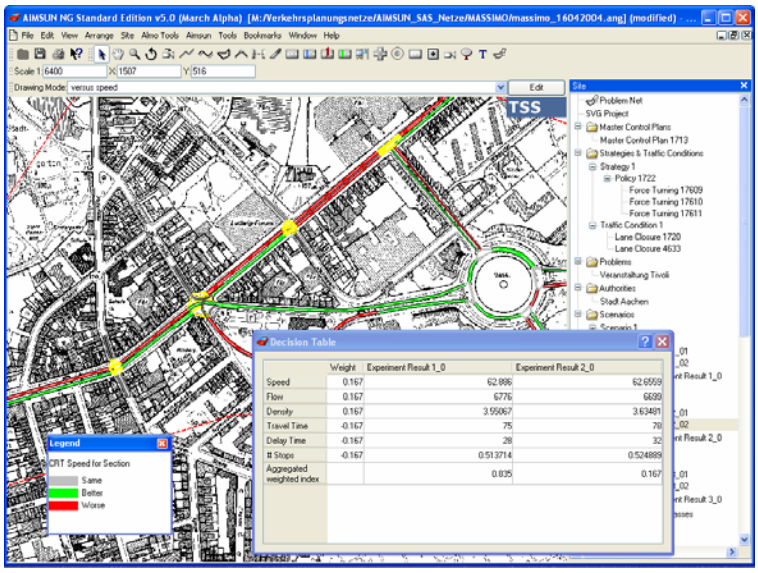

Fig. 11: Decision table to compare relevant scenarios by performance data

CONCLUDING REMARKS AND OUTLOOK

AIMSUN NG and ALMO offer the integrated traffic management planning, -optimisation and evaluation for a variety of traffic technology applications:

- Cross-competence strategy management
- Interurban traffic management e.g. traffic control systems on freeways and metering
- Rerouting with dynamic route information panels
- Traffic management of fee-suppressed traffic demand
- Safety warranty in case of dangerous traffic situations in tunnels
- Urban traffic control systems (fixed, actuated and adaptive control)

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