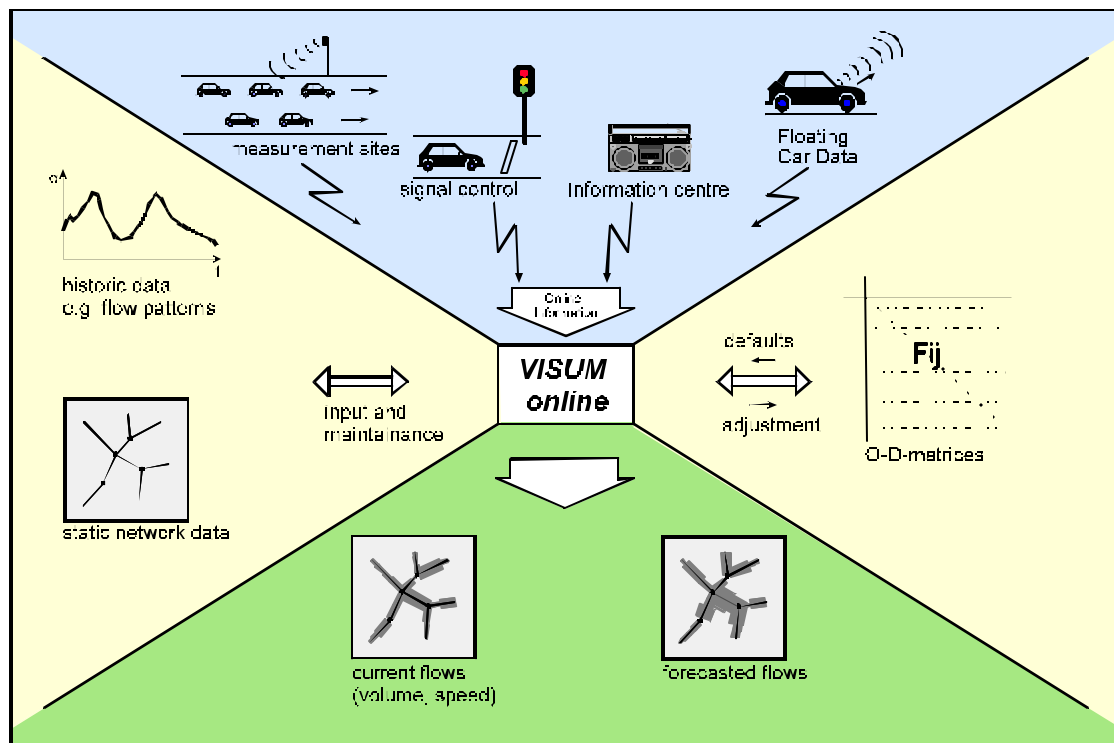


# VISUM-online

*Traffic Flow Prediction for  
Transportation Management Centers*

## System Architecture



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## 1 Principles

Planning of short term traffic-control measures within the framework of a traffic management system requires comprehensive knowledge of the current state of the transportation network. Furthermore, the decision process may improve if information about future (15 minutes to one hour) traffic conditions could be forecasted. In a modern inner-city road network, traffic flow data are collected at many sites. At traffic-actuated signal control sites, for example, traffic volumes are recorded, other measurement sites gain data on speed and flow composition.

Within the framework of a traffic management system, the central computing unit integrates traffic flow data collected at various sites. This merged data, in turn, can be visually aggregated to monitor and evaluate the road network. For the purpose of traffic flow forecasts and the evaluation of mitigation alternatives, the system must include an appropriate traffic network model and tools for editing and maintaining network data.

*VISUM-online* is the model with the appropriate tools. *VISUM-online* is currently being installed in Hanover and Berlin, Germany. The *VISUM-online* software for transportation management centers is based on the transportation planning software VISUM which is widely used in Europe. *VISUM-online* provides additional functionality for both input and processing of continuously recorded measurement data, which serve for modeling the traffic flow, for display and assessment of the current state condition, and for forecast and evaluation calculations. The following processing steps achieve this functionality:

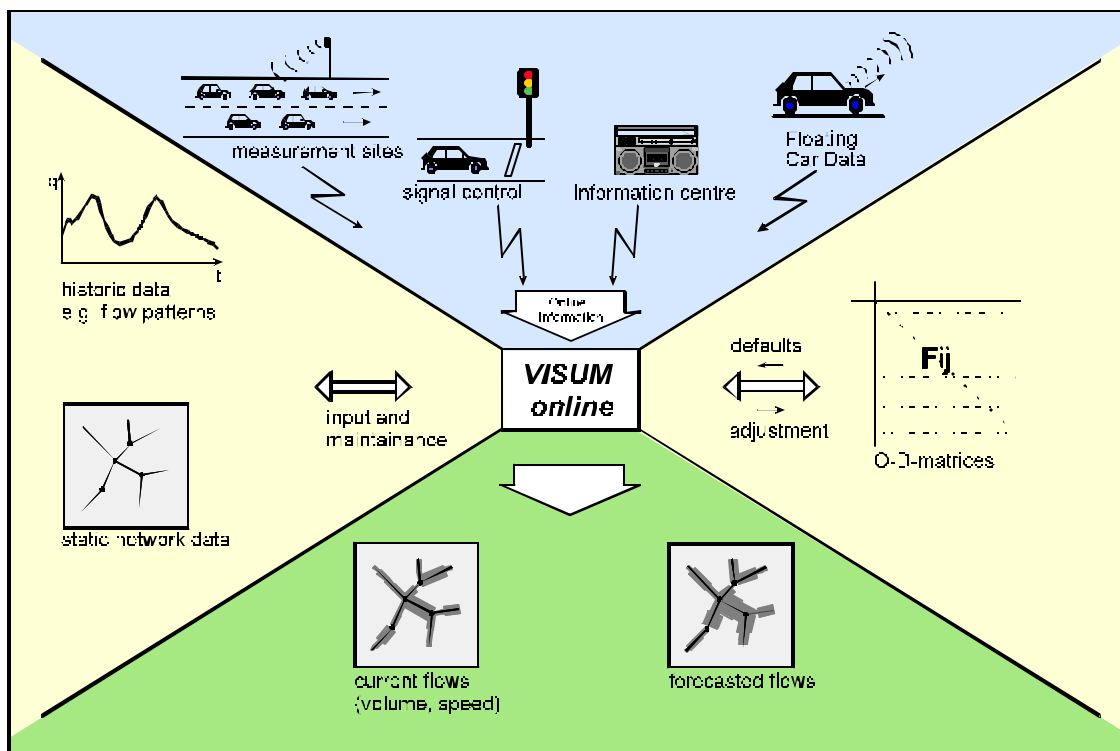
1. Processing incoming online data

2. Modeling current network state (data completion)

3. Visualization and assessment of current network state

4. Forecasting traffic flows for the network

Interactions between *VISUM-online* and various data sources are displayed below:

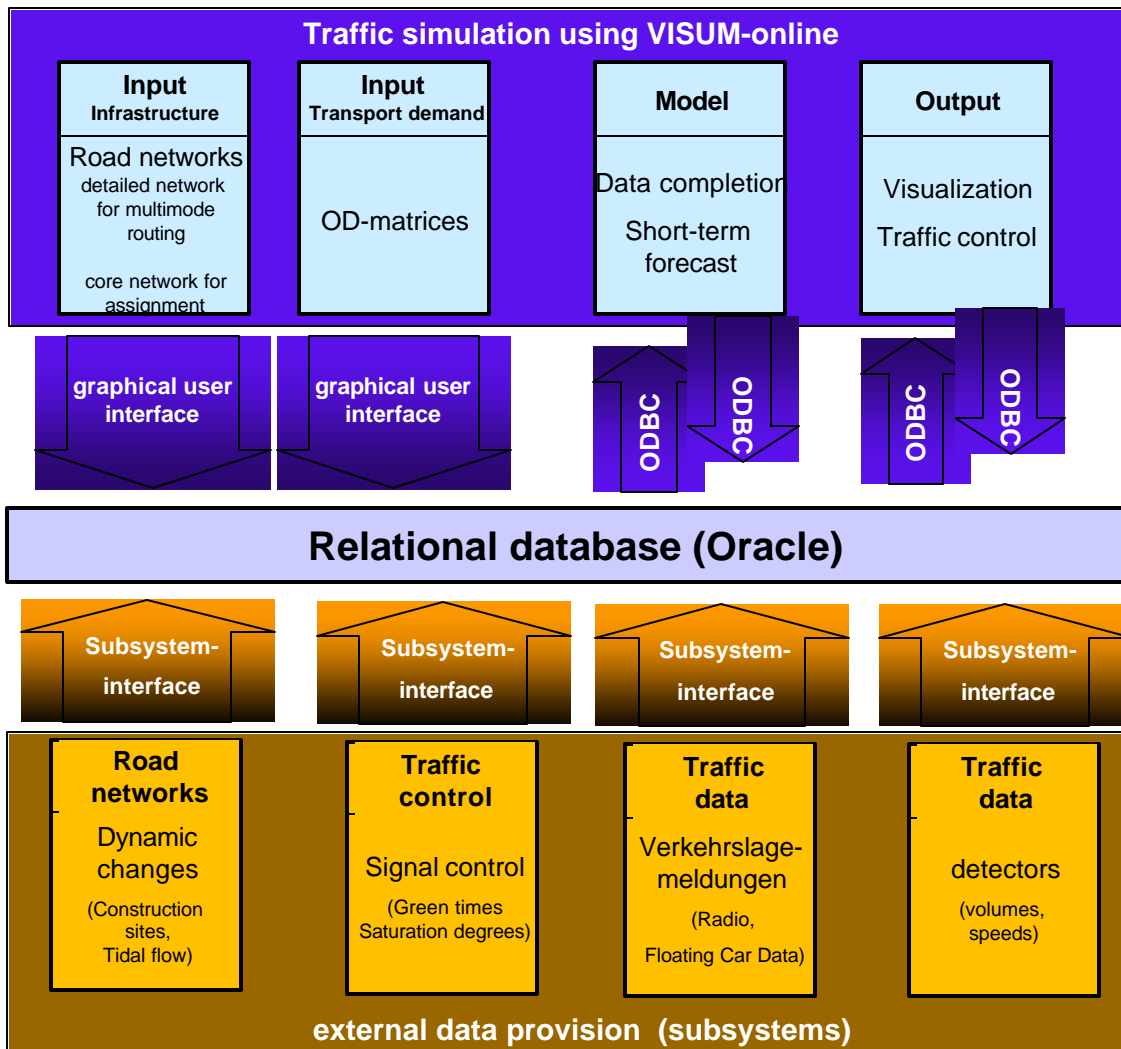


**Figure 1.** General data flow in *VISUM-online*

During operation, the incoming online data are the essential inputs for *VISUM-online*. Information on traffic flows may be gained from different sources, partly from existing devices such as traffic-actuated signal control units or also from dedicated traffic monitoring devices. Available floating car data (i.e., AVI equipped vehicles) may also be used.

The *VISUM-online* system continuously computes the current flows in the modeled road network and displays graphically and numerically estimated flow volumes and travel times. Based on the current network state, short-term traffic flow forecasts can be computed and displayed in the same way.

Various data have to be supplied to the system, of which the most important is the traffic network model which includes road geometry data as well as parameters of roads and intersections. These data are edited with the help of the graphic network editor provided by *VISUM-online*. Furthermore, demand matrices have to be available which describe travel demand within the network. These O-D matrices may be updated as a result of the current measurements during system operation.



**Figure 2.** System architecture of the central transportation management system for the Hanover EXPO 2000 implemented by PTV (Germany) and TENET (UK) under supervision of move GmbH, Hanover

## 2 Functionality and Methods

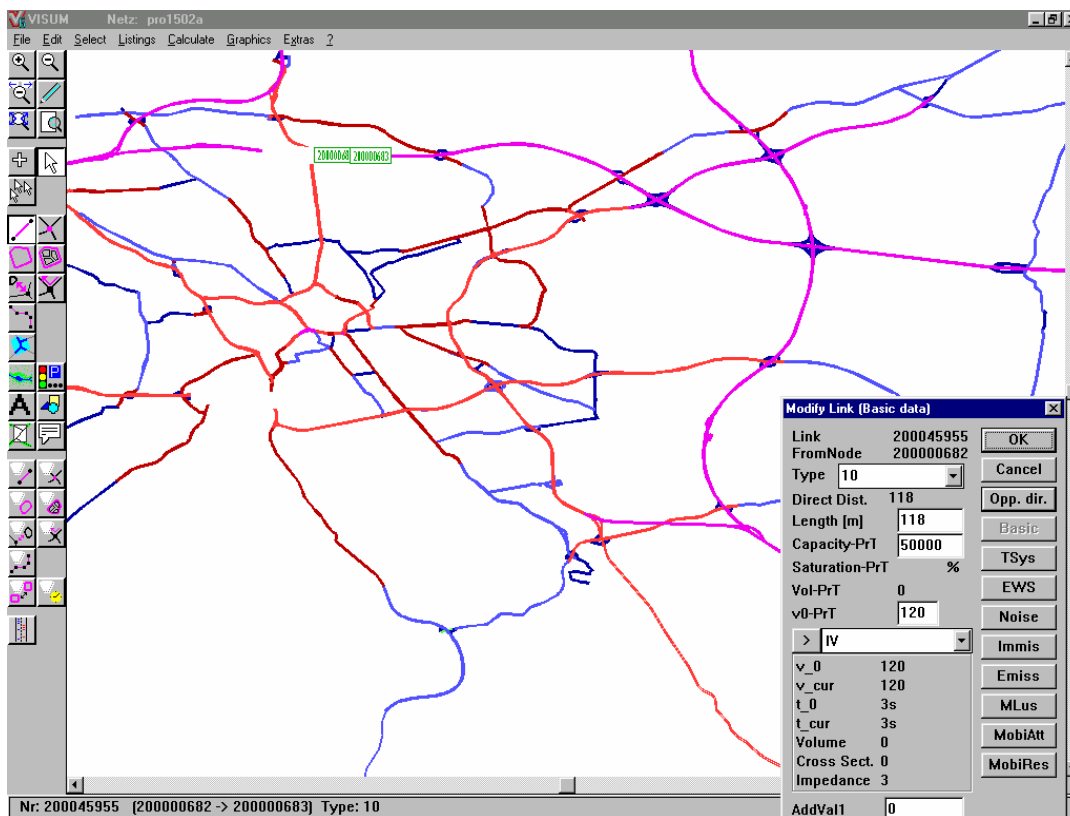
### 2.1 Management of static and historical network data

The system has to be supplied with comprehensive information about the road network and relevant infrastructure such as the location of signalized intersections, measurement sites, etc. For input and editing of these data, the graphical user interface of the transportation planning system, VISUM, is used in *VISUM-online*. Thus numerous functions for data management of integrated transportation networks (GP traffic and transit) are provided.

The procedures applied for forecast calculations partly use flow patterns, which had been measured at detectors in the past. To fill in the data gaps (i.e., data completion), the knowledge of an existing O-D matrix version is necessary, which is used as an initial solution. Therefore *VISUM-online* provides functions for data management of both detector time series data and O-D matrices.

The data calculated by *VISUM-online* are provided for further processing in an appropriate form via interfaces. A certain percentage is stored as historical information and will be used for future calculations. The results of data completion and forecasts, combined with an assessment of traffic flow quality, may serve as the basis of a network-wide control strategy. Similar to the input data, output information formats may require an adaptation to the specific needs of the user.

Separately from the data formats that *VISUM-online* uses internally and the data formats provided by the subsystems of the control center, it is advantageous to store the data described above in a standardized database, which allows data exchange with other components of the traffic management center. *VISUM-online* allows both import and export of network data from and into a relational database.



**Figure 3.** Graphical network editor to edit link attributes using the classified core street network of Hanover as an application

## 2.2 Treatment of incoming online measurement data

*VISUM-online* evaluates data recorded via traffic flow detectors (i.e., loops, transponders, etc.) from traffic flow. Technical standards of detectors, transmission protocols and the quality and level of aggregation of these data may differ. The system is able to prepare and process data from different sources. These data are classified by type and level of aggregation (counts or speed records, vehicle-based or interval-based), which are internally displayed in a unified format. The data of each subsystem has to be mapped to these formats, i.e. the interfaces have to be adapted. The possibility of including floating car data (i.e., from AVI equipped vehicles) in the future is provided.

## 2.3 Data completion

From the incoming current measurement data, the current state of traffic flow, that is volumes and travel times, is derived for the entire modeled road network. Data from temporarily inoperative detectors are estimated.

Data completion is based on algorithms, which originally served to estimate an O-D matrix from traffic counts at cross-sections. *VISUM* already uses procedures like this for calibration of the modeled link network based on the "Path Flow Estimator (PFE)" developed by Prof. Bell<sup>1</sup>. Using an approximate (historical) O-D matrix as the initial solution, these procedures deliver an estimated current O-D matrix. *VISUM* already provides the static PFE variant. For data completion purposes, however, a dynamic variant is recommended<sup>2</sup>. Depending on their location within the network, inoperative detectors can be identified during the O-D estimation procedure. Their data can then be replaced by results of the data completion, if the decline in reliability of the result is accepted, or values are substituted from historical measurements.

The basic idea of the estimation procedures is to modify the assignment of a known estimated O-D matrix in a way, that assigned traffic volumes at measurement sites are equal to counted data. Therefore, the impedance of links is increased or reduced in an iterative process, as required by the deviations between assigned and counted volumes (either positive or negative). The estimation may differ from the given O-D matrix within a scaleable range, in order to allow a better solution for the overall network. Thus, on the one hand, the matrix

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<sup>1</sup> Bell, M.G.H.; Shield, C.M. (1995): A log-linear model for path flow estimation. Proceedings of the 4<sup>th</sup> International Conference on the Application of Advanced Technologies in Transportation Engineering, Capri, 695-699.

<sup>2</sup> Bell, M.G.; Lam, W.H.K.; Iida, Y. (1996): A time-dependent multiclass path flow estimator, Proceedings of the 13<sup>th</sup> International Symposium on Transportation and Traffic Theory, Lyon.

serves as a frame for the estimation of traffic flows, on the other hand, it can be updated continuously due to measured data.

The procedures applied for data completion in *VISUM-online* not only provide traffic volumes on links, but also routes for O-D relations and the volumes on these routes. Thus one of the requirements for future integration of floating car data is fulfilled.

By storing measured and computed data and reusing these data in the following computations, a learning behavior of the procedures is achieved. For instance, one may start without historical flow patterns and will gain a more and more reliable and extensive database during operation.

## 2.4 Visualization and Assessment

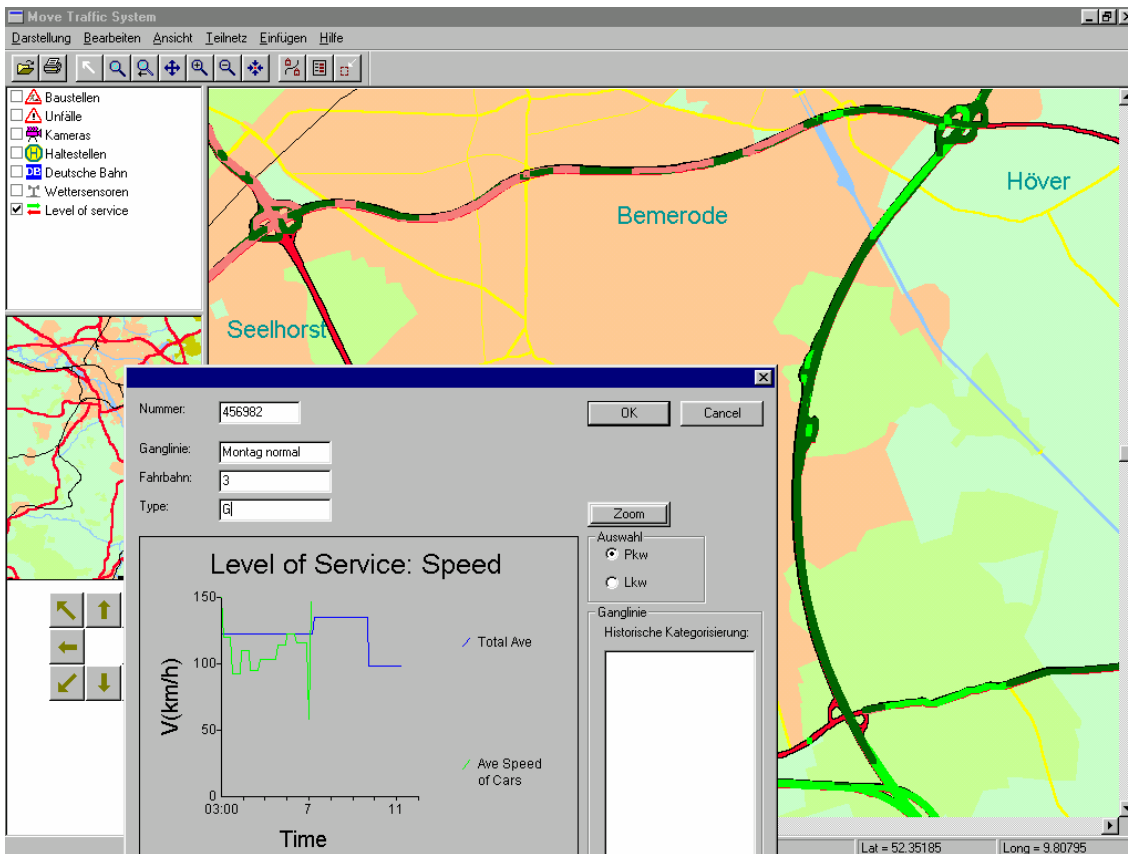
Incoming online measurement data and information derived during data completion and forecast are displayed graphically in the network and may be listed in tabular form, if required. This includes volume flows at individual measurement sites, volumes and speeds for roads as well as turning movements and congestion at junctions. The predicted evolution of flows resulting from forecast calculations is presented as an animated display.

The graphical VISUM user interface provides numerous functions for display of various types of data on the road network. The user can configure displays. Additionally, VISUM provides extensive filter functions which serve for selection of particular information, either via the spatial filter (so-called areas) or via filter parameters (e.g. all major roads with saturation > 80%). For traffic flow assessment, travel times can be displayed for links and routes. Estimated travel times result from the data completion procedure, as well as the knowledge of routes within the network. For the estimation of emissions resulting from current or forecasted traffic flow, two different procedures are provided. Implausible data from detectors (e.g. as detector is faulty or has not been positioned correctly in the network) are marked, data plausibility is checked during data completion.

## 2.5 Forecast

Based on the current network state, a short-term forecast is computed (for 15 minutes up to one hour). The appropriate forecast period mainly depends on size and structure of the network. This is used to determine appropriate management solutions not only on current conditions, but based on what can be expected within the near future. As an example, this allows to set variable messaging signs (VMS) to avoid traffic hot spots expected to develop within the next hour. The ability to predict short term developments is crucial for VMS signs

since it prevents sending motorists into congested areas, which would undermine their trust into the VMS system, thus making it useless.



**Figure 4.** Online-visualization of current traffic conditions (density) in Hanover (TENET)

Incoming traffic at the gates of the analyzed network is derived from current flows and historical flow patterns. Within the network, macroscopic traffic flow simulation models are applied. VISUM includes such a model, which is applied for dynamic traffic assignment calculations. Within the inner-city area, which is mainly signal controlled, the platoon dispersion model formulated by Robertson is suitable, though also simpler models may be used which are based on traffic volumes and mean travel times.

To forecast the incoming flows at network gates, a pattern-based method is applied. Therefore, detector time series are classified in flow patterns and stored in an archive. From this archive, those historic flow patterns are chosen that match most closely the actual measurements. This archive can also be used to substitute estimated values for faulty detectors.