Better answers to traffic congestion

Martin Fix and Volker Waßmuth describe Germany's Validate, the world's largest traffic model.

Validate is currently the world's largest traffic model designed for analysis of current usage levels of, and future demand for, private and commercial road transport. Developed by German transportation planning consultancy PTV, it delivers accurate information about traffic volumes on the highly digitally-monitored German national road network, with its 1.4 million or so road sectors. The resulting information is available for applications including traffic planning analyses, dynamic routing and traffic forecasts.

Traffic and transportation planning is a continuous process, with the interaction between supply and demand leading to new requirements that constantly have to be taken into account. This, of course, is nothing new.

The setting up and maintenance of transportation development plans and traffic masterplans by central, regional or local authorities tend to form part of a single project, for financial and political reasons as well as for planning security. Typically, however, a specialist external consultancy builds up a transportation model, while its maintenance is the responsibility of the owner – usually a public authority.

This formal separation may have negative consequences, for example if the model for a specific local or regional area is not further developed, or if the modelling is discontinued altogether. It is a frequent problem that an expensively-produced transportation model may not be used to its full potential, or may not be kept up to date.

The public authority – and not the consultancy – has the continuing responsibility for the model content. The result is that ongoing maintenance and updating may become more difficult and time-consuming, because there are not enough human and financial resources available.

The effects are clear. After a certain period, the transportation model is no longer up to date. Meanwhile, maintenance of the network with the successive changes that have been made, can prove time consuming and error-prone.

Medium-sized and even large transportation models can nowadays, of course, be handled much more easily thanks to the higher performance of modern computer systems. But even so, their complexity can make it difficult to gain a clear overview of the situation.

Again, different transportation models use different approaches for neighbouring areas with similar characteristics, for example adjacent municipalities, or parts of the same districts or regions. Hence the desirability of establishing a standard basis in order to improve the reliability of data and reduce the time required for its collection and maintenance.

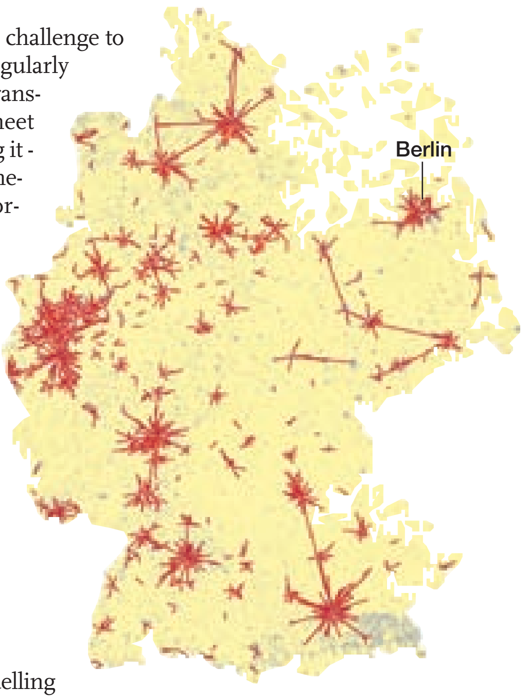
Traffic data basis

Over recent years, PTV has been working on the creation of a comprehensive traffic data basis for the whole of Germany, with the aim of providing the necessary standardised basic data for internal and external use. It has been a major challenge to devise a means of regularly adjusting an existing transportation model to meet new needs, and updating it - without the need for time-consuming and error-prone manual network checks and coding – while keeping costs under control.

The resulting PTV Validate traffic database, which incorporates the modelling process, is now in use in Germany as a trip-end approach to modelling motorised private and road freight transport movements.

It has also proved suitable for modelling other means of transportation.

Generated each year from scratch, it builds on knowledge gained in the modelling and development process of previous traffic models, with alternative approaches and new input data constantly being incorporated into the data pool and so continually enhancing the entire process.



Daily commuter patterns in Germany *(source: German Federal Employment Office)*

The Validate six-step approach

Step	Action
1	Creating traffic zones
2	Creating the network model
3	Collecting and updating structural data
4	Generating demand
5	Assigning calibrating data
6	Quality assurance

Given the size of the model, which currently has some 1.4 million road sectors and 9,800 individual traffic zones, it is essential for each step to be automated, with a particular emphasis on quality assurance. All the steps are linked, and cannot be performed separately; for example, the creation of traffic zones takes the network structure into account.

Key factors within the iterative process of demand modelling are capacity-restraint travel times resulting from the calculations based on congestion levels. To achieve the desired quality and accuracy, it is essential to consider the overall process as well as the optimisation of individual steps.

PTV has succeeded in standardising the process in Validate – which does not claim to provide perfect results down to the very last detail – by aiming to find the best compromise between quality and feasibility. It aims to correctly model supra-regional travel behaviour and improve the level of detail available throughout the development process. This, it believes, is the only way to provide a national transportation model with correct traffic volumes which also cover inner-city areas.

Input data and its availability are of particular importance. All the basic data used is commercially or freely available and regularly updated.

The entire process can be completed regardless of whether some or even all of the basic data has been updated. This also makes it possible to produce a new version of Validate, based on the latest data, very quickly. Standardised processes and data are the key factors.

Traffic zones and travel demand

The first step is to generate the traffic zones; these are not re-generated for each release, unlike the other components. This process has to take into account the three basic types of German region – rural, urbanised or city – each of which is assigned a specific method.

All, however, take account of administrative boundaries to ensure comparability with official statistics. This is an important factor for quality assurance and further processing of results.

An average traffic zone has a population of around 8,400, those in rural areas containing one or more entire communities. In urbanised regions, they centre on 'collectors', which are main roads carrying the bulk of incoming and outgoing traffic; city zoning meanwhile is on the principle of 'natural divisors' – main roads, streets, rail or tram tracks, rivers and other natural obstacles that can cause problems when road users have to cross them.

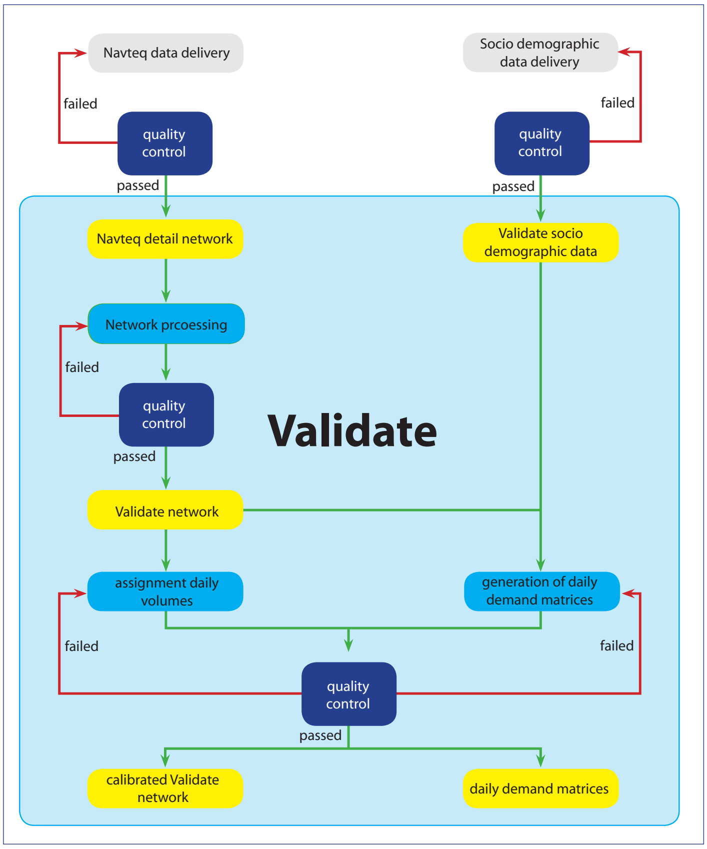
The first part of the zone generation process is fully-automated, using GIS input data and specific algorithms, for subsequent manual editing. This is essential because an algorithm cannot completely fulfil specific model requirements. Manual quality assurance, complemented by automatic methods, also belongs to this part of the process and ensures high-quality results.

This process creates 9,800 traffic zones, which are then used to produce traffic demand calculations with the help of PTV's VISEVA demand-generation software, based on the EVA approach developed by Dieter Lohse of Germany's University of Dresden. This calculates trip purpose- and time-dependent origin/destination (O/D) information based on a minimum of general data input, for example that which is used in transport modelling.

Validate uses commercially-available structural data, such as inhabitants classified by age group, and employees by industry and traffic generation rates; information on car ownership and licences; and the modal split between private and public transport. It then matches this against official statistics at individual municipality level, to ensure national comparability and provide a satisfactory basis for traffic forecasts.

Its calculations are based on 21 groups of people that share homogeneous behaviour patterns. It then divides travel demand into nine travel-purpose combinations (O/D groups), with statistics on relationships between home and work provided by the German Federal Employment Office as an additional source.

The commuter matrix as edited by PTV shows some historical particularities in the spatial distribution of traffic relationships, which cannot be included in a purely synthetic demand calculation. The map of daily commuter patterns *(see page 12)* shows that city-surrounding area relationships in Berlin are considerably weaker than those of smaller German cities such as Hamburg, Munich or Frankfurt.



Flowchart of the PTV Validate process and quality control

The results are purpose-related matrices of DTVw, which is average daily workday traffic, excluding public holidays. Calibration of travel demand is based on modelled trip-length distributions matched against empirical trip length distributions.

The table below shows the difference, using two major regular German traffic surveys, Mobilität in Deutschland (MID) and System repräsentativer Verkehrsbefragungen (SrV). Demand levels for private and road freight transport are calculated separately, the latter in collaboration with German traffic research consultants TCI Traffic Consult International Röhling.

Trip length matching

Trip purpose	Empirical method (MID/ SrV)	Validate
Work	15.3 km	15.3 km
Business	32.9 km	31.8 km
Shopping	10.6 km	10.7 km
Other	20.8 km	20.3 km
All trips	16.9 km	17.0 km

Network model

Validate's network model uses navigation data delivered in geographic data file format four times a year. It automatically integrates this into an assignment-ready transportation network and complements it with important additional information, for example road capacity and speed.

This automated process allows the determination of traffic-related attributes – including mapping provider Navteq's length and speed categories, official speed limits, and categorisation –with the help of a comprehensive set of rules, some 1,000 in all.

Generated information, for example on road bends, is being added. Each new release will be checked for completeness and accuracy, and updated if necessary.

PTV applies specific network-reduction methods in order to obtain a manageable and reasonable number of route sections used for planning purposes. First, it removes all subordinate network sectors, which are only used as residential or feeder roads; second, it compresses the remaining sectors without loss.

This enables the creation of a traffic network model which has approximately 1.4 million sectors on the basis of about 13 million in all. All results calculated with the reduced network model can be re-applied to the original network without loss – an important prerequisite for being able to use the original network on a detailed level, as is sometimes required for local applications.

PTV uses the network model not only as a basis for Validate, but also as a standard data basis for model networks within and outside the company. Standardisation enables the fast and easy creation of high-quality network models while considerably reducing the time and cost involved.

The network model, which covers the entire Federal Republic of Germany, is created once or twice a year. A similar process, based on Navteq data but not on the full Validate scale, visualises traffic flows in other European countries.

Connectors

Connectors are the links between the demand model – the traffic zones and O/D matrices – and the supply model – the network – and are also generated automatically. The subordinate elements of the network model, the population figures and the traffic zones are used as input parameters. The generation method ensures that all feeder points are located at the nodes of the subordinate network model and that traffic can be distributed from here on to the network. The average traffic zone has about five to ten connectors.

This number may increase computation times, but it is very important for detailed distribution of traffic within relatively large traffic zones.

Assignment calculation

The assignment method combines the edited input data, traffic zones, network model, connectors and demand. This is the basis for the calculation of traffic volumes by road section and direction.

The process takes up a lot of CPU time and requires RAM, owing to the model's complexity. It is, however, possible to compute the entire assignment of passenger cars and freight vehicles in less than 24 hours.

Assignment quality is measured by comparing the results with those from permanent the traffic counters of the German Federal Highway Research Institute and other data such as road traffic counts and detector data. A comparison with about 2,000 permanent traffic counters operating in both directions provides a high correlation rate which is more than 95%.

It must be emphasised, however, that this model cannot always reach this high level of performance in every region without local post-calibration. The flowchart on the previous page gives an overview of the standardised process for the creation of the Validate model.

Outcomes

Transportation networks and traffic volumes gained from Validate can be used for example as regional network sections with incoming and outgoing traffic; for transportation planning investigations; to deliver better use of infrastructure; and for all applications requiring information about traffic flow or volume on specific routes.

Similar analyses can have commercial applications. They can, for example, help evaluate potential locations for advertising sites, by indicating routes where the largest number of drivers will come into visual contact with billboards.

For road users, data from Validate can provide realistic journey times. Until now, estimated time of arrival calculation has been less reliable than it might be because travel times were being calculated on the basis of speeds pre-defined for specific road categories independently of time of day and day of week.

Now Validate can be supplemented with measured and historical data from detectors, floating car data and traffic reports. The result: road sector- and direction-related journey times based on day of week and time of day, including allowances for holidays, and weather conditions.

Network model for the Ruhr region

Business and professional users in particular will benefit. In logistics, for example, dispatching becomes much more efficient when drivers can avoid traffic trouble spots.

A company can create more reliable trip schedules, and increase deliveries per trip, because routing recommendations will enable road users with some flexibility to choose a different time – in turn impacting positively on traffic flows.

The outlook

The modelling process is designed to ensure continuous model maintenance within a highly-standardised procedure, so that users always have the latest model data. As soon as new information comes in, for example from traffic counts or structural data, or often new network data, the model can be updated in a time- and cost-efficient manner.

This means that a reliable model basis is available for any type of application, including short-term projects. Next steps will include differentiation of time and network enhancement, to create a multimodal model that includes rail transport.

The success of Validate has already led to its application in other European countries. The basic framework for Validate UK, which is now available, provides a network covering some 600,000 road sections and 8,000 traffic zones. It uses the same German methododology but incorporates some minor UK-specific changes, for example to take account of traffic driving on the left. There are plans for France and Italy, while a similar approach is being adopted in the Greater Chicago area of the US.

High-quality network basics, resulting from advances in the dynamic navigation market, will enable new approaches to traffic modelling. Standardised processes which continuously maintain and update a model, will improve the basic data used for traffic studies and provide more reliable results. Validate is one example of this approach. It would also be desirable to apply similar procedures to other local or regional models, regardless of whether Validate or any other specific software is used for the calculations.

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