Big picture, small picture

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The integration of macroscopic and microscopic transportation analysis...

Transportation analyses are becoming more complex and involving multiple modes, often asking questions that traditional methods are unable to answer. These analyses require the integration of two analysis methods, macroscopic and microscopic, bringing the disciplines of transportation planning and transportation engineering closer together. Recently the PTV Vision® software suite, consisting of the planning model VISUM and microscopic simulation model VISSIM, has provided new software features to support the integrated analysis for either the transportation planner or traffic engineer.

Two levels of analysis

Transportation professionals need both levels of analysis; both have their purpose and there are reasons why each of them uses different data resolution.

The macroscopic analysis is used for strategic planning. Thus it needs a higher degree of abstraction, dealing mainly with aggregated travelers and rarely with time-dynamic methods. Planning models include the ability to forecast the impacts of future land use on travel demand. In the PTV Vision suite, the software VISUM has all the macroscopic algorithms and planning tools necessary for such forecasting. The network model consists of nodes and links – as a consequence intersections and traffic control are highly simplified.

The microscopic analysis is mainly used for operational analysis. It simulates independent entities for vehicles and travelers in time. For traffic engineering, its main advantage is that it can quantify and help explain congestion due to complex transportation systems involving several modes. VISSIM, the microscopic traffic simulator within the PTV Vision suite, allows users to describe networks in high operational detail. As a consequence, the network model is composed of lane and link objects, removing the limitations of the node and link structure, and results in a seamless transition between intersection and roadway.

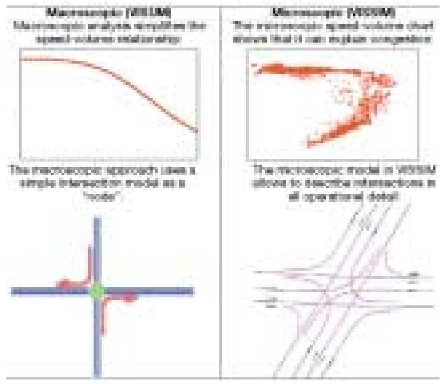

Figure 1: Comparison of macro and micro analysis

Why integrate?

The natural workflow in any transportation project starts with macroscopic planning, then goes to design and operational analysis before the new infrastructure or service will be implemented. Thus there is an exchange of data and concepts from planning into operations during several stages of a transportation project. Integrated tools and models support such exchange of information.

The most efficient process involves the utilization of the macroscopic tool as a decision support mechanism during operational analysis. For example, VISUM is used as a quick response system for the major operational choices, such as one-way or two-way conversions, road opening or closure, or site impact analysis; while VISSIM is used to determine the operational feasibility of such decisions. In addition, the more data shared between planning and operations, the more inconsistencies that can be avoided in both approaches.

Connecting micro and macro models

If there is a regional demand model, the first step of integrated analysis is to cut a sub-area from the regional model and refine it within VISUM. A parallel VISSIM model is then constructed. The two models must correspond, meaning that the databases must be compatible in how they reference different network facilities in all scenarios.

The PTV Vision suite supports the integrated analysis by enabling the creation of the VISSIM microscopic model from the VISUM model. In this case, the two models will automatically correspond. From the point of view of software development, the network export represents a major challenge as the whole microscopic network detail must be generated based on the simplistic macro network. PTV has built a very efficient macro to micro exporter which guarantees corresponding models.

What happens often in practice, however, is that the micro model is derived from a different database, for example from signal optimization software. In this case, VISSIM can create a VISUM network for the strategic planning process. While the two models will automatically correspond, the feedback to VISSIM must be configured to ensure a seamless dataflow. Overall, this process has proven effective for developing small to medium size models that have not been derived from the regional transportation model.

Integrated modeling guidelines

Since this integrated workflow concept is new to both the planner and the engineer, considerations must be made in both models for improving the data communication between the two models.

Additional network resolution is needed in the macroscopic network for demand flow management and volume balancing required for microsimulation. The key is to avoid artificial congestion in the microscopic model, caused by the network or demand being modeled in an inappropriate way in the macroscopic model. Some important guidelines to consider while using an integrated approach:

- Additional zones are needed;
- Several connectors per zone, ideally with enforced percentages (also called 'multi-point' assignment);
- Use virtual mid-block zone feeder links located in between intersections for flow management, consideration must be made for actual capacity based on simulation;
- Transit: use readily available detailed modeling, e.g. stops which are linearly referenced on links instead of abstract node based stops.

Seamless demand data flow

With corresponding network and demand models, the PTV Vision suite

Figure 3: VISSIM multimodal 4d simulation – Munich example

allows a seamless communication of demand data. The suite supports the transfer of travel demand information in three forms:

- The path set (all routes of travelers);
- Trips tables (OD matrices);
- Volumes (for example turn volumes).

The transfer of routes is the best application because it has the highest level of detail. The other two approaches are only an extraction of the path data asset. The path set of a network state is the complete description of how each traveler traverses the network, including the order of all network objects used.

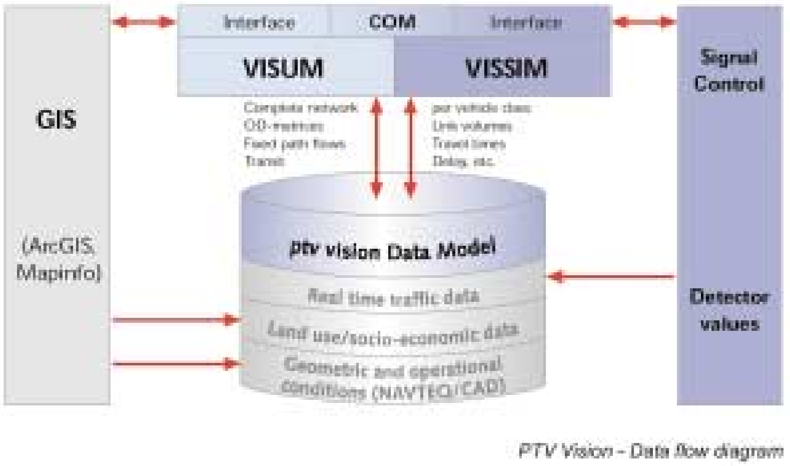

Figure 4: PTV Vision Data Flow within a transportation model

The greatest challenge in practice is to avoid traffic volumes over capacity. In planning models, it is accepted that assignment routines exceed capacity on side-streets and turning movements. In microscopic simulation, however, these same volumes will create artificial spill back and are not acceptable. In practice there is a need to recalibrate the macroscopic models to higher standards of goodness of fit to meet the calibration standards for the microscopic models. Most regional planning models are far from fulfilling the necessary standards, especially since they are seldom calibrated at a turn volume level which is a consideration for microscopic models. Also there is no way around trip table calibration: processing the number of trips until the assignment matches the counts.

One field where integrated modelers are still experimenting with different methodologies is the travel time model in assignment. The PTV Vision suite allows intersection control models embedded in the macroscopic model to determine the delays for the assignment procedure. The most integrated assignment routine is VISSIM's dynamic assignment, which uses the travel times and delays resulting from microscopic vehicle interaction with signal control and network elements. The more integrated the algorithms, the more consistent the results. There are the drawbacks of an integrated assignment, however, such as the complexity of its approach and some loss in the macro model's ability to act as a quick-response system.

Pedestrian integration

The practice of integration over the last couple of years has mainly covered vehicle traffic, as private car transportation or as public bus and rail transportation. There is little experience yet for integrated analysis of pedestrians and bikes. The microscopic simulation in both VISSIM and VISUM models have explicit approaches for non-motorized modes. The shortcoming for integration lies mainly in planning models, where pedestrians and bikes are very simplified if they are modeled at all.

An unsolved problem in practice is to explain on the macroscopic level how and where pedestrian trips cross streets. Current practice typically inserts pedestrian cross volumes into intersection from external sources. For public transportation, PTV Vision suite allows the data flow from macro to micro for the in-vehicle part of their trips. PTV is conducting research on how to improve bike and pedestrian models.

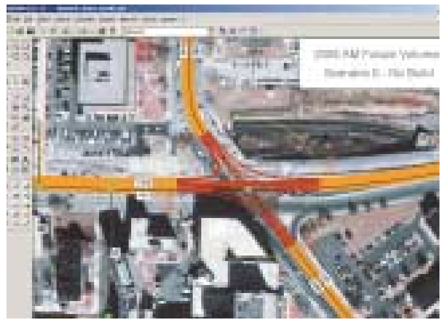

Figure 2: Macroscopic intersection

Fields of application

The best applications of this integrated approach involve models where procedures can be simplified or where conventional planning methods have difficulties estimating capacity.

Several applications of the PTV Vision suite involve downtown networks where vehicle routing becomes difficult for the operational modeler. Using VISUM and the TFlowFuzzy approach to build trip tables and assign paths to match traffic volume counts, VISUM can provide considerable savings for data input into VISSIM. These models may also include VISUM to provide the initial path solution for the VISSIM dynamic assignment process. Other applications involve ITS studies where VISSIM can provide the necessary detail to estimate and evaluate capacity. For example, understanding the impacts of shared lane light rail or bus rapid transit require the use of a simulation environment; that capacity information is then fed back into the strategic planning process. Integrated analysis has also been successfully applied in many freeway studies and helped to determine the effects of design decisions and control strategies on the choices of individual travelers and thus on the overall system performance.

Overall, the PTV Vision suite process has proven to be a time saving and cost-effective process for standard and complex models, and helps the transportation planner or engineer answer questions with more certainty. ■

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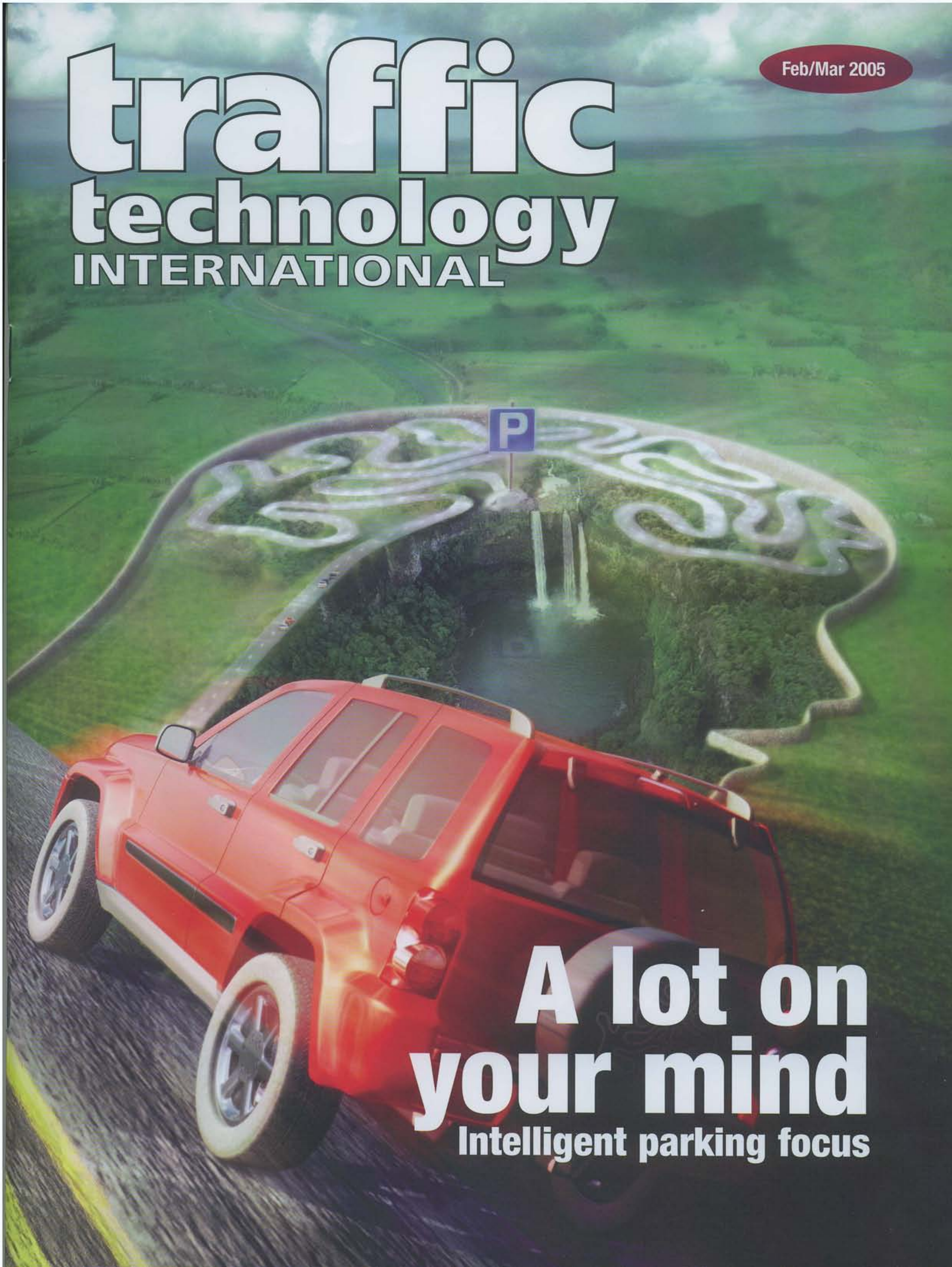

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