by Alexandre Torday & Alex Gerodimos

FUSION POWER

COMBINING THE BEST OF ALL WORLDS FOR BETTER TRANSPORT SIMULATION

Instead of viewing today's various modeling tools as separate and incompatible entities, a more effective method is to integrate them and start to regard each individual component as part of an overall toolbox

For decades now, transport engineers have been increasingly relying on the use of mathematical models and specialist software for analyzing the performance of current and future transportation networks. Macroscopic software packages (generally based on static paradigms) pioneered the field, and were followed later by more disaggregated and dynamic models. Benefiting from the steadily increasing availability of affordable computing power, these more detailed models have become the tool of choice for operational studies, commonly in the form of microscopic simulators. Among other dynamic models, mesoscopic ones have more recently started to receive attention as a viable and interesting compromise between the macro and micro levels. With the introduction of new technologies, data of unprecedented quantity, detail and ultimately quality is set to become available – making nanoscopic models a viable future prospect and an interesting direction for various forms of research.

THE QUEST FOR VICTORY

The proliferation of levels, approaches and software packages inevitably creates a temptation to compare. Comparisons quickly mutate into contests that focus on limitations – after all, those can easily be identified by taking a critical look at a model's underlying assumptions. For example, a static model is by definition not appropriate for studying the impact of different adaptive control regimes. A dynamic equilibrium assignment approach is probably not the most realistic way of predicting driver response to a non-recurrent incident. Using a microsimulator for a 35-year strategic plan without information on the location and capacity of roads – let alone traffic control plans, types of vehicles and driver behavior – is likely to be a waste of resource. Mesoscopic models, whether working with platoons or individual vehicles, are not the most precise when dealing with merging, oversaturated flows, actuated detection and interactions with pedestrians at crossings. And the list continues. Today's fastest microsimulator may be good enough to run a simulation of the entirety of Singapore faster than real time, but it is still far too slow for carrying out real-time traffic analysis in the entire Los Angeles metropolitan area. With its detailed modeling of a driver's decision-making process every fraction of a second, a nanoscopic model seems a promising and appropriate way of analyzing aspects such as emission patterns or ADAS. But what about its (currently) disproportional calibration and computing time requirements?

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The obvious conclusion is that there is no overall 'contest winner' and that each model has its limitations and strengths and those depend on the intended application, data availability, time horizon and evolution of computing and ITS technology. In that sense, promoting a model, principle or approach (no matter how well conceived and developed) as a one-size-fits-all solution seems doomed to fail.

However, this is only the theory. In practice, model developers and practitioners need to do the best job with what they have available so they often have to deal with the temptation to cross a model's 'natural' boundaries. Working with a particular model over several years allows one to develop intelligent 'workarounds', which extend the model's applicability by masking its limitations. The use of devices that vary by model and include penalties, dynamic approximations, fictitious entities and so on is sometimes deployed in real-life projects to include, in proxy form, aspects that were not originally included within a particular framework. Still, no amount of creativity and enthusiasm will make microsimulation the best approach for a 50-year strategic plan, or a static traffic assignment approach the best platform for real-time traffic forecasting. Some boundaries are hard.

Assessing the full impact of new tramlines on traffic conditions in major cities requires the combined use of pedestrian and vehicle simulation models

PERFECT MATCH

Specialist consultants typically adopt an impartial approach, opting to acquire and learn a variety of tools and to use 'the right model for the right job'. Practically, it is both attractive and appropriate to devise informed rules of thumb for choosing a particular approach. Although this is clearly less error-prone than a dogmatic approach, one might question whether it is actually possible to compartmentalize transport engineering projects in such a neat way. Is it really possible to speak of a 'static assignment project' and a 'microsimulation project'? What if one needs both models within the project? And what about mesoscopic approaches? Should we look for 'mesoscopic project' opportunities? What's more, what if one needs to use two types of models iteratively – or even concurrently?

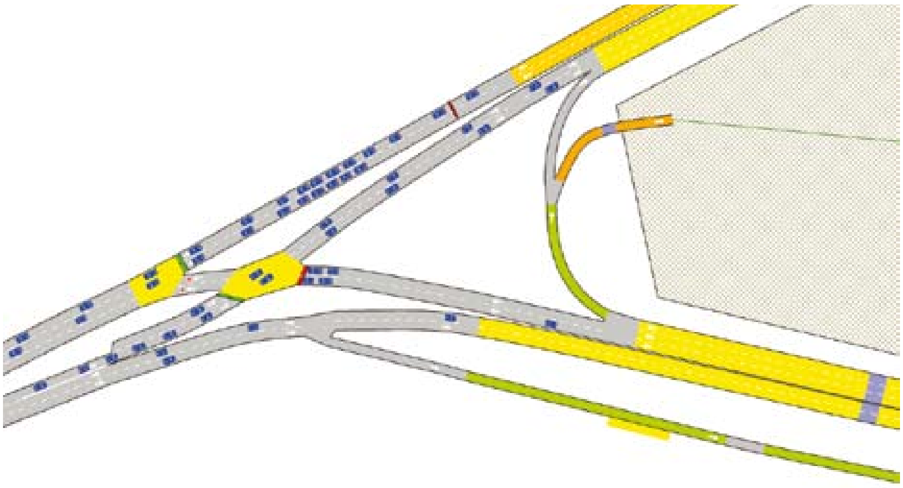
In TSS's experience, real-life traffic engineering and traffic management projects have such varied requirements that drawing lines based on narrow modeling paradigms becomes an artificial exercise.

The company has recently completed a number of projects assessing the impact of new tramlines on the traffic conditions of major European cities. At the detailed level, this is an exercise of optimizing adaptive control (tram preemption) so as to keep the tram moving while minimizing the impact on cross traffic. It is also subject to various other criteria that vary by city.

There is plenty of detailed input and output information available and required, making this type of study a strong candidate for microsimulation. But where should the data come from for such a detailed study? The origin-destination matrix for the base case can be obtained from surveys, but what about the predicted impact of the tramway on modal split? And what about the impact that actual (as opposed to hoped-for) tramway performance will have on modal split? It soon becomes clear that this is not a 'microsimulation project', but rather a complex impact assessment study necessitating the use of (at least) a modal split model, a public transport assignment model, an equilibrium model that may be static or dynamic depending on the available data, and a microsimulation model. In this context, individual models are best tailored to dealing with tasks, not projects.

PREDICTION SYSTEM

The statement that dynamic and disaggregate models are generally much more appropriate for real-time traffic forecasting than static and aggregate ones is hardly controversial. However, once again, the final answer is not that simple. First of all, the identification of the area that needs to be included in an online model is typically the result of extensive what-if analysis in the preparatory phase. The aim of this offline analysis is to quantify the network-wide effect of local disruptions. The task lends itself to a static assignment model as it involves vast areas, comprises hundreds of scenarios, and only seeks to establish an approximate understanding of the impact. Finally, it needs to be performed rapidly.



↑ Snapshot from a hybrid simulation. Traffic around the signalized intersection is simulated microscopically (sections with vehicles) with the mesoscopic model simultaneously applied to the surrounding area (sections in colors)

↑ The Aimsun Online project in Madrid made use of both static assignment models (offline phase) and microsimulation (online phase)

For the online part, when dealing with a metropolis of several million inhabitants and a corresponding number of trips, mesoscopic models provide an excellent balance of performance-versus-calibration requirements, but only for some parts of the network. Other parts may include complex roundabouts, be subject to actuated control, or contain busy pedestrian crossings and other 'problem' areas for which microscopic simulation is more suited. This is a case where not only are the two models (micro and meso) complementary, but they need to be used together at the same time, giving rise to a hybrid simulation that fuses the best elements of both. In this context, individual models are best tailored to dealing with parts of tasks within an overall project.

The model integration that TSS advocates is possible to implement either within a single multi-level framework, or by integrating modeling approaches originally developed independently. The second method relies on the exchange of information via files and lacks some of the convenience, possibilities and economy of the first method. Multiple tools imply duplication of cost, effort and data, and propensity for error. That said, the multi-tool approach is feasible and can be considered in projects where different models are used in sequence. Where TSS believes that a single model and software architecture has a distinct advantage is when models must be used concurrently or iteratively. Working inside the same software is not just a case of convenience for the user (or the developer). For one, the coherence of the two models forming a hybrid is a necessary condition for its robustness and fidelity and the ultimate reason why fusion is the way forward. ■

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