Institute of Transport Economics
Norwegian Centre for Transport Research

**Summary:**

# Evaluation of methods for calculating traffic assignment and travel times in congested urban areas with strategic transport models

*TØI Report 1358/2014*
*Author(s): Stefan Flügel (TØI), Gunnar Flötteröd (KTH),Chi Kwan Kwong (TØI), Christian Steinsland (TØI)*
*Oslo 2014, 57 pages English language*

*Transport processes, i.e. movements of persons and goods in space and time, are by nature dynamic. Decisions on the demand side are made in a dynamic context of reaching and scheduling activities at desirable starting times. The network performance (representing the short-term supply side) depends on traffic flow propagations resulting from dynamic interactions of many vehicles and the given infrastructures. Travel times experienced by travellers in urban areas can vary significantly over the day due to congestion patterns which are both depending on human behaviour (in particular mode, departure time and route choice) and complex physical processes in the network.*

*Our evaluation of traffic assignment models found that dynamic meso/micro models are most appropriate for all application purposes in congested urban areas. The biggest advantages are connected to the realistic modelling of congestion and the richness in analysis (allowing to aggregate results in any desirable way). Those models have some practical challenges/disadvantages. They require more detailed input data, are more demanding with respect to implementation, calibration and usage and set high requirements (expert knowledge) on the users.*

The Institute of Transport Economics (TØI) and Associate Professor Gunnar Flötteröd from KTH's Department for Transport Science had been commissioned by the Norwegian Road Administration to

- Review and compare different methods for calculating traffic assignment and travel times in congested urban areas with strategic transport models
- Discuss how static [travel demand] and dynamic [traffic assignment] models can be combined and to evaluate the advantages and disadvantages of such approaches

Table S1 and S2 summaries the results of the evaluation (the evaluation for "travel demand management" and "equity analysis" rests on the assumption that they are coupled with corresponding disaggregated travel demand models).

*Table S1: Evaluation of network assignment packages for application purposes*

| | Static macro | Dynamic macro | Dyn. meso/micro |
|---|---|---|---|
| **Congestion mitigation** | Inadequate (S) | Adequate | Adequate |
| **ITS** | Inadequate (S,A) | Inferior (A) | Adequate* |
| **Travel demand management** | Inferior (A) | Acceptable | Adequate |
| **Equity analysis** | Inadequate (A) | Inferior (A) | Adequate |
| **Standard Cost-benefit analysis** | Adequate if congestion low | Adequate | Adequate** |

Reasons (S): Static, (A): Aggregated; *micro-level might be necessary **if distributions of predictions are compared

*Table S2: Evaluation of network assignment packages on general model capabilities and practical features*

| | Static macro | Dynamic macro | Dyn. meso/micro |
|---|---|---|---|
| **Robust and accountable** | Yes but potential biased (S) | Sensitive | Stochastic* |
| **Richness in analysis** | Limited (S,A) | Moderate (A) | High |
| **Computation times** | Fast** | Slow | Slow*** |
| **Implementation, calibration, use & maintenance** | Simple (S,A) | Moderate (A) | Involved |
| **Flexibility and extendibility** | Low | Moderate | High |

Reasons (S): Static, (A): Aggregated; *single model runs not robust **slow if number of segments high ***micro-level may be too slow for large scenarios

Static assignment models are inadequate to calculate traffic flows and travel time in congested urban areas. Assuming instantaneous network flows, these models are not capable of accounting for spatiotemporal dynamics of traffic flow. Most static assignment models are based on volume-delay-functions (VDF) which predict travel time delays as an increasing function from traffic flow but independent of the traffic density (level of congestion). This makes travel times estimates in congested traffic conditions unreliably. The same applies to estimates of traffic flow, which come with the additional danger that the model may predict traffic flow beyond capacity, i.e. traffic assignment that is physically not possible. Another shortcoming of these models, especially severe in the context of urban areas, is that these models cannot capture congestion spill-backs. This makes the calculation of travel time and prediction of route choice for links upstream of bottlenecks biased.

For a strategic transport model, i.e. a model systems that couples a travel demand model with a traffic assignment (or traffic flow) model component, an obvious question relates therefore to if and how the static assignment component can be replaced with a dynamic one. Dynamic traffic assignment (DTA) models come in various resolutions and instances, reaching from (aggregated) macroscopic models to (fully disaggregated) micro-simulation models. The adequateness of possible couplings is strongly related to the data structures of the model components. A static/macroscopic travel demand model, as the Norwegian TraMod_by, produces OD-matrices which is a fit to static/macroscopic assignment models that produce inter-zonal travel cost matrices (as Emme or Cube Voyager). Data structures are not directly compatible, when coupling a static/macroscopic travel demand model with a dynamic meso/microscopic assignment model (e.g. coupling TraMod_by with Aimsun meso),. To achieve a technical coupling, methods to disaggregate demand (by exogenous data) are required and for the iterative process, the detailed measures of network performance must be aggregated again before they can feedback to the travel demand model. This will always come with information losses.

For strategic transport models, the questions about appropriate traffic assignment models is therefore inevitably connected to the question about appropriate travel demand models. The best fit to a dynamic meso/microscopic assignment model is a demand model that can fully utilize the dynamic and detailed network performance measure that it produces. The best travel demand models are therefore also dynamic and disaggregated. Activity-based demand models (ABDM) based on all-day trip (activity) lists come in mind. These models have a strong behavioural foundation and can be built on a synthetic population enabling a high degree of traveller's heterogeneity.

Our evaluation of traffic assignment models found that dynamic meso/micro models are most appropriate for all application purposes in congested urban areas. The biggest advantages are connected to the realistic modelling of congestion and the richness in analysis (allowing to aggregate results in any desirable way). Those models have some practical challenges/disadvantages. They require more detailed input data, are more demanding with respect to implementation, calibration and usage and set high requirements (expert knowledge) on the users.

The stochasticity of dynamic meso/micro models is argued to be conceptually favourable but it can involve some challenges in practical applications. In particular, stochasticity affects the prediction from a single model run such that distributions of predictions (rather than fixed point predictions) should be compared. This might be time-consuming in particular for cost-benefit analysis where many alternatives/scenarios need to be compared to each other.

MATSim, which has in Norway been prototypically implemented for the region of Trondheim, is a model system that can be used for dynamic and detailed traffic flow and (short-term) travel demand modelling (i.e. changes in mode-, departure time and route choice but not in destination choice and trip frequency). Its integrated approach avoids information losses and guarantees a one-to-one mapping of decision makers and vehicles. As the standard model in MATSim does not include trip generation and destination choice, it should be coupled with full-fletched ABDM or land use models such to make it applicable for long-term strategic transport modelling purposes.

As dynamic and meso/microscopic transport model systems are feasible and favourable, the choice of which type of strategic transport model to apply amounts to how much simplification one is willing to accept. Even if most (current) application purposes seemingly allow for simplifications (as arguable in ("standard") cost-benefit-analysis that only are meant to provide rough estimates of aggregated measures), pragmatic decisions for simple models put bounds on possible future developments. This is because it is virtually impossible to make a static model dynamic and ad-hoc modifications are likely to be insufficient to truly account for the dynamic nature of transportation processes.

All strategic transport model systems are very complicated and the knowhow of the users are essential for successful modelling and result interpretation. For a possible transition in Norway to more advanced models it is therefore inevitable to educate (potential) users in the theory and practice of these new methods; international collaborations are an effective mean towards this goal.