
# True grid

The Manhattan Traffic Model (MTM) is one of the most complex large-scale simulation models in existence. **Vassilis Papayannoulis** and **Alexandre Torday** explain how this integrated modeling platform is used to assess traffic operations for Manhattan, New York

Images courtesy of TSS-Transport Simulation Systems & Claranet

Manhattan's grid system was introduced 200 years ago, transforming New York into a 'city of angles' and spurring unprecedented development. However, the rigid 90° street matrix also gave birth to vehicular gridlock, jaywalking and a whole new breed of creative parking.

Manhattan's infamous congestion problems are further complicated by round-the-clock truck deliveries, bikes, buses and more than 10,000 taxis, not to mention the pedestrian movements of its 1.6 million inhabitants and vast working and tourist populations. Keeping Manhattan moving is an even more daunting challenge when you add the complexities of traffic enforcement, managed-use lanes, signal coordination, various bridges and tunnels connecting the various New York boroughs, and the disruption of various major construction projects dotting the network.

Small wonder, then, that by 2009 the New York City Department of Transportation (NYCDOT) was feeling the need for an analytical tool that would permit the consistent assessment of the network-wide cumulative impact of current and future traffic management projects. "Our long-term aim," says Michael Marsico, assistant commissioner at NYCDOT, "is to have a base network that forms the cornerstone for future analyses and expansion to other boroughs and where possible, the region."

**It became apparent to NYCDOT that there was a need for an analytical tool that would permit the assessment of network-wide cumulative impacts**

## Model scope

The Manhattan Traffic Model (MTM) is a multi-tier model developed for NYCDOT by Cambridge Systematics, STV and TSS-Transport Simulation Systems. Although it will probably expand in the future, the current model incorporates different levels of detail: the core focuses in fine detail (including pedestrian movements) on the area between 28$^{th}$ Street and 44$^{th}$ Street and includes a microscopic traffic model stretching from 31$^{st}$ Street to 37$^{th}$ Street; the primary area is a detailed mesoscopic model stretching between 14$^{th}$ Street and 66$^{th}$ Street; and the larger secondary area is a less detailed mesoscopic model covering the tip of Lower Manhattan up to 179$^{th}$ Street and also including major links in Eastern New Jersey, Queens and Brooklyn. This area acts as a kind of wide-ranging background model: it covers over 1,000 miles of roadway (2,800 miles of lanes), 1,583 centroids/zones, and millions of private vehicle trips throughout the day, making the MTM one of the most complex large-scale simulation models in existence.

## Building and running the MTM

The MTM covers a sub-area of the New York Metropolitan Transportation Council's (NYMTC) macroscopic Best Practice Model (BPM) – the region's multimodal activity-based travel-demand model that consists of over 3,600 zones and 70,000 links. The BPM is utilized in regional and corridor analysis studies and constitutes, among other things, the primary source for the Origin-Destination (O-D) trip table in the mesoscopic study area. Data from the BPM is also supported in the MTM by a GIS database, which fuses data from a variety of sources and formats and, crucially, includes public transport lines and schedules.

Although this level of detail is sufficient for regional analysis, closer evaluation requires additional network and zonal detail along with a model capable of analyzing the operational effects of any proposed traffic management operations. "There was a need to investigate all of the complex time-varying phenomena in the network, right down to the nuances of parking regulations, transit priority schemes or managed tunnel lanes," Marsico explains.

In contrast with the travel-demand models, mesoscopic and microscopic models are particularly well suited for assessing the traffic operating conditions of congested environments. The mesoscopic and microscopic layers of the MTM both use the Aimsun software, which has also been used successfully by NYCDOT and its consultants in Lower Manhattan, the Upper East Side and Long Island.

The initial trip table for the mesoscopic study area was extracted from the BPM model and then adjusted to reflect more detailed traffic counts in the project area using a series of O-D Matrix Estimation (ODME) techniques, ranging from proportional fitting to sophisticated linear programs. The challenge was to keep the data and calculations consistent between the BPM and the dynamic model. This has important consequences for the bigger picture, as Marsico points out: "All work on the MTM goes hand in hand with the task of maintaining a GIS database where all information for a large-scale dynamic model can be stored while ensuring consistency with the BPM model to facilitate interchanging updates and results from one modeling level to another."

The model includes all applicable traffic signal plans and hour-by-hour information on parking and turning regulations as well as incorporating curbside observations such as the presence of stopped and double-parked vehicles. Surveying played an essential part: although the roadbed may show five available lanes, in practice stopped or double-parked vehicles can reduce that number to three. During a particular simulation, lanes and turning movements become available as a function of time, adding significant complication to the operational characteristics of the model. This is particularly true of tunnel operations where toll booths open and close and lane directions change according to complex and dynamic criteria.

The model includes three scenarios – morning, midday and evening, each consisting of millions of trips – in which drivers select routes in accordance with a generalized equilibrium principle. An important innovation is the software's ability to retrieve data from previous equilibrium runs and use it to set up runs for subsequent periods, in doing so maintaining consistency.

## The best of both worlds

Microscopic traffic simulation models the movement decisions of each vehicle inside a traffic network in every time step - typically every fraction of a second. These models are capable of modeling complex interactions between public and private vehicles, or between vehicles and pedestrians. Their disaggregate nature allows them to realistically represent a variety of complex operational conditions although they require some effort to put together and calibrate.

Macroscopic models rely on relationships between pairs of aggregate measures such as flow, speed and density and, unlike microscopic models, they are typically link-based rather than lane-based. The assumptions they rely on limit in many ways their applicability to operational problems but, at the same time, makes them easy and quick to set up. For these reasons, they are better suited to modeling strategic planning decisions.

Depending on the adopted approach, mesoscopic models may simplify the demand, the supply or just the way these interact, compared to a microscopic model. They can potentially approach the speed and ease of calibrating macro models and (especially if they are lane-based) the dynamic nature and realism of micro models; as such, they excel in dealing with medium-term planning decisions with straightforward operational challenges. In the form of concurrent hybrid simulation, mesoscopic models are the ideal complement to microscopic models approaching what might be thought of as 'the best of both worlds'.

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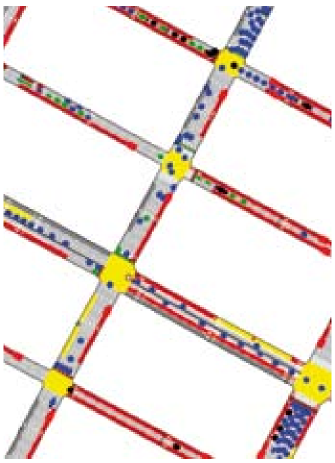

(Below right) **A screen shot showing the less-detailed secondary area mesoscopic model** (Below left) **Showing more detailed microscopic data**

### What's next?

With the mesoscopic model calibrated and the microscopic area nearing completion, future plans include the addition of detail in areas where previous modeling work has been undertaken.Marsico also explains that NYCDOT is working with other regional agencies to coordinate modeling activities where the MTM network will be made available to address cumulative network impacts of construction projects, roadway closures and traffic operations plans, as well as to provide a point of departure for future work. "By working with other agencies, we can leverage ITS data to create a sustainable regional model," he concludes.

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