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Operational Implementation of the TASHA Agent-Based Microsimulation Travel Model System in the Greater Toronto-Hamilton Area [ITM # 14]

Abstract

The University of Toronto (UofT) has a long history of working actively with the City of Toronto, the Ontario Ministry of Transportation, other transportation planning agencies in the Greater Toronto-Hamilton Area (GTHA), and the local consulting community to improve the operational state of travel demand modelling practice within the region. This collaboration has been mutually beneficial in that it has provided UofT researchers with the opportunity to work on a wide variety of basic and applied research topics of practical importance while providing cost-effective support for regional agency modeling needs. Most recently this collaboration has resulted in the implementation of a state-of-the-art activity-based microsimulation model of urban weekday travel (TASHA) for the GTHA for operational planning applications by the City of Toronto. This brief's objectives are to:1.Describe Toronto's university – public agency collaboration. 2. Provide an overview of the TASHA operational implementation.

Statement of Financial Interest

The author is a university professor describing university-based research and how it has been used to advance operational planning practice in the Toronto region. All software described in the paper is open-source. There is no financial or commercial implications of the work or the models reported in the paper.

Statement of Innovation

The paper describes two innovative components: 1. A very successful university - planning agency collaboration that provides a very cost-effective means of advancing operational modeling methods. 2. Operational implementation of an activity-based travel modeling system that differs from standard tour-based methods currently common in the US.

Operational Implementation of the TASHA Agent-Based Microsimulation Travel Model System in the Greater Toronto-Hamilton Area

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1. INTRODUCTION

The University of Toronto (UofT) has a long history of working actively with the City of Toronto, the Ontario Ministry of Transportation, other transportation planning agencies in the Greater Toronto-Hamilton Area (GTHA), and the local consulting community to improve the operational state of travel demand modelling practice within the region. This collaboration has been mutually beneficial in that it has provided UofT researchers with the opportunity to work on a wide variety of basic and applied research topics of practical importance while providing cost-effective support for regional agency modeling needs. Most recently this collaboration has resulted in the implementation of a state-of-the-art activity-based microsimulation model of urban weekday travel (TASHA) for the GTHA for operational planning applications by the City of Toronto. This brief's objectives are to:

1. Describe Toronto's university – public agency collaboration.
2. Provide an overview of the TASHA operational implementation.

2. THE TORONTO UNIVERSITY – PUBLIC AGENCY COLLABORATION

The current era of UofT collaboration with GTHA transportation agencies began in the mid-1980s with the undertaking of the first Transportation Tomorrow Survey (TTS) in 1986. Modeled on the successful Montreal travel survey program that had been underway since 1972, TTS is an on-going program for collecting large-sample (5% of regional households), one-day trip information on an every 5-year basis.[1] While not without its weaknesses, the TTS provides a very rich database for travel demand modeling and for analyzing regional travel trends over time (Miller and Mercado, 2010). TTS surveys have been undertaken in 1986, 1991, 1996, 2001, 2006 and 2011, providing a 25-year time-series of consistent repeated cross-sectional data for the Toronto region. With over 150,000 households surveyed over a 3-month period in the fall of the survey year, TTS is arguably the largest urban travel survey program in the world. While TTS is funded by all the regional transportation agencies and the Province of Ontario, the Data Management Group (DMG) at UofT manages the TTS data collection process on their behalf

[1] For further details on TTS see: http://www.dmg.utoronto.ca/transportationtomorrowsurvey/index.html.

and then maintains the TTS data in a relational database management system. The data are publically available through an interactive web interface maintained by DMG, as well as through requests to DMG staff for more complex data queries not supportable by the web interface.

In addition to the TTS data, the DMG has long maintained the Emme network modeling software and associated base networks for regional planning agency use. The use of a common, centrally-supported network modeling system has led to the development of strong network modeling expertise within regional agencies and considerable collaboration among these agencies in terms of the sharing of data, networks and expertise. UofT, again, has also benefited from having royalty free access to the Emme software through the DMG licences and computer system.

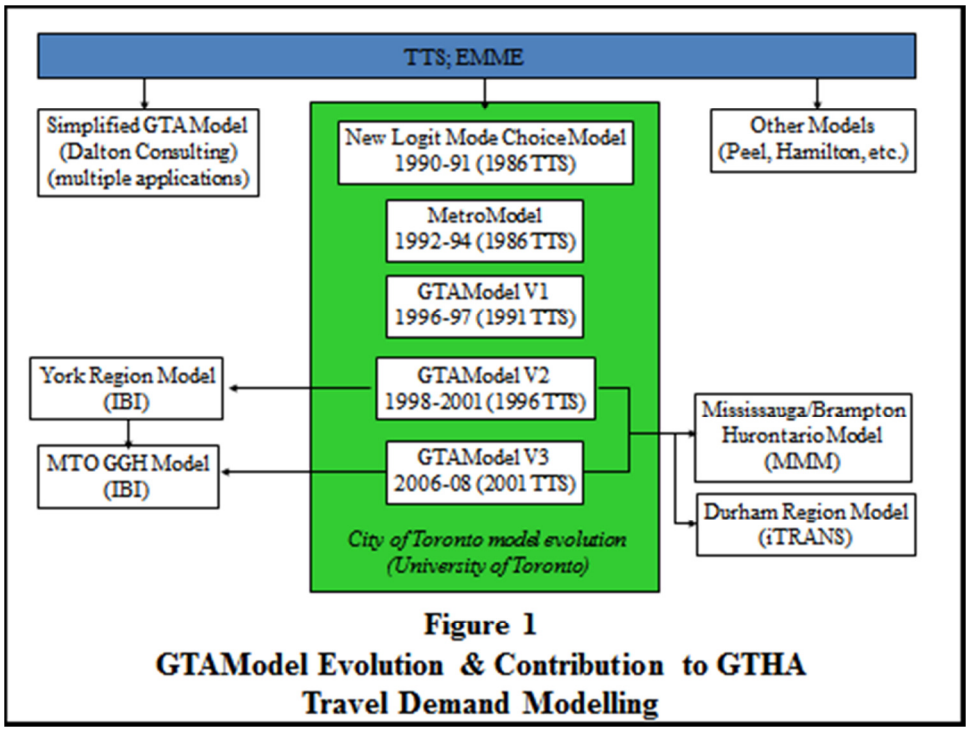


Figure 1
GTAModel Evolution & Contribution to GTHA Travel Demand Modelling

The DMG has been extremely successful in meeting the travel data management needs of the region in a cost-effective, professional, reliable manner while also providing a huge resource to university researchers who have access to the data for their research work.[2]
Building upon the availability of the TTS database and the Emme network modeling capabilities, UofT has worked regional agencies and consultants in the GTHA to develop best-practice four-step model systems for the region. As illustrated in Figure 1, these models largely derive from UofT-based work which has developed over time a fairly standardized "model system template" for regional modeling, known as GTAModel. In particular, various versions of GTAModel are the operational model systems for the City of Toronto, the Region of Durham and the Cities of Mississauga and Brampton, while two of the other major model systems – the York Region

[2] See: http://www.dmg.utoronto.ca/.

model and the Ontario Ministry of Transportation's (MTO) "GGH Model" are largely derived from the GTAModel basic design.[3] Key features of GTAModel include:

- The conventional work trip distribution model is replaced by a "place of residence – place of work" (PORPOW) model in which workers are linked to jobs, as opposed to connecting work trip productions to trip attractions. Work trips are then generated and split by mode given known worker places of residence and employment.
- Considerable attention is paid to mode choice, particularly "getting transit right", given the critical role that transit plays in the region and the complexity of the region's multi-agency and "multi-modal" transit system.

This model development work has been organized so that development occurs "off-line" from day-to-day planning applications and, as much as possible, disconnected from urgent deadlines associated with specific planning studies. This permits new model updates/versions to be developed and tested before the model goes into service. It also means that experimentation/research into new methods can be undertaken without the pressure to simply adopt the "tried and true" to meet short-run deadlines.

Starting in 2011 the UofT-GTHA agencies modeling R&D relationship was formalized through the creation of the Travel Modelling Group (TMG). TMG involves UofT faculty, students and full-time technical staff working on the development of models and "modeling support tools" that are of common benefit to the participating agencies. This has included developing a common regional network coding standard, building base networks for all TTS survey years, and developing a large "tool kit" of standardized Emme Modeller scripts and other "tools" for data manipulation and analysis, model parameter estimation and network analysis and modeling.

The biggest task undertaken by TMG to date has been the development of the eXtensible Travel Modelling Framework (XTMF), which is very modular software within which travel model systems can be readily constructed from common base modules. This is facilitating the development and sharing of common model systems and the evolutionary improvement of model systems without requiring massive reprogramming or re-invention of modeling tools and capabilities. Both GTAModel and TASHA (discussed below) have been implemented in XTMF, and it is expected that most, if not all, regional modeling will eventually migrate into this common software environment, thereby further facilitating sharing of ideas, data, models and expertise. XTMF is written in C# within .net for a PC Windows environment, but can also run under Linux. It currently seamlessly interfaces with Emme, but can readily work with other network modeling packages as required.

3. TASHA

The Travel/Activity Scheduler for Household Agents (TASHA) has been under development at UofT since 2001. It began as a project to develop a model of 24-hour weekday travel for the City of Toronto to use to predict transportation-related greenhouse gas emissions associated with various regional land development policies that were being debated at that time (Miller and

[3] Why there are so many model systems active within the GTHA is a good question but well beyond the scope of this research brief to answer!

Roorda, 2002). Since this initial implementation (Miller and Roorda, 2003), TASHA has undergone continuing development (Miller et al., 2005; Roorda et al., 2006, 2008, 2009b), been tested in applications in Montreal, London and Changzhou, China (Deng et al., 2014), and been used in various analyses of transportation environment impacts (Hatzopoulou et al., 2007, 2011). Key features of TASHA include:

- It is an agent-based microsimulation in which every person and household within the analysis region is synthesized and their weekday out-of-home activity patterns and associated travel are simulated.
- It is a household-based model in that each person exists within a specific household and household interactions (resource sharing, joint activities, constraints) are explicitly modelled in detail.
- It is an activity-scheduling model, in which each individual's daily activity pattern is "built from scratch" given person activity participation needs. Arbitrarily complex activity patterns (and associated trip chains) ae generated without having to pre-determine a feasible set of patterns/tours.
- Mode choice is determined on a tour basis. Tour-level feasibility constraints (e.g., if a car leaves the driveway it must return) are enforced. Again, arbitrarily complex tours (including work-based or other non-home-anchor-based sub-tours) can be readily handled and do not require prior specification of feasible tour combinations.
- Within household allocation of cars to drivers is explicitly modelled, as is within-household ridesharing and participation in out-of-home joint activities.
- It models all out-of-home activities and their associated trips in continuous time.

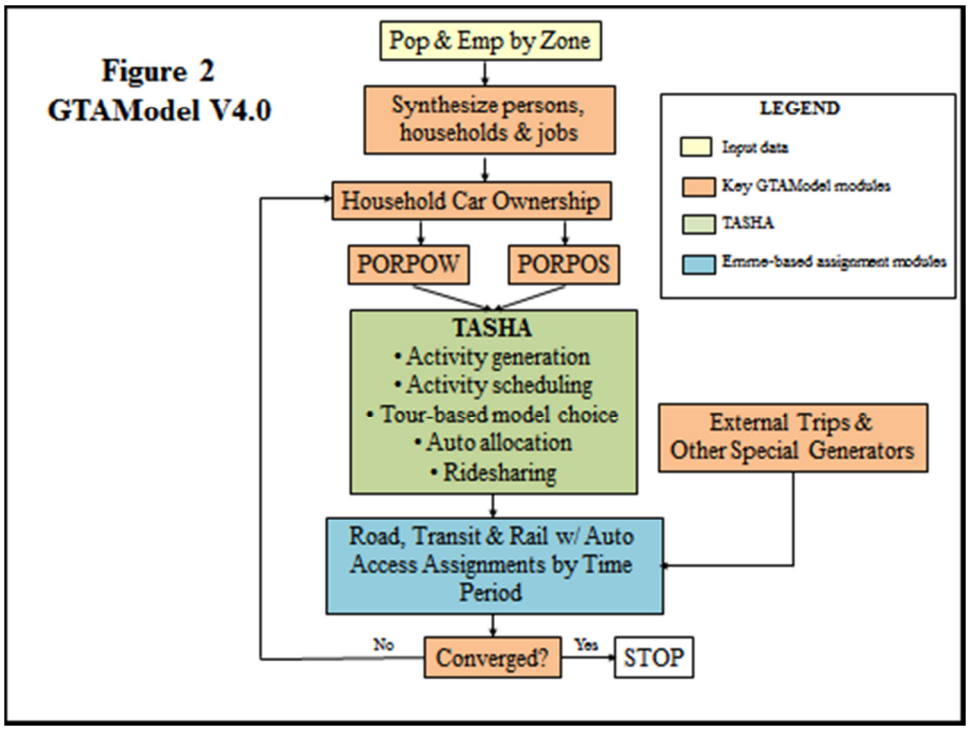
TASHA has been designed to replace the generation, distribution and mode choice stages of the standard four-step modelling process. It can integrate with a variety of network modeling packages for road and transit route choice. Currently interfaces are operational for Emme and MATSim (Gao et al., 2010). It has also been designed to be used as a stand-alone travel model system (such as in the application described below) or as part of a larger integrated transportation – land use model system.

While it can make use of more detailed activity diary data, TASHA has been estimated and calibrated using standard trip survey data. TASHA was originally developed using 1996 TTS data and was subsequently validated against 2001 TTS data. It is currently being completely updated and re-estimated using the recently released 2011 TTS dataset.

4. CITY OF TORONTO IMPLEMENTATION: GTAMODEL V4.0

TASHA must interface with road and transit network models to determine path choices and transportation network level-of-service attributes. It also assumes that its person and household agents living in each traffic zone have been previously synthesized, including workers' workplaces, students' school locations and households' automobile ownership levels. As shown in Figure 2, GTAModel V4.0 is an extension of earlier operational versions of GTAModel that brings all these pieces together (with TASHA as its "kernel" activity/travel generator) into the overall travel demand forecasting system being implemented for the City of Toronto. Key points to note concerning the V4.0 model system include:

- It is fully implemented within the XTMF software system, thereby ensuring maximum modularity and extensibility, as well as compatibility with other regional model systems.
- Population synthesis is performed using a modified version of the "full joint distribution" approach recently developed by Farooq et al. (2013).
- Household auto ownership levels are endogenously generated and are sensitive to household travel needs and stresses as determined by TASHA. This model builds on earlier work by Mohammadian and Miller (2002, 2003), Roorda et al. (2009a) and Duivestein (2013).
- Staying within long-standing GTHA practice, workplaces for each worker are assigned based on a disaggregate doubly-constrained entropy model for each of four worker occupation groups and two employment status levels (full-time and part-time). Explanatory variables within the entropy model "impedance functions" (aka utility functions) include modal levels of service and household auto ownership levels. Doubly-constrained entropy models are still widely used in Canada since they balance workers and jobs and the model can be viewed as static (Nash) equilibrium representation of the urban labour market.
- Student's school locations are currently modeled extremely simplistically by simply factoring up base year distributions to reflect the future year student population. This reflects a current lack of good data within the region to build a better model and is clearly an area for future research and development.
- Considerable attention is paid to modeling commuter rail and subway access mode and station choice, given the important role that these modes play in the region's commuting patterns. A new, detailed method for computing auto-access rail path choices has been developed that accounts for both parking lot and train capacity constraints within a stochastic user equilibrium framework.



5. CURRENT & FUTURE WORK

At the time of this brief's submission the V4.0 model system is being estimated and calibrated, which is why no results are reported herein. By the time of the ITM conference it is expected that the model system will be undergoing operational testing and validation by the City of Toronto and these results that are available at that time will be reported then.

In addition to being the new operational model for the City of Toronto, GTAModel V4.0 will provide the "research platform" for TMG to continue the development of improved modeling methods. We already have many ideas concerning "V4.1" and "V4.2" model systems that will incorporate a variety of improvements (e.g., improved non-work-school activity episode location choice; improved school location models; between-home car-pooling; etc.). Many of these will require recoding the TASHA core activity generation and scheduling modules, something we did not want to undertake as part of this initiation operational implementation of TASHA.

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