travel modelling group

ANNUAL REPORT, 2020-21

Eric J. Miller, Ph.D. Brendan Reilly, h.BSc. James Vaughan, h.BSc. Yang (Luna) Xi, B.A.Sc., M.A.Sc.

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1. **INTRODUCTION**

This document describes the activities of the Travel Modelling Group (TMG) during its 10th year of operation, 2020-21 (April 1, 2020 through March 31, 2021).

Section 2 summarizes and comments on TMG activities and outcomes during the reporting period. Section 3 then describes the TMG budget and resources that enabled these activities.

2. **2020-21 PROJECTS & ACTIVITIES**

2.1 Introduction

Table 2.1 presents the 2020-21 work plan as approved by the TMG Steering Committee. As indicated in this figure, the work plan tasks divided into 12 primary tasks. TMG activities in each of these areas are discussed in the following Sections 2.1 through 2.12, inclusive. Section 2.13 then discusses additional significant TMG activities over the past year not included in the official work plan.

TMG 2020-21 Work Plan		MONTH	1											Days A	located
No.	TASK	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total ¹	%
1	Large-Scale Model System Calibration Guidance	3	3	3	2									44	8.5%
2	Large-Scale Model System Convergence Testing & Guidance				2	3	3	3						44	8.5%
3	Volume-Delay Function (VDF) Evaluation & Calibration								3	3	3	3		48	9.2%
4	PORPOS Modelling ²	2	2	2	2	2	2							48	9.2%
5	PORPOW Modelling							2	2	2	2	2	2	48	9.2%
6	Traffic Zone System Update ³													0	0.0%
7	GTAModel Maintenance & V4.2 Release	2	2	2	2	2	2	2	2	2	2	2	2	96	18.5%
8	TMG Aimsun & Emme Toolbox Development & Maintenance	1	1	1	1	1	1	2	2	2	2	2	2	72	13.8%
9	XTMF: Upgrades/ Maintenance & V2.0 Release	2	2	2	2	2	2	1	1	1	1	1	1	72	13.8%
10	Documentation of TMG products	1	1	1	1	1	1	1	1	1	1	1	1	48	9.2%
11	Outreach & Training (3 workshops)		W1				W2					W3		520	Total
12	Meetings: TMGSC (2) & TMGTAC (5)	TAC		TAC		TAC		SC	TAC		TAC		SC		
	TMG Staff Average Weekly Time Allocation (Days) ⁴ 11 11 12 11		10.8												
Suggested Workshops ⁵															
W1	Volume-Delay Function (VDF) Evaluation & Calibration														
W2	Large-Scale Model System Calibration Guidance														
W3	Large-Scale Model System Convergence Testing & Guidance														
Lege	nd														
n	Lighter, on-going effort n = approximate, average number of TMG days per week for this task														
n	Heavy, focussed effort														
	"Research" activity														
	"Maintenance & support" activity														

Table 2.1: 2020-21 Work Plan

2.2 Large-Scale Model System Calibration Guidance and Convergence Testing & Guidance

Calibrating a large-scale regional travel demand model system such as GTAModel or GGHM4 is a non-trivial and very time-consuming task. It is much an "art" as a "science", despite decades of experience among planning agencies and modelling consultants worldwide. Global, systematic/automated model system wide optimization of parameters is not a feasible proposition at this time, despite research efforts aimed at this objective.¹ Nevertheless, more systematic procedures and guidance for the calibration of a model system such as GTAModel V4 are

¹ Najmi, A., T.H. Rashidi, J. Vaughan and E.J. Miller, "Calibration of Large-Scale Transportation Planning Models: A Systematic Approach", *Transportation*, 2019. DOI: 10.1007/s11116-019-10018-6.

required in order to ensure that operational implementations are as robust and credible as possible.

Closing associated with model system calibration is the issue of determining convergence criteria, which are required at two levels within a travel demand forecasting model system: convergence of both road and transit assignments within each "outer loop" iteration of the model system, and the convergence of this "outer loop". i.e., the overall model system. The later is particularly crude at the moment in GTAModel, simply consisting of iterating the model system for a fixed number of iterations. Appropriate convergence criteria, however, are very important for both minimizing model system run times and for ensuring that model runs do, indeed, converge, as opposed to simply terminating at an arbitrary point in the "solution space".

These two issues of model system calibration and convergence were jointly investigated. Four activities were undertaken with respect to this combined task:

- 1. A workshop was held on May 6, 2020 to discuss model calibration issues and options. The appendix contains the workshop agenda and workshop presentations are available on the TMG website.²
- 2. Updated methods for model system calibration were used in the development of GTAModel V4.2 (Task 7, below), notably with respect to transit assignment parameter calibration.
- 3. A range of convergence criteria for both the network assignment models and the overall model system where tested, with these tests examining the level of convergence achieved (based on industry standard convergence criteria) versus the computation times involved. Trade-offs between various levels of "tightness" in assignment convergence criteria versus overall model system convergence and overall run times were investigated.
- 4. A report documenting the findings of this task and guidance for calibration methods and convergence criteria was prepared and is available on the TMG website.

Calibration and convergence issues will continue to be investigated as part of continuing work in 2021-22 of developing improved volume-delay functions for the region (Task 3).

2.3 Volume-Delay Function (VDF) Evaluation & Calibration

Calibration of the volume-delay functions (VDFs) used in Emme road assignments in the GTHA has never received the same level of attention that transit assignment models have received. This task represented a first step towards addressing this gap. Tasks undertaken included:

- Review data availability within the GTHA for VDF parameter calibration.
- Review the literature to identify best practice.
- Identify a list of issues to be addressed (intersection vs. link segment delay, turning movements, treatment of tolled highways, etc.) and options (with respect to functional form, etc.).
- Sensitivity testing of parameters in the current VDFs.
- Recommended work plan for developing and testing improved VDFs for the GTHA.

² https://tmg.utoronto.ca/documents/#workshops



A report documenting the findings of these preliminary investigations is available on the TMG website. Work on testing improved VDFs will continue as part of the 2021-22 TMG work plan

2.4 Place of Residence – Place of School (PoRPoS) Modelling

School location choice (elementary, secondary and, especially, post-secondary) is a significantly under-studied component of the overall travel demand modelling process. As a result, these models are typically very simplistic relative to other model system elements. School travel, however, is a very important component of overall daily travel (particularly during peak periods) and of considerable policy interest. Modelling school location choice well, however, is a non-trivial task, for a variety of reasons, including (often) lack of detailed data concerning school locations and capacities, as well as lack of explanatory variables to robustly explain why students do not simply travel to the nearest school. The complexity of the Ontario education system, with its three parallel systems of public, Catholic and private schools, also poses challenges. To begin to address this gap in our modelling capabilities two undergraduate summer research students (Ethan Baron and Gonzalo Santos) worked with TMG staff to undertake the following tasks:

- Review of the literature to identify best practice in the field.
- Assembly of data concerning school locations and capacities/enrollments by school classification.
- Empirical analysis of school location choice by level for using TTS 2016 and StudentMoveTO 2015 and 2019 to identify relationships between location choice and potential explanatory variables, including travel distance/time, household income and household employment/occupation status, among other possible variables.
- Develop and test of a range of location choice models for each school level.

A report documenting the findings of this work is available on the TMG website.

2.5 Place of Residence – Place of Work (PoWPoR) Modelling

Modelling PoRPoW linkages is a critical step in travel demand modelling, given the important role that work trip commuting plays in daily travel. While the parameters of the current model in GTAModel is continuously updated as new versions of the model are developed, the overall approach to PoRPoW modelling has not been revisited for some time. In this task, a few first steps were undertaken towards developing an improved PoRPoW model structure:

- Investigating how the model system iterates through PORPOW and whether this introduces unwanted "instability" in the results, in terms of model system convergence, comparison across alternatives, etc.
- Improving model specification, including investigating incorporating additional variables (such as income) in the model.
- Reviewing options for modelling working from home.
- Revisiting the relationship between workplace location and auto ownership. GTAModel V4.1 adopted the GGHM4 approach of determining PORPOW prior to determining household auto ownership. Arguments, however, for a more joint approach (or at least some form of "feedback" between the two decisions exist.

A report documenting the findings of this work is available on the TMG website.

2.6 Traffic Zone System Update

TMG has been working with DMG to develop a new base traffic zone system for the GTHA to replace the 2006 TTS zone system, which is the last "standard" zone system currently available. The new zone system will incorporate the many changes that regional agencies have introduced into their zone systems over the past number of years. It will also include an extended "Planning District" systems to replace the 46-zone system that has been in use for decades and is now clearly outdated given the massive growth that has occurred in the region. The new draft zone system will be released for comment in April, 2021. Once finalized, it will become the standard, base zone system for TMG modelling and analysis work.

A report discussing traffic zone system design and providing guidance for zone system design has also been written and is available on the TMG website.

2.7 GTAModel V4 Maintenance & V4.2 Release

Various versions of GTAModel V4 are now being used or are in the process of being adopted by the Cities of Toronto, Mississauga, Brampton and Vaughan and by the Regions of Durham, Halton and Peel. As usage of the model system increases, so does the need for TMG staff to provide technical support to the agencies and their consultants using the software and to continuously update/fine-tune the software as usage identifies weaknesses in the code that can be incrementally improved. Considerable TMG staff time over the past year has gone into providing this on-going support to our member agencies and their consulting support teams.

The latest version of GTAModel, V4.2, incorporating numerous upgrades of V4.1, was also released in March, 2021.

2.8 TMG Aimsun & Emme Toolbox Development & Maintenance

A primary rationale for the TMG is to develop standard tools, procedures and templates for general use by member agencies. Historically, these tools have been primarily of two types: XTMF-based modules and Emme/4 Modeller procedures. Continuing work begun in 2019-20, an Aimsun Toolbox has also been developed and is undergoing continuous testing and elaboration. V2.0 Toolbox modules have also been under development to work with XTMF 2.0. All Toolbox modules and documentation are available on the TMG website.

2.9 XTMF Upgrades/Maintenance & V2.0 Development

Similarly, XTMF, as a primary software system for TMG work, is constantly being upgraded, it needs to be maintained, and technical support needs to be provided for its use by member agencies, their consultants, etc. Incremental additions and improvements (and associated updating of documentation) occurs continuously as needed, and as they are generated by continuing development of the TMG Toolbox and other TMG modules and models. V1.8 is the most recent release of XTMF.

As time has permitted, work has continued on developing a significantly upgraded and redesigned XTMF V2. In addition to a major refactoring of the XTMF design, this new version will include a major rewrite of major TASHA components that are at the core of GTAModel. V2.0 is also essential to support the expected major upgrade of GTAModel to V5.0 (a similarly



major upgrade and redesign of the model system), which is anticipated to commence in 2022. A prototype of XTMF 2.0 is planned to be demonstrated during the 2021-22 work year.

2.10 Documentation of Software & Models

Up-to-date documentation of GTAModel V4.1, XTMF and Emme Toolbox modules is available on the TMG website. Website improvements and updating are on-going tasks.

2.11 Outreach & Training

A critical component of TMG activities in all phases of its work must be training, technology transfer and outreach. In order to succeed, TMG must be responsive to its collaborating partners' needs. It must also get the tools that it is developing into the hands of its partners for their use. The TMG's role is intended to be one of tool developer, not to be the user of these tools on behalf of its partners in operational applications (except in special cases). In addition to Task 9 documentation and website maintenance activities, 2020-21 activities included:

- Six meetings were held with TMGTAC to discuss work in progress, next steps in the work plan and to disseminate work plan results.
- Three training workshops were held to present and discuss in greater detail recent TMG work and products:
 - February 5, 2020: "Mobility Tools & Services"
 - May 6/20: "Calibrating Large-Scale Travel Demand Models: Issues & Options"
 - December 9/20 "Population Synthesis Methods for the GTHA".

Given the COVID-19 pandemic restrictions, these meetings were all held on-line. An advantage of this necessity was that the workshops could be opened up to a much a larger audience of professionals and students. See the appendix for workshop agendas. Workshop presentations are available on the TMG website.³

2.12 Steering Committee Meetings

In addition to the TMGTAC meetings discussed in Section 2.11, two meetings with the TMG Steering Committee (TMGSC) were held (on October 7/20 and March 3/21) to discuss work plan progress, budget, overall TMG directions for work and other administrative and supervisory matters.

2.13 Additional TMG Activities

In addition to the tasks scheduled in its work plan and discussed in the sections above, TMG undertook a number of additional activities in support of research and planning activities within the University and the GTHA planning community. These included:

- Starting to develop a modified version of GTAModel (dubbed "Version C19") to provide a platform for modelling pandemic impacts on GTHA travel behaviour. This work will be ongoing in 2021-22 TMG activities.
- Development of a transit operating cost model for GTHA transit agencies and implementation of this model within the TMG Emme Toolbox: a summer project by

³ https://tmg.utoronto.ca/documents/#workshops



undergraduate student Peter Lai. A report documenting the work and the resulting model is available on the TMG website.

- Research project funded by Mitacs and Telus Communications, Inc. to explore the use of Telus cellphone trace data for travel demand modelling purposes. An immediate application of the research will be using the time-series Telus database to document changes in travel behaviour through the pandemic, from initial lockdown in March 2020 to the current day. This work is in a preliminary stage and will continue through 2021-22.
- Support for:
 - HDR applications of GTAModel on behalf of ETR407.
 - Mott Macdonald study of TTC fare integration options.
 - GTAModel implementations for research purposes in:
 - Melbourne, Australia (Collaborator: Prof. Hai Vu, Monash University).
 - Sydney, Australia (Collaborator: Prof. Taha Rashidi (University of New South Wales). This work has supported the development of a combined travel model

 COVID infection model to test the efficacy of control strategies in the Sydney context.⁴
 - Regina, Canada (Collaborator: Prof. Madeleine McPerson, University of Victoria).
 - Temuco, Chile (Collaborator: Prof. Juan Carrasco, Universidad de Concepción).
 - Helsinki, Finland (Collaborator: Prof. Nønne Prisle, University of Oulu).
 - Various graduate student projects.

3. **2020-21 BUDGET & REVENUES**

Table 3 1 presents the 2020-21 TMG expenditures and revenues. This budget supported two fulltime technical staff persons (Luna Xi, Network Modeller/Analyst and Brendan Reilly, software programmer/designer), one day a week of UTTRI's Senior Software Architect, James Vaughan, and, in whole or in part, three undergraduate summer student research assistants (Ethan Baron, Peter Lai and Gonzalo Santos).

⁴ Journal papers under review documenting this work are:

Najmi, A., F. Safarighouzhidi, R. MacIntyre, E.J. Miller, and T.H. Rashidi, "Facemask and social distancing, pillars of opening up economies", submitted to *Sustainable Cities & Society*, 2020.

Najmi, A., F. Safarighouzhidi, E.J. Miller, R. MacIntyre and T.H. Rashidi, "Easing or tightening control strategies: Determination of COVID-19 parameters for an agent-based model", submitted to *Sustainable Cities & Society*, 2020.

Table 3.1: 2020-21 Expenditures & Revenues

TMG Budget	2020-21	
Expenses	Amount	
Salaries ¹	\$211.965.02	
Supplies, Misc. Expenses	\$250.00	
Emme & Aimsun Licences	\$6,000.00	
Contingency	\$0.00	
Overhead (@40%)	\$76.857.14	
Total Expenses	\$295,072.17	
Percent increase in expenses over previous year	#DIV/0!	
Revenues	2020-21	
Member Contributions	Amount	
Metrolinx	\$66,000.00	
MTO	\$34,000.00	
City of Toronto	\$34.000.00	
City of Hamilton	\$21.000.00	
Region of Durham	\$21.000.00	
Region of Halton	\$21.000.00	
Region of Peel	\$21.000.00	
Region of York	\$21,000.00	
City of Brampton	\$7.500.00	
City of Mississauga	\$7,500,00	
City of Vaughan	\$7,500.00	
Toronto Transit Commission	\$7,500.00	
Total Member Contributions	\$269,000,00	
Comme Forward from Dravious Voor ³	\$205,000.00	
Carry-Forward from Previous Year	\$26,072.17	
	\$0.00	
Total Revenues ⁻	\$295,072.17	
Percent Increase in contributions over previous year	#DIV/0!	
Total Revenues-Total Expenses	\$0.00	
Contributions-Actual Expenses	-\$26,072.17	
Notes:		
1. 2 full-time TMG staff salaries + benefits + 2 undergrad	luate summer re	esearch assistants
plus 1 day/week of James Vaughan. TMG staff salary	increases based	d on an assumed
increase of 4% per annum as of July 1 each year.		
2. "Total Revenues" include carry-forward from the prev	vious year.	
University of Toronto In-Kind Contributions		
Principal Investigator Time	\$45,000.00	
Co-Investigators' Time	\$15,000.00	
Post-Doctoral Fellow Time	\$0.00	
PhD Graduate Research Assistants Time	\$30,000.00	
Office Space & telephones	\$6,194.26	
Total	\$96,194.26	
This excludes other UofT in-kind contributions to TMG the terms of t	hat are difficult	to quantify. These include:
Data Management Group support of TMG		
Internet access		
University of Toronto library access		
Administrative support		
TMG computers & software		



APPENDIX: TMG WORKSHOP AGENDAS Workshop 1: Mobility Tools & Services

Wednesday, February 5, 2020 9:00AM – 12:00AM University of Toronto ITS Lab, Sandford Fleming Building, Room 3103

9:00 – 9:25:	James Vaughan (TMG):
	Modelling Driver's Licences & Auto Ownership in GTAModel 4.1
9:25 – 9:50:	Francisco Calderón (Civil PhD Student):
Model	ling Mobility Service Provision
9:50 – 10:15:	Gozde Ozonder (Civil PhD Student):
	Uber vs. Taxi Usage: the Toronto VfH Case Study
10:15 - 10:30	Break
10:30 - 10:55	Shauna Brail (Innis Urban Studies Program & School of Cities):
Taking	Canada for a Ride: Digital Ride-Hailing and Its Impact on Canadian Cities.
10:55 – 11:20	Eric Miller (TMG):
	Preparing for Modelling CAVs
11:20 - 12:00	Open discussion

Workshop 2: Calibrating Large-Scale Travel Demand Models:

Issues & Options

Wednesday, May 6, 2020 9:00AM - 11:40AM Call-in Meeting on Microsoft Teams

9:00 – 9:15: Eric Miller (TMG): *Workshop Objectives, Issues & Needs*

9:15 – 10:00: Perspectives, Part I: (15 minutes per presentation, including Q&A)

Balthazar Crane & Kareem Kobeissi (HDR): Calibrating the GTAModel for Local Municipalities

David Forsey (IBI): Beyond the GTA: Lessons Learned from Small and Medium-Sized Urban Areas

Michael Hain (City of Toronto): A Municipal Perspective on Model Calibration

10:00 – 10:05: Break

10:05 – 10:50: Perspectives, Part II: (15 minutes per presentation, including Q&A)

Mausam Duggal (WSP Canada): Estimation, Calibration, Validation: What, Why, and How?

Adam Lanigan (Dillon): Demanding Change / Changing Demand.

Rick Donnelly (WSP USA): Towards Statistically Solid Thinking About Validation

10:50 – 10:55: Break

10:55 – 11:40: Open Discussion & Next Steps



Workshop 3: Population Synthesis Methods for the GTHA

Wednesday, December 9, 2020 9:10 – 11:45 AM Call-in Meeting on Microsoft Teams

- 9:10 9:15: Workshop welcome, objectives & agenda (Eric Miller)
- 9:15 9:30: Overview of Population Synthesis Methods (Ted Lin)
- 9:30 11:00: Introduction to MetroPop:
 - 9:30 9:45: Overview (David Forsey)
 - 9:45 10:15: Population Synthesis (Eric Petersen)
 - 10:15 10:30: Synthesizing Place of Work & Place of School (Ted Lin)
 - 10:30 11:00: Software & Demonstration (James Vaughan / Brendan Reilly)
- 11:00 11:05 Break
- 11:05-11:25: Towards Dynamic Modelling of Demographic & Socio-Economic Evolution (Eric Miller)
- 11:25 11:45: Open Discussion