

travel
modelling
group



ANNUAL REPORT, 2018-19

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March, 2019



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1. INTRODUCTION

This document describes the activities of the Travel Modelling Group (TMG) during its eighth year of operation, 2018-19 (April 1, 2018 through March 31, 2019).

Section 2 describes the budget and resources of the TMG during the reporting period. Section 3 then provides an overview of TMG activities with a comparison to the proposed work plan for the year. Finally, Section 4 summarizes TMG accomplishments in 2018-19.

2. 2018-19 BUDGET & REVENUES

Table 2 1 presents the 2018-19 TMG expenditures and revenues. This budget supported two full-time technical staff persons (Bilal Yusuf, Network Modeller/Analyst and Brendan Reilly, software programmer/designer, one day a week of UTTRI's Senior Software Architect, James Vaughan and one graduate summer student research assistant (Joven Chew). Bilal Yusuf resigned his position as of February 15, 2019 to take a new position at Metrolinx. His replacement has not yet been determined at the time of preparation of this report.

Table 2.1: 2018-19 Expenditures & Revenues

TMG Budget	2018-19	2019-20	2020-21
Expenses	Amount	Amount	Amount
Salaries ¹	\$175,308.00	\$182,320.32	\$189,613.13
Supplies, Misc. Expenses	\$250.00	\$250.00	\$250.00
Emme Licence Maintenance	\$3,000.00	\$3,000.00	\$3,000.00
Contingency	\$0.00	\$0.00	\$0.00
Overhead (@40%)	\$67,428.57	\$72,571.43	\$77,714.29
Total Expenses	\$245,986.57	\$258,141.75	\$270,577.42
<i>Percent increase in expenses over previous year</i>		4.94%	4.82%
Revenues	2018-19	2019-20	2020-21
Member Contributions	Amount	Amount	Amount
Metrolinx	\$64,000.00	\$66,000.00	\$68,000.00
MTO	\$32,000.00	\$34,000.00	\$36,000.00
City of Toronto	\$32,000.00	\$34,000.00	\$36,000.00
City of Hamilton	\$19,000.00	\$21,000.00	\$23,000.00
Region of Durham	\$19,000.00	\$21,000.00	\$23,000.00
Region of Halton	\$19,000.00	\$21,000.00	\$23,000.00
Region of Peel	\$19,000.00	\$21,000.00	\$23,000.00
Region of York	\$19,000.00	\$21,000.00	\$23,000.00
City of Brampton	\$6,500.00	\$7,500.00	\$8,500.00
City of Mississauga	\$6,500.00	\$7,500.00	\$8,500.00
Total Member Contributions	\$236,000.00	\$254,000.00	\$272,000.00
<i>Carry-Forward from Previous Year</i>	\$15,000.00	\$5,013.43	\$871.68
<i>Additional Revenue (UofT Subsidy)</i>	\$0.00	\$0.00	\$0.00
Total Revenues²	\$251,000.00	\$259,013.43	\$272,871.68
<i>Percent Increase in contributions over previous year³</i>	0.0%	7.6%	7.1%
<i>Total Revenues-Total Expenses</i>	\$5,013.43	\$871.68	\$2,294.26
<i>Contributions-Actual Expenses</i>	-\$9,986.57	-\$4,141.75	\$1,422.58
Notes:			
1. 2 full-time TMG staff salaries + benefits + 1 undergraduate summer research assistant + 1 day/week of James Vaughan.			
TMG staff salary increases based on an assumed increase of 4% per annum as of July 1 each year.			
2. "Total Revenues" include carry-forward from the previous year.			
3. The increase in total contributions in 2018-19 is due to the City of Brampton rejoining the TMG.			
For all current members the 2018-19 contribution is unchanged from 2017-18, as had been forecast.			
University of Toronto In-Kind Contributions			
Principal Investigator Time	\$45,000.00		
Co-Investigator Time	\$29,000.00		
Office Space & telephones	\$6,194.26		
Total	\$80,194.26		
This excludes other UofT in-kind contributions to TMG that are very difficult to quantify. These include:			
Data Management Group support of TMG			
Internet access			
University of Toronto library access			
Administrative support			
TMG computers & software			

3. 2018-19 PROJECTS & ACTIVITIES

Table 3.1 presents the 2018-19 work plan as approved by the TMG Steering Committee. As indicated in this figure, the work plan tasks divided into 10 primary tasks. TMG activities in each of these areas are discussed in the following Sections 3.1 through 3.10, inclusive.

Table 3.1: 2018-19 Work Plan

No.	TASK	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total ¹	%
1	Finalizing Historical Networks ²	0.5	0.5	0.5	0.5	0.5								10	1.9%
2	GTAModel V4 operational support	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	24	4.5%
3	GTAModel V4.1 update w/ 2016TTS data	7	7	7	7	7	6	6	6	6	6	6	6	308	58.3%
4	GGHM Freight Model Conversion to XTMF	0.5	0.5	0.5	0.5	1	2.5	2.5	2.5	2.5	2.5	2.5	2.5	82	15.5%
5	DTA testing	0.5	0.5	0.5	0.5									8	1.5%
7	TMG Toolbox Improvements	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	24	4.5%
8	XTMF Maintenance	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	24	4.5%
9	Documentation of TMG products	1	1	1	1	1	1	1	1	1	1	1	1	48	9.1%
10	Outreach & Training (3 workshops)		W1				W2					W3		528	Total
11	Meetings: TMGSC (2) & TMGTAC (5)	TAC		TAC		TAC		SC	TAC		TAC		SC		
TMG Staff Average Weekly Time Allocation (Days)		11	11	11	11	11	11	11	11	11	11	11	11		
Suggested Workshops ³															
W1	GTAModel V4.0 & XTMF Hand-On Training														
W2	Freight Model & V4.1 Updates														
W3	Freight Model & V4.1 Updates														
Legend															
n	Light, on-going effort	n = approximate, average number of TMG days per week for this task													
n	Heavy, focussed effort	Includes allocation of time for documentation, meetings, etc.													
Notes:															
1 Estimated total days of staff time allocated to the task, assuming 48 working weeks per year (staff take 2 weeks vacation and the University closes for about 2 weeks/year during the Christmas Break).															
2 An undergraduate summer research assistant will work full-time on this task, supervised by Bilal Yusuf.															
3 Provisional. Topics may change.															

In addition to the tasks anticipated in the 2018-19 shown in Table 3.1, an unanticipated activity was investigation of suspected under-reporting of trip rates in the 2016 TTS. Since such under-reporting could have a significant impact on TMG modelling activities (notably the GTAModel V4.1 update, discussed in Section 3.3), TMG staff spent a considerable amount of time investigating this issue. The work undertaken and our findings with respect to the 2016 TTS investigation are summarized in Section 3.3.1.

3.1 Finalizing Historical Base Networks

During the 2016-18 time period TMG employed undergraduate summer research assistants to work on developing pre-2011 Emme road and transit networks for TTS years, coded to NCS11 (now NCS16). Pre-existing Emme/2 networks provide a good starting point for this work. The major challenge, however, has been developing 24-hour transit networks to support 24-hour travel demand modelling analysis, since earlier year base networks only coded transit for the morning peak period. This task of filling-in 24-hour transit data becomes increasingly difficult as one moves further back in time. Prior to the 2018-19 work year, complete 2001 and 2006 networks had been developed, as well as the 1996 road network. Another student was hired to continue working on this task in the spring/summer of 2018. In addition, graduate students supervised by Prof. Marianne Hatzopoulou assisted in improving our historical road networks to support their time-series analysis of roadway emissions in the GTHA. The result of these efforts is that we now have road networks going back to 1986. TTC information is missing for 1986 and 1991, while Durham, Halton, and York Region transit information is missing for 1986. We feel that we have accomplished as much as possible in terms of constructing these historical

networks, given currently available data, and TMG will not spend additional time on this task going forward.

3.2 GTAModel V4 Operational Support

GTAModel V4.0 is now being used by the Cities of Toronto, Mississauga and Brampton, as well as by Halton Region. An earlier version of GTAModel (coded in XTMF) is used by Durham Region. During 2018-19 the Regions of Durham and Peel committed to converting to GTAModel V4.1, once it is available. Considerable TMG staff time was spent on supporting GTAModel V4.0 implementation and usage by our partner agencies. This included supporting a major recalibration of V4.0 using 2016 TTS data by the City of Mississauga and their modelling consultants (WSP). This work proved to be very supportive of TMG's V4.1 upgrade (see next section). On-going support of these agencies and their consultants in the operational use of GTAModel will be required going forward.

3.3 GTAModel V4.1 Update

The single biggest task in the 2018-19 work plan was the V4.1 update of GTAModel based on 2016 TTS data. The very late release of the 2016 TTS data in the fall of 2018 meant that it was impossible to undertake the V4.1 update in 2017-18, as originally planned back in 2017. In addition, once the 2016 data became available, serious concerns were raised concerning what appeared to be possible serious under-reporting of trips relative to previous years. As discussed in the next sub-section, this further slowed down the V4.1 development while TMG staff investigated this issue. I.e., we were not willing to start recalibrating models until we had confidence in the trip rates with which we were working.

3.3.1 Analysis of 2016 TTS Trip Under-Reporting

The issue of adjustments for TTS under-reporting, or other desired changes in TTS sample weights to improve modelling performance is a particularly important issue. This is a matter of considerable concern to all agencies, whether they use GTAModel or not. Once the 2016 TTS finally became available in the fall of 2018, considerable effort was expended by TMG staff, assisted by a postdoctoral fellow and a senior PhD student, to investigate the extent and sources of suspected under-reporting of trips in the survey data. This resulted in two major reports being generated.^{1,2} Key findings of this analysis include:

- There is no clear evidence of under-reporting of “first-trips” to work or school.
- Second/subsequent trips to work and school, however are under-reported for non-respondents (i.e., surveyed household members who did not personally answer questions during the survey).

¹ Faghih Imani, A., J. Vaughan and E.J. Miller (2018) *Analysis of TTS 2016 Trip Rates, Toronto: Travel Modelling Group*, University of Toronto Transportation Research Institute, July, 61 pages.

² Ozonder, G. and E.J. Miller (2018) “Longitudinal Analysis of Activity Generation in the GTHA”, presentation to the TMG Technical Advisory Committee, Toronto, November 7. This analysis is documented in greater detail in two papers under preparation at the time of this report's preparation. These papers will be provided to TMG partners upon their completion the papers are: Ozonder, G. and E.J. Miller (2019) “Longitudinal Analysis of Activity Generation in the Greater Toronto and Hamilton Area: Part I – Work- and School-Related Activities” and “Longitudinal Analysis of Activity Generation in the Greater Toronto and Hamilton Area: Part II – Non-Work/School Activities: Marketing/Shopping and Other”, to be submitted to *Transportation Research A*.

- There is clear evidence that non-work/school (NWS; i.e., “market/shopping” and “other purpose”) trips are under-reported both for non-respondents and by households completing the survey by web (as opposed to telephone-based respondents).
- Facilitate-passenger trips are also under-reported in the survey. This is undoubtedly largely due to an error in the wording in the online survey concerning the definition of these trips. This error was not discovered and corrected until mid-way through the survey. After the correction was made, reporting of facilitate-passenger trips increased, but the overall rate for this trip purpose remained lower than expected based on past years’ data. Similarly, trips by the auto-passenger mode seem to be much lower than expected given past years’ experience.

Based on these findings, a procedure has been developed to correct 2016 TTS-based NWS trip rates in GTAModel. This procedure has been tested in collaboration with WSP in the Mississauga model update and has been incorporated into the V4.1 model system. Note that this procedure involves attempting to remove the survey instrument bias from the trip generation models, resulting in the model generating higher daily trip rates than observed in the base TTS data. It does not involve reweighting TTS trip records per se – an approach which TMG considered but does not recommend adopting.

3.3.2 V4.1 Update

One advantage of the delay in starting the V4.1 update is that it meant that a number of the findings from TMG 2017-18 activities could be incorporated into V4.1, including:

- Surface transit speed updating.
- Improved road and transit assignment convergence criteria.
- Logit path choice transit assignment.
- Refinement of transit transfer link length definitions.
- Implementation within NCS16.

The V4.1 update thus is not just a recalibration of V4.0 with 2016 data, but involves upgrading of numerous individual components of the model system where data, need and resources permit. Further, emphasis has been placed on making as many of these components stand-alone XTMF-based modules that can be used by TMG agencies for their own purposes, outside of the GTAModel model system per se. Emphasis has also been placed on making these components compatible with GGHM V4 wherever possible. Specific components that represent stand-alone deliverables (but which will also be implemented within V4.1) include upgraded:

- *Population synthesis procedure.* The open-source population synthesis software, *Doppelganger*, developed by Sidewalk Labs,³ has been used to develop a new synthesis procedure for V4.1. This represents a significant upgrade on the very simple V4.0 synthesizer.
- *Driver’s license possession model.* A binary logit random utility choice model, based on 2016 TTS data, has been developed and implemented in V4.1. This model determines the probability of each person 16 years of age or older having a driver’s license, given their age, occupation, employment status, household income level and accessibility to work/school.

³ <https://github.com/sidewalklabs/doppelganger>

- *Auto ownership model.* An ordered-logit random utility choice model, based on 2016 TTS household ownership levels has been developed and implemented in V4.1. This model predicts the number of cars (from 0 to 4+) that are owned/leased by each. Explanatory variables in the model include: household structure (number of adults, children and workers), number of licensed drivers, household income level, and neighbourhood accessibility to work locations.
- *Passenger mode modelling.* Developing significantly improved treatment of passenger mode choice (including use of Uber/Lyft type mobility services and the HOV/"carpooling" mode) is a very challenging task. Full-treatment of these modelling issues was beyond the time, data and TMG staff resources within the V4.1 update, and work on improving our models of these processes will continue in the 2019-20 work plan. But we took a few important first steps in working towards this long-term objective in the V4.1 update. Specific improvements in V4.1 include:
 - Implementation of an explicit representation of HOV trips in the model system.
 - Taxi and Uber/Lyft are modelled as a separate mode.
 - Transit passenger access and egress modes and station choice models have been added to the model system to complement the current drive access/egress model.

Figure 3.1 presents the GTAModel V4.1 development work flow. As indicated, many tasks were undertaken in parallel (such as testing of the population synthesis procedure and calibration of the road and transit network models), but the overall sequence of major tasks (defined by logical dependencies in the model system) consisted of:

- Data preparation.
- Road and transit network assignment model development. This included the various improvements in road and transit assignment procedures listed above.
- Development of location and access station choice models. These models were largely unchanged in structure from V4.0, but parameters were re-estimated using 2016 TTA data. The notable exception to this was the inclusion of passenger access/egress to/from transit station choice.
- Development of the activity episode generation model. As discussed above, this included correctly for survey under-reporting of trip/episode rates.
- Tour-based mode choice model development. These models were largely unchanged in structure from V4.0, with the notable exception of the inclusion of taxi and Uber trips as a new mode in the model system. All model parameters were re-estimated based on 2016 TTS data.
- Overall model testing, calibration and validation. This work will continue into the 2019-20 work year. In particular, using the new 2016-based V4.1 to "backcast" 2011 observed behaviour will be undertaken as a validation exercise. Note that, as opposed to V4.0, we have imposed very limited calibration adjustments to the V4.1 estimated model parameters. Our experience with V4.0 implementations by the various users of the model system is that considerable time and effort was usually expended by each agency "re-calibrating" the calibrated V4.0 model system to their local needs. We believe that a much more "lightly calibrated" base V4.1 model system will make local agency-specific calibrations easier and more straightforward to do this time around.

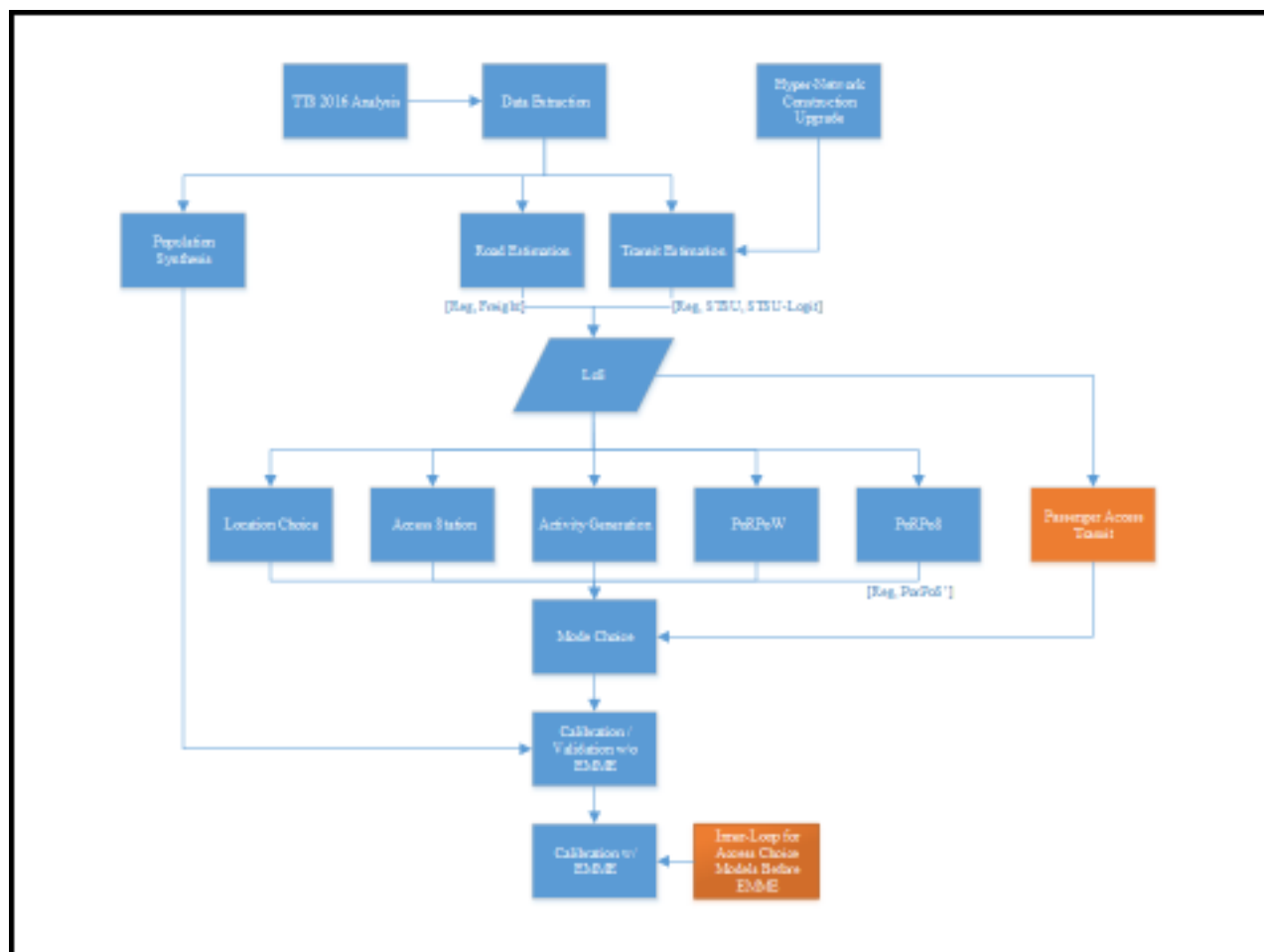


Figure 3.1: GTAModel V4.1 Update Work Flow

3.4 Freight Modelling in XTMF

In the original 2018-19 work plan it was intended to convert the GGHM V4 Freight Model into XTMF. In the event, it turned out that MTO was not yet ready to release this model to TMG to undertake this task. Given this, TMG instead implemented a simple three-step freight model for the GTHA developed by Prof. Matthew Roorda and one of his PhD students. This model has been implemented within GTAModel V4.1, thereby providing an explicit freight component within the model system for the first time. It is expected that this quite simple model can be upgraded in future years as time, data and need permit.

3.4.1 Network Updating

The freight modelling component also required extensive network improvements especially with respect to the freight restrictions on roads. After contacting the agencies, significant improvements have been made to the network. The network has also been improved to actually explicitly model the core/collector highway system, along with the interchanges between them, in the GTHA. Previously, the network did not model this system with no distinction being made as to whether a car was on the core or the collectors. It is expected that this modification will give better fits to observed counts, which only exist on either the core or the collectors.

3.5 DTA Testing

Building on the preliminary discussions in 2017 concerning dynamic traffic assignment (DTA) methods, some time was invested in 2018-19 to undertake a preliminary investigation of the macro- and meso-scopic road assignment procedures of the Aimsun network modelling software, which is seeing increasing usage both operationally and for research purposes within the GTHA. The work this year was limited to testing of the Aimsun Barcelona-based tutorial network. Progress was made on how to connect Aimsun assignments into the TMG XTMF/Emme workflow. This work will continue in the 2019-20 work year, with an XTMF-based “Aimsun Toolbox” being developed to facilitate Aimsun applications, similarly to the extensive Emme Toolbox that TMG has developed over the past number of years. TMG has also obtained a GTA (No Hamilton) Aimsun network that has been developed at the University of Toronto for use in this work.

In addition, a half-day workshop on DTA applications in the GTHA was held on March 13 at the University of Toronto. This workshop showcased public agency and private consultants experience to date with DTA methods for a variety of applications, providing considerable insight into the current strengths and weakness of these methods that will serve TMG and its partners well as we continue to investigate these methods going forward.

3.6 TMG Toolbox Improvements

A primary rationale for the TMG is to develop standard tools, procedures and templates for general use by member agencies. These tools are primarily of two types: XTMF-based modules and Emme/4 Modeller procedures. Tool development occurs in two primary ways. First, TMG staff are constantly refining/extending existing tools and developing new tools through the course of their on-going model system development, network coding and testing and other work tasks. Second, recommendations for tool development are regularly generated by the TMGTAC on an on-going basis.

The TMG Toolbox is open source software and is available to anyone through Github. Documentation for the tools is available on the TMG website.

3.7 XTMF Maintenance

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) occur as needed and as they are generated by continuing development of the TMG Toolbox and other TMG modules and models. During 2018-19 Versions 1.4, 1.5, and 1.6 of XTMF were released and are available on Github. Important improvements introduced during the past year include:

- The ability to queue a number of runs to execute one after another, immediately, or at a scheduled time (1.4).
- Linking errors with the module that they occurred in, where possible (1.4).
- Integrated system and in app notifications for model system run completion (1.4).
- The ability to reorder the run queue (1.5).
- An improved interface for viewing run errors (1.5).
- Logging of the console output into the run output (1.5).

- Model System Regions, a new view allowing the logical grouping of modules to ease the interaction with increasingly complex model systems (1.5).
- Live documentation for XTMF 1.4+ is available now at <http://tmg.utoronto.ca/doc>.
- In app documentation is now pulled from the TMG website (1.5).

3.8 Documentation of Software & Models

Up-to-date documentation of GTAModel V4.0, XTMF and EMME Toolbox modules is available on the TMG web site. Web site improvements and updating are on-going tasks.

3.9 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). These activities in 2018-19 included:

- On-going updating and elaboration of the TMG web site.
- Documentation of all procedures, etc. developed by the TMG (Task 8).
- Six meetings were held with TMGTAC to discuss work in progress, next steps in the work plan and to disseminate work plan results.
- Two training workshops were held to present and discuss in greater detail recent TMG work and products. In addition to the March 13 DTA Applications Workshop described in Section 3.5, a hands-on GTAModel V4.0 training session was held on May 16, 2018.

3.10 Steering Committee Meetings

In addition to the TMGTAC meetings discussed in Section 3.9, two meetings with the TMG Steering Committee (TMGSC) were held (on October 17/18 and March 6/19) to discuss work plan progress, budget, overall TMG directions for work and other administrative and supervisory matters