travel modelling group

tmg

ANNUAL REPORT 2013-2014

Submitted to the TMG Steering Committee

Eric J. Miller, Ph.D.
Peter Kucirek, M.A.Sc.
James Vaughan, h.Bsc.
May 3, 2014

UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING
Transportation Research Institute

Table of Contents

List of Tables

List of Figures

1 Introduction

This document describes the activities of the Travel Modelling Group (TMG) during its third year of operation, 2013-14 (April 1, 2013 through March 31, 2014).

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 2012-13.

2 2013 – 2014 Budget & Resources

Table 2-1 and Table 2-2 provide the 2013-4 TMG budget. This budget supported two full-time technical staff persons. The TMG staff for 2013-14 consisted of:

- One full-time network analyst/modeller. This person (Peter Kucirek) possesses strong EMME-based network modelling capabilities, strong programming skills and a sound understanding of four-step travel demand modelling methods.
- One full-time software programmer/designer. This person (James Vaughan) possesses strong software design and programming skills as well as strong computer system skills.

2.1 Budget Tables

Expenditures	Amount
Staff Salary & Benefits[1]	$148,863.30
Principal Investigator Time[2], In-Kind	$45,000.00
Office Space[3], In-Kind	$6,194.26
Supplies & Misc. Expenses[4]	$500.00
University Overhead[5]	$52,857.14
TOTAL	**$253,414.70**

Table 2-1: 2013-2014 Expenditures

Member Contributions	**Contribution**	**Overhead[5]**	**Net**
Metrolinx	$50,000.00	$14,285.71	$35,714.29
MTO	$25,000.00	$7,142.86	$17,857.14
City of Toronto	$25,000.00	$7,142.86	$17,857.14
City of Hamilton	$15,000.00	$4,285.71	$10,714.29
Region of Durham	$15,000.00	$4,285.71	$10,714.29
Region of Halton	$15,000.00	$4,285.71	$10,714.29
Region of Peel	$15,000.00	$4,285.71	$10,714.29
Region of York	$15,000.00	$4,285.71	$10,714.29
City of Mississauga	$5,000.00	$1,428.57	$3,571.43
City of Brampton	$5,000.00	$1,428.57	$3,571.43
Sub-Total, Member Contributions	***$185,000.00***	***$52,857.14***	***$132,142.86***
UofT In-Kind Contribution	$51,194.26	$0.00	$51,194.26
2012-13 Carry Forward	$6,500.58	$0.00	$6,500.58
UofT Cash Contribution[6]	$10,719.86	$0.00	$10,719.86
TOTAL		**$52,857.14**	**$200,557.56**
TOTAL, INCLUDING OVERHEAD	**$253,414.70**		

Table 2-2: 2013-2014 Revenues

[1] Two full time technical staff: 1 software designer/programmer; 1 modeller

[2] 50 days of PI time allocated to TMG activities.

[3] GB305L (office for TMG technical staff), 1 year @ $4839.16 per year. GB305A (office for TMG PI), 1 day/working week = $994.58 per year. Plus $360.52 per annum for TMG technical staff telephone.

[4] Meeting expenses, report preparation, computer supplies, etc.

[5] University overhead is 40% of member contributions. Note that total U of T contributions = **$72,633.99**, which exceeds the total overhead paid by TMG members @ **$52,857.14**.

[6] Note that at the agreed-upon 2013-14 rates (which are identical to the 2012-13 rates, the TMG will operate at a deficit that will be covered by the TMG from other research funds (unless other sources of TMG revenue can be obtained).

3 2013 – 2014 Projects & Activities

Table 3-1 presents that 2013-14 workplan as approved by the TMG Steering Committee. As indicated in this figure, the work plan tasks divided into five primary categories:

- Model system conversions to XTMF
- Transit assignment model development and testing
- Base network assembly
- Development of common tools & software to support GTHA travel demand modelling
- Training, outreach, and technology transfer

TMG activities in each of these areas are discussed in the following sub-sections.

	MONTH											
TASK	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**
1. Conversions to XTMF												
Durham Model Conversion												
City of Toronto V2.00 Conversion												
2. GTAModel "V4" Development												
3. Base Network Assembly												
2006 24-hour network												
2011/12 networks (AM & 24-hour)												
4. TDM Tool Development												
5. Meetings, Training, Outreach												
Website												
Workshops			*				*					
Tech. Adv. Committee Meetings		*		*		*		*		*		*
Steering Committee Meetings	*					*			*			*

Table 3-1: Original 2013-2014 Work Plan

"Full-time" effort "Part-time" effort

3.1 Model System Development in XTMF

The Durham Region Model, and the City of Toronto V2.0 models have been converted and deployed during the 2013-2014 work year. Through these model conversions we have learned many lessons which will help expedite the processes significantly if another model system would need conversion in the future.

For GTAModel V4.0 we have developed a model system framework that will be used for the development of the model. We have automated extraction of data for any TTS year, generation of TASHA specific inputs from the TTS data. We have a mode choice estimation model that can utilize the same framework used for the GTAModel V4.0 transit assignment model.

3.2 GTAModel V4.0 Development

A second major task during 2013-14 was commencing the development of a new, advanced activity-based microsimulation travel model for the GTHA. The objectives of developing this model system include providing:

- An operational demonstration of the practicality of developing such a model system for the GTHA using available data and software tools.
- A platform for the development, testing and demonstration of new model components for the GTHA (tour-based mode choice models, etc.).
- A working activity-based model system for use by any TMG member agency that is interested in adopting it as their operational regional travel demand forecasting tool. At the time of preparing this annual report, it is the intention of at least the City of Toronto to do this.

It had originally been hoped that V4.0 would have been fully developed by the end of the 2013-14 work period. This proved not to be feasible, however, for several reasons, including:

- The extended period of time required for the Durham and Toronto V2.0 model system conversions delayed the start of work on this task.
- It was decided to wait for the 2011 TTS data to be available so as to directly build the model system using the most current data (originally it had been anticipated that a preliminary version of the model system would be build using 2006 TTS data).
- Development of the 24-hour 2012[7] base transit network required to build a 24-hour travel model system took longer than originally estimated.

Given these issues, development of the V4.0 model system will continue into the 2014-15 work period. Accomplishments with respect to this task in 2013-14 include:

- Design of the overall V4.0 model system framework.
- Assembly of all 2011 base data required to estimate and calibrate the model system.
- Development and calibration of the Emme road assignment models required by the new system.
- Development of the Emme transit assignment models required by the new model system.

Each of these components of the work are briefly described in the following sub-sections.

3.2.1 Overall V4.0 Model System Framework

Figure 3-1 displays the overall framework for the GTAModel V4.0 model system. As shown in this figure the model system consists of the following main components:

[7] While labelled the "2011 TTS", this survey actually was undertaken in the falls of both 2011 and 2012, with a majority of the observations actually being gathered in 2012. It was decided to develop the base network for V4.0 development (as well as other TMG-supported modelling activities) on fall, 2012 conditions. See Section 3.3 below.

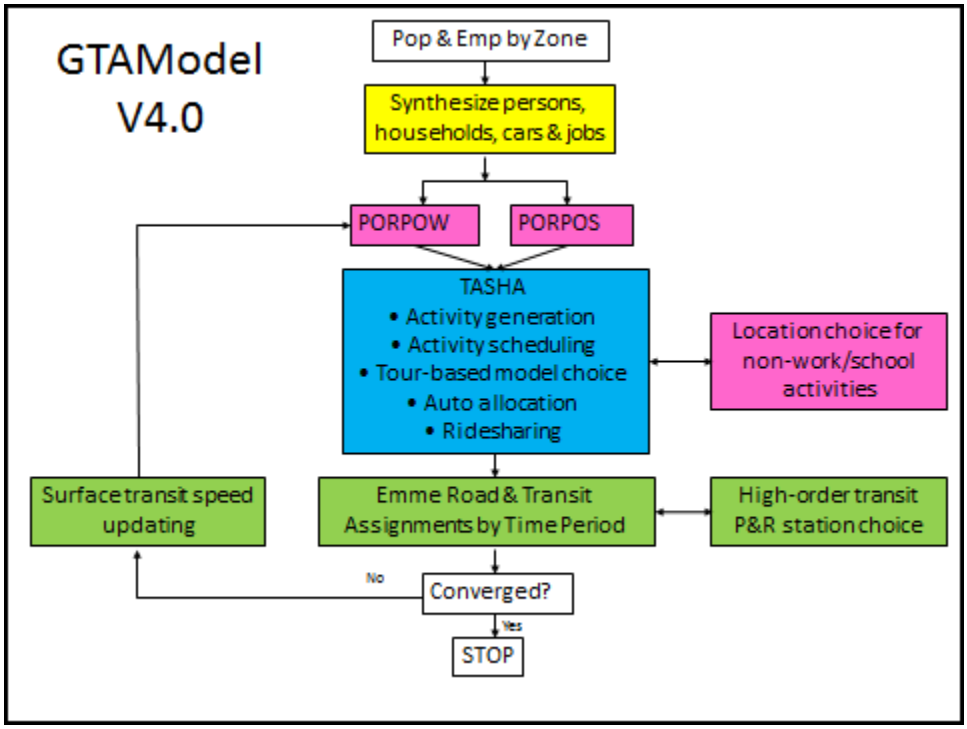

Figure 3-1: GTAModel V4.0 Model System schematic

- The "core" of the model system is the TASHA (Travel/Activity Scheduler for Household Agents) model. TASHA is an activity-based microsimulation model which generates every out-of-home activity "episode" (i.e., trip) engaged in by every person in the GTHA during a typical 24-hour weekday period. For each episode (trip) it determines the type (work, school, etc.) and trip start time. Once all trips have been generated, a tour-based model choice model determines the mode used on each trip within each trip chain undertaken by each person within the GTHA. The tour-based approach ensures that cars (and bicycles) are used on all legs of a tour and that modes are explicitly chosen within the context of the overall tour. Constraints on auto usage by household members sharing vehicles are enforced (i.e., only one person within a household can use a given vehicle at any point in time) and ridesharing among household members is explicitly modelled. For further documentation of TASHA, see E.J. Miller (2014) TASHA Overview on the TMG web site.
- Work and school locations for each worker and student are determined by Place of Residence – Place of Work (PORPOW) and Place of Residence – Place of School (PORPOS) models similar to those used in previous versions of GTAModel and GGH Model.
- Episode locations (trip destinations) for all non-work/school (NWS) activity episodes are determined as each NWS episode is generated using logit destination choice models.
- V4.0 interfaces through the Emme Toolbox with Emme to perform road and transit assignments by time period (discussed further below). Important features in V4.0 include explicitly modelling higher-order transit Park & Ride (P&R) access station choice (accounting for parking lot capacities) and updating surface transit (bus and streetcar) speeds as a function of roadway congestion.

- TASHA operates upon lists of persons and their associated households, processing the travel decisions of individual persons and their associated household one household at a time. These lists of persons and households (and their associated attributes age, employment and student status, occupation type, number of household vehicles, etc.) must be synthesized for the forecast year, given the projected total population and employment in each traffic zone within the GTHA. A new population synthesis procedure is being developed for V4.0 to perform this task.

3.2.2 Base Data Assembly and Model Estimation Tools

V4.0 is based on 2011 TTS data. All data required for model parameter estimations and calibrations have been extracted from the TTS database. As part of this work, automated tools for data extraction (for any TTS year) have been developed in XMTF, generation of TASHA specific inputs from the TTS data.

A suite of model parameter estimation procedures have also been developed and tested in XTMF to support the estimation and calibration of V4.0 model components (assignment, mode choice, etc.).

3.2.3 Network Assignment Modelling

TASHA generates trip start times continuously over the 24-hour time period being modelled. For network assignment purposes, these trips are aggregated into road and transit origin-destination (O-D) matrices for five time periods (AM-peak, mid-day, PM-peak, evening and night) and separate road and transit assignments are run for each time period.

Emme road assignment modules have been developed within the TMG Toolbox and tested for use in V4.0.

Although not shown as an explicit task within the 2013-14 workplan, improving the practice of GTHA transit assignment modelling continued to be a significant on-going task during the past year, with this work originally being driven by the Durham and Toronto model system conversions and then subsequently by the V4.0 development work. In particular, significantly advanced transit assignment methods have been extensively tested during the 2013-14 period for use in V4.0. These involve the following new features available within Emme 4 relative to former GTHA practice:

- Use of stochastic (as opposed to deterministic) assignment, so as to "spread" trips for a given O-D pair across multiple "likely" paths instead of assigning all flow to the single "best" path. This provides a more realistic representation of actual trip-makers' route choice behavior. It also is essential for adopting the integrated transit network approach discussed below.
- Use of congested assignment, in which transit vehicle (and line) capacities are recognized as limiting factors on the ability of a given line to carry passengers. This is critical for more realistically modelling path choices in networks involving heavily congested peak-period routes (such as the Yonge Subway and GO Rail and GO bus routes).
- Treatment of all transit services (local bus, subway, GO Rail and Bus, etc.) as part of an integrated transit network and treating the choice of, for example, using GO Rail versus subway as a choice among competing paths through the transit network, rather than as a choice among competing modes of travel. This approach has several significant advantages, including:
    - It greatly simplifies the mode choice model, replacing several separate "transit modes (GO Rail, GO Bus, local transit, etc. – the current regional practice) with a single "transit"

mode. This not only simplifies the model and the associated calculations but it is greatly simplifies the introduction of new transit services (such as BRT or LRT) into the model system.
- It eliminates considerable complexity and computation in transit assignment calculations (GTAModel 2.5 required multiple transit assignments per iteration to extract the various individual transit mode travel times and costs; V4.0 will require a single, unified assignment).
- It is essential in order to be able to do congested transit assignment.

Development and testing of the V4.0 transit assignment component incorporating all of these features was not quite complete as of March 31, 2014, but the test results were extremely encouraging, and it is expected that this task will be completed very early in the 2014-15 work period, thereby permitting completion of the development of the V4.0 tour-based mode choice model and other model system components that depend upon transit times and costs as explanatory variables.

3.3 Base Network Assembly

The 2013-2014 work year saw the completion of the 2012 Base Network, which is available on the TMG website and has been distributed to all member agencies.

A major new feature of this network is that it is an "all-day" base network which can be processed into arbitrary time-period networks. In other words, this network no longer ties modellers to the standard AM/PM formulation, and could even be extended to dynamic simulation.

Much work was performed to increase the resolution of transit stops, to reflect both network changes but also to accommodate the high resolution of stop data present in the GTFS files. This increased resolution allows GTFS files to be used to completely and explicitly define transit routes, allowing networks to be generated automatically. This represents a major improvement step forward in transit modelling capabilities for the region that we will be able to exploit as we move forward. Not only does this considerably reduce the labour involved in constructing a base network and increase the accuracy and precision of these networks, but it also made constructing 24-hour models of travel demand for the region a much more practical proposition.

Originally, it was intended to extend the 2006 network to multiple time periods, to allow for easier back-casting of models. However, the absence of a common file format for transit data has increased the scope of this project considerably. As of this writing, converting the 2006 network is not on the group's upcoming work plan.

As with all networks developed by TMG, this network is coded using the 2011 Network Coding Standard (NCS11) developed by TMG in Year 1 in collaboration with GTHA agencies.

3.4 Tool Development

A primary rationale for the TMG is to develop standard tools, procedures and templates for general use by member agencies. This will be an on-going, primary activity of the TMG throughout its existence, as it evolves an ever-increasing suite of tools for members' use.

Tools have been developed both within XTMF (relating to non-network data manipulations) and within Emme Modeller (involving transportation network-related calculations), with the two sets of tools being able to "speak with one another" as needed.

Tools for Emme Modeller are deployed as a plugin known collectively as the "TMG Toolbox". The TMG Toolbox is available for users on the TMG website, and can be downloaded with the Python source code files if required. Highlights from the TMG Toolbox include:

- Road and Transit Assignment tools designed to be called from XTMF but also could be used on their own. Many of these are "translations" of historic assignment macros, while others have been developed for new models (such as GTAModel V4). These procedures no longer require hard-coded matrices or parameters, and are much more flexible than the old macros. These new tools have also been compared against the original macros to ensure congruency.
- Tools for analyzing road and transit assignments, such as count station results for auto, or the operator-to-operator transfer matrix for transit.
- A tool for automatically generating centroid connectors for a new zone system (CCGEN).
- A tool for copying zone systems (including connectors) from one databank to another.
- Tools for importing/exporting Network Package files (*.NWP) to facilitate sharing of network data. An entire scenario can be exported with just a few clicks.
- A Geometry library which adds input/output support for the widely-used ESRI shapefile format. This allows users to include geometric operations (such as intersection testing) within their own Python scripts to facilitate complex geospatial analyses.
- A Network Editing library which adds script-level support for "second-order" network operations such as link splitting (node insertion). It also includes a shortest-path algorithm to get node-to-node paths.

A full list of tools inside the TMG Toolbox to date can be found in Appendix A.

3.5 XTMF Development

XTMF is a constantly evolving software system. It is being continuously extended and improved as opportunity permits and new needs arise. Much of this evolution over the past year has been driven by the Durham and Toronto model system conversions, as well as by the continuing development of the TMG Toolbox. Specific extensions/improvements to XTMF over the past year include:

- Implemented integrated documentation with XTMF.
- Implemented Linked Parameters in XTMF to allow automated grouping of parameters (e.g., 'EMME Scenario' which appears in multiple modules, can be set just once).
- Greatly improved the speed of the graphical interface for running and editing models.
- Improved error handling within XTMF – including when XTMF runs out of memory.
- Ongoing work documenting code and tools.
- A robust integer population synthesis procedure was finalized. The output from this procedure is the same from one run to another given the use of the same initial random number seed.

3.6 Training, Technology Transfer, and Outreach

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 (except perhaps in special cases) to be the user of these tools on behalf of its partners in operational applications.

TMG staff are committed to increasing the rate and content of two-way interactions in 2013-14. Regular meeting time slots with both the Technical Advisory Committee and the Steering Committee are being scheduled. In addition, a much more concerted effort will be made to make effective, on-going use of a significantly enhanced TMG web site.

3.6.1 Technical Advisory Committee Meetings

The Technical Advisory Committee (TAC) meets regularly every other month, on the first Wednesday of the month. In the past work year, 6 TAC meetings were held on the following dates: May 8, 2013, July 3, 2013, September 11, 2013, November 13, 2013, January 8, 2014 and March 5, 2014. Agendas and presentation material from these meetings are available on the TMG web site.

3.6.2 Steering Committee Meetings

The Steering Committee (SC) meets every three months, on the first Wednesday of the moth (unless a TAC meeting is also scheduled in which case the SC meeting follows the week after). Normally, 4 such meetings occur each year, however this year the Committee decided to meet two additional times. This was in order to discuss creating a common Terms of Reference for this group to guide future work. As such, the 6 meetings occurred on the following dates:

- April 13, 2013
- September 17, 2013
- December 4, 2013
- January 22, 2014 (special meeting)
- February 19, 2014 (special meeting)
- April 2, 2014

3.6.3 Technical Memoranda

Five technical memoranda were written during the 2013-2014 year:

- 2013-02 Getting the TMG Toolbox
- 2013-03 CCGEN Algorithm Documentation
- 2013-04 Tips on Using Link Shapes
- 2013-05 Network Package Files
- 2013-06 Transit Modes, Vehicles, and ROW Encoding

3.7 TMG Website

The TMG website was developed over the last year to provide easy access to memos, networks, software, and contact information. In addition all meeting slides have been added for future reference. Work is also under way to provide the ability to make feature requests for TMG software in a simple, and transparent interface.

4 Summary of 2013-14 Accomplishments

Table 4-1 summarizes the key accomplishments by the TMG over the 2013-14 work period. As noted in this table, these include:

- The TMG Website is operational: http://tmg.utoronto.ca
- Durham Region Model conversion to XTMF is complete.
- The City of Toronto V2.0 Model conversion to XTMF has been completed. The City has performed some preliminary validation exercises.
- The 2012 base network has been completed and released.
- TMG Toolbox for Emme Modeller has been licensed as an open-source product, and released to TMG member agencies and is receiving regular updates.
- A CCGEN tool for automatically generating centroid connectors has been completed, tested, and deployed.
- Numerous new features for XTMF have been developed. XTMF has also be licenced as an open-source product and released to member agencies for their use.
- GTAModel V4.0 development is well underway and will be completed in the 2014-15 work year.

Task	Deliverable	Date Completed
1.1	Durham model conversion to XTMF	Apr. 24, 2014
1.2	City of Toronto V2.00 conversion	Oct. 24, 2013
1.3	GTAModel "V4"	In-progress
3.1	2006 24-hour base network	Deferred
3.2	2011/12 24-hour base network	Jan. 31, 2014
4	TDM tool development	On-going
5.1	Website	May. 7, 2013
5.2	Meetings, training, etc.	On-going

Table 4-1: TMG Accomplishments 2013-14

Appendix: TMG Toolbox Tools

Folder	Tool Name	Type
Analysis	Export Partition Average	Tool/Module
Analysis	Matrix Statistics	Tool/Module
Analysis	Create Zone Adjacency Matrix	Tool
Analysis/Screenlines	Export Screenline Results	Tool
Analysis/Screenlines	Flag Screenlines as Attribute	Tool
Analysis/Traffic	Export Countpost Results	Tool/Module
Analysis/Traffic	Flag Link Direction	Tool
Analysis/Transit	Export Line Group Results	Tool
Analysis/Transit	Export Transit Line Results	Tool
Analysis/Transit	Export Subway Station Usage	Tool
Analysis/Transit	Get Station Access File	Tool/Module
Analysis/Transit/Strategy	Export Transfer Matrix	Tool
Analysis/Transit/Strategy	Extract Constrained LOS	Tool/Module
Analysis/Transit/Strategy	Extract Feasibility Matrix	Tool/Module
Analysis/Transit/Strategy	Extract Flagged Line Matrix	Tool/Module
Analysis/Transit/Strategy	Select Line Analyses	Tool/Module
Analysis/Transit/Strategy	Extract Travel Time Matrices	Tool/Module
Assignment/Pre-Processing	Assign V4 Boarding Penalty	Tool/Module
Assignment/Pre-Processing	Calculate 407 ETR Tolls	Tool/Module
Assignment/Pre-Processing	Check Network Integrity	Tool/Module
Assignment/Pre-Processing	Flag Premium Bus Lines	Tool/Module
Assignment/Pre-Processing	Import V3 Boarding Penalties	Tool/Module
Assignment/Road	Toll Attribute	Tool/Module
Assignment/Road	Toll Attribute with Transit Background	Tool/Module
Assignment/Road	Toll Based Road Assignment / Uniform Tolls	Tool/Module
Assignment/Transit	Basic Transit Assignment	Tool/Module
Assignment/Transit	Legacy FBTA	Tool/Module
Assignment/Transit	Legacy Station-to-station Assignment	Tool/Module
Assignment/Transit	Station to Station Assignment	Tool/Module
Assignment/Transit	V4 Transit Assignment	Tool/Module
Input/Output	Export Network Package	Tool/Module
Input/Output	Export Network Package EM3	Tool

Input/Output	Import Network Package	Tool/Module
Input/Output	Import Network Package EM3	Tool
Input/Output	Merge Functions	Tool
Input/Output	Network Update	Tool
Network Editing	Optimize Network	Tool
Network Editing	Prorate Transit Line Speed	Tool
Network Editing	Delete Highway Stops	Tool
Network Editing	Rotate Network	Tool
Network Editing/Centroid Connectors	CCGEN	Tool
Network Editing/Centroid Connectors	Copy Zone System	Tool
Network Editing/Dynamic	Create Time Period Network	Tool
Network Editing/GTFS	Clean GTFS	Tool
Network Editing/GTFS	Generate Itineraries from GTFS	Tool
Network Editing/GTFS	Convert GTFS Stops to Shapefile	Tool
Network Editing/NCS11/Conversion	Change Walk Modes	Tool
Network Editing/NCS11/Conversion	Convert VDFs	Tool
Network Editing/NCS11/Conversion	Convert Vehicles	Tool
Network Editing/NCS11/Conversion	Geo Renumber Nodes	Tool
Network Editing/NCS11/Conversion	Move Networks	Tool
Network Editing/NCS11/Conversion	Renumber Nodes	Tool
Network Editing/NCS11/Validation	Check Connector Speeds	Tool
Network Editing/NCS11/Validation	Check Link # of Lanes	Tool
Network Editing/NCS11/Validation	Check Link Lengths	Tool
Network Editing/NCS11/Validation	Check Link Types	Tool
Network Editing/NCS11/Validation	Check Link VDFs	Tool
Network Editing/Network Merging	Flag Network Changes	Tool
Network Editing/Network Merging	Create Correspondence File	Tool
Common	Network Editing	Library
Common	Geometry	Library
Common	Screenline	Library
Common	TMG Tool Page Builder	Library
Common	Utilities	Library
	License	Other
	Execute Python Script	Tool