APPENDIX 8

Spatial Emission Estimator (SEE)

Spatial Emissions Estimator (SEE): Overview and User Documentation for Houston-Galveston- Brazoria Implementation

FINAL REPORT

Prepared for:

Houston-Galveston Area Council

Prepared by:

Eastern Research Group, Inc.

Eastern Research Group, Inc.

October 1, 2014

ERG Project No: 3924.00.001.001

Spatial Emissions Estimator (SEE):

Overview and User Documentation for

Houston-Galveston-Brazoria Implementation

FINAL REPORT

Prepared for:

Houston-Galveston Area Council

Prepared by:

Scott Fincher

Allison DenBleyker

John Koupal

Sandeep Kishan

3508 Far West Blvd., Suite 210, Austin, TX 78731 • Phone: 512-407-1820 • Fax: 512-419-0089

Arlington, VA • Atlanta, GA • Austin, TX • Boston, MA • Chantilly, VA • Chicago, IL • Cincinnati, OH • Hershey, PA

Prairie Village, KS • Lexington, MA • Nashua, NH • Research Triangle Park, NC • Sacramento, CA

www.erg.com

Eastern Research Group, Inc.

David Kall

Tarannum Rima

Cambridge Systematics, Inc.

October 1, 2014

3508 Far West Blvd., Suite 210, Austin, TX 78731 • Phone: 512-407-1820 • Fax: 512-419-0089

Arlington, VA • Atlanta, GA • Austin, TX • Boston, MA • Chantilly, VA • Chicago, IL • Cincinnati, OH • Hershey, PA

Prairie Village, KS • Lexington, MA • Nashua, NH • Research Triangle Park, NC • Sacramento, CA

Table of Contents

List of Appendices

List of Tables

List of Figures

1.0 INTRODUCTION

Under contract with the Houston-Galveston Area Council (H-GAC), Eastern Research Group, Inc. (ERG) and Cambridge Systematics, Inc. have developed a modeling framework for estimating regional on-road emission inventories of criteria, toxic and GHG emissions for each hour of a day with highly detailed spatial resolution, including emission “hot-spots” not on the traditional travel network such as truck stops and port terminals. This framework has been named the Spatial Emissions Estimator (SEE) and employs MOVES2010b at both the project and county scale to cover all needed emission processes in accord with EPA modeling guidance (1). The first implementation of SEE has been completed for the Houston-Galveston-Brazoria (HGB) metropolitan area of Texas, and is termed HGB-SEE. Among the novel features of the first HGB-SEE implementation are a) the application of MOVES project scale to develop a regional emissions inventory, which introduces the possibility of including road grade impacts at an area-wide level; b) allocation of off-network emissions to transportation analysis zones based on travel demand model origin/destination matrices and spatial analysis of truck extended idle locations. For future implementation, the framework can be extended to include heavy-duty emission “hot spots” not already accounted for in the travel model network such as port terminals and distribution centers. HGB-SEE also incorporates an updated version of a link processing script (TRANSVMT) developed by the Texas Transportation Institute (TTI). The updated TRANSVMT includes the option of a new speed-post processing model which provides a broader range of average network speeds, to allow a more accurate assessment of speed distribution and related emissions across the HGB area.

The SEE framework provides a comprehensive system for estimating regional emissions per EPA guidance, and a platform for further customization to account for emissions hot-spots. The high degree of spatial detail lends itself well to improving input of on-road emissions to photochemical air quality model frameworks, which require hourly emission estimates often by 1 or 4km grid cell. Finally, the ability to account for road grade in regional emissions analysis adds a new dimension previously focused only on project level hot spot analysis for MOVES. This report presents an overview of the broader HGB-SEE design, results of benchmark runs compared to MOVES2010b run in county scale inventory mode, detailed user documentation for the first implementation of HGB-SEE, and updates to the TRANSVMT utility. A discussion of how the framework could be expanded to improve the emissions inventory from this benchmark baseline is also included.

2.0 MODEL DESIGN

2.1 Overview

The Houston-Galveston-Brazoria modeling domain covers eight counties in Southeast Texas, encompassing one of nation's largest ozone nonattainment areas outside of California, with a population of over 6 million people. H-GAC's travel demand modeling characterizes this area with approximately 68,000 unique roadway links and 5,000 travel analysis zones (TAZs). H-GAC's motivation for a new modeling tool was to update to MOVES from MOBILE6 for conformity-level analysis while estimating emissions for each link and zone in the HGB area. An additional motivation was to have a framework that could account for emissions from heavy-duty trucks that occur at specific locations not accounted for on the travel network, the foremost being terminals at the Port of Houston, as well as numerous distribution centers and warehouses with a high concentration of trucks.

Previously, H-GAC's emission inventory development with MOBILE6 relied on a suite of programs developed by TTI which combine MOBILE6 emission rates with travel activity data to estimate emission as the roadway link level (2). As part of the upgrade to MOVES, H-GAC desired not only link-level emissions for running emissions, but also emissions at the TAZ level for the off-network emission processes of vehicle start, evaporative and heavy-duty truck extended idle. This required full integration of link travel and zone-based trip activity from the H-GAC travel model. For zone-level extended idle emission, this also involved estimating specific locations of truck idling based on GIS analysis of truck stops in the HGB area. For use of the emissions in SIP and conformity analysis, a primary requirement was that SEE produce an inventory consistent with that estimated with MOVES run in county scale inventory mode and developed based on EPA's modeling guidance.

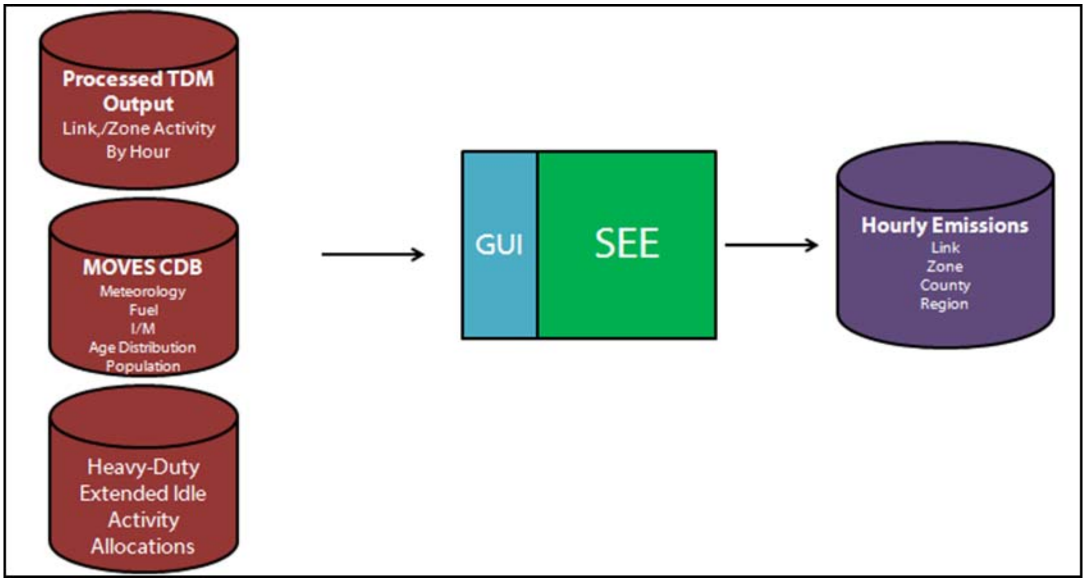
Broader software requirements were a simple GUI-driven system, ability to model base and projection years per conformity requirements, flexibility in output aggregation (e.g. link, zone, county, region), and ability to use MOVES database tables directly to supply needed data not provided by travel model activity data. The latter requirement allows the user to employ the MOVES county data manager (CDM) framework to populate tables containing necessary input data such as vehicle population, fuels, inspection/maintenance, meteorology and age distribution. In this way, execution of SEE parallels that of MOVES in terms of input preparation, a key difference being the use of travel demand model output directly to provide major activity inputs such as VMT, average speed and road type distribution. The modeling suite makes use of a pre-processing utility that prepares raw travel demand model output for use in SEE, known as TRANSVMT. TRANSVMT was first developed by TTI to produce link-level activity for emissions modeling from raw travel model output by post-processing link speeds, and creating links to represent bidirectional travel and trips within a travel zone (i.e. intrazonal links). For SEE, TRANSVMT was updated by Cambridge Systematics to give the user the option of using an updated TTI speed post-processing model that results in a broader, and more realistic, range of network speeds.

Another requirement was the ability to quickly incorporate updates to SEE when new versions of MOVES are released. To address this, SEE was designed to use direct MOVES runs as much as possible, while relying on supplemental scripting for calculations that are universal to different MOVES versions. The conceptual design of SEE realizes this goal to a high degree, in that it is possible for the SEE approach to rely almost exclusively on direct MOVES runs and output. The need for improved runtime performance did require moving some MOVES calculation steps outside of MOVES using PERL scripts, so that direct MOVES runs could focus on producing the output needed for these calculation steps.

Figure 1 shows an overall flow of SEE. The data canisters in red denote input data preparation before running SEE. Beginning with raw travel demand model output (traffic volume and average speed by link; trip origins and destination by TAZ), pre-processing for SEE includes running the updated TRANSVMT script to produced hourly link-level volume and speeds. SEE also requires data in MOVES input table format for non-travel related inputs. For allocation of extended idle emissions, a table of idle activity allocation factors by TAZ is also required. For HGB-SEE, the MOVES and idle allocation inputs were developed and provided to H-GAC, and will generally be re-used for HGB-SEE runs until a change in input is desired by H-GAC. Pre-processing of travel demand data is required for each unique travel model run or to invoke the alternate speed post-processing routine.

Once the inputs have been prepared, to execute SEE the user makes basic input/output selections in a simple GUI. Within SEE, the on-network and off-network approaches are different but integrated into one system, with common input/output databases. PERL scripts set up and execute a separate set of MOVES runs for on-network and off-network emission processes and then post-processes the MOVES results into link- and zone-level emissions, or sum to a coarser level of aggregation as specified by the user. The post-process scripts also implement the Texas Low Emission Diesel (TxLED) program reductions. The details of the on- and off-network processes are discussed in the following sections.

Figure 1. Overview of SEE Flow



2.2 On-network approach

Within SEE, on-network and off-network emissions are generated through a separate set of MOVES runs which share basic inputs for fuels, meteorology, age distribution, I/M and vehicle population. On-network emissions (except ramps and running loss evaporative emissions, as described below) are generated using MOVES project scale runs combined with PERL scripts that scale emissions to every link in the HGB area, for each hour of the day. This approach allows bottom-up calculation of regional emission inventory from individual links, while retaining the spatial distribution of travel network emissions. Using MOVES at the project scale to estimate link-level emissions also introduces the possibility of including road grade in regional emission inventory estimates. This was not implemented in HGB-SEE because the HGB modeling domain is fundamentally flat, and road grade effects are assumed to be small in the regional inventory. However, for areas with more varied terrain, this feature could allow for estimation of a potentially meaningful grade effect on overall inventory.

Within SEE, PERL scripts are used to prepare MOVES inputs by converting TRANSVMT output to MOVES project database link inputs. It is possible to set up MOVES project scale to run all links in the HGB area directly, for each hour of the day. This approach was initially attempted to address the desire for more reliance on direct MOVES runs over external scripting, but abandoned when it became clear that runtime would be prohibitive. This led to the development of a streamlined approach, where the links defined for the MOVES project runs were only those with unique combinations of road type and average speed, known as "unique links". With emissions from these links, the remainder of links can be estimated simply by scaling emissions from the unique links according to source hours operating (SHO) of each link, defined in MOVES as VMT divided by the average speed for each link. This process replicates internal MOVES logic for calculating total emissions in inventory mode. In Harris County (the largest in the eight-county HGB area), using the unique link approach with the exact post-processed travel model speeds reduced the number of links to process through MOVES from roughly 25,000 to 425. This approach made the runtime of SEE manageable; however, in benchmark runs comparing to MOVES county scale inventory runs, it was determined that a more exact replication of the MOVES county scale approach could be achieved by defining unique links not by the exact link speeds, but by the midpoint of the 16 MOVES speed bins the link would fall into. This replicated the county-level on-network results better, and had the residual impact of reducing the number of unique links further, to just 26 in Harris County (down from 25,000). This became the default approach for SEE, for optimum runtime performance and best replication of county-scale results. However, the option for exact speed unique links was retained, because despite longer runtime, using exact speeds produces a more refined emissions estimate. Sensitivity runs comparing the exact speed vs. bin speed approaches found small emission differences, on the order of 1-2 percent.

Differences in the MOVES county and project scale approaches led to some challenges in getting the project–based SEE results to match MOVES county scale results. The first was that within MOVES, county scale converts age distributions to travel fraction (fraction of miles driven by each age), while project scale does not. This is intentional, as the travel fraction calculation within county scale is meant to estimate regional trends of older vehicles driving less; for project scale this calculation isn't done as age distribution is mean to reflect the actual distribution of vehicles in the specific project area. For application of project scale for regional analysis within SEE, however, the travel fraction calculation needed to be introduced. A related challenge was reconciling the VMT mix approach between project scale and county scale. County scale uses information provided by the user for total VMT, road type distribution and vehicle population to estimate a regional mix of source type VMT, on each road type. Project scale instead uses source type fractions for each link (sourceTypeHourFraction). For the SEE project scale runs, age distributions and SourceTypeHourFractions had to be produced for MOVES which would replicate the county-scale travel fraction and VMT mix calculations. To accomplish this, PERL scripts were developed which adjusted the user-provided age distribution to account for relative mileage accumulation rates, and to calculate sourceTypeHourFractions by road type that mimicked the MOVES county-scale VMT mix approach.

Another challenge introduced by differences in MOVES project and county scale approach was freeway ramps. The HGB travel model estimates ramps as separate roadway links, with variations in speed. Some links classified as ramps are relatively long, e.g. ½ mile or more (the Houston freeway system has many flyovers transitioning from one freeway to another that contribute to this). Since it was desirable to estimate emissions for these individually in SEE, an approach was developed to define each ramp as a link in MOVES, with a unique operating mode distribution assigned based on average speed. This approach was developed using the operation mode distributions derived from MOVES county scale runs for restricted roads with ramp fraction set to 100 percent, for each of the MOVES speed bins. However, in implementing this approach SEE was not able to match the emissions increment at county scale when ramp fraction derived from the HGB travel model was introduced. The inclusion of ramp-specific link emissions was ultimately dropped, and ramp emissions in SEE are instead calculated using the county scale runs performed for off-network emissions, based on ramp fractions calculated from the HGB travel model at the county, rather than link, level. For future improvements it is still desirable to model each ramp link individually; MOVES2014 will treat ramps as separate road types, which will make link-specific ramp emissions in SEE more feasible when updated to MOVES2014.

A final challenge introduced by differences in MOVES project and county scale approach was on-network evaporative emissions (i.e., running loss). MOVES project scale doesn't include evaporative emissions, so these emissions were also added to the "off-network" county scale runs within SEE.

While not implemented in the first version of HGB-SEE, using MOVES project scale provides the opportunity to include road grade in regional emission inventory calculations. This would require road grade estimates for each link on a network, or at the least the subset where grade would be significant enough to influence emissions. It could be implemented in SEE by adding grade to speed and road type in the determination of unique links.

2.3 Off-network approach

Off-network emissions include start (exhaust and crankcase), evaporative (permeation, vapor venting, liquid leaks and refueling) and extended idle emission processes. With the exception of refueling, these are estimated in SEE with a MOVES county scale run for a weekday, producing emission results by hour. Refueling is not estimated in SEE intentionally, following the precedent set by the TTI's suite of modeling tools for on-road emissions. The county scale MOVES run shares input tables with the on-network project scale runs for vehicle population, fuels, fuel technology, inspection/maintenance, meteorology, age distribution. For the remaining input tables unique to county scale activity (total VMT, hourly VMT distribution, road type VMT distribution and average speed distribution), input tables are produced by PERL scripts that aggregate link-level activity estimated by the travel model and pre-processed using TRANSVMT, according to EPA's modeling guidance. This is needed because in MOVES, off-network activity is related to on-network activity (e.g., hours parked depends on hours operating); using aggregated TRANSVMT activity ensures the off-network activity is consistent with travel model network results.

The results of the county-scale MOVES runs are then allocated to roughly 5,000 TAZs in the HGB area with PERL scripts and allocation factors by TAZ and time of day. This process could also happen within MOVES, and was first attempted using MOVES custom domain and populating the Zone table directly with start, park and extended idle allocation factors. However, the runtime was prohibitively long, likely because when this approach is used in MOVES the model is repeating the entire emissions calculation process for each zone, allowing for different meteorology by zone as would occur with emission inventories at the grid cell level prepared for photochemical air quality modeling. If the same meteorology is used for an entire county, the level of detail in the internal MOVES allocation approach is unnecessary, and allocation of emissions to zones can be done through post-processing. This approach was taken in SEE because runtime performance was much better.

Allocation factors for start and evaporative emissions are calculated within SEE using PERL scripts, based on travel demand model origin/destinations by zone. Start allocations are based on number of trip origins by zone, and evaporative (park) allocations are based on number of trip ends by zone. These are estimated by the HGB travel model for four time periods - AM peak, Midday, PM peak and Overnight – and allocations are estimated for each time period and applied to the appropriate hourly MOVES results. Example start and park allocations are shown in Figure 2 and Figure 3, for the AM peak in Harris County.

Figure 2. Start Allocation Example (Harris County AM Peak)

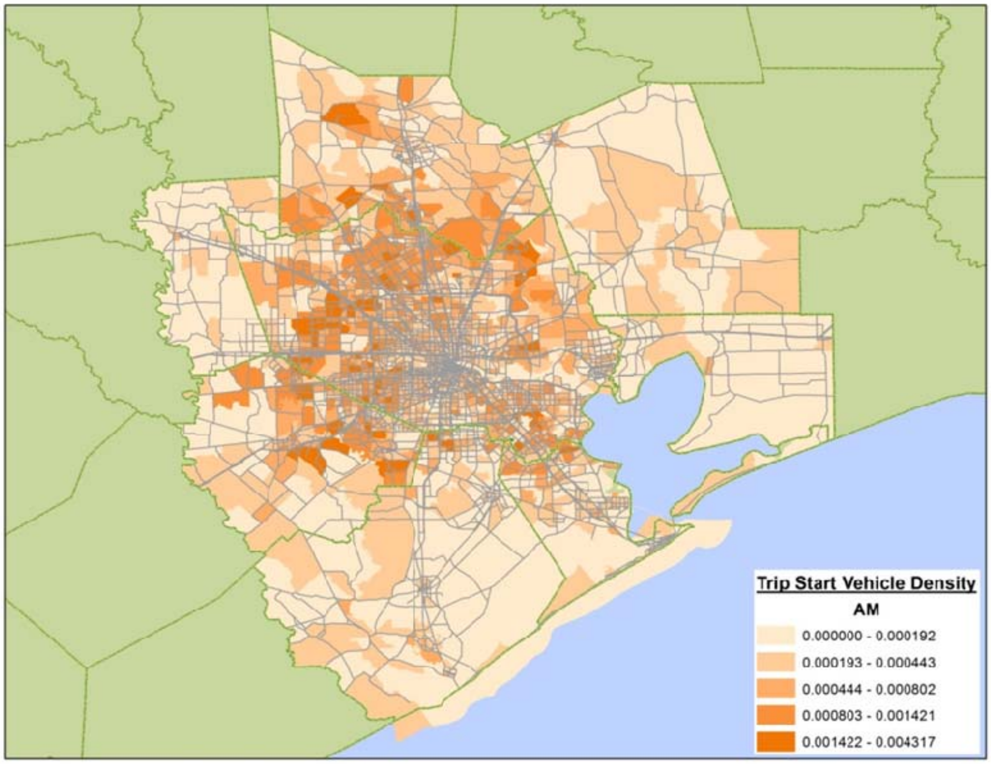
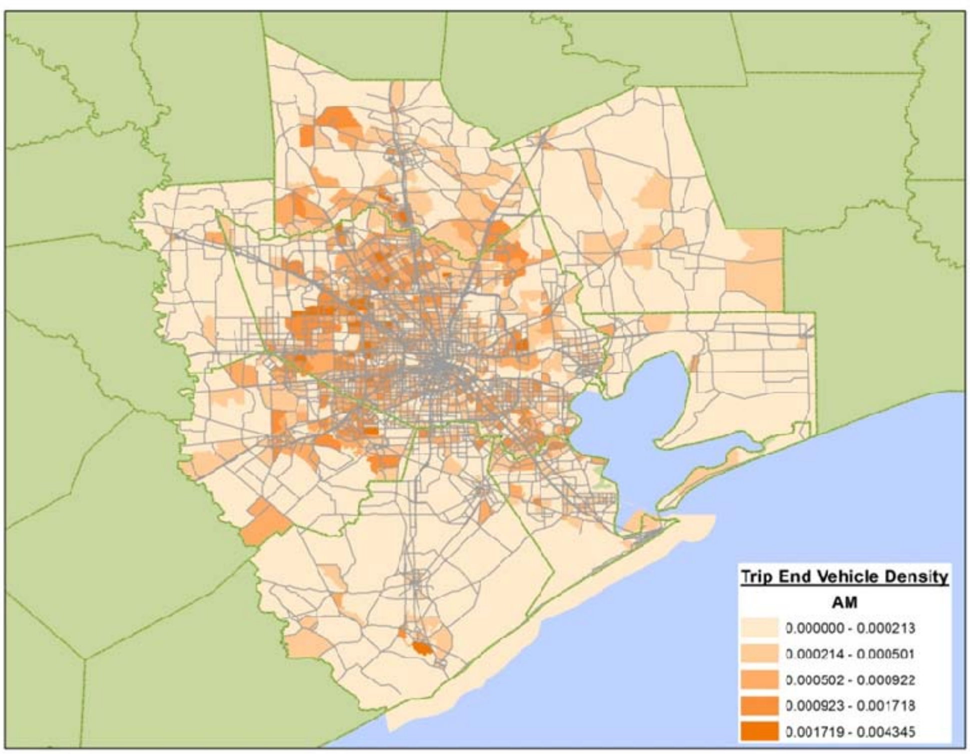
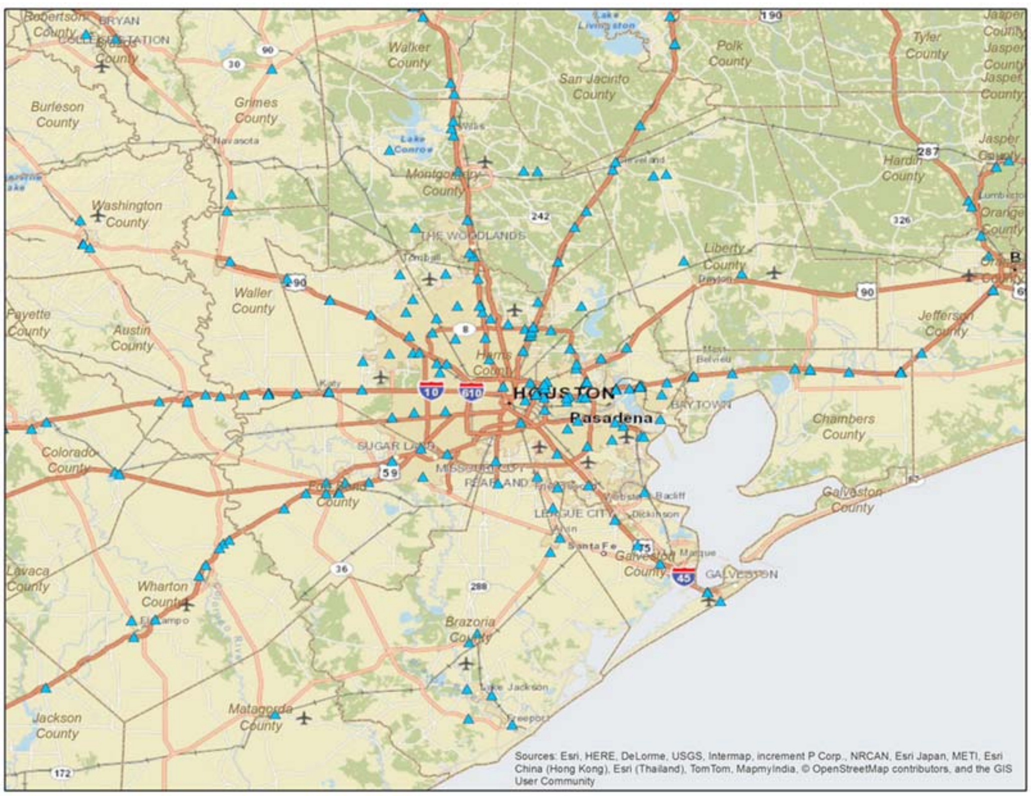


Figure 3. Park Allocation Example (Harris County AM Peak)



Extended idle allocations by TAZ were developed using GIS analysis of locations where extended idling will most likely occur across the HGB area – i.e. truck stops, rest stops and other commercial establishments that allow truck idling. For this analysis ERG used the commercially available Truck Stops Plus database, which contains over 7,300 trucks stops nationwide and includes all major chain truck stops, as well as independent truck stops (3). This dataset includes the size category of each truck stop (less than 20 parking spaces, 20-70 parking spaces, and more than 70 parking spaces), and other relevant detail such as whether overnight parking is allowed, fees charged for overnight parking, and what services and facilities (e.g. showers) are offered. These data were deemed useful to determine how much extended idling may occur at any given location; candidate locations for the HGB area are shown in Figure 4. These were used to assign extended idle activity to TAZ, and produce the allocation factors applied to county-scale extended idle emissions by hour.

Figure 4. Potential Extended Idle Locations from Truck Stop Plus database



3.0 BENCHMARK RESULTS

Initial runs were performed to compare SEE results to MOVES county scale inventory mode results using inputs developed for the 2018 HGB SIP, and updated travel demand modeling produced by HGAC. All inputs were aligned between SEE and MOVES, with MOVES inputs for meteorology, fuels, inspection/maintenance, vehicle population, age distribution and fuel technology mix taken directly from SIP inputs posted publicly by the Texas Commission on Environmental Quality (TCEQ) (4). SEE's processing of the TRANSVMT output for 2018 produced the link-level inputs for the project scale SEE runs, and the county-scale inputs of VMT, hourly VMT distribution, average speed distribution, and road type distribution. This ensured that the SEE vs. MOVES county scale runs were directly comparable.

Results of the benchmark runs are shown in Table 1, with emission results for HC, CO and NOx reported in tons per day (TPD) for each of the eight counties. As shown, the county level and overall totals for SEE and MOVES county scale are within one-half percent for each pollutant.

Table 1. Benchmark Comparison of SEE and MOVES County Scale Runs

Benchmark (*EPA's Guidance of running MOVES at County Domain/Scale*)

2018 Summer Weekday

County	CountyName	HC (TPD)	CO (TPD)	NOX (TPD)	VMT (Mi/day)	Population
48201	Harris	32.78	404.92	56.22	106,980,215	3,183,222
48039	Brazoria	3.05	31.35	4.54	7,236,298	327,273
48071	Chambers	0.88	10.29	3.65	3,275,260	42,386
48157	Fort Bend	4.91	49.20	6.83	11,892,122	587,414
48167	Galveston	2.28	24.86	3.17	5,849,575	250,959
48291	Liberty	1.30	13.67	2.90	2,966,501	84,882
48339	Montgomery	4.50	47.97	7.37	12,438,787	469,788
48473	Waller	0.70	9.12	1.74	2,322,507	39,278
8-County Total		**50.40**	**591.39**	**86.43**	**152,961,266**	**4,985,203**

HGB-SEE Results

2018 Summer Weekday

County	CountyName	HC (TPD)	CO (TPD)	NOX (TPD)	VMT (Mi/day)	Population
48201	Harris	32.78	405.04	56.10	106,980,205	3,183,222
48039	Brazoria	3.05	31.37	4.54	7,236,300	327,273
48071	Chambers	0.88	10.30	3.65	3,275,260	42,386
48157	Fort Bend	4.91	49.22	6.82	11,892,122	587,414
48167	Galveston	2.28	24.87	3.16	5,849,576	250,959
48291	Liberty	1.30	13.68	2.90	2,966,501	84,882
48339	Montgomery	4.50	48.00	7.35	12,438,783	469,788
48473	Waller	0.70	9.13	1.74	2,322,507	39,278
8-County Total		**50.40**	**591.61**	**86.25**	**152,961,252**	**4,985,203**

Results are produced by SEE at the link and TAZ level for each hour of the day. Example results of this are shown in Figure 5 and Figure 6 for midnight and 6 PM. The links reflect on-network emission totals, while the zones reflect off-network totals. Note that some zones show high emissions even at midnight; these are the zones where extended idle emissions were allocated.

Figure 5. NOx results by Link/TAZ (12 AM)

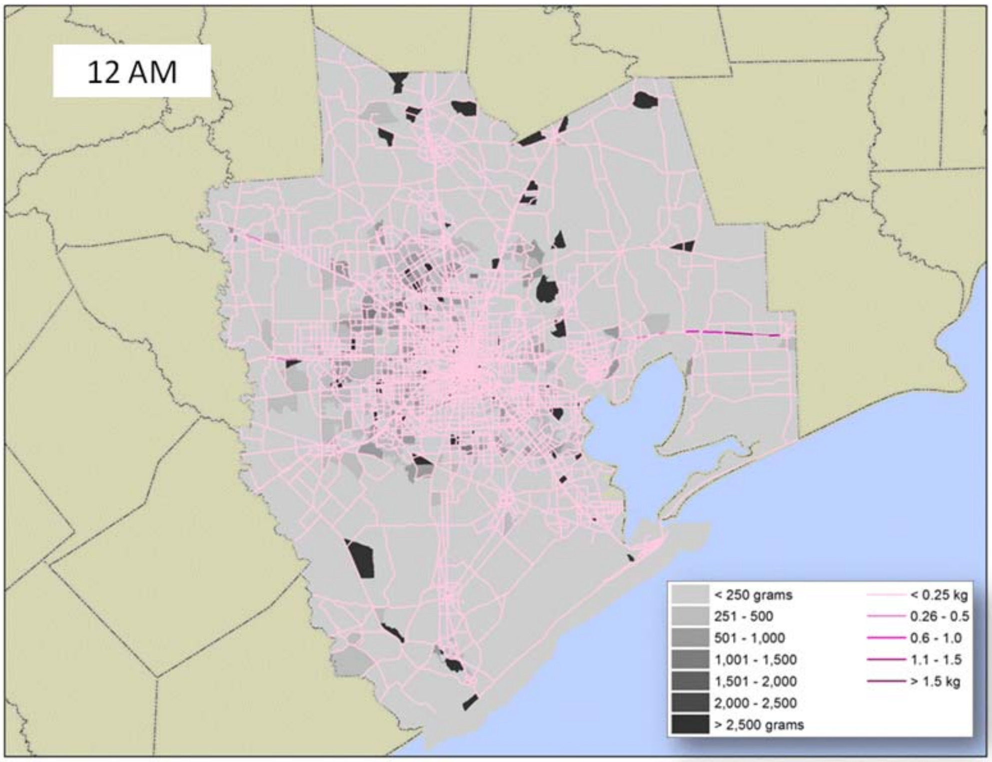
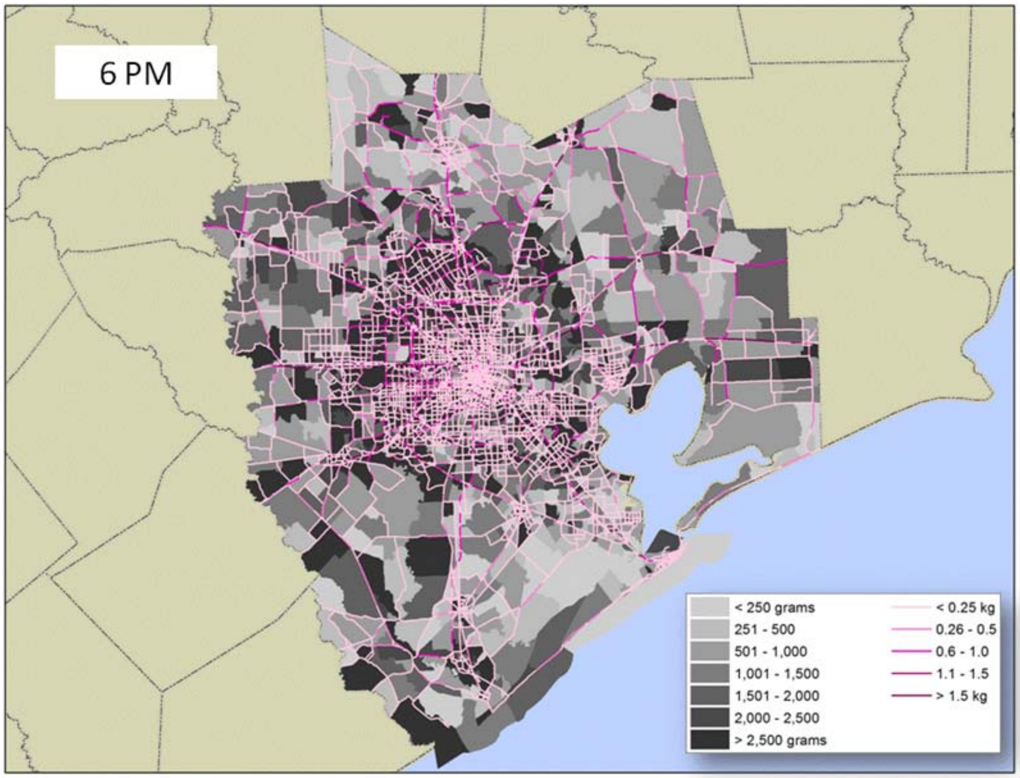


Figure 6. NOx results by link/TAZ (6 PM)



4.0 USING SEE

The first implementation of SEE uses a Microsoft Excel-based user interface to accept user inputs, execute a series of PERL scripts which set up and run MOVES2010b, and summarize outputs to the level of detail specified in the user. This section serves as a User's Guide for each of these steps. In general, because SEE was designed to set up and execute MOVES runs, the user does not need to interact directly with MOVES in execution of the model. However, as discussed in Section 4.2, SEE does use MOVES input database tables directly (in .csv format), meaning that the user will need to be familiar with the format of these tables, and their creation/modification through EPA-provided tools such as the MOVES County Data Manager (CDM). While MOVES is not run directly by the user in SEE, the user will need to have basic familiarity with the model and MOVES county database inputs.

4.1 Getting Started: Requirements, Installation, Configuration, and Execution

Requirements: SEE requires installation of Microsoft Excel 2007 (or later), ActivePerl 5.16.2 (or later), and MOVES2010b (with its associated MySQL version 5.5.12 installation).

Without any of these components, SEE will fail to run properly. MOVES and MySQL should be installed and configured following EPA's guidance provided as part of the MOVES installation package. Perl is provided with the SEE.zip installation and Perl must be installed in order for the SEE tools to run. The location of the Perl installation is not important, and ERG recommends using the paths that are recommended by Perl's installer.

Installation: SEE is packaged in a .zip file provided to the user. To install SEE, download SEE.zip and extract it to your C:\ directory. The installation file contains several sample inputs for the tool, including a set of TRANSVMT hourly files, and MOVES inputs for the SIP benchmark case. It also contains the Perl scripts and GUI. The first time you open SEE, it is helpful to open Excel first, and then find SEE through the open file dialog. Doing this helps Excel establish the native path for the tool. The SEE.zip file must be unzipped directly under C:\ such that the following directory structure exists:

- C:\SEE\CSVInputs
- C:\SEE\LocalGen
- C:\SEE\LOOKUPS
- C:\SEE\MOVESXML
- C:\SEE\TCEQ_MOVES_INPUTS
- C:\SEE\TRANSVMT

Configuration: To configure SEE, open up the tool by double-clicking on SEE_GUI_beta.xlsm. This will start the tool within Microsoft Excel. Every time you launch SEE, Excel will display a security warning; click on the associated Options button, then enable the content. To turn off this security warning, the trust center can be configured within Excel to allow SEE to run without displaying security warnings.

SEE comes pre-populated with data and options that should allow the user to begin an initial run. However, for future runs, the user will want to update the options. In reviewing the GUI, note the following:

- Yellow fields are static and *must not be modified*.
- Peach fields are user inputs.
- Green fields are descriptive information.
- The white block at the bottom contains buttons to execute various scripts.

Many of the options listed will not need to be modified by the user at all, especially the path statements. However, updates to calendar year, month, day type, counties to model, and so forth can all be made here. Note that although the initial configuration only contains a single county, modeling of multiple counties is allowed by using a comma-delimited list of FIPS codes in the *countylist* field.

Execution: There are three ways to execute the scripts that make up the SEE tool. In any case, start by pressing the **Generate Options File** button. This takes all of the user variables and writes them to a config.ini file in the SEE directory. Next, the user may run the scripts collectively by (1) clicking on the **Run ALL Scripts** button or (2) clicking on the **Run OFF-Net Scripts** button, followed by the **Run ON-Net Scripts** button. This process steps through all 10 scripts, from pre-processing, to model setup and execution, to post-processing.

Alternatively in a third option, the user may click through each of the scripts individually using the bottom set of buttons (starting with **1- PreProc VMT** and continuing onward). This is sometimes helpful as a quality assurance step when setting up new scenarios or testing new input files. In any case, the scripts *must be run sequentially*, since later scripts are dependent on results from earlier scripts.

Explanation of the Function of each Script:

Script 1 (1_Process_TransVMT_Links.plx). Script 1 imports the 24 hourly and calculates many of the activity inputs for the off-network county scale and project scale MOVES runs. The exact MOVES inputs that SEE produces are listed document in Table 2 and

Table 3 denoted by the 'X' in the column '**Calculated by SEE**.'

Script 2 (2_Process_ZonePeriodTrips.plx). Script 2 imports the 4 (or different number of time periods) Origin/Destination (O/D) trip files and calculates the trip start and end allocations for each period and assigns them to hours of day based on the time period definitions file.

Script 3 (3_Generate_off-net_MOVES_DataImporter.plx). Script 3 writes the MOVES data importer XML files for the off-network county scale MOVES run; by default the location of these intermediate files for SEE can be found under C:\SEE\MOVESXML. This script executes quickly in a matter of 1-2 seconds.

Script 4 (4_Generate_off-net_MOVES_RunspecFiles.plx). Script 4 writes the MOVES run specification (a.k.a. runspec) XML files for the off-network county scale MOVES runs; by default the location of these intermediate files for SEE can be found under C:\SEE\MOVESXML. This script executes quickly in a matter of 1-2 seconds.

Script 5 (5_Execute_off-net_MOVES_Runs.plx). Script 5 executes two Windows batch (.BAT) files that were created by Script 3 and 4 respectively. The .BAT files run MOVES from the command line to (1) build the county scale MOVES input database and (2) execute the county scale MOVES run.

Script 6 (6_PostProcess_off-net_MOVES_CountyScale.plx). Script 6 allocates the county total emissions to TAZ using the allocations SEE calculated in Script 2 and MOVES outputs produced by Script 5. Script 6 also applies TxLED adjustments and sums the emissions to prepare them for later addition to the on-network results.

Script 7 (7_Generate_on-net_MOVES_XML.plx). Script 7 writes the MOVES data importer XML files for the on-network project scale MOVES runs for each hour; by default the location of these intermediate files for SEE can be found under C:\SEE\MOVESXML. This script executes quickly in a matter of 1-2 seconds.

Script 8 (8_Generate_on-net_MOVES_Runstreams.plx). Script 8 writes the MOVES run specification (runspec) XML files for the on-network project scale MOVES runs for each hour; by default the location of these intermediate files for SEE can be found under C:\SEE\MOVESXML. This script executes quickly in a matter of 1-2 seconds.

Script 9 (9_Execute_on-net_MOVES_Runstreams.plx). Script 9 executes two Windows batch (.BAT) files that were created by Script 7 and 8 respectively. The .BAT files run MOVES from the command line to (1) build the project scale MOVES input databases and (2) execute the project scale MOVES runs.

Script 10 (10_PostProcess_on-net_MOVES_Links.plx). Script 10 uses the output from the on-network project scale MOVES runs for unique links (completed in Script 9) to calculate the emission inventory for all links, and it applies TxLED fuel adjustments. Script 10 also compiles the previously-calculated off-network emissions, adding them to a common table with the on-network emissions. Finally, Script 10 prepares summaries of the total emissions and outputs them as text files to C:\SEE\LocalGen. The GUI imports these files into Excel when the "**Import Results**" button is pushed.

MOVES Multiple Worker Configuration: Sample files have been included to set up MOVES to work with a single master and multiple workers. In doing so, the user must first enable file sharing within Windows, and specifically grant read/write access to the shared work folder defined in MOVESConfiguration.txt, located in the main MOVES directory. By default, this is the \SharedWork folder.

Once this access is granted, the user should update WorkerConfiguration.txt and manyworkers.txt to reflect the location of the shared directory. This will take the form of \\MasterComputer\Sharedwork, as shown in the example files. The user may then run the provided MOVES3Workers.bat to have three concurrent workers running on a single machine. This file may be modified to prepare other numbers of workers as well – 2 and 4 are common.

4.2 SEE Inputs

SEE requires a variety of inputs from the user that fall into one of four broad categories below. The category with the greatest number of files by far is item # 3, MOVES inputs.

1. Inputs to SEE from the GUI
2. Inputs to SEE related to the TDM or TRANSVMT
3. Inputs to SEE required by MOVES
4. Other inputs that are ancillary to SEE (e.g., cross-reference "lookup" files)

The corresponding four sections in this guide outline each SEE input type and where it can be found in the installation in order to change the file for a different application.

4.2.1 Inputs from the GUI

The Excel GUI contains a number of options used to run SEE, as shown in Figure 7. Starting at the top of Figure 7 moving downward, the User inputs and their function are briefly described.

User model selection options:

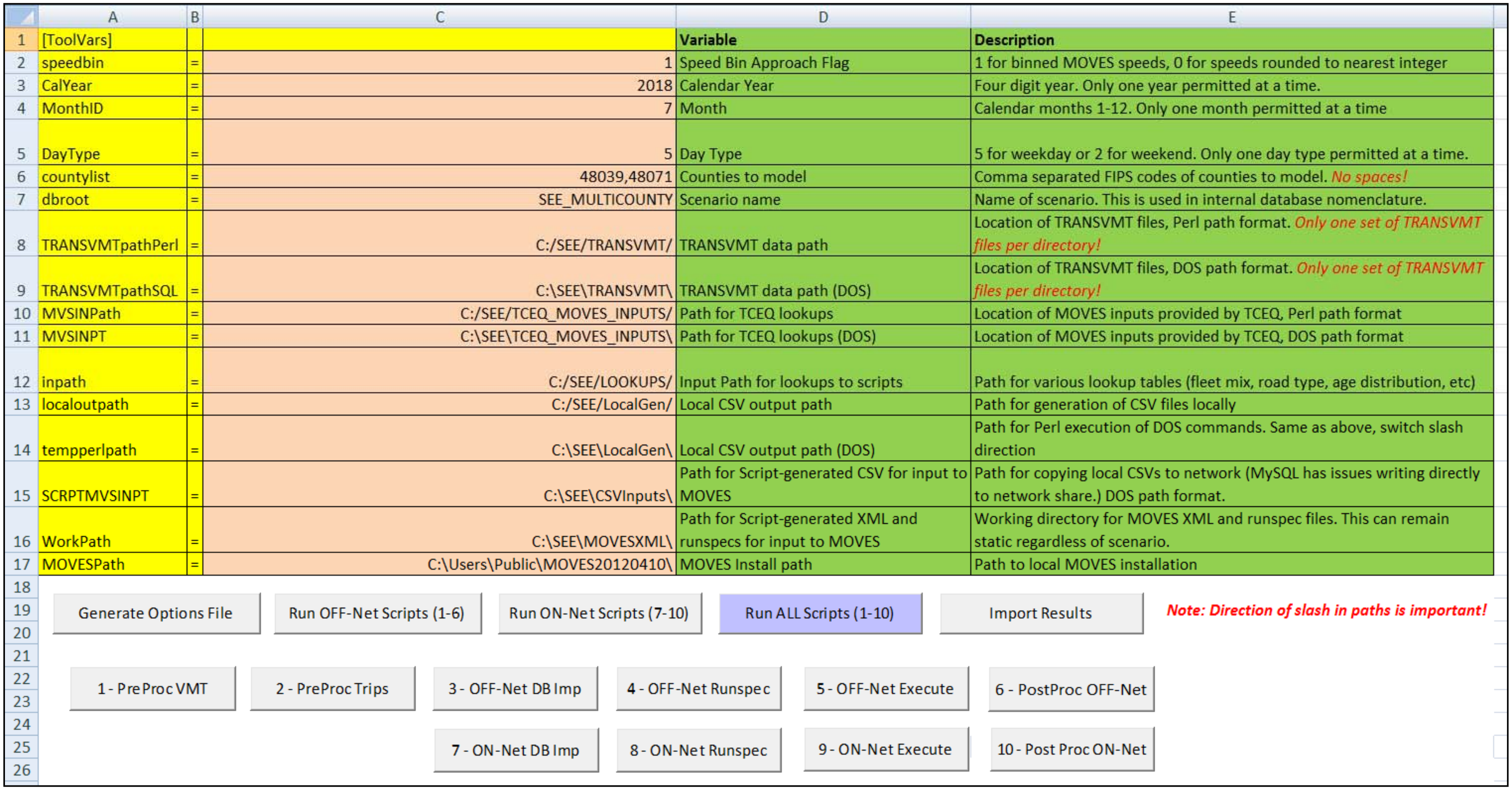
1. **Speedbin** may be set to either "0" (run all distinct links using all speeds rounded to the nearest integer) or a value of "1" (run distinct links where speeds have been binned into the 16 MOVES speed bins). The default value of "1" reduces MOVES runtime by running fewer links.
2. **CalYear** determines the calendar year of the MOVES run. It is the User's responsibility to ensure that the TRANSVMT year matches this year. Acceptable values include 1990 or 1999-2050.
3. **MonthID** determines the month of the MOVES run. It is the User's responsibility to ensure the seasonality of the TRANSVMT results is consistent with the MonthID.

4. **DayType** determines the day type of the MOVES runs: weekday or weekend. It is the Users responsibility to ensure that the TRANSVMT results (typically a weekday) match this day type.
5. **Countylist** is a list of one or more counties in the 8-county HGB area to run.
6. **Dbroot** is the naming scheme that SEE will use to name the MySQL databases where emissions results are calculated and stored. The variable can be used as a scenario description to track different executions of SEE.

User directory options:

1. **TRANSVMTpathPerl** is a directory location where SEE expects to finds the hourly link files from TRANSVMT and the origin/destination trip matrices. The User can set any directory path, but the slashes must be forward slash format "/".
2. **TRANSVMTpathSQL** must be the same directory as above (7), but using backward slash formats "\".
3. **MVSINPath** is the location of all MOVES model inputs to run SEE for the default case (July 2018 Weekday, all 8 counties). More detail on these files can be found in section 3 of this document. User must input a directory with a forward slash format "/".
4. **MVSINPT** is the same as above (9), but using backward slash formats "\".
5. **Inpath** is the location of lookups required by SEE. Most of these files should not need to be modified by the User, but they are described in detail in Section 4.
6. **Localoutpath** is the location where SEE's Perl scripts write a lot of their intermediate output files, which are CSV-formatted files that will be some key inputs to MOVES. Section 3 clearly defines which MOVES inputs are calculated by SEE vs. User-supplied. Use forward slashes "/".
7. **Tempperlpath** is the same directory as above (12) except using a backward slash format "\".
8. **SCRPTMVSINPT** is a directory where all CSV are copied from **localoutpath** (item 12). This is an extra step to enable SEE's files to be copied to a network location that is regularly backed up, rather than a local hard drive location such as C:\.
9. **Workpath** is another directory that SEE writes to. All MOVES data importer XML files, MOVES run specification XML files, and Windows executable batch files are written to this directory.
10. **MOVESPath** is the path to the local MOVES2010b installation.

Figure 7. SEE GUI Input tab, shown pre-populated with values.



	A	B	C	D	E
1	[ToolVars]			**Variable**	**Description**
2	speedbin	=	1	Speed Bin Approach Flag	1 for binned MOVES speeds, 0 for speeds rounded to nearest integer
3	CalYear	=	2018	Calendar Year	Four digit year. Only one year permitted at a time.
4	MonthID	=	7	Month	Calendar months 1-12. Only one month permitted at a time
5	DayType	=	5	Day Type	5 for weekday or 2 for weekend. Only one day type permitted at a time.
6	countylist	=	48039,48071	Counties to model	Comma separated FIPS codes of counties to model. *No spaces!*
7	dbroot	=	SEE_MULTICOUNTY	Scenario name	Name of scenario. This is used in internal database nomenclature.
8	TRANSVMTpathPerl	=	C:/SEE/TRANSVMT/	TRANSVMT data path	Location of TRANSVMT files, Perl path format. *Only one set of TRANSVMT files per directory!*
9	TRANSVMTpathSQL	=	C:\SEE\TRANSVMT\	TRANSVMT data path (DOS)	Location of TRANSVMT files, DOS path format. *Only one set of TRANSVMT files per directory!*
10	MVSINPath	=	C:/SEE/TCEQ_MOVES_INPUTS/	Path for TCEQ lookups	Location of MOVES inputs provided by TCEQ, Perl path format
11	MVSINPT	=	C:\SEE\TCEQ_MOVES_INPUTS\	Path for TCEQ lookups (DOS)	Location of MOVES inputs provided by TCEQ, DOS path format
12	inpath	=	C:/SEE/LOOKUPS/	Input Path for lookups to scripts	Path for various lookup tables (fleet mix, road type, age distribution, etc)
13	localoutpath	=	C:/SEE/LocalGen/	Local CSV output path	Path for generation of CSV files locally
14	tempperlpath	=	C:\SEE\LocalGen\	Local CSV output path (DOS)	Path for Perl execution of DOS commands. Same as above, switch slash direction
15	SCRPTMVSINPT	=	C:\SEE\CSVInputs\	Path for Script-generated CSV for input to MOVES	Path for copying local CSVs to network (MySQL has issues writing directly to network share.) DOS path format.
16	WorkPath	=	C:\SEE\MOVESXML\	Path for Script-generated XML and runspecs for input to MOVES	Working directory for MOVES XML and runspec files. This can remain static regardless of scenario.
17	MOVESPath	=	C:\Users\Public\MOVES20120410\	MOVES Install path	Path to local MOVES installation

4.2.2 Inputs related to the TDM or TRANSVMT

The inputs related to the travel demand model (TDM) consist of one of four types—the hourly link files from TRANSVMT, the O/D trips, the time period definitions file, and the link definitions file.

Default Locations:

C:\SEE\TRANSVMT\	(24 hourly link files and 4 period trip files)
C:\SEE\LOOKUPS\TimePeriodDesignation.tab	(definition of time periods)
C:\SEE\LOOKUPS\link_definitions.tab	(definition of links)

Requirements: The hourly link files from TRANSVMT must be named ending with the capital letter T, followed by the two digit hour of day (i.e., T01, T02 … T23, T24). SEE is programmed to loop through as many hourly files as are present in the directory entered in the GUI. Only one set of 24 files should be present.

The O/D trip files are flexible in the number of time periods allowed, but SEE requires a very specific filename format. The first of two requirements is that the time period abbreviation must be embedded in the filename as the first two characters of the file (for example, “AM” for morning peak period O/D trips file). The second requirement is that the filename must end with the six characters “HR.ASC” including the period. SEE loops through and calculates the start and ends distribution from every file in the directory that ends in `HR.ASC`.

The time period definition file is a TAB-formatted file that can be opened and modified with Excel. There are 3 columns in this file (1) hour, (2) time period description, and (3) time period as a 2-character abbreviation. Column 2 is not used by SEE and is only helpful for documenting Column 3, the time period code. SEE uses Column 3 to assign trip start or end distributions to hours of the day.

The link definition file is a TAB-formatted file with three columns—link ID, Anode, and Bnode. The file should contain each combination of Anode and Bnode present in any hour of TRANSVMT files. The link ID is a unique identifier to refer to each Anode, Bnode combination. The SIP budget TRANSVMT files had 44,633 link IDs and the revised 2018 transportation model’s TRANSVMT files (current as of September 2014) have 68,036 unique link IDs.

How to change:

There should only be one set of TRANSVMT link files and one set of O/D trip files in the directory at one time and they need to match the existing file fixed-column formats.

The default names for the default 4 trip files provided with the tool are the following:

AM_3HR.ASC

MD_6HR.ASC

PM_7HR.ASC

OV_11HR.ASC

In order to accommodate different periods, for example two overnight time periods, one possibility for new naming that meets SEE's requirements could be "O1_5HR.ASC" and "O2_6HR.ASC".

4.2.3 Inputs required by MOVES

The two tables below list all MOVES inputs for on-network using the Project Scale (Table 2) and off-network using the County Scale (

Table 3), the source (SEE or User), and the default location of the files. As shown, SEE calculates the inputs related to fleet activity while the User must supply inputs related to fleet descriptions (e.g., source type age distribution) and meteorology. Most of the user-supplied MOVES inputs are used in both on-network and off-network runs and they require a specific naming convention that makes use of the county FIPS code.

Table 2. Project Scale (On-network) MOVES inputs for SEE

Database table name	Calculated by SEE	Provided by User	Default Location
AVFT		X	C:\SEE\TCEQ_MOVES_INPUTS
Fuel Formulation		X	C:\SEE\TCEQ_MOVES_INPUTS
Fuel Supply		X	C:\SEE\TCEQ_MOVES_INPUTS
IM Coverage		X	C:\SEE\TCEQ_MOVES_INPUTS
Link	X		C:\SEE\CSVInputs
Link Source Type Hour	X		C:\SEE\CSVInputs
Source Type Age Distribution		X	C:\SEE\TCEQ_MOVES_INPUTS
Zone Month Hour		X	C:\SEE\TCEQ_MOVES_INPUTS

Table 3. County Scale (Off-Network) MOVES inputs for SEE

Database table name	Calculated by SEE	Provided by User	Default Location
AVFT		X	Same as Table 2
Average Speed Distribution	X		C:\SEE\CSVInputs
Day VMT Fraction[1]	*N/A*		C:\SEE\TCEQ_MOVES_INPUTS\dummy
Fuel Formulation		X	Same as Table 2
Fuel Supply		X	Same as Table 2
Hour VMT Fraction	X		C:\SEE\CSVInputs
HPMS Vtype Year	X		C:\SEE\CSVInputs
IM Coverage		X	Same as Table 2
Month VMT Fraction[2]	*N/A*		C:\SEE\TCEQ_MOVES_INPUTS\dummy
Road Type[3]	X		C:\SEE\CSVInputs
Road Type Distribution	X		C:\SEE\CSVInputs
Source Type Age Distribution		X	Same as Table 2
Source Type Year		X	C:\SEE\TCEQ_MOVES_INPUTS
Zone Month Hour		X	Same as Table 2

[1, 2] These are required by MOVES but should not be modified by the User; they are automatically looked up by SEE.

[3] Road Type contains ramp fractions by MOVES road type that are set to zero in order to match the TTI approach**.**

Requirements: The User supplied MOVES files must follow the existing naming convention of provided files with the tool. These are listed below:

Table 4. File naming requirements for all User supplied MOVES inputs

Database table name	Filename, where ${c}= County FIPS Code
AVFT	AVFT_**${c}**.csv
Fuel Formulation	fuelFormulation_mvs10bFormatted.csv
Fuel Supply	mvs10a_hgb2018_s_**${c}**_er_CDB_in.fuelsupply.csv
IM Coverage	mvs10a_hgb2018_s_**${c}**_er_CDB_in.imcoverage.csv
Source Type Age Distribution	mvs10a_MDB20100830_HGB**${c}**_2011j_SUTage.csv
Source Type Year	hgb2018_mvs10a_**${c}**_VEHPOP_2018_sourcetypeyear.csv
Zone Month Hour	ZoneMonthHour_8county.csv

The month and year inside these files must match the GUI inputs for **CalYear** and **MonthID** from Figure 7. All the MOVES input files for the HGB area year 2018 were downloaded directly from the TCEQ FTP site and most are provided directly with SEE unmodified. In some cases, files had to be converted from MOVES version 2010a to 2010b formats. One example of this conversion was the fuel engine fractions (of gas and diesel) by model year. The TCEQ website version lists a fuel engine fractions text file that MOVES2010a used to read through the GUI. However, in MOVES2010b this is an actual input table called AVFT. ERG reformatted this MOVES input for compatibility with the latest version of MOVES. Minor reformats were also necessary for the fuel formulation file (relating to T50, T90 fuel parameter fields which were not part of MOVES2010a fuel formulation format). The AVFT file provided with SEE is based on TTI's fuel mix information that is county-specific rather than a statewide average.

How to change: We highly recommend leaving the provided example files unmodified, and copying the entire directory to a new name to update the files that need changing. Note that the provided MOVES inputs are specific to the month July and year 2018 and reflect the files provided by TCEQ for calculating the SIP budget.

To assist with input file formatting, the MOVES county data manager in the MOVES model GUI can be used to export tables in the correct format for MOVES to provide to SEE. Also, the existing example files are correctly formatted, so any User-generated files could also be compared to these as a check. Below, Table 5 through Table 11 list all MOVES-related input files by input for – Alternate Vehicles and Fuels Table (AVFT), Fuel Formulation, Fuel Supply, Inspection and Maintenance (I/M) Coverage, Source Type Age Distribution, and Population (Source Type Year). The other MOVES input data, as noted previously, is created by SEE based on TRANSVMT hourly files. Each User input for MOVES is explained in a separate table, with the column names (Field Name) listed in order as they should appear from left to right. For example, the AVFT input provided to SEE should be a CSV file with 5 columns—from Left to Right as sourceTypeID, modelYearID, fuelTypeID, engTechID, fuelEngFraction—as shown below in Table 5.

Table 5. Details for the AVFT Table User Input

Columns of the AVFT table For more information, see Section 3.9.1 of the MOVES2010b Technical Guidance http://www.epa.gov/otaq/models/moves/documents/420b12028.pdf		
Field Name	**Data Type**	**Comment**
sourceTypeID	smallint(6)	Numeric value defining a MOVES source type (e.g., 11 for motorcycle)
modelYearID	smallint(6)	Numeric value identifying a model year.

Columns of the AVFT table For more information, see Section 3.9.1 of the MOVES2010b Technical Guidance http://www.epa.gov/otaq/models/moves/documents/420b12028.pdf		
Field Name	**Data Type**	**Comment**
fuelTypeID	smallint(6)	Identifies a basic kind of fuel used by SourceTypes: 1 = Gasoline 2 = Diesel Fuel 3 = Compressed Natural Gas (CNG)
engTechID	smallint(6)	Identifies an engine technology.
fuelEngFraction	double	Fraction that must sum to 1 for each combination of sourceTypeID and modelYearID

Table 6. Details for the Fuel Formulation Table User Input

Columns of the Fuel Formulation Table For more information, see Section 4.10.1.1 of the MOVES2010b Technical Guidance http://www.epa.gov/otaq/models/moves/documents/420b12028.pdf		
Field Name	**Data Type**	**Comment**
fuelFormulationID	smallint(6)	Numeric value to uniquely identify a fuel type.
fuelSubtypeID	smallint(6)	Identifies a particular kind of fuel within a FuelType. e.g. Gasoline may be conventional, or RFG, diesel may be conventional, biodiesel, Fischer-Troppes, etc.

Columns of the Fuel Formulation Table For more information, see Section 4.10.1.1 of the MOVES2010b Technical Guidance http://www.epa.gov/otaq/models/moves/documents/420b12028.pdf		
Field Name	**Data Type**	**Comment**
RVP	float	Vapor pressure, expressed in psi.
sulfurLevel	float	sulfur content, expressed in ppm
ETOHVolume	float	Ethanol content, expressed in volume percentage
MTBEVolume	float	MTBE content, expressed in volume percentage
ETBEVolume	float	ETBE content, expressed in volume percentage
TAMEVolume	float	TAME content, expressed in volume percentage
aromaticContent	float	aromatic content, expressed as a volume percentage
olefinContent	float	olefin content, expressed as a volume percentage
benzeneContent	float	benzene content, expressed as a volume percentage
e200	float	percentage vapor at 200 degrees F
e300	float	percentage vapor at 300 degrees F
BioDieselEsterVolume	float	percent volume of biodiesel in diesel fuel
CetaneIndex	float	Not Used in MOVES2010b
PAHContent	float	Not Used in MOVES2010b
T50	float	temperature in degrees F at which 50% of a sample of gasoline evaporates

Columns of the Fuel Formulation Table For more information, see Section 4.10.1.1 of the MOVES2010b Technical Guidance http://www.epa.gov/otaq/models/moves/documents/420b12028.pdf		
Field Name	**Data Type**	**Comment**
T90	float	temperature in degrees F at which 90% of a sample of gasoline evaporates

Table 7. Details for the Fuel Supply Table User Input

Columns of the Fuel Supply Table For more information, see Section 4.10.1.2 of the MOVES2010b Technical Guidance http://www.epa.gov/otaq/models/moves/documents/420b12028.pdf		
Field Name	**Data Type**	**Comment**
countyID	int(11)	1000* FIPS state code + FIPS county identification code.
fuelYearID	smallint(6)	Identifies a year for which fuel supply data has been entered in the FuelSupply table. (May be used by multiple calendar years.)
monthGroupID	smallint(6)	Numeric value of 1-12 and the value ***must match the SEE GUI Month ID***
fuelFormulationID	smallint(6)	Numeric value to identify a fuel type and it must have a corresponding entry for the fuelFormulationID in the Fuel Formulation table.
marketShare	float	Decimal Fraction of the supply of this fuel type which this fuel formulation constitutes. Market shares must sum to 1 over fuel subtype.
marketShareCV	float	Not Used in MOVES2010b

Table 8. Details for the I/M Coverage Table User Input

Columns of the I/M Coverage Table For more information, see Section 4.11 of the MOVES2010b Technical Guidance http://www.epa.gov/otaq/models/moves/documents/420b12028.pdf		
Field Name	**Data Type**	**Comment**
polProcessID	smallint(6)	100*pollutantID + processID Set of valid combinations is determined by rows in this table.
stateID	smallint(6)	FIPS state identification code.
countyID	int(11)	1000* FIPS state code + FIPS county identification code.
yearID	smallint(6)	An actual calendar year. ***This must match the SEE GUI calendar year (CalYear)***
sourceTypeID	smallint(6)	Numeric value defining a MOVES source type (e.g., 11 for motorcycle)
fuelTypeID	smallint(6)	Identifies a basic kind of fuel used by SourceTypes: 1 = Gasoline 2 = Diesel Fuel 3 = Compressed Natural Gas (CNG)
IMProgramID	smallint(6)	Numeric value to uniquely identify the application of an IM program to a set of model years.
inspectFreq	smallint(6)	"1" means annual "2" means biennial "3" means continuous

Columns of the I/M Coverage Table For more information, see Section 4.11 of the MOVES2010b Technical Guidance http://www.epa.gov/otaq/models/moves/documents/420b12028.pdf		
Field Name	**Data Type**	**Comment**
testStandardsID	smallint(6)	Numeric value corresponding to one of 13 exhaust emissions tests or 7 evaporative tests listed in Table 4 of the MOVES2010b Technical Guidance.
begModelYearID	smallint(6)	Numeric value identifying a model year.
endModelYearID	smallint(6)	Numeric value identifying a model year.
useIMyn	char(1)	"Y" means I/M program is in effect "N" means I/M program is turned off
complianceFactor	float	Decimal fraction to indicate the I/M compliance rates, waiver rates and the regulatory class adjustment. See Section 4.11.1.6 of the MOVES 2010b Technical Guidance for more information.

Table 9. Details for the Source Type Age Distribution Table User Input

Columns of the Source Type Age Distribution Table For more information, see Section 4.4 of the MOVES2010b Technical Guidance http://www.epa.gov/otaq/models/moves/documents/420b12028.pdf		
Field Name	**Data Type**	**Comment**
sourceTypeID	smallint(6)	Numeric value defining a MOVES source type (e.g., 11 for motorcycle)
yearID	smallint(6)	An actual calendar year. ***This must match the SEE GUI calendar year (CalYear)***

Columns of the Source Type Age Distribution Table For more information, see Section 4.4 of the MOVES2010b Technical Guidance http://www.epa.gov/otaq/models/moves/documents/420b12028.pdf		
Field Name	**Data Type**	**Comment**
ageID	smallint(6)	Identifies a SourceUseType age category. Values from 0 to 30. 0 = new 1 = one year old 2 = two years old ... 30 = thirty or more years old
ageFraction	float	Fraction of total domain SourceUseType population which, in a given calendar year, are a given age. (A set of these elements is sometimes often referred to informally as a "registration distribution".)

Table 10. Details for the Population Table User Input

Columns of the Population (Source Type Year) Table For more information, see Section 4.3 of the MOVES2010b Technical Guidance http://www.epa.gov/otaq/models/moves/documents/420b12028.pdf		
Field Name	**Data Type**	**Comment**
yearID	smallint(6)	An actual calendar year. ***This must match the SEE GUI calendar year (CalYear)***
sourceTypeID	smallint(6)	Numeric value defining a MOVES source type (e.g., 11 for motorcycle)
salesGrowthFactor	float	Not used for MOVES runs in SEE.
sourceTypePopulation	float	The total population in the county of a SourceUseType in the calendar year.

migrationrate	float	Not used for MOVES runs in SEE.

Table 11. Details for the Meteorology Table User Input

Columns of the Meteorology (Zone Month Hour) Table For more information, see Section 4.2 of the MOVES2010b Technical Guidance http://www.epa.gov/otaq/models/moves/documents/420b12028.pdf		
Field Name	**Data Type**	**Comment**
monthID	smallint(6)	Numeric value of 1-12 and ***the value must match the SEE GUI Month ID***
zoneID	int(11)	Identifies a zone. Use the county ID * 10.
hourID	smallint(6)	Numeric value of 1-24.
temperature	float	Units of degrees Fahrenheit.
relHumidity	float	The ratio of the amount of water vapor in the air at a specific temperature to the maximum amount that the air could hold at that temperature, expressed as a percentage.

4.2.3.1 Other Inputs

This last category of inputs to SEE are mostly lookup files required for the model to run, but aren't directly related to MOVES. Table 12 lists each lookup file, its purpose and when the User should update it.

Default Location: C:\SEE\LOOKUPS\

Table 12. List of SEE ancillary input files, their purpose, and when they need updating by User.

Filename	Purpose	When to update
CountyLookup.tab	Cross-reference of TDM County Code to FIPS Codes	If TDM county codes 1-8 change, or if TDM coverage is expanded to a new county
DummySpeed.tab	Required file to help SEE correctly format the `Average Speed Distribution` table	Never
ExtIdle_8Co_Zone_and_Capacity.tab	Provides SEE total number overnight truck parking spaces by county and TAZ	If the spatial location of TAZ's change, or new/better truck stop data become available
Link_definitions.tab	Provides SEE with a list of all links (distinct Anode, Bnode pairs) in the travel network	If TDM link definitions change, or a different year of TDM is run
RoadtypeLookup.tab	Cross-reference of TDM functional class and area type to the MOVES Road Type ID 2-5	If user decides to model ramps explicitly as ramps or H-GAC transportation planners change the definitions of TDM functional classes or area types
TimePeriodDesignation.tab	Assigns hours of day (1-24) to a TDM time period	If TDM time periods change. This file was described in more detail in Section 4.2.2.
TTI_**${c}**_StFtRt_FleetMix.tab (where **${c}** = County FIPS Code)	VMT fractions for each MOVES road type where fractions sum to 1 over source and fuel type	If trying to have SEE match TTI and TTI changed their VMT Mix by county and road type
TxLEDadjustments.tab	Adjustment factors to reduce NOx emissions from diesel-fueled vehicles. Factors depend on Source Type and Calendar Year	SEE is already populated with reasonable estimates for all calendar years out to 2050; however a precise year's adjustment factors can be replaced if running different calendar year than 2018 or if age distributions change.

Below defines the fields of each ancillary file, separately by filename listed above in Table 12.

Table 13. Details for the County Lookup SEE Ancillary File

Columns of the CountyLookup.tab file (in C:\SEE\LOOKUPS)		
Field Name	**Data Type**	**Comment**

Columns of the CountyLookup.tab file (in C:\SEE\LOOKUPS)		
Field Name	**Data Type**	**Comment**
County Code	Integer	County code in the TRANSVMT files; values currently used are 1-8.
County FIPS	Integer	5-digit FIPS (e.g., 48201) that corresponds to each County Code in TRANSVMT.
County Name	Text	County name (e.g., Harris). This field is not used by SEE.

Table 14. Details for the Dummy Speed SEE Ancillary File

Columns of the DummySpeed.tab file (in C:\SEE\LOOKUPS)		
Field Name	**Data Type**	**Comment**
sourceTypeID	Integer	Numeric value defining a MOVES source type (e.g., 11 for motorcycle)
roadTypeID	Integer	Road types are 2-5.
hourDayID	Integer	hourID*10+dayID
avgSpeedBinID	Integer	Speed bin IDs are 1-16.
avgSpeedFraction	0	Value is always 0. This is a dummy file.

Table 15. Details for the Extended Idle Allocation SEE Ancillary File

Columns of the ExtIdle_8Co_Zone_and_Capacity.tab file (in C:\SEE\LOOKUPS)		
Field Name	**Data Type**	**Comment**
County FIPS	Integer	5-digit code (e.g., 48201)
TAZ	Integer	Transportation Analysis Zone
Parking capacity	Integer	Number of Overnight Truck Parking Spaces in the TAZ

Table 16. Details for the Link Definitions SEE Ancillary File

Columns of the Link_definitions.tab file (in C:\SEE\LOOKUPS)		
Field Name	**Data Type**	**Comment**
Link ID	Integer	Unique link identification code, numbers from 1 to N where N is the total number of links in the TRANSVMT files in any hour.
A node	Integer	The start node ID code of a directional link, as defined in TRANSVMT
B node	Integer	The end node ID code of a directional link, as defined in TRANSVMT

Table 17. Details for the Road Type Lookup SEE Ancillary File

Columns of the RoadtypeLookup.tab file (in C:\SEE\LOOKUPS)		
Field Name	**Data Type**	**Comment**
Road Type Code	Integer	Road type code of each link from the TRANSVMT files. Current values are: 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 40
Area Type Code	Integer	Area type code of each link from the TRANSVMT files. Current values are: 1, 2, 3, 4, 5, 40
MOVES roadTypeID	Integer	Corresponding MOVES2010b road type ID. Values can only be 2, 3, 4, or 5.

Table 18. Details of the Time Periods Designation SEE Ancillary File

Columns of the TimePeriodDesignation.tab file (in C:\SEE\LOOKUPS)		
Field Name	**Data Type**	**Comment**
Hour ID	Integer	Hour of Day, 1-24.
Description of Time Period	Varchar(20)	Text description up to 20 characters. This field is not used by SEE.
Time Period ID	Char(2)	Must be a two-character description of the time period (e.g., AM, MD, PM, OV—or suggested O1, O2 if there are two overnight periods)

Table 19. Details of the VMT Mix SEE Ancillary File

Columns of the TTI_${c}_StFtRt_FleetMix.tab file where ${c} = County FIPS Code (in C:\SEE\LOOKUPS)		
Field Name	**Data Type**	**Comment**
roadTypeID	Integer	Numeric value defining a MOVES road type. Values can be 2, 3, 4, or 5.
sourceTypeID	Integer	Numeric value defining a MOVES source type (e.g., 11 for motorcycle)
fuelTypeID	Integer	Numeric value identifying a type of fuel used by SourceTypes: 1 = Gasoline 2 = Diesel Fuel 3 = Compressed Natural Gas (CNG)
SUTMix	Double Precision	Decimal fraction for each combination of source and fuel type, must sum to 1 over each road type.

Table 20. Details of the TxLED Adjustment Factor SEE Ancillary File

Columns of the TxLEDadjustments.tab file (in C:\SEE\LOOKUPS)		
Field Name	**Data Type**	**Comment**

Columns of the TxLEDadjustments.tab file (in C:\SEE\LOOKUPS)		
Field Name	**Data Type**	**Comment**
yearID	Integer	An actual calendar year. ***This must include the SEE GUI calendar year (CalYear)***
sourceTypeID	Integer	Numeric value defining a MOVES source type (e.g., 11 for motorcycle)
Adjustment Factor	Double Precision	Numeric value between 0 and 1. SEE multiplies this factor with diesel-fueled NOx emissions. A value of "0" will result in a 100% NOx reduction; a value of "1" will result in 0% NOx reduction (no change).

4.3 SEE Outputs

This section provides a quick guide on how to review outputs from SEE. There are two methods that can be used to look at SEE results. The first method is through the Excel GUI, and the second is to navigate SEE's output databases using the MySQL query browser.

4.3.1 Instructions for Reading Outputs using the GUI

Steps:

11. Wait for confirmation that Script 10 has completed.
12. Click the button "Import Results" located to the right side of the GUI.

The "Import Results" button brings in SEE emissions and VMT summaries into the GUI into spreadsheet tabs located to the right of the Input tab. The summary tabs are named:

13. 'HourlyEmiss,'
14. 'DailyEmiss,'
15. 'HourlyVMT,'
16. 'DailyVMT' and
17. 'Summary'

The 'Summary' sheet contains total on-road emissions by county in units of tons. The 'HourlyEmiss' and 'DailyEmiss' emissions summaries contain fields of: year ID, month ID, day type ID (5=weekday), hour ID (for 'HourlyEmiss' tab only), county ID, pollutant ID, MOVES road type ID, and 13 columns corresponding to the 13 MOVES source types. The emissions under the source types are in units of kilograms.

In the VMT tables, the fields are: county ID, MOVES road type ID, hour ID (for 'HourlyVMT' only), and 13 source type columns where the VMT is in units of miles.

4.3.2 Instructions for Reading Outputs using the MySQL Query Browser

The Query Browser allows the User to export the highest level of detail results in SEE that contains emissions by link, zone, and hour. This result set is too large to bring into the Excel GUI.

Steps:

18. Wait for confirmation that Script 10 has completed.
19. Open MySQL Query Browser and use the following query to display the full set of results:
    - select * from **${dbroot}**_offnet.output_fulldetail_**${c}**;
20. Substituting the variables:
    - **${dbroot}** = the scenario name specified in the input panel of the GUI, row 7.
    - **${c}** = county FIPs code

5.0 TRANSVMT UPDATES

TRANSVMT is a script developed by TTI that processes direct output from HGAC's four-step travel demand model into link and zone level activity data used for emissions estimation. As part of the work under this contract, H-GAC requested new quality assurance checks on TRANSVMT to ensure transportation network changes were reflected in final VMT results, and an update to add the option of a second speed post-processing model that reflects a more accurate distribution of network average speeds, especially for heavy congestion levels. These tasks were undertaken by Cambridge Systematics, Inc., and are documented fully in Attachment A. An excerpt from this work is included in this section, to provide documentation to users wishing to implement the updated speed model in the TRANSVMT hourly files provided as input to SEE, discussed previously in Section 4.2.2.

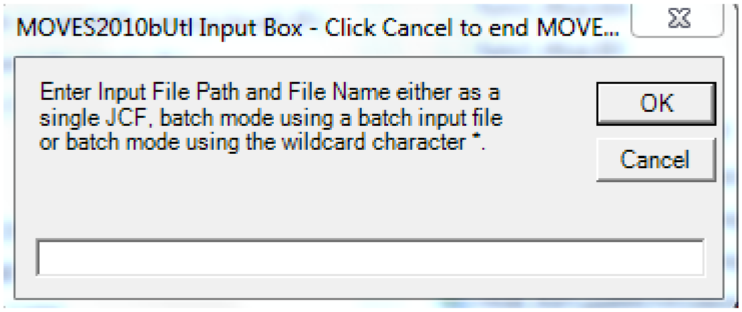
The revised TRANSVMT program includes three speed models: Dallas, Houston (current speed model) and new speed model (based on Fortran code). The Dallas and current Houston speed model were implemented by (Texas Transportation Institute) TTI and can be run using the guidance provided by TTI's MOVES Utility user guide. Cambridge Systematics incorporated the new speed model (originally written in Fortran Language) into the TRANSVMT program. The revised TRANSVMT program is capable of running any of the three speed models using the JCF file and the input files appropriate for the speed model. Appendix F provides the sample JCF file for the new speed model.

5.1 Running TRANSVMT with new speed model

21. Download the revised application TTIDEV2014.exe to the local machine.
22. Prepare the JCF file. The sample JCF file is shown in Appendix F. In the JCF file, the code “/SPDF” tells the program to use new speed model.
23. Prepare the input files. The new speed model requires almost all of the input files used by the current speed model. The new speed model has its own speed reduction factor file. In addition to the files that are already used by the TRANSVMT program, the new speed model requires the following files:
    - Speed Limit File
    - Free Flow Speed File
    - LOS E Speed File
    - g/c Ratio File
    - Run Time Factor File
    - Signal Type File
    - Arrival Type File
    - Progression Factor File
    - Cycle Length File
    - Speed Reduction Factor File

24. Before running the TRANSVMT program, please make sure that there is no blank space in the file names and in the folder names. For example, if the folder name is “Speed Model” then rename it to “SpeedModel”. Otherwise, the program will give an error since the program reads the keywords from each line of the JCF by using the delimiter of blank space or tab.
25. Before running the program, please make sure the output folder is empty. Otherwise, the program will give error.
26. Click on the exe file. The dialog box shown in Figure 8 will pop up. Type the JCF file name along with path in the textbox of the dialog box.

Figure 8. Input Dialog Box



5.2 Input Files Required for New Speed Model

The following describes the input files used by the new speed model.

Speed Limit File

This file should be in *.txt format. The snapshot of the sample file is provided at Appendix G. The file should have column headers and the name of the headers should be named as the following:

RTYPE: This column represents road type. The road type codes follow the same coding configuration as the RTYPE field in the network link data files.

LANE: This column represents the number of lanes.

SPDA1: Speed limit in area type code equals to 1.

SPDA2: Speed limit in area type code equals to 2.

SPDA3: Speed limit in area type code equals to 3.

SPDA4: Speed limit in area type code equals to 4.

SPDA5: Speed limit in area type code equals to 5.

Free Flow Speed File

This file should be in *.txt format. The snapshot of the sample file is provided at Appendix G. The free flow speed is calculated by adjusting the speed limit. The program uses different adjustment methods and the adjustment values based on the area type and the road type. The program uses the Equation 1 or Equation 2 to calculate the free flow speed.

If Adjustment method = 1 then Free flow speed = Speed limit + Adjustment value	Equation 1
*If Adjustment method = 2 then Free flow speed = Speed limit * Adjustment value*	Equation 2

The file should have column headers and the name of the headers should be named as the following:

RDTYP: This column represents road type. The road type codes follow the same coding configuration as the RTYPE field in the network link data files.

ADJTYP1: This column represents the adjustment method for area type code equals to 1.

ADJVAL1: This column represents the adjustment value for area type code equals to 1.

ADJTYP2: This column represents the adjustment method for area type code equals to 2.

ADJVAL2: This column represents the adjustment value for area type code equals to 2.

ADJTYP3: This column represents the adjustment method for area type code equals to 3.

ADJVAL3: This column represents the adjustment value for area type code equals to 3.

ADJTYP4: This column represents the adjustment method for area type code equals to 4.

ADJVAL4: This column represents the adjustment value for area type code equals to 4.

ADJTYP5: This column represents the adjustment method for area type code equals to 5.

ADJVAL5: This column represents the adjustment value for area type code equals to 5.

LOS E Speed File

This file should be in *.txt format. The snapshot of the sample file is provided at Appendix G. The LOS E speed is calculated by adjusting the free flow speed. The program uses different adjustment methods and the adjustment values based on the area type and the road type. The program uses the Equation 3, Equation 4, or Equation 5 to calculate the LOS E speed.

If Adjustment method = 1 then LOS E speed = Free flow speed + Adjustment value	Equation 3
*If Adjustment method = 2 then LOS E speed = Free flow speed * Adjustment value*	Equation 4
If Adjustment method = 3 then LOS E speed = Adjustment value	Equation 5

The file should have column headers and the name of the headers should be named as the following:

RDTYP: This column represents road type. The road type codes follow the same coding configuration as the RTYPE field in the network link data files.

ADJTYP1: This column represents the adjustment method for area type code equals to 1.

ADJVAL1: This column represents the adjustment value for area type code equals to 1.

ADJTYP2: This column represents the adjustment method for area type code equals to 2.

ADJVAL2: This column represents the adjustment value for area type code equals to 2.

ADJTYP3: This column represents the adjustment method for area type code equals to 3.

ADJVAL3: This column represents the adjustment value for area type code equals to 3.

ADJTYP4: This column represents the adjustment method for area type code equals to 4.

ADJVAL4: This column represents the adjustment value for area type code equals to 4.

ADJTYP5: This column represents the adjustment method for area type code equals to 5.

ADJVAL5: This column represents the adjustment value for area type code equals to 5.

g/c Ratio File

This file should be in *.txt format. The snapshot of the sample file is provided at Appendix G. The file should have column headers and the name of the headers should be named as the following:

RDTYP: This column represents road type. The road type codes follow the same coding configuration as the RTYPE field in the network link data files.

LANE: This column represents the number of lanes.

GCR1: This column represents the traffic signal's g/c ratio for area type code equals to 1.

GCR2: This column represents the traffic signal's g/c ratio for area type code equals to 2.

GCR3: This column represents the traffic signal's g/c ratio for area type code equals to 3.

GCR4: This column represents the traffic signal's g/c ratio for area type code equals to 4.

GCR5: This column represents the traffic signal's g/c ratio for area type code equals to 5.

Run Time Factor File

This file should be in *.txt format. The snapshot of the sample file is provided at Appendix G. The TRANSVMT program determines the run time factor of the arterial links based on the distance between the traffic signals and the free flow speed on the link. The program logic determines the distance between signals based on the link length of the arterial road types. The value of the run time factor is interpolated from the input data file by the program. The file should have column headers and the name of the headers should be named as the following:

LENGTH: This column represents the distance between traffic signals.

25: This column represents the run time factors at 25 mph free flow speed.

30: This column represents the run time factors at 30 mph free flow speed.

35: This column represents the run time factors at 35 mph free flow speed.

40: This column represents the run time factors at 40 mph free flow speed.

45: This column represents the run time factors at 45 mph free flow speed.

50: This column represents the run time factors at 50 mph free flow speed.

55: This column represents the run time factors at 55 mph free flow speed.

60: This column represents the run time factors at 60 mph free flow speed.

Signal Type File

This file should be in *.txt format. The snapshot of the sample file is provided at Appendix G. The file should have column headers and the name of the headers should be named as the following:

RDTYP: This column represents road type. The road type codes follow the same coding configuration as the RTYPE field in the network link data files.

LANE: This column represents the number of lanes.

SGLA1: This column represents the traffic signal type for area type code equals to 1.

SGLA 2: This column represents the traffic signal type for area type code equals to 2.

SGLA 3: This column represents the traffic signal type for area type code equals to 3.

SGLA 4: This column represents the traffic signal type for area type code equals to 4.

SGLA 5: This column represents the traffic signal type for area type code equals to 5.

Arrival Type File

This file should be in *.txt format. The snapshot of the sample file is provided at Appendix G. The file should have column headers and the name of the headers should be named as the following:

RDTYP: This column represents road type. The road type codes follow the same coding configuration as the RTYPE field in the network link data files.

LANE: This column represents the number of lanes.

ARVTYP1: This column represents the arrival type at signal for area type code equals to 1.

ARVTYP2: This column represents the arrival type at signal for area type code equals to 2.

ARVTYP3: This column represents the arrival type at signal for area type code equals to 3.

ARVTYP4: This column represents the arrival type at signal for area type code equals to 4.

ARVTYP5: This column represents the arrival type at signal for area type code equals to 5.

Progression Factor File

This file should be in *.txt format. The snapshot of the sample file is provided at Appendix G. The TRANSVMT program determines the progression factor based on the volume to capacity ratio, the signal type and the arrival type. The program determines the factor for the link volume to capacity (VC) ratio by rounding the VC ratio to the single decimal digit. If the V/C ratio less than 0.1 then the progression factor for VC ratio equals to 0.1 is used. If the V/C ratio greater than 1 then the progression factor for VC ratio equals to 1 is used. The file should have column headers and the name of the headers should be named as the following:

VC: The column represents the volume to capacity ratio.

SG1_A1: This column represents the progression factor for signal type=1 and arrival type = 1.

SG1_A2: This column represents the progression factor for signal type=1 and arrival type = 2.

SG1_A3: This column represents the progression factor for signal type=1 and arrival type = 3.

SG1_A4: This column represents the progression factor for signal type=1 and arrival type = 4.

SG1_A5: This column represents the progression factor for signal type=1 and arrival type = 5.

SG2_A1: This column represents the progression factor for signal type=2 and arrival type = 1.

SG2_A2: This column represents the progression factor for signal type=2 and arrival type = 2.

SG2_A3: This column represents the progression factor for signal type=2 and arrival type = 3.

SG2_A4: This column represents the progression factor for signal type=2 and arrival type = 4.

SG2_A5: This column represents the progression factor for signal type=2 and arrival type = 5.

SG3_A1: This column represents the progression factor for signal type=3 and arrival type = 1.

SG3_A2: This column represents the progression factor for signal type=3 and arrival type = 2.

SG3_A3: This column represents the progression factor for signal type=3 and arrival type = 3.

SG3_A4: This column represents the progression factor for signal type=3 and arrival type = 4.

SG3_A5: This column represents the progression factor for signal type=3 and arrival type = 5.

Cycle Length File

This file should be in *.txt format. The snapshot of the sample file is provided at Appendix G. The file should have column headers and the name of the headers should be named as the following:

RDTYP: This column represents road type. The road type codes follow the same coding configuration as the RTYPE field in the network link data files.

LANE: This column represents the number of lanes.

CYCLE1: This column represents the traffic signal’s cycle length for area type code equals to 1.

CYCLE2: This column represents the traffic signal’s cycle length for area type code equals to 2.

CYCLE3: This column represents the traffic signal’s cycle length for area type code equals to 3.

CYCLE4: This column represents the traffic signal’s cycle length for area type code equals to 4.

CYCLE5: This column represents the traffic signal’s cycle length for area type code equals to 5.

Speed Reduction Factor File

This file should be in *.txt format. The TRANSVMT program determines the speed reduction factors based on the volume to capacity ratio. The value of the factor is interpolated from the input data. The snapshot of the sample file is provided at Appendix B. The file should have column headers and the name of the headers should be named as the following:

VC: This column represents the volume to capacity ratio.

SRF: This column represents the speed reduction factor.

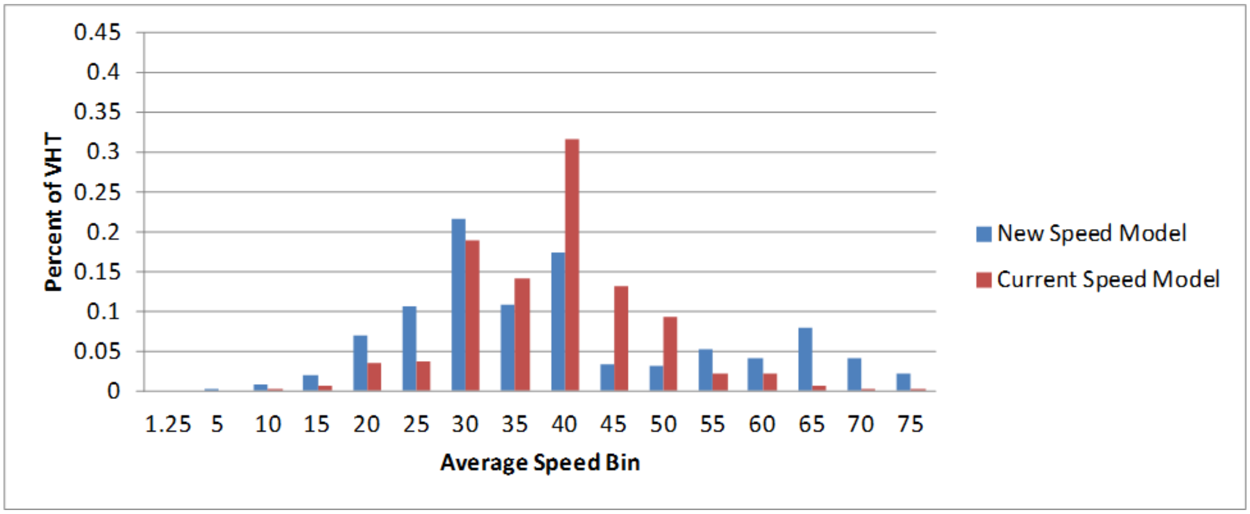
6.0 OPPORTUNITIES FOR INVENTORY IMPROVEMENT

The benchmark results presented above were focused on replicating MOVES county level results using MOVES inputs developed for the HGB SIP. As such, the results do not include several potential improvements to the HGB inventory possible through SEE. Features which H-GAC can implement through SEE that are not included in the current HGB SIP inventory are outlined in this section.

6.1 Updating speed model

As discussed in Section 5.0, Cambridge Systematics implemented a new speed post-processing model provided by H-GAC (and developed by TTI) into the TRANSVMT travel model processing script. The new model broadens the range of average speeds coming out of the travel model by considering signals in arterial speed calculations. The new model also calculates free flow and congested speeds for freeways differently, and accounts for very low speeds on highly congested roads by continuing to lower speed at volume/capacity ratios greater than 1.5. The resulting changes in speed are shown in Figure 9. Initial MOVES sensitivity runs suggest that the new speed model results will increase typical day NOx emissions about two percent, with larger increases (closer to ten percent) during periods of congestion.

Figure 9. Average Speed Distribution with New Speed Model



6.2 Adding Heavy-duty "hot spots"

SEE will include the feature to add heavy-duty hot spots as individual links run through MOVES project scale. The initial implementation of this is focused on two port container terminals operated by the Port of Houston – Bayport and Barbour's Cut – with significant operation of heavy-duty "drayage" trucks (Figure 10). Drayage truck activity, fleet characteristics and emissions in these port terminals were characterized as part of the Houston Port study conducted by EPA/TCEQ/H-GAC and supported by ERG in 2009-10 (5). This study used gate entry/exit data to quantify truck age distribution (which can vary considerably from regional distributions) and the number of trucks by hour in each terminal. Portable activity monitors were used to establish the within-terminal operating mode distribution, characterized by idle and low speed operation. These data were used to develop MOVES project-scale inputs to model heavy truck emissions within the port terminal for each hour of a typical summer day. Results for Bayport terminal are shown in Figure 11, by hour (the terminal is only open during the day). The daily total is small, about 0.1% of total NOx inventory in Harris County, however with the potential to extend this approach to the large number of private terminals in Houston and other hot spots like distribution centers, warehouses etc. when truck activity data are available, the influence on regional emissions as well as localized exposure will be more significant. Within SEE these emissions will be assigned to TAZ to increase overall inventory, and account for spatial and temporal contributions of these emissions.

Figure 10. Bayport Container Terminal, Port of Houston

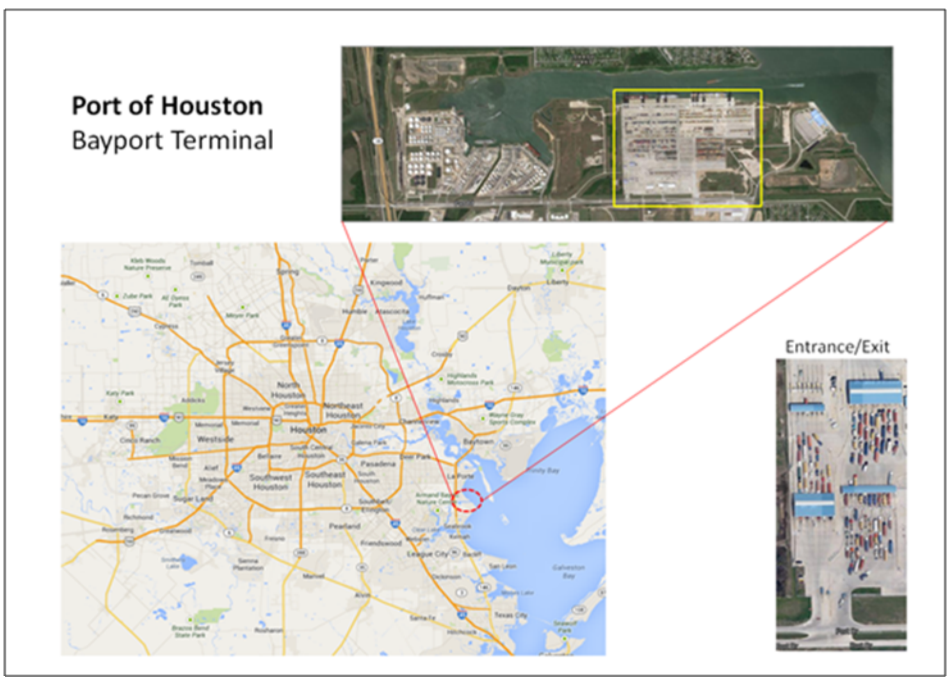
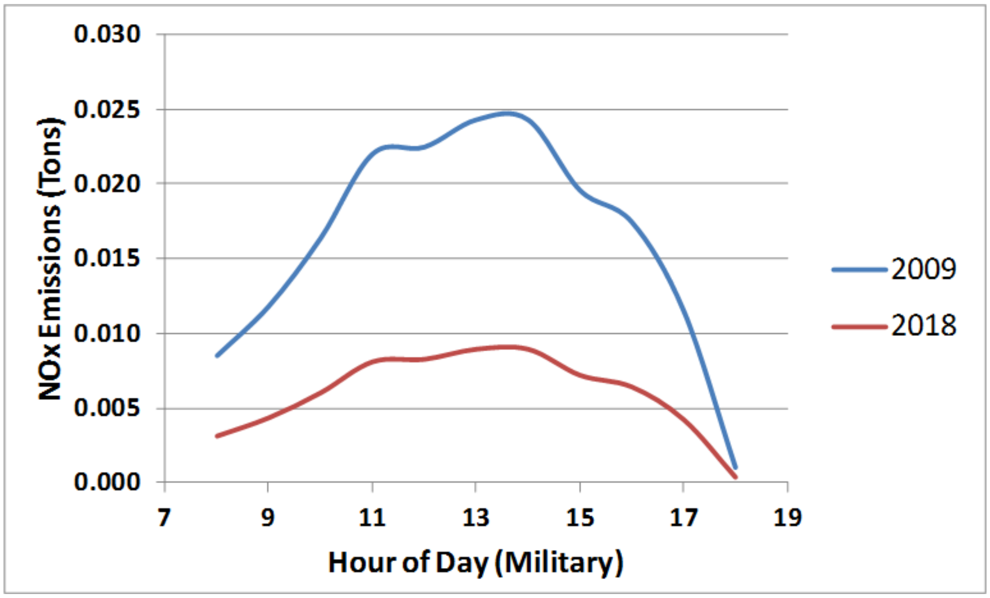


Figure 11. Heavy-Duty Truck NOx Emissions, Bayport Terminal



6.3 Updating vehicle starts based on travel model

For the benchmark runs, the initial implementation of HGB-SEE relies on the MOVES default estimate of the number of starts per vehicle, coupled with HGB-specific vehicle populations. This results in a total start estimate that differs considerably from the number of trips estimated by the travel demand model. For example, for the AM peak the in Harris County, the MOVES default approach results in 2.7 million starts, while the HGB travel model estimates 2.0 million starts. This difference would results in a large change in start, and overall emissions. The number of starts/vehicle in MOVES could be updated to reflect the travel model trips and/or other HGB-specific travel activity data gathered via travel surveys, etc. However, careful consideration must be given to account for chained trips, or trips that have more than one engine start. For example a single home-to-work trip in the travel model may not account for short-term stops such as a stop for a cup of coffee. From an emissions perspective, this is two starts not one.

6.4 Updating Long-Haul VMT and Idle Hours

For consistency with the current SIP, current long-haul truck VMT estimates in HGB-SEE are based on MOVES default allocations which are uniform across road type and region of the country. Under a separate project, ERG has developed long-haul truck VMT allocations that vary by region and MOVES road type based on FHWA’s Freight Analysis Framework, for use in the 2011 National Emissions Inventory (6). These updated allocations could be implemented in SEE, and also used to update the total extended idle hours for the HGB, which are based in part on long-haul truck activity.

6.5 Adding Road Grade

While not implemented in HGB-SEE, using MOVES project scale provides the opportunity to include road grade in regional emission inventory calculations. This would require road grade estimates for each link on a network, or at the least the subset where grade would be significant enough to influence emissions.

6.6 Using Actual Speeds

As discussed under on-network approach above, the option for using exact speed unique links was retained because despite longer runtime. This approach does produce a more refined emissions estimate by not binning the average speeds, which was necessary to match benchmark runs. Initial runs comparing the two approaches found that exact speed vs. binned unique links resulted in small emission differences, on the order of 1-2 percent.

7.0 CONCLUSIONS

The SEE modeling framework combines project and county scale features of MOVES into an integrated regional emissions inventory tool with a high degree of spatial detail. The model adheres to EPA modeling guidance to ensure applicability for SIP and transportation conformity analyses. Among the novel features of HGB-SEE are a) the application of MOVES project scale to develop a regional emissions inventory, which introduces the possibility of including road grade impacts at an area-wide level; b) allocation of off-network emissions to transportation analysis zones based on travel demand model origin/destination matrices and spatial analysis of truck extended idle locations; and c) inclusion of heavy-duty emission “hot spots” not already accounted for in the travel model network such as port terminals and distribution centers. Users interact with SEE through a simple GUI, and are able to use MOVES inputs directly, so that existing MOVES tools such as the county data manager can be used to prepare SEE inputs. Benchmark runs of SEE show agreement of MOVES county scale runs to within one-half percent for all pollutants. The framework provides many opportunities for improving regional emissions inventory based on better local data.

8.0 ACKNOWLEDGEMENTS

The authors gratefully acknowledge Graciela Lubertino, Chris Van Slyke and Chi Ping Lam of H-GAC for project funding and technical direction; Heather Perez of ERG, who performed GIS analysis and produced the allocation and emission maps presented in this paper; Alan Standard of ERG, who produced Bayport emission results presented in Section 6; Kelly Martin of ERG for report formatting and editing; and Dennis Perkinson and L.D. White of TTI for providing model inputs previously developed for the HGB region.

9.0 REFERENCES

27. U.S. EPA, Using MOVES to Prepare Emission Inventories in State Implementation Plans and Transportation Conformity: Technical Guidance for MOVES2010, 2010a and 2010b, Report No. EPA-420-B-012-028, 2012
28. TTI, Texas Transportation Institute Emissions Inventory Utilities User's Guide, 2009
29. Memorandum from ERG to Coordinating Research Council: "Processing of Truck Stop Plus Database", 2014 (http://www.crcao.com/reports/recentstudies2014/A-88/CRC A88_TruckStopDatabase Memo.pdf)
30. TCEQ Emissions Modeling FTP Site (ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/HGB/mvs/)
31. Fulper et. al, "Preliminary Results of Drayage Heavy-Duty Diesel Truck Testing in the Port of Houston Area", Presentation at Coordinating Research Council On-Road Vehicle Emissions Workshop, 2010
32. Memorandum from ERG to Coordinating Research Council: "Evaluation of Data Sources for Improving NEI Inputs", 2014 (http://www.crcao.com/reports/recentstudies2014/A-88/CRC A-88 Task 1 Memo Final 04302014.pdf)

Attachment A: TRANSVMT Analysis

Memorandum

TO: John Koupal and Scott Fincher, ERG; Graciela Lubertino, H-GAC

FROM: Tara Rima and David Kall, Cambridge Systematics

DATE: September 16, 2014

RE: TRANSVMT program documentation for H-GAC

This technical memorandum documents the work of Cambridge Systematics (CS)'s as a subcontractor to ERG on the H-GAC project entitled "Motor Vehicle Emission Simulator (MOVES) Suite of Programs to Estimate Emission Inventories at Link Level." The memo describes CS's effort on upgrading the TRANSVMT module, which is a post-processing script that helps to add detail to travel demand model outputs for use in the creation of MOVES inputs. In this task, CS team performed the following actions in chronological order:

1. Review of Existing TRANSVMT Program.
2. Evaluating the Current and New Speed Models.
3. Implementation of the new speed model in TRANSVMT program and providing guidance to use the revised program.

1. Review of Existing TRANSVMT Program

The existing TRANSVMT program code was reviewed to understand the inputs, outputs and functionalities of the program. To test the sensitivity of program results towards the changes in the inputs, the program was run using different inputs and the outputs were investigated.

The TRANSVMT module has the following major functions:

- Calculates hourly VMT (vehicle mile travelled) for each of the 24 hours of the day using travel model volumes by four times of day and an hourly factor input file.
- Adjusts calculated VMT using three factors: HPMS adjustment factors (often suggested by EPA for conformity work to reconcile HPMS VMT with model VMT), seasonal factors (could be used to adjust annual average VMT from the model to a particular season, such as summer when conducting MOVES runs for ozone), VMT adjustment factor (appears to be available for the user to make any other VMT adjustments they deem necessary).
- Applies split factors for the links from the travel demand model that have combined volumes for both directions. TRANSVMT reports the split volumes as two links (on two lines of the output) instead of one.
- Applies one of two speed post-processing methods (Dallas model and current Houston model) to calculate speed for each link for each of the 24 hours of the day. Since centroid connectors represent a collection of small roads in a zone, capacity is not available and speed from the travel demand model is used directly.
- Creates intra-zonal VMT to represent all travel within a single TAZ since the travel demand model does not account for this travel on its network links or centroid connectors. TRANSVMT estimates speed and VMT for these intra-zonal links and adds them on to the end of the link output tables.

The resulting outputs are 24 files (one for each hour of the day) that each includes VMT and operational speeds for each link (network links, centroid connectors, and intra-zonal links). TRANSVMT also provides a summary output file that includes the VMT, the VHT (vehicle hour travelled) and the operational speed by hour, county, and roadway functional class (centroid connectors and intra-zonal links are listed as a separate functional class).

Calculation of Hourly VMT

The hourly VMT is calculated for each link of the travel model network. The process calculates the inter-zonal and the intra-zonal VMT. The input files used in the calculation are:

- Travel model's output link-database that contains assigned traffic volume, distance travelled, county, zone, functional class and area type information for each of the network links by each of the time of day (TOD) periods (AM, PM, midday and overnight).
- Trip tables (travel model output files) that contain trips between each of the origin and destination zones in the network by each of the TOD periods.
- Intra-zonal travel time from the travel model.
- Hourly fraction of VMT for each of the 24 hours of a day. The hourly fractions for each of the TOD periods sum up to 1. Since there are four TOD periods, the hourly fractions sum up to four for 24 hours.
- HPMS adjustment factor by county.
- VMT adjustment factor by county.
- Seasonal adjustment factor by county.
- Directional split factor by area type, functional class and each of the TOD periods.

The inter-zonal VMT is calculated from the assigned traffic volume and the distance travelled. Equation 6 is used to calculate the hourly VMT.

$VMT_{lchfad} = Traffic\_Volume_{lt} * Distance\_Travelled_{lt} * Direction\_Split_{fa} * Hourly\_Fraction_{h} * HPMS\_Adjustment\_Factor_{c} * VMT\_Adjustment\_Factor_{c} * Seasonal\_Adjustment\_Factor_{c}$	Equation 6
Where: l = Travel model network link c = County in which the link exists h = Hour of a day (varies between 1-24) f = Functional class of link a = Area type of link d = Direction of link t = TOD periods (AM, midday, PM or overnight)	

The intra-zonal VMT is calculated from the travel model generated intra-zonal trips and the intra-zonal distance travelled. The program gets the average travel speed in each zone from the travel data. It calculates the intra-zonal VMT using Equation 7.

VMT_{zchfad} = Intrazonal_Trip$_{zt}$ * Average_Zonal_Speed$_{zt}$*60*Intrazonal_Time$_{zt}$* Direction_Split$_{fa}$ *Hourly_Fraction$_{h}$* HPMS_Adjustment_Factor$_{c}$* VMT_Adjustment_Factor$_{c}$* Seasonal_Adjustment_Factor$_{c}$	Equation 7
Where: z = Travel analysis zone c = County in which the zone exists h = Hour of a day (varies between 1-24) f = Functional class of zone connector link a = Area type of zone d = Direction of zone connector link t = TOD periods (AM, midday, PM or overnight)	

Testing the TRANSVMT program

TRANSVMT program was tested to assess the program's response towards the changes in travel demand model data. The testing was performed by modifying the travel model files by four times of day (*_*HRAM.asc, *_*HRMD.asc, *_*HRPM.asc and *_*HROV.asc). These files have the traffic volume by network link. The field TOT_FLOW represents the traffic volume in these files. Two tests were performed to determine the program's responses. In the first round of the testing, the TRANSVMT input files that were not available and was created from the examples in the TTI documentation. These are shown in Appendix A. The second round of testing was performed after receiving the TRANSVMT input files from HGAC for the model scenarios FOC and Phase3.

First Round of Testing

In the first test of the first round, the TOT_FLOW flow column was multiplied by 0.5 in all of travel data files (*_*HRAM.asc, *_*HRMD.asc, *_*HRPM.asc and *_*HROV.asc). That means, the flow was reduced by 50% all over the network for each of the TOD periods. Then, the TRANSVMT program was run in Visual Studio using the modified files as inputs. The output files were compared with the outputs from the run using the original files. The comparison shows that the VMT decreased by almost 50% from the original VMT. The reduction in flow means less congestion. As a result, the speed increased in the peak periods (AM or PM).

In the second test of the first round, the TOT_FLOW flow column was multiplied by 2 in all of travel data files (*_*HRAM.asc, *_*HRMD.asc, *_*HRPM.asc and *_*HROV.asc). That means, the flow was doubled all over the network for each of the TOD periods. Then, the

TRANSVMT program was run in Visual Studio using the modified files as inputs. The output files were compared with the outputs from the run using the original files. The comparison shows the increase in VMT by almost 100% from the original VMT. The increase in flow means more congestion. As a result, the speed got reduced in the peak periods (AM or PM).

Please note that the changes in flow had insignificant impact on the speed during overnight and midday period since congestion was not an issue in these periods.

Second Round of Testing

After receiving the TRANSVMT input files for the travel model scenarios FOC and Phase3 from H-GAC, the second round of testing was performed. The TRANSVMT program was run from Visual Studio.

To run TRANSVMT for scenario FOC, all the input files for this scenario are placed under the "FOC" scenario folder. The JCF file for the scenario was updated based on the path locations of the input and the output files.

Similarly, to run TRANSVMT for scenario Phase 3, all the input files for this scenario are placed under the "Phase3" scenario folder. The JCF file for the scenario was updated based on the path locations of the input and the output files

Table 1 shows the VMT summaries for the inputs and the outputs of TRANSVMT program. Note that the VMT output differs from the input, but this is expected due to the use of HPMS adjustment factors and another VMT adjustment factor. The VMT output by TRANSVMT differs between scenarios by approximately the same percentage as the VMT inputs.

Table 1. VMT Input/Output Summary for Two Scenarios

	Input to TRANSVMT		Output from TRANSVMT	
	FOC	Phase3	FOC	Phase3
AM	35,574,200.89	35,578,873.45	33,153,284.80	33,157,536.62
MD	45,547,209.88	45,553,143.38	42,577,724.76	42,583,041.82

PM	53,757,911.13	53,763,990.78	50,185,866.03	50,191,306.38
OV	26,518,976.58	26,522,430.18	24,806,981.86	24,810,056.55
Daily	**161,398,298.47**	**161,418,437.80**	**150,723,857.46**	**150,741,941.36**
Daily VMT % Difference between FOC and Phase 3	**0.0125%**		**0.0120%**	

The test runs of the TRANSVMT programs confirmed that the program is sensitive to model changes and the changes in the program outputs are consistent with the changes in the input data.

. Evaluating the Current and New Speed Models

This section focuses on the findings related to investigating the speed post-processing procedures currently employed by TRANSVMT and by a new speed model found in a separate Fortran program. The TRANSVMT program considers two speed model options: Dallas Model and current Houston model. The current Houston speed model resembles the HGAC's new preferred speed model that is implemented in the Fortran program (provided to CS by HGAC). The differences between the new speed model and the current Houston model portion of TRANSVMT were investigated to determine if changes need to be made to TRANSVMT to reflect the method in the new speed model.

The evaluation process adopted following steps:

- Calculation of post-processed speed in different speed models.
- Comparison of post-processed speeds calculated by different speed models.
- Recommendations on speed models.

The current and new speed models use different equations and factors depending on area type and facility type. For simplicity, two facility types: freeways (facility types 1-8) and arterials (facility types 9-17) were considered in the comparison of two models. The full list of facility types can be found in Appendix B.

New Speed Model – Freeway Links

The new speed model uses Equation 8 or Equation 9 to calculate the post-processed (operational) speed for freeway links. If the link volume to capacity (v/c) ratio is less than or equal to 1 then the program uses Equation 8. Equation 9 is used when v/c ratio is greater than 1. For centroid connectors, the program uses the model speed.

*P*OST-PROCESSED SPEED (V/C<=1) =FREE FLOW SPEED – SRF* (FREE FLOW SPEED-ESTIMATED SPEED)	Equation 8
Where:	

SRF =Speed-reduction-factor (see Appendix C)
FREE FLOW SPEED = Speed Limit +X;

Where X=3 mph for area types 1-3 (CBD, urban, suburban)
X=4 mph for area type 4 (fringe suburban)
X=6 mph for area type 5 (rural)
Note: Speed Limit is from a speed limit file that varies by functional class and area type.

ESTIMATED SPEED = Speed at LOS E = 35 mph for area types 1 &2 (CBD, urban); 40 mph for area type 3 (suburban); 50 mph for area types 4 & 5 (fringe suburban, rural)

POST-PROCESSED SPEED(V/C>1) =((ESTIMATED SPEED - 0.1*ESTIMATED SPEED)*(1.15/(1.0+(0.15*(VC^4.2))))) + 0.1*ESTIMATED SPEED	Equation 9
Where: VC = Volume to capacity ratio ESTIMATED SPEED = Speed at LOS E = 35 mph for area types 1 &2 (CBD, urban); 40 mph for area type 3 (suburban); 50 mph for area types 4 & 5 (fringe suburban, rural)	

Appendix C shows the speed-reduction-factors used in the new speed model, which varies by volume to capacity ratio. The model code interpolates the value of SRF from the table using the link v/c ratio. Note that the existing TRANSVMT program uses similar speed reduction factors, but actually employs 25 sets of them that vary by area type and functional class.

New Speed Model – Arterial Links

The new speed model uses Equation 10 through Equation 14 to calculate the post-processed (operational) speed for arterial links when the volume to capacity ratio is less than or equal to 1. The calculated speed on the arterial captures the signal operational factors. These factors depend on the area type and the road type of the arterial links.

D1=((0.38*C)*((1.0-GC)**2))/(1.0-(GC*VC))	Equation 10
D2=SQRT(((VC-1.0)**2)+((16.0*VC)/(CAPPL)))	Equation 11
D3=(173.0*(VC**2))*((VC-1.0)+D2)	Equation 12
DLNK=1.3* (D1+D3)* PF *XSGMI*XDST	Equation 13
SPD1=(XDST)/((XRTF*(XDST/XSPV0))+(DLNK/3600.0))	Equation 14
Where: C = Cycle length of signal along the arterial link GC= GC ratio of signal along the arterial link VC = Volume to capacity ratio CAPPL = Capacity per hour per lane (=900 vehicle/hr/lane used in the program) PF = Progression factor at traffic signals XRTF = runtime factor	

XDST = Link length in mile XSPV0 = Free flow speed in mph SPD1 = Speed on arterial in mph

For volume to capacity ration greater than 1, the program uses Equation 15.

*SPD2=((SPD1-0.1*SPD1)*(1.15/(1+0.15*VC^3))+0.1*SPD1*	Equation 15
Where: SPD1 = Speed in mph on arterial calculated from Equation 14	

Please note that the process applies Equation 14 regardless of the values of volume to capacity ratio (VC). For VC less than or equal to 1, the value calculated from the Equation 14 is set to the final operational speed on the arterial link. For VC greater than 1, the process further applies Equation 15.

Current Speed Model – Freeway and Arterial Links

The current speed model (Houston portion of the TRANSVMT program) uses Equation 16, Equation 17, or Equation 18 to calculate the post-processed speed for both freeway and arterial links. Equation 16 is used when v/c ratio is less than or equal to 1. Equation 17 is used when v/c ration greater than 1 and less than 1.5. Equation 18 is used when v/c ratio is greater than or equal to 1.5. For the centroid connectors, model speed is used as post-processed speed.

POST-PROCESSED SPEED (V/C<=1) =FREE FLOW SPEED – SRF* (FREE FLOW SPEED-ESTIMATED SPEED)	Equation 16
POST-PROCESSED SPEED (1<V/C<1.5) = ESTIMATED SPEED * (1.15/(1.0+(0.15*(VC^4)))	Equation 17
POST-PROCESSED SPEED(V/C>=1.5) = ESTIMATED SPEED * (1.15/(1.0+(0.15*(1.5^4)))	Equation 18
Where SRF =Speed-reduction-factor (see Appendix D) V/C = Volume to capacity ratio	

In the current speed model, SRF for a given V/C ratio varies by functional class and by area type (see Appendix D). The input SRF values are interpolated to get the SRF for link v/c ratio.

Equation 19 and Equation 20 are used to calculate the free-flow speed and the estimated speed respectively, which are used as inputs to Equation 16 through Equation 18 above.

FREE FLOW SPEED = Model Speed * Speed Factor for free-flow	Equation 19
ESTIMATED SPEED = Model Speed * Speed Factor at LOS E	Equation 20

The speed factors used in Equation 19 and Equation 20 vary by the functional class and area type. They can be found in Appendix E.

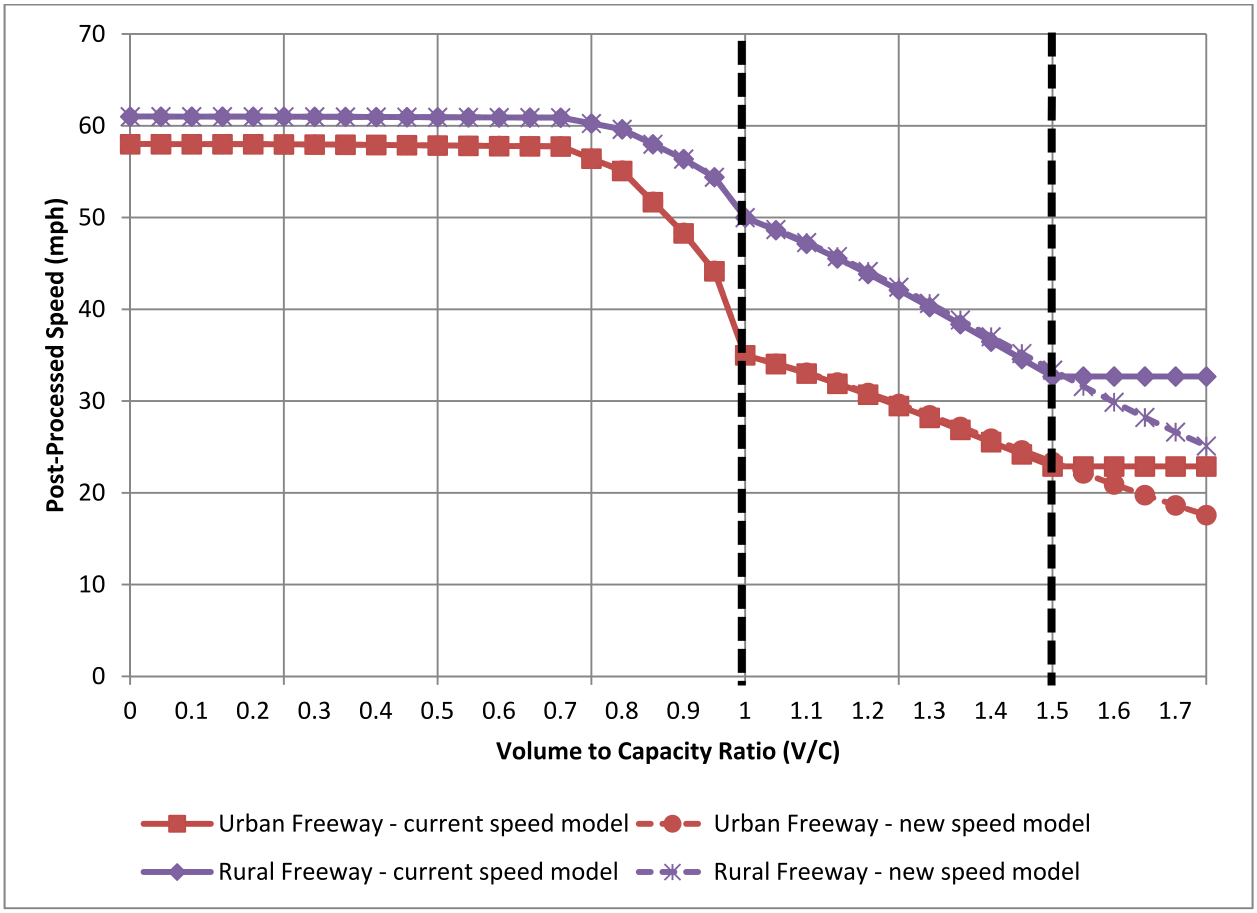
Example Post-Processed Speed Results for Four Link Types

Figure 1 shows example results for post-processed speed for an example urban freeway link and an example rural freeway link. For each of these two links both the current and new speed model equations and factors described above were employed for comparison of the difference in results. Figure 2 presents the same results, but sets the free flow speed and LOS E speed for the current speed model to that used in the new speed model. This illustrates the remaining differences if the method for calculating free flow speed and LOS E speed in the current speed model were altered to equal the method from the new speed model. As can be seen in Figure 2, the two models predict almost exactly the same speed when the free flow speed and LOS E speed inputs are equal. The only significant difference is that current model speeds stay the same for all V/C above 1.5.

Figure 3 shows example results for post-processed speed for an example urban arterial link and an example rural arterial link. For each of these two links, both the current and new speed model equations and factors described above were employed for comparison of the difference in results. Figure 4 presents the same results, but sets the free flow speed for the current speed model to that used in the new speed model. It also sets the LOS E speed to 30% of the free flow speed (default for freeways in new speed model with no area type, although LOS E speed is not used in new speed model for arterials). This illustrates the remaining differences if the method for calculating free flow speed in the current speed model were altered to equal the method from the new speed model and the LOS E speed calculation method were simplified. As can be seen in Figure 4, these modifications help bring the rural arterial speeds predicted by the current speed model closer to those predicted by the new speed model, but actually make the urban arterial speed predictions further apart. Overall, the arterial speed results between the current and new speed models are very different due to the completely different calculation approaches.

Figure 1. Example Post-Processed Speeds on a Freeway Link

Figure 2. Example Post Processed Speeds on a Freeway Link with Modifications


Post-Processed Speed (mph)
70
60
50
40
30
20
10
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
Volume to Capacity Ratio (V/C)
Urban Freeway - current speed model
Urban Freeway - new speed model
Rural Freeway - current speed model
Rural Freeway - new speed model

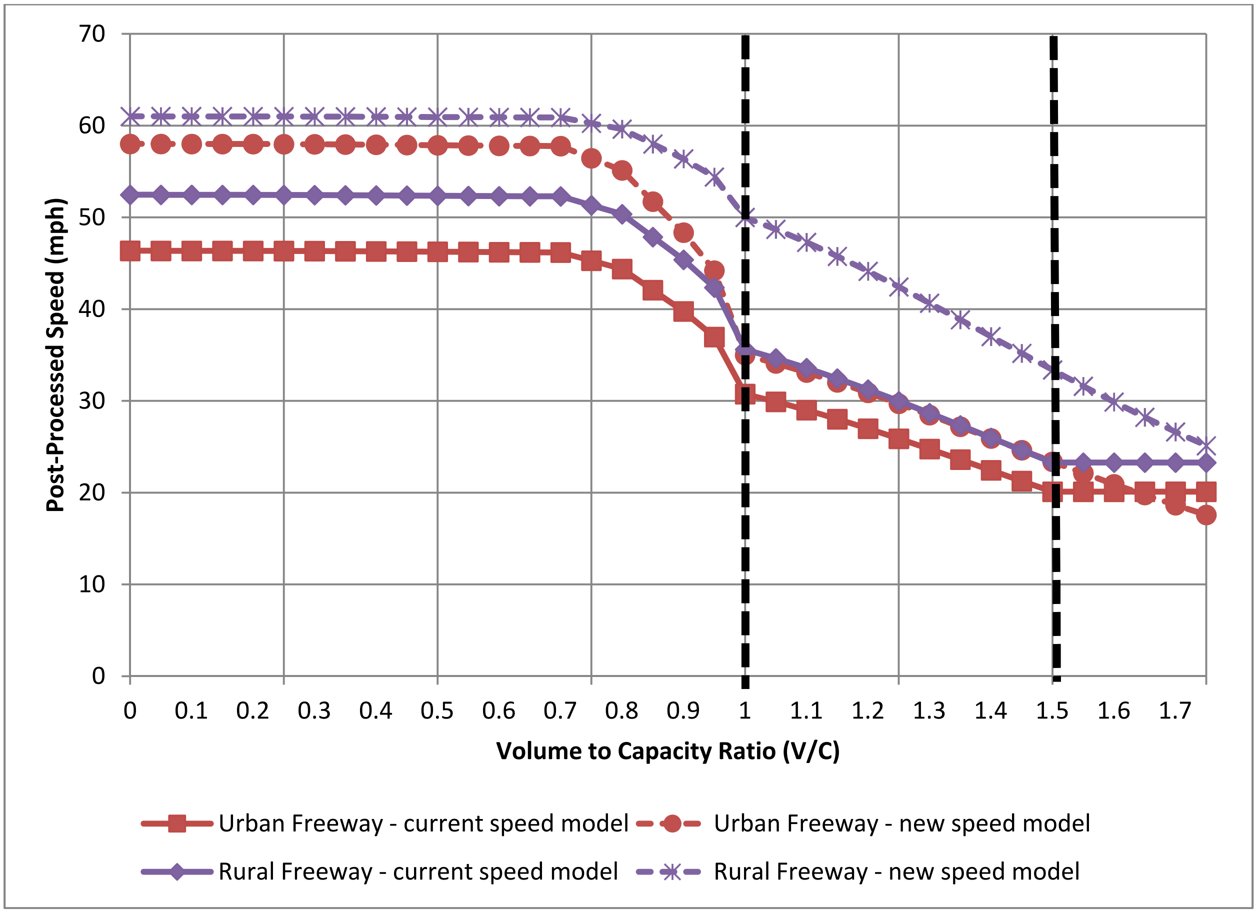
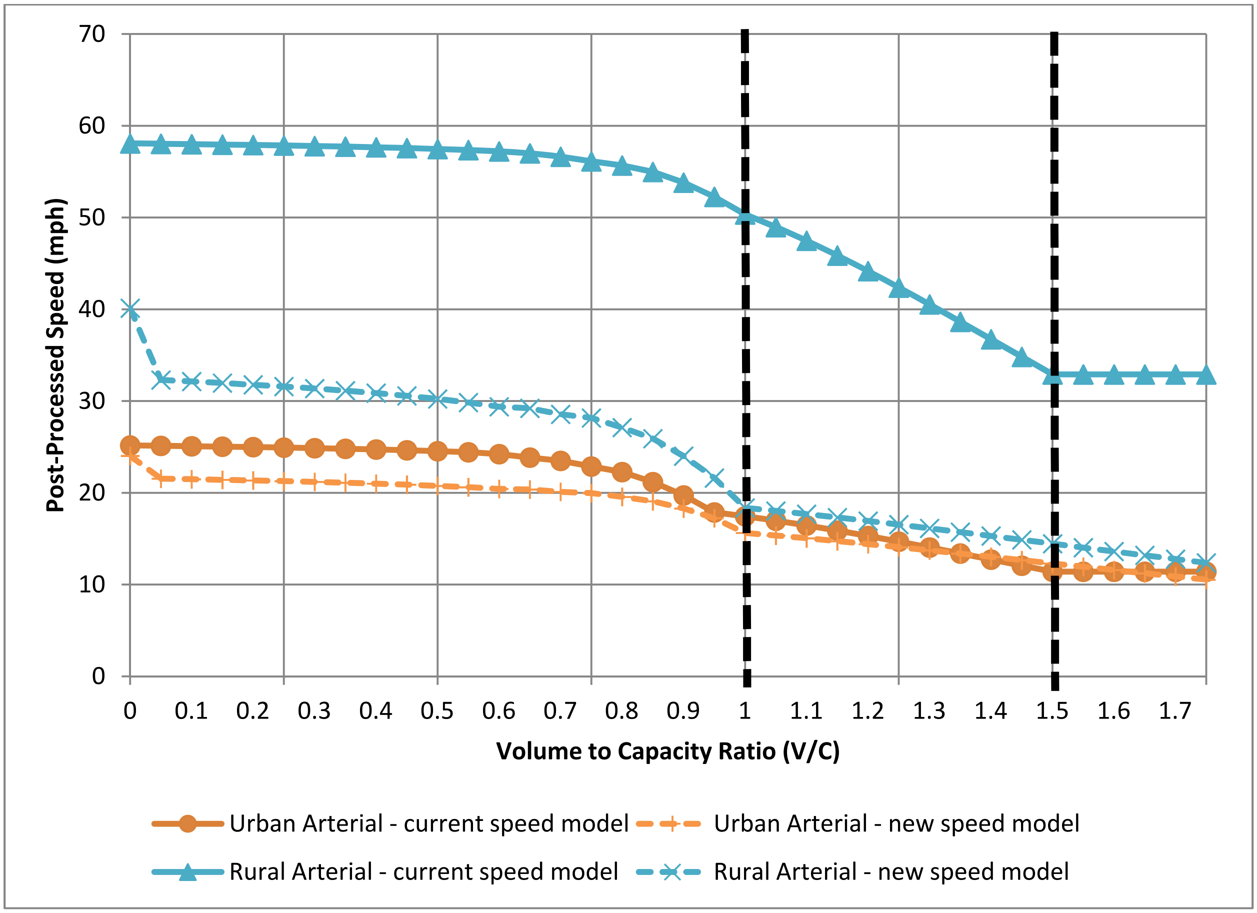
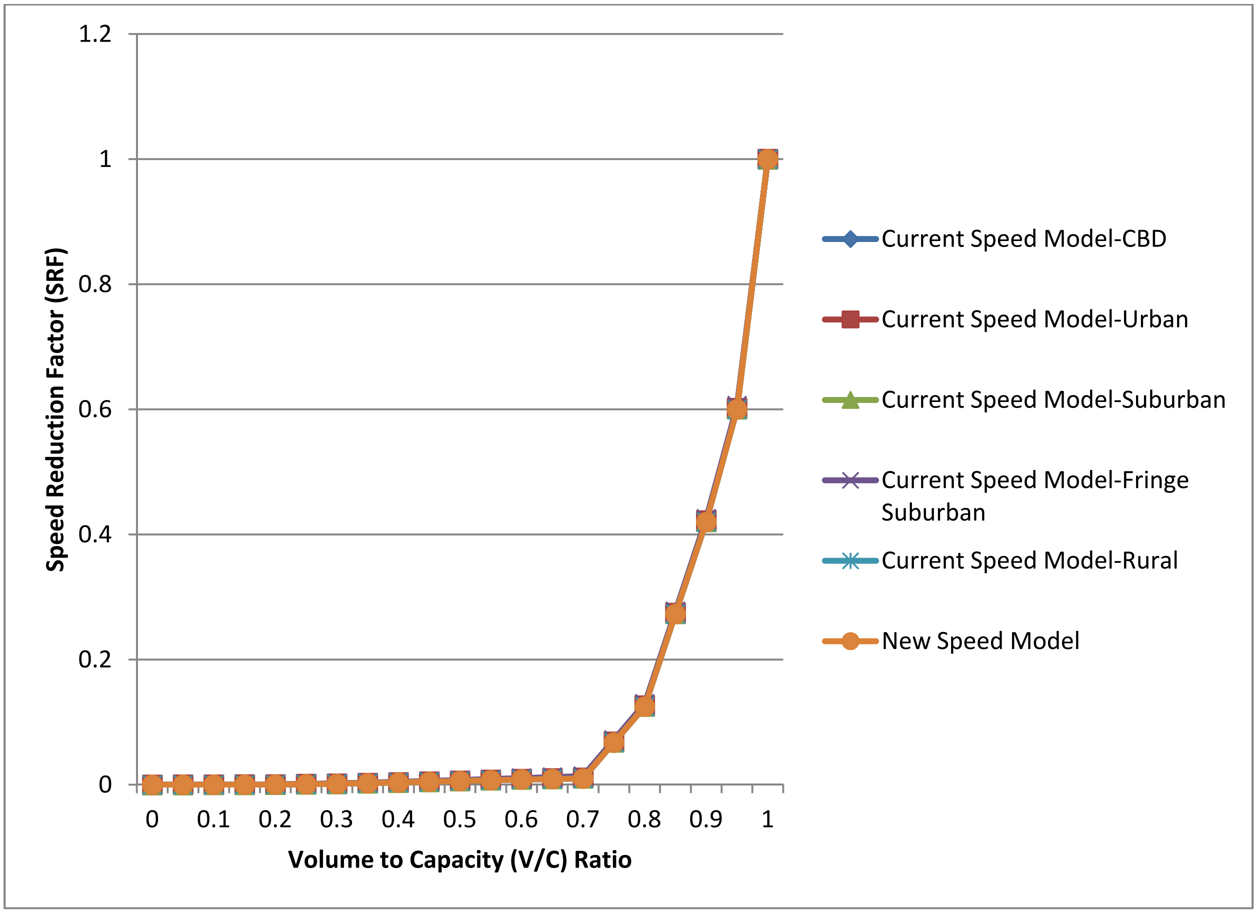


Figure 3. Example Post-Processed Speeds on an Arterial Link


70
60
50
40
30
20
10
0
Post-Processed Speed (mph)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
Volume to Capacity Ratio (V/C)
Urban Arterial - current speed model
Urban Arterial - new speed model
Rural Arterial - current speed model
Rural Arterial - new speed model


1.2
1
0.8
0.6
0.4
0.2
0
Speed Reduction Factor (SRF)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Volume to Capacity (V/C) Ratio
Current Speed Model-CBD
Current Speed Model-Urban
Current Speed Model-Suburban
Current Speed Model-Fringe Suburban
Current Speed Model-Rural
New Speed Model

3. Revised TRANSVMT Program

The revised TRANSVMT program includes three speed models: Dallas, Houston (current speed model) and new speed model (based on Fortran code). The Dallas and current Houston speed model were implemented by (Texas Transportation Institute) TTI and can be run using the guidance provided by TTI's MOVES Utility user guide. Cambridge Systematics incorporated the new speed model (originally written in Fortran Language) into the TRANSVMT program. The revised TRANSVMT program is capable of running any of the three speed models using the JCF file and the input files appropriate for the speed model. Appendix F provides the sample JCF file for the new speed model.

Instructions to run TRANSVMT program with Fortran Speed Model

1. Download the revised application TTIDEV2014.exe to the local machine.

2. Prepare the JCF file. The sample JCF file is shown in Appendix F. In the JCF file, the code "/SPDF" tells the program to use new speed model.

3. Prepare the input files. The new speed model requires almost all of the input files used by the current speed model. The new speed model has its own speed reduction factor file. In addition to the files that are already used by the TRANSVMT program, the new speed model requires the following files:

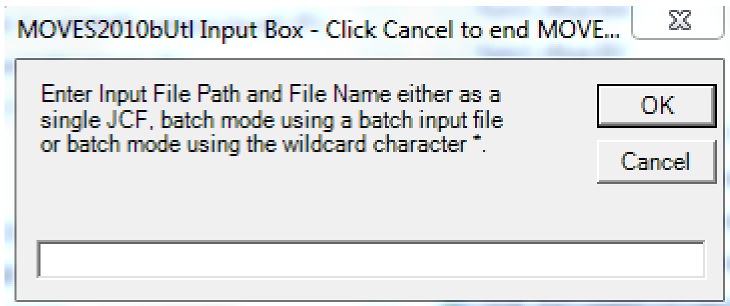
    - Speed Limit File
    - Free Flow Speed File
    - LOS E Speed File
    - g/c Ratio File
    - Run Time Factor File
    - Signal Type File
    - Arrival Type File
    - Progression Factor File
    - Cycle Length File
    - Speed Reduction Factor File

4. Before running the TRANSVMT program, please make sure that there is no blank space in the file names and in the folder names. For example, if the folder name is "Speed Model" then rename it to "SpeedModel". Otherwise, the program will give an error since the program reads the keywords from each line of the JCF by using the delimiter of blank space or tab.

5. Before running the program, please make sure the output folder is empty. Otherwise, the program will give error.

6. Click on the exe file. The dialog box shown in Figure 6 will pop up. Type the JCF file name along with path in the textbox of the dialog box.

Figure 6. Input Dialog Box



Input Files Required for New Speed Model

The following describes the input files used by the new speed model.

Speed Limit File

This file should be in *.txt format. The snapshot of the sample file is provided at Appendix G. The file should have column headers and the name of the headers should be named as the following:

RTYPE: This column represents road type. The road type codes follow the same coding configuration as the RTYPE field in the network link data files.

LANE: This column represents the number of lanes.

SPDA1: Speed limit in area type code equals to 1.

SPDA2: Speed limit in area type code equals to 2.

SPDA3: Speed limit in area type code equals to 3.

SPDA4: Speed limit in area type code equals to 4.

SPDA5: Speed limit in area type code equals to 5.

Free Flow Speed File

This file should be in *.txt format. The snapshot of the sample file is provided at Appendix G. The free flow speed is calculated by adjusting the speed limit. The program uses different adjustment methods and the adjustment values based on the area type and the road type. The program uses the Equation 1 or Equation 2 to calculate the free flow speed.

If Adjustment method = 1 then Free flow speed = Speed limit + Adjustment value	Equation 21
*If Adjustment method = 2 then Free flow speed = Speed limit * Adjustment value*	Equation 22

The file should have column headers and the name of the headers should be named as the following:

RDTYP: This column represents road type. The road type codes follow the same coding configuration as the RTYPE field in the network link data files.

ADJTYP1: This column represents the adjustment method for area type code equals to 1.

ADJVAL1: This column represents the adjustment value for area type code equals to 1.

ADJTYP2: This column represents the adjustment method for area type code equals to 2.

ADJVAL2: This column represents the adjustment value for area type code equals to 2.

ADJTYP3: This column represents the adjustment method for area type code equals to 3.

ADJVAL3: This column represents the adjustment value for area type code equals to 3.

ADJTYP4: This column represents the adjustment method for area type code equals to 4.

ADJVAL4: This column represents the adjustment value for area type code equals to 4.

ADJTYP5: This column represents the adjustment method for area type code equals to 5.

ADJVAL5: This column represents the adjustment value for area type code equals to 5.

LOS E Speed File

This file should be in *.txt format. The snapshot of the sample file is provided at Appendix G. The LOS E speed is calculated by adjusting the free flow speed. The program uses different adjustment methods and the adjustment values based on the area type and the road type. The program uses the Equation 3, Equation 4, or Equation 5 to calculate the LOS E speed.

If Adjustment method = 1 then LOS E speed = Free flow speed + Adjustment value	Equation 23
*If Adjustment method = 2 then LOS E speed = Free flow speed * Adjustment value*	Equation 24
If Adjustment method = 3 then LOS E speed = Adjustment value	Equation 25

The file should have column headers and the name of the headers should be named as the following:

RDTYP: This column represents road type. The road type codes follow the same coding configuration as the RTYPE field in the network link data files.

ADJTYP1: This column represents the adjustment method for area type code equals to 1.

ADJVAL1: This column represents the adjustment value for area type code equals to 1.

ADJTYP2: This column represents the adjustment method for area type code equals to 2.

ADJVAL2: This column represents the adjustment value for area type code equals to 2.

ADJTYP3: This column represents the adjustment method for area type code equals to 3.

ADJVAL3: This column represents the adjustment value for area type code equals to 3.

ADJTYP4: This column represents the adjustment method for area type code equals to 4.

ADJVAL4: This column represents the adjustment value for area type code equals to 4.

ADJTYP5: This column represents the adjustment method for area type code equals to 5.

ADJVAL5: This column represents the adjustment value for area type code equals to 5.

g/c Ratio File

This file should be in *.txt format. The snapshot of the sample file is provided at Appendix G. The file should have column headers and the name of the headers should be named as the following:

RDTYP: This column represents road type. The road type codes follow the same coding configuration as the RTYPE field in the network link data files.

LANE: This column represents the number of lanes.

GCR1: This column represents the traffic signal’s g/c ratio for area type code equals to 1.

GCR2: This column represents the traffic signal's g/c ratio for area type code equals to 2.

GCR3: This column represents the traffic signal's g/c ratio for area type code equals to 3.

GCR4: This column represents the traffic signal's g/c ratio for area type code equals to 4.

GCR5: This column represents the traffic signal's g/c ratio for area type code equals to 5.

Run Time Factor File

This file should be in *.txt format. The snapshot of the sample file is provided at Appendix G. The TRANSVMT program determines the run time factor of the arterial links based on the distance between the traffic signals and the free flow speed on the link. The program logic determines the distance between signals based on the link length of the arterial road types. The value of the run time factor is interpolated from the input data file by the program. The file should have column headers and the name of the headers should be named as the following:

LENGTH: This column represents the distance between traffic signals.

25: This column represents the run time factors at 25 mph free flow speed.

30: This column represents the run time factors at 30 mph free flow speed.

35: This column represents the run time factors at 35 mph free flow speed.

40: This column represents the run time factors at 40 mph free flow speed.

45: This column represents the run time factors at 45 mph free flow speed.

50: This column represents the run time factors at 50 mph free flow speed.

55: This column represents the run time factors at 55 mph free flow speed.

60: This column represents the run time factors at 60 mph free flow speed.

Signal Type File

This file should be in *.txt format. The snapshot of the sample file is provided at Appendix G. The file should have column headers and the name of the headers should be named as the following:

RDTYP: This column represents road type. The road type codes follow the same coding configuration as the RTYPE field in the network link data files.

LANE: This column represents the number of lanes.

SGLA1: This column represents the traffic signal type for area type code equals to 1.

SGLA 2: This column represents the traffic signal type for area type code equals to 2.

SGLA 3: This column represents the traffic signal type for area type code equals to 3.

SGLA 4: This column represents the traffic signal type for area type code equals to 4.

SGLA 5: This column represents the traffic signal type for area type code equals to 5.

Arrival Type File

This file should be in *.txt format. The snapshot of the sample file is provided at Appendix G. The file should have column headers and the name of the headers should be named as the following:

RDTYP: This column represents road type. The road type codes follow the same coding configuration as the RTYPE field in the network link data files.

LANE: This column represents the number of lanes.

ARVTYP1: This column represents the arrival type at signal for area type code equals to 1.

ARVTYP2: This column represents the arrival type at signal for area type code equals to 2.

ARVTYP3: This column represents the arrival type at signal for area type code equals to 3.

ARVTYP4: This column represents the arrival type at signal for area type code equals to 4.

ARVTYP5: This column represents the arrival type at signal for area type code equals to 5.

Progression Factor File

This file should be in *.txt format. The snapshot of the sample file is provided at Appendix G. The TRANSVMT program determines the progression factor based on the volume to capacity ratio, the signal type and the arrival type. The program determines the factor for the link volume to capacity (VC) ratio by rounding the VC ratio to the single decimal digit. If the V/C ratio less than 0.1 then the progression factor for VC ratio equals to 0.1 is used. If the V/C ratio greater than 1 then the progression factor for VC ratio equals to 1 is used. The file should have column headers and the name of the headers should be named as the following:

VC: The column represents the volume to capacity ratio.

SG1_A1: This column represents the progression factor for signal type=1 and arrival type = 1.

SG1_A2: This column represents the progression factor for signal type=1 and arrival type = 2.

SG1_A3: This column represents the progression factor for signal type=1 and arrival type = 3.

SG1_A4: This column represents the progression factor for signal type=1 and arrival type = 4.

SG1_A5: This column represents the progression factor for signal type=1 and arrival type = 5.

SG2_A1: This column represents the progression factor for signal type=2 and arrival type = 1.

SG2_A2: This column represents the progression factor for signal type=2 and arrival type = 2.

SG2_A3: This column represents the progression factor for signal type=2 and arrival type = 3.

SG2_A4: This column represents the progression factor for signal type=2 and arrival type = 4.

SG2_A5: This column represents the progression factor for signal type=2 and arrival type = 5.

SG3_A1: This column represents the progression factor for signal type=3 and arrival type = 1.

SG3_A2: This column represents the progression factor for signal type=3 and arrival type = 2.

SG3_A3: This column represents the progression factor for signal type=3 and arrival type = 3.

SG3_A4: This column represents the progression factor for signal type=3 and arrival type = 4.

SG3_A5: This column represents the progression factor for signal type=3 and arrival type = 5.

Cycle Length File

This file should be in *.txt format. The snapshot of the sample file is provided at Appendix G. The file should have column headers and the name of the headers should be named as the following:

RDTYP: This column represents road type. The road type codes follow the same coding configuration as the RTYPE field in the network link data files.

LANE: This column represents the number of lanes.

CYCLE1: This column represents the traffic signal's cycle length for area type code equals to 1.

CYCLE2: This column represents the traffic signal's cycle length for area type code equals to 2.

CYCLE3: This column represents the traffic signal's cycle length for area type code equals to 3.

CYCLE4: This column represents the traffic signal's cycle length for area type code equals to 4.

CYCLE5: This column represents the traffic signal's cycle length for area type code equals to 5.

Speed Reduction Factor File

This file should be in *.txt format. The TRANSVMT program determines the speed reduction factors based on the volume to capacity ratio. The value of the factor is interpolated from the input data. The snapshot of the sample file is provided at Appendix B. The file should have column headers and the name of the headers should be named as the following:

VC: This column represents the volume to capacity ratio.

SRF: This column represents the speed reduction factor.

Appendix A: Existing TRANSVMT Input Files

The following JCF file was created to instruct TRANSVMT on the input file locations.

/JOB Cal VMT
/STEP Step1 TRANSVMT
/LST C:\D-Drive\HGAC_AirQuality\TRANSVMT\output\HGA_2018_TRANSVMT.lst
/HDR C:\D-Drive\HGAC_AirQuality\TRANSVMT\input\HGA_2018TRANSVMT.txt
/HRF C:\D-Drive\HGAC_AirQuality\TRANSVMT\input\PERFACT3.txt
/CCFC C:\D-Drive\HGAC_AirQuality\TRANSVMT\input\HGA_ccCode.txt
/SPLT C:\D-Drive\HGAC_AirQuality\TRANSVMT\input\HGAC_DIRSPLITS.txt
/DTYP C:\D-Drive\HGAC_AirQuality\TRANSVMT\input\HGA_daytype.txt
/VADJ C:\D-
Drive\HGAC_AirQuality\TRANSVMT\input\COUNTY_VMTadjustment_newHPMS2.txt
/RADI C:\D-Drive\HGAC_AirQuality\TRANSVMT\networks\radii2018.asc
/TMPD C:\D-Drive\HGAC_AirQuality\TRANSVMT\input\TimePerDesignation.txt
/LNKA C:\D-Drive\HGAC_AirQuality\TRANSVMT\networks\2018_3hram.asc
/LNKM C:\D-Drive\HGAC_AirQuality\TRANSVMT\networks\2018_6hrmd.asc
/LNKP C:\D-Drive\HGAC_AirQuality\TRANSVMT\networks\2018_4hrpm.asc
/LNKO C:\D-Drive\HGAC_AirQuality\TRANSVMT\networks\2018_11hrov.asc
/MTXA C:\D-Drive\HGAC_AirQuality\TRANSVMT\intratrips_output\intratrips_18_am.txt
/MTXM C:\D-Drive\HGAC_AirQuality\TRANSVMT\intratrips_output\intratrips_18_md.txt
/MTXP C:\D-Drive\HGAC_AirQuality\TRANSVMT\intratrips_output\intratrips_18_pm.txt
/MTXO C:\D-Drive\HGAC_AirQuality\TRANSVMT\intratrips_output\intratrips_18_ov.txt
/SPDH C:\D-Drive\HGAC_AirQuality\TRANSVMT\input\HGAC2007_CAPFACT_SPDFACT.txt
/SRFD C:\D-Drive\HGAC_AirQuality\TRANSVMT\input\srfdata.txt
/CRD C:\D-Drive\HGAC_AirQuality\TRANSVMT\input\HGA_coordinates.txt

Appendix B: Facility Type Codes

Code	Description	Code	Description
0	Centroid Connector	20	HOV/transitways (barrier-separated)
1	Radial freeways without frontage roads	21	HOV ramps – bus only
2	Radial freeways with frontage roads	22	Transfers from park-and-ride (PNR) to transit stop
3	Circumferential freeways without frontage roads	23	Transfers from local bus to commuter/express bus
4	Circumferential freeways with frontage roads	24	Transfers from walk access node to transit stop
5	Radial tollways without frontage roads	25	Drive-access connectors
6	Radial tollways with frontage roads	26	Bus only: from street to transit center (TC)
7	Circumferential tollways without frontage roads	27	HOV-only slip ramps
8	Circumferential tollways with frontage roads	28	Transfer from pseudo-PNR to transit stop
9	Principal arterials with some grade separations	29	HOV terminal ramps
10	Principal arterials – divided	30	Rail
11	Principal arterials – undivided	40	High-Occupancy Toll (HOT) Lane
12	Other arterials – divided	41	HOT ramp to PNR/TC
13	Other arterials – undivided	47	HOT slip ramp
14	One-way pairs	49	HOT ramp
15	One-way facilities	50	Freeway frontage road
16	Major Collectors	51	Tollway frontage road
17	Minor Collectors	52	Freeway/tollway ramps to/from frontage roads
18	Ferries	53	Freeway/tollway direct connector (DC) ramps
19	Saturated arterials	60	Diamond lane (non-barrier separated HOV lane)
For yellow highlighted facility codes, Model Speed = Post-Processed Speed			

Appendix C: Speed Reduction Factors from New Speed Model

Volume/Capacity (V/C) Ratio	Speed Reduction Factor (SRF)
0	0.00000
0.05	0.00005
0.10	0.00010
0.15	0.00025
0.20	0.00040
0.25	0.00095
0.30	0.00150
0.35	0.00250
0.40	0.00350
0.45	0.00480
0.50	0.00610
0.55	0.00735
0.60	0.00860
0.65	0.00930
0.70	0.01000
0.75	0.06750
0.80	0.12500
0.85	0.27300
0.90	0.42000
0.95	0.60000
1.00	1.00000

Appendix D: Speed Reduction Factors from Current Speed Model

SRFATYPE	1	2	3	4	5	1	2	3	4	5
SRFFUNCL	1	1	1	1	1	2	2	2	2	2
VC000	0	0	0	0	0	0	0	0	0	0
VC005	0.000071	0.00007	0.000059	0.000152	0.00005	0.006115	0.005572	0.005318	0.005797	0.005024
VC010	0.000143	0.000141	0.000118	0.00031	0.000101	0.012657	0.011546	0.011023	0.012013	0.010428
VC015	0.000317	0.000314	0.000277	0.000575	0.000251	0.019681	0.017955	0.017138	0.018665	0.01622
VC020	0.000493	0.000489	0.000438	0.000848	0.000401	0.027301	0.024897	0.023755	0.025844	0.022486
VC025	0.00107	0.001066	0.000999	0.001528	0.00095	0.035656	0.032494	0.030987	0.033665	0.029339
VC030	0.00165	0.001647	0.001561	0.00222	0.001501	0.044925	0.040897	0.038973	0.042266	0.036903
VC035	0.002683	0.002681	0.002574	0.003373	0.002501	0.055333	0.050301	0.047893	0.051826	0.045354
VC040	0.003721	0.003721	0.003588	0.004548	0.003501	0.067177	0.060958	0.057977	0.062574	0.054902
VC045	0.005064	0.005069	0.004904	0.006046	0.004801	0.080856	0.073209	0.069537	0.074814	0.065836
VC050	0.006416	0.006427	0.006223	0.007579	0.006101	0.096929	0.087524	0.083001	0.088967	0.078542
VC055	0.007729	0.007751	0.007496	0.009112	0.007351	0.116198	0.10458	0.098982	0.105624	0.093568
VC060	0.009198	0.009231	0.008777	0.010808	0.0086	0.178632	0.150135	0.134765	0.143449	0.117174
VC065	0.010014	0.010075	0.009532	0.012323	0.009301	0.212849	0.191713	0.180643	0.189867	0.166438
VC070	0.011025	0.011134	0.01033	0.013813	0.01	0.299051	0.257425	0.235109	0.247396	0.210565
VC075	0.068545	0.068664	0.067864	0.071657	0.067501	0.364268	0.327594	0.309366	0.322575	0.291684
VC080	0.126384	0.126589	0.125365	0.129613	0.125	0.512044	0.44555	0.408617	0.420419	0.364731

VC085	0.274393	0.274656	0.273275	0.277432	0.272998	0.661535	0.596413	0.558168	0.563032	0.502952
VC090	0.421942	0.422511	0.420317	0.425296	0.419998	0.943044	0.847576	0.781113	0.777343	0.678943
VC095	0.601467	0.601927	0.600379	0.606288	0.599998	0.999574	0.994104	0.979402	0.968648	0.927899
VC100	1	1	1	1	1	1	1	1	1	1

Appendix D: Speed Reduction Factors from Current Speed Model (continued)

SRFATYPE	1	2	3	4	5	1	2	3	4	5
SRFFUNCL	3	3	3	3	3	4	4	4	4	4
VC000	0	0	0	0	0	0	0	0	0	0
VC005	0.005904	0.005165	0.005825	0.005719	0.004897	0.007019	0.008344	0.008245	0.008569	0.007211
VC010	0.012232	0.010713	0.012089	0.011889	0.010213	0.014519	0.017349	0.017148	0.017841	0.015096
VC015	0.019026	0.016652	0.018799	0.018496	0.01591	0.022519	0.026856	0.026545	0.027575	0.023369
VC020	0.026397	0.02307	0.02606	0.025642	0.022083	0.031138	0.036976	0.036546	0.037877	0.032129
VC025	0.03448	0.030074	0.034001	0.033447	0.028842	0.04052	0.047843	0.047285	0.048874	0.041494
VC030	0.043445	0.037801	0.04278	0.042068	0.036326	0.050845	0.059625	0.058925	0.060728	0.051616
VC035	0.053507	0.046422	0.052601	0.051696	0.04471	0.062344	0.072527	0.071673	0.073637	0.062683
VC040	0.06495	0.056159	0.063727	0.06258	0.054217	0.075319	0.086815	0.085794	0.087858	0.07494
VC045	0.078149	0.06731	0.076509	0.075052	0.065142	0.090167	0.102834	0.101634	0.103727	0.08871
VC050	0.093626	0.080277	0.091426	0.089559	0.077877	0.107441	0.121044	0.119657	0.121696	0.104427
VC055	0.112125	0.095637	0.109158	0.106729	0.092971	0.127931	0.14208	0.140503	0.142391	0.122696
VC060	0.160931	0.121772	0.137353	0.133021	0.111686	0.17756	0.166845	0.165088	0.166705	0.144383
VC065	0.204527	0.170557	0.180732	0.170111	0.139717	0.213854	0.201498	0.195405	0.195963	0.170771
VC070	0.27396	0.217161	0.229772	0.221289	0.186973	0.287648	0.239409	0.232326	0.233805	0.204167
VC075	0.347177	0.29678	0.303847	0.292276	0.25228	0.356337	0.294192	0.280575	0.282181	0.247513

VC080	0.467852	0.375617	0.388437	0.370352	0.310705	0.477705	0.359918	0.344583	0.344944	0.305887
VC085	0.618592	0.517077	0.520689	0.486983	0.401186	0.61675	0.461761	0.435804	0.433434	0.389197
VC090	0.853008	0.704824	0.718901	0.672792	0.55156	0.85407	0.600135	0.570212	0.56603	0.51483
VC095	0.994426	0.945199	0.940031	0.879321	0.753091	0.973073	0.812025	0.772738	0.762127	0.709009
VC100	1	1	1	1	1	1	1	1	1	1

Appendix E: Speed Factors for Free Flow Speed and LOS E Speed in Current Speed Model

ATYPE	FUNCL	SRFATYPE	SRFFUNCL	SPD0FACT	SPD1FACT
1	1	1	1	1.198177	0.802524
2	1	2	1	1.158839	0.768691
3	1	3	1	1.063315	0.757099
4	1	4	1	1.168733	0.901573
5	1	5	1	1.192189	0.809269
1	2	1	1	1.198177	0.802524
2	2	2	1	1.158839	0.768691
3	2	3	1	1.063315	0.757099
4	2	4	1	1.168733	0.901573
5	2	5	1	1.192189	0.809269
1	3	1	1	1.054545	0.636364
2	3	2	1	1.054545	0.636364
3	3	3	1	0.997586	0.689655
4	3	4	1	0.950484	0.806452
5	3	5	1	1.083538	0.769231
1	4	1	4	1.238447	0.750462
2	4	2	4	0.895662	0.636429
3	4	3	4	0.89064	0.662149
4	4	4	4	1.199254	0.913293
5	4	5	4	1.192486	1.006409
1	5	1	2	1.154026	0.642357
2	5	2	2	0.827978	0.560208
3	5	3	2	0.890652	0.668272
4	5	4	2	1.102505	0.822853
5	5	5	2	1.176415	0.955472

ATYPE	FUNCL	SRFATYPE	SRFFUNCL	SPD0FACT	SPD1FACT
1	6	1	3	1.145946	0.681081
2	6	2	3	0.811634	0.562673
3	6	3	3	0.81318	0.616082
4	6	4	3	0.81318	0.865193
5	6	5	3	1.290531	1.118835
1	7	1	4	1.238447	0.750462
2	7	2	4	0.895662	0.636429
3	7	3	4	0.89064	0.662149
4	7	4	4	1.199254	0.913293
5	7	5	4	1.192486	1.006409
1	8	1	5	1	1
2	8	2	5	1	1
3	8	3	5	1	1
4	8	4	5	1	1
5	8	5	5	1	1
1	9	1	4	1	1
2	9	2	4	1	1
3	9	3	4	1	1
4	9	4	4	1	1
5	9	5	4	1	1
1	10	1	1	1.198177	0.802524
2	10	2	1	1.158839	0.768691
3	10	3	1	1.063315	0.757099
4	10	4	1	1.168733	0.901573
5	10	5	1	1.192189	0.809269
1	11	1	1	1.198177	0.802524
2	11	2	1	1.158839	0.768691

ATYPE	FUNCL	SRFATYPE	SRFFUNCL	SPD0FACT	SPD1FACT
3	11	3	1	1.063315	0.757099
4	11	4	1	1.168733	0.901573
5	11	5	1	1.192189	0.809269
1	12	1	2	1.154026	0.642357
2	12	2	2	0.827978	0.560208
3	12	3	2	0.890652	0.668272
4	12	4	2	1.102505	0.822853
5	12	5	2	1.176415	0.955472
1	13	1	3	1.145946	0.681081
2	13	2	3	0.811634	0.562673
3	13	3	3	0.81318	0.616082
4	13	4	3	0.81318	0.865193
5	13	5	3	1.290531	1.118835
1	14	1	3	1.145946	0.681081
2	14	2	3	0.811634	0.562673
3	14	3	3	0.81318	0.616082
4	14	4	3	0.81318	0.865193
5	14	5	3	1.290531	1.118835
1	15	1	4	1.238447	0.750462
2	15	2	4	0.895662	0.636429
3	15	3	4	0.89064	0.662149
4	15	4	4	1.199254	0.913293
5	15	5	4	1.192486	1.006409
1	16	1	5	1	1
2	16	2	5	1	1
3	16	3	5	1	1
4	16	4	5	1	1

ATYPE	FUNCL	SRFATYPE	SRFFUNCL	SPD0FACT	SPD1FACT
5	16	5	5	1	1

Appendix F: Sample JCF file

/JOB TRANSVMT

/STEP Step1 TRANSVMT

/LST C:\TRANSVMT\speedmodel\networks\output\HGA_2017_transvmt.lst

/HDR C:\TRANSVMT\speedmodel\input\HGA_2017transvmt.txt

/HRF C:\TRANSVMT\speedmodel\input\PERFACT3.txt

/CCFC C:\TRANSVMT\speedmodel\input\HGA_ccCode.txt

/SPLT C:\TRANSVMT\speedmodel\input\HGAC_DIRSPLITS.txt

/DTYP C:\TRANSVMT\speedmodel\input\HGA_daytype.txt

/VADJ C:\TRANSVMT\speedmodel\input\COUNTY_VMTadjustment_newHPMS2.txt

/RADI C:\TRANSVMT\speedmodel\networks\radii2017.asc

/TMPD C:\TRANSVMT\speedmodel\input\timePerDesignation.txt

/LNKA C:\TRANSVMT\speedmodel\networks\2018AQ_AM3HR_NETWORK.asc

/LNKM C:\TRANSVMT\speedmodel\networks\2018AQ_MD6HR_NETWORK.asc

/LNKP C:\TRANSVMT\speedmodel\networks\2018AQ_PM4HR_NETWORK.asc

/LNKO C:\TRANSVMT\speedmodel\networks\2018AQ_OV11HR_NETWORK.asc

/MTXA C:\TRANSVMT\speedmodel\networks\intratrips_output\intratrips_17_am.txt

/MTXM C:\TRANSVMT\speedmodel\networks\intratrips_output\intratrips_17_md.txt

/MTXP C:\TRANSVMT\speedmodel\networks\intratrips_output\intratrips_17_pm.txt

/MTXO C:\TRANSVMT\speedmodel\networks\intratrips_output\intratrips_17_ov.txt

/SPDF C:\TRANSVMT\speedmodel\input\HGAC2007_CAPFACT_SPDFACT.txt

/CRD C:\TRANSVMT\speedmodel\input\HGA_coordinates.txt

/SPDLMT C:\TRANSVMT\speedmodel\input\speedlimit.txt

/FFSPD C:\TRANSVMT\speedmodel\input\Freeflowspeed.txt

/LSESPD C:\TRANSVMT\speedmodel\input\LOSESpeed.txt

/SGLTYP C:\TRANSVMT\speedmodel\input\sglty.txt

/PFFAC C:\TRANSVMT\speedmodel\input\pffac.txt

/RUNF C:\TRANSVMT\speedmodel\input\runfac.txt

/CYCLE C:\TRANSVMT\speedmodel\input\cycle.txt

/ARVTY C:\TRANSVMT\speedmodel\input\arvty.txt

/GCRAT C:\TRANSVMT\speedmodel\input\gcratio.txt

/SRFF C:\TRANSVMT\speedmodel\input\SRFF.txt

Appendix G: Sample Inputs for New Speed Model

Figure G.1: Snapshot from speed limit file

RDTYP	LANE	SPDA1	SPDA2	SPDA3	SPDA4	SPDA5
1	1	55	60	60	65	65
1	2	55	60	60	65	65
1	3	55	60	60	65	65
1	4	55	60	60	65	65
1	5	55	60	60	65	65
1	6	55	60	60	65	65
1	7	55	60	60	65	65
1	8	55	60	60	65	65
1	9	55	60	60	65	65
1	10	55	60	60	65	65
2	1	55	60	60	65	65
2	2	55	60	60	65	65
2	3	55	60	60	65	65
2	4	55	60	60	65	65
2	5	55	60	60	65	65
2	6	55	60	60	65	65
2	7	55	60	60	65	65

Figure G.2: Snapshot from free flow speed file

RDTYP	ADJTYP1	ADJVAL1	ADJTYP2	ADJVAL2	ADJTYP3	ADJVAL3	ADJTYP4	ADJVAL4	ADJTYP5	ADJVAL5
1	1	3	1	3	1	3	1	4	1	6
2	1	3	1	3	1	3	1	4	1	6
3	1	3	1	3	1	3	1	4	1	6
4	1	3	1	3	1	3	1	4	1	6
5	1	3	1	3	1	3	1	4	1	6
6	1	3	1	3	1	3	1	4	1	6
7	1	3	1	3	1	3	1	4	1	6
8	1	3	1	3	1	3	1	4	1	6
9	2	0.85	2	0.85	2	0.85	2	0.9	1	4
10	2	0.85	2	0.85	2	0.85	2	0.9	1	4
11	2	0.85	2	0.85	2	0.85	2	0.9	1	4
12	2	0.85	2	0.85	2	0.85	2	0.9	1	4
13	2	0.85	2	0.85	2	0.85	2	0.9	1	4
14	2	0.85	2	0.85	2	0.85	2	0.9	1	4

Figure G.3: Snapshot from LOS E speed file

RDTYP	ADJTYP1	ADJVAL1	ADJTYP2	ADJVAL2	ADJTYP3	ADJVAL3	ADJTYP4	ADJVAL4	ADJTYP5	ADJVAL5
1	3	35	3	35	3	40	3	50	3	50
2	3	35	3	35	3	40	3	50	3	50
3	3	35	3	35	3	40	3	50	3	50
4	3	35	3	35	3	40	3	50	3	50
5	3	35	3	35	3	40	3	50	3	50
6	3	35	3	35	3	40	3	50	3	50
7	3	35	3	35	3	40	3	50	3	50
8	3	35	3	35	3	40	3	50	3	50
9	2	0.3	2	0.3	2	0.3	2	0.3	2	0.3
10	2	0.3	2	0.3	2	0.3	2	0.3	2	0.3
11	2	0.3	2	0.3	2	0.3	2	0.3	2	0.3
12	2	0.3	2	0.3	2	0.3	2	0.3	2	0.3

Figure G.4: Snapshot from g/c ratio file

RDTYP	LANE	GCR1	GCR2	GCR3	GCR4	GCR5
1	1	1	1	1	1	1
1	2	1	1	1	1	1
1	3	1	1	1	1	1
1	4	1	1	1	1	1
1	5	1	1	1	1	1
1	6	1	1	1	1	1
1	7	1	1	1	1	1
1	8	1	1	1	1	1
1	9	1	1	1	1	1
1	10	1	1	1	1	1

Figure G.5: Snapshot from runtime factor file

LENGTH	25	30	35	40	45	50	55	60
0.2	1.146	1.142	1.241	1.278	1.363	1.447	1.588	1.692
0.25	1.063	1.079	1.17	1.222	1.3	1.378	1.482	1.586
0.3	1.032	1.048	1.069	1.133	1.237	1.342	1.446	1.55
0.35	1.03	1.045	1.045	1.1	1.206	1.313	1.419	1.525
0.4	1.027	1.041	1.021	1.067	1.175	1.283	1.392	1.5
0.45	1.025	1.038	1.011	1.05	1.138	1.225	1.312	1.4
0.5	1.023	1.034	1.001	1.033	1.1	1.167	1.233	1.3
0.55	1.021	1.031	1.001	1.03	1.09	1.15	1.21	1.27
0.6	1.018	1.027	1.001	1.027	1.08	1.133	1.187	1.24
0.65	1.016	1.024	1.001	1.023	1.07	1.117	1.163	1.21
0.7	1.014	1.021	1.001	1.02	1.06	1.1	1.14	1.18
0.75	1.011	1.017	1.001	1.017	1.05	1.083	1.117	1.15
0.8	1.009	1.014	1.001	1.013	1.04	1.067	1.093	1.12
0.85	1.007	1.01	1	1.01	1.03	1.05	1.07	1.09
0.9	1.005	1.007	1	1.007	1.02	1.033	1.047	1.06
0.95	1.002	1.003	1	1.003	1.01	1.017	1.023	1.03
1	1	1	1	1	1	1	1	1

Figure G.6: Snapshot from signal type file

RDTYP	LANE	SGLA1	SGLA2	SGLA3	SGLA4	SGLA5
9	1	2	2	2	3	1
9	2	2	2	2	3	1
9	3	2	2	2	3	1
9	4	2	2	2	3	1
9	5	2	2	2	3	1
9	6	2	2	2	3	1
9	7	2	2	2	3	1
9	8	2	2	2	3	1

Figure G.7: Snapshot from arrival type file

RTYPE	LANE	ARVTYP1	ARVTYP2	ARVTYP3	ARVTYP4	ARVTYP5
9	1	5	5	5	5	5
9	2	5	5	5	5	5
9	3	5	5	5	5	5
9	4	5	5	5	5	5
9	5	5	5	5	5	5
9	6	5	5	5	5	5
9	7	5	5	5	5	5
9	8	5	5	5	5	5
10	1	5	5	5	5	5

Figure G.8: Snapshot from progression factor file

VC	SG1_A1	SG1_A2	SG1_A3	SG1_A4	SG1_A5	SG2_A1	SG2_A2	SG2_A3	SG2_A4	SG2_A5	SG3_A1	SG3_A2	SG3_A3	SG3_A4	SG3_A5
0.1	1.85	1.35	1	0.72	0.53	1.54	1.08	0.85	0.62	0.4	1.85	1.35	1	0.72	0.42
0.2	1.85	1.35	1	0.72	0.53	1.54	1.08	0.85	0.62	0.4	1.85	1.35	1	0.72	0.42
0.3	1.85	1.35	1	0.72	0.53	1.54	1.08	0.85	0.62	0.4	1.85	1.35	1	0.72	0.42
0.4	1.85	1.35	1	0.72	0.53	1.54	1.08	0.85	0.62	0.4	1.85	1.35	1	0.72	0.42
0.5	1.85	1.35	1	0.72	0.53	1.54	1.08	0.85	0.62	0.4	1.85	1.35	1	0.72	0.42
0.6	1.85	1.35	1	0.72	0.53	1.54	1.08	0.85	0.62	0.4	1.85	1.35	1	0.72	0.42
0.7	1.675	1.285	1	0.77	0.6	1.395	1.03	0.85	0.665	0.45	1.675	1.285	1	0.77	0.475
0.8	1.5	1.22	1	0.82	0.67	1.25	0.98	0.85	0.71	0.5	1.5	1.22	1	0.82	0.53
0.9	1.45	1.2	1	0.86	0.745	1.205	0.96	0.85	0.745	0.555	1.45	1.2	1	0.86	0.59
1	1.4	1.18	1	0.9	0.82	1.16	0.94	0.85	0.78	0.61	1.4	1.18	1	0.9	0.65

Figure G.9: Snapshot from cycle length file

RTYPE	LANE	CYCLE1	CYCLE2	CYCLE3	CYCLE4	CYCLE5
9	1	75	75	70	70	60
9	2	75	75	70	70	60
9	3	75	75	70	70	60
9	4	75	75	70	70	60
9	5	75	75	70	70	60
9	6	75	75	70	70	60
9	7	75	75	70	70	60
9	8	75	75	70	70	60
10	1	75	75	70	70	60

Figure G.10: Snapshot from speed reduction factor file

VC	SRF
0	0
0.05	0.00005
0.1	0.0001
0.15	0.00025
0.2	0.0004
0.25	0.00095
0.3	0.0015
0.35	0.0025
0.4	0.0035
0.45	0.0048
0.5	0.0061
0.55	0.00735
0.6	0.0086
0.65	0.0093
0.7	0.01
0.75	0.0675
0.8	0.125
0.85	0.273
0.9	0.42
0.95	0.6
1	1