

## Appendix 6

### TTI Suite of Programs

## **TTI EMISSIONS ESTIMATION PROGRAMS**

The following is a summary of the series of programs developed by TTI for developing link-based, time-of-day, on-road mobile source emissions estimates for air quality analyses.

These programs produce emissions factors with the latest version of EPA's MOBILE emissions factor model, and apply them to travel model-based activity estimates to calculate emissions at user-specified temporal and spatial scales. The location of emissions by grid, or travel network link coordinates, may also be specified.

The emissions estimation programs are: TRANSVMTHSPDWKD and TRANSVMTHSPDWKE, POLFAC62\_3, RATEADJ62, RATEADJV62, IMPSUM62, and SUMALL62. TRANSVMTHSPDWKD and TRANSVMTHSPDWKE prepare activity input for weekday and weekend day types, respectively, POLFAC62\_3 prepares emissions factor input, the RATEADJ programs make special adjustments to emissions factors when required, IMPSUM62 calculates emissions by time period, and SUMALL62 summarizes emissions at various levels by 24-hour period. Another utility, M6INPUTBUILD, creates hourly VMT, speed VMT, and VMT by facility external data MOBILE6 input files from inventory activity inputs.

### **TRANSVMTHSPDWKD and TRANSVMTHSPDWKE**

The TRANSVMTHSPDWKD and TRANSVMTHSPDWKE programs are TRANSCAD based utilities that post-process TDMs to produce time-of-day specific, on-road vehicle, link VMT and speed estimates. The TRANSVMTHSPDWKD program processes a TDM traffic assignment consisting of four time-of-day assignments by scaling the link volumes by the appropriate HPMS, seasonal, or other VMT factors. Time-of-day factors are then applied to distribute the link VMT to each hour in the day. The Houston speed model is used to estimate the operational time-of-day speeds for each link (or by direction if the assignment is not directional). Since intrazonal links are not included in the TDMs, special intrazonal links are created and the VMT and speeds for these special links are estimated. The TRANSVMTHSPDWKD program is specifically designed for estimating VMT and speeds for Weekdays (day types Weekdays and Friday). The TRANSVMTHSPDWKE program operates in a similar manner as the TRANSVMTHSPDWKD program except that it allows for an extra VMT factor that can be used to estimate VMT and speeds for Weekends (day types Saturday and Sunday). The link VMT and speeds produced by these programs are subsequently input to the IMPSUM62 program for the application of MOBILE6 emission factors.

### **M6INPUTBUILD**

The M6INPUTBUILD program processes the TRANSVMT program output to produce the MOBILE6 VMT by hour, speed VMT, and VMT by facility input files. The MOBILE6 input files created by this program are in the proper format for use in

## MOBILE6.

### **POLFAC62\_3**

The POLFAC62\_3 program is used to apply the EPA's MOBILE6 program (MOBILE6.2.3 September 2003 version with additional pollutant capabilities) to calculate the on-road mobile emissions factors. The MOBILE6 emissions factors may be produced for each of the pollutant-specific emissions types (e.g., depending on the pollutant and vehicle type, the total composite, exhaust running, exhaust start, plus the six sub-component evaporative rates), 28 vehicle types, four MOBILE6 functional classifications (or drive cycles, i.e., Freeway, Arterial/Collector, Local, and Ramp), 14 speeds (i.e., 2.5 mph, and 5 mph through 65 mph at 5 mph increments for Freeway and Arterial functional classifications — MOBILE6 Local and Ramp functional classification rates are single speed only, 12.9 mph, and 34.6 mph, respectively), and each of the 24 hours of the day. The POLFAC62\_3 emissions factors are average vehicle class rates calculated from the MOBILE6 database output by weighting the by-model-year emissions rates within each vehicle class by its corresponding travel fraction. These emissions factors are tabulated individually by geographical area (county or county group) and analysis day for the evaluation year.

These emissions factors are output to an ASCII file for subsequent input to the IMPSUM62 program. The IMPSUM62 program is then used to apply the hourly emissions factors to hourly VMT estimates by link. (POLFAC62\_3 also optionally produces a set of daily emissions factors.) POLFAC62\_3 also calculates the additional pollutant emissions factors provided by the MOBILE6 October 2002 version.

### **RATEADJ62**

RATEADJ62 is a special utility program that produces a new set of emissions factors by linearly combining the emissions factors from multiple applications of POLFAC62\_3. There is one set of linear factors. Each factor is applied to all emissions rates in a single data set. A practical application of the RATEADJ62 program is the combining of two sets of emissions factors, where each set has different control program credits, into one set including the combined credits. For example, this program may be used to combine different ATP credits from two separate POLFAC62\_3 runs into one set of emissions factors that includes the credits for both ATPs.

### **IMPSUM62**

The IMPSUM62 program applies the emissions factors obtained from POLFAC62\_3 (or from one of the RATEADJ programs, when used) and VMT mixes (fractions of fleet VMT attributable to each vehicle classification in the study) to the time-of-day fleet VMT and speed estimates to calculate emissions by the specified time periods. The five primary inputs to IMPSUM62 are:

- MOBILE6 emissions factors developed with POLFAC62\_3 (or a RATEADJ62, if used);
- link-based hourly VMT and speeds developed using the TRANSVMTHSPDWKD or TRANSVMTHSPDWKE program. For each link,

the following information is input to IMPSUM62: county number, roadway type number, VMT on link, operational link-speed estimate, and link distance;

- VMT mix by time period, county and roadway type;
- X-Y coordinates (optional for gridded emissions); and
- data records associating the MOBILE6 drive cycle (Freeway, Arterial, Local, Ramp) emissions factors (or percentages thereof) to specific travel model

functional classifications. These MOBILE6 drive cycle emissions factor percentages (valid from zero to 100) must sum to 100 percent for each travel model functional classification.

Using these input data, the VMT for each link is stratified by MOBILE6 drive cycle and the 28 vehicle types. The MOBILE6 emissions factors are matched to link VMT by drive cycle, speed, and vehicle type and are interpolated (for the speed that falls between the 14 MOBILE6 speeds, see the MOBILE6 interpolation methodology below) and multiplied by the link VMT to estimate the mobile source emissions for that link. Emissions factors for 65 mph are used for links with speeds greater than 65 mph and emissions factors for 2.5 mph are used for links with speeds lower than 2.5 mph. The emissions for the county and emissions type are reported by both roadway type and vehicle type for each of the subject time periods. A data set is produced for subsequent input to the SUMALL62 program. Also, link emissions may be written by county at the pollutant-specific emissions type sub-component level and 28 vehicle types level.

A tab-delimited output is optionally produced. This output includes all 28 vehicle types (or eight vehicle types in the compressed format) across a single output line. Each field in the output is separated by a tab character.

#### *Example Emissions Factor Interpolation*

To calculate emissions factors for average operational speeds that fall between two of the 14 MOBILE6 speed bin speeds, MOBILE6 interpolates each emissions factor using a factor developed from the inverse link speed and the inverse high and low bounding speed bin speeds (Section 5.3.4, MOBILE6 User's Guide, January 2002).

Using the MOBILE6 emissions factors tabulated by the 14 speeds, the IMPSUM62 program uses the MOBILE6 method to interpolate emissions factors as shown in the following example. This example interpolates an emissions factor corresponding to an average speed of 41.2 mph.

The interpolated emissions factor ( $EF_{\text{Interp}}$ ) is expressed as:

$$EF_{\text{Interp}} = EF_{\text{LowSpeed}} - FAC_{\text{Interp}} \times (EF_{\text{LowSpeed}} - EF_{\text{HighSpeed}})$$

Where:

$EF_{\text{LowSpeed}}$  = emission factor (EF) corresponding to tabulated speed below the average link speed;

$EF_{\text{HighSpeed}}$  = EF corresponding to tabulated speed above the average link speed;

and

$$FAC_{Interp} = \left( \frac{1}{Speed_{link}} - \frac{1}{Speed_{low}} \right) / \left( \frac{1}{Speed_{high}} - \frac{1}{Speed_{low}} \right)$$

Example:

$$\begin{aligned} EF_{LowSpeed} &= 0.7413 \text{ g/mi;} \\ EF_{HighSpeed} &= 0.7274 \text{ g/mi;} \\ Speed_{link} &= 41.2 \text{ mph;} \\ Speed_{low} &= 40 \text{ mph;} \text{ and} \\ Speed_{high} &= 45 \text{ mph.} \end{aligned}$$

$$FAC_{Interp} = \left( \frac{1}{41.2mph} - \frac{1}{40mph} \right) / \left( \frac{1}{45mph} - \frac{1}{40mph} \right) = \frac{-0.00073}{-0.00278} = 0.26214,$$

$$\begin{aligned} EF_{Interp} &= 0.7413 \text{ g/mi} - (0.26214) \times (0.7413 \text{ g/mi} - 0.7274 \text{ g/mi}) \\ &= 0.7377 \text{ g/mi} \end{aligned}$$

## SUMALL62

The SUMALL62 program is used to sum the emissions estimates for the time-of-day periods (e.g., 24 periods in the case of hourly analyses) to develop 24-hour emissions estimates. The emissions by pollutant type are reported by roadway type and 28 vehicle types (or optionally condensed to eight vehicle types).

A tab-delimited output is optionally produced. This output includes all 28 vehicle types (or eight vehicle types in the compressed format) across a single output line. Each field in the output is separated by a tab character.

## M6INPUTBUILD

The M6INPUTBUILD utility post-processes the TRANSVMT utility output (hourly link VMT/speed data sets) and VMT mix data sets to produce the MOBILE6 VMT by hour, speed VMT, and VMT by facility input files. The MOBILE6 input files created by this utility are in the required MOBILE6 format. Although these files are not used developing the hourly link-based emissions estimates, these files may be used with MOBILE6 to develop aggregate daily emissions factors reflective of the county or regional hourly VMT distributions (by hour, speed, and facility type) for various applications.

The overall emissions estimate process flow is shown in the diagram below.

# General Process Flow

Travel Demand Model Network Link-Based Hourly MOBILE6 Emissions Estimates with Texas Mobile Source Emissions Software

