

# Appendix 6

## TTI Suite of Programs



## **TTI EMISSIONS ESTIMATION UTILITIES**

Following is a summary of utilities developed by TTI for producing detailed, link-based, hourly, and 24-hour emissions estimates for on-road mobile sources. The utilities are also used in formatting the results in EPA's NEI reporting format (NIF 3.0), and converting from the NIF form to the XML document form according to EPA's latest NEI reporting requirements.

These utilities produce emissions factors with the latest version of EPA's MOBILE emissions factor model, and multiply them with travel model link-based or HPMS-based (virtual link) activity estimates to produce emissions at user-specified temporal and spatial scales.

The main utilities for calculating hourly and 24-hour emissions are TRANSVMT, VirtualLinkVMT, POLFAC62\_3, RATEADJ (several utilities), and EMSCALC. TRANSVMT and VirtualLinkVMT prepare activity input; POLFAC62\_3 prepares emissions factor input; the RATEADJ utilities make special adjustments to emissions factors when required; and EMSCALC calculates emissions by hourly time periods and produces 24-hour totals.

Additionally, the EMISSIONSFORMAT utility formats EI data in the EPA's NIF 3.0 reporting format, and the XMLFORMAT utility converts the NIF EI summaries to an XML document according to EPA's latest NEI reporting requirements. All of the utilities were written in the Visual Basic programming language, except for POLFAC62\_3, which was developed in FORTRAN.

A process flow diagram follows the utility descriptions.

### **TRANSVMT**

The TRANSVMT utility post-processes TDMs to produce hourly, on-road vehicle, seasonal and day-of-week specific, directional link VMT, and speed estimates. The TRANSVMT utility processes a TDM traffic assignment by multiplying the link volumes by the appropriate HPMS, seasonal, or other VMT factors. Hourly factors are then used to distribute the link VMT to each hour in the day. The TTI speed model is used to estimate the operational time-of-day link speeds for each direction. Since intrazonal links are not included in the TDM, special intrazonal links are created and the VMT and speeds for these special links are estimated using the intrazonal trips from the trip matrix and the zonal radii. The link VMT and speeds produced by TRANSVMT are subsequently input to the EMSCALC utility for applying the MOBILE6 emissions factors.

### **VirtualLinkVMT**

The VirtualLinkVMT utility post-processes county HPMS AADT VMT, centerline miles, and lane miles by functional classification and area type (from TxDOT's annual Roadway Inventory Functional Classification Record [RIFCREC] report) to produce hourly, on-road vehicle fleet, seasonal and day-of-week specific actual or projected VMT, and directional operational speed estimates. These estimated VMT and speeds are produced for up to 42 directional HPMS functional classification/area type combinations, or "links." The VirtualLinkVMT utility was developed for use in areas that do not have TDM networks, as well as for EI applications for which network link-based detail is not required. The main inputs to VirtualLinkVMT are: 1) county HPMS data sets, which include AADT VMT, centerline miles, and lane miles by HPMS

area type and functional class; and 2) county-level VMT control totals. The other main inputs are: 3) hourly VMT distributions; and 4) speed model inputs to include volume/delay equation parameters adapted for HPMS, and freeflow speeds and lane capacities by HPMS functional classification and area type.

VirtualLinkVMT initially scales the county HPMS AADT VMT at the link level to the appropriate VMT (e.g., uses county-level VMT control total-to-AADT ratio to produce seasonal, day-of-week specific VMT). Hourly factors and directional split factors are applied to the adjusted VMT on each link to estimate the hourly, directional VMT (and volumes) by HPMS link. Congested speed models, each for the high- and low-capacity links, are used to estimate the hourly operational speeds by direction for each link. The operational speeds are based on v/c derived directional delay (minutes/mile) applied to the estimated freeflow speeds for each link. The virtual link VMT and speeds produced using the VirtualLinkVMT utility are an input to the emissions calculation utility, EMSCALC.

### **POLFAC62\_3**

The POLFAC62\_3 utility is used to apply the EPA's MOBILE6 program (September 2003 release) to calculate the on-road mobile source 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, and four MOBILE6 functional classifications (or drive cycles, i.e., Freeway, Arterial/Collector, Local, and Ramp). They are produced for 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 detailed database data by weighting each by-MY emissions rate within a vehicle class by its corresponding travel factor, and summing the results. These emissions factors are produced 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 EMSCALC utility. The EMSCALC utility is then used to multiply the hourly emissions factors by hourly VMT estimates by link. (POLFAC62\_3 also optionally produces a set of daily emissions factors.) POLFAC62\_3 also calculates the additional pollutant (i.e., PM-related pollutants and toxics) emissions factors provided by MOBILE6.

### **RATEADJV62DK**

RATEADJV62DK is a special utility that produces a new set of emissions factors by applying emissions factor adjustments to each pollutant, emissions type, and vehicle type. RATEADJV62DK can be applied to emissions rates produced by POLFAC62\_3, RATEADJV62DK, RATEADJ62DK, or RATEADJV62hrDK.

A practical application of RATEADJV62DK is the application of emissions factor credits by individual vehicle class and/or individual pollutant. For example, for analyses requiring the effects of the Texas Low-Emission Diesel (TxLED) fuel program in MOBILE6 emissions factors, RATEADJV62DK may be used to apply reduction factors to the NOx emissions factors for diesel-fueled vehicle classes only.

### **RATEADJ62DK and RATEADJ62X**

RATEADJ62DK is a special utility that produces a new set of emissions factors by linearly combining the emissions factors from multiple applications of POLFAC62\_3, RATEADJV62DK, RATEADJ62DK, or RATEADJV62hrDK. There is a separate set of factors for each of the input emissions factor data sets.

A practical application of RATEADJ62DK 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 utility 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.

The RATEADJ62X utility performs the same function as RATEADJ62DK, except that the input emissions factor look-up tables to be combined are not required to have the same number of records (i.e., pollutants and emissions types). This may be useful when combining monthly rates to produce an annual average rate table, for instance, if the winter month temperatures are low enough that some of the evaporative emissions rates are not produced.

### **RATEADJV62hrDK**

RATEADJV62hrDK is a special utility that produces a new set of emissions factors by applying emissions factor adjustments to each pollutant, emissions type, and vehicle type by hour. RATEADJV62DK can be applied to emissions rates produced by POLFAC62\_3, RATEADJV62DK, RATEADJ62DK, or RATEADJV62hrDK.

### **EMSCALC**

The EMSCALC utility uses the emissions factors, VMT mixes (fractions of fleet VMT attributable to each vehicle classification in the study), and the time-of-day fleet VMT and speed estimates to calculate emissions by the user-specified time periods for the specified county. This utility calculates emissions for the one user-specified county. The four primary inputs to EMSCALC are:

- MOBILE6 emissions factors developed with POLFAC62\_3 (or a RATEADJ62, if used);
- link-based hourly VMT and speeds developed with the TRANSVMT or VirtualLinkVMT utility. For each link, the following information is input to EMSCALC: county number, roadway type number, VMT on link, operational link-speed estimate, and link distance;
- VMT mix by time period, county, and roadway type; and
- associations of the MOBILE6 drive cycle (Freeway, Arterial, Local, and Ramp) emissions factors (or percentages thereof) to specific travel model functional classifications. These percentages of MOBILE6 drive-cycle emissions factors (valid from zero to 100) must sum to 100 percent for each travel model functional classification.

The VMT for each link is distributed by MOBILE6 drive cycle to each of the 28 vehicle types. The emissions factors are selected based on drive cycle, speed, and vehicle type. For those speeds that fall between the 14 MOBILE6 speeds, the emissions factors are interpolated using the MOBILE6 interpolation methodology (see the following section). These vehicle-type-specific emissions factors are multiplied by the vehicle-type-specific VMT to estimate the mobile source emissions for that link by vehicle type. For link speeds greater than 65 mph, the

emissions factors for 65 mph are used. For link speeds less than 2.5 mph, the emissions factors for 2.5 mph are used.

The emissions estimates are output in a tab-delimited file (including all 28 vehicle types on a single line, separated by a tab character) for the specified county by pollutant, roadway type, and vehicle type for each of the specified episode time periods. This emissions data is also saved for the 24-hour output (or time period if all 24 hours are not specified). Link emissions may also be output by county, pollutant, sub-component, and the 28 MOBILE6 vehicle types.

*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*, August 2003).

Using the MOBILE6 emissions factors sorted by the 14 speeds, the EMSCALC utility 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 ( $EF_{Interp}$ ) is expressed as:

$$EF_{Interp} = EF_{LowSpeed} - FAC_{Interp} H (EF_{LowSpeed} - EF_{HighSpeed} )$$

Where:

$EF_{LowSpeed}$  = emissions factor (EF) corresponding to the speed below the average link speed;

$EF_{HighSpeed}$  = EF corresponding to the speed above the average link speed; and

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

Given that:

$EF_{LowSpeed} = 0.7413 \text{ g/mi};$

$EF_{HighSpeed} = 0.7274 \text{ g/mi};$

$Speed_{link} = 41.2 \text{ mph};$

$Speed_{low} = 40 \text{ mph};$  and

$Speed_{high} = 45 \text{ mph}.$

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

$EF_{Interp} = 0.7413 \text{ g/mi} - (0.26214) H (0.7413 \text{ g/mi} - 0.7274 \text{ g/mi});$

$= 0.7377 \text{ g/mi}.$

## **TABCOMB**

The TABCOMB utility combines the tab-delimited output from multiple runs of the EMSCALC utility to produce a regional summary of the VMT, VHT, speed (VMT/VHT), and emissions for each hour and a 24-hour summary. A maximum of 10 tab files can be combined in one run of the TABCOMB utility. However, each tab file must have the same roadway types or the utility will not function properly.

The new regional tab-delimited file is in the same form as the individual county files taken as input, except that each time period includes the individual county data summaries plus the regional summary. The individual county summaries are taken directly from the input tab-delimited files. The regional data summaries are summations of the county data except for “speed,” which is calculated as regional VMT/regional VHT.

## **EMISSIONSFORMAT**

The EMISSIONSFORMAT utility converts the tab-delimited 24-hour and/or annual output from an EMSCALC or ANNUALIZATION application into a format similar to the NIF 3.0 format (for more information regarding the NIF 3.0 format see *NEI Input Format [NIF] Version 3.0, User's Guide Instructions and Conventions for Use*, EPA, November 2003). There are three records that can be produced using this utility — a transmittal record, an emissions period record, and an emissions record. The transmittal record contains information regarding the tab-delimited file that is being converted, as well as other inventory-specific-related information. The emissions period record contains the VMT data for the specified inventory. The emissions record contains the emissions estimates contained within the tab-delimited output file.

For the TDM-based counties, the functional class system must be converted to the HPMS functional class system. This conversion is performed by applying the HPMS VMT proportions by roadtype (calculated from the HPMS data for the specified year) and the vehicle type VMT proportions from the tab-delimited output file to the 24-hour total VMT from the tab-delimited output file. A similar conversion is performed for each pollutant using the pollutant-specific vehicle type proportions and the 24-hour total for the specific pollutant.

## **XMLFORMAT**

The XMLFORMAT utility converts the annual EI output from the EmissionsFormat utility (emissions summary data in NIF form) to an XML format specified by EPA for reporting the 2008 NEI data, and is thus compatible with EPA's CERR reporting requirements. The inputs include the list of pollutant names, an XML input file (containing elements that the user specifies for inclusion in the XML output file), and the NIF files from which EI data are to be converted to XML form (includes transmittal records, emissions records, and emissions period records). The outputs include the XML output file containing the annual EI summary data as specified in the *2008 NEI EIS Implementation Plan, Section 10, Reporting Instructions for Onroad and Nonroad Emissions*, EPA, December 22, 2008. The outputs also include a tab-delimited summary file including a table of the VMT and emissions for each county and source classification code (SCC) found in the XML output file, and a file listing the XMLFORMAT run script, inputs, outputs, and execution begin and end times.

## **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 following diagram shows the overall emissions estimate process flow for an HPMS virtual-link-based analysis.



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



