Development of Link-Level Mobile Source Emission Inventories

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ABSTRACT

Highly resolved emission inventories for on-road mobile sources are needed for air quality modeling to develop the necessary technical support for new State Implementation Plans (SIPs) for regional haze, fine particles, and ozone. Emissions for on-road motor vehicles are estimated using vehicle miles traveled, trip starts and ends, speed, and other activity data developed by State Agencies and Metropolitan Planning Organizations (MPOs) using transportation demand models (TDMs), and emission factors from EPA's MOBILE6 model. To support this modeling in the upper Midwest, ENVIRON, working with LADCO, State DOTs, and local MPOs, has developed a software tool (the TDM Transformation Tool, or "T3") that takes TDM output from approximately twenty transportation networks using a variety of models, applies appropriate data transformations, and outputs link- and county-level activity data in a uniform format for input to the CONCEPT emissions processing model (a new emissions processing model also developed with funding from LADCO). In a parallel effort, analyses of extensive automatic traffic recorder (ATR) data collected by State DOTs were conducted to develop temporal profiles (hour of day, day of week, and month of year) of vehicle counts and vehicle mix by roadway type for developing the detailed on-road emission inventories.

This paper describes the T3 software, which was developed using open source and freely available programming languages (the PostgreSQL database management system and perl). T3 works with many spatial and temporal layers of vehicle miles traveled (VMT), speed, and Traffic Analysis Zone (TAZ) starts/stops, and provides emissions modelers with a wide range of options for converting and using TDM data. Example link-level emission inventories generated using T3 and CONCEPT will be shown.

INTRODUCTION

Current models that are available for producing high resolution emissions inventories for use in air quality modeling have marked disadvantages. These disadvantages include the requirement of expensive third party software, such as SAS[1] for the Emissions Modeling System (EMS)[2], or the lack of transparency in processing with easy to use intermediate quality assurance output, such as the Sparse Matrix Operator Kernel Emissions (SMOKE)[3] modeling system.

The Lake Michigan Air Director's Consortium (LADCO) recognized a need for a new emissions processing system that is open source, transparent, and has intermediate quality control capability at each step of the emissions calculations. LADCO contracted with Alpine Geophysics, LLC and ENVIRON Corporation, with Midwest RPO and joint RPO funding, to design and implement the initial version of the CONsolidated Community Emissions Processing Tool (CONCEPT)[4]. Other papers at this conference focus on the implementation details of the CONCEPT model. CONCEPT provides emissions modelers with flexible and transparent modules for generating temporalized, gridded, and speciated emissions estimates for area, point, biogenic, on-road motor vehicle, and off-road motor vehicle sources. One of the main areas where prior-generation emissions models have lacked focus, detail, and specificity is in the generation of high-resolution on-road motor vehicle emission inventories. This is the area of focus of the T3 tool, and this paper.

T3 is short for the TDM (Traffic Demand Model) Transformation Tool. T3 provides a conduit from the projections of traffic demand modelers regarding vehicle types, road networks, and vehicle activity to the activity data required by emissions modelers. The primary goals of T3 are to provide an easy mechanism for incorporating TDM model outputs in as "raw" a format as possible, while simultaneously providing a great degree of flexibility in representing the TDM projections in terms acceptable to most air quality models. These goals have been achieved through the use of a dimensional transformation approach, where the dimensions of the various transformations are user-defined – hence the name of the tool.

To maximize the availability (and thus utility) of T3, it has been written in PostgreSQL and perl, which are both open source and freely available. The programming approach follows the community model embodied in the CONCEPT model, allowing emissions modelers to download, use, modify, and contribute new functionality to T3 freely. T3 will operate on Windows, Linux, and other unix platforms and is written in a modular fashion to encourage community contributions to the source base. The T3 source will be released under a GPL (GNU Public License) style license, and maintained on a publicly accessible web site to facilitate public access, discussion, and enhancement.

The focus of this paper is the generation of inputs for the CONCEPT model; however the input requirements of many other emissions models are similar and should be equally served by T3.

TECHNICAL APPROACH

For the T3 project, data from twenty regional and statewide networks in the uppermidwest were analyzed. For most of these networks on-road motor vehicle activity is being modeled by the respective State Agency, or Regional or Metropolitan Planning Organization (MPO) using one of several different TDMs; in a few cases the vehicle activity was estimated using network volumes from actual observed traffic flows. ENVIRON collected the outputs from the various TDMs in the most easily accessible output formats generated by those models.

There are three principal blocks of data that are typically available from transportation modeling:

1. Link characteristics,
2. Link traffic volumes, and
3. Vehicle trips by traffic analysis zone (TAZ).

Link-level characteristics include descriptive statistics about each roadway link in a network. These characteristics include variables such as: number of lanes, posted speed limit, direction, link capacity, width, length, and coordinates of the two end points of the link. The traffic volume data are generally given for specific time periods and for a specific type of day (average day in the year, average weekday, average weekend day). Many networks do not estimate trip data; those that do generally describe vehicle trips in terms of trips to and from each Traffic Analysis Zone (TAZ).

T3 is reads the output from the different formats of data provided by the transportation modeling organizations, applies the various transformations permitted by the tool to convert the TDM data to emissions-modeling terms, and outputs the data in a format defined in the RPO Data Exchange Protocol

(DEP). The RPO DEP format is suitable for input to a number of emissions modeling systems, including the CONCEPT model.

T3 (and CONCEPT) represent a new approach to emissions data processing and inventory development – the combination of open-source technologies with database management systems to provide transparent, easily accessible, and community-owned models as opposed to proprietary-technology, closed systems that are difficult or impossible to analyze or enhance. All of the T3 computations and transformations are transparently available as tables in the PostgreSQL database management system, open to any user familiar with the Structured Query Language (SQL).

For additional detail on the T3 program design, see "Support Development of Motor Vehicle Emissions Inventories Task 1a: Tool Development for Processing Motor Vehicle Activity Data Draft Design Document," Haasbeek et. al., and other documentation on T3 available on the CONCEPT model web site at http://www.conceptmodel.org.

Required Inputs

To generate a complete set of inputs to CONCEPT, the T3 tool requires a certain amount of information from the TDM model outputs. Where required data was not provided, appropriate defaults were substituted for the missing data. Since the goal of the T3 tool is to provide a conduit for TDM data to emissions models like CONCEPT, we chose to pass data through T3 where appropriate conversions were not available rather than imposing overly strict input requirements.

<u>Link Data</u>

On-road vehicle emissions are dependent on a number of factors, including vehicle class, average speed, roadway class, ambient temperature, and humidity. Gridded temperature and humidity are available to CONCEPT from the meteorological data within the model inputs. The TDM vehicle classification information is passed from T3 to CONCEPT with a cross-reference from the TDM classes to the CONCEPT classes, and CONCEPT conducts the necessary disaggregation from TDM vehicle classes to CONCEPT vehicle classes. The average speed and roadway classification must come from T3. Average speeds by link may be provided as actual TDM projected speeds, post-processed hourly speeds, or instructions for estimating hourly speeds from hourly volume/capacity ratios. Finally, the location of each link must be known in order to place the emissions from that link within the CONCEPT modeling domain.

The minimum required link characteristic data required are:

1) endpoint coordinates and the coordinate projection definition,
2) average speed or speed adjustment instructions,
3) volume and vehicle miles traveled, and
4) facility class (including area type).

There were two networks that were generated from observed volume counts and did not have link speeds (Minnesota statewide and Illinois statewide). For these two networks, an average speed was tabulated by taking a weighted average of national average heavy- and light-duty speeds by facility class. The light-duty and heavy-duty vehicle speeds were weighted by factors calculated from the MOBILE6 VMT mix for 2002.

Trips Data

Vehicle trips data is used by CONCEPT to calculate start, hot-soak, and diurnal evaporative emissions. Trips data were available for fourteen of twenty networks. In cases where trips data were not available, the default number of trips per vehicle generated by MOBILE6 (represented by the gram/mile start emission factors) was used to estimate emissions from these modes.

For the non-running emissions, the number of vehicle origin trips is reported by Traffic Analysis Zone (TAZ). The vehicle origin trips are treated as vehicle starts, and the start emissions are calculated inside CONCEPT by multiplying the grams of emissions per start by the start count in each area.

Available Network Data

The percent of links captured in the modeled networks is typically greater for larger roadways than for smaller, local roads. In an effort to capture the VMT from the smaller roadways, T3 allows for the input of an "HPMS Adjustment." This is a factor applied to the network volumes to bring the total VMT into agreement with VMT data from the federal Highway Performance Monitoring System (HPMS). The factor can vary by county, roadway type, or specific link ID.

Most of the network data were supplied for the year 2002. In a few cases, we received network data for prior years. For these cases, T3 allows for input of a growth factor to bring the total volumes up to 2002 values. T3 allows the growth factors to vary by county, roadway type, or specific link ID.

For the trips data, some networks provided both origin and destination trips, others provided only origin trips, and still others provided only the total of all origin and destination trips. In cases where only the total trips are provided, T3 outputs half of the trip count by county to CONCEPT for the start emissions calculations.

The transportation modeling organizations provided data in dBase files, Microsoft Excel spreadsheets (either in Comma Separated Value (CSV) format or we converted them to CSV format), ASCII text files (either delimited or fixed-width columns), Tranplan formatted output reports, and EMME2 bank files. For the EMME2 bank files, we purchased M2Assistant Version 3.0[6] software to be able to read and extract the data into ASCII format that could be read by T3. The other file formats are read natively by T3. Table 1 provides a description of the various characteristics of each network.

Table 1. Attribute of network data processed by T3.

State	Network	**TDM**	**# Links**	**HPMS Adjustment**	**Growth Applied**	**Trips**
Illinois	CATS Chicago Area	EMME2	32,341	No	No	Yes, both origins and destinations
Illinois	ILDOT Statewide	Generated from Observed	303,297	No	No	No
Indiana	MPO Indianapolis	TransCAD	7,599	No	2% / year	No
Indiana	NIRPC Northwest Indiana	EMME2	9,023	Yes, by area and facility class	No	Yes, start trips
Indiana	INDOT Statewide	TransCAD	31,181	No	2% / year	No
Michigan	SEMCOG Detroit Area	TransCAD	15,021	Yes, by link	No	No
Michigan	MIDOT Statewide	TransCAD	9,227	No	No	Yes, total trips / 2

State	Network	TDM	# Links	HPMS Adjustment	Growth Applied	Trips
Minnesota	MMC Minneapolis St. Paul Area	TP+	20,898	No	Yes, by county	Yes, origin trips only
Minnesota	MNDOT Statewide	Generated from Observed	4,402	No	No	No
Ohio	9 Locals Nine Urban Areas	CUBE-TRANPLAN	3,723 to 25,424	No	No	Yes, origin trips only
Ohio	OH DOT Statewide	TransCAD	50,644	No	No	Yes, total trips / 2
Wisconsin	SEWRPE Milwaukee Area	TRANPLAN	17,054	No	No	No

The level of detail in the network data varied a great deal from one network to another. For example, the Chicago area network data were provided for seven different daily time periods for six vehicle classes, whereas other network data were only for total daily volume for all vehicle classes combined. Some networks had for each link a free flow speed, congested speed, and posted speed limit. Others had no speeds at all by link. Similarly, some networks had origin and destination vehicle trips by time period and vehicle class, and others had no trip data at all. T3 provides flexibility in defining the input time periods and generates the correct RPO DEP files for each of the networks.

Cross-References

In order to manage the many different input formats and levels of detail possible in the transportation data, T3 uses a standard set of cross-reference files that indicate the level of detail in the data and provide a mapping from the TDM variable definitions into CONCEPT definitions. The standard set of cross-reference files created for T3 are entered in Table 2.:

Table 2. Standard T3 cross-reference file.

TDM Definitions	CONCEPT Definitions
TDM facility classification	HPMS facility classification
TDM area type code	Urban/Rural designation
County	FIPS code
TAZ number	County containing that TAZ

Input to T3 is defined using facility classifications from the TDM. T3 transforms these to HPMS roadway classifications (slightly modified) using a conversion matrix that the user can define by county, urban/rural designation, and (optionally) link ID. The matrix is not binary – meaning that an incoming TDM facility classification can be split into multiple HPMS roadway types. The HPMS roadway classifications and the corresponding MOBILE6 roadway classifications used in CONCEPT are defined as shown in Table 3. HPMS where 03 and 13 are not official HPMS roadway classes, but were added to T3 in order to allow CONCEPT to model ramps separately.

Table 3. T3 roadway classification and MOBILE6 designation.

HPMS Code	Classification Description	MOBILE6 Facility
Rural		
01	Principal Arterial – Interstate	Freeway
02	Principal Arterial – Other	Arterial
03	Ramp	Ramp
06	Minor Arterial	Arterial
07	Major Collector	Arterial
08	Minor Collector	Arterial
09	Local System	Local
Urban		
11	Principal Arterial – Interstate	Freeway
12	Principal Arterial - Other Freeways or Expressways	Freeway
13	Ramp	Ramp
14	Principal Arterial – Other	Arterial
16	Minor Arterial	Arterial
17	Collector	Arterial
19	Local System	Local

Table 4 is an example of the first few lines of the facility cross-reference for Chicago area network. In this case, the variable "@atype" is the TDM variable name for area type, and "V/D Function" is the TDM variable name for the volume delay function. The volume delay function indicates the facility class.

Table 4. Example lines of the facility cross-reference for Chicago area network.

@atype	Area Type Description	V/D Function	Facility Class	HPMS
Urban				
1	CBD	1	Arterial	14
1	CBD	2	Freeway	12
1	CBD	3	Ramp Freeway/Arterial	13
1	CBD	4	Expressway	12
1	CBD	5	Ramp Freeway/Freeway	12
1	CBD	8	Metered Ramp	13
10	Rural	1	Arterial	02
10	Rural	2	Freeway	01
10	Rural	3	Ramp Freeway/Arterial	03
10	Rural	5	Ramp Freeway/Freeway	01
10	Rural	7	Toll Collection link	03

Most of the volume data from the networks consists of total volume over all vehicle classes. In some cases, however, the volume data are provided separately for more than one vehicle class grouping. The incoming TDM vehicle classifications are maintained in the T3 output; however, the during T3 project we developed a cross-reference matrix for input to CONCEPT indicating which of the eight MOBILE5 vehicle classes correspond to the TDM vehicle class group, as shown in Table 5 (MOBILE6 has 2% vehicle classes, but TS and CONCEPT have been designed and work into the eight M5 classes). CONCEPT uses this information to split the volume data into the MOBILE5 vehicle classes using detailed vehicle mix profiles.

Table 5. Cross-reference table of vehicle classes in each network vehicle group.

Network	Vehicle Group	State	LDGV	LDGT1	LDGT2	LDDV	LDDT	MC	HDGV	HDDV
CATS	ima	Illinois	X			X		X		
CATS	nima	Illinois	X			X		X		
CATS	imb	Illinois		X	X		X			
CATS	nimb	Illinois		X	X		X			
CATS	lght	Illinois							X	X
CATS	med	Illinois							X	X
CATS	hevy	Illinois							X	X
CATS	bus	Illinois							X	X
ILDOT	ALL	Illinois		X	X	X	X	X	X	X
INDY	ALL	Indiana		X	X	X	X	X	X	X
NIRPC	autos	Indiana	X			X		X		
NIRPC	ltrucks	Indiana		X	X		X			
NIRPC	htrucks	Indiana							X	X
NIRPC	transit	Indiana							X	X
INDOT	ALL	Indiana	X	X	X	X	X	X	X	X
SEMCOG		Michigan								
MDOT	ALL	Michigan	X	X	X	X	X	X	X	X
MMC	ALL	Minnesota	X	X	X	X	X	X	X	X
MNDOT	LD	Minnesota	X	X	X	X	X	X		
MNDOT	HC	Minnesota							X	X
AKRON	ALL	Ohio	X	X	X	X	X	X	X	X
CANTON	ALL	Ohio	X	X	X	X	X	X	X	X
CINDAY	ALL	Ohio	X	X	X	X	X	X	X	X
CLVLAND	ALL	Ohio	X	X	X	X	X	X	X	X
COLUMBUS	ALL	Ohio	X	X	X	X	X	X	X	X
NEWARK	ALL	Ohio	X	X	X	X	X	X	X	X
SPRFLD	ALL	Ohio	X	X	X	X	X	X	X	X
TOLEDO	ALL	Ohio	X	X	X	X	X	X	X	X
YNGTWN	ALL	Ohio	X	X	X	X	X	X	X	X
SEWRPC	ALL	Wisconsin	X	X	X	X	X	X	X	X

The TDM county is sometimes provided as the actual character name of the county, other times it is provided as a character or numeric code. The standard RPO format for CONCEPT requires the county identification to be provided as the FIPS code. For each network, a cross-reference between county name or code and FIPS is provided, along with a flag indicating whether or not to include the county in the model. The flag is used in this application to avoid double counting regions where TDM networks overlap or where the network coverage of that county is incomplete. Following is an example of the county FIPS cross-reference file for the Columbus, Ohio Network:

```
Network COUNTY     FIPs  FullName    Include
COL     DEL        39041 Deleware    0
COL     FAI        39045 Fairfield   1
COL     FRA        39049 Franklin    0
COL     LIC        39089 Licking     1
COL     MAD        39097 Madison     1
COL     PIC        39129 Pickaway    1
COL     UNI        39159 Union       1
```

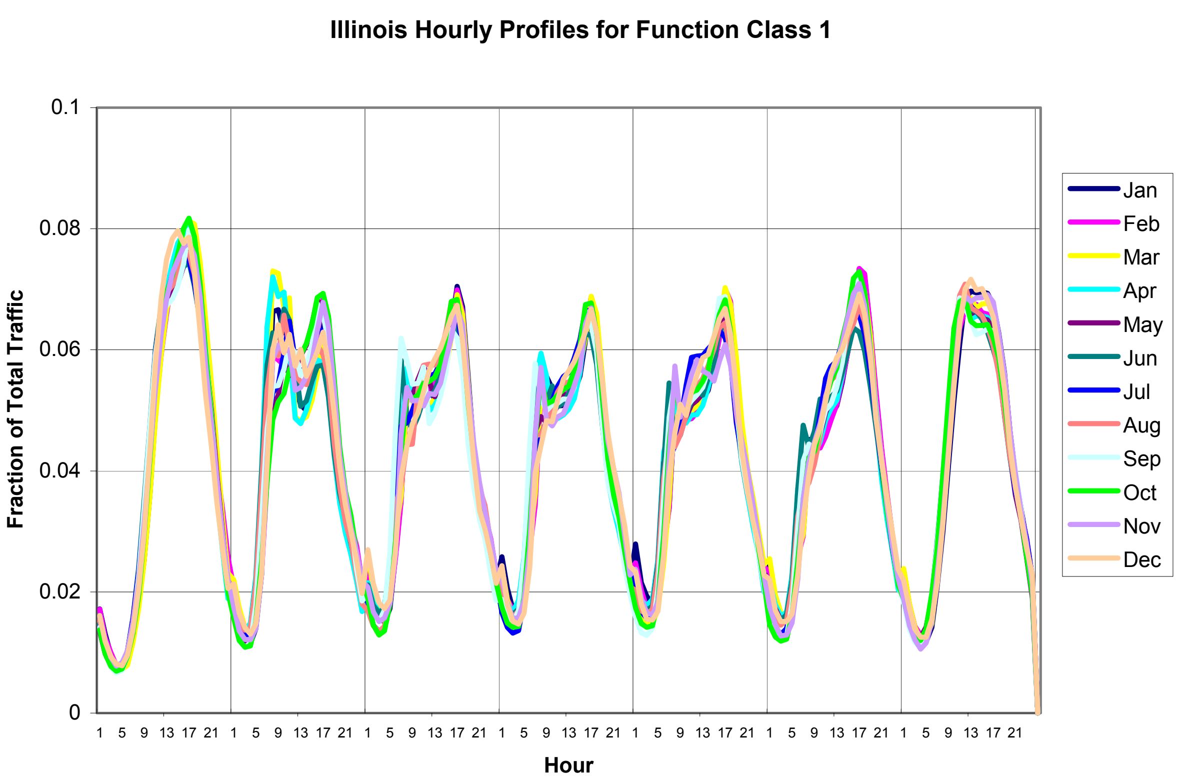
For each network there is also a cross-reference between TAZ number and county FIPS code. T3 outputs the number of trips by FIPS code so that CONCEPT can spatially allocate the trips by county. Ideally the trips would be spatially allocated by TAZ (which are geographically smaller than the county), but at this time the spatial surrogates used by CONCEPT are constructed only down to the county level.

Temporal and Vehicle Mix Profiles

As part of a separate work effort for LADCO and MPCA, ENVIRON calculated temporal profiles for total volumes and vehicle mixes for Illinois, Michigan, Minnesota, and Wisconsin[7]. The temporal profiles were generated from 2002 data collected with automated traffic recorders (ATRs). These temporal profiles are stored in RPO format and read directly into CONCEPT during emissions processing.

The volume profiles are the hourly fraction of the total vehicle volume by HPMS facility class, month, and day of week. There are 12 HPMS facility classes (not including ramps) X 12 months X 7 days of the week, for a total of 1008 hourly profiles. The twenty-four hourly fractions sum to 1, where each fraction corresponds to the fraction of the total volume occurring during that hour. Because these profiles are by HPMS facility class, T3 outputs the link data by HPMS facility class. Figure 1 is an example of the hourly volume profiles for Illinois, HPMS facility class 1 (Interstates). The hour on the x-axis begins at midnight Sunday and extends through midnight on Saturday.

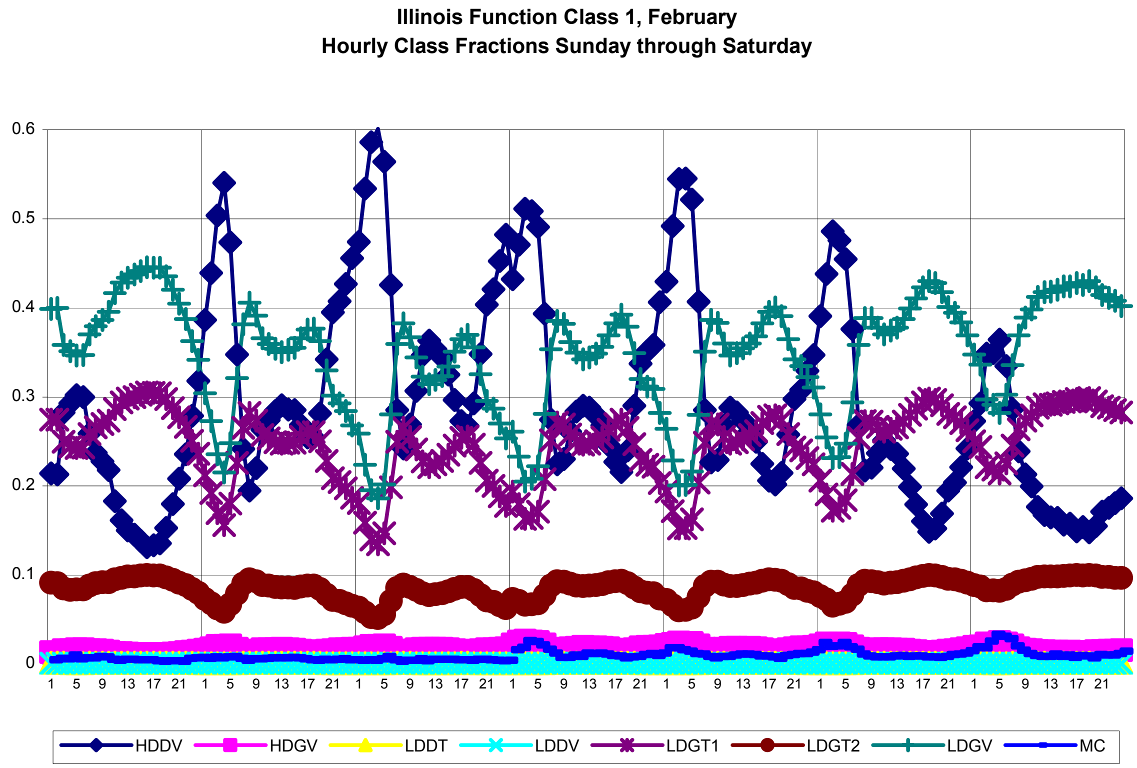
Figure 1. Example daily (Sunday through Saturday) temporal profiles for total vehicle count for a seven-day week, for Illinois Interstates.



Given the HPMS facility class of each link, CONCEPT is able to disaggregate the volumes to an hourly basis. Where the TDM volume is average daily total (ADT), CONCEPT disaggregates directly using the temporal profiles. Where the TDM volumes are those from a smaller time period of the day, CONCEPT disaggregates the periods into hourly values by calculating the relative hourly fractions for that period.

The vehicle mix profiles were generated by HPMS facility class, month, day of week, and hour of day. An example vehicle mix temporal profile is provided in Figure 2. Given the month, facility class, day of week, and hour, the vehicle mix profiles give CONCEPT the fraction of the volume that is made up of each of the eight MOBILE5 classes.

Figure 2. Example vehicle mix temporal profile, for Illinois Interstates.



T3 passes on to CONCEPT the TDM vehicle class groupings. Using the TDM vehicle class cross-reference Table 5 provided by T3, CONCEPT disaggregates the TDM class groups into MOBILE5 classes by calculating the relative fraction of the MOBILE5 class within all MOBILE5 classes contained within the TDM vehicle class group. CONCEPT does this after spatially allocating the activity data to an hourly increment.

Speed Adjustments

The free flow speed is a required variable for T3, but the free flow speed is not representative of link speeds during an entire 24-hour period. Since CONCEPT calculates hourly emissions, hourly adjusted speeds are required by CONCEPT for input to MOBILE6. In some cases, an adjusted speed is provided with the TDM network data, but the TDM period is not hourly. In most cases, however, the TDM does not provide speeds – they are either not calculated or are generated by post-processing models using a variety of queuing algorithms or volume-delay functions. In order to estimate hourly speeds, the methods employed by the transportation modelers are matched as closely as possible in T3 and applied to the hourly link volumes (calculated by CONCEPT applying the temporal profiles). T3 does not calculate the speed adjustment, but rather passes to CONCEPT the required information on how CONCEPT is to adjust the free flow speeds using volume-delay functions. Note that the speed adjustment methods employed by T3/CONCEPT are best approximations to those applied by the TDMs; while the results will be close to those produced by the TDM, they may not match exactly.

If a TDM modeler has adjusted hourly speeds generated by a custom post-processing algorithm, the speeds can be passed directly to CONCEPT using the RPO DEP formatted input files. In cases where hourly post-processed speeds are not available, T3 can be used to generate a variety of inputs to CONCEPT for calculating adjusted speeds. The most common method for adjusting speeds in a TDM is to use a volume-delay function, and the most common of these is a BPR (Bureau of Public Roads) curve. The general form of the BPR curve is:

$$S_a = \frac{S_{ff}}{1 + \left[A * \left(V/C \right)^B \right]}$$

where:

S_a	=	actual link speed (mph)
S_{ff}	=	reported link free flow speed (mph)
V	=	total link volume (vehicles OR vehicles per hour)
C	=	total link capacity (vehicles OR vehicles per hour)
A, B	=	curve calibration coefficients

Note that in order to adjust the link speeds, the link capacity is another required variable in addition to those listed in the “Link Data” section of this paper.

In real-world applications, the BPR speed adjustment typically has the following constraints or additional rules:

- If the TDM provides a calculated congested speed, the lower bound of the computed actual link speed is set to the TDM congested speed.
- The volume-capacity ratio is often capped at some value (may be 1.0 or higher). Where the TDM reports a volume-capacity ratio higher than the cap value, the speed adjustment is calculated using the cap value rather than the reported value.
- The values of the curve calibration coefficients vary by free flow speed, functional class, and area type (urban/rural). Indeed, the coefficients may vary by other parameters (e.g., vehicle class); however, T3 currently allows variability by free flow speed, functional class, and area type only.
- If lookup tables are provided listing the speed adjustment factor by volume-capacity ratio, these tables may be specified by functional class and area type as well.

T3 is designed to retain this level of flexibility as the TDM data are processed through T3 and output to the CONCEPT model.

In order to accommodate networks where the speed adjustment is other than a standard BPR curve, T3 can also pass to CONCEPT a lookup table of speed adjustments. For any speed adjustment equation, it is possible to generate a lookup table facility class, speed, and volume to capacity ratio. For example, the speed adjustments for the CATS network are based on the following two equations:

- For freeways and expressways:

$$S_2 = \frac{S_1}{(1 + 0.15 * \left(V/C\right) * (1 + 0.15 * \left(V/C\right)^8)}$$

where:

S_2 = congested speed (mph)

S_1 = free flow speed (mph)

V = total link volume

C = total link capacity

- For arterials:

$$S_2 = \frac{S_1}{(\ln(S_1) * 0.249 + 0.153 * \left(V/(C * 0.75)\right)^{3.98})}$$

where:

S_2 = congested speed (mph)

S_1 = free flow speed (mph)

V = total link volume

C = total link capacity

In this case, a lookup table was generated for T3, which formatted the information for CONCEPT.

The link data that T3 passes on to CONCEPT includes a unique speed adjustment curve ID. T3 writes out a new RPO DEP format file (MobileMC) for use in CONCEPT with the additional information for each speed adjustment curve:

1. The curve type ("BPR" or "TABLE"), and volume-capacity ratio cap value, and
2. The BPR coefficients defining the A and B values by speed bucket for "BPR" type curves or
3. A lookup table defining the speed adjustment factor values for each curve ID, speed bucket, and volume/capacity ratio bucket.

With the adjusted speed, hourly VMT (hourly volume * link length), MOBILE6 facility class, MOBILE5 vehicle class, temperature and humidity, CONCEPT has all the required information to determine the correct MOBILE6 emission factors for calculating running loss emissions.

Start Emissions

The TDM trip data required by CONCEPT is the number of vehicle origin trips by TAZ. TAZ's are smaller geographic regions that are contained within county boundaries. Currently the trips are totaled by county and then spatially allocated by CONCEPT at the county level. This is done because the resolution of the spatial surrogates used by CONCEPT are currently limited to the county level. Future improvements to the start emissions calculations will include adding the capability of generating spatial surrogates at the TAZ level and passing the trip count information to CONCEPT at the TAZ level.

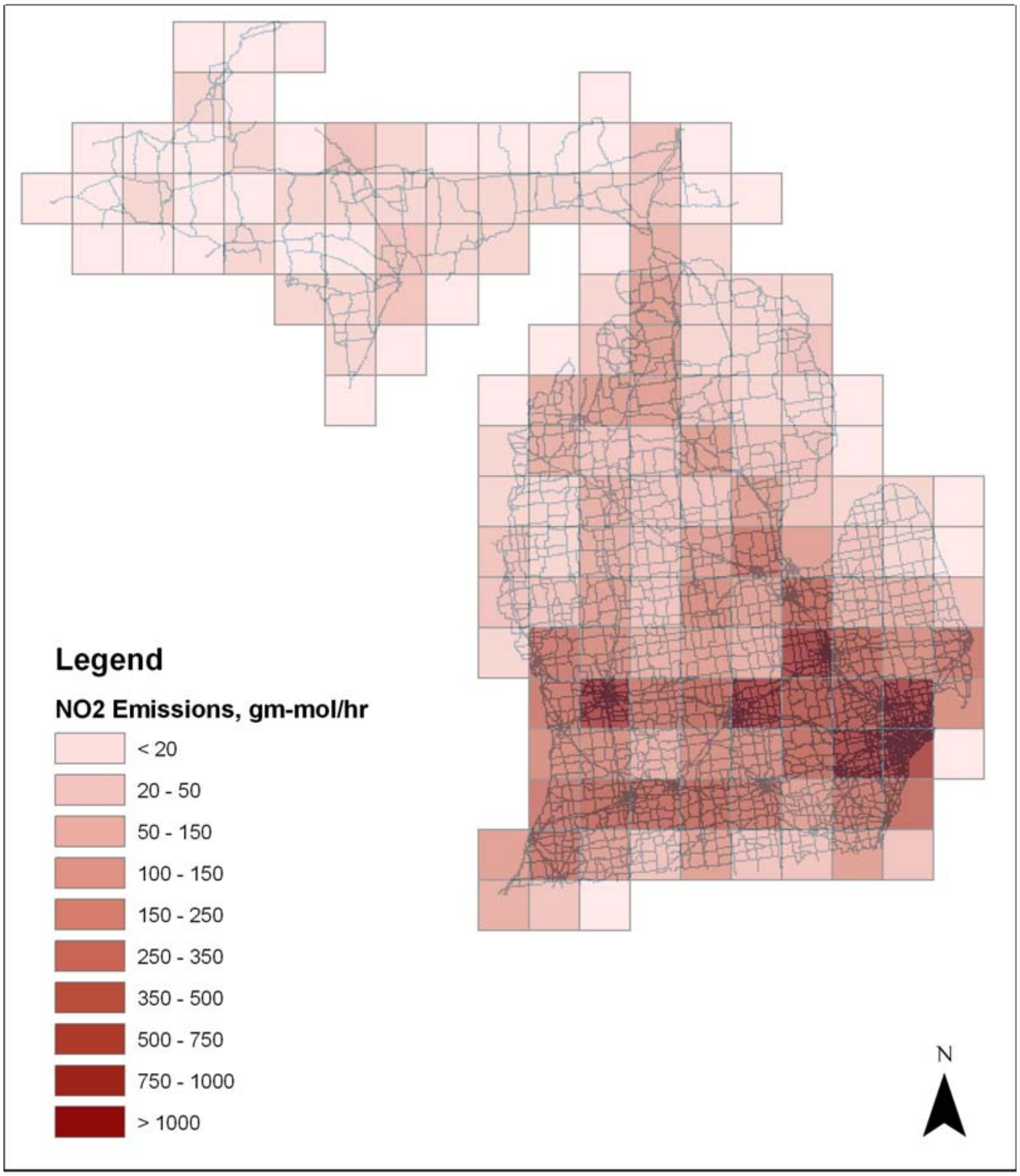
If trip data are available, the start emissions are calculated as the product of the trip start count and the MOBILE6 start emissions factor. MOBILE6 outputs starting emissions as a grams per mile factor and a grams per hour factor. The grams per hour factor is divided by the default number of vehicle starts per hour (also contained in the MOBILE6 output) to generate a grams per start emission factor.

If no trip data are available, CONCEPT calculates the start emissions using the starts gram/mile MOBILE6 emission factor applied to the link VMT. This implies the use of the default number of starts per vehicle used by the MOBILE6 model to estimate start emissions based on the vehicle volume.

EXAMPLE

Figure 3 shows the link-based running exhaust emissions of NO_2 for the Michigan Statewide road network for a morning rush hour on July 6, 2002. The emissions have been gridded in CONCEPT to the 36km grid resolution being used for regional haze modeling. The inputs to the CONCEPT model for these emissions estimate were generated using the T3 tool. Inputs to T3 included daily average link-based volumes, capacities, and free-flow speeds, as well as TAZ-based trip counts. These data were transformed by T3 for input to CONCEPT, which then generated the emissions estimates. The plot shown is a small subset of the total emissions data generated by CONCEPT. More detail on the CONCEPT emissions algorithms is presented in other papers.

Figure 3. Michigan Statewide roadway network and gridded (36km) NO_2 exhaust emissions for July 6, 2002, 8am-9am.



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