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Application of MOVES to Static and Simulation Travel Demand Models

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Background:

The Environmental Protection Agency (EPA) is currently developing MOVES (Motor Vehicle Emission Simulator) emissions analysis tool. The MOVES software will estimate emissions for on-road and non-road sources and generate emissions quantities for a number of pollutants at macro, meso and microscopic levels of detail. It is widely anticipated that MOVES will replace MOBILE6 and NONROAD for emissions estimation when the final version of the software is made available by EPA. The Federal Highway Administration (FHWA) has engaged AECOM to test the MOVES software during its development phase to gain hands-on experience with using MOVES and identify the level of effort required by transportation planning agencies to transition from MOBILE6 to MOVES. As the MOVES software generates emissions lookup rates at finer levels of detail as compared to MOBILE6, the emissions estimates may change as a result of replacing MOBILE6 with the MOVES software. This study applies MOBILE6 and MOVES emissions lookup rates to travel demand data and determine the differences in emissions estimate.

The MOVES software has the ability to accept vehicle operation data from traffic operations and simulation models and facilitates performing finer level emissions analysis based on detailed operating characteristics of different vehicle types at specific locations at specific times of day. Given this enhancement, it is essential to determine the applicability of the MOVES software with the simulation data. MOBILE6 and MOVES will be applied to the travel data from simulation models and the differences will be determined. While the total analysis will not be complete until the final version of the MOVES software is released by EPA and all the emissions rates are approved, the initial phase of the study focuses on identifying applicability of the MOVES software for estimating emissions using travel demand model data. The study is being performed using Portland, Oregon's static and simulation data. It is important to note that the objective of this study is not to replicate emissions estimates generated for air quality analyses in Portland, but to use the travel data generated for Portland using static and simulation models to test the MOVES software. The study uses general methods adopted by many planning agencies to generate emissions estimates by applying MOBILE6 or

MOVES emissions rate lookup tables to the speed and volume data generated by the travel demand forecasting models.

Agency Level of Effort:

The MOVES software is capable of generating emissions rate lookup tables for road types and speed bins within counties. The transportation modeler must then develop tools to apply the emissions rates to the travel demand data. In this respect, the application of MOVES is very similar to how MOBILE6 is typically applied for conformity analysis. The MOVES software uses several input tables the planning agencies would like to adjust to estimate emissions rate specific to their modeling region. For example a transportation planner may like to adjust the default values of vehicle age, VMT and speed distributions. The level of effort involved in changing the default values of the MOVES input tables and the impact it has on the emissions rates is an important concern to the planning agencies. This study determines the MOVES input tables that can or should be manipulated by the planning agencies to estimate emissions specific to their modeling region. This study also identifies options available to manipulate the MYSQL database used by the MOVES software to store data and the post processing required for converting the emissions rate lookup table into a format that can be readily applied with the travel demand model data.

Applying Emissions Rates for Static Assignment Data:

Emissions lookup rates were generated for Portland by running MOBILE6 several times to obtain VOC, CO and NOX emission rates for each combination of three study years (1996, 2007 and 2020), two seasons (Summer and Winter), two vehicle types (Auto and Truck), two fleet types (with and without 2001 OBD inspection programs) and four link facility types (with 14 speed bins for freeways and arterials and 1 average speed for local roads and freeway ramps). The speed bins for freeways and arterial are centered on 2.5 mph and each 5 mph increment between 5mph and 65 mph. The emission rates for local roads and freeway ramps were based on single average speeds (Local Roads – 12.9 mph, Ramps – 34.6 mph). An Emissions lookup table was created to store the emission rates generated by MOBILE6 for the above combinations. Given the roadway classifications, there were 30 sets of emission rates for 18 different combinations of years, season, vehicle type and fleet mix. The lookup table has 540 records with three sets of emission rates (VOC, CO and NOX) for each record. A similar emissions rate lookup table will be created using the MOVES software. The general level of effort and the complexity of the process will be discussed.

The EMME/2 software was used to assign Portland trip tables by three time periods (Daily, AM peak period and PM peak period). The loaded speeds were derived using the volume-delay functions included in the EMME/2 assignment process. The loaded speed was then used to select the emissions rate from MOBILE6. The emissions rates were then applied to individual links and then summed up over the entire network to compute the total emissions. The MOVES emissions rates will be applied to the EMME/2 travel data in a similar fashion. The emissions estimates generated by applying MOBILE6 and

MOVES emissions lookup rates to the Portland's static travel demand forecasting (EMME/2) model data will be compared.

Applying Emissions Rates for Simulation Assignment Data:

Planning agencies typically apply emissions rates to static travel demand data to generate emissions inventories. The traditional static travel demand models produce regional level transportation speed and volume data at link level and do not reflect accurately the impacts of traffic operations on the speed estimates. Many planning agencies are in the process of developing more sophisticated regional or subarea level simulation models that look to address time of day traffic variations and traffic operations more accurately.

With this in mind, the impact of using simulation data to estimate emissions as a replacement for the traditional static assignment data is determined. A Microsimulator was used to generate detailed speed and volume information for 30-meter link segments at 15-minute time intervals throughout the day for the Portland region. Second-by-second vehicle speeds are summarized using six speed bins (0 mph, 13.4 mph, 26.7 mph, 40.1 mph, 53.5 mph and 66.9 mph). The MOBILE6 emission rates were applied to the simulation data to generate emission inventories. The MOVES emissions lookup rates will be applied in a similar fashion to the simulation data. The differences in emissions estimates as a result of applying MOBILE6 and MOVES emissions lookup rates to simulation data instead of static travel demand model data will be studied.

Impact of Aggregation on Emissions Estimates:

The Microsimulator generates detailed speed and volume information for 30-meter link segments at 15-minute time intervals throughout the day. The detailed simulation results are aggregated at different levels and applied with the MOBILE6 and MOVES emissions rate lookup tables to generate emissions inventories. The aggregation methods used for this study vary by segment types, time periods and speed method as shown in the Table below:

TABLE: Methods of Aggregating Simulation Data

Level	Segment Type	Time Steps	Speed
1	30m Link Segment	15 mins.	6 speed Bins
2	30m Link Segment	15 mins.	Average
3	30m Link Segment	60 mins.	Average
4	Entire Link Length	60 mins.	Average
5	Facility Type	60 mins.	Average
6	Facility Type	3 periods	Average

In its raw format the discrete simulation data includes the count of number of vehicles in each of the six speed bins during each 15-minute time period for each 30-meter segment of roadway. The vehicles are counted once every second. The average speed, therefore, for a given aggregation level is based on the weighted average of the number of

observations in each speed bin. The average speed was calculated using the total distance traveled divided by the total time traveled during the aggregate time period. The emissions generated for each combination of attributes was summed up to calculate the total emissions for a given aggregation level. The difference in the total emissions between aggregation levels will be calculated by applying MOBILE6 and MOVES emission rates separately. Application of MOBILE6 rates to the simulation data has shown that the aggregation levels impact the emissions estimates by 4 percent to 10 percent. For this analysis, all of the aggregation totals are compared to the total emissions calculated using the most disaggregate data (30 meter segments, 15 minutes time steps, and 6 speed bins). The absolute and percent differences in emission estimates as a result of aggregating the simulation results will be tabulated. Also the differences in emission estimates as a result of applying MOVES emissions rate to aggregated simulation data instead of MOBILE6 rates will be discussed.

Conclusion:

Most planning agencies use traditional travel demand forecasting models to generate input data for the air quality analysis. Some agencies are migrating towards developing more sophisticated models that capture the impacts of traffic operations. The MOVES software has the potential to support finer level emissions analysis by allowing the modeler to control the driver behavior and the VMT distributions by time of day. As transitioning from MOBILE6 to MOVES can impact the air quality conformity requirements, a number of planning agencies are looking forward to understanding the implications of using MOVES instead of MOBILE6 as their air quality conformity analysis tool. This study determines the potential changes in MOVES and MOBILE6 emissions estimates and also determines the impacts of using detailed simulation models for air quality conformity analyses purposes instead of the traditional travel demand forecasting models.

At this time, the MOBILE6 emissions lookup rates have been applied to the static and simulation travel demand model data. The impacts of aggregating the simulation results to estimate emissions have also been studied using the MOBILE6 emissions rates. In general, the emissions estimates vary by 4 percent to 10 percent as a result of aggregating the simulation results. Also, the emissions estimated from simulation data is generally higher than the emissions estimated from the traditional model data. In the next couple of months a lot of progress will be made in estimating the emissions lookup rates from the MOVES software to help determine the differences between MOVES and MOBILE6 emissions analysis tools.