FHWA EVALUATION OF METHODS FOR MODELING VEHICLE ACTIVITY AT SIGNALIZED INTERSECTIONS FOR AIR QUALITY HOT-SPOT ANALYSES

U.S. Department of Transportation
Federal Highway Administration

Project Objective

The objective of this research was to conduct an evaluation that compares methods of representing vehicle activity at signalized intersections for use in air quality hot-spot analyses.

Modeling emissions is more complicated for signalized intersections than for free-flowing highway traffic, due to the flow of traffic being interrupted by traffic signals, which leads to four modes of vehicle activity: cruise, idling, acceleration, and deceleration.

- The CAL3QHC and CAL3QHC/R dispersion models have a queueing algorithm that uses idle links to account for the spatial distribution of at least one of the four modes of vehicle activity at signalized intersections.
- The MOVES emissions model provides advanced options for modeling vehicle activity that considers the modal nature of the underlying emission rates.

This evaluation was done using Next Generation Simulation (NGSIM) video recordings that captured 100% of vehicles passing through two intersections, paired with processing algorithms to produce real world vehicle traces for the inputs to the advanced MOVES options. These trajectory data were used to create a detailed baseline (Method 1) for comparing against other methods (Methods 2 through 9) that are more practical to implement for air quality hot-spot analyses.

Methods

- **Method 1** (Detailed Baseline) uses NGSIM trajectory data (second-by-second speeds) to produce detailed operating mode distribution inputs for MOVES for each (20-40 ft.) lane- by-lane link.
- **Method 2** (current CAL3QHC queuing algorithm) places queue links to represent the red signal phase on top of cruise links which represent the green signal phase at the approach to the intersection.
- **Method 3** uses the same inputs as Method 2, except that it removes idle from the MOVES default drive cycles for cruise links to address potential double counting of idle emissions.
- **Method 4** builds upon Method 2 by providing four types of overlapping links representing the distinct types of vehicle activity at signalized intersections. This model separates cruise links from acceleration links and deceleration links to allow for more precise calculations.
- **Method 5**, while initially considered, was determined to be redundant and was not modeled. Therefore, there is no further mention of Method 5 in this factsheet.
- **Method 6** follows EPA's PM Hot-Spot Guidance by using non-overlapping cruise, acceleration, and queue links.
- **Method 7** is the same as Method 6 with idle removed from MOVES default drive cycles for acceleration and cruise links.
- **Method 8** uses the same link network as Method 2, but it uses the results from the Highway Capacity Software (HCS7) to calculate queue length instead of the default queueing algorithm.
- **Method 9** uses the same link network as Method 6, but it uses an adjusted operating mode distribution to reallocate activity associated with vehicle speeds higher than 50 mph to corresponding bins associated with speeds between 25 – 50 mph.

Key Findings

Emissions

- Methods 2 – 9 overpredict total CO emissions and underpredict total PM10 emissions.
  - Underpredictions for PM10 emissions are strongly influenced by the amount of braking in all baseline links.
  - Queue link speeds in Methods 2, 3, 4, and 8 are set to 0 mph, which forces MOVES to not produce brakewear or tirewear emissions.
- Speed and acceleration values for the far-right lane were affected by vehicles turning in and out of adjacent parking garages, which led to increased emissions.

Concentrations

- Underpredicting total emissions does not necessarily mean that the models will underpredict maximum concentrations.

Recommendations

- The creation of a link network with non-overlapping queue, acceleration, and cruise links to represent all of the intersection activity is a critical first step.
- The speed on the link should be set to the average speed that represents all of the activity on the link.
- The link network design should consider surrounding intersections and features (e.g., parking garages) to capture all traffic.
- The use of traffic analysis models and Highway Capacity Manual equations should be considered for improved queue and acceleration link length estimation.

For more information, such as the final report, please contact:

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Study Domain

Figure 1: *Baseline network for Intersections 2 (left) and 3 (right).*

Modeling Results

- **Emissions**: Method 6 performed the best for CO and performed comparatively well for $PM_{2.5}$ and PM_{10}.
- **Concentrations**: Method 6 performed best in terms of predicting maximum concentrations for all pollutants at both intersections.

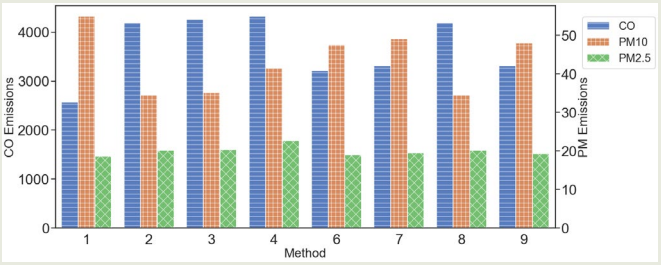

Figure 2: *Total emissions (grams) over the domain for Intersection 2.*

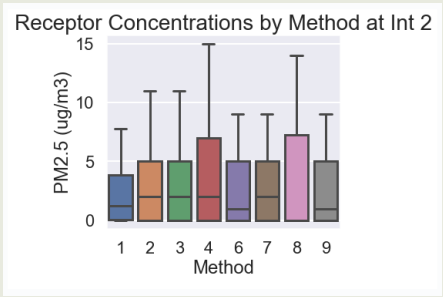

Figure 3: *Example box-and-whisker plot of receptor concentrations for $PM_{2.5}$ by method at Intersection 2.*