Toward Best Practices for Conducting a MOVES Project-Level Analysis

Robert Chamberlin, Ben Swanson, Eric Talbot, Subramanian Sharma ‡, and Peter Crouch‡

Resource Systems Group, Inc. White River Junction, VT, ‡New Hampshire Department of Transportation, Concord, NH

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INTRODUCTION

In 2012 EPA will require the use of MOVES for conducting a quantitative hot-spot analysis within PM# nonattainment and maintenance areas.

A Project-Level analysis requires interfacing a traffic model with MOVES, and MOVES with an air dispersion model such as AERMOD. The linking of different model types and the imminence of their use for compliance purposes creates a need to define Best Practices.

The motivation for this research is summarized as follows:

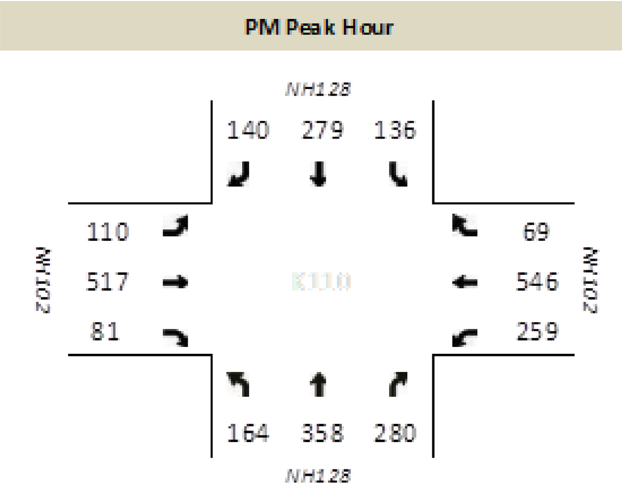
1. "Best Practices" for establishing emissions impacts of traffic operational improvements are needed.
2. The linking of 3 model types – traffic activity, emission, and air dispersion -- indicates a need for consistency in how links are defined through the modeling chain.
3. There is a need for developing practical methods for preparing a Project-Level analysis where a traffic microsimulation model feeds inputs to MOVES. A signal optimization project can be a case study for demonstrating these methods.

RESEARCH TEST BED: TRAFFIC SIGNAL OPTIMIZATION (NHDOT CMAQ PROJECT)

The subject test bed is the NH 102/NH 128 intersection in Londonderry, New Hampshire . This is a fully actuated signalized intersection of two state-maintained arterials. The traffic signal timings were optimized as part of a CMAQ-funded signal optimization project conducted for the New Hampshire Department of Transportation.

This intersection was selected for the test bed due to the significant reduction (30+/-%) in vehicle queuing observed in the field after signal optimization. Thus, the "Project Level" analysis conducted in this research encompasses a "No Build" (i.e. **baseline**, or non-optimized) and a "Build" (**optimized**) scenario.

VISSIM Model Superimposed on an Aerial Photograph of the NH102/NH128 Intersection



Turning Movement Volumes Used for the Analysis

TWO KEY QUESTIONS:

For a Project-Level analysis using MOVES, "Best Practices" should provide guidance on 2 key questions:

1. Anticipating the connection of MOVES emissions output to an air dispersion model such as AERMOD, how should links be defined through the microsimulation-MOVES-air dispersion modeling system?
2. MOVES accommodates 3 types of traffic activity data: average speed, link drive schedule, and operating mode distribution. Assuming microsimulation modeling is used to generate the vehicle activity data, what are the implications of each approach?

MODELING ASSUMPTIONS

Traffic microsimulation models generate a significant amount of detail on vehicle performance that is critical for determining air quality impacts . Details such as second-by-second speed/acceleration profiles, vehicle characteristics, and network characteristics can be directly linked with MOVES.

For this research a detailed microsimulation model of the subject intersection was created using the VISSIM microsimulation software. The baseline (non-optimized) and optimized signal timings as observed and implemented in the field are as follows:

Phase & Movement (seconds)

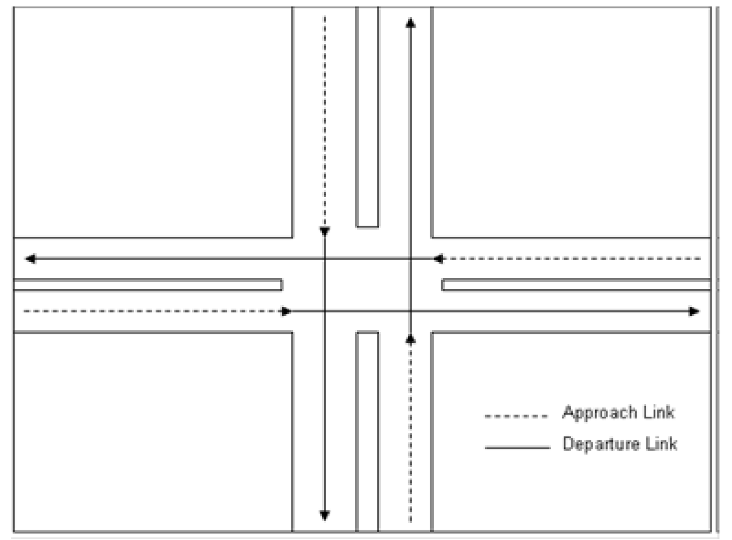
	Cycle Length	1 WBL	2 EBT	3 NBL	4 SBT	5 EBL	6 WBT	7 SBL	8 NBT
Baseline	159	31	61	31	36	31	61	31	36
Optimized	100	30	24	19	27	18	36	16	30

The following assumptions were used in the modeling test bed:

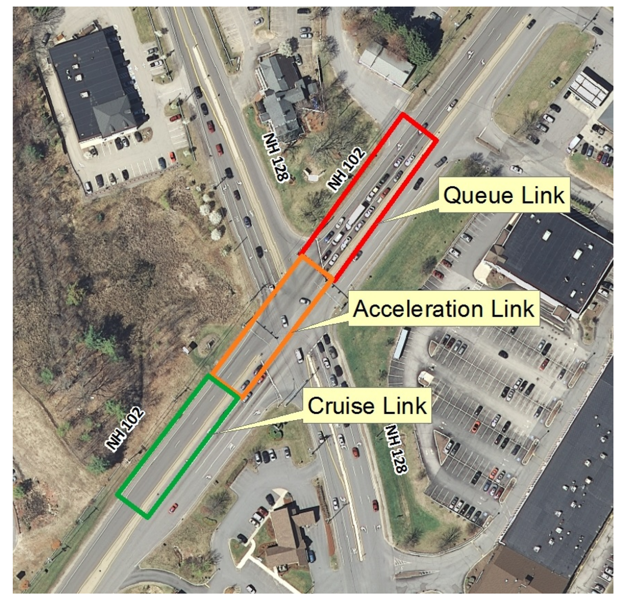
- Turning lanes were coded with storage lengths obtained from field measurements.
- Approach links were extended 1,200 feet to capture the maximum queuing observed in the baseline condition.
- All links are modeled with 0% gradient.
- All vehicles were coded as MOVES SourceType 21 (passenger car).
- Speed distributions were based on the 35 mph (NH128) and 40 mph (NH 128) posted speed limits.
- Reduced speed areas were applied within the intersection for left-turning (turning speeds ranging from 15-18 mph) and right-turning vehicles (speeds ranging from 9-12 mph).
- Intersection approach links were coded for Urban behavior and use the Wiedemann 74 car following model.
- 30 model runs for each of the two scenarios (baseline and optimized) were conducted, and the results averaged for analysis.

QUESTION 1: How Should Links Be Defined through the Modeling Chain?

Air dispersion models define links as a series of area or volume sources (AERMOD); or as a series of line sources (CAL3QHC). Links in dispersion models must be equated to the link geometries of the originating traffic model and to the links defined in MOVES. Three possible ways of defining links are shown below:



As a Geometric Space (Line, Area, or Volume) Incorporating the Approach or Departure of Each Leg of the Intersection
From EPA: Transportation Conformity Guidance for Quantitative Hot-Spot Analysis. Section 7.4



As a Geometric Space (Line, Area, or Volume) Incorporating Homogenous Traffic Activity (i.e. idling, cruising, etc.)

As a Geometric Space Incorporating Approach and Departure Traffic in Cells Based on Air Dispersion Concerns

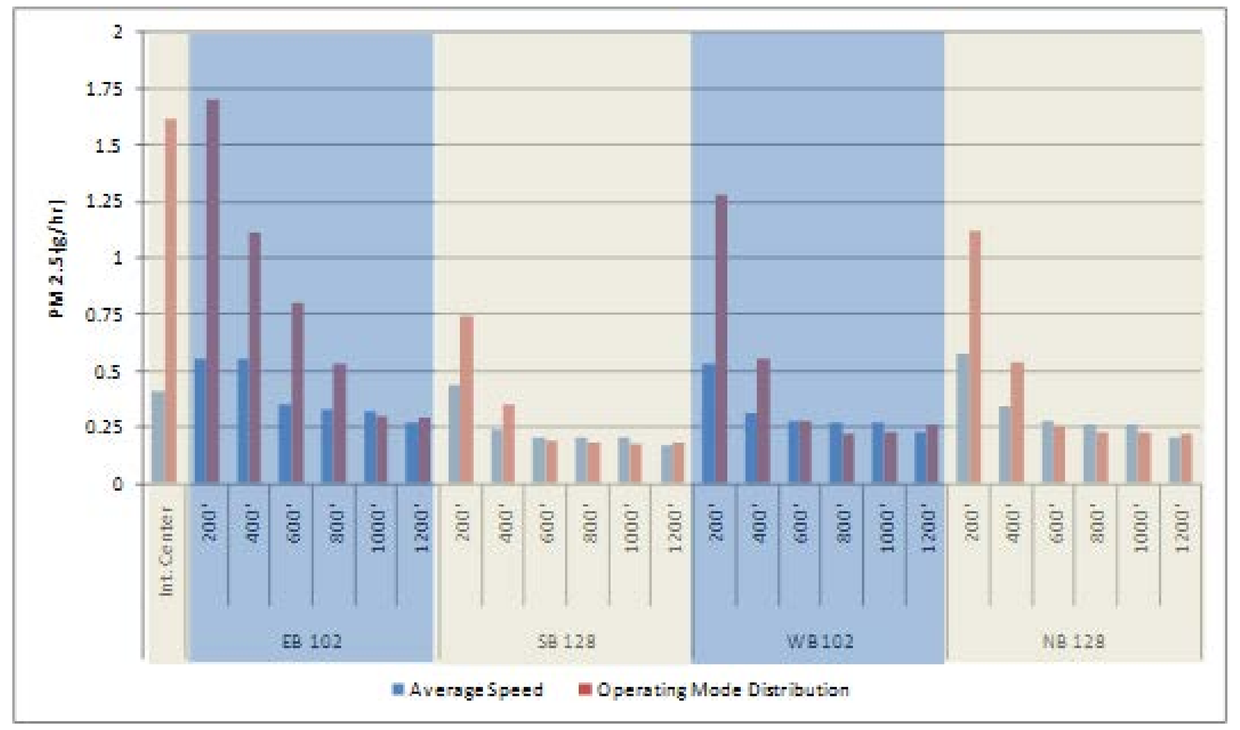
Most traffic microsimulation models geo-reference vehicle trajectory output so that each second of vehicle performance can be assigned to a "link" or "dispersion cell" defined by the analyst. This approach allows for a consistent definition of links through the modeling chain. This approach to defining links is used in this case study.

QUESTION 2: How Do Different Approaches to Traffic Activity Affect MOVES Emissions Estimates?

MOVES provides 3 ways of using vehicle activity data at the project level: average speed, link drive schedule, and operating mode distribution. For the average speed and link drive schedule approaches MOVES assumes a default **operating mode distribution.** The operating mode distribution is determined by the vehicle speed and Vehicle Specific Power (VSP).

To maintain the richness of vehicle operating behavior it is advantageous analytically to pre-process vehicle activity data obtained from a microsimulation model directly into an Operating Mode Distribution.

The chart below shows MOVES output for the Baseline (non-optimized) case, comparing emissions by link segment for the "Average Speed" and "Operating Mode Distribution" approaches to estimating emissions.



The Average Speed approach to characterizing traffic activity reduces operational variations that affect tailpipe emissions. For this case study, the average speed approach results in 25% lower emissions when compared to the estimates from the Operating Mode Distribution. Petrol Energy consumption is nearly identical for the average speed and operating mode distribution approaches, however.

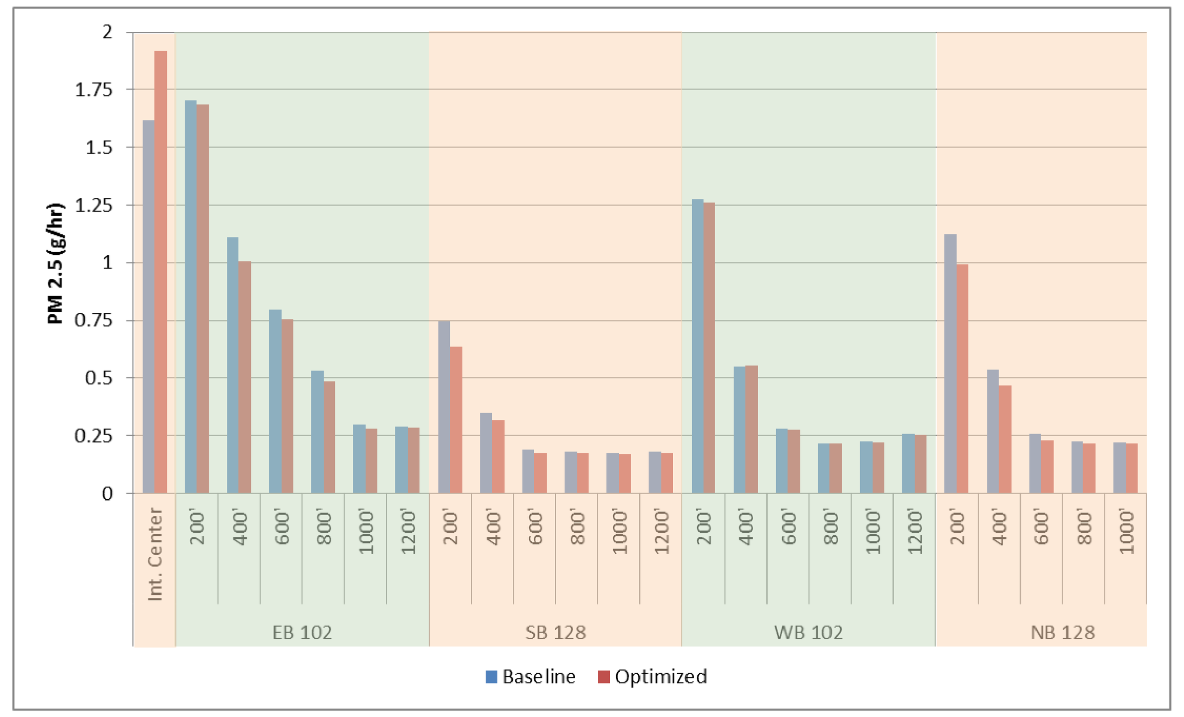
Total PM2.5 (grams/hr)

Estimation Approach	Baseline	Optimized	% Reduction
Average Speed	26	25	3.8%
Operating Mode Distribution	35	33	5.7%
Average Speed/OMD	74.3%	75.8%	

Petrol Energy (BTU/hr)

Estimation Approach	Baseline	Optimized	% Reduction
Average Speed	8,153,775,000	7,682,323,000	5.8%
Operating Mode Distribution	8,021,591,000	7,690,586,000	4.1%
Average Speed/OMD	101.6%	99.9%	

RESULTS OF THE ANALYSIS



The figure above gets to the crux of emissions generation related to traffic signal operations. The objective of signal optimization is to maintain vehicle speeds and reduce acceleration events. The traffic smoothing effects of optimized operations reduce emissions notably in the links most proximate to the intersection.

Why are there greater emissions in the Intersection Center after optimization? Under optimized conditions there are 36 cycles per hour compared to 22 in the baseline. As a result there are a greater number of vehicles accelerating within the Intersection Center under optimized timing. Under baseline, non-optimized timings, more acceleration events occur within the "links" adjacent to the Intersection Center.

This research has generated the following findings:

1. Air dispersion modeling considerations should determine how links are defined through the modeling chain.
2. Greater resolution in link geometry closer to the intersection center will capture the greater emissions generated at this location.
3. If microsimulation models are used to provide traffic activity input into MOVES, vehicle trajectory data should be pre-processed into Operating Mode Distributions for greater modeling resolution.
4. Signal optimization can lead to greater emissions within the intersection center, but this is offset by greater emission reductions along the approach links to the intersection.
5. Overall, the optimized scenario is estimated to reduce $PM_{2.5}$ emissions by 5.7% when compared to the baseline scenario. Estimated reduction in fuel consumption is 4.1%.