Draft Tool to Model Ramps in Project Scale

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MOVES Review Work Group
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Outline

• Objective
  – To share development of the MOVES Ramp Tool

• Background
  – MOVES ramp modeling in project mode

• Ramp Tool Development
  – Data collection using PAMS
  – Summary of tool development

• Potential MOVES Ramp Tool Usage
  – Use cases
Background

• We are removing ramps as a separate emission calculation from National and County Scales
  – See September 2016 Workgroup presentation

• Ramps still need to be accounted for as separate links in Project Scale analyses
  – Project Scale allows users to define vehicle activity on individual links
  – Differences between individual ramps, especially between on-ramps, off-ramps, and highway links can be important at Project Scale
Background

- Activity on ramps differs from highway activity
  - More acceleration or deceleration depending on ramp type
  - Previous work showed on-ramps have higher exhaust emission rates than highway driving; off-ramps have less

In Project Scale, users have the option of defining vehicle activity on a link using:

- Average speed on the link: *easiest but least precise*
- A second-by-second drive schedule: *next best*
- An operating mode distribution: *most precise, but data intensive*

When using average speed approach, MOVES treats ramps the same as all other highway links:

- User enters average speed for ramp
- MOVES calculates operating mode distribution for restricted road (highway) driving at that speed
- Emission rates based on the same average speed would be the same for highway links and ramp links, but vehicle activity on ramps differs from highways
• Using operating mode distributions that reflect real ramp activity would provide a more precise emissions estimate
  – We have ramp data collected as part of our Detroit ramp study
  – We have created a tool that provides operating mode distributions from this data, based on user inputs
• Objective of ramp tool: *Estimate operating mode distributions based on average speed on highway off- and on-ramps*
Data Used in the Draft Ramp Tool

- **PAMS - Portable Activity Monitoring System**
  - Devices that collect second-by-second speed and position information
  - No emission data measured with PAMS

- **Data collected on passenger cars driving in the Detroit, MI area during 2012**

- **EPA isolated 270 instances of ramp driving using GPS data**
  - Did not include interchange ramps where behavior would be more similar to highway driving
  - Mix of ramp type (on/off), ramp connection (free flow/stopped), ramp shape, and average speed

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Development of the Draft Ramp Tool

• Trips grouped into bins by ramp type and average speed
• Bin speed ranges adjusted for consistent emission trends relative to average speed for all pollutants
  – Each second of data assigned an operating mode for three source types
    • Passenger car, passenger truck, and light commercial truck
    • Operating mode calculated using:
      – Vehicle specific power
      – MOVES default characteristics for source types
      – No grade data available; assumed grade of 0
      – MOVES emission rate for each trip calculated based on op modes
• Stored the average operating mode distribution for each ramp type, source type and speed bin
On-Ramp Speed Bins and Emission Rates

- Each point represents the average speed and emission rate for one trip.
- Colors show grouped speed bins as discussed earlier.
- Blue points (with trend line) are average speed and emission rate for each speed bin.
On-Ramp Speed Bins and Emission Rates

On-Ramp HC g/hr Emissions vs Average Speed

On-Ramp NOx g/hr Emissions vs Average Speed

On-Ramp CO g/hr Emissions vs Average Speed

On-Ramp CO2 g/hr Emissions vs Average Speed
Off-Ramp Speed Bins and Emission Rates

Off-Ramp PM 2.5 g/hr Emissions vs Average Speed

Off-Ramp PM 10 g/hr Emissions vs Average Speed

Off-Ramp Brake Wear g/hr Emissions vs Average Speed
Off-Ramp Speed Bins and Emission Rates

Off-Ramp HC g/hr Emissions vs Average Speed

Off-Ramp CO g/hr Emissions vs Average Speed

Off-Ramp NOx g/hr Emissions vs Average Speed

Off-Ramp CO2 g/hr Emissions vs Average Speed
Development of the Draft Ramp Tool

• Based on user-provided average speed, the Draft Ramp Tool interpolates between stored operating mode distributions.

<table>
<thead>
<tr>
<th>ON RAMPS</th>
<th>OFF RAMPS</th>
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<tbody>
<tr>
<td>Average Speed in Data (mph)</td>
<td>Grouped Speed Bin</td>
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<tr>
<td>20.39</td>
<td>1</td>
</tr>
<tr>
<td>23.58</td>
<td>2</td>
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<tr>
<td>36.77</td>
<td>3</td>
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<tr>
<td>47.53</td>
<td>4</td>
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</tbody>
</table>
Draft Ramp Tool Usage

• Potential applications:
  – Users need operating mode distributions for passenger cars, passenger trucks, or light commercial trucks on either on- or off-ramps
    • Tool not applicable to other source types
  – Average vehicle speed on ramp is between 18-50 mph
  – Traffic observation or simulation is not available
  – Users are not comparing emissions related to ramp geometry or grade
Next Steps

• Consider any comments from work group

• Additional details on development of the ramp tool and usage of the tool will be made available in the appendix of the report:
  – “Draft Population and Activity of On-road Vehicles in MOVES201X”
  – Will be made available with the MOVES peer-review materials

• Based on feedback, determine whether to make final version of tool publicly available on MOVES website in the future