

Federal Advisory Committee Act  
Clean Air Act Advisory Committee

**Mobile Sources Technical Review Subcommittee (MSTRS)  
MOVES Work Group: Meeting Summary**

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June 7, 2017  
U.S. EPA Office of Transportation & Air Quality  
2000 Traverwood Drive  
Ann Arbor, MI 48105

**Welcome from the Chairs**

Ms. Megan Beardsley welcomed the Clean Air Act Advisory Committee (CAAAC), Mobile Sources Technical Review Subcommittee (MSTRS) MOVES Work Group to its fourth meeting. She also reported that co-chair Dr. Matt Barth was unable to attend the meeting and presented the meeting agenda (see Table 1).

**Table 1. MOVES Review Work Group Meeting Agenda:  
June 7, 2017 (1 pm to 4 pm)**

<b>Topic</b>
Welcome from the Chairs
General Announcements
Member Roll Call
Report from MSTRS Meeting
Presentations -Revising Start/Soak Relationships for Light-Duty Gaseous Emissions -Heavy-Duty Start Emission Rates -Heavy-Duty CNG Vehicles in MOVES -Telematics and MOVES -Updated Speciation Profiles in MOVES -Updates to Total Organic Gases (TOG) Calculations in MOVES
Future Meetings/Wrap-up

**General Announcements**

Dr. Sarah Roberts made general announcements regarding meeting procedures, including how participants should signal when they had questions (i.e., by using the raised hand feature in Adobe Connect). Dr. Roberts stated that the meeting minutes will be submitted to the Work Group members for review before posting to the website and that any additional questions about the technical content of today's presentations should be sent to her by July 7, 2017 at her e-mail address: [Roberts.sarah@epa.gov](mailto:Roberts.sarah@epa.gov).

## **Member Roll Call**

After the general announcements were made, Dr. Roberts conducted a Work Group member roll call. A list of Work Group members in attendance is presented in an Attachment to these meeting minutes.

## **Report from MSTRS Meeting**

Prior to the presentations, Dr. Roberts reported on Dr. Barth's presentation at the MSTRS meeting on May 31<sup>st</sup>. She reviewed some of the feedback received both at the meeting and outside the meeting and stated that his presentation is available on the MSTRS website. Dr. Roberts then proceeded to introduce the first presenter, Mr. James Warila.

### **Presentation: Revising Start/Soak Relationships for Light-Duty Gaseous Emissions - James Warila, Carl Fulper, Erin McCurry**

Mr. Warila presented the purpose of the start/soak relationship test program (test program), a summary of the test program methodology and results, and how the EPA proposes to use the test program results to update start/soak curves in MOVES.

Mr. Warila began by defining "start emissions" as excess emissions occurring during a brief period following engine start at a warm ambient temperature. Start emissions are expressed as mass (g/start), and operating modes are defined in terms of time since key-off (i.e., soak time).

He explained that MOVES estimates light-duty start emissions based on the Federal Test Procedure and operating mode identification codes that define soak periods. The MOVES start emission rates were developed from "soak curves," which are based on the ratio of start to cold-start emissions and soak time.

Mr. Warila explained that the EPA developed the test program with the goal of updating the soak curves used in MOVES for Tier-2 vehicles. The test program method used to measure hydrocarbon (HC), carbon monoxide (CO) and nitrogen oxide (NOx) emissions was described. The program involved the use of portable emissions measurement systems (PEMS), multiple drives on the same route, and measurements taken at a "warm ambient" temperature. Four vehicle models were tested, including two Bin 5 vehicles (ultra-low emission vehicle (ULEV)) and two Bin 4 vehicles. The procedure and drive sequence for each vehicle was repeated multiple times. Each sequence included a soak indoors at ambient temperature for a period equal to MOVES soak operating mode periods. The drive sequence route appropriateness was verified by measuring catalyst temperature, oil temperature and cumulative emissions to ensure the complete start period was captured.

Mr. Warila explained the methodology that was used to develop the updated start emission rate soak curves. He presented the soak curves for NOx, HC and CO and how they compared to the California Air Resources Board (CARB) ratio data for NOx and HC.

Mr. Warila reviewed the results. The start/soak relationships differed from older results, and these findings were corroborated by other studies (i.e., CARB data). Hydrocarbon and NO<sub>x</sub> emissions were highest at shorter soaks. Based on these results, the EPA proposes to update MOVES emission rates for model years 2004 and later using revised soak curves for “warm” to “hot” starts.

### *Discussion*

Mr. Jeremy Heiken stated that vehicle variability in this data is significant and asked why the CARB data was not incorporated into the EPA’s dataset. He also asked if the soak bins were reviewed for adequacy. Mr. Warila responded that they had not considered redesigning the soak bins (i.e., operating modes) in MOVES. He explained that the CARB data is qualitatively similar to the EPA’s data, and he is not sure the results would be different using that data. He also noted that the CARB data has only been preliminarily presented and will not be available in time for it to be used in this MOVES update.

Ms. Julie McDill referred to the cumulative NO<sub>x</sub> emissions chart shown in the presentation (slide 17) and asked whether the EPA had looked at whether the reason the emissions increase in a stair-step fashion is due to idling or whether it is due to the use of emissions control devices. She also wondered whether the observed stair-stepping is due to vehicle idling. Mr. Warila stated that they do not have an answer for the stair-stepping shape of the graphed cumulative emissions, but there are likely multiple causes (e.g., variability in traffic conditions, engine control and fuel strategies, driver variability). He noted that this observed manner of emissions increase could be an area for further investigation.

Mr. Jim Kliesch commented that he had questions regarding the robustness of the data. He asked whether Mr. Warila could elaborate on the sample size, the standard deviation (variability), how many times the route was driven, and whether the findings were repeatable. He also inquired why they used vehicle models that are so different from each other. Mr. Warila responded that, for each soak period, each vehicle was driven the route two to five times. He further responded that there is a high degree of variability in emissions between and among vehicles. Mr. Kliesch commented that variability distilled to one curve is the reason why data robustness and repeatability of the analysis is important.

Mr. John German noted that the data presented seemed to show that the emissions were increasing even after the catalyst is at operating temperature. He stated that this is worrisome, and he would like to see how emissions correlate to catalyst temperature by soak period. He also asked whether the occurrence of the continued emissions increases, after the catalyst should be working, could be due to defeat devices. He offered to assist with additional analyses.

Dr. Britt Holman asked whether the test program reflected single or multiple drivers. Mr. Warila responded that it involved multiple drivers. Dr. Holman also asked whether the EPA believed that the sample size of four vehicles and use of multiple drivers was sufficient. Mr. Warila responded that, due to costs and other practical considerations and because the results were

corroborated with the CARB data, the data is sufficient to use. He commented that it is not uncommon to have an order of magnitude of variability in running emissions between vehicles.

Mr. Gil Grodzinsky asked whether the Tier 2 levels of control accounted for the 2004 and later model year results and asked what model years were included in the CARB impact study. He also asked whether the stairstep effect could be due to catalyst temperature. Mr. Warila responded that EPA does not have the CARB model years used (it was not included in the data presentation), but that the CARB report with this information should be out soon. He further stated that he is not sure about the cause of the observed stairstep in emissions, but it is possible that these results could be an indirect effect of how engines comply with standards.

Mr. Grodzinsky inquired why EPA chose model year 2004. Mr. Warila responded that the volume of data that they can use is limited, and model year 2004 was chosen because it is the year that Tier 2 data vehicles were introduced to the market. This newer data is more applicable to newer vehicles, and the older data is more applicable to older vehicles.

Mr. Grodzinsky asked whether the EPA could do a parallel analysis with CARB's EMFAC raw data and do a side by side comparison to assess data similarities. Mr. Warila responded that based on currently available data, the highest peak points for the two data sets can be observed, and there are similarities. The EPA will consider showing both data sets together when the raw CARB data becomes available.

Mr. Tom Darlington commented that the differences observed between vehicles for HC support combining the CARB data with the EPA's data for analysis. He also asked what the EPA's plans were for particulate emissions. Mr. Warila responded that they could combine the CARB and EPA data if they had the CARB data, and he stated that they would conduct an analysis using both data sets if there is time between receiving the data and when the MOVES update is scheduled. As for particulate emissions, Mr. Warila responded that measuring particulate emissions is more difficult and expensive, and the EPA does not have data or a current plan to collect PM data for new or old vehicles.

Ms. Beardsley introduced the second presenter, Ms. Angela Cullen.

**Presentation: Heavy-Duty Start Emission Rates - Angela Cullen, Carl Fulper, Connie Hart, Erin McCurry, James Warila**

Ms. Cullen reported that the current MOVES model includes start emissions for heavy-duty vehicles, and the emission rate varies by the amount of soak time preceding the start. The EPA is proposing to update cold start emissions and emissions for starts with soak times ranging between 3 minutes and over 720 minutes. These updates would apply to model year 2010 and newer heavy-duty diesel and gasoline vehicles in the next version of MOVES.

Ms. Cullen stated that they analyzed model years 2015-2017 heavy-duty engine data (new data) from the EPA's Compliance Division. Comparing the cold start results (grams/start) from MOVES2014 and the new data for heavy-heavy-duty diesel, medium-heavy-duty diesel, light-

heavy-duty diesel and heavy-duty gasoline vehicles, they observed cold start emission differences for heavy-duty vehicles.

Ms. Cullen reported the heavy-duty soak time impacts currently in MOVES are based on light-duty soak period effects. She stated that two new sets of testing were conducted: (1) heavy-duty chassis testing for emissions vs. soak time for CO, HC, NO<sub>x</sub> and PM, and (2) PEMS on-road tests on a medium-duty gasoline truck and medium-duty diesel truck. The heavy-duty diesel truck testing showed different trends than the ratios currently in MOVES. The medium-duty diesel gasoline truck shows similar trends as the soak ratios currently in MOVES.

Based on the presented data, the EPA proposes to update:

- Model year 2010 and newer heavy-duty gasoline vehicle emissions based on new cold start 12-hour soak emission rates.
- Model year 2010 and newer heavy-duty diesel vehicle emissions based on new 12-hour soak emission rates and the new soak curve.

### *Discussion*

Mr. Heiken inquired whether they had investigated light-duty diesel start emissions. Mr. Heiken stated that light-duty diesel start emissions are not like heavy-duty gasoline start emissions, and he commented that the current MOVES model does not address light-duty diesel start emission rates. Mr. Warila responded that, although not ideal technically, MOVES currently replicates gasoline rates for light-duty diesel rates. He further stated that the EPA does not yet have plans to update the light-duty diesel start emission rates. Mr. Heiken suggested that the EPA not assume that the gasoline NO<sub>x</sub> split is the same as it is for diesel, and the split should be rebalanced for diesel.

Mr. Darlington asked whether the EPA could comment on why there are so many tests at zero hours for particulate emissions and not as many for longer soak times. He also commented that it does not look like particulate emissions are influenced much by soak time. Ms. Cullen responded that the reason why there were so many tests at zero hours is because they were not able to obtain particulate emissions in every test, which is a limitation of the data set. She also responded that Mr. Darlington was correct that particulate emissions were not influenced much by soak time for the vehicle represented in the presentation.

Ms. Beardsley introduced the third presenter, Dr. Darrell Sonntag.

### **Presentation: Heavy-Duty CNG Vehicles in MOVES - Darrell Sonntag (EPA) and Gurdas Sandhu (ORISE Participant)**

Dr. Sonntag reported that the current version of MOVES enables users to model compressed natural gas (CNG) emissions for transit buses based on model years 1996-2004 CNG transit bus emission rates and that emission rates for model year 2007 and newer are based on scaling the base emission rates using engine certification data. He stated that the population of CNG transit buses is provided in the default MOVES database.

Dr. Sonntag reported that MOVES users have expressed interest in modeling CNG in vehicle types other than transit buses, however, data is not available on other CNG vehicle source populations.

Dr. Sonntag stated that the EPA is proposing to remove CNG vehicles from the default population in MOVES because the national default CNG usage for transit buses does not reflect the actual CNG usage in individual states, counties, and metropolitan areas. He reported that the EPA is proposing to allow users to supply CNG use for all heavy-duty source types in MOVES by entering the fraction of CNG-fueled vehicles by source type through the Alternative Vehicle Fuel Table (AVFT) importer.

Dr. Sonntag stated that the EPA is also proposing to apply the current power-based CNG emission rates derived from CNG-fueled transit buses to newly-allowed heavy-duty CNG source types. He further stated that the EPA is proposing to update the CNG emission rates for 2007 and newer model year engines based on new emissions certification data.

### *Discussion*

Mr. Heiken expressed concern that the model will be used for policy decisions and asked the EPA how they are handling deterioration in emissions for CNG. He also asked whether CNG is treated like diesel. Dr. Sonntag responded that he believes that deterioration in emissions for CNG is treated more like gasoline than diesel but would need to check the technical documentation to verify this.

Mr. David Kall notes that the increasing trend shown for CO emission rates was counter-intuitive. Dr. Sonntag stated that he assumes the trend is related to the catalysts, but he is unsure of the cause of this increase in emissions.

Ms. Beardsley introduced the fourth presenter, Mr. David Brzezinski.

### **Presentation: Telematics and MOVES - David Brzezinski (EPA) and Aman Verma (ORISE Participant)**

Mr. Brzezinski reported that MOVES uses default national activity parameters when detailed county-specific analysis/data is not available. The EPA proposes to use telematics data to improve the default national averages.

Mr. Brzezinski explained that telematics refers to any technology that provides a continuous stream of vehicle activity data, which offers both challenges and opportunities. Mr. Brzezinski presented an overview of the three telematic data sets the EPA is using: Verizon, NREL and CE-CERT. He reported that they screened the data to eliminate “bad” data (e.g., incomplete or damaged trips and potential vehicle selection bias).

Mr. Brzezinski reported that the EPA analyzed light-duty telematic Verizon data for VMT, vehicle starts, engine start soak time, and total idle time. The data from 5 states was associated with nearby states to create weighted-national averages or regional-specific values for light-duty vehicles. Based on an analysis of the data, the EPA is proposing to update the default VMT

distributions for light-duty cars and trucks based on national average Verizon data. The EPA is also proposing to update the default start frequency and soak distributions for light duty vehicles based on the national average Verizon data and to update light-duty idle defaults based on urban/rural region-specific Verizon data.

Mr. Brzezinski stated that the EPA has begun looking at the heavy-duty telematics NREL and CE-CERT data, and those results will be presented at a future meeting. He reported that they will be evaluating temporal distributions, idle time and engine starts.

### *Discussion*

Mr. John German asked whether there was self-selection bias in people participating in the Verizon samples. Mr. Brzezinski responded that there is probably some bias, and they are planning to conduct additional analyses (e.g., comparison of miles driven per year) to assess for bias, but he did not think it would affect the results of the analysis.

Mr. Dale Wells noted that it may be possible to get idle duration at the start of the trip from the Verizon data, and this could be used to explain monthly variation (e.g., people warming up their vehicles in the winter). He also asked whether there is overlap with CRC A-100 data. Mr. Brzezinski responded that they had not looked at the CRC A-100 data to update national defaults, and he was not sure about the types of idle information in that data.

Mr. Heiken asked whether the EPA investigated trip frequency as a function of age with this data. Mr. Brzezinski responded that MOVES could not currently perform this calculation and would need to be redesigned to be able to do this. Mr. Heiken noted that the start proportion of emissions will be increasing and is already higher than the running emissions, so it would be useful to be able to model trips as a function of age.

Dr. Holman asked how the telematics data defines idle and whether it is defined the same for both heavy-duty and light-duty vehicles. Mr. Brzezinski responded that the telematics data defines idle for both heavy-duty and light-duty vehicles as any time the speed of the vehicle drops below one mile per hour and has an RPM greater than zero.

Mr. Vivek Thimmavajjhala asked how light-duty and heavy-duty vehicles are defined. Mr. Brzezinski responded that passenger cars are light-duty vehicles, light-duty trucks are 2-axle, 4 tire trucks, and heavy-duty includes anything beyond that.

Ms. Beardsley introduced the fifth presenter, Mr. Rich Cook.

### **Presentation: Updated Speciation Profiles in MOVES - Rich Cook, Harvey Michaels, and Darrell Sonntag**

Mr. Cook provided background information on speciation in MOVES and SMOKE for onroad and nonroad vehicles. He reported that the MOVES model requires users to allocate constituent chemical species prior to air quality modeling through the application of speciation profiles. He explained that prior to MOVES2014, mobile source VOC and PM emissions were speciated outside of MOVES using the SMOKE emissions processor. He reported that this became increasingly burdensome due to the complexities related to the mix of technologies, fuel types,

and location. MOVES2014 included VOC and PM speciation for onroad sources and MOVES2014a updated toxic emission rates for nonroad engines based on newer data and speciation profiles. MOVES2014a applies speciation from 2007 to 2009 to all 2007 and later engines (based on ACES Phase I data).

Mr. Cook reported that data from ACES Phase II recently became available for heavy-duty diesel engines equipped with diesel particulate filter (DPF) and selective catalytic reduction (SCR) systems, which has a large effect on VOC speciation. Because of this, the EPA is proposing to update the data for all 2010 and later highway diesel vehicles to reflect the ACES Phase II data for VOC.

Mr. Cook stated that, for nonroad diesel Tier 4 engines over 56 kW, MOVES2014 uses the ACES Phase I onroad profile data. He reported that there have been significant reductions in NMHC and NOx emissions for Tier 4 engines over 56 kW with DPF and SCR. Because of this, the EPA is proposing to use the ACES Phase II onroad speciation profile for VOC, which accounts for DPF and SCR, in the next version of MOVES.

Lastly, Mr. Cook stated that the EPA is considering maintaining the use of the ACES Phase I PM<sub>2.5</sub> speciation profile for all 2007 and newer trucks and nonroad Tier 4 > 56 kW engines because the Phase II data is not sufficient (e.g., does not include DPF regeneration events, minimal SO<sub>2</sub> measured) to support making changes.

#### *Discussion*

No comments or questions.

Ms. Beardsley introduced the presenters of the last presentation, Dr. Sonntag and Dr. Claudia Toro.

### **Presentation: Updates to Total Organic Gases (TOG) Calculations in MOVES - Darrell Sonntag (EPA) and Claudia Toro (ORISE Participant)**

Dr. Toro presented background information about how TOG are treated in MOVES. She explained that MOVES2014 uses total hydrocarbon (THC) emission rates to estimate all other organic gas aggregates (NMHC, VOC, NMOG, TOG) through a series of calculations.

Dr. Sonntag stated that methane (CH<sub>4</sub>) is calculated as a fraction of THC. The CH<sub>4</sub>/THC ratios in MOVES2014 are based on a CH<sub>4</sub> emission rate for running and a CH<sub>4</sub> rate for starts based on test data. Data available for THC emission rates varied with opModes and other factors. The data for CH<sub>4</sub> emission rates did not vary with opModes or age, resulting in decreases in CH<sub>4</sub>/THC ratios with age.

The EPA is proposing updates to CH<sub>4</sub>/THC ratios in the next MOVES version by calculating ratios based on each SPECIATE profile used in MOVES. For Tier 2 vehicles running on low-level ethanol blends, the EPA is proposing to include CH<sub>4</sub>/THC ratios for cold starts and running emissions based on bag-specific data from EPA Act Phase 1.

For CNG exhaust, the EPA is considering using CARB measurements not currently included in the SPECIATE database.

The EPA is also proposing updates to speciation constant parameters used in MOVES. Dr. Sonntag reported that they are proposing that NMOG/NMHC and VOC/NMHC ratios be calculated based on MOVES SPECIATE profiles. The EPA is also proposing that Tier 2 vehicles running on low-level ethanol blends include NMOG/NMHC and VOC/NMHC ratios for cold starts and running emissions based on bag-specific data from EPhase 1.

Dr. Toro presented the results of an analysis of EPhase I data for Tier 2 vehicles suggesting that the relationship with ethanol composition is significant for starts but not running emissions. Because of this, for Tier 2 vehicles, the EPA is proposing to use CH<sub>4</sub>/THC, NMOG/NMHC and VOC/NMHC ratios that vary with ethanol levels (0-15%) for starts while using a constant ratio for running emissions.

Dr. Sonntag concluded that, in summary, for the next MOVES, the EPA is proposing the following changes:

- Update CH<sub>4</sub>/THC ratio to be consistent with other TOG calculations and data
- Remove the age effect, which is expected to increase the methane from gasoline vehicles.

The updates to speciationConstant parameters are expected to result in negligible changes to TOG emissions.

### *Discussion*

Mr. Stephen Vander Griend inquired whether the EPhase I data is the only data being used for speciation. He expressed concern about speciation and match blending in that it would not be possible to model hazardous air pollutants due to match blending. He also stated that e10 to e15 fuels should not increase benzene emissions. Dr. Sonntag stated that the EPA is using the EPhase I data to be consistent with their speciation profiles.

Mr. Heiken suggested that the EPA maintain the ability to model historic oxygenates, and the removal of MBTE would make that problematic. He noted that the ability to model historic fuels was necessary for the conduct of time series analyses.

Mr. Heiken asked whether the EPA is planning to include carbon bond chemical composition speciation by emission process in the model. He stated that start emissions are different from running exhaust emissions in ozone reactivity. Dr. Sonntag responded that the model has separate VOC, toxics, and non-methane organic gases (NMOG) ratios for start and running emissions.

Mr. Heiken inquired why Phase III fuel data was not used. The EPA responded that they used the Phase I fuel data over Phase III fuel data because it reflected real-world end-use fuel. *(EPA clarification: Since the EPhase study was primarily designed to measure effects of fuel property changes on emissions, not emission rates, the fuel properties in Phase 3 were chosen to bracket the ranges found in in-use fuels. For example, Phase 3 included no mid-level aromatics fuels and only two mid-level T90 fuels. In contrast, the Phase 1 pilot study tested three fuels with*

*properties more reflective of average market fuels at the time of the study. Since speciation profiles are used to estimate emission rates for air toxics, EPA chose to base the profiles on Phase 1 results.)*

## **Wrap-Up**

In closing, Ms. Beardsley thanked the meeting participants and informed them of the tentative topics for the next meeting, which is planned for September 13, 2017. Ms. Beardsley reminded attendees that additional comments are to be sent to Dr. Sarah Roberts at [Roberts.sarah@epa.gov](mailto:Roberts.sarah@epa.gov) by July 7, 2017,

A full list of participants is provided as an attachment to this summary. Copies of the presentations given during this meeting will be available at <https://www.epa.gov/moves/moves-model-review-work-group>.

## Attachment – Work Group Meeting Attendance List

### 2017 MOVES Review Work Group Attendees

Name	Home Organization	Representing Organization
Megan Beardsley	EPA OTAQ	EPA; Workgroup Co-Chair
Susan Collet	Toyota	Coordinating Research Council (CRC)
David D'Onofrio	Atlanta Regional Commission	Association of Metropolitan Planning Organizations (AMPO)
Tim French	Engine Manufacturers Association (EMA)	Engine Manufacturers Association (EMA)
Mike Geller	Manufacturers of Emission Controls Association (MECA)	Manufacturers of Emission Controls Association (MECA)
John German	International Council on Clean Transportation (ICCT)	International Council on Clean Transportation (ICCT)
Gil Grodzinsky	Georgia Department of Natural Resources	National Association of Clean Air Agencies (NACAA)
Cecilia Ho	Federal Highway Administration (FHWA)	Federal Highway Administration (FHWA)
Britt Holmen	University of Vermont	University of Vermont
Vernon Hughes	California Air Resources Board (CARB)	California Air Resources Board (CARB)
Joseph Jakuta	Ozone Transport Commission (OTC)	Ozone Transport Commission (OTC)
Mark Janssen	Lake Michigan Air Directors Consortium (LADCO)	Lake Michigan Air Directors Consortium (LADCO)
Chris Kite	Texas Commission on Environmental Quality	Association of Air Pollution Control Agencies (AAPCA)
Jim Kliesch	Honda	Honda
David Lax	American Petroleum Institute (API)	American Petroleum Institute (API)
Ross Patronsky	Chicago Metropolitan Agency for Planning	Association of Metropolitan Planning Organizations (AMPO)
Matt Solomon	Northeast States for Coordinated Air Use Management (NESCAUM)	Northeast States for Coordinated Air Use Management (NESCAUM)
Steven Vander Griend	ICM Inc.	Energy Future Coalition/Urban Air Initiative
Chris Voigt	Virginia Department of Transportation	Amer. Assoc. of State Highway and Transportation Officials (AASHTO)
Dale Wells	Colorado Department of Public Health and Environment	National Association of Clean Air Agencies (NACAA)

### Non-Work Group Attendees

Name	Home Organization	Representing Organization
Kevin Black	FHWA	FHWA
Christopher Boyd	Shelby County Health Department	Shelby County Health Department
David Brzezinski	Environmental Protection Agency	Environmental Protection Agency
Ying-Tzu Chung	Michael Baker International	Michael Baker International
Rick Cook	Environmental Protection Agency	Environmental Protection Agency
Marc Corrigan	Tennessee Department of Environment and Conservation	Tennessee Department of Environment and Conservation
Louis Corsino	Connecticut Department of Energy and Environmental Protection	Connecticut Department of Energy and Environmental Protection
Angela Cullen	Environmental Protection Agency	Environmental Protection Agency
Tom Darlington	Air Improvement Resource, Inc.	Air Improvement Resource, Inc.
Jeremy Heiken	Oak Leaf Environmental, Inc.	Oak Leaf Environmental, Inc.
David Kall	Federal Highway Administration (FHWA)	Federal Highway Administration (FHWA)
Sonya Lewis-Cheatham	Virginia Department of Environmental Quality	Virginia Department of Environmental Quality
Natalie Lijenwal	Oregon Department of Transportation	Oregon Department of Transportation
Jeff Long	California Air Resources Board (CARB)	California Air Resources Board (CARB)
Julie McDill	Mid-Atlantic Regional Air Management Association	Mid-Atlantic Regional Air Management Association
Joanne O'Loughlin	SC&A, Inc.	EPA Contractor
Steven Potter	Connecticut Department of Energy and Environmental Protection	Connecticut Department of Energy and Environmental Protection
Dr. Sarah Roberts	Environmental Protection Agency	Environmental Protection Agency
Yue Shan	Michael Baker International	Michael Baker International
Jolyon Shelton	Delaware Dept. of Natural Resources and Environmental Control	National Association of Clean Air Agencies (NACAA)
Lubna Shoaib	East-West Gateway Council of Governments	Association of Metropolitan Planning Organizations (AMPO)
Darrell Sonntag	Environmental Protection Agency	Environmental Protection Agency
Lesley Stobert	SC&A, Inc.	EPA Contractor
Vivek Thimmavajjhala	North Central Texas Council of Governments	North Central Texas Council of Governments
Claudia Toro	ORISE Participant	ORISE Participant
Madhu Venugopal	Texas A&M Transportation Institute (TTI)	Texas A&M Transportation Institute (TTI)
Jeff Vukovich	Environmental Protection Agency	Environmental Protection Agency
James Warila	Environmental Protection Agency	Environmental Protection Agency
Wei Zhang	Idaho Department of Environmental Quality	National Association of Clean Air Agencies (NACAA)