Modeling Workgroup
Mobile Sources Technical Review Subcommittee
Clean Air Act Advisory Committee

Minutes of the Workgroup's Meeting on June 10, 2003
Alexandria, Virginia

Introduction and Opening Remarks

John Koupal (EPA, co-chair) called the meeting to order at approximately 10:00 a.m., and Workgroup members introduced themselves. A meeting agenda and two handouts (Summary of Stakeholder and Peer Review Comments On MOVES Planning Documentation; MOVES Update for FACA Modeling Workgroup) were distributed prior to the meeting. The handouts are attached at the end of these minutes.

Handout: Summary of Comments on MOVES Planning Documentation

The EPA published two MOVES planning documents in the Fall of 2002: (1) *Draft Design and Implementation Plan for EPA's Multi-Scale Motor Vehicle & Equipment Emission System (MOVES)* and (2) *Emission Analysis Plan for MOVES GHG*. Mr. Koupal noted that the review process for these documents is now complete, including both public review by stakeholders and a formal peer review administered by Southwest Research Institute. The handout summarizes the comments received from both groups, divided into four broad categories: (1) General, (2) Design, (3) Emission Analysis, and (4) Input/Output/Model Operation. The Workgroup discussed selected comments, as summarized below.

Comment 1. There is not a need for the greenhouse gas version of MOVES. Current methods for estimating greenhouse gas inventories are sufficient. MOVES GHG will create unnecessary duplication with DOE (AAM, EMA).

Tom Darlington (AIR, Inc.) explained this comment further, indicating that other existing models are capable of estimating greenhouse gas (GHG) emissions and are already doing so. These include models created by the Energy Information Agency and DOE, as well as GREET coupled with MOBILE6. (Gene Tierney [EPA] noted that GREET is currently coupled with MOBILE5.)

Mr. Koupal noted that EPA has the lead on GHG reporting for the International Panel on Climate Change (IPCC). The IPCC is a United Nations group that coordinates inventory production; member nations report emissions annually. These GHG reports will be similar to the current TRENDS reports for criteria pollutants. MOVES will be used to generate these reports in the future.

Mr. Koupal explained that current emission models use a top-down approach to estimate emissions of CO_2 and a bottom-up approach to estimate CH_4 and N_2O. The IPCC has recommended developing a bottom-up model for CO_2 as well. The existing top-down model for CO_2 does not allow a breakdown of fuel use by vehicle classes, time of day, area of the country,

etc. The bottom-up model will be developed to match the top-down benchmark for total CO_2 emissions.

Mr. Tierney added that model development plans include moving GREET into the MOVES framework. Joon "John" Byun (Federal Highway Administration [FHWA]) supported development of MOVES for GHG, noting that existing models do not meet the needs of traffic engineers for microscale modeling.

Mr. Darlington responded that he has heard this reasoning before, but he is unsure how much MOVES will improve on the current models. Jeanette Clute (Ford) added that top-down CO_2 emissions are appropriate for the type of inventory IPCC produces.

Comment 8. If MOVES is released in Fall 2005 as a replacement to MOBILE6, a number of important policy issues will need to be addressed, and MPOs will be facing tremendous burden on data gathering and modeling efforts – particularly many new ozone nonattainment areas who will be spending a lot of time and effort to set up MOBILE6 for their conformity analysis by 2005 (U.S. DOT).

Mr. Koupal explained that U.S. DOT raised this timing issue related to developing State implementation plans (SIPs) for areas that are designated as nonattainment areas for the new 8-hour ozone or $PM_{2.5}$ national ambient air quality standards (NAAQS). The concern is that the States will be using MOBILE6 for their attainment planning, and then be required to make a mid-course shift over to MOVES when it is introduced to replace MOBILE6.

Bruce Spear (FHWA) pointed out that their concern is conformity demonstrations. Many areas will be designated nonattainment for the first time under the new 8-hour ozone NAAQS.
Mr. Spear believes that it will impose a tremendous burden if these areas are required to gear up and develop the conformity demonstration using MOBILE6, only to have to switch suddenly to MOVES. He suggested that there be a waiver to allow areas to complete the first phase of the conformity demonstration with MOBILE6, and then switch over to MOVES later.

Mr. Tierney stated that an area is never required to switch models for a demonstration that is in progress. He pointed out that under the regulations, the 2-year clock for conformity starts when MOVES is officially adopted. Thus, areas will have until 2008 to make the switch.

Mr. Koupal pointed out that it is always messy when a new model is adopted. Comment 7 raises this issue, suggesting that frequent MOVES updates (which will be facilitated by the modular structure planned for MOVES) will necessitate equally frequent SIP and TIP updates.
Mr. Koupal noted that EPA is required to update the emission factors every 3 years, and plans to update MOVES every 2 to 3 years. There is always a catch-up issue when a new model is adopted, and this will be exacerbated this time because of the new 8-hour ozone NAAQS.

Mr. Spear stated that the relationship between SIPs and conformity demonstrations can be a problem. The regulations don't require a SIP update when a new model is adopted. Thus, conformity often must be demonstrated using a new model against a SIP budget that was developed with an older model.

Mr. Tierney noted that his group in EPA is not involved in SIPs. He suggested that Mr. Spear contact Lee Cook to discuss SIP requirements and policies. Mr. Koupal added that the MOVES team will be working with the EPA's SIP group to figure out appropriate approaches.

Comment 27. In order to not "seriously shortchange" an important group of users, ensure that good and easy-to-use default information, or data generation capability, be available to relatively modest users at the mesoscale (Ross). Some users may be disheartened by the potential data requirements, but the establishment of national default data to fill some gaps addresses this concern (Replogle).

Mr. Koupal explained that at its simplest, at the macroscale level MOVES can be run entirely using defaults. Such macroscale results can be apportioned down to the county level, but users who want accurate county-level results should not use this approach. Instead, they should use actual local VMT and registration data, etc. For accurate mesoscale results, the user must supply link level, zone level, and speed data, although default information for such variables as fleet mix and fuel properties can be used and will be available. To get accurate results at the microscale, the user needs local information for all variables.

Mr. Spear stated that it would be valuable to users for EPA to include sensitivity analyses on the variables so that users will be able to tell for which variables it is important to obtain detailed local data. Dr. Byun noted that MOBILE includes defaults for trip length and number of starts that will often not be accurate for a locality. It would be helpful for EPA to provide guidance with MOVES to point out when defaults are not appropriate.

Mr. Koupal noted that uncertainty and how it should be addressed is an issue, as expressed in Comment 55 and others. The EPA has considered two approaches to evaluating uncertainty in MOVES: Monte Carlo and propagation of error. The EPA initially proposed to use the propagation of error approach as a simple first step. However, when Dr. Frey at North Carolina State University looked into this approach, he discovered that it will be more complicated than initially thought. As a result, EPA may decide to use the Monte Carlo approach. MOVES will start out with uncertainty analysis capabilities for a few emission rate variables, but the structure of the model will allow additional variables to be added. Sensitivity information will fall out from the uncertainty analyses.

Mr. Spear asked how the uncertainty results will be used. He indicated that DOT's concern with uncertainty analyses pertains to comparing model results with the transportation budget in a conformity demonstration. Specifically, if the model output is a range (to account for uncertainty), how will conformity be determined if the budget lies somewhere in that range?

Mr. Tierney responded that MOVES will provide a point number to be used in conformity and other applications. The uncertainty routine will not be a customary part of modeling. Instead, uncertainty analyses will be used to provide information on the model's capabilities and to help focus efforts to upgrade the model.

Mr. Darlington stated that the uncertainty routine should be provided to all users. Dr. Byun noted that the user would not be required to run the uncertainty routine just because the option was available. He noted that Monte Carlo analyses may help to reduce uncertainty in the future.

Mr. Koupal indicated that the uncertainty routine is intended for special analysis purposes. It may not be provided for all uses.

Comment 34. The binning approach is more problematic for some variables than others. VSP [i.e., vehicle specific power] binning (and the use of VSP as the driving variable that determines emissions) is a good approach, but vehicle odometer would be better served through a linear function (Ross, Russell). Linear functions are preferable to binning, particularly for uncertainty estimation (Russell).

Mr. Koupal explained that the binning approach is attractive in that it simplifies model calculations and understanding. However, EPA realizes that some variables, such as fuel and temperature, are better treated as continuous linear functions. For this reason, MOVES will back off on binning for such variables. The issue of whether to use odometer or age as a variable has not been resolved. Age would lend itself to binning, while odometer would be better as a linear function.

Comment 38. Evaluations presented in emission analysis plan do not consider sensitivity to changes in control systems over the years. The approach should be analyzed by comparing two or more datasets with vehicles that use control technologies of different vintages (Ross). The proposal should be evaluated on second-by-second data from for non-Tier 1 light duty gasoline vehicles, light-duty gasoline trucks, light-duty diesel trucks, heavy-duty gasoline and heavy-duty diesel vehicles (AAM, EMA).

Mr. Koupal responded to this comment by noting that recently EPA has been looking at non-Tier1 vehicles. A shoot-out showed that binning works well for diesel buses. The EPA is currently looking at pilot work on heavy-duty (HD) vehicles and non-Tier 1 light-duty (LD) vehicles.

Comment 61. Representative vehicle recruitment will continue to be an issue (Buckingham). The success of using a continuous distribution to define variability in fleet will depend largely on the ability to recruit high emitters (Ross). EPA voluntary programs and IM [i.e., inspection and maintenance] programs tend to leave out the grossest emitters (Stedman). How will high emitter data be selected, collected and included in bins (U.S. DOT)?

Mr. Koupal noted that high emitters are not relevant to the GHG portion of MOVES that is currently under development. For the subsequent portions of the model, EPA proposes to characterize vehicles in different ways for the different pollutants. As the commenters indicated, EPA will need to obtain good data on the distribution of vehicles.

Mr. Tierney pointed out that vehicle recruitment will always be imperfect. The EPA hopes that on-board portable emission measurement systems (PEMS) deployment will overcome some of the resistance to participating in vehicle studies. This will help obtain more complete

information, but will not completely solve the problem. The EPA will use other information to fill the gaps to the extent possible, but it should be understood that there will never be perfect data.

Comment 30. Does EPA intend to develop a companion intersection dispersion model to replace CAL3QHC, or re-validate CAL3 using MOVES? (U.S. DOT)

Dr. Byun stated that transportation engineers use two types of models: area-wide and project-specific. When EPA issues a new model, the emission rate and dispersion outputs are changed. Does EPA have good guidance on which model to use with MOVES, or a way to calibrate the models?

Mr. Koupal responded that CAL3QHC continues to be EPA's recommended model for intersections. He noted that the MOVES team will need to coordinate with OAQPS on this issue, but he is not aware of an effort to update the model.

Comment 42. EPA has not adequately characterized which variables are most important in explaining variability in HC, CO, and NOx emissions. These analyses should be conducted on test data from a variety of vehicle types and technologies before selecting a binning strategy for each of these pollutants.

Mr. Darlington stated that he saw an ERG report showing that vehicle power is the most important variable for CO_2 emissions. Why are there not similar reports for the other pollutants? Mr. Koupal responded that EPA plans to conduct analyses to determine the appropriate binning strategies for each pollutant. The analyses to date indicate that the binning strategy for CO_2 will also work well for NO_X and pretty well for CO. It does not work well for HC.

Mr. Darlington noted that MOBILE6 includes a number of correction factors. He asked which of these will be included in MOVES, and which will be included in the bins.

Mr. Koupal replied that the speed correction will be replaced by VSP binning in MOVES, an odometer/age bin in MOVES may replace the deterioration factor, and the air conditioning adjustment will largely be replaced by bins in MOVES, although the user will have to supply information on how much the air conditioner is on. The fuel, temperature, and operating mode correction factors from MOBILE6 will be retained in MOVES.

Comment 67. On-Board measurement may be costly and inefficient; flexibility should be retained in data collection (Ross).

Mr. Tierney stated that EPA expects on-board measurement (i.e., PEMS) to be less costly and more efficient than other types of data collection. Mr. Koupal noted that this comment is meant to address vehicle recruitment; i.e., there are lots of data on cleaner vehicles, while more data are needed on high-emitters. Mr. Tierney responded that the use of PEMS will allow EPA to obtain a better random sample of vehicles. With PEMS, EPA is not tied to certain localities because a PEMS can be sent anywhere. This will make nationwide random sampling possible.

Mr. Tierney added that there has been a lot of work on evaluating the accuracy of PEMS. A PEMS shoot-out among instrument manufacturers is being planned. PEMS will be compared to mobile lab results. So far, EPA has been pleased with PEMS results for HC, CO, and NO_X. More problems have been experienced with the lab measurements than with PEMS. Under the Kansas City PM program, emissions from 480 vehicles will be measured.

Mr. Spear asked what strategies for vehicle recruitment will be employed to obtain high-emitters. Will there be anything beyond voluntary participation? Mr. Tierney responded that all recruitment efforts will be voluntary; EPA has no authority to compel participation. EPA will offer incentives to recruit high-emitters.

Dr. Byun recommended that EPA fill data gaps using remote sensing data. He indicated that there needs to be a flow of data between remote sensing and voluntary programs. Mr. Koupal agreed, but noted that the question is how to use the remote sensing data. Dr. Byun suggested that high-emitters can be identified using remote sensing data, and the license tag number can be used to obtain the IM240 or lab test data for these vehicles.

Handout: MOVES Update for FACA Modeling Workgroup

Mr. Koupal presented this update on MOVES. The handout is attached at the end of these minutes.

Mr. Koupal discussed the implementation plans for MOVES. The release of the draft MOVES GHG on-road model is now scheduled for early 2004. This release has been delayed slightly due to integration of the GREET model. The EPA has begun considering adding aircraft, commercial marine, and locomotive emissions to MOVES, rather than to NONROAD. The timeline for this addition is not certain, but is tentatively expected in 2005. Full on-road implementation (with all pollutants) is still scheduled for Fall 2005, at which time MOVES will replace MOBILE6. The final step will be to move NONROAD into MOVES in 2006.

Mr. Koupal noted that the MOVES GHG draft release will be a working model accompanied by a variety of documentation. This release will trigger a new review period, including stakeholder review and a formal peer review.

Mr. Koupal summarized activity in emission data gathering. Data from a number of sources are being added to the Mobile Source Observation Database, with expected completion in July 2003. ERG is working with the various organizations to obtain and check the quality of the data. Where there are missing fields, they are determining if the data were ever collected, or if the fields can be filled from alternative sources.

Mr. Koupal discussed the default fleet and activity analyses and sources of data. Regarding the use of vehicle registration databases to develop vehicle populations and distributions, Dr. Byun asked whether the model will have a method for reflecting how the registration data change over time. Mr. Koupal responded that MOVES will have a dynamic registration update process. David Lax (API) asked whether the fleet data will be disaggregated down to the county level. Mr. Koupal answered that the model will use an approach similar to assessing nonroad vehicles,

where the fleet characteristics are developed on a national level and allocated down to the county level near the end of the process.

Mr. Spear suggested caution in using data from the Highway Performance Monitoring System (HPMS). He noted that there is tremendous variation among the States in the quality of these data. It may be problematic to aggregate all the data, and then reallocate to the States. He suggested using these data on a State-by-State basis. Dr. Byun stated that HPMS data are accurate at the State level, but not at the county level. He added that funding is continuously shrinking for HPMS, and that detail and accuracy are suffering as a result.

Ms. Clute asked if the fleet and activity approach presented by Mr. Koupal differs from the approach laid out in the MOVES design plan. Mr. Koupal responded that it is not different; this is the analysis being done to fill in the information mentioned in the design plan.

Ms. Clute added that the fleet and activity data and assumptions are very important, and asked how and when EPA will publicize the details to allow for review and discussion. Mr. Koupal replied that this will all be documented in the reports issued at the time of the MOVES GHG draft release. In addition, EPA will update the Workgroup as the work progresses. Contractor reports will be made available as they are completed, as will intermediate products. Ms. Clute suggested that EPA make materials available as the analyses proceed to allow for comments while development is still in progress.

Mr. Koupal noted that extended idle activity will be included in MOVES. It will be based on regulations that limit idling by trucks and on recent studies. He added that any additional data in this area would be welcome.

Mr. Koupal stated that the national default values for vehicle survival rates will be drawn from Oak Ridge data. A telephone participant noted that the Oak Ridge data have recently been updated for trucks, but not for cars. As a result, the data now indicate that LD trucks are scrapped faster than automobiles. This participant suggested that it would be desirable to update the other types of vehicles. Mr. Dilip Patel (CARB) asked whether survival rates vary by geographic area, and whether this would be accounted for within MOVES. Mr. Koupal responded that MOVES will include national default survival rates, but users may enter more accurate local data for modeling at a finer scale.

Mr. Koupal asked if any participants knew of sales growth projection data that EPA can use in developing this aspect of MOVES. Mr. Darlington noted that sales projections are much harder to develop than stock projections.

Mr. Koupal reviewed the source use types planned for MOVES. He pointed out that the cutoff between commercial trucks (i.e., trucks engaged in local activity) and delivery trucks (i.e., longer haul trucks) has been changed from 50 miles to 200 miles.

Regarding the binning strategy, Mr. Darlington asked whether loaded weights will coincide at all with emission standards. Mr. Koupal explained that the bins will vary by pollutant. Where there

are emission standards, the bins will be based on the standard instead of on weight and engine size.

Ms. Clute noted that the slide on the modal binning approach indicates that there are "hundreds of bins" under the currently proposed approach, and asked how many bins there are. She speculated that that there may be thousands. Mr. Koupal responded that there are hundreds of VSP and weight bins, so in combination with the source bins, there will be thousands of bins. Ms. Clute pointed out that source types will change over time. For example, LD trucks and automobiles are being merged by emission standards. Mr. Koupal agreed—MOVES will use emission standards where they apply, and the bins do not distinguish whether the vehicle is an automobile or a truck.

Mr. Spear asked whether EPA will use national averages for weight distribution and other source bins, or investigate geographical variability. Mr. Koupal replied that MOVES will include national averages for national scale modeling, but more accurate data can be entered for modeling at finer scales. Currently, the model will accept only one distribution for the entire scale that the user is modeling. The EPA is considering how to allow the user to vary the fleet for different areas within the scale being modeled. Mr. Spear pointed out that using national averages won't account for local area weight restrictions and other local factors. Mr. Koupal noted that a local area can use its own data; it is not tied to the national default.

Mr. Koupal discussed VSP and potential approaches for supplementing VSP for binning. He noted that the GHG Emission Analysis Plan had proposed binning by VSP and average speed. However, EPA has found that when average speed is used, the results do not agree with the second-by-second and remote sensing data that have been collected. Using average speed introduces a bias because it does not account for engine friction (which varies with rotations per minute [rpm]). After investigating possible approaches, EPA has decided to bin by VSP and instantaneous speed. It appears that about 14 bins will be adequate for this approach.

Michael Reale (Daimler Chrysler) asked whether EPA has looked into this approach for all pollutants. Mr. Koupal replied that all pollutants have been evaluated, and the revised binning approach improves results for all pollutants except HC. The EPA is still looking at HC.

Mike Rodgers (Georgia Tech) discussed the slide that presents the options investigated by EPA, which included defining a new variable (ESP) that would be calculated by adding a new term to the VSP equation. He suggested that this approach would not truly add a new term, but would simply modify the A coefficient in the VSP equation (since both A and the new coefficient would be multiplied times speed). Mr. Koupal acknowledged that this is true in a sense, but pointed out the differences between the terms. He noted that this approach would be very complicated, while the adopted approach (VSP and instantaneous speed) is simpler and produces good results.

Mr. Koupal discussed how the ability to perform life cycle analyses for a variety of vehicle technologies is being built into MOVES. This will allow the model to be used as a tool for policy evaluation. Susan Collet (Toyota) asked what would come out of such policy analyses. Mr. Koupal responded that policymakers will be able to compare emissions for different vehicle

technologies across the entire life cycle of the vehicles. Mr. Tierney added that EPA has been asked to weigh in on this issue. These analyses will inform the discussion of national priorities, whether or not they have regulatory implications.

Ms. Clute posed a general question about the priorities for MOVES development. She noted that attainment planning for new nonattainment areas is coming, yet it appears that development of the model for criteria pollutants is being put on the second tier, with the GHG model as the highest priority. Mr. Koupal replied that the MOVES design structure and approach are being developed for all pollutants, while the associated databases are being populated for GHG first. The EPA is considering the criteria pollutants as development progresses, and the model is being built to be very flexible so it will be able to accommodate the criteria pollutants as needed. He added that it will not take nearly as long to add the criteria pollutant portions of the model as it has taken to develop the GHG portions. Adding criteria pollutants will primarily involve filling the databases for these pollutants, not building new software.

Mr. Tierney noted that priorities for MOVES development have not changed. The EPA still expects to complete the criteria pollutant portions of MOVES by the end of 2005. The only change in the originally planned development sequence is that aircraft, ships, and locomotives are being integrated sooner than previously planned. The NONROAD people are being brought into the MOVES team earlier than originally planned.

Discussion: Modeling High Emitters, IM and OBD

Mr. Koupal started this discussion by noting that there are limitations in all types of data. He asked the participants for ideas about how to use remote sensing and/or IM data to fill the gaps.

Mr. Darlington stated that the threshold question is: How effective is on-board diagnostic (OBD) equipment without an inspection and maintenance (IM) program? He suggested that EPA should reverse the typical focus; that is, look at OBD first, then at IM. Rick Barrett (Colorado Dept. of Public Health and Environment) noted that, even if OBD indicates that there is a problem with a vehicle, one doesn't know whether the vehicle is a high emitter.

At Mr. Koupal's suggestion, Mr. Barrett summarized work that has been going on in the area of OBDs. He noted that some data have been collected on OBD performance, including Colorado data on 100 vehicles procured from the IM program, a few hundred cars in an Arizona study compared with IM147 data, EPA's 200-vehicle OBD dataset, and the high-mileage study which gathers progressively more data. The OBD Technical Workgroup has been discussing how to analyze these data to determine how well OBD works. An area of concern is the high emitters that are not caught by OBD. Remote sensing can be helpful in identifying such vehicles. Mr. Barrett indicated that the farther one gets from the lab, the more representative the distribution data. Accordingly, remote sensing data give good fleet distribution data, IM program data are in the middle, and lab (voluntary) data are the most gapped.

Dr. Byun mentioned that MOBILE6 includes assumptions for how many people will obtain repairs when the OBD light comes on. He noted that the factor is only 20 percent after the vehicle's warrantee expires (3 years). He asked if any data are being gathered on such repairs.

Mr. Tierney asked a hypothetical question: What if MOVES ignores OBD, simply including the distribution of high emitters instead? Mr. Darlington responded that he would agree with this approach if EPA had a lot of data on new cars, as well as on old. Mr. Koupal noted that the proponents of remote sensing would say that we do have such data. Mr. Darlington responded that that depends on whether one believes that remote sensing data are good enough for this purpose.

Dr. Byun asked whether, if OBD works well, IM programs can be discontinued. Mr. Tierney noted that EPA must include IM in MOVES, but is not necessarily required to include OBD. Mr. Darlington questioned the concept of including a distribution of high emitters in the model and assuming that it remains constant without first gathering additional data on newer cars and future technology, including ultra-low emitting vehicles (ULEVs). Mr. Tierney responded that owners' responses to malfunction indicator lights (MILs) now and in the future can change as well. Mr. Koupal noted that OBD should not be modeled based on empirical data; EPA should collect distribution data instead. Mr. Koupal asked how remote sensing data can be used to help develop the distribution of high emitters in the fleet.

Dr. Rodgers stated that he is a proponent of remote sensing data. He discussed a problem that he believes is developing. He noted that over the next decade, the population of high emitters largely will be comprised of pre-OBDII vehicles from the early 90's. There will be fewer such cars, but they will be a large fraction of the high emitters. He noted that it will be difficult to model as fewer cars account for more and more of the emission inventory. In this situation, identification of the very high emitters becomes more important. However, it will be difficult to identify these vehicles as IM programs decline, as a result of more cars having OBD and States not maintaining their IM facilities. The issue is about modeling IM programs, and whether States can afford to maintain universal testing programs to catch fewer and fewer high emitters.

Mr. Tierney indicated that a significant part of the complexity of MOBILE6 comes from modeling IM. He would like not to have to build such complexity into MOVES. He noted that based on Dr. Rodger's discussion, it appears that State IM programs may become more varied. The MOVES approach to IM modeling needs to be more flexible and simpler.

Larry Caretto (California State University – Northridge) noted that States use their IM programs to generate emission inventory credits. He suggested that MOVES address only emissions, not IM program inventory credits.

A telephone participant asked whether a data-based distribution of high emitters (as opposed to modeling of IM programs) will have to be used for HD vehicles in any case, because such vehicles are not subject to IM programs. Mr. Barrett responded that Colorado has had an IM program for such vehicles for years. Other states that are pursuing IM for HD vehicles include New Jersey, Pennsylvania, and Georgia. The telephone participant stated that EPA cannot model all aspects and variations of IM programs in MOVES. He agreed with the idea of not including IM in MOVES.

Dr. Byun expressed concern with local areas that take credit for IM programs for all of the vehicle miles traveled (VMT) in the area. In truth, up to 30 percent of the VMT in the area may be vehicles that are just passing through, and are not subject to the IM program. Dr. Rodgers stated that this is not likely to be a problem—his remote sensing data in 20 States have never shown that transient vehicles have higher emissions than the local vehicles.

Mr. Tierney suggested that MOVES just needs to include the distribution of high emitters in each category. The effect of IM programs should be separate from the distribution. Mr. Barrett agreed that it probably would be good to decouple the distribution from IM program modeling. He noted, however, that in developing the distribution, EPA may be using data from all types of areas (i.e., areas with IM, OBD, and neither). Dr. Rodgers added that there are many factors that can affect the distribution of high emitters that don't have anything to do with IM, such as fleet turnover measures, etc.

Ms. Clute returned to the subject of OBD. She was concerned with the idea that EPA does not need to look into OBD response rates. She indicated that this is an important topic, regardless of how it is incorporated into MOVES. Mr. Tierney responded that this is not a concern now for pre-OBD cars, and asked why it is necessary for cars with OBD. The OBD response rate is irrelevant for pre-OBD cars; instead, the model must include the distribution of high emitters in this segment of the population. He suggested that perhaps the OBD response rate is not important for inventory modeling for newer cars either, that it may be better just to develop directly the distribution for this segment of the population as well.

Ms. Clute replied that she did not see why OBD response rate is any different from the other variables that are included in the model. Mr. Caretto stated that it does not matter how the distribution data are obtained; what is important is that the model contain the correct distribution.

Wrap-Up

The next Workgroup meeting will be scheduled around the October 2003 Subcommittee meeting. The meeting adjourned at 1 p.m.

Action Items

No action items were discussed at the meeting.

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Summary of Stakeholder and Peer Review Comments
On MOVES Planning Documentation

DRAFT June 9, 2003

Overview

In the fall of 2002 EPA published planning documentation for MOVES in the form of two reports: "Draft Design and Implementation Plan for EPA's Multi-Scale Motor Vehicle & Equipment Emission System (MOVES", and "Emission Analysis Plan for MOVES GHG". These reports subsequently underwent two paths of review: public review, in which comments were solicited from model stakeholders, and independent formal peer review, in which comments were solicited from peer reviewers paid by the Agency according to Agency peer review guidelines.

This document provides a summary of written comments received as a result of both review paths. The commenter of a specific comment is identified in parentheses, identified according to the bolded designation in the list below. Each comment number captures a unique sentiment, although variation on the general idea may have been submitted by several commenters as reflected in commenter identifications.

Comments were received from the following parties:

Public Review:

- Alliance of Automobile Manufacturers (**AAM**)
  - Review prepared by Tom Darlington, AIR
- Engine Manufacturer's Association (**EMA**)
  - Review prepared by Tom Darlington, AIR
- David **Roden**, AECOM Consult
  - Review prepared for U.S. DOT with respect to MOVES design applicability to TRANSIMS
- **U.S. DOT** – FHWA
- Peter **McClintock**, Applied Analysis
  - written comments in response to 11/2002 workshop
- Wayne Elson, **EPA Region 10**
- Donald **Stedman**, Professor, University of Denver
- **Natural Propane Gas Association / Propane Vehicle Council**
- Phyllis Jones, **North Carolina DAQ**

Formal Peer Review:

- Administered by Southwest Research Institute
- Reviewers:
  - Marc **Ross**, Professor Emeritus, University of Michigan
  - Ted **Russell**, Professor, Georgia Tech

- Michael **Replogle**, Transportation Director, Environmental Defense
- Janet **Buckingham**, Principle Analyst, Southwest Research Institute (Emission Analysis Plan only)

Comments are divided in four general areas: General, Design, Emission Analysis and Input/Output/Model Operation, with subareas defined as appropriate.

General Comments

1. **Comment:** There is not a need for the greenhouse gas version of MOVES. Current methods for estimating greenhouse gas inventories are sufficient. MOVES GHG will create unnecessary duplication with DOE. (AAM, EMA).

2. **Comment:** Should consider inclusion of indirect greenhouse gases in MOVES GHG, e.g. organic and elemental carbon and sulfur dioxide (Russell)

3. **Comment:** Policy evaluation in EPA's models is often circular, as assumed benefits of policies are built into the model (Stedman)

4. **Comment:** EPA should clarify the applicability and release plan for different "iterations" (U.S. DOT)

5. **Comment:** EPA should provide a detailed list of the differences in input data between MOBILE and MOVES GHG (U.S. DOT)

6. **Comment:** MOVES GHG raises many policy issues, including when and how to perform GHG analyses; how to interpret and apply the uncertainty estimates; which version of the model must be used for conformity; how to use the model for conformity (i.e., which analysis scale to use--countywide vs link/zone); whether to include extended idle emissions in conformity determinations; and, whether it is appropriate to use the model for microscale analyses. Has EPA considered how to address these policy issues in order to assist the transportation community in using the model? (U.S. DOT)

7. **Comment:** EPA's modular approach to the MOVES model, in general, will help to facilitate frequent updates. This may create a problem since updating planning assumptions for SIPs and TIPs require the use of the latest planning model. If EPA plans to update MOVES on a frequent basis, every time that a new version of the model is released that SIPs, TIPs will need to be updated (U.S. DOT)

8. **Comment:** If MOVES is released in Fall 2005 as a replacement to MOBILE6, a number of important policy issues will need to be addressed, and MPOs will be facing tremendous burden on data gathering and modeling efforts – particularly many new ozone nonattainment areas who will be spending a lot of time and effort to set up MOBILE6 for their conformity analysis by 2005 (U.S. DOT)

9. **Comment:** Since the model's structure and emissions calculation framework is so different from MOBILE, there will probably be a significant demand for training on how the new model actually works. Has EPA developed a training plan for users? (U.S. DOT)

10. **Comment:** Does EPA plan to provide a site for maintaining MOVES, and also for maintaining the databases? Will the system be readily modified by others and EPA itself? Is the coding going to be well documented? It would be very good if the model is developed in such a way as to be modified by groups doing research in this area, e.g. a community model such as MODELS-3. (Russell)

11. **Comment**: Is it possible to minimize the differences between MOVES and the CARB equivalent. Is it possible to get a common model? (Russell)

Design Comments

Use Cases

12. **Comment:** MOVES design "remarkably flexible" and would be relatively easy to implement in many of the wide range of use cases (Ross). The multi-scale emission estimation architecture appears sound (Replogle). The model design is well thought out, provides a sufficiently broad range of use cases, and satisfies these use cases (Russell, McClintock). MOVES is highly compatible with the level of detail and focus of TRANSIMS (Roden).

13. **Comment**: additional capabilities with regard to design are desired, as follows:
    a. Environmental justice evaluation (Replogle)
    b. Greater accommodation of use cases related to health effects and toxicity studies, e.g. modeling on 100 meter road segments or lane-specific information (Russell)
    c. Data visualization capability (Russell)
    d. Sketch modeling applications for transportation planning and traffic impacts, in collaboration with US DOT. Without this MOVES will be overly focused on policies related to vehicle technology and fuels (Replogle)
    e. "On-Road Microscale Inventory" scale to more explicitly accommodate TRANSIMS (Roden)
    f. Should explicitly include initial idle warmup emissions ad the effects of engine block heaters for cold climates (EPA Region 10, U.S. DOT)

14. **Comment:** model evaluation should be considered separately from model validation under the "model analysis" use case (Russell)

15. **Comment:** Not enough information is provided to know whether MOVES will interact with SMOKE adequately (Russell).

16. **Comment:** it would be useful to have MOVES link to transportation modeling programs such as TransCAD, EMME2, TP+ (Replogle) and PAVE (Russell).

17. **Comment:** Specific attention should be paid to the variety of use cases associated with modifying vehicle operation, such as traffic calming, mode choice, and congestion pricing (Replogle)

18. **Comment:** More detail is necessary on how the design accounts for two important sources of emissions, cold starts and high emitters (Ross)

19. **Comment:** "low-end" users are adequately served; concern is with high-end users. Will MOVES allow for sub-link analysis. e.g. spatial scale below a link (50-100 meters) in a convenient way? (Russell)

20. **Comment:** What provisions are being designed in to identify errors and do quality assurance? (Russell)

Total Activity and Operating Mode Formulations

21. **Comment:** With regard to the mathematical formulation presented in the design plan, modeling capability would be improved by using explicit models to produce what are proposed as static inputs, such as VMT, vehicle population, vehicle speed, temporal allocation of VMT and source hours parked. In general a significant investment in transportation and activity models, including TRANSIMS - by EPA, DOT and other organizations - is needed to make full use of MOVES (Replogle).

22. **Comment:** Whether mileage accumulation rates vary with vehicle age warrants some research (Replogle)

23. **Comment:** Concern that the method proposed for determining VSP bins over 12 HPMS roadway types using average speed will fail to capture growth in recent years of higher traffic speeds, the shift from lower speed arterials to higher speed freeways, and the potential for further shifts in speed distribution within roadway types (Replogle).

24. **Comment:** The user's ability to gather data on total activity should be relatively straightforward, but not so for operating modes. Operating modes may vary by region, calendar year and vehicle age, which would comprise the use of generic data derived from driving survey data (Ross). The distribution of activity by VSP bin should be validated using instrumented vehicle data (AAM, EMA)

25. **Comment**: The issue of aggregation across scales requires close attention to network specifications in mesoscale models and understanding the limitations of HPMS. This requires more attention from EPA and should be addressed as part

of a larger strategy to integrate MOVES with TRANSIMS and other tools (Replogle). Should detail limitations of HPMS (U.S. DOT). Using the same modeling approach on all three scales could result in significant problems with the macroscale inventory (AAM, EMA)

26. **Comment:** Since SHO is the key activity variable, the approach calculating SHO from speed and VMT should be verified (AAM, EMA). Concern with vehicle mileage/hours and speed and the degree to which these data will be produced satisfactorily especially for mesoscale operation (Replogle).

27. **Comment:** In order to not "seriously shortchange" an important group of users, ensure that good and easy-to-use default information, or data generation capability, be available to relatively modest users at the mesoscale (Ross). Some users may be disheartened by the potential data requirements, but the establishment of national default data to fill some gaps addresses this concern (Replogle)

28. **Comment**: More information is needed on how users would supply local travel activity data and road grade, and how it would be translated into a useable form in the model (U.S. DOT). Assuming a default grade of zero would be problematic (Replogle)

29. **Comment**: Does EPA intend to develop new driving cycles representing intersection activity? (U.S. DOT)

30. **Comment:** Does EPA intend to develop a companion intersection dispersion model to replace CAL3QHC, or re-validate CAL3 using MOVES? (U.S. DOT)

County Database

31. **Comment:** Concept of a "County Default Database" is supported, including emissions. Additional breakdowns may be required in Alaska; Tribal Default Database should also be considered (EPA Region 10)

Emission Analysis Comments

Fuel-based emission rates and inventories:

32. **Comment:** Producing fuel-based emission estimates will be useful (Russell). Fuel-based emission estimates will reduce variability (Stedman).

33. **Comment:** An alternative method for generating emission inventories would be to use fuel sales rather than VMT, and remote sensing device (RSD) data used for direct emission factors. The proposed "bottom-up" approach should be checked against top-down fuel sales data (Stedman, Russell, U.S. DOT)

Binning/analysis approach:

34. **Comment:** The binning approach is more problematic for some variables than others. VSP binning (and the use of VSP as the driving variable that determines emissions) is a good approach, but vehicle odometer would be better served through a linear function (Ross, Russell). Linear functions are preferable to binning, particularly for uncertainty estimation (Russell)

35. **Comment:** Additional binning by speed, engine displacement and odometer is recommended, as is investigation of other variables (Replogle). Where other operating variables also examined besides cycle speed (Buckingham)?

36. **Comment:** Allowing source bins to vary by pollutant is supported, to allow MOVES to be credible across a wide range of applications (Replogle)

37. **Comment:** Direct measurement of acceleration should be used in VSP calculation, rather than indirect methods (Ross). Using an aggregate statistic for acceleration/deceleration rates (e.g. "jerk") appears warranted, particularly for HC (Replogle)

38. **Comment**: Evaluations presented in emission analysis plan do not consider sensitivity to changes in control systems over the years. The approach should be analyzed by comparing two or more datasets with vehicles that use control technologies of different vintages (Ross). The proposal should be evaluated on second-by-second data from for non-Tier 1 light duty gasoline vehicles, light-duty gasoline trucks, light-duty diesel trucks, heavy-duty gasoline and heavy-duty diesel vehicles (AAM, EMA).

39. **Comment:** EPA should not rely on CO_2 performance in selection an appropriate emissions modeling approach for any group of vehicles (AAM, EMA)

40. **Comment:** The proposed binning approach based on VSP was based on Tier 1 vehicles and may not be appropriate for LEV or Tier 2 vehicles. Tier 2 vehicles no longer differentiate based on weight class, so the MOVES design should ensure that emissions are equivalent for all passenger vehicle weight categories. (AAM, EMA)

41. **Comment:** Concern that large number of VSP bins brought on by criteria that no more than 10 percent of total emissions be allowed in a given bin may have sparse emission data; was analysis performed with looser cutpoint (e.g. 15 percent)? (Buckingham)

42. **Comment:** EPA has not adequately characterized which variables are most important in explaining variability in HC, CO, and NOx emissions. These

analyses should be conducted on test data from a variety of vehicle types and technologies before selecting a binning strategy for each of these pollutants.

43. **Comment:** The "Modeling Dataset" used by NCSU uses an uneven mixture of data from onboard vehicles, twin-roll dynamometers, and single-roll dynamometers. Due to the limitations of twin-roll dynamometers and onboard instrumentation, and differences in time-alignment methods, the quality of the second-by-second data is suspect (AAM, EMA)

44. **Comment:** NCSU should have done an apples-to-apples comparison by comparing the same vehicles driven on different cycles rather than validating on an independent sampling of vehicles and cycles. In addition, NCSU used the same estimates for frontal area and rolling resistance for all vehicles in the "Modeling Dataset". The emissions correlations could have been improved by using vehicle-specific estimates for these inputs (AAM, EMA).

45. **Comment:** How will EPA estimate VSP coefficients by vehicle use type, and how will uncertainty in these values affect uncertainty of the emission results (AAM, EMA).

Use of Physical Model (PERE)

46. **Comment:** The use of both physically and empirically-based analysis is supported. Both have advantages and limitations which can be traded off (Replogle, Ross)

47. **Comment:** Engine-out emissions have become relatively stable in recent years, so modeling engine-out distinctly from tailpipe could be useful for modeling emission variability and modeling new technologies (Ross)

48. **Comment:** Calibration of physical model to empirical data should include inventory-weighted comparison (Russell). The method for calibrating the physical model has not been adequately described and requires more detail (Buckingham). Physical model provides more opportunity for "gaming", which should be managed by calibration process (Replogle).

49. **Comment:** Given the number of source and operating mode bins it would be helpful to estimate how many might be flagged as not having enough data (i.e. less than 40 seconds based on the criteria presented in the emission analysis plan) (Buckingham). Not enough analysis presented on the 40 second criteria (AAM, EMA)

50. **Comment:** What method for estimating emission rates will be used for bins with little data, but no bag data (Buckingham)? EPA currently does not plan to use the MSOD bag data (other than to "calibrate" the PERE), a huge source of EPA data which has been relied upon in developing the MOBILE series of models. EPA

should explore more options for using these data to "anchor" the MOVES model, especially for older vehicles (AAM, EMA).

51. **Comment:** EPA plans to use the PERE model to fill "data-gaps." The development work on PERE has focused on warmed-up operation from Tier 1 light duty vehicles only; therefore, this work has not progressed to the point where a decision can be made to rely on this model for this purpose (AAM, EMA).

Time Weighting of Emissions:

52. **Comment:** Weighting by time rather than be vehicle will reduce the influence of high emitters with small amounts of data (i.e. RSD) (Stedman, Ross). The one-second weighting approach proposed for MOVES is accepted as valid (Buckingham, Replogle, Russell)

Age and Odometer:

53. **Comment:** Age is a better indicator of vehicle deterioration than odometer and should be considered in MOVES (McClintock). The correlation between odometer and age is not static, and to assume so is a considerable source of uncertainty (Stedman)

54. **Comment:** More emphasis should be placed on older vehicles. It would be challenging to do an analysis of policies addressing older vehicles in MOVES unless the user provided data directly. Information on older vehicles will tend to be inaccurate and location-dependent (Ross)

Uncertainty and Sensitivity:

55. **Comment:** In general the inclusion of uncertainty is supported (Russell, EPA Region 10). How will uncertainty be used in a policy context, i.e. the application of uncertainty tolerances in determining conformity? (U.S. DOT)

56. **Comment:** The equation given for calculating uncertainty is an approximation; a more pure form would explicitly account for uncertainty and sensitivity of each term (Russell)

57. **Comment**: Monte Carlo methods for generating uncertainty are time consuming; analytical methods as proposed in the emission analysis plan are faster and can identify sensitivities (Buckingham, Russell). Use of such methods requires an assumption of normality, but this is appropriate (Buckingham).

58. **Comment:** MOVES does not address location dependence of activity or emission information well; specifically, operating mode distributions, information on older vehicles, and vehicle age distribution (Ross). Uncertainty of vehicle activity and characteristic components are not considered, and could be considerable, resulting

in serious underestimation of overall uncertainty (AAM, Replogle). Will MOVES consider uncertainty of the model computation process and the input data supplied by the user? (U.S. DOT)

59. **Comment:** The uncertainty correction for different averaging times proposed in the emission analysis plan appears justified and reasonable (Buckingham)

60. **Comment**: EPA should perform a comprehensive sensitivity analysis for the model and publish the results so this task is not left to the users.

High Emitters and Tampered Vehicles:

61. **Comment:** Representative vehicle recruitment will continue to be an issue (Buckingham). The success of using a continuous distribution to define variability in fleet will depend largely on the ability to recruit high emitters (Ross). EPA voluntary programs and IM programs tend to leave out the grossest emitters (Stedman). How will high emitter data be selected, collected and included in bins (U.S. DOT)?

62. **Comment:** The single distribution method is not recommended for characterizing high emitters, because the shape can easily be skewed, masking the true variation of normal and high emitting groups. Malfunction categories may not be easy to implement. The discrete emitter category approach is recommended (Buckingham).

63. **Comment:** EPA's proposed methods of calibrating emitter distributions in MOVES to local data contradicts its preliminary decisions on the use of IM240 and remote sensing data in developing emission rates for VSP bins (AAM, EMA).

64. **Comment:** Treatment of tampering needs to be more explicitly addressed; new surveys are needed (EPA Region 10)

65. **Comment:** The "unrepresented" distribution method is preferable because it captures I/M and other strategies as well as local data (NC DAQ)

On-Board Measurement (PEMS):

66. **Comment:** EPA should not use PEMS until data accuracy issues are resolved (AAM, EMA)

67. **Comment:** On-Board measurement may be costly and inefficient; flexibility should be retained in data collection (Ross)

Data Collection

68. **Comment:** Data proposed for MOVES GHG appears to be a good cross section of labs, companies and studies with no bias toward a particular study. The EPA MSOD format and a definitive set of units is suggested as a requirement for future studies to reduce the merging effort. Is there a recommended method for cross-checking data quality (Buckingham)?

69. **Comment:** IM240 data should not be used to determine VSP bin emission rates in MOVES until the uncertainties in fuels, test temperatures, and vehicle preconditioning are resolved or addressed. (AAM, EMA). IM240 data has fuel inconsistencies but would be sufficient as a validation tool for CO_2 data. (NC DAQ)

70. **Comment:** Use of the US06 cycle for model and inventory development, including its use for the calibration of the PERE, is inappropriate. The US06 cycle is a severe cycle and is not representative of real-world driving. We believe that the use of the US06 driving cycle in the development of MOVES would affect inventory development assessments performed using the model. (AAM, EMA)

71. **Comment**: Some vehicle classes/ages are poorly represented in the Mobile Source Observational Database (MSOD). For example, the entire Tier 1 national vehicle population over 50,000 miles is represented by only 50 vehicles, although they were tested multiple times. In addition, the MSOD apparently does not include any second-by-second data for NLEV or Tier 2 vehicles. When will this data be incorporated into the MSOD? (U.S. DOT)

72. **Comment:** Concern with using limited dataset of diesel buses to represent heavy-duty vehicles (EMA)

Remote Sensing Data

73. **Comment:** RSD can be helpful in "filling the gaps" for determining emitter distributions and deterioration with age and odometer (McClintock). Only RSD captures the gross emitters (Stedman). Remote sensing should be used if not directly, at least as a verification step (Russell).

74. **Comment:** RSD sampling is not akin to 1 second on on-board data, because the vehicle is moving relatively rapidly in the course of a 1 second RSD measurement (Ross)

Fuel Effects

75. **Comment:** Oxygenate is important for fuel economy (Stedman)

76. **Comment:** Binning fuel parameters is not a good approach. It would result in a very high number of bins; and emission response should be continuous. A better approach is to use continuous corrections within each bin (Russell)

77. **Comment**: MOVES should add the functionality to deal with fuel properties and reformulation issues, i.e. as the EPA Complex Model does (Russell)

78. **Comment:** MOVES GHG should include LPG as a fuel type (Natural Propane Gas Association / Propane Vehicle Council)

Methane

79. **Comment:** High emitters drive methane, and should be accounted for in MOVES (Stedman). Proposed methane approach likely too simplistic, should add complexity of CO_2 or criteria pollutants (Russell).

Temperature Effects

80. **Comment:** Low and high temperature effects should be included in the analysis (Russell)

Model Accuracy

81. **Comment:** CO_2 should be able to be modeled within 10 percent in average driving; the possibility of achieving anything near this level of accuracy for the criteria pollutants is unclear (Ross). Validation results of VSP and average speed bins presented in emission analysis plan (e.g. prediction of Bag 3 emissions within 10 percent, prediction of most UCC cycles within 10-20 percent) were quite good (Buckingham).

82. **Comment:** The validation results performed by EPA for HC, CO, and NOx of the UCC dataset (light duty vehicles only)—the best validation test of the VSP approach provided by the EPA—indicate that there are serious concerns with using VSP and speed to characterize HC, CO, and NOx (AAM, EMA).

General Emission-Related Comments

83. **Comment:** EPA's efforts in improving emission for MOVES should be as robust for nonroad sources as for on-road sources (AAM, EMA)

84. **Comment:** Pre-Tier 0 vehicles should be grouped up account for non-catalyst controls implemented in the 1970's (AAM, EMA)

85. **Comment:** Will EPA consider incorporating fugitive dust in the PM emission factor estimation process? (U.S. DOT) It would be worth considering (Replogle)

86. **Comment:** CO_2 is not a pollutant (AAM).

Input/Output/Model Operation Comments

87. **Comment:** MOVES should allow more sophisticated users to bypass the GUI (Russell)

88. **Comment**: It would be useful to archive calculations for efficiency, e.g. location-specific I/M results (Russell)

89. Comment: MOVES should be designed to run on operating systems other than Windows, e.g. LINUX (Russell)

90. **Comment:** Include a fast-run feature that requires few if any inputs and bypasses the standard screens (EPA Region 10)

91. **Comment:** Results should be available in various forms to help understand results, such as ratios of emissions to fuel or by model year group (Ross)

MOVES Update for FACA Modeling Workgroup

John Koupal
MOVES Team Leader
June 10, 2003

Overview

- **Implementation Plan**
- **Progress Report**
  - Emission Data Gathering
  - Default Fleet & Activity Analyses & Sources
  - Vehicle Characterization
  - Modal Binning Approach
  - VSP Analysis
  - Life Cycle Modeling
  - Advanced Technologies in MOVES

MOVES Implementation Plan

- **MOVES GHG (on-road)**
  - Draft release: Early 2004
  - Energy consumption (Total, Petroleum, Fossil), CO_2, CH_4, N_2O
  - U.S. at county level inventories 1999 forward
  - Well-to-pump (GREET) integration
- **New implementation under consideration: 2005**
  - Add Aircraft, Commercial Marine, Locomotives
- **Full on-road implementation: Fall 2005**
  - Add HC, CO, NOx, Toxics, PM, NH_3, SO_2
  - Microscale analysis capability
  - Will replace MOBILE6
- **NONROAD to MOVES: 2006**

MOVES GHG Draft Release

- **Working model**
- **Documentation**
  - Design (math formulation, database design etc.)
  - Fleet and Activity Analysis
  - Energy Consumption/Emission Analysis
  - Model Performance (results, validation)
  - GREET Integration
  - User's Guide
- **Will trigger new review period**

Emission Data Gathering

- **Adding data (mostly second-by-second) in EPA Mobile Source Observation Database from:**
  - CARB (UCC data, N_2O)
  - CRC (E-55 and other studies)
  - UC Riverside (CMEM, HD Trailer, N_2O)
  - Environment Canada (N_2O and other studies)
  - WVU (Thousands of HD chassis tests)
  - IM240 programs (Millions of vehicles)
  - NC State (on-board testing)
  - New York State (IM240 tests)
  - University of Texas
- **Expected Completion: July 2003**

Default Fleet/Activity Analyses & Sources

- **Vehicle populations and distributions**
  - Registration databases, Vehicle In-Use Survey, cert data
- **Base year VMT**
  - HPMS Highway Statistics
- **VMT allocations by time, roadway type**
  - New analysis of HPMS ATR data (EPA/ORD)
- **Driving cycles**
  - Light-duty: MOBILE6 facility cycles
  - Heavy-duty: New analysis of HD surveys (ERG); WVU cycles
- **Average speed distributions**
  - Default speed distributions developed for MOBILE6

Default Fleet/Activity Analyses & Source, cont.

- **Start activity**
  - MOBILE6 analyses based on driving survey work
- **Extended idle activity**
  - Idle regulations and recent studies
- **County-level activity allocations**
  - Based on County-level VMT develop for NEI
- **Survival rates**
  - Oak Ridge
- **VMT and sales growth**
  - Evaluating existing projections (DOE, DOT)

Vehicle Characterization

- **Source Use Types**
  - Subsets of HPMS vehicle classes
  - Grouped by differences in activity
- **Source Bins**
  - Subsets of source use types
  - Grouped by differences in emissions

Source Use Types

HPMS Vehicle Type	MOVES Use Type
Passenger car	Passenger car
Other 4-tire / 2-axle	Passenger truck Light commercial truck
Single Unit Trucks	Refuse truck Commercial truck (< 200 miles) Delivery truck (> 200 miles) Motorhomes
Combination Trucks	Commercial truck Delivery truck
Buses	Urban buses School buses Interstate buses
Motorcycles	Motorcycles

Source Bins
(fuel consumption)

Source Bin Field	Source Bin
Fuel Type	Gas, Diesel, CNG, LPG, Ethanol (E85/95), Methanol (E85/95), Gas H_2, Liquid H_2, Electric
Engine Technology	Conventional, Direct Injection, Hybrid, Fuel Cell
Model Year Group	Pre-1981, 1981-85, 86-90, 91+
Loaded Weight	< 2000 lbs, 2000-2500 lbs,...>130,000 lbs
Engine Size	< 2.0 liters, 2.1 – 2.5 liters, …> 5.0 liters

Modal Binning Approach

Fuel	Criteria Pollutants	Emission Rates	Comments
VSP & Weight Bins	VSP Bins	Gram/sec	Current proposal; hundreds of bins
Power Bins	Power Bins	Gram/sec	Significantly reduces bins
Power Bins	VSP Bins	Gram/sec	VSP better than power for criteria pollutants
Power Bins	VSP Bins	Gram/Gallon	Likely fewest number of bins

VSP Approaches

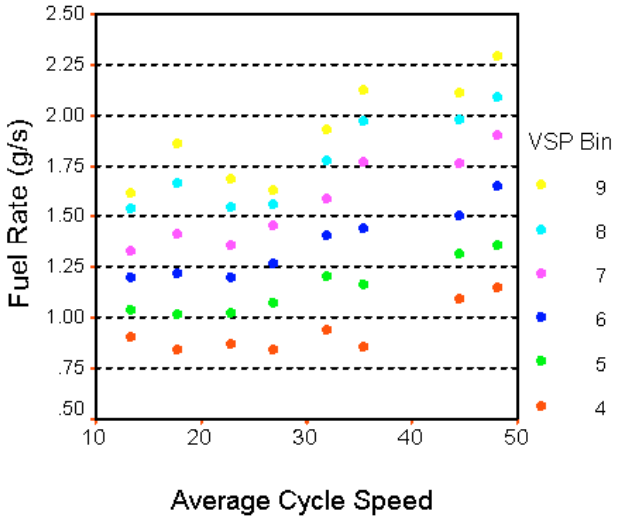
- **Jiménez-Palacios (MIT, 1999)**
  - VSP = $v*(a*(1+\varepsilon) + g*grade + g*C_R) + 0.5\rho*C_D*A*v^3/m$
  - Applied generic coefficients for light-duty:
    - VSP (kW/ton) = $v*(a*(1.1) + g*grade + 0.132) + 0.0003*v^3$
  - Can be applied to heavy-duty as well
- **CMEM / PERE**
  - VSP = $[A*v + B*v^2 + C*v^3 + m*v*(a + g*grade))]/m$
  - Use road load (A/B/C) coefficients:
    - Light-duty: derived from dyno hp target (IM240 lookup)
    - Heavy-duty: available estimates of C_r, $C_{d,}$ Frontal Area

Supplementing VSP

- **VSP by itself does not explain variability observed across full range of driving**
- **MOVES GHG Emission Analysis Plan proposed binning by average speed and VSP**
- **Limitations of binning by average speed:**
  - Doesn't address physical nature of bias
  - Requires knowing average speed of driving pattern, rather than relying on instantaneous driving only

Fuel Rate By VSP Bin and Average Cycle Speed

ARB UCC Dataset (26 1983-1998 LDV/LDTs)



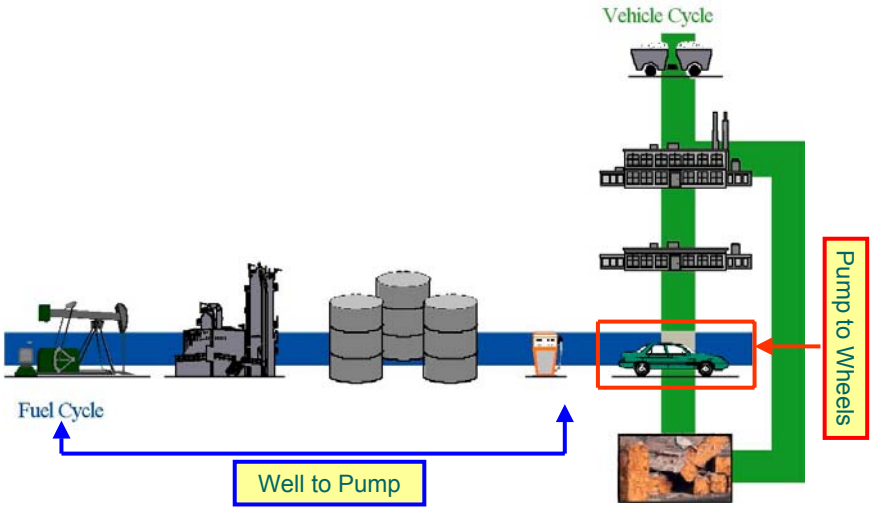
Engine Friction Investigation

- **Observed bias due to engine friction**
- **Options evaluated:**
  - Add engine friction term to VSP (CRC 2003)
    - ESP = VSP + Gamma * Speed
    - ESP = VSP + Gamma * RPM
  - Bin by VSP and (instantaneous) speed
    - NCSU (Frey et al) performed preliminary investigation
- **Results and planned course:**
  - All methods reduce bias considerably
  - Binning by VSP and speed simple, introduces less error
  - Plan to analyze light-duty and heavy-duty datasets to determine optimum VSP and speed bin definitions across pollutants

Life Cycle Analysis in MOVES

- **Joint EPA/DOE effort via Argonne Lab**
- **GREET/MOVES integration (EPA)**
  - Improve time resolution of GREET projections
  - Integrate GREET uncertainty estimates
  - Add vehicle manufacture/disposal “template”
  - Enable update to GREET inputs via MOVES GUI
- **Add several hydrogen production and storage pathways (DOE)**

Life Cycle – The Big Picture

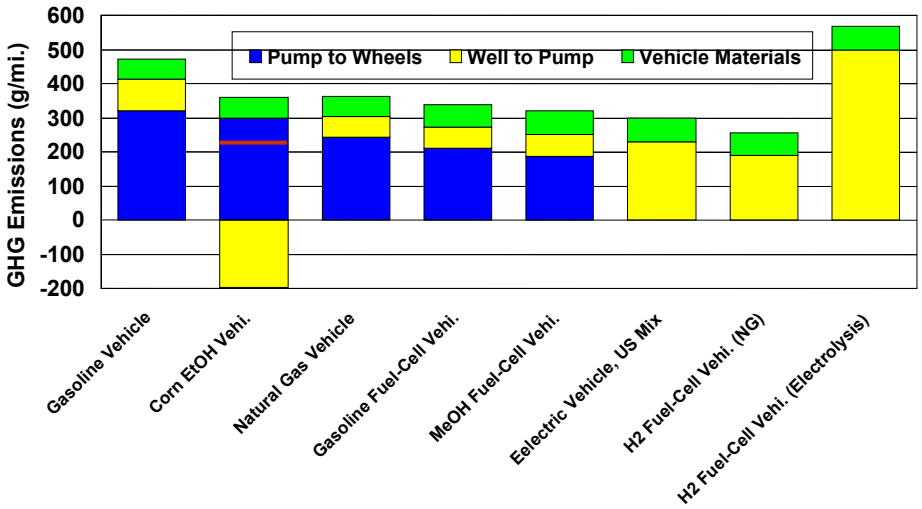


Source: Argonne National Lab

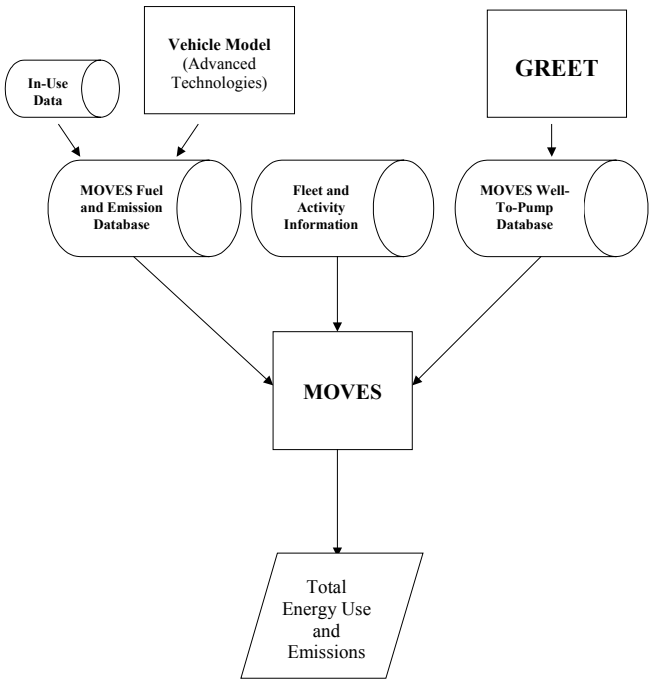
Life Cycle Analysis In A Nutshell

Source: Adrian Raeside

Accounting for Life Cycle Important For Technology Evaluation



Source: GREET, Argonne National Lab



Advanced Technologies in MOVES

- **Physical model (PERE) will be expanded to include advanced technologies (hybrid, fuel cells)**
  - Will generate fuel/emission rates for use in MOVES
- **MOVES will accommodate several hybrid and/or fuel cell configurations**
- **Alternative scenarios can be evaluated via Source Bin Control Strategy**
  - Alternative penetration scenarios
  - Additional configurations can be defined as source bins and data populated by running PERE
- **Proposed methodology to be published Fall 2003**