MOVES Review Workgroup
Final Report to Mobile Source Technical Review Subcommittee
9/27/10

Background

The Environmental Protection Agency's Motor Vehicle Emission Simulator (MOVES) is an emission modeling system used to estimate air pollution emissions from highway vehicles (and eventually nonroad mobile sources). MOVES2010 was released in December 2009, and in March 2010, EPA approved the model for use in State Implementation Plans and regional transportation conformity determinations. A minor update, MOVES2010a, was made public in September 2010.

The MOVES Review Workgroup was formed by the Mobile Sources Technical Review Subcommittee (MSTRS) in April 2007 to provide input to EPA on MOVES development. Members of the workgroup represented a spectrum of stakeholders, including vehicle and engine manufacturers, fuel producers, state and local emission modelers, academic researchers, environmental advocates, and affected federal agencies. (See Appendix A & B for the workgroup charge and membership list.)

Over the course of three years, the MOVES Review Workgroup met 15 times to review and provide comments on draft information on MOVES algorithms, data inputs (e.g., emission rates, vehicle activity, etc.), and other features. (See Appendix C for a list of meeting topics.) Notes from the workgroup meetings were distributed to workgroup members and comments on the meeting materials were compiled. EPA generally responded to comments at each subsequent meeting. Workgroup members also reviewed MOVES draft technical reports. The workgroup also developed specific recommendations (see below) and provided status presentations to the Subcommittee in May 2008 and again in October 2009. In April 2010, the workgroup compiled a final set of comments and recommendations as listed at the end of this report.

Since the release of MOVES2010, MOVES updates are continuing and, as these efforts progress, EPA will seek feedback through peer review, rulemaking comment periods, and other means. As needed, or requested, EPA will provide updates about the MOVES model to the Subcommittee, and continues to welcome feedback on MOVES from Subcommittee members. However, with the completion and release of MOVES2010, EPA's need for a formal workgroup to review model development has ended. If there is a future need to reactivate the MOVES Review workgroup or to form a new MOVES workgroup with different expertise, EPA will consider this with the Subcommittee.

Workgroup Recommendations and EPA Response

EPA has been responsive to workgroup comments and recommendations. The following table lists the key recommendations the workgroup has made at past Subcommittee meetings, and EPA responses.

Workgroup Recommendation	EPA Responses
EPA needs to plan for long-term data collection The workgroup members believe that the overall structure of MOVES is solid, providing a good deal of flexibility for a variety of mobile source emissions modeling applications. However, there is still concern that there will be significant data gaps, particularly in the initial stages of the model deployment. Because MOVES is much more of a database-oriented model (compared to previous MOBILE models), it is crucial that a data collection plan be developed to identify where the data gaps are and to prioritize how and when to collect current and future data for the model.	EPA's routine emission factor test program ended in the early 1990's and since this point research has focused on emerging issues such as gasoline PM. EPA has initiated new programs to addressing ongoing high priority needs, often in collaboration with states, CRC and others. Current projects include: -- In-use emissions study of 100-200 Tier 2 vehicles using PEMS equipment, with CRC -- Characterization of Evaporative Leak Frequency using remote sensing, with State of Colorado -- Heavy Duty drayage truck testing with PEMS in the Port of Houston, with State of Texas / Houston-Galveston Area Council
Because MOVES depends heavily on data, it is important the MOVES development team continue to seek out additional data from other research programs in other states (e.g., from the California Air Resources Board) and possibly other countries.	EPA has been able to obtain I/M and RSD data from several states to help develop MOVES, and has established Cooperative Research and Development Agreements (CRADAs) with Texas and Colorado to conduct mutually beneficial research. EPA is currently in discussion with California on such an agreement.
During the evaluation of MOVES, it is critical that mechanisms exist to obtain feedback from a variety of users, and that this feedback be incorporated into the model.	Draft MOVES2009 was released in April 2009 and underwent extensive stakeholder review (through the FACA workgroup and directly from users), and formal peer review. Hundreds of comments were received and reviewed, and many updates made to the final MOVES2010 as a result The MOVES team has regular communications with stakeholders and users, and their comments continue to shape planned improvements and updates.
During the initial evaluation phase, it is important to carry out a variety of validation exercises for the model. Outside organizations are encouraged to fund independent evaluation/validation exercises, which may include comparisons between MOVES and other mobile source emission models (e.g., older MOBILE versions, California's EMFAC model, etc.). In particular, future year predictions should be carefully compared and analyzed.	EPA has performed extensive comparison of MOVES results to independent data sets, including top-down fuel sales, in-use emission studies, remote sensing, I/M program data and roadside ambient monitoring (an article has been submitted to ES&T summarizing this work) EPA also supported an independent review of MOVES by the Coordinated Research Council (CRC –E68).
Looking back into past modeling efforts, emissions estimation problems in MOBILE have arisen due to several factors (e.g., higher than predicted speeds, SUV/truck fleet fractions, turnover rates, I/M effectiveness). There is concern that MOVES might also suffer from similar problems, therefore these and other potential problems should be examined in detail by the MOVES model development team.	EPA has used the review and independent data comparison processes to verify current MOVES estimates. The model is structured such that updates can be made more easily as new data becomes available. Through ongoing research, including cooperation with CRC, states and other stakeholders, future projections will be regularly assessed.

Workgroup Recommendation	EPA Responses
EPA needs to continue model updates after release of MOVES 2010 and to update emission rates as well as features. EPA should consider planning for annual or biennial release The MOVES development team should determine a strategy for releasing new versions well into the future. This will be challenging since not only with the model (i.e., application) change, but also the underlying database. Do these two components of the model change at the same time? Does the database get updated more often? New versions should not be released too often due to their use in the SIP process, however they should be released on a regular basis with significant improvements and new data.	In determining future updates of MOVES, EPA will continue to assess what new research is telling us, the needs of states in the SIP process, and the Clean Air Act requirement that EPA updates emission factors every 3 years.

Workgroup Final Comments and Recommendations to MSTRS (April 2010)

- The overall structure of MOVES is solid, providing a good deal of flexibility for a variety of mobile source emissions modeling applications.
- The MOVES validation and corroboration work has been helpful. EPA has compared MOVES results to a variety of independent data sets.
    - EPA should budget funds for an ongoing effort to identify areas for improvement
    - Data comparisons should be conducted by other organizations as well as U.S. EPA
- EPA needs to continue model updates.
    - EPA should update emission rates as well as features
    - In the short term, EPA needs to improve user features, reduce model run time and to update information on light duty energy consumption and gasoline fuel effects and to add additional air toxics.
    - EPA should consider planning for annual or biennial release.
        - EPA needs to balance user's need for continuity with their need to incorporate the most up-to-date understanding of emissions. New versions should not be released too often due to their use in the SIP process, however they should be released on a regular basis with significant improvements and new data.
- EPA needs to plan for long-term data collection, identifying data gaps and prioritizing data collection efforts.
    - EPA needs to budget and plan for continued data collection on vehicle emissions and activity.
    - EPA needs to seek out additional data from the private sector, academia, state research programs and other sources

Additional MSTRS Questions	EPA Response
What are EPA plans for addressing the known uncertainties in the model (e.g. fuel effects, operation at higher power, modeling of conventional hybrid and PHEV)?	For the past 3 years, EPA, DOE and CRC have collaborated on the largest evaluation of fuel effects since the Auto/Oil study in the early 1990's; this study is focused on Tier 2 vehicles. Project partners are currently analyzing these data, and we EPA plans to integrate the findings from the research as part of the anti-backsliding study required by Congress and future model updates. Data on emissions in higher power bins will be collected in our Tier 2 PEMS study, beginning this fall . Hybrid vehicles are addressed below.
What are EPA plans for scheduling new releases of the model (e.g. annual, biennial, point releases)?	Each MOVES release requires careful consideration of the policy implications and technical justification for a model change. It also requires overcoming the analysis, software and design challenges required to update the model. Because the policy climate and technical context are not easily predicted, future MOVES releases will not meet a rigid pre-determined schedule. However, EPA does plan to continuously improve the MOVES model, as we did with our recent release of MOVES2010a, and to update the model frequently enough that it continues to reflect our best understanding of vehicle emissions.
What are EPA plans for incorporating new technologies into the model as they become important (e.g. various biodiesel blends and feedstocks, ethanol blends between E10 and E-85, diesel hybrids, PHEV, transponder based I/M, etc.)?	Explicit modeling of hybrid vehicles and other vehicle technologies is not necessary for MOVES traditional uses (SIPs, conformity, EPA inventories). Our current version of MOVES does not model conventional and plug-in hybrids; rather it computes emissions for "average vehicles" for each model year and includes hybrids in the average. EPA is now anticipating what kinds of modeling will require explicit consideration vehicle technologies and is considering whether this should be designed into future versions of MOVES or developed as a stand-alone modeling tool. We do plan to update MOVES with information on E-85 and other ethanol blends. Other new technologies will be added to the model as they become important and data becomes available.

Appendix A

Mobile Sources Technical Review Subcommittee
Charge for MOVES Review Workgroup
April 2007

The MOVES Review Workgroup is a workgroup formed under the Mobile Sources Technical Review Subcommittee (MSTRS). The MOVES Review Workgroup is charged to provide input to EPA via the MSTRS and the Clean Air Act Advisory Committee on specific issues regarding the development of the Motor Vehicle Emission Simulator (MOVES). MOVES is an emission modeling system used to estimate air pollution emissions from highway vehicles and nonroad mobile sources.

The MOVES Review Workgroup shall serve as an advisory group to the MSTRS on:

1. Evaluating data sources and analysis methods proposed for use in developing **emission rates** to be used in the MOVES model.

2. Evaluating data sources and analysis methods proposed for use in developing **fleet and activity inputs** to be used in the MOVES model.

3. Evaluating data sources and analysis methods proposed for use in developing **fuel adjustments and other inputs** to be used in the MOVES model.

4. Evaluating the format of MOVES **input and output structures** and the usefulness of these formats in meeting the needs of modelers developing State Implementation Plans (SIPs) and transportation conformity determinations.

The MOVES Review Workgroup shall meet periodically over the next few years, in person and in conference calls, until the completion of the draft highway vehicle implementations of the MOVES model in late 2008, and the completion of the draft nonroad implementation, likely in 2010.

MOVES Review Workgroup members will review draft MOVES reports as they become available and shall work collaboratively to provide timely, shared recommendations to the MSTRS which will evaluate them and decide how these issues should be reported to the full Clean Air Act Advisory Committee, which alone may formally give EPA collective advice.

The MOVES Review Workgroup shall consist of members who have expertise in modeling emissions from highway and nonroad vehicles and who represent a spectrum of stakeholders, including vehicle and engine manufacturers, fuel producers, state and local emission modelers, academic researchers, environmental advocates, and affected federal agencies.

Appendix B

MOVES Review Workgroup Membership 2007-2010

Organization	**Representative**
Alliance of Automotive Manufacturers (Alliance)	Giedrius Ambrozaitis
Association of International Automobile Manufacturers (AIAM)	Bob Maxwell
American Petroleum Institute (API)	David Lax
Engine Manufacturers Association (EMA)	Tom Darlington
Coordinating Research Council (CRC)	Chris Tennant
National Association of Clean Air Agencies (NACAA)	Mike Sheehan, Chris Bovee
California Air Resources Board (CARB)	Seungju Yoon
American Association of State Highway and Transportation Officials (AASHTO)	John Zamurs
Federal Highways Administration (FHWA)	Cecilia Ho
National Resources Defense Council (NRDC)	Luke Tonachel
Environmental Defense (ED)	Michael Repogle/Vicky Patton
Cornell University	Oliver Gao
Georgia Tech	Michael Rodgers
North Carolina State University	Chris Frey
University of California, Riverside	Matthew Barth (co-chair)
EPA	John Koupal (co-chair)

Appendix C

MOVES Review Workgroup
Meeting Dates & Topics

- May 18, 2007
  - MOVES Overview
  - Fleet & Activity
  - LD Start Emissions
  - LD Running Emissions
- June 26, 2007
  - Evaporative Emissions
- Aug. 16, 2007
  - LD PM Emissions and Kansas City Program
- Sept. 18, 2007
  - Fuel Effects and Fuel Effects Testing
- Nov. 8, 2007
  - Inspection & Maintenance
- Dec. 13, 2007
  - HD Emissions
  - Temperature Effects
- Jan. 29, 2008
  - Interface with Transportation Models
  - MOVES Importers and Guidance
- Apr. 24, 2008
  - HC, CO & NOx: LD Tier 2 and Future Emissions
  - Filling High VSP bins
  - LD Particulate Matter
  - Run-time issues
- Oct. 27, 2008
  - Air Toxics and HC Speciation in MOVES
  - Emission Rates for MOVES -- HC and NO_x emissions from LD
  - E10 and E85 Emission Effects in Draft MOVES
  - Longitudinal Test Program for MOVES using RSD and PEMS
- Dec. 15, 2008
  - HD rates in MOVES
    - HC, CO & NOx
    - PM
    - Tampering & Mal-maintenance
  - Crankcase emissions
- April, 28 2009
  - Draft MOVES2009 release
  - Project Domain Manager

- July, 28 2009
  - Initial EPA validation results: Comparisons to Georgia remote sensing data (RSD)
  - Workgroup member comments on Draft MOVES2009
- Sept. 14, 2009
  - Additional validation results with comparisons to:
    - Chicago I/M data
    - Chicago RSD
    - Atlanta RSD (refined)
  - Likely changes in emission rates for final
  - Plans for draft and final guidance documents
  - Update on new fuels code
  - Workgroup member comments on technical reports
- Nov. 10, 2009
  - Final plans for the model
  - Preliminary final results
- April 26, 2010
  - MOVES2010 results and comparisons
  - Next steps for MOVES
  - Reporting to MSTRS