MOVES Review Work Group Update

October 14, 2021

Work Group Co-Chairs

Dr. Matthew Barth
Director, Center of Environmental Research and Technology
Yeager Families Professor, University of California-Riverside

Megan Beardsley
Leader, MOVES Team
EPA Office of Transportation & Air Quality

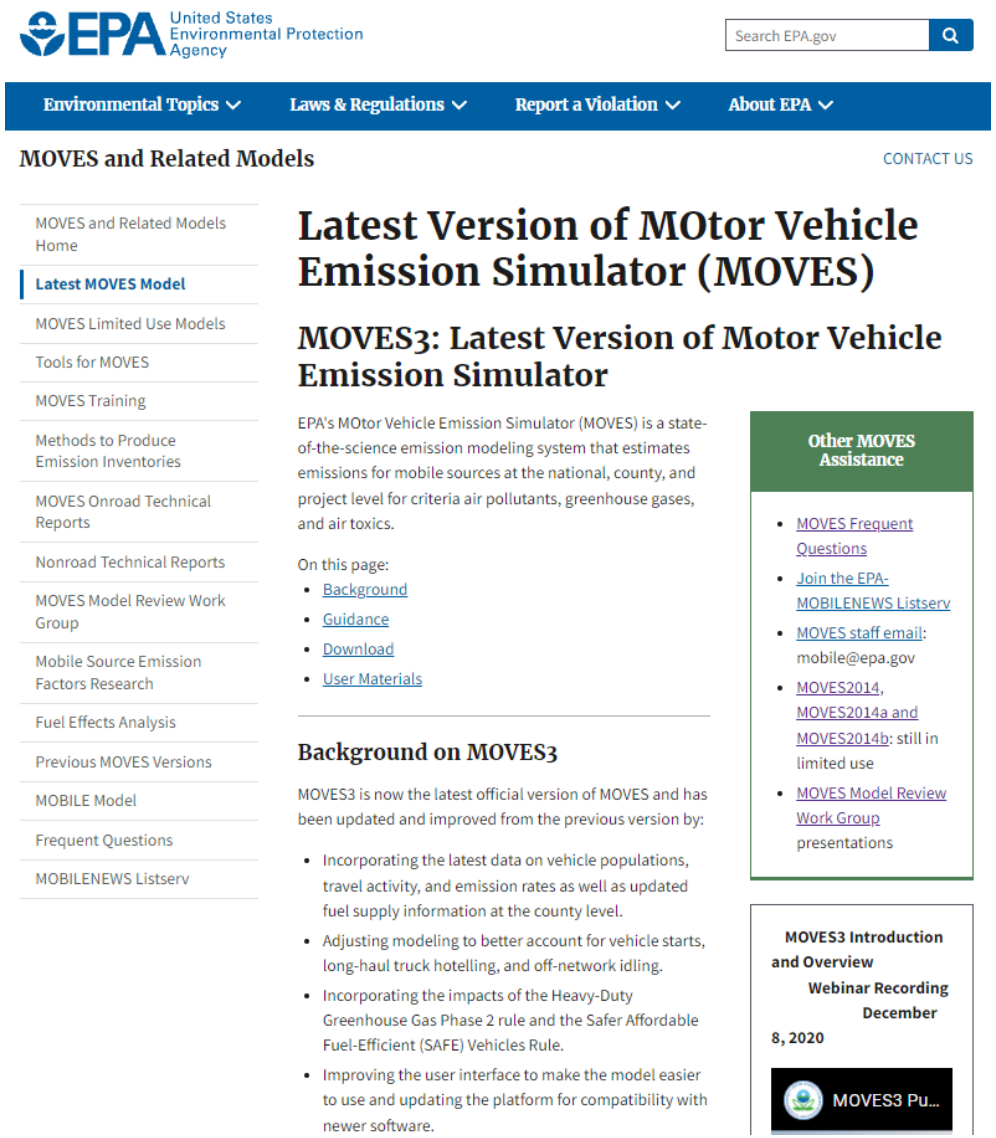
EPA MOVES Model

- U.S. EPA's **Mo**tor **V**ehicle **E**mission **S**imulator estimates emissions and energy use from
  - Onroad vehicles: passenger cars, light- and heavy-duty trucks, buses, motorcycles
  - Nonroad equipment: construction, agricultural, industrial, lawn & garden, commercial, logging, airport support, oil & gas, mining, railroad service, recreational vehicles and boats
- MOVES accounts for national emission standards, vehicle populations and activity, local rules, fuels, and meteorology
- EPA uses MOVES to estimate emission impacts of mobile source emissions regulations and policies and to generate national inventories of air pollutants
- State and local agencies use MOVES to prepare emission inventories for state implementation plans and transportation conformity
- MOVES is also used in academic research and to model effects of policy choices

MOVES
Motor Vehicle Emission Simulator

Current MOVES Status

- MOVES3 released November 2020
  - Overview Report summarizes model updates and results
  - Onroad and Nonroad Technical Reports provide details on technical inputs
  - Guidance and Training and In Box support help modelers use MOVES well
  - Minor “patches” distributed March and September 2021
  - Now being used to develop mobile source emission estimates for the 2020 NEI



MOVES Review Work Group

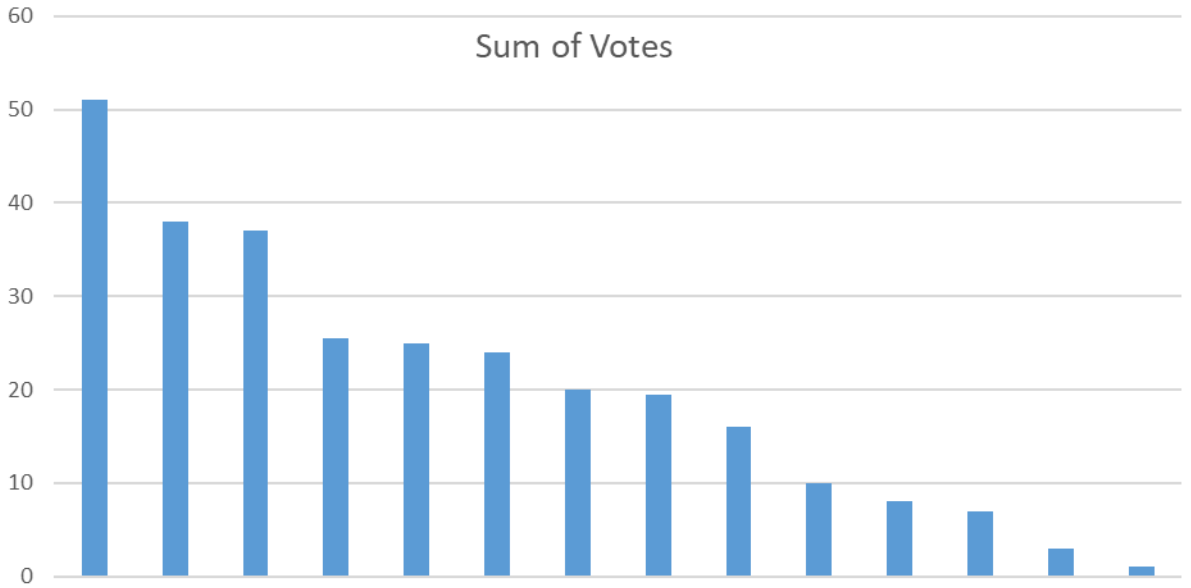
- Created by MSTRS to provide input on the development of MOVES
- Members have expertise in modeling emissions from highway and nonroad vehicles and represent a wide spectrum of stakeholders
- Met from September 2016 to September 2021
- Meeting notes and presentations available at https://www.epa.gov/moves/moves-model-review-work-group
  - EPA presented planned updates to MOVES, including underlying data and analyses
  - Work group members and other experts also shared relevant information.
- The work group developed recommendations to the MSTRS based on the proceedings of work group meetings
  - Most of the group's short-term recommendations have already been incorporated into MOVES3.

Work Group Members

Name	Home Organization	Representing Organization
Matthew Barth	University of California, Riverside (CE-CERT)	University of California-Riverside (CE-CERT); Work Group Co-Chair
Megan Beardsley	EPA OTAQ	EPA; Work Group Co-Chair
Elena Craft	Environmental Defense Fund (EDF)	EDF
Tim French	Engine Manufacturers Association (EMA)	EMA
Mike Geller	Manufacturers of Emission Controls Association (MECA)	MECA
Gil Grodzinsky	Georgia Department of Natural Resources	Association of Air Pollution Control Agencies (AAPCA)
Michael Hartrick	Alliance for Automotive Innovation	Alliance for Automotive Innovation
Cecilia Ho	Federal Highway Administration (FHWA)	FHWA
Britt Holmen	University of Vermont	University of Vermont
Jeremy Hunt	Northeast States for Coordinated Air Use Management (NESCAUM)	NESCAUM
Mark Janssen	Lake Michigan Air Directors Consortium (LADCO)	LADCO
Andrew Kotz	National Renewable Energy Laboratory (NREL)	NREL
David Lax	American Petroleum Institute (API)	API
Sam Pournazeri	California Air Resources Board (CARB)	CARB
Lubna Shoaib	East-West Gateway Council of Governments	Association of Metropolitan Planning Organizations
Jenny Sigelko	Volkswagen of America, Inc.	Coordinating Research Council (CRC)
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
Dale Wells	Colorado Department of Public Health and Environment	National Association of Clean Air Agencies (NACAA)
Wei Zhang	Idaho Department of Environmental Quality	NACAA

Recommendation Prioritization

- Work group members suggested recommendations for future MOVES development in discussion and email.
- The co-chairs compiled these into a list of 14 recommendations.
- Work group members then voted for their top five priorities.



#1

Improve modeling of energy use and direct emissions from vehicles using **alternative fuels and technologies,** by compiling emissions, activity, and vehicle characteristics of, for example:

- battery electric,
- hybrid electric,
- hydrogen fuel cell,
- natural gas, and
- propane

#2

Update modeling of exhaust emissions from **conventional (diesel and gasoline) heavy-duty vehicles** in MOVES, such as:

***Activity* –** Incorporate latest heavy-duty vehicle project data sets, modify operating modes, and better account for road grade and changes in vehicle mass and road load.

***Emissions* –** Update with latest real-world data, including starts. Account for new regulations, including California's Advanced Clean Truck program.

***Adjustments* –** Better account for tampering and diesel I/M programs. Better account for biodiesel fuels.

***Speciation* –** Better account for secondary organic aerosol (SOA)-precursors and ultra-fine particles.

#3

Update modeling of exhaust emissions from **conventional (gasoline and diesel) light-duty vehicles** in MOVES, such as:

***Activity* –** Make use of large vehicle activity datasets that are becoming increasingly available (e.g., connected and automated vehicle data sets, vehicle telematics) to improve driving cycles, starts activity and other defaults. Better account for road grade and changes in vehicle mass and road load.

***Emissions* –** Collect more data on light-duty starts, including particulate matter and LD diesel. Improve IM and non-IM emission rates for GDI and Tier 3-and-later vehicles. Account for new regulations such as EPA's August 2021 proposal on new GHG standards for passenger cars and light trucks.

***Adjustments* –** Update air conditioning effects. Account for role of lubricating oil with respect to particle emissions. Update default fuel properties and fuel property effects, including those related to ethanol and aromatics.

***Speciation* –** Better account for secondary organic aerosol (SOA)-precursors and ultra-fine particles

#4

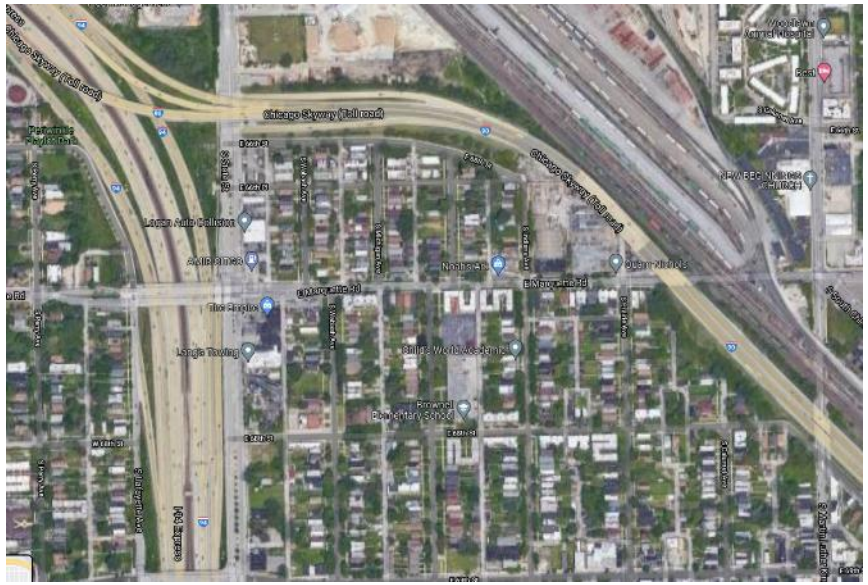
Improve how MOVES **works with other models and tools** (SMOKE, GREET, VISSIM, AERMOD, etc.), for example:

- Develop, test, and document best practices.
- Provide software tools and application programming interfaces (APIs).
- Facilitate Life-Cycle Analysis for electric vehicles and GHGs.
- Simplify source types to better align with FHWA vehicle categories.
- Allow additional user inputs such as vehicle load or weight.

#5

Improve MOVES capabilities for **community-scale modeling and equity analysis**, for example:

- Expand on existing project-level guidance to estimate emissions at the community level;
- Develop and testing techniques such as Automated License Plate Readers to estimate vehicle mix and activity at the sub-county level;
- Develop MOVES-based tools for equity or environmental justice analyses, or to support other EPA tools such as EJSCREEN, COBRA, etc. that require mobile source emissions input.



#6

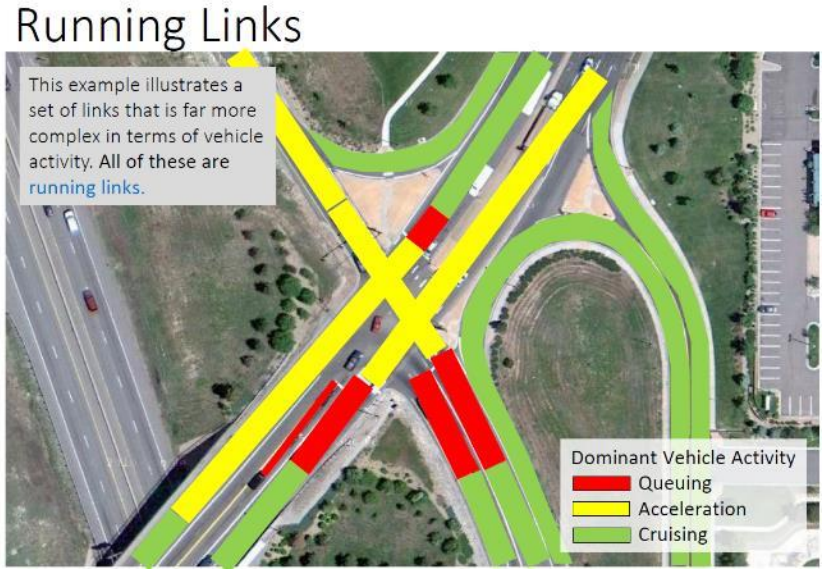
Update modeling of **nonroad equipment**, such as:

- Replace with a modern software design that is easy to update.
- Update nonroad equipment populations and emissions.
- Account for battery-electric equipment and other alternative technologies.
- Account for possible altitude effects.

#7

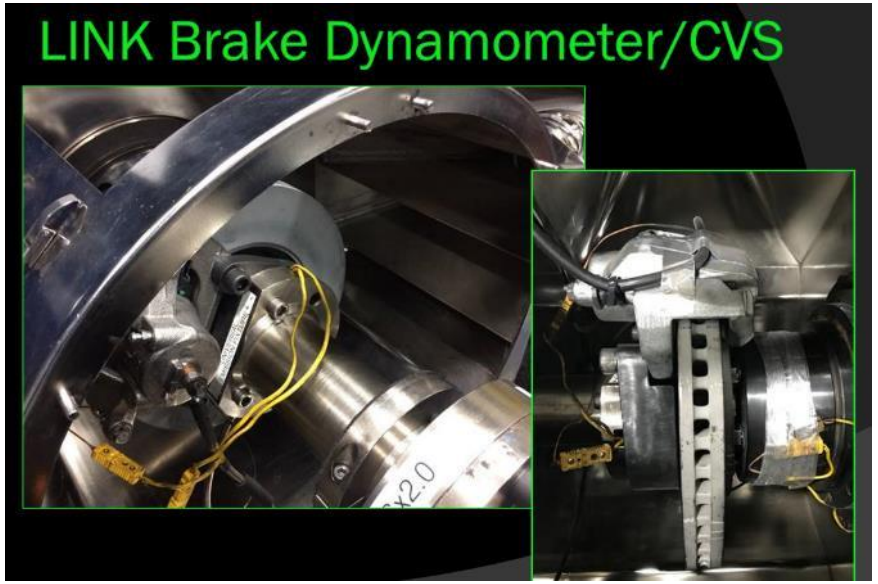
Improve MOVES capabilities for **project level analyses**, for example:

- Improve linkages with traffic models and dispersion models.
- In documentation and/or code, limit modeling of road grades to realistic levels.
- Continue improving the MOVES Ramp Tool and create similar tools for acceleration and deceleration links for congested (arterial street) intersections.
- Consider adding libraries of vocational duty cycles.
- Make vehicle load a user input variable in MOVES.
- Add tools to help model project level activity, such as tools to calculate travel fraction by age or model year.
- Provide default values for inputs required by regulation (e.g. fuel properties).
- Improve interface to facilitate selection of correct pollutants & processes for PM, CO, or air toxics analysis.
- Improve interface with AERMOD.



#8

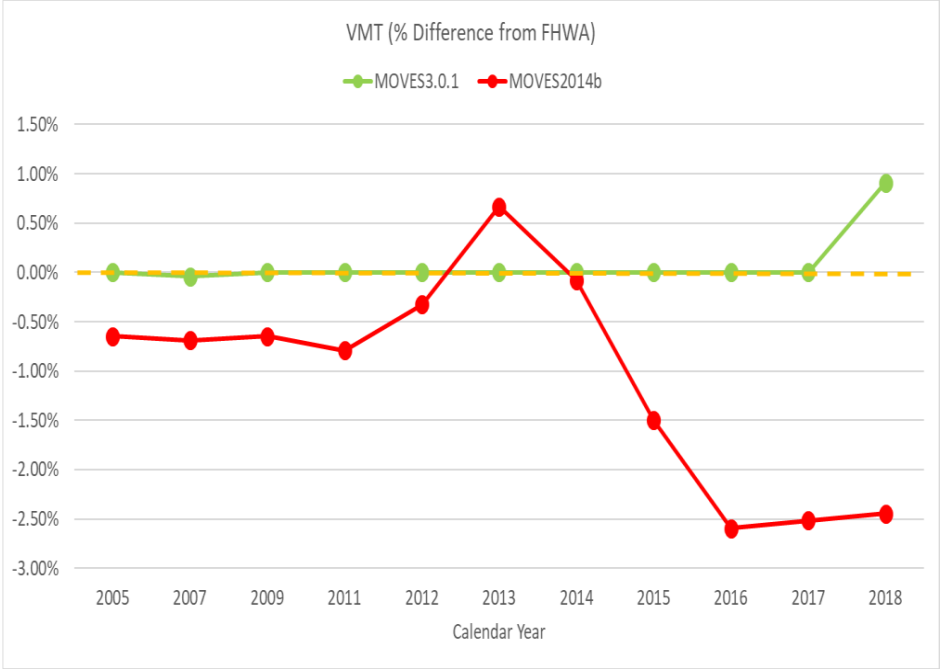
Update modeling of brake and tire wear particulate emissions from conventional, electric, and other alternative vehicles—both heavy duty and light-duty. Consider incorporating the calculations of road dust from AP-42 into MOVES.



#9

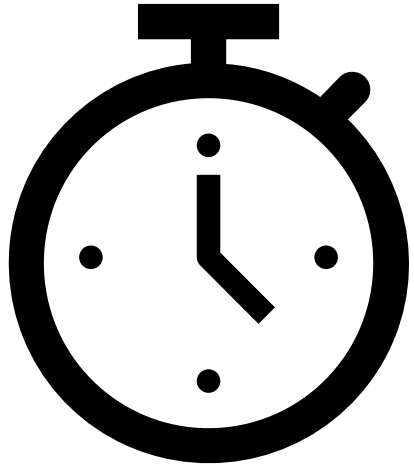
Better **evaluate MOVES accuracy and applicability** through analyses such as:

- Comparisons to real-world data, including grade and speed effects.
- Comparisons with California's EMFAC model, including results, projections, and policy implications.
- With FHWA, create a Transportation Pooled Fund Study that would work with state DOTs and FHWA on assessing uncertainty for the entire project level modeling chain. Involve EPA emission modeling and dispersion modeling staff.



#10

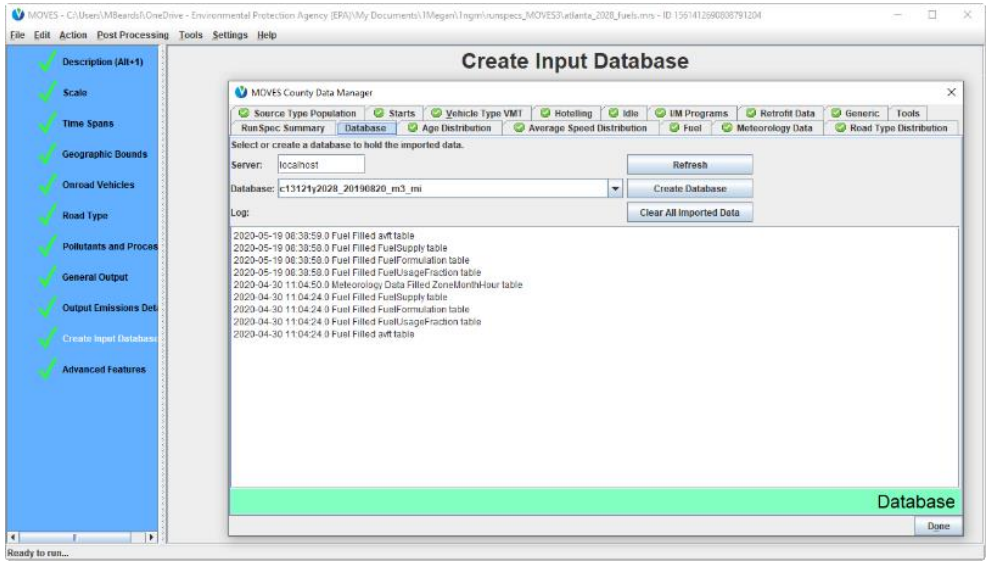
Incorporate new options to **reduce processing time**: e.g., consider pre-calculating look-up tables for cities or regions (e.g., MOVES MATRIX) or converting additional modules to faster languages like Go.



#11

Improve the user interface for inputs and outputs, for example:

- Consider different graphical user interfaces for different uses.
- Provide explicit output of diesel particulate matter.
- Provide a “start per vehicle” input as in MOVES2014b.
- Allow “custom domain” modeling as in MOVES2014b.
- Allow additional user inputs such as vehicle load and weight.
- Allow finer day of the week detail (not just weekend day and weekday).
- Streamline the export of default data for county databases.
- Enable use of the same project and county databases when changing evaluation years in a runspec.
- Create a “Scenario Manager” to allow users to better manage modeling multiple runs, compare incremental results, and automate post-processing (e.g. for emission rates).



#12

Improve MOVES ability to model emissions from **automated and connected vehicles**, e.g. through refined operating mode bins or incorporating a true modal emissions model.

#13

"Write In" recommendations:

We offered members the opportunity to "Write In" a recommendation if they felt the options listed on the ballot did not capture their highest priorities.

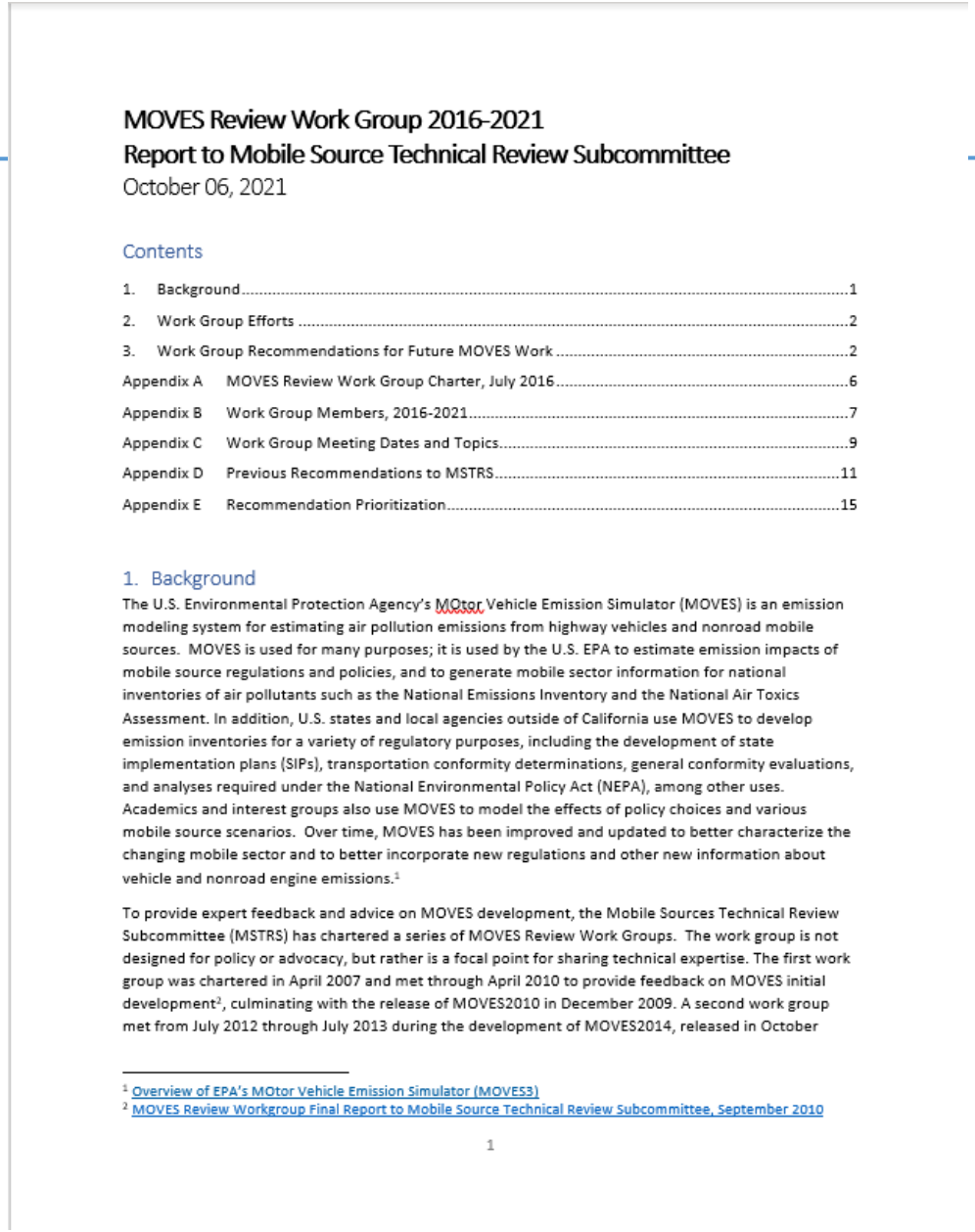
> Steven Vander Griend wrote in: *Mobile Sources Technical Review Subcommittee (MSTRS) comprises of approximately 30 technical experts drawn from a wide range of stakeholder organizations. The MOVES Model Review Work Group also list multiple outside members but past meetings clearly show EPA controls the direction and decisions of this group. More transparency is needed in future work groups.*
>
> Chris Voigt wrote in: *Work with US DOT and state DOTs on development of tool for specifying links for intersections for project-level modeling.*

#14

Improve software **installation and update processes.** For example, provide test files that users can run to ensure that they have MOVES installed correctly and are generating valid results.

Final Report

- The MOVES Review Work Group has created a final report that lists these 14 recommendations.
- The report also describes the work group charter and membership, lists all the work group meetings and presentations, and summarizes previous communication with MSTRS.
- The report was shared with MSTRS members last week.



MOVES Review Work Group 2016-2021
Report to Mobile Source Technical Review Subcommittee
October 06, 2021

Contents

1. Background

The U.S. Environmental Protection Agency's MOtor Vehicle Emission Simulator (MOVES) is an emission modeling system for estimating air pollution emissions from highway vehicles and nonroad mobile sources. MOVES is used for many purposes; it is used by the U.S. EPA to estimate emission impacts of mobile source regulations and policies, and to generate mobile sector information for national inventories of air pollutants such as the National Emissions Inventory and the National Air Toxics Assessment. In addition, U.S. states and local agencies outside of California use MOVES to develop emission inventories for a variety of regulatory purposes, including the development of state implementation plans (SIPs), transportation conformity determinations, general conformity evaluations, and analyses required under the National Environmental Policy Act (NEPA), among other uses. Academics and interest groups also use MOVES to model the effects of policy choices and various mobile source scenarios. Over time, MOVES has been improved and updated to better characterize the changing mobile sector and to better incorporate new regulations and other new information about vehicle and nonroad engine emissions.[1]

To provide expert feedback and advice on MOVES development, the Mobile Sources Technical Review Subcommittee (MSTRS) has chartered a series of MOVES Review Work Groups. The work group is not designed for policy or advocacy, but rather is a focal point for sharing technical expertise. The first work group was chartered in April 2007 and met through April 2010 to provide feedback on MOVES initial development[2], culminating with the release of MOVES2010 in December 2009. A second work group met from July 2012 through July 2013 during the development of MOVES2014, released in October

[1] Overview of EPA's MOtor Vehicle Emission Simulator (MOVES3)
[2] MOVES Review Workgroup Final Report to Mobile Source Technical Review Subcommittee, September 2010

1

Requested Action from MSTRS

The MOVES Review Work Group requests that MSTRS approve the final report and the work group recommendations and forward them both to the Clean Air Act Advisory Committee for CAAAC consideration.