Frequently Asked Questions (FAQs): FHWA Recommendations for Conducting Quantitative Mobile Source Air Toxics (MSAT) Analysis for FHWA NEPA Documents

This document provides detailed Federal Highway Administration (FHWA) recommendations on how to conduct a quantitative MSAT analysis using the U.S. Environmental Protection Agency's (EPA) MOtor Vehicle Emissions Simulator (MOVES) model. This document provides information on how FHWA recommends that project sponsors can use MOVES for National Environmental Policy Act (NEPA) MSAT analysis including: a) defining the scope of MOVES work; b) gathering input data; and c) post-processing results. All references to MOVES are for MOVES3unless otherwise noted. These are insights based on our experience in conducting quantitative MSAT analysis and questions received. The FHWA recommends reviewing the EPA MOVES user documents and tools posted at: https://www.epa.gov/moves.

Q. 1) What information will I need to prepare?

A. 1) The first thing you need is a plan that scopes out the analysis. Questions to ask include:

What pollutants am I modeling?

What years and seasons am I modeling?

How do I set up the run specification (RunSpec)?

What input data do I need?

What inputs vary by year? By season? By time of day? By alternative?

What traffic and other data do I need to develop the inputs?

Q. 2) How do I define the affected environment?

A. 2) NEPA documentation should focus on the impacts of the proposed project on the affected environment. Traffic analysis normally performed for NEPA (purpose and need, scope, design, etc.) should be the basis of the MSAT analysis and defining the affected environment. MSAT analyses are intended to capture the anticipated changes in emissions within an affected environment, defined as the transportation network directly affected by the project. Analyzing MSATs only within a geographically-defined "study area" will not capture the emissions effects of changes in traffic on roadways outside of that area, which is particularly important where the proposed project would create an alternative route or divert traffic from one roadway class to another. At the other extreme, analyzing a metropolitan area's entire roadway network will result in emissions estimates for many roadway links not affected by the project, diluting the results of the analysis.

The FHWA recommends analyzing all segments associated with the project, plus those segments expecting meaningful changes in emissions due to the project (e.g., ± 10 percent or more). Define the affected network based on available project-specific information in the environmental document's traffic analysis, considering changes in such metrics as:

± 5 percent or more in annual average daily traffic (AADT) on congested highway links of level of service (LOS) D or worse;

± 10 percent or more in AADT on uncongested highway links of LOS C or better;

± 10 percent or more in travel time; or

± 10 percent or more in intersection delay.

These recommendations are not a substitute for project-specific knowledge and consideration of local circumstances. For example, if traffic modeling shows that some low-volume links far removed from the project area show a meaningful change in traffic, one would have to consider whether this is a real effect, or a modeling artifact. Likewise, when analyzing a project that has no meaningful alternative routes (e.g., upgrading an isolated river crossing), it may not be necessary to evaluate traffic changes on other routes. Any such deviation from these recommendations should include documentation in the project file explaining what segments were included or excluded from the affected area and why.

Q. 3) What inputs will I need for an MSAT emissions analysis using MOVES?

A. 3) Since MOVES analysis involves many individual input and output files, good file organization is very important. It is helpful to start by establishing a file structure and naming conventions. The FHWA recommends that you develop a master checklist of inputs needed for each run, and define what each run will address, and what files will be needed for input data and outputs. The following table is one example. Some input spreadsheets may be used for all runs, some are specific to each calendar year, and some are specific to individual alternatives. These variations are discussed in more detail in the County Data Manager Template under Question 9. Also, while an input database is needed for each run, modelers have the option of defining an output database for each run (shown here) or using the same output database for multiple MOVES runs. The key is to establish a written "roadmap" of all the related files, so that they can be easily referenced to develop summary information for the NEPA document, and so that reviewers can follow how you conducted the analysis.

2020 Base Year No Action run

Input database: 2020_NA_in; Output database: 2020_NA_out	
Input:	**Spreadsheet data file:**
Age distribution	Age_allruns.xls
Sourcetype population	Population_2020.xls
I/M	IM_2020.xls
Fuel: Fuel Supply	Fuel_Supply_2020_.xls
Fuel: Fuel Formulation	Fuel_Formulation_2020.xls
Fuel: Fuel Usage Fraction	Fuel_Usage_Fraction_2020.xls
Fuel: AVFT	Fuel_AVFT_2020.xls
Vehicle Type VMT: **HPMS or MOVES Source Type Annual** **VMT**	VMT_HPMS2020_NA.xls or VMT_SourceType_2020_NA.xls
Vehicle Type VMT: Month VMT Fraction	VMT_monthvmtfraction_2020_allruns.xls
Vehicle Type VMT: Day VMT Fraction	VMT_dayvmtfraction_2020_allruns.xls
Vehicle Type VMT: Hour VMT Fraction	VMT_hourvmtfraction_2020.xls
Speed distribution	Speed_2020_NA.xls
Road type distribution	Roadtype_2020_NA.xls

Q. 4) Where do I get the data?

A. 4) Coordinating with other local agencies to see if relevant input data has already been developed is the best way to start. Other agencies in the project area (the metropolitan planning organization (MPO), State department of transportation (State DOT), and/or State air agency) may have already developed data for some of the necessary MOVES inputs. For example, the State DOT may have developed an age distribution, the MPO may have developed future source population estimates and hourly vehicle miles travelled (VMT) distributions, and the State air agency may have developed fuel and inspection/maintenance (I/M) inputs that substitute for model defaults. Early coordination with the project team can help identify these sources of input data and avoid repeating work that some other group has already completed.

Q. 5) How do I develop and perform quality assurance (QA) on the input spreadsheets?

A.5) In FHWA's experience, most cases of incorrect or counterintuitive MOVES results are explained by input errors. Thus, it is worthwhile to QA and test a sample of MOVES input data before conducting many MOVES runs that may have to be repeated if an error in the input data is found.

First, develop a set of spreadsheet inputs for one MOVES run and test them. Create the necessary RunSpec and import the input data using the County Data Manager (it's good to label this run as a Test run to avoid later confusion). Find and resolve any error messages that appear in the County Data Manager as you're importing data. For this run, you can also obtain results by Fuel Type, Emission Process, Road Type, and Source Use Type by choosing options provided in Output Emissions Detail panel, which can help in troubleshooting problems.

Execute the RunSpec and QA the output. Are all pollutants, emission processes, road types, etc. that you requested in the RunSpec included in the output? Did you get "0" for any emissions? Do the distance outputs agree with your VMT inputs (e.g., does the annual VMT you entered along with the month and day VMT fractions give you the same daily VMT you started with)?

If everything looks OK, then develop the spreadsheet inputs for the remainder of the runs.

Additional QA checks:

- Related spreadsheets should each have the same number of rows and file size;
- Check that distributions that should sum to one, do sum to one; and
- Carry out reality checks on spreadsheets and raw data: Does VMT triple between No Action and Build? Is 30 percent of traffic moving at 2.5 mph? Do we have motorcycle VMT in the winter, or twice as much heavy-duty vehicle VMT as car VMT?

Q. 6) What is recommended for MOVES RunSpecs and inputs for MSAT analysis?

A. 6) FHWA's recommendations for a MOVES RunSpec and data inputs are contained in the two tables at the end of this document. This FAQ provides some additional explanation on specific elements of the analysis. For more information on developing MOVES RunSpecs and data inputs, FHWA recommends reviewing the MOVES User Materials posted at https://www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves#materials.

In March 2021, EPA released MOVES3. Recommendations in this FAQ are applicable to MOVES3unless specifically noted.

MOVES Domain/Scale and Calculation Type: County, Inventory:

The FHWA recommends using MOVES at the County scale for quantitative MSAT analysis. The County scale refers to a method of operating MOVES and does not imply that an entire geographic county is being modeled. The County scale requires area-specific input data, which is conducive to developing MSAT emission inventories for the affected transportation network or affected environment of a proposed project in the NEPA context. The County Data Manager tool for importing data provides important error-checking capabilities, and can export defaults for some inputs where local data won't be used.

The default scale relies on national average data that may not reflect conditions in the project area, and is not recommended for quantitative MSAT analysis. The project scale requires link-level input data. It is possible to use MOVES at the project scale to develop MSAT emission inventories by entering data for all links in the affected transportation network directly rather than pre-processing these data to produce the input data distributions required to operate MOVES at the County scale. However, operating MOVES at the project scale requires more runs, requires more post-processing in spreadsheets, and is more cumbersome to troubleshoot.

The FHWA recommends selecting the Inventory Calculation Type because MOVES runs faster and MOVES output can be used directly to produce reports for most MSAT pollutants to include in NEPA documentation. The MOVES Rates Calculation Type requires more post-processing in spreadsheets, takes longer to run, and is more cumbersome to troubleshoot.

Representing annual emissions

Since FHWA guidance is based on addressing the priority MSAT from EPA's 2011 National Air Toxic Assessment of chronic health exposure, the analysis should reflect annual emissions accounting for temporal changes (i.e., by hour, day, month, and season, as appropriate) in traffic, meteorology, and fuels during the year. Contact FHWA to request technical assistance, if needed.

Vehicles/equipment

By default, MOVES allocates a portion of VMT to source use types that can utilize compressed natural gas (CNG) and E85 fuels. In addition to all the source use types that can utilize gas and diesel fuels, Source use types that utilize CNG and E85 fuels need to be modeled. If there are none of these source use types utilize CNG or E85 in the area, they do not need to be selected, but inputs are needed for Alternative Vehicles, Fuels, and Technologies (AVFT) in the County Data Manager specifying no VMT for these source use type/fuel types for all model years. MOVES3 includes Electricity as a fuel type, however there are no VMT associated with Electricity in the default AVFT therefore the Electricity fuel type do not need to be selected.

Pollutants and processes

For most highway projects affecting vehicle activity on the network, FHWA recommends that quantitative MSAT emissions analyses reflect only emissions process that occur on the roadway including running exhaust, crankcase running exhaust, evap permeation, and evap fuel leaks (processID = 1, 15, 11, 13). The other emission processes from vehicles do not occur on roadways. For major intermodal freight facilities, off-network vehicle activity may need to be characterized in MOVES along with any significant number of new trips occurring on the network. For these projects, off-network emission processes, such as start, extended idle, and evap components, should also be reflected in the quantitative MSAT emissions analysis. Contact FHWA to request technical assistance, if needed.

The MSAT RunSpec Template under Question 9 indicates which pollutants to model to capture the 9 MSATs listed in FHWA's interim guidance.

Diesel particulate matter (Diesel PM) emissions are not computed as a separate pollutant species in MOVES. They are represented by selecting Primary Exhaust PM10 — Total for diesel fuel vehicles only (not gasoline vehicles). To calculate diesel vehicle PM10 exhaust, there are two options: 1) conduct separate MOVES runs with *only* Diesel Fuel vehicles selected in the Onroad Vehicles panel (recommended—note that the VMT inputs do not change, since MOVES will ignore VMT from other vehicles), or 2) model PM10 exhaust with the rest of the MSATs, and with "Fuel Type" selected in Output Emissions Detail. Note that this latter approach will double the size of the output for all pollutants, or triple it if CNG is modeled. Use results reported in the MOVES output for Primary Exhaust PM10 — Total (pollutantID = 100), for diesel fuel vehicles (fueltypeID = 2), and for running exhaust and crankcase running exhaust processes (processID = 1 and 15) depending on the Output Emissions Detail options selected. Be aware that MOVES requires prerequisite pollutants to be selected to model Primary Exhaust PM10 — Total and these results will also be included in the MOVES output. These can be selected with the "Select Prerequisites" button and include Primary Exhaust PM2.5 — Total and the Primary Exhaust PM2.5 — Species of Composite — NonECPM, Elemental Carbon, H2O (aerosol), and Sulfate Particulate (pollutantID = 110, 118, 112, 119, 115).

The POM (polycyclic organic matter) is not as an individual "pollutant" in MOVES and can be modeled by selecting the Polycyclic Aromatic Hydrocarbons (PAH) pollutant under the Pollutants and Processes panel. To calculate emissions of POM the emissions from the following individual pollutants need to be summed together. Please note that naphthalene gas and naphthalene particle are not included as POM when summing the emissions together but is still be selected to be modeled.

Pollutant ID	Pollutant Name	Pollutant ID	Pollutant Name
68	Dibenzo(a,h)anthracene particle	168	Dibenzo(a,h)anthracene gas

69	Fluoranthene particle	169	Fluoranthene gas
70	Acenaphthene particle	170	Acenaphthene gas
71	Acenaphthylene particle	171	Acenaphthylene gas
72	Anthracene particle	172	Anthracene gas
73	Benz(a)anthracene particle	173	Benz(a)anthracene gas
74	Benzo(a)pyrene particle	174	Benzo(a)pyrene gas
75	Benzo(b)fluoranthene particle	175	Benzo(b)fluoranthene gas
76	Benzo(g,h,i)perylene particle	176	Benzo(g,h,i)perylene gas
77	Benzo(k)fluoranthene particle	177	Benzo(k)fluoranthene gas
78	Chrysene particle	178	Chrysene gas
81	Fluorene particle	181	Fluorene gas
82	Indeno(1,2,3,c,d)pyrene particle	182	Indeno(1,2,3,c,d)pyrene gas
83	Phenanthrene particle	183	Phenanthrene gas
84	Pyrene particle	184	Pyrene gas

Q. 7) What Post-MOVES QA is needed?

A. 7) After the MOVES runs are complete it is important to QA and interpret output:

- Check file size and number of rows in output—related runs should have the same size output.
- Check for and investigate cases where emissions = 0.
- Some QA questions may include:
  - Do the emissions trends make sense?
  - Are there any obvious outliers?
  - Can you explain why emissions between alternatives are different?
  - Why are emissions higher (or lower) for the build alternatives compared to No Action?
  - Do the results make sense in the context of project purpose and need?

Q. 8) Are there other tips that make this process run more smoothly?

A. 8) Yes, It is good to use naming conventions so that it's easy to tell which RunSpecs, input databases, input data spreadsheets, and output databases go together.

Use the Description panel in the RunSpec to explain what each run does.

The FHWA is available to help with troubleshooting, so when sending a group of files for review, include a brief "readme" document explaining what each file is. Send every file needed to trace the process from beginning to end (the MOVES RunSpecs, input data spreadsheets, input databases, output databases, and post-processing spreadsheets used to generate the results tables for the NEPA document).

Explain any anomalies (e.g., an output database that contains more than one run when others don't, etc.).

Q. 9) Are there templates for the MOVES RunSpec and County Data Manager inputs?

A. 9) Yes, they are provided below. If desired, these templates can be employed as checklists, to organize the work flow and to facilitate discussions among the project team on options for the analysis framework before MOVES analysis begins.

FHWA MOVES MSAT RunSpec Template

MOVES GUI Panel	Recommendation	Notes
Description	Use this to document the purpose of each run (e.g., "base year MSATs," "2040 No-build MSATs," etc.)	
Scale	Use County scale and Inventory mode	Inventory mode easier to use, less potential for error in post-processing
Time Spans	Model base year, project design year, first year of operation (optional but recommended) (separate runs needed for each year). Model 12 months Model weekdays AND weekends. Model all 24 hours.	All 12 months needed to generate annual emissions. Weekdays and Weekends needed to generate annual emissions. All 24 hours needed to capture effects of hourly temperature and traffic speed variations.
Geographic Bounds	County where project is located	
Onroad Vehicles	All gas and diesel vehicle types; CNG fuel type; E85 fuel type	CNG needed unless local AVFT inputs available with zero CNG fraction for associated vehicle types. E85 needed for three vehicle types. MOVES3 includes

		Electricity as a fuel type, however there are no VMT associated with Electricity in the default AVFT therefore the Electricity fuel type do not need to be selected.
Road type	All road types in affected transportation network; not "off-network"	"Off-network" includes only non-roadway emissions that are not included in MSAT analysis. However, this may be relevant for analysis of intermodal freight facilities.
Pollutants and Processes	**Pollutants:** Primary Exhaust PM10-Total (as Diesel PM) Benzene 1,3-Butadiene Formaldehyde Acrolein POM — All PAHs minus naphthalene gas and naphthalene particle Naphthalene — naphthalene gas plus naphthalene particle Ethyl Benzene Acetaldehyde **Processes:** running exhaust, crankcase running exhaust, evap permeation, and evap fuel leaks.	See Table in Question 6 above for pollutants to include for POM
General Output	Units of grams or pounds recommended so results don't round down to zero; report distance travelled for QA checks	
Output Emissions Detail	Aggregation by Time: Year - *only valid if all months, weekdays and weekends, and all 24 hours selected in the Time Spans panel* Selecting road type and source type may be useful in some	Selecting "Year" as aggregation by time, allows MOVES to generate annual emissions, but this is only valid if all months, days (weekdays & weekends), and all 24 hours selected in the Time Spans panel

	situations (e.g., troubleshooting); but not emissions process or model year. Selecting fuel type may be useful for diesel PM (see notes).	For Diesel PM, two options: 1) choose fuel type in Output Emissions Detail, and use results only for diesel fuel vehicles, or 2) do a separate run for Diesel PM with only diesel fuel vehicles selected in Onroad Vehicles panel
Create Input Database	Create input database for project runs	This is also where the County Data Manager can be accessed.
Advanced Features	Verify that Hour is selected in Time Aggregation under the Preaggregation Options	

FHWA MOVES MSAT County Data Manager Template

Input	Level of Detail/notes	Possible data sources
Age distribution	Same for all runs	State air agency, MPO, State DOT
Sourcetype population	Project-specific data should be used for projects that affect off-network (non-roadway) emissions; otherwise input values for the area should be reasonable.	MOVES defaults, State air agency, MPO, State DOT
Meteorology	Same for all runs. For simplicity, recommend one input table covering all months and hours.	State air agency, MOVES defaults
I/M, fuels	Same for all alternatives, differ by year, fuels vary by season. One I/M table needed for each year; one complete set of fuel inputs can also be used for each year (instead of separate inputs by month).	State air agency, MOVES defaults

VMT and speeds	Unique inputs needed for each run (these vary by year and by alternative). Speed inputs should be as detailed as possible to capture congestion relief impacts.	Project traffic modeling
Road type distribution	Include unique input for each run if the project changes these factors (e.g., shifting VMT from arterial to freeway). Also, varies by year.	Project traffic modeling, MPO, State DOT
Day and month VMT fractions	Same for all runs	MPO, State DOT, MOVES defaults
Hour VMT fractions	Same for all alternatives, may differ by year	MPO, State DOT, MOVES defaults

Additional County Data Manager inputs are available for Hoteling, off-network idling, Retrofit, and Starts in MOVES3 that may be applicable to certain types of projects (e.g., intermodal freight facilities).

Q. 10) What if I still have questions?

A. 10) If you have questions on how to define the scope of the analysis, set up the runs, or develop any input data, don't hesitate to ask for advice. The FHWA provides assistance on MSAT analysis for projects all around the country. It's better to resolve an issue before starting an analysis than to spend time revising inputs and rerunning multiple MOVES runs later.

If you have questions, please contact Victoria Martinez at victoria.martinez@dot.gov, or George Noel at george.noel@dot.gov.