Peer Review Comments and EPA Responses: Population and Activity of Onroad Vehicles in MOVES201X

December 2020

Peer review is an important element in ensuring the quality and integrity of the MOVES model. Peer review for the Population and Activity of Onroad Vehicles in MOVES201X was carried out under procedures described in the EPA Peer Review Handbook.[1] A contractor managed the peer review process, selecting qualified independent experts and arranging for letter reviews.

This document lists the comments received from peer reviewers on an August 2017 version of this report. The specific questions, including supplemental material for the questions, are included in the charge questions located with the peer-review material. Reviewer comments on minor formatting issues and typos are omitted. The peer-reviewed report, charge questions to the peer-reviewers and received peer-review comments, and other associated peer-review materials are located on EPA's science inventory webpage.[2]

In this document, report section headings and EPA questions to the reviewers are listed in bold; reviewer comments are in normal text; EPA response to the comments is in italic.

In response to these peer-review comments, we updated the draft report. An October 2019 version of the draft report, "Population and Activity of Onroad Vehicles in MOVES_CTI_NPRM," was peer-reviewed again in 2019 and is available on the EPA's science inventory webpage.[3] "MOVES_CTI_NPRM" refers to an EPA version of MOVES used in work that is intended to inform a future Cleaner Trucks Initiative (CTI)[4] Notice of Proposed Rulemaking (NPRM).

In November 2020, EPA publicly released MOVES3. MOVES3 builds on the work peer reviewed in 2017 and 2019 as documented in "Population and Activity of Onroad Vehicles in MOVES3".[5]

In our response to comments we refer to updates made to the draft, October 2019 "Population and Activity of Onroad Vehicles in MOVES_CTI_NPRM"[3] and use the section numbering from that report. In addition, we have attempted to clarify updates that were addressed differently or more fully for the final, November 2020 MOVES3 population and activity report.[5] Note the section, table, and figure references made by the peer-reviewers refer to the August 2017 version of the report which may not be consistent with the October 2019 or the November 2020 version of the report.

Comments from Dr. Song Bai, Sonoma Technology, September 25, 2017

Overall the draft report was very well organized and provided sufficient technical information regarding vehicle population and activity data used in the MOVES default database. My comments are organized into two categories: (a) individual responses to seven specific questions; and (b) additional comments by specific report chapter.

Peer Review Charge Questions

1. **Do you have any recommendations of better sources or techniques for projecting bus populations and VMT estimates?**

The data sources used in this report for estimating bus VMT and population are valid (e.g., the Federal Transit Administration's National Transit Database, the School Bus Fleet Fact Book and the Highway Statistics), although the data are relatively old. For long-term improvement of collecting bus data, regional transit authority and MPOs (regional planning agencies) would serve as potential sources for getting bottom-up bus population and VMT estimates. Most bus activities are in the large urban areas; therefore, identifying regions and transit agencies with large bus fleets would be a reasonable first step to understand the data availability.

For the approaches described in the report on bus VMT and population projections, I recommend using annual miles per vehicle information to conduct cross-checking. It's good to acknowledge the additional uncertainty for bus VMT and population projections, but the basic assumptions are inconsistent – total heavy-duty VMT growth was used as a surrogate for bus VMT growth (page 22) and total stock growth was used as a surrogate for bus population growth (page 28). Annual miles per bus could be calculated to check whether the heavy-duty VMT growth and total stock growth assumptions are very different. If they are very different (heavy-duty VMT growth vs. total stock growth), it would be important to consider alternative approaches – for example, using total stock growth for bus population projection and estimating an average (or assuming constant) annual VMT per bus to estimate future year bus VMT growth.

> *Response: We agree that the sources described could be useful sources to quality check the population and VMT projections.*
>
> *Table 4-3 (Mapping AEO categories to source types for projecting vehicle populations) had an omission; bus populations are actually projected using total heavy-duty stock, not total stock and this has been corrected in the table.*
>
> *We checked the bus VMT/vehicle rates for future years and they appear reasonable, compared to calculated VMT/vehicle for similar types of vehicles in the National Transit Database[6] and the School Bus Fleet Fact Book.[7]*
>
> Additionally, bus VMT and population are updated in MOVES3 based on newer version of the same data sources.

2. **Are there any sources of vehicle survivability or scrappage information that are missing, particularly for heavy-duty vehicles? Are there alternatives to this approach for estimating age distributions for future calendar years? As described in Sections 10 and 12, EPA intends to use information from instrumented vehicles to develop default inputs for idle and start activity for heavy-duty trucks. EPA has not yet completed this analysis, so the draft report does not include results. However, EPA would appreciate feedback on its proposed techniques and data sources.**

Using registration data as the basis for vehicle survivability and scrappage estimates is typical and appropriate, which is also similar to the approach used by the California Air Resources Board in the EMFAC model for vehicle population and activity modeling. For estimating age distributions, the approaches look reasonable (e.g., in Section 6) for base age distribution (using 2014 IHS and NTD data), historic age distributions and projected age distributions. However, the report didn't include discussions about unregistered vehicles (for both light-duty and heavy-duty vehicles). Unregistered vehicles could be short-term or chronic – is there adjustment needed to the IHS or NTD base data to reflect the impact of unregistered vehicles on age distributions (especially for future calendar years)?

Sections 10 and 12 include information on using instrumented vehicles to develop default inputs for idle and start activity. Overall, using instrumented vehicles data (e.g., the Verizon Telematics data and NREL Fleet DNA Database) is a good approach to improve idle and start activity estimates compared to historical approaches. One key issue to address is the regional variation – how idle and start activities vary by state/region and how MOVES adjusts the data processing approach to better reflect the spatial variability in activity data. The limitation of both the Verizon Telematics and NREL Fleet DNA data is that data were collected only for a few states. What is the justification for mapping individual states to the Verizon data for light duty activities (as shown in Figure 10-2)? Should state specific vehicle population, VMT and/or other fleet characteristics be considered in mapping individual states to the states with Verizon Telematics data? For heavy-duty trucks, it is very important to develop additional analyses to address representativeness issues in the NREL data (e.g., very high start activities from delivery trucks in Texas and Minnesota, as shown in Figures 12-4 and 12-5).

Response: EPA estimates for emissions from vehicles are a function of vehicle activity. The primary source for vehicle miles traveled are measurements made by the Federal Highway Administration Highway Performance Monitoring System (HPMS) which would capture activity by any vehicles operated on public roads whether registered or not. The primary concern for EPA emission estimates related to vehicle populations would be the proper characterization of the vehicle fleet and accounting for emissions from vehicles when they are not operating (parked). EPA assumes that unregistered vehicles are primarily unused (antique, inoperable, etc.) or used very little and would not have a significant effect on emission estimates made with age distributions based on only registered vehicles. EPA is not aware of any studies that quantify the activity of unregistered vehicles or suggest that unregistered vehicles are a significant source of vehicle activity.

Although the MOVES model provides default values for idle and start activity,

modelers may replace them if they have better regional or local data. As such, the improvement in the activity estimates over historical methods provides adequate justification for their application in MOVES. The improvements in user access to these factors will provide a method for states to determine and apply local information to their own counties as such information becomes available. It will not be necessary for MOVES default values to be updated to improve the estimates made by states or by EPA after the release of the model.

The analysis of the idle and start activity is limited by the available data, both in application to specific locations and vehicle populations. The report acknowledges the potential for bias and limitations of the data. Until more detailed information is available, the improvement in these activity estimates justifies making change now, based on these limited data. A more detailed handling of idle and start activity would be premature and cannot be justified by the available information.

For heavy-duty trucks, the NREL Fleet DNA dataset covers a diverse data set encompassing 23 vehicle vocations in 36 states. We acknowledge that the behavior of some vehicles in the dataset are drastically different from others and we believe we limited the influence of these vehicles by applying the "normalized sum-over-sum" approach (Method 3) described in Appendix J (Appendix I in the MOVES3 Report). NREL compared the idle, starts and soak behavior of vehicles from several states in their interim report for EPA.[8] They noted some differences, which they hypothesized could be due to regional idle restrictions, but we did not investigate those differences further. As noted in the MOVES3 report (Section 10.3.1), the NREL project report observed that activity were largely a function of vehicle vocation, rather than geographic location. Our intent is to provide national-scale, average values to represent MOVES defaults. MOVES users are encouraged to apply more region-specific inputs for their own purposes.

3. **In Section 11, EPA has updated the national default hotelling rate to be consistent with current hours-of-service regulations. For this updated report, EPA evaluated studies of extended activity to inform the hotelling rate but found that the studies did not report hotelling activity data in sufficient detail for EPA to update its national hotelling rate. For example, Frey et al. (2012) did not report extended idle and APU usage that occurred for stop durations between 3 and 7 hours and less than 15 minutes. As described in Sections 10 and 12, EPA is currently analyzing truck activity data from the instrumented truck database maintained by the National Renewable Energy Laboratory (NREL). From this data set, EPA can obtain detailed data on extended idling, but not hotelling activity when the main engine is not on, including when the driver is using an APU. By using EPA's current hotelling activity distribution assumptions about the fraction of hotelling that operators idle the main engine, EPA could potentially use the NREL database to inform the national hotelling rate, instead of using the current assumptions with hours-of-service. Would you recommend that EPA use this approach (instrumented truck data on extended idling and assumptions regarding the hotelling activity distribution) to estimate the national hotelling rate?**

I would recommend EPA use the instrumented truck data to improve the estimates of the national hotelling rate. Given the calculation approach with equations 16, 17, 18 and xx (see pages 87 and 88), a key assumption is that all trips of long-haul combination trucks are longer than 10 or 11 hours. The NREL data need to be checked (or adjusted as needed) to ensure that this assumption is met; otherwise the hotelling hours could be over-estimated, because any trips shorter than 10 or 11 hours will incorrectly contribute to the hotelling hours calculation. Using VMT for restricted access roads in both urban and rural areas is a better approach than using just rural VMT, when calculating national hotelling rate. EPA also needs to consider spatial allocation of hotelling activities (e.g., in addition to using state-wide VMT for urban and rural restricted access roads and an overall average hotelling rate).

Response: We have proceeded with the reviewer's recommendation to use the NREL instrumented data as the source for hotelling hours. We have documented the analysis and assumptions regarding the hotelling hour distribution in the updated Section 11.

We also agree with the reviewer's comment that the assumption that all trips are longer than 10 or 11 hours is a source of overestimation in hotelling hours in the previous method. We have included that point when discussing why the current method yields lower hotelling hours compared to using the previous hours-of-service assumptions in Section 11.

4. **As described in Sections 10 and 12, EPA intends to use information from Verizon Telematics to develop default inputs for idle and start activity for light-duty cars and trucks. Are there any concerns about using this data source? In particular, do you recommend any techniques that would allow us to investigate selection bias or other bias in the data?**

As commented for Question #2, using the Verizon Telematics data can potentially improve estimates of default idle and start activity inputs in MOVES. The key issues are related to the data representativeness and temporal and spatial allocations. The QA/QC work described in the report seems reasonable in terms of removing missing or incomplete data. Some specific issues that need to be further discussed include: a. Justification of individual states mapping (Figure 10-2 default regions for weighting light duty activity). b. Equation 6 needs to clarify that the regression model handled ordinal categorical variables as independent variables (as shown in Appendix F for the estimated coefficient values). c. In Figure 10-3, the modeled TIF and Actual TIF are very different for idleRegionID=105 (California), for both passenger cars and passenger trucks; the modeled TIF and Actual TIF appear much more consistent for other regions. This is concerning and needs to be further investigated – is there potential bias in the Verizon Telematics data for California? d. A typical approach to reduce bias is to apply appropriate weighted average, instead of simple average, when calculating parameters at an aggregate level. For heavy-duty trucks, as described in page 80 (above Section 10.2.2), "The results of each vehicle are then averaged resulting in an even weighting for all vehicles in the sourceTypeID category." – Why is a simple averaging used, not a weighted averaging?

Response: EPA has updated the discussion of the mapping of idle rates to regions to better explain how states were grouped and has updated the discussion of the regression analysis to include the handling of ordinal variables. We also further discuss the observed differences between the modeled and measured TIF values (Figure 10-3). In the text proceeding the Figure 10-3, we provided an explanation about California: "As expected, Region 105 (California) which has the smallest sample size also shows the most variation and deviation from the regression results. For example, for Region 105 (California), passenger trucks (sourceTypeID 31), weekdays (dayID 5), the model fit smooths out the abnormally high idle fraction measured for July (monthID 7)."

For heavy-duty vehicles, we updated our approach from a simple averaging approach (average of ratios) we had applied in the previous draft. We are now using a sum-over-sum approach which normalizes the recorded activity by the amount of time each vehicle was instrumented and weights the average idle fraction towards the vehicles with the most daily-average activity as discussed in Section 10.3.3 and Appendix J. (Appendix I in the MOVES3 Report)

5. **EPA has not updated the average speed distributions in MOVES since MOVES2014. New information, such as the telematics analytics used in the CRC A-100 analysis, "Improvement of Default Inputs for MOVES and SMOKE-MOVES," may be available in time for inclusion in the next version of MOVES. How important is it to update the national average speed distributions to account for such data?**

In general, speed distributions are important for mobile source emissions modeling. If we are talking about replacing national default data with local data, then speed distributions are unquestionably key inputs and the quality of speed data is very important. In MOVES, emissions are typically more sensitive to the drive schedule and operation mode distribution (especially for county-scale and project-scale modeling runs); this is at a more detailed activity level beyond average speed distributions. For national level application, however, I suggest that EPA consider placing a higher priority on improving the quality of vehicle population and VMT estimates by source type and vehicle age distribution, instead of average speed distributions. It will be good strategy to first compare speed distributions between the telematics data and the MOVES2014 default, understand how different they are and then decide whether the average speed distributions need to be updated in MOVES201X with the new telematics data. A potential challenge for using the telematics data would be the representativeness issue – how can we process the telematics data collected from certain states properly so they can represent an overall national average? Much effort will be needed to develop a reasonable approach for repopulating representative speed distributions in the MOVES database (proportions by source type, road type and hour of day).

Response: Since the peer review was completed, EPA has leveraged the CRC A-100 county-specific, hourly speed data generated as input for the 2014 NEI and created average speed distributions at the national level. The derivation of these average

speed distributions is described in Section 8. These speeds are based on information from millions of vehicles in 3,109 counties in the mainland US and thus are much more representative than previous estimates. The comparison to the average speed distributions included in MOVES2014 shows that the major differences are seen for vehicles at speeds between 60-70 mph.

The major caveat for this new dataset is that there is still not enough detail to differentiate between vocation-specific trucks, resulting in light-commercial trucks, buses and refuse trucks using the same average speed distribution. Nonetheless, this dataset constitutes a substantial improvement over the data used for MOVES2014. EPA continues to work to obtain more specific data (e.g. FleetDNA data from the National Renewable Fuels Laboratory).

6. **EPA has not updated the geographical allocation of activity since MOVES2014, but it intends to update these allocations when Version 2 of the 2014 National Emission Inventory is available. Are there any concerns about using the new data with the same MOVES2014 approach described in this report?**

Updating the geographical allocation of activity using Version 2 of the 2014 NEI will be an effective improvement for MOVES and the approach described in the report seems reasonable.

Response: The 2014 NEI version2 was used for geographic allocation in MOVES_CTI_NPRM. The 2017 NEI was used for geographic allocation of vehicle activity in MOVES3.

7. **EPA is considering a new approach for estimating heavy-duty source mass and heavy-duty fixed mass factors such that they vary by regulatory class and are more closely linked to the actual mass of the heavy-duty vehicles. Details on the proposal for updating source mass values are provided in Attachment A to this Peer Review Charge. Would the new approach be an improvement for MOVES? Are the proposed data sources and analysis approaches appropriate and reasonable? Are there better data sources or techniques for estimating bus source mass?**

The new approach will improve the vehicle mass estimates in MOVES. Overall the analysis approaches are appropriate; the vehicle class mapping (Table 1 of Attachment A) is reasonable. For the weighted average gross vehicle mass calculation (see the third paragraph in Attachment A, where multiple FHWA Vehicle Classes are listed for a given source type and regulatory class), VMT is more appropriate than vehicle counts as weighting factors to calculate weighted average mass (because the major emission process is running exhaust that is directly related to VMT, instead of vehicle population). I am not aware of any better data sources for bus source mass. Regional transit authorities or large bus fleet management agencies may be a good start for finding a better data source.

Response: We incorporated the proposed updated vehicle weights in MOVES_CTI_NPRM and MOVES3. EPA agrees that VMT is a more appropriate weighting factor than vehicle counts. See Section 15.1.

Additional comments by specific report chapter

The following review comments are more specific regarding the technical contents described in the report. There are minor formatting issues and typos in the report, which are listed at the end of this section.

Response: The MOVES3 report was reviewed multiple times to correct formatting and typos.

Section 3.1 (page 20), paragraph above Table 3-1: need to clarify that these revised VMT values ("revised by FHWA in subsequent publications") were used in MOVES201X.

Response: Table 3-2 summarized the data source and FHWA revision date that we used/updated for each historical year in MOVES. It has the information about the exact version from FHWA that we have used in MOVES.

Section 3.2 (page 21), first paragraph: need to clarify the base year in "…applied to the base year HPMS data." Is this base year 2015?

Response: EPA has clarified the base year in MOVES_CTI_NPRM and also in MOVES3 report.

Section 6.2.2 (page 45), first paragraph, last sentence: why was extrapolation used here? Note that the regression approach is typically used to identify statistical relationships within the sample data range and is not appropriate to be used for extrapolation. To be conservative (error to the higher VMT and emissions side), consider the assumption that age 26 and beyond passenger cars have the same VMT as age 25 passenger cars.

Response: EPA has clarified the VMT discussions.

A conservative assumption, that all older vehicles would have the same mileage accumulation rate, is unreasonable given the relatively steep observed trend and the fact that assuming higher mileage accumulation rates for the older vehicles has a disproportionate impact on emissions, since these vehicles emit significantly more per mile than the newer vehicles.

While few studies include gathering data on vehicles this old, we are now working to analyze a dataset that we hope will shed light on trends for the oldest vehicles.

Section 6.2.2, Table 6-2 (page 46): need to fill in VMT data for passenger cars; also, why do light trucks of age 29 have high annual miles?

Response: EPA has added text to point out that regression results were used, not the raw data, so that there is no anomaly in the mileage accumulation rates used by MOVES. The anomaly in the raw data is likely due to the increasingly small sample sizes for the oldest vehicles.

Section 6.2.4 (page 48): mileage accumulation rates #2 "Ages 4 through 16 use…" is very confusing.

Response: The text has been changed to more clearly point out what was done for ages 4 through 16.

Section 9.1 (page 67), last paragraph: this paragraph describes quite a few bus-specific cycles, why does the first sentence say, "most of the driving schedules used for buses are borrowed directly from driving schedules used for single-unit trucks"?

Response: EPA has changed"most" to "some" to make it clear that substitutions were made, but not most.

Section 9.2 (page 69), first paragraph: "Modeling ramps as part of highway driving using the current driving cycles overstates tailpipe exhaust emissions by less than 3 percent…" What emissions (across all pollutants or for a specific pollutant)?

Response: The tailpipe exhaust criteria pollutants (HC, CO and $PM_{2.5}$) all changed less than 1 percent and NOx changed less than 3 percent. The text has been updated to reflect this clarification.

Section 10 (page 70), first paragraph, last sentence: "… MOVES2014 may not have accounted for the increased amounts of congestion in recent years" – I suggest that EPA clarify idle activities and "stop-and-go" activities in MOVES. Accounting for traffic congestion is related to "stop-and-go" activities and is at least partially addressed in driving cycles. These activities are different from activities in drive-ways, parking lots, or during delivery operations, which are not reflected in any driving cycles. Using Telematics data is potentially addressing both types of activities.

Response: EPA has updated the description to more clearly indicate the two types of idle and how telematics will potentially address both.

Section 10.2.3, Table 10-7 (page 82): the NREL vehicle population for CA is 47, while the number is 48 in Table 10-5 (see page 79) – need to double check and keep data consistent.

Response: Since this peer-review, Section 10 has been completely revised and the tables are now consistent.

Section 10.2.3, Table 10-8 (page 82): what's the reason behind the CE-CERT data with high total idle fractions for weekend? Some data investigation and quality checking is needed.

Response: Since this peer-review, we reevaluated how we processed our heavy-duty data and applied a "normalized sum-over-sum" approach (see Appendix J) to the

NREL Fleet DNA dataset only. At the time of this report, we have not applied the same approach to the CE-CERT dataset and CE-CERT is currently not included in our off-network idle calculations or the tables of default values in MOVES_CTI_NPRM or MOVES3. We hope to combine the Fleet DNA and CE-CERT datasets in a future version of MOVES.

Section 10.3 (page 84): the title of this section is for "Work-day…" – why work-day? The description seems to be applicable for all days.

Response: Since this peer-review, we changed our terminology and no longer refer to "work-day" idle. Instead, we use the more general term "off-network" idle.

Section 13.3 (page 106): will EPA consider developing HourVMTFraction distributions by source type?

Response: The MOVES HourVMTFraction table allows for separate VMT distributions to hour of the day for each source type. Separate hourly distributions for source types have yet not been developed by EPA. However, this table is part of the required user input for County Scale MOVES runs and provides an opportunity for users to provide this information, if hourly VMT distributions by source type by hour of the day become available.

Section 13.4, Table 13-8 (page 110): these starts per day data (e.g., for passenger cars and passenger trucks) are much higher than those presented in Table 12-1 (see page 93). How are the data presented in these two tables related?

Response: EPA has added a discussion of how the parking activity estimates differ from the engine start activity estimates.

Section 13.5 (page 113), first paragraph, last sentence: what is the justification for assuming 60 percent to account for those unsynchronized trips?

Response: Because we had data only at hourly intervals, the 60 percent was one of the assumptions used to derive the hourly hotelling distribution from the instrumented truck trip data coupled with the hotelling survey data. We have since compared the estimated hourly hotelling data using this method, to data collected from a NCHRP 08-101 study (See Figure 13-2). We added text explaining that the methods used produces a reasonable estimate of the hotelling hourly distribution.

Comments from Dr. Reza Farzaneh, Texas Transportation Institute, September 26, 2017

Peer Review Charge Questions

1. **Do you have any recommendations of better sources or techniques for projecting bus populations and VMT estimates?**

Travel Demand Models (TDM) and transportation conformity documents from nonattainment areas can be a useful source of information for projecting transit bus VMT. The VMT projections are derived from the best local knowledge (especially land use and demographics) available at the time of the analysis and in theory one of the most reliable sources for VMT projections. The transportation conformity documents are generally available through MPOs' websites. The following table shows an example from North Central Texas Council of Government's (NCTCOG) 2016 Conformity Document (Section 5.6.1, available at http://www.nctcog.org/trans/air/conformity/2016TransportationConformity.asp).

Transit Name	2017	2027	2037	2040
DART Bus	71,308	79,175	90,049	90,049
FWTA Bus	17,903	31,532	38,658	38,672
DCTA Bus	3,583	6,379	6,379	6,379
Rail	18,795	23,623	37,410	37,410
Total Daily VMT	**111,589**	**140,709**	**172,496**	**172,510**

Besides nonattainment areas, all medium and large metropolitan areas in the U.S. have travel demand models that produce VMT projections. EPA can potentially obtain the travel forecasts from a large sample of metropolitan areas working with organizations such as Association of Metropolitan Planning Organizations (AMPO). VMT projections from the above sources can be used for validation and quality control.

Response: EPA agrees that these could be useful sources to validate bus VMT projections and we may explore this avenue in the future.

2. **a) Are there any sources of vehicle survivability or scrappage information that are missing, particularly for heavy-duty vehicles? Are there alternatives to this approach for estimating age distributions for future calendar years?**

The reviewer is not aware of any alternative sources of information for vehicle survivability or scrappage. All the applications that the reviewer has encountered to-date are based on MOVES defaults.

No response needed.

2. **b) As described in Sections 10 and 12, EPA intends to use information from instrumented vehicles to develop default inputs for idle and start activity for heavy-duty trucks. EPA has not yet completed this analysis, so the draft report does not include results. However, EPA would appreciate feedback on its proposed techniques and data sources.**

The proposed techniques and overall methodology are valid and appropriate for extracting information regarding start and idling activity for HDVs. While the datasets are valid, the reviewer has a concern about the representativeness of them to establish national default values. A more diverse sample (i.e. from more states) would address this concern. I am aware of at least one HDV data collection effort in Texas that might be of use for this purpose. A survey of subject matter experts at TRB Annual Meeting 2018 can help identifying other potential sources of data relevant to this purpose.

Response: We have applied the NREL Fleet DNA dataset that covers a diverse data set encompassing 23 vehicle vocations in 36 states and we believe this data improves the representativeness of the model over its previous versions. We hope to combine the NREL data with the California-focused CE-CERT dataset in the future and we welcome and continue to seek out additional datasets to improve the representativeness of our model.

3. **In Section 11, EPA has updated the national default hotelling rate to be consistent with current hours-of-service regulations. For this updated report, EPA evaluated studies of extended activity to inform the hotelling rate but found that the studies did not report hotelling activity data in sufficient detail for EPA to update its national hotelling rate. For example, Frey et al. (2012) did not report extended idle and APU usage that occurred for stop durations between 3 and 7 hours and less than 15 minutes. As described in Sections 10 and 12, EPA is currently analyzing truck activity data from the instrumented truck database maintained by the National Renewable Energy Laboratory (NREL). From this data set, EPA can obtain detailed data on extended idling, but not hotelling activity when the main engine is not on, including when the driver is using an APU. By using EPA's current hotelling activity distribution assumptions about the fraction of hotelling that operators idle the main engine, EPA could potentially use the NREL database to inform the national hotelling rate, instead of using the current assumptions with hours-of-service. Would you recommend that EPA use this approach (instrumented truck data on extended idling and assumptions regarding the hotelling activity distribution) to estimate the national hotelling rate?**

The reviewer strongly supports the proposed approach (i.e. using data from instrumented vehicles); however, the reviewer has a concern with regards to representativeness of the NREL dataset for calculating national default values. Some providers of fleet management services

(such as Teletrac Navman, ITURAN, Omnitracs) are specifically monitoring idling and start events. In theory, their dataset can provide EPA with a larger sample. The reviewer acknowledges the difficulties with obtaining reliable information on APU usage. A series of truck driver surveys can be a useful source of data. The following are additional sources that might be of use to refine the APU usage:

- 2016 Annual Fleet Fuel Study, North American Council for Freight Efficiency. https://nacfe.org/downloads/nacfe-2016-annual-fleet-fuel-study/

- A Survey of Fuel Economy and Fuel Usage by Heavy-Duty Truck Fleets (2016), UMTRI, http://umich.edu/~umtriswt/PDF/SWT-2016-12.pdf

Response: We appreciate the recommendations for obtaining telematics data to better inform the idle and start data in MOVES. We are interested in obtaining more telematics data in the future. Currently, the NREL Fleet DNA data is the best data we have available

With regard to APU usage, we evaluated the APU usage assumptions compared to the suggested data surveys. The surveys qualitatively agreed with the APU diesel assumptions, but suggest that the current assumption for hotelling battery units is low. We added this information to the discussion in Section 11.1. In addition, modifications in the user inputs for MOVES_CTI_NPRM and MOVES3 will make it easier for users to replace EPA default estimates with better information as this information becomes available.

4. **As described in Sections 10 and 12, EPA intends to use information from Verizon Telematics to develop default inputs for idle and start activity for light-duty cars and trucks. Are there any concerns about using this data source? In particular, do you recommend any techniques that would allow us to investigate selection bias or other bias in the data?**

The reviewer supports the use of vehicle telematics data; however, the reviewer has a concern with regards to representativeness of the selected states in the Verizon Telematics dataset that EPA has obtained.

The reviewer strongly suggests adding a few additional states. Selection of these states could be based on considerations such as trade corridors, freight hubs/ports, population and VMT. To investigate the selection bias, the reviewer suggests identifying relevant datasets from the literature and work with the authors to obtain the information. Most of these alternative datasets are incomplete and limited (both temporally and spatially); however, they can be used for quality control and validation of different parameters.

Response: Thank you for your suggestions. Obtaining data of this sort is currently very expensive. EPA is investigating and evaluating alternative sources of data that can be used for this purpose.

5. **EPA has not updated the average speed distributions in MOVES since MOVES2014. New information, such as the telematics analytics used in the CRC A-100 analysis, "Improvement of Default Inputs for MOVES and SMOKE-MOVES,"[a] may be available in time for inclusion in the next version of MOVES. How important is it to update the national average speed distributions to account for such data?**

It is very important; however, the reviewer suggest EPA to wait and consider all the available options. For example, FHWA is in the process of starting an initiative to develop methods and tools to generate county-level average speed distributions based on National Performance Management Research Dataset (NPMRDS) and HPMS. These tools and methods will be based on processed speed data (5-min interval) for a large sample of roads in the United States. These tools and methods can be used by EPA to update the MOVES default values. The reviewer suggests that the EPA staff obtain more information from FHWA headquarters air quality and transportation conformity team.

Response: As discussed in this question from Dr. Bai, EPA has incorporated data from CRC A-100 data used for SMOKE-MOVES to also be used to update the average speeds in MOVES.

EPA will continue to improve our coordination with FHWA and keep abreast of the types of data they can provide that is relevant to our activity needs. However, we note that the NPMRDS dataset represents mostly restricted access roads (highways and ramps) and only some arterial roads. Furthermore, the NPMRDS dataset only differentiates between passenger vehicles and freight trucks. On the other hand, the dataset used for in the update to the default average speed distributions (CRC A-100 based on StreetLight Data) has a better representation of the complete road network and provides more detail to differentiate between medium-duty and heavy-duty trucks in addition to separating them from passenger cars. Because of the reasons mentioned above, we are confident that this dataset is currently the best available information for our purposes.

6. **EPA has not updated the geographical allocation of activity since MOVES2014, but it intends to update these allocations when Version 2 of the 2014 National Emission Inventory is available. Are there any concerns about using the new data with the same MOVES2014 approach described in this report?**

The reviewer suggests that EPA considers the use of NPMRDS v2.0 dataset for quality control of the restricted access roads. The FHWA initiative mentioned in response to question 6 also involves assignment of VMT to MOVES road types. The reviewer suggests that the EPA staff

[a] See https://crcao.org/reports/recentstudies2017/A100/ERG_FinalReport_CRCA100_28Feb2017.pdf.

obtain more information from FHWA headquarters air quality and transportation conformity team.

Response: We have met with FHWA staff to learn more about NPMRD and, as noted above, we are concerned about data limitations. We will continue to improve our coordination with FHWA and keep abreast of the types of data they can provide that is relevant to our activity needs.

7. **EPA is considering a new approach for estimating heavy-duty source mass and heavy-duty fixed mass factors such that they vary by regulatory class and are more closely linked to the actual mass of the heavy-duty vehicles. Details on the proposal for updating source mass values are provided in Attachment A to this Peer Review Charge. Would the new approach be an improvement for MOVES? Are the proposed data sources and analysis approaches appropriate and reasonable? Are there better data sources or techniques for estimating bus source mass?**

The reviewer believes that the proposed approach is an improvement for MOVES and the proposed methods and data sources are appropriate and reasonable. The reviewer is not aware of better data sources or techniques for this purpose.

Response: As mentioned in the response to Dr. Bai's comment on this question, we have incorporated these proposed changes in MOVES_CTI_NPRM and MOVES3 (See Section 15.1 of those reports).

General Comments

This report is well written and methodologies and assumptions are adequately described. EPA staff have applied sound methodologies to address the data gaps.

No response needed

The emergence of fine-grained vehicle activity data such as vehicle telematics has provided a great opportunity to establish the values of MOVES parameters based on larger and more representative data. The reviewer strongly supports the use of these and other similar datasets in updating MOVES parameters and methods.

No response needed

The methodologies and datasets described in the document are substantial improvements to the MOVES model. Some of the national values described in the document are widely used by practitioners for SIP and conformity analyses. Any improvement to them based on more recent data from larger samples will translate into more accurate emissions inventories.

No response needed

—FHWA, state DOTs and state air agencies have also started initiatives to use these new sources of data for establishing local and regional parameters used in MOVES-based emissions inventories. EPA and FHWA can play a central role to coordinate these efforts which can greatly benefit all parties.

No response needed

—Section 3.2. – AEO numbers are influenced by assumptions regarding energy prices and can vary between different releases of the AEO report. The reviewer suggests an evaluation of the impact of these changes on the numbers used for MOVES.

Response: We will consider this for the future.

—Section 3.2. – AEO has multiple scenarios. Please specify which scenario was adopted to be used for MOVES. The reviewer suggests including more details on AEO assumptions and methods that are relevant to the numbers used for MOVES.

Response: We have clarified that we use the reference case.

—Section 6.2.2 – The light truck vs. cars population and their driving behaviors have seen substantial changes since 2001. The reviewer suspects that RMAR of 0.885 might not be a valid number anymore.

Response: We are gathering new data on light duty mileage accumulations and hope to update the RMARs for future versions of MOVES.

—Section 6.2.2 - The reviewer is surprised to see that vehicle types 31 and 32 have the same RMAR. The reviewer suspects that vehicle types 21 and 31 have similar usage patterns and probably the same RMAR.

Response: Vehicle types 31 and 32 have the same RMAR because they were not distinguished in the source data. We are gathering new data on light duty mileage accumulations and hope to update the RMARs for future versions of MOVES.

—Section 6.2.3. – The reviewer suspects that the assumption of "the same annual mileage accumulation rate for each age" might not be valid for older school buses. Old school buses are often retired to other uses such as kid's clubs or after school programs that might have different usage patterns.

Response: We agree that some kind of downward trend with age seems likely. This was not changed in MOVES_CTI_NPRM, but in MOVES3, we updated the RMAR for school buses to be based on the transit bus RMAR, adjusted down such that year 0 is based on the 9,939 miles per year from the School Bus Fleet Fact Book.

—Section 6.2.4 –Cities and local governments track the mileage and fuel usage of their fleet. These datasets could be a useful resource for quality control and validation purposes.

Response: EPA has begun examining fleet data for nonroad activity and will consider options for doing a similar analysis for onroad vehicles. While we are concerned that mileage accumulations of fleet vehicles would not provide a good representation of activity by typical passenger cars and trucks, fleets may be a good source of data for mileage accumulations of other sourcetypes, especially at younger ages.

—Section 9.1. - A TxDOT research study developed local drive schedules for major metropolitan areas of Texas. These drive schedules and the data used for developing them can be used for quality control and validation purposes by EPA.

Response: EPA intends to evaluate the TxDOT driving schedules as part of an overall evaluation of the current default driving schedules for a future revision of MOVES.

—Section 10.1.1 – Please specify the basis for selecting the list of states that Verizon Telematics data was acquired.

Response: We added text to Section 10.2.1 to add explanations why the five states were chosen. Illinois was selected specifically to match with the pilot study using Verizon data. The other states were selected to represent areas with a significant population of instrumented vehicles, geographic differences, and a combination of states with and without Inspection and Maintenance programs. More areas would improve the analysis, but selection was limited by the funding available for this project.

—Page 69, Section 10.1.1 – "All of the activity by vehicles was assumed to occur within the county assigned to the vehicle by their registration location." This is a common assumption by practitioners when performing emissions inventories. However, it is a common knowledge that it is not accurate. Has there been any evaluation of the potential biases or errors because of this assumption?

Response: The Coordinating Research Council has completed a project, "Evaluating the Sensitivity of MOVES2014a to Local Start Activity Data,[9]" that evaluates start activity using a different telematics source that can resolve start location. Differences in methodologies make it difficult to directly compare the results, but we hope to use this type of data in the future to better allocate start emissions.

—Page 87 - Please specify the basis for assuming 80 percent for hotelling time to power accessories.

Response: We revised the text and provided a reference for this fraction. As noted in Section 11, we updated our hotelling opmode distribution to reflect FMCSA's hours-of-service regulations. Drivers could split their 10 hours of mandated off-duty time

between the sleeper berth for at least 8 hours and another location for the remaining 2 hours. For MOVES_CTI_NPRM and MOVES3, we assumed the drivers did not require power when not in the sleeper berth and applied a constant 20 percent of hotelling time to represent the 2 hours off-duty time not in the sleeper berth for all years.

—Page 108 – Has there been any validation of the assumption of "all trips are 10 hours long"?

Response: This was one of the assumptions used to derive the hourly hotelling distribution from the presented instrumented truck trip data coupled with the hotelling survey data. We have since compared the estimated hourly hotelling data using this method, to data collected from the NCHRP 08-101 study (See Figure 13-2). We added text that explains that the methods used produces a reasonable estimate of the hotelling hourly distribution.

—Section 14.2 & 14.3 – the reviewer suspects that Equation 21 might lead to overestimation for urban counties and underestimation for rural counties. Has there been any evaluation of the impact of the underlying assumptions of Equation 21?

Response: MOVES2014a used only VMT on rural restricted access roads to distribute hotelling activity. Feedback from users demonstrated that hotelling activity occurs in urban areas as well. However, EPA is not aware of any data sources that can adequately quantify the distribution of hotelling hours nationally. EPA will continue to evaluate other sources of data and surrogates that can better allocate hotelling activity. MOVES_CTI_NPRM and MOVES3 has been updated to make it easier for users to supply hotelling activity information when such data becomes available.

References

[1] USEPA (2015). *U.S. Environmental Protection Agency Peer Review Handbook*. EPA/100/B-15/001. Prepared for the U.S. Environmental Protection Agency under the direction of the EPA Peer Review Advisory Group. Washington, D.C. 20460. October 2015. https://www.epa.gov/sites/production/files/2020-08/documents/epa_peer_review_handbook_4th_edition.pdf.

[2] USEPA (2017). *Population and Activity of Onroad Vehicles in MOVES201X - Draft Report*. Draft report and peer-review documents. Record ID 328870. EPA Science Inventory. September 2017. https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=328870.

[3] USEPA (2019). *Population and Activity of Onroad Vehicles in MOVES_CTI_NPRM - Draft Report*. Draft report and peer-review documents. EPA Science Inventory. December 2019. https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=347136.

[4] USEPA (2020). Cleaner Trucks Initiative. https://www.epa.gov/regulations-emissions-vehicles-and-engines/cleaner-trucks-initiative

[5] USEPA (2020). *Population and Activity of Onroad Vehicles in MOVES3*. EPA-420-R-20-023. Office of Transportation and Air Quality. US Environmental Protection Agency. Ann Arbor, MI. November 2020. https://www.epa.gov/moves/moves-technical-reports.

[6] US Federal Transit Administration (FTA), *National Transit Database*, 2002-2017, https://www.transit.dot.gov/ntd.

[7] Bobit Publications, *School Bus Fleet Fact Book*, Torrance, CA: 1992, 2002, 2004-2018, http://www.schoolbusfleet.com.

[8] Kotz, A. and K. Kelly (2019). *MOVES Activity Updates Using Fleet DNA Data: Interim Report*. NREL/TP-5400-70671. National Renewable Energy Laboratory. Golden, CO. January 2019. https://www.nrel.gov/docs/fy19osti/70671.pdf.

[9] CRC Report No. A-106 EVALUATING THE SENSITIVITY OF MOVES2014A TO LOCAL START ACTIVITY DATA Final Report December 2017 http://crcao.org/wp-content/uploads/2019/08/CRC-A106-Final-Report_Dec2017.pdf