Texas A&M Transportation Institute

Addressing New Technologies and Data in Transportation Conformity: Overview and Assessment

MEMORANDUM

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Texas A&M Transportation Institute

TECHNICAL MEMORANDUM

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1) INTRODUCTION

1.1 Background

Transportation conformity requirements apply to air quality nonattainment areas across the United States. They were initially introduced in the early 1990s through the Clean Air Act Amendments (CAA). The conformity process is designed to ensure that transportation plans, programs and projects are consistent with the air quality goals established by a state air quality implementation plan (SIP) (*1*).

Federal regulations establish the link between air quality planning and transportation planning, wherein each Metropolitan Planning Organization (MPO) must work with State Departments of Transportation (DOTs) and other consultative partners to make a positive conformity determination for metropolitan transportation plans and transportation Improvement Programs (TIPs). This is generally known as regional conformity. Further, project-level conformity requirements may apply in certain areas, for projects of air quality concern (*2*). With a few exceptions, most conformity determinations require a regional emissions analysis, to estimate transportation network emissions for comparison with an emissions budget. These analyses must make use of latest planning assumptions and the latest EPA emission model, namely the Motor Vehicle Emission Simulator (MOVES) model (*2*).

Over the years, transportation agencies have developed systematic approaches to efficiently meet conformity requirements, including processes for conducting regional emissions analyses and meeting interagency consultation requirements (*3*). At the same time, there have been several proposals to investigate streamlining of conformity processes and updating approaches and methods to incorporate new data and models, as well as to reduce the burden on staff (*4*).

The question of new and alternative data sources that can be used for meeting analytical needs of the conformity process (specifically in conducting a region emissions analysis) is a timely one, as we move to a world that is more connected, and where disaggregated, fine-scale data and models are available to represent travel activity. Further, as the transportation sector faces rapid change, there is a need to revisit and retool approaches to conformity, to account for disruptors, such as electric vehicles (EVs) and other alternative fueled vehicles and connected and automated vehicles. In this context, there is a need for transportation practitioners to understand possible implications for the state-of-practice.

1.2 Task Overview

The aim of this task is to provide a forward-looking assessment of how transportation conformity analyses can potentially incorporate new and innovative data and methods, to advance the state-of-practice in Texas. This work is conducted in a two-part task. This report covers the first part and provides a simple overview of the current state-of-practice, geared towards assessing the potential of using advanced data or methodologies to enhance conformity analyses and to improve communication with stakeholders. The report also reviews approaches and tools used by other states and MPOs. A companion deliverable on the second part of this work focuses on a pilot analysis demonstrating the use of alternative data and assumptions in a hypothetical application of a regional emissions analysis.

1.3 Task Scope and Approach

This assessment is conducted within the context of the existing Texas state-of-practice, specifically in terms of analytical methodologies established by the Texas A&M Transportation Institute (TTI). TTI supports state agencies and their local partners in the area of mobile source emissions analysis by 1) conducting mobile source emissions inventories statewide for SIP development purposes, and 2) providing technical support and data to MPOs who conduct their own emissions inventories. TTI also assists the Texas Department of Transportation (TxDOT) and its partner agencies by providing other transportation air quality assistance such as project-level air quality analyses, congestion mitigation and air quality (CMAQ) assessment, etc. TTI's methods and procedures for regional emissions analyses that form the state-of-practice in Texas are documented in two guidebooks (*5*, *6*), which are updated periodically.

This report does not make specific recommendations and recognizes that the established state-of-practice was developed after considerable efforts among interagency consultative partner groups. As such, the authors acknowledge that changes to procedures can occur only through agreement of interagency consultative partners. Therefore, this report provides an overview of current practice and emerging considerations which can assist in "future-proofing" the current processes and informing stakeholders.

1.4 Report Outline

Following this introductory section, this report provides a high-level overview on current conformity work to complement the existing technical guidance prepared by TTI under the TTI-TxDOT Air Quality and Conformity Interagency Contract (IAC)(*5*, *6*). After summarizing the Texas state-of-practice, the report also briefly discusses practices in other states, including an overview of tools developed by other states and regions for the purpose of transportation conformity. Finally, the report provides a simple overview of the Texas state-of-practice as established in the TTI/TxDOT IAC, in the form of a "quick-reference guide", which is then used as a reference point to evaluate the potential for using alternative advanced data or methodologies to improve the analysis.

2) REVIEWING THE TRANSPORTATION CONFORMITY PROCESS – CURRENT AND HISTORICAL CONTEXT

As mentioned in the introductory section, the Clean Air Act Amendments (CAA) of 1990, provided the framework of much of the transportation conformity process that we recognize today. In the early 1990s, agencies struggled with implementing transportation conformity requirements, with problems occurring under six major categories – 1) emissions tests/meeting budget requirements, 2) modeling procedures, 3) transportation control measure (TCM) implementation, 4) fiscal constraint, 5) SIP failure, and 6) human error due to procedural confusion and/or data analysis mistakes (*7*).

Over the years, several of these problems have been resolved, as agencies have developed methods, procedures, and systems to navigate conformity requirements, usually coordinated on a statewide basis. For example, in Texas, the Technical Working Group for Mobile Source Emissions (TWG)[1] provides a platform for the statewide discussion of topics related to air quality planning, and a framework for interagency consultation procedures that are required for each nonattainment area's metropolitan transportation plan.

However, the conformity requirements in nonattainment areas are still very complex. While conformity requirements are guided by an overarching framework prescribed by federal regulations and guidance, the conformity demonstration process emphasizes the use of local data wherever feasible and relies on interagency consultation and public involvement at the state and regional level. Further, a state's environmental or air agency's approach to development of the SIP will also affect assumptions, methods and procedures for quantitative elements of the process.

In this context, continually updating methods and procedures for regional emissions analysis is not always viewed as feasible. First, the effort that goes into developing standardized, approved procedures and methods is significant. Second, there is the need for consistency with methods used in the SIP, which are done by state air agencies. Any updates and improvements to conformity methods therefore require coordination to be consistent with SIP, which can delay and add complexity to the process. Finally, there is the potential costs of a conformity lapse or potential costs of litigation and

[1] https://www.texastwg.org/

other risks if the processes are derailed, including delays to major planned and ongoing transportation projects.

Therefore, as outlined in the introductory section, we acknowledge that there are several reasons why the existing conformity processes follow historical precedent in their methods and procedures. However, advances in computation, data analysis and data availability suggest there is much to gain from developing a forward-thinking approach to improving the current state-of-practice.

The EPA's Motor Vehicle Emissions Simulator (MOVES) model is also an important factor to consider in the context of revisiting conformity methods and procedures. MOVES was developed by U.S. EPA as a regulatory tool for mobile source emission inventory calculation (*8*). It allows national-scale, county-scale and project-scale analysis. Compared to its predecessor MOBILE, MOVES not only improves emissions inventory estimates, but also expands the capabilities to perform quantitative project-level emission inventories with greater flexibility and range of inputs (*9*). MOVES adopts a modal-based approach, rather than simplified average speed-based approach, for emission factor estimation. It allows analysis at macro-, meso-, and micro- scales, and adopts more sophisticated GHG estimation mechanisms and total energy consumption estimations (*9*). MOVES has allowed emission modeling to become more sophisticated and flexible, with the ability to better reflect vehicle activity and population at a granular level.

3) METHODS AND TOOLS FOR DEVELOPING REGIONAL EMISSIONS INVENTORIES

This section focuses on the regional emissions inventory estimation process, which is the main quantitative aspect of the conformity process. First, the current practice in other regions are summarized and discussed in contrast to the Texas state-of-practice. Following this, a brief overview of tools used to automate the emissions inventory process is included here.

3.1 STATE-OF-PRACTICE IN TEXAS AND OTHER STATES/REGIONS

The prevailing state-of-practice across the US is the MOVES model. However, the MOVES model can be used in two ways, in an emissions rate mode and inventory mode (8). The inventory mode generates emissions inventories using MOVES directly, while in the emission rate mode, emission rates are generated by MOVES and other external tools or procedures are used to compute the emission inventories.

Compared to the inventory mode, the emission rate mode is often more flexible in form, can provide detailed results (e.g., at link-level and by each hour) and is often adopted by non-attainment areas that need both short-term and long-term transportation air quality assessments. Further, vehicle population and activity data are critical inputs for calculating emission inventories from various processes such as running exhaust, start exhaust, and evaporative emissions (*10*). Different states and regions have developed different technical approaches to produce a regional emissions inventory for conformity purposes, or other applications, depending on their attainment status and availability of data/resources.

In Texas, the Houston-Galveston Area Council and the North Central Texas Council of Governments develop their own emissions inventories, while TTI develops inventories for other nonattainment areas in the state. TTI also provides data, inputs, and emissions inventory development utilities for use with MOVES to all nonattainment regions in Texas. TTI acquires and maintains the latest data sets for use in preparing MOVES inputs and vehicle activity measures for conformity analyses, such as the latest Highway Performance Measurement System (HPMS) data, the vehicle registration records, and other data for the post-processing of regional travel demand models (*5*). TTI also uses several utilities developed in-house to assist with MOVES-based emissions analysis. These utilities are used for a range of activities, such as data cleaning and processing, QA/QC, and post-processing of results.

In general, TTI adopts the emission rate approach provided by U.S. EPA (*8*). The technical aspects of the modeling approach are simplified in Figure 1. The MOVES model is used to generate emission rates per unit of vehicle activity. The vehicle activity related to all emission generation processes is gathered from various transportation studies and databases. The process-specific vehicle activity is multiplied by corresponding emission rates to obtain the regional emission inventory used for conformity analysis.

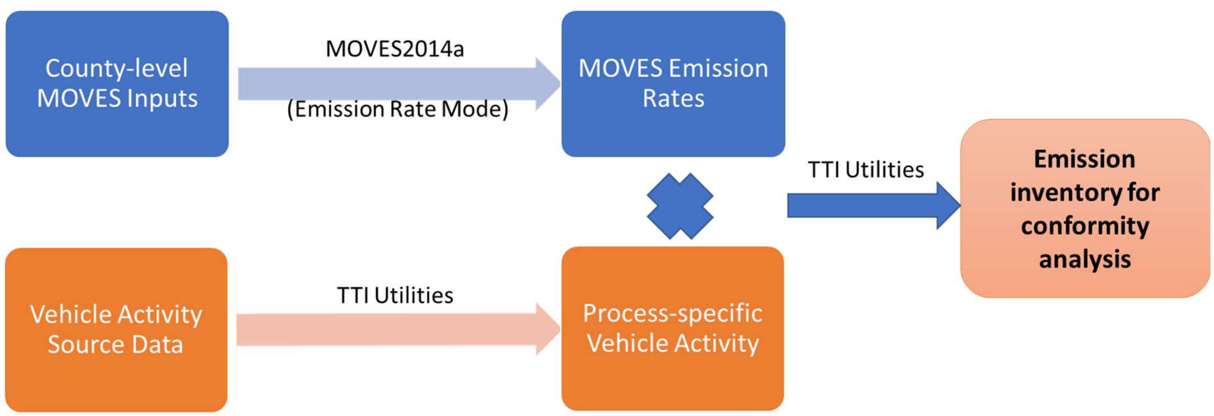

Figure 1. Simplified Conformity Analysis Workflow

To compare prevailing Texas practices with other areas, the TTI team reviewed recent conformity analysis methods from various MPOs. These are summarized in Table 1.

Table 1. Summary of State-of-practice in Other States

Region	Agency	Attainment status	MOVES Version	MOVES model type	Travel demand model	Source of vehicle type composition data
Chicago, IL (*11*, *12*)	Chicago Metropolitan Agency for Planning (CMAP)	Ozone NA $PM_{2.5}$ NA	2014a	Inventory mode	4-step travel demand model	TDM vehicle type specification
Atlanta, GA (*13*)	Atlanta Regional Commission (ARC)	Ozone NA $PM_{2.5}$ NA	2014	Inventory mode	Activity-based model	Vehicle registration database from R.L. Polk & Co.
Phoenix, AZ (*14*)	Maricopa Association of Governments (MAG)	Ozone maintenance, $PM_{2.5}$ NA	2014a	Emission rate mode	Activity-based model	Vehicle registration database provided by state DOT
Grand Rapids, MI (*15*)	Michigan Department of Transportation (MDOT)	Attainment	2014b	Inventory mode	Several 4-step models for different counties	Vehicle registration database from the Michigan Secretary of State
Washington, D.C. (*16*)	Metropolitan Washington Council of Governments (MWCOG)	Ozone NA	2014a	Inventory mode	4-step travel demand model	Vehicle registration database from Maryland Department of the Environment
Triangle Region, NC (*17*)	Capital Area Metropolitan Planning Organization (CAMPO)	Attainment	2014a	Inventory mode	4-step model; NCDOT non-modeled area analysis	Vehicle registration database from state DOT
New York City (*18*, *19*)	New York Metropolitan Transportation Council (NYMTC)	Ozone NA, $PM_{2.5}$ and CO maintenance	2014a	Emission rate mode	Activity-based model	Vehicle registration database from DMV
Christian County, KY (*20*)	Clarksville Urbanized Area MPO (CUAMPO)	Ozone maintenance	2014a	Inventory mode	4-step travel demand model	Vehicle registration database from Kentucky Transportation Cabinet

*NA – Nonattainment area

Table 1 shows that all the agencies are using recent releases of MOVES (later than MOVES 2014). Compared to other states, conformity analysis techniques developed by TTI are relatively advanced in terms of model complexity and flexibility with the use of the emissions rate mode. Based on a review of other MPOs' practices, two main areas for future enhancements could be considered for Texas. These are improving data sources for vehicle activity and obtaining more details regarding vehicle population characteristics, from sources such as vehicle registration databases. These can especially help with incorporating new data and disruptors, including technologies such as EVs. These two aspects are described below:

1. **Improving the data source for vehicle activities:** some other MPOs have adopted advanced travel demand models, such as activity-based or agent-based models, instead of traditional four-step models. Compared to traditional four-step models, activity-based or agent-based models predict tours (chained trips throughout a day) made by individual travelers instead of trips. Those tour-based models can better reflect the travel behavior changes in response to some system-level changes (e.g., toll lane, ride sharing, etc.) and open the door for investigating the impact of disruptive technologies on travel behavior and traffic conditions.
2. **Collecting more information on vehicle population characteristics:** most MPOs use vehicle registration database either provided by state agencies or data from private companies for generating fleet-related inputs in conformity analysis. However, it is worth exploring other attributes (such as vehicle make and model) in those datasets if applicable to generate fleet information regarding disruptive technologies, especially EVs.

3.2 Existing Tools to Automate Emissions Estimations

In order to improve the efficiency and repeatability of conformity analysis, many agencies and research institutes have developed tools to partially or fully automate the conformity analysis process. This section provides a review of selected tools.

3.3.1 TTI MOVES Utilities

MOVES2014aUtl is a collection of emissions inventory estimation utilities developed by TTI and specifically designed for use with MOVES2014a (*5*, *6*). As introduced in Section

4, TTI uses a detailed, MOVES rates-per-activity, Travel Demand Model (TDM) link-based, on-road mobile inventory method for emissions inventories involving counties included in TDMs. This method produces hourly emissions estimates for each link in the TDM by vehicle type, pollutant, and emissions process for each county inventory.

3.3.2 PPSUITE

The conformity analysis of Centre County, Pennsylvania is performed by Pennsylvania Department of Transportation (PennDOT) and Centre County Metropolitan Planning Organization (CCMPO) (*21*). The MOVES inputs for generating regional emission inventories are calculated using a custom post-processing software called PPSUITE with input traffic data from PennDOT's Roadway Management System (RMS). PPSUITE can analyze highway operating conditions, calculate highway speeds, compile VMT and vehicle type mix data, prepare MOVES runs and process MOVES outputs. After processing all the traffic data, PPSUITE prepares traffic-related inputs needed to run EPA's MOVES software. Currently, MOVES2014a is used to generate the final regional emission inventories.

3.3.3 MOVESLink

MOVESLink is software developed by Maricopa Association of Governments (MAG) to process link data files output by the MAG transportation model (*14*). MOVESLink can calculate spatial and temporal allocations of on-road vehicle emissions using the emission factors from the above models and travel and speed data from the TransCAD transportation model. Vehicle miles of travel (VMT) output by link from TDM are input to the MOVESLink model for estimating on-road mobile source emissions for conformity purposes. Hourly emission factors are developed by running MOVES2014a for each facility type, area type, and vehicle class using link speeds by time of day. MOVESLink emission outputs include an hourly, gridded on-road mobile source emissions file and several summary files containing emissions and traffic data in the maintenance area.

3.3.4 GT MOVES-Matrix

To improve modeling speed, but at the same time ensure that regulatory requirements for use of MOVES are met, the Georgia Tech research team developed MOVES-Matrix to support emissions modeling (*22*). The MOVES model was run hundreds of thousands of times to generate a matrix for all combinations of MOVES input variables. The MOVES-Matrix has been implemented in a variety of emission modeling research, including connection with travel demand model for conformity analysis purpose (*23*). An automatic linkage between MOVES-Matrix and the activity-based model for 20-county Metropolitan Atlanta area has been developed to generate regional-level running, start, evaporative and truck hoteling emission inventories. The results have been verified using MOVES and the emission inventories generated using MOVES-Matrix exactly match the results from MOVES.

4) REGIONAL EMISSIONS ANALYSIS PROCESS OVERVIEW

This section provides an overview of the TTI-TxDOT emissions inventory process, geared toward understanding each component of the process, and how alternative or new data may be used. More detailed information on TTI's Utilities and Procedures can be found in TTI's accompanying guidance documents (*5*, *6*).

Based on EPA requirement and current practices in Texas, the regional emission inventories includes the following sources, consistent with the Motor Vehicle Emissions Budget (MVEB) from the State Implementation Plan (SIP) developed by the Texas Commission on Environmental Quality (TCEQ) (*5*):

1. running emissions,
2. evaporative emissions,
3. start emissions and
4. truck hoteling emissions,

In MOVES, the running emissions are estimated for several road types (urban restricted road, urban unrestricted road, etc.), and is sometimes referred as 'on-road' emissions. The evaporative emissions from parking, start emissions and truck hoteling emissions are estimated using 'off-network' road type, and is sometimes collectively referred as 'off-network' emissions. Each of these components are briefly described in Table 2.

In addition, in some regions, the PM emissions from re-entrained road dust (also known as 'resuspension emissions') need to be quantified as part of the emissions inventory. This is to be done using EPA's 2011 AP 42 methodology in PM_{10} nonattainment and maintenance areas and any $PM_{2.5}$ nonattainment and maintenance areas if certain conditions apply (*24*). In Texas, the only PM nonattainment area where these requirements apply is El Paso County. The AP-42 methodology is not included in TTI's current conformity analysis tool and is performed using a separate spreadsheet calculator. This section therefore does not discuss these emissions further, though the technical details are discussed in the accompanying case study analysis for El Paso (*25*).

Table 2. Components of Regional Emissions Inventory

Process	Definition	Notes
Running emissions	Emissions generated during vehicle movement after the engine and emission control systems have stabilized at operating temperature	Brake wear, tire wear only available/applicable for PM emissions
Evaporative emissions	Emissions from unburned fuel which evaporates from vehicles throughout the day	Generated when the vehicle is parked as well as when in operation
Start emissions	Emissions generated during the first few minutes after an engine is started, before the engine and emission control systems have stabilized at operating temperature	-
Truck hoteling emissions	Emissions generated during "hoteling" period, in which truck drivers remain in their parked, often idling, vehicles during mandated driver break periods	Only applicable to long-haul combination trucks

There are various data sources that are required for quantifying each of the four elements above, with one or more datasets used for input preparation and modeling. For each source of emissions, MOVES can supply source-specific emission rates after users define the **county-scale inputs** (such as fuel specifications and existence of I/M programs). To quantify each source of emissions, the **MOVES-generated emission rates** need to be combined with one or more **vehicle activity** inputs, such as VMT, speed, vehicle start, source hour parked and hoteling hours. In addition, vehicle population were used for preparing vehicle activity related to multiple emission sources as this attribute is involved in multiple emission generating process. Finally, those activity data come from a variety of **activity data sources**, with some data sources containing several aspects of travel characteristics that can serve more than one activity at a time (e.g., travel demand model, HPMS data).

The current data sources and MOVES-generated data used by TTI are summarized in Figure 2, grouped into four input components: 1) MOVES county-scale inputs, 2) MOVES emission rates, 3) vehicle activities, and 4) vehicle activity sources. The first two components represent the MOVES input and outputs that feed into the process, while the other two represent the vehicle-specific activities used in conjunction with the MOVES emission rates, and the sources that are used to generate these activity inputs.

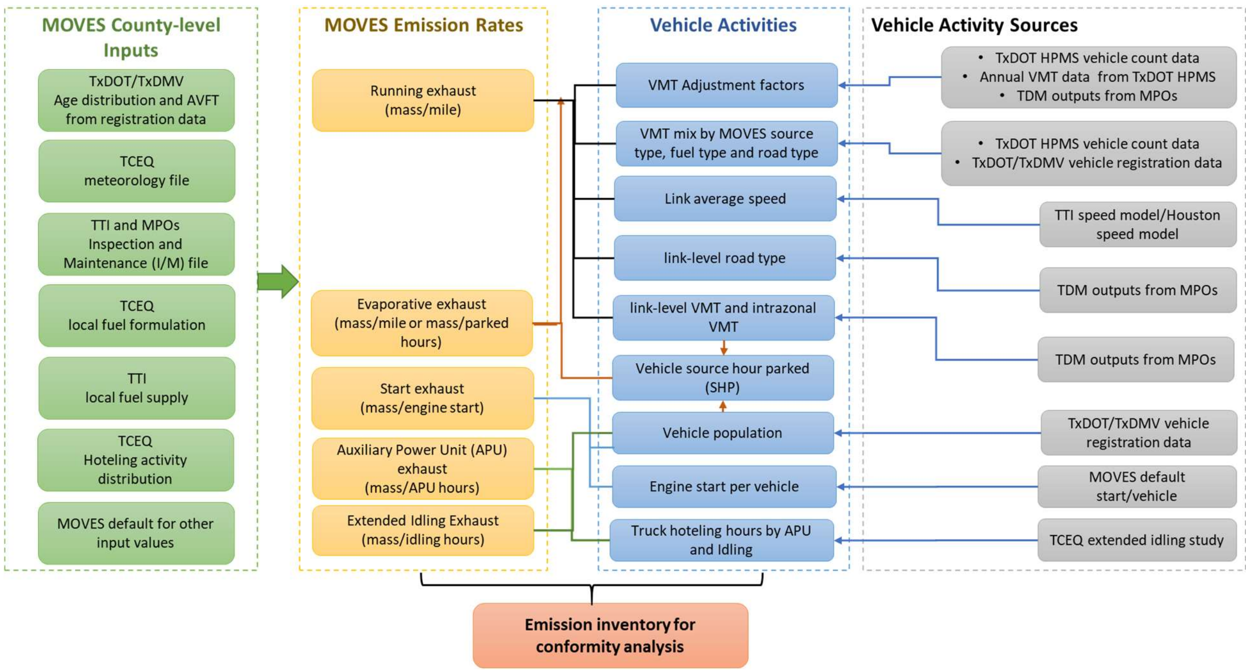

Figure 2. Data sources and computational elements used for developing an on-road mobile source emissions inventory

4.1 MOVES County-scale Inputs and Outputs

Under current practice, the MOVES county-scale emission rate model is used to generate source-specific emission rates. County-scale inputs are prepared to reflect local conditions and are used to adjust baseline emission rates in MOVES. The local inputs that have been developed so far using best available data are shown in

Table 3.

Table 3. MOVES County-scale Inputs

Input	Definition	Data source	Data description
Time span and geographic bound	Year, month, day-type, hours, state and county	Defined by the scope of analysis	N/A
Age distribution	A dataset that includes vehicle age distribution by MOVES source types that reflects level of vehicle degradation.	TxDOT/TxDMV vehicle registration data	By source type and independent of fuel type and powertrain specification. Contains age information in the form of a set of 31 age fractions that sum to 1.0.
Alternative Vehicle and Fuel Technologies (AVFT)	A dataset that includes fuel type and vehicle technology that reflects local fleet composition by fuel type and powertrain	TxDOT/TxDMV vehicle registration data	Contains information by source type and model year, on fuel type and powertrain specifications
I/M (inspection and maintenance) program	A dataset that reflects local emission control program designs (such as test type, percentage of compliance and potential exemptions)	Local MPOs	Reflects I/M coverage in non-attainment areas within Texas to limit hydrocarbon (HC), carbon monoxide (CO), and oxides of nitrogen (NOx) emissions
Local fuel supply and formulation	A dataset that reflects the market shares of fuels in the area and the properties of each fuel (e.g., sulfur content, ethanol volume, etc.)	TCEQ and EPA	Local gasoline and diesel fuel supply market share and property of fuels are largely collected from local survey data
Meteorology input	A dataset that reflects local temperature and humidity for each hour of the day and that may have substantial effects for some fuel types on many pollutant processes	TCEQ	Developed from local hourly temperature and relative humidity, and 24-hour barometric pressure averages for the seasonal period
Hoteling activity distribution	A dataset that reflect the fractions of truck hoteling hours by APU and extended idling	TCEQ	The fraction of truck hoteling activity distribution from the TCEQ 2017 study performed by TTI has been used in Houston, El Paso, and San Antonio conformity analyses

Table 4 shows the emission rates generated in mass per unit source activity from the MOVES County-scale model.

Table 4. MOVES County-scale Emission Rate Output

Emission Rate by Source	Components	MOVES Source Type	Units
Running emissions	Running exhaust, crankcase running exhaust, brake wear and tire wear (for particulate matter, PM)	All 13 source types	Mass/mile
Evaporative emissions*	hydrocarbon (HC) permeation, fuel leaking and vapor venting	All 13 source types (for heavy-duty diesel vehicles, evaporative emissions only include fuel leaks. No permeation and tank vapor venting emissions due to diesel fuel properties)	Mass/mile or mass/parked hour**
Start emissions	Start and crankcase start emissions	All 13 source types	Mass/engine start
Truck hoteling emissions	Auxiliary power unit (APU) exhaust, extended idling and crankcase extended idle emissions	Long-haul combination trucks	Mass/APU hour or mass/idling hour

*Refueling emissions at gas stations are not included as it is accounted in the stationary area source emission analysis

** The evaporative emission rates in mass/parked hour is not a direct MOVES output. The evaporative emission rates in mass/parked hour is generated by TTI by post-processing MOVES emission rates in mass/vehicle and vehicle population outputs.

4.2 MOVES Process-specific Activity and Data Sources

After generating emission rates for each emission sources, the emission rates need to be matched to corresponding on-road or off-network activities to obtain the regional emission inventory. The vehicle activity inputs that need to be prepared for each source are shown in Table 5.

Table 5. Summary of Vehicle Activities by Emission Sources

Emission sources	Vehicle activity	Description	Data sources
Running exhaust	Link-level VMT by time of day	Link-level VMT comes from network assignment of O-D pairs in TDM model	Regional travel demand models (TDMs) developed by Metropolitan Planning Organizations (MPOs)
	Intrazonal VMT by time of day	Intrazonal VMT comes from driving with origins and destinations located within the same zones	TDM trip matrices
	Year, season, day-type, hour, and directional VMT factors	Factors used to adjust link-level VMT and obtain seasonal, hourly VMT	TxDOT HPMS data and TDMs
	VMT mix	The fraction of VMT by vehicle types (combinations of MOVES source use types and fuel types)	TxDOT HPMS data, TxDOT/TxDMV vehicle registration data and MOVES default values
	Link-level speed	Average speed on each link	TTI speed model/ Houston speed model
Start exhaust	Number of engine starts per vehicle per hour	The frequency of engine starts per hour by county	MOVES national-scale default
	Vehicle population	Number of vehicles by MOVES source type and fuel type	TxDOT/TxDMV vehicle registration data and local VMT mix estimate by source-type and fuel type
Evaporative emissions	Hourly VMT	Same as link-level VMT used for running exhaust, used to estimate evaporative emissions during vehicle operation	From running exhaust
	Vehicle source hours parked	Vehicle hours while parked, used to estimate	Derived from total hours subtracted by hours driving on

		parked vehicle evaporative emissions	roads for entire source type population
Truck hoteling exhaust	APU hours and idling hours for each county	Define hours of truck hoteling with or without auxiliary power units (APU)	Total hoteling hours and fractions of APU/idling hours comes from real-world observation data on truck activities, with MOVES default fractions of APU/idling hours used for some regions

The source-specific activities shown in Table 5 are generated using data sources shown in Table 6, in addition to the use of MOVES defaults.

Table 6. Summary of Conformity Analysis Data Sources

Data source	**Provider**	**Data description**	**Supplied vehicle activities**
Regional Travel Demand Models (TDMs)	MPOs	Used for short-term and long-term transportation planning The current TDMs were four-step models (trip-based model) Common output includes trips from origin to destination, zonal radii and traffic assignment results Provide link-level facility type, direction, volume, speed by different time periods of the day	Link-level VMT, intrazonal VMT, future year VMT projections and directional factors
Highway Performance Monitoring System (HPMS) data	TxDOT	Traffic count data that follows FHWA sampling procedure Vehicle counts are available by season, month, day-of-week, as well as on an annual average daily basis Some TxDOT classification counts separate vehicles into the standard FHWA HPMS vehicle classifications The county total annual average daily VMT is used to ensure the TDM VMT is consistent with the HPMS VMT	Year adjustment factors, seasonal and hourly VMT adjustment factors and VMT Mix

Vehicle registration data	TxDOT/TxDMV	Include all the vehicles by vehicle type, model year, engine type and fuel type in a region	Vehicle age distributions, AVFT distributions, vehicle population and VMT Mix
Speed model	TTI/Houston MPO	An equation used to estimate the hourly, directional, congested speed for each link, except for the TDM centroid connectors and added intrazonal links Calculating speed based on free-flow speed, roadway capacity and traffic volume	Link-level speed
Extended idling study data	TCEQ	Obtained from 2004 summer weekday extended idling estimates for each Texas county. The new truck hoteling study has been performed in 2017 and the collected hoteling data are currently in use to develop new hoteling activities	APU hours and idling hours

Some MOVES default values are still used in addition to the data sources introduced in Table 6. Also, assumptions were made in order to fill the input values that are not available from current data sources (e.g., road grade). Table 7 describes MOVES default values or assumed values used in current conformity analysis within Texas, for each of the four emissions source components.

Table 7. Summary of Conformity Inputs from MOVES default

Process	Input	Method
Running emissions	MOVES source type and fuel type distributions	MOVES default source type and fuel type fraction is used to split passenger trucks and light-commercial trucks and split AVFT as a supplement to vehicle registration data
Start emissions	Engine starts per vehicle	MOVES national-scale default start per vehicle value for each county is used

Evaporative emissions	Start operating mode distribution (soak time distribution)	MOVES default soak time distribution is used to determine the fractions of cold start/hot start and the soak time duration before cold start
Truck hoteling emissions	Hoteling activity distribution	MOVES default fractions are used to separate truck hoteling hours by APU hours and extended idling hours in some regions

5) ADDRESSING NEW DATA AND DISRUPTORS

This section provides an assessment of the potential for future updates to current regional emissions analysis processes, based on the review of current TTI methods, based on recent research, and EPA's recommendations for use of the MOVES model.

5.1 Recommendations from Review of Texas Practice

The current conformity analysis procedure in Texas does not explicitly account for emission impact of technologies such as EVs beyond what is built into MOVES. While the impact of EVs and other vehicle technologies are included in MOVES, they are not explicitly considered beyond being accounted for in emissions rate assumptions based on future year engine and fuel efficiency standards. Thus, current practice may not be sufficient to investigate more drastic EV adoption scenarios under much higher EV adoption levels. The existing conformity analysis tools and frameworks provide potential for expanding current modeling work to incorporate new data and technologies. Some aspects to consider include:

- **Emission rates (running, evaporative, start, auxiliary power and extended idling):** the update of emission rates to better reflect the adoption of new technologies in Texas depends on the future release of the USEPA MOVES model and would be one of the biggest challenges for the conformity process. It is possible that the emission rates and vehicle activity associated with those emission rates will be updated in the future MOVES release.

- **EV population and AVFT distribution in Texas:** currently, EV population and EV fractions are not estimated from existing data. If registration data specific to EVs are known, the data can be used to develop in-state EV population estimates for use in future analyses. In addition, the registration data during recent years and incoming years, or sales information can help update the fraction of alternative fuel and vehicle technologies.

- **VMT and activity data:** the primary source of VMT in current conformity analyses is the traditional four-step travel demand model, which will pose additional challenges for developing vehicle-type specific VMT information that can be used to reflect different travel characteristics by vehicle type. The four-step model does not provide daily mileage for individual vehicles (which is crucial for determining EV driving range), the VMT mix by vehicle type (current VMT mix comes from real-world observations, which does not include EV-related data) and any other behavior changes of EVs (e.g., changes in total VMT). Similarly, current modeling processes require VMT to be assigned into "peak" and "off-peak" periods based on time-of-day, while modeling using novel methods such as dynamic traffic assignment (DTA) could potentially provide more accurate characterization of congested conditions. There is the potential to adopt better data sources for acquiring vehicle activity data, such as using activity-based travel demand models or other novel modeling approaches, or observational studies to enhance the vehicle activity inputs.

- **Speed distribution of disruptive technologies:** due to potential different driving behavior, route choices and vehicle performance, the speed distribution of vehicles including EVs could be different from the results derived from the speed formula currently used in regional emissions analyses. The new data sources for vehicle speed distribution (such as vehicle telematic data discussed in Section 5.3), could be implemented in the travel demand model and subsequently used to update the inputs of conformity analysis.

- **Off-network activities**: In the context of EVs, off-network emissions are currently not a big concern for battery electric vehicles as they do not use evaporative fuels and not yet adopted for combination trucks in the current market. The current off-network data source adopted by TTI does not include EV-specific information, either. However, it might be helpful to also collect EV-specific off-network activity data to adjust the fraction of off-network activities between ICEVs and EVs to account for emission reduction from EV adoptions.

5.2 Recommendations from Recent Research

There are numerous research efforts that discuss improvements to the data sources for emissions analyses, several of which are relevant to the development of regional emission inventories. The methodologies and data sources applied in those studies can be used to improve or expand current conformity analyses to include new data and parameters. Table 8 summarizes the new data sources used for improving/expanding conformity analysis in recent years.

Table 8. New Data for Conformity Analysis Based on Recent Research

Study	Relevance to Conformity Process	Emission Sources	Data Source	Results
Vallamsundar, et al. 2016 (*26*)	Update all vehicle activities	Running exhaust, crankcase running exhaust, brake wear and tire wear	Activity-based model (ABM) and Dynamic Traffic Assignment (DTA) model	The developed framework including transportation, emissions, air quality and population exposure can reveal a chain effect of travel demand on population exposure
Xu, et al. 2016 (*27*)	Update all vehicle activities, Fleet composition	Running exhaust	Real-time monitored traffic operation data and License plate reading	The results in Atlanta, GA suggest that an HOV-to-HOT conversion project may have increased mass emissions on the corridor
Perugu, et al. 2016 (*28*)	Update truck activities	All emission sources	Spatial regression and optimization truck (SPARE-Truck) model	The air quality estimation with updated truck data matches the trend of monitored air quality
Xu, et al. 2018 (*23*)	Update all vehicle activities	All emission sources	Atlanta Regional Activity-based TDM	With data from activity-based model, the spatial and temporal distributions of regional emissions can be generated
Rohan, et al. 2018 (*29*)	Update all vehicle activities	Running exhaust	DTA model	Emission estimates are proved to be sensitive to traffic time resolution, road type, speeds, and lengths
Liu, et al. 2019 (*30*)	Add road grade to regional emission	Running exhaust	Digital Elevation Model (DEM) database	Road grade has significant impact on regional $PM_{2.5}$ emissions and air quality

	inventory calculation			
Hu, et al. 2019 (*31*)	Update VMT mix, emission rates	Running exhaust	MA^3T model for EV market penetration; Emission rates developed by TTI	High energy price may induce more EV purchase and potentially change GHG and criteria pollutants emission from LDVs

As seen in Table 8, most of the research has focused on improving on-road running exhaust emission estimation and associated vehicle activities due to the importance of running exhaust in the regional emission inventory and the availability of data sources. It is also worth noting that new data and sources are available for alternative fuel vehicles, including populations and emission rates. Finally, due to the scale of the new data sources and the computational needs for data processing, most of the studies above have developed some form of automated tools to process the datasets and perform the emission analysis. TTI can continue maintaining and developing conformity analysis tool to incorporate new data sources when possible.

5.3 EPA's Recommendations on Potential New Data Sources

In recent years, the USEPA has incorporated numerous new data sources for on-road vehicle population and activity information and updated the default database in incoming versions of MOVES (*10*). The new data sources adopted by US EPA are often available at the state-level and have applicability for Texas. Some new data sources by activity categories that can be collected/applied in Texas are provided below:

- **Source type population and age distribution:** USEPA purchased nationwide vehicle registration data for calendar years 1999 and 2014 from a private company called IHS Markit (https://ihsmarkit.com/products/maritime-world-fleet-statistics.html) to develop source type distribution fractions from national vehicle registration data. The data is available for Texas and may contain critical information about market penetration of disruptive vehicle technologies such as EVs. In addition, the source type classification criteria in the future version of MOVES is largely depending on the IHS vehicle registration information (e.g., passenger truck vs. commercial light-duty truck).
    - **School bus (MOVES source type = 43) population:** USEPA adopts School Bus Fleet Fact Book to obtain the school bus population across US.

This data set also contains school bus counts within Texas from 2002 to 2015 (*32*).

- **Transit bus (MOVES source type = 42) population and age distribution:** USEPA estimated the transit bus population from Federal Transit Administration's National Transit Database (NTD) (*33*), which has transit bus data available since 1997. The transit bus fleet within Texas, as well as their fuel types and energy use, is also available from the NTD.
- **Future source type projection:** The future vehicle population from 2016 to 2060 is estimated using the vehicle stock information from the Annual Energy Outlook (AEO) developed by U.S. Energy Information Administration (USEIA). The data is aggregated at national-level and does not include state-level results for Texas.

- **VMT distribution of source type by road type (VMT mix):** USEPA will use the VMT distribution by source type and road type developed from National Emission Inventory (NEI). In Texas, The NEI data is produced by TTI for Texas under contract to TCEQ submitted by TCEQ every three years and available for Texas.
- **Speed distribution**: Speed distributions are generally a function of the travel demand modeling process, and speed models need to be consistent with the TDM and in processes used for both SIP and conformity purposes. However, given that TDMs were not developed for the end-use of emissions analysis in mind, there is potential to investigate alternatives to speed distribution data than current practice.
    - **Speed distribution for individual counties:** USEPA suggested county-level speed distribution by combination of source type, road type, day, and hour can be found in a recent study completed by Coordinating Research Council (CRC) Atmospheric Impacts panel (*34*). The study performed by Eastern Research Group (ERG) adopted nationwide telematic data to collect vehicle speed at each county and has enough sample size for many counties within Texas.
    - **LDV specific speed distribution**: USEPA uses LDV speed distributions by road type that are developed using in-vehicle global position system (GPS) data collected by ERG and TomTom. The speed distributions by road type,

weekday/weekend, hour of the day, and average speed bin during 2011 are available for the 50 states, including Texas. A limitation is that the data does not contain detailed vehicle type information, which make them only applicable for LDVs..

- **Off-network activities:**
  - **LDV off-network idle, soak time and engine start:** USEPA has purchased Verizon telematic data for some of the states to develop the off-network activities (engine starts, soaks and idle) for LDVs. Although the current purchased data does not cover Texas, the activity data from Georgia (similar to Texas) can be adopted or additional telematic data can be purchased.
  - **HDV off-network hoteling, soak time and engine start**: USEPA developed the HDV off-network activity data using truck study performed by (1) the University of California Riverside, Bourns College of Engineering Center for Environmental Research and Technology (CE-CERT) (*10*) and (2) the National Renewable Energy Laboratory (NREL) Fleet DNA clearinghouse of commercial fleet vehicle operating data (*35*). Both results can provide helpful insights for collecting Texas-specific HDV off-network data, such as using telematic data and using engine control unit reading data to investigate off-network HDV activities.

5.4 Summary

In this section, the new data sources that can be potentially adopted for future conformity analysis have been discussed from three aspects:

1. **Improved data incorporated into current conformity practice.** As discussed in Section 2, the current conformity analysis has been developed and widely adopted for a long period of time. To incorporate new data sources into the conformity analysis, the most practical solution is to link the new data source to existing analysis framework. Based on the current practice in Texas, data sources that can be used for improving modeling components, such as vehicle speed and VMT mix, have been discussed in Section 5.1.
2. **Data sources from academic research that have applicability to regional emission inventories:** Data sources that have been successfully used to develop

regional emission inventories, such as DTA and license plate data, have been summarized in Section 5.2. Those data sources were compatible with MOVES or MOVES emission rates and can be used to improve the resolution of emission estimation and reflect the variation of emissions under different congestion levels, if available in Texas.

3. **Data sources adopted by EPA for latest MOVES development**. As discussed in Section 5.3, the data sources adopted by EPA for developing the default MOVES database is often aligned with current MOVES methodology and can be used for state-level practice as well. For example, the NTD database and nationwide telematic data can also be used for conformity analysis in Texas.

Overall, in recent years, mesoscopic and microscopic transportation simulation tools, such as DTA and activity-based TDM, have attracted growing interest in replacing traditional macroscopic planning tools like four-step models. On the other hand, high-resolution real-world monitoring data, such as telematic data, GPS traces and on-road license plate readings, are also becoming more popular for estimating regional-level emissions. With the modeling flexibility provided by TTI's utilities for conformity analysis, it is possible to incorporate some of the new data sources into the current work flow and evaluate the impact of new data sources and new technologies. The impact of introducing new data into conformity analysis is demonstrated in the pilot study, which was done as part of this IAC task.

6) CONCLUDING REMARKS

This report provides an in-depth review on current Texas state-of-practice and potential data source and methodology for addressing new data and disruptive technologies in the conformity process. This report provides an overview of the following topics:

1. **Policy and legislative context:** There are established procedures, tools, and consultative processes that govern Texas nonattainment areas' conformity analyses, including regional emissions analyses. Any changes to methodologies and past precedent will require stakeholder involvement and approval.
2. **Current state-of-practice:** The current Texas state-of-practice is on par with several comparable states and MPOs, with MOVES' capabilities being leveraged by use of the emissions rate mode and in several local data parameters.
3. **Available sources and methodology for future improvement:** This report provides a comprehensive review on data source and methodologies that are currently available for considering disruptive technologies in developing regional emission inventories. This report also provides suggestions for further enhancements including adopting advanced transportation simulation models and real-world vehicle operation data for preparing conformity analysis inputs.

In conclusion, this report provides stakeholders with an overview of current practices in Texas, and a forward-looking assessment of how new data and new vehicle technologies or transportation sector disruptors can be incorporated into air quality planning activities in the future.

The TTI team also conducted a case study analysis for a Texas non-attainment area in the second part of this task. This pilot study aims to demonstrate how new data or assumptions can be incorporated into a regional emission inventory and is described in a separate technical memorandum.

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