Texas A&M Transportation Institute

Evaluation of
TxDOT's Non-Road Fleet Activity Data for Air Quality Applications

TECHNICAL MEMORANDUM

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TECHNICAL MEMORANDUM – DRAFT FOR REVIEW

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Sub-Task 2.1 TWG Technical Issues Analysis – Evaluation of TxDOT's Non-Road Fleet Activity Data for Air Quality Applications

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EVALUATION OF
TXDOT'S NON-ROAD FLEET ACTIVITY DATA FOR AIR QUALITY APPLICATIONS

BACKGROUND

This memorandum summarizes work performed by Texas A&M Transportation Institute (TTI) staff on evaluating TxDOT's non-road fleet activity data for potential air quality applications. This work was conducted as part of Subtask 2.1 (Technical Working Group [TWG] Air Quality Planning Technical Issues Analysis) of the TTI-TxDOT Air Quality and Conformity Interagency Contract 00000015198. The activities on this topic were initiated as part of a larger effort of interest to TxDOT and the TWG members to obtain and analyze non-road equipment activity data. This analysis can generate various information items in support of air quality initiatives in Texas.

The goal of the effort is to support TxDOT, TWG, and other stakeholders such as Texas Commission on Environmental Quality (TCEQ) in using non-road equipment activity data for air quality-related purposes. The TxDOT Fleet Operations Division is specifically interested in using the non-road fleet activity data to identify pieces of TxDOT's non-road equipment operating in non-attainment and near non-attainment areas of the state that are best suited for replacement using funding sources such as grants and rebates under the Diesel Emissions Reduction Act (DERA) and TCEQ's Texas Volkswagen Environmental Mitigation Program. The replacement of TxDOT's older heavy-duty non-road diesel equipment operating in non-attainment and near non-attainment areas is expected to provide emission reductions in these areas.

The remainder of this memorandum covers the background and summarizes the activities on this task to date.

BACKGROUND

Since 2014, the TxDOT Fleet Operations Division has been using the Fleet Navigator system, a telematics-based fleet management system developed by AssetWorks, to track and manage TxDOT fleet activities throughout the state. Using GPS and vehicle telematics systems, Fleet Navigator enables the TxDOT fleet managers to track and monitor the usage, movement, and fuel purchases for each piece of equipment in near

real-time. All the data from each piece of equipment and vehicle are wirelessly transmitted to and recorded in a database.

TxDOT's Fleet Navigator database has a large amount of equipment and vehicle usage data detailing the temporal and spatial distribution of activity parameters for each piece of equipment. This database is a rich source of information that can be used in support of efforts to improve air quality in Texas and update current and future emissions inventories.

Work Completed in FY2018

TTI staff were tasked to evaluate the potential use of TxDOT's non-road equipment activity data to support these applications. TTI staff performed the following activities under this subtask:

- Evaluated the data needs for the EPA's NONROAD model.
- Engaged in preliminary discussions with TxDOT Fleet Operations Division. Explained the potential air quality applications of TxDOT's fleet operations data. TxDOT staff provided an overview of the Fleet Navigator system.
- TxDOT provided a small extract of the fleet operations data to TTI (April 2018). The sample contained 6 months of data (October 2017 to March 2018) for non-road equipment operating in the Houston District.
- TTI staff imported the sample data into an integrated data system (Microsoft Power BI) to prepare/process the raw data, build a preliminary data structure model, analyze, and visualize the equipment usage.
- TTI team presented the visual dashboards and interim results to TxDOT Fleet Operations Division staff. TxDOT Fleet Operations staff expressed interest in using the system developed by TTI to help them on identifying equipment units that are most suitable for replacement.
- TxDOT Fleet Operations provided the statewide data tables for non-road equipment in June 2018.
- After receiving the statewide non-road activity data tables, TTI started cleaning up the data tables, importing them into Microsoft Power BI, and preprocessing them into a standard format.

WORK COMPLETED IN FY2019

TTI staff performed the following activities under this subtask in FY2019:

Quality Control and Quality Assurance

The TTI team finished importing the data tables into Power BI in the standard tabular format. A series of quality assurance/quality control (QA/QC) steps were conducted to ensure that there are no major errors in the data used in estimating equipment activity and fuel consumption summaries. The following steps were performed as part of the QA/QC process:

- TTI staff conducted a thorough review of all the tables and data items in the statewide database received from TxDOT in FY2018.
- The findings and questions from the database review were compiled into a summary document.
- The summary document was shared with TxDOT Fleet Operations Division. TxDOT provided clarification and additional information via email and conference calls.
- Once the definitions of different parameters in all the tables were correctly established, the following quality control steps were conducted:
    - The timestamps in the applicable data tables were processed through a quality check to identify and flag gaps in the data.
    - Usage hours were checked to make sure no incorrect usage were being recorded, such as usage hours that exceed maximum realistic hours based on input from TxDOT staff.
    - The equipment type was checked to make sure that all units were assigned to correct equipment categories and subcategories.
- A data model for the data tables was established. This step included identifying necessary relationship and subsequently implementing and testing them. Figure 1 shows the resulted data model.
- In addition to its data processing and analysis functions, the interactive visual dashboarding capabilities of Power BI enabled the TTI team to perform quality control. TTI staff developed a series of data quality control dashboards for this purpose.

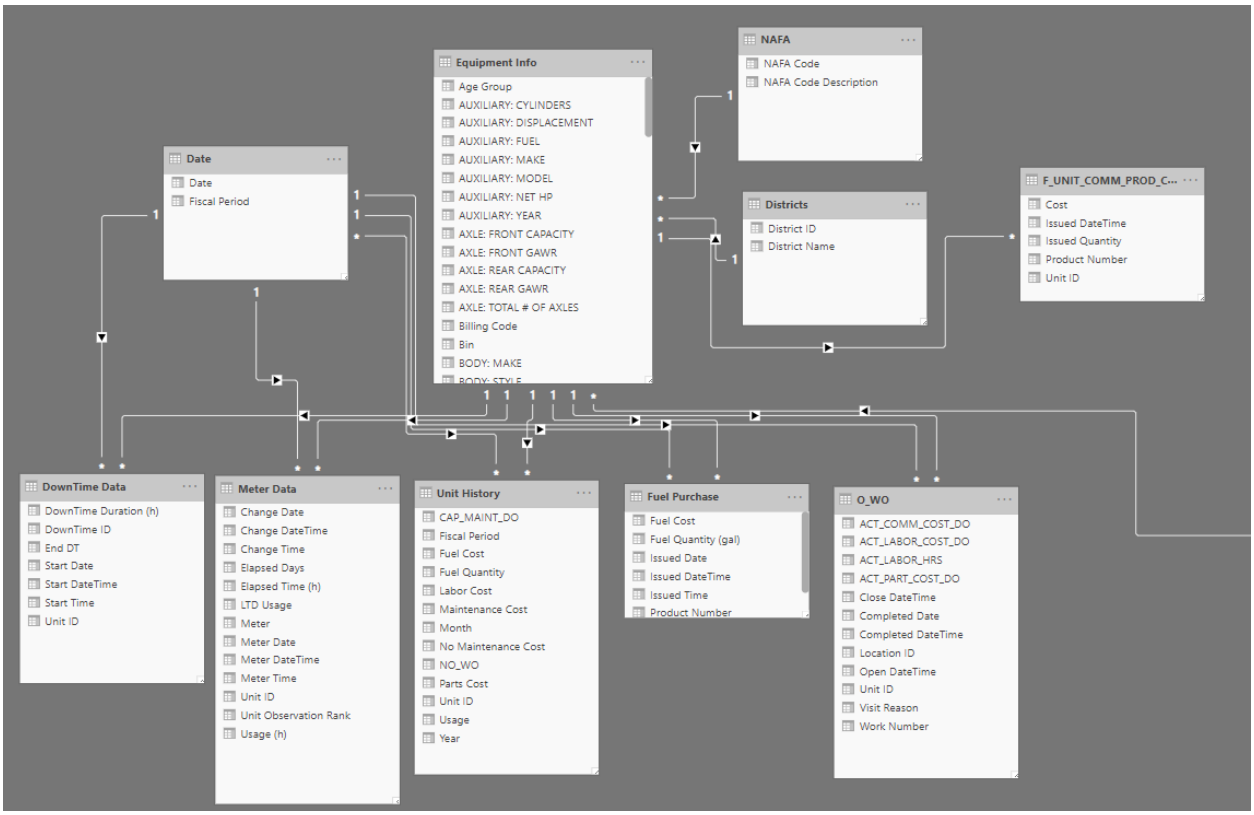


Figure 1. Data Model for TxDOT Off-Road Data Tables.

The quality control steps revealed that there is a higher number of inconsistent information in fuel and usage data that were collected prior to 2015. To minimize the impact of these inconsistencies on the analysis results, the analysis performed under the current IAC support task includes only data from 2016, 2017, and 2018.

Data Analysis

The data analysis effort focused on developing a ranking process to identify the equipment units that their replacement could provide high emission reduction benefits to Texas' non-attainment and near non-attainment areas. In formulating the criteria for a ranking system, TTI staff used information from a previous subtask completed under this support contract on summarizing the *Texas Volkswagen Environmental Mitigation Program* (also referred to as VW mitigation program). This summary was documented and submitted to TxDOT in May 2019. The technical memorandum included a summary of the program, eligible equipment types, eligible counties, and any other criteria that was specified in the program document. Figure 2 shows the priority areas for the VW mitigation program.

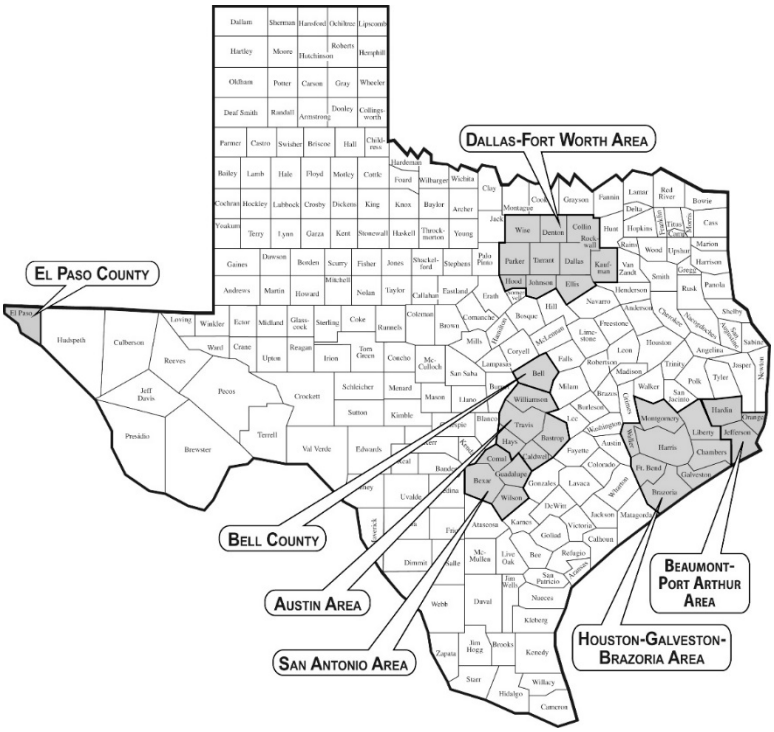


Figure 2. Priority Areas for Texas Volkswagen Environmental Mitigation Program (Source: TCEQ).

According to TCEQ's plan, the following mitigation action categories are eligible for funding under the VW settlement program:

- **Replacements and Repowers:**
  - Class 4 – 7 Local Freight Trucks.
  - Class 8 Local Freight Trucks and Port Drayage Trucks.
  - Class 7 – 8 Refuse Vehicles.
  - School Buses.
  - Transit and Shuttle Buses.
  - Forklifts and Port Cargo Handling Equipment (Electric).
  - Airport Ground Support Equipment (Electric).
- **Shore Power—**Ocean-Going Vessel Shore Power.

Of the categories listed above, only forklifts are present in the current TxDOT non-road fleet data. Hence further analysis was focused on the forklifts in the priority areas shown in Figure 2. At the time of this analysis (June 2019), TCEQ had not released grant information for forklifts.

A ranking system based on a Multi-Objective Decision Analysis (MODA) methodology was developed using R within the Power BI environment to identify potential pieces

equipment for replacement under the VW mitigation program. Figure 3 shows the steps that were followed in implementing a MODA for identifying and ranking TxDOT forklifts.

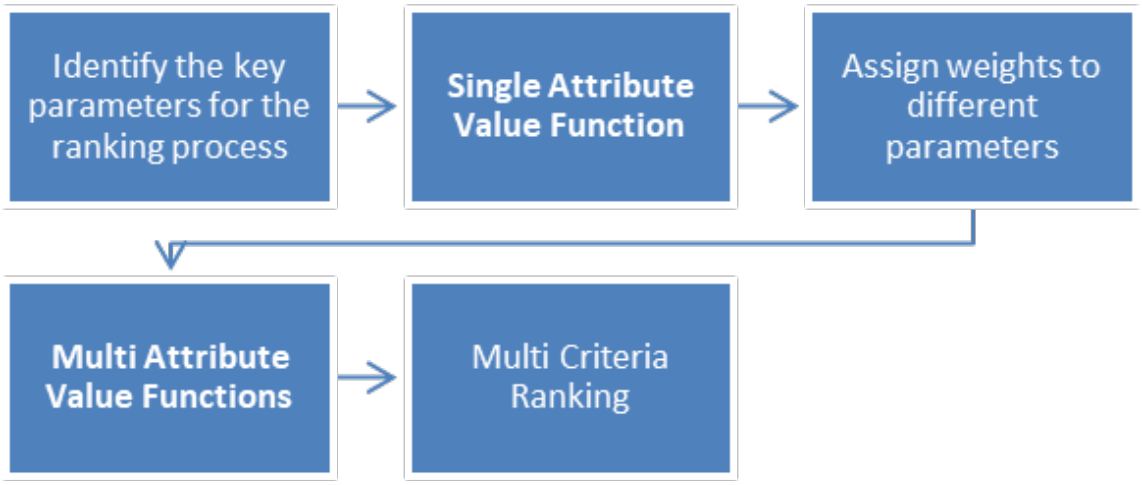


Figure 3. MODA Process.

The following parameters were identified in the first step as the key factors that would maximize the air quality benefits of a forklift replacement grant program:

- Equipment Usage (hours) – More usage hours correspond to a higher potential for replacement.
- Fuel Consumption (gallon) – More fuel consumption corresponds to a higher potential for replacement.
- Down Time (hours) – The number of hours that an equipment is out-of-service for maintenance or repair; longer down time duration corresponds to a higher potential for replacement.
- Model Year Group – The older pieces of equipment are expected to have higher NOx emissions than newer ones and therefore correspond to a higher potential for replacement. The following model year groups were used in this analysis:
  - 2010 and newer.
  - 2005 to 2009.
  - 2000 to 2004.
  - 1995 to 1999.
  - 1990 to 1994.
  - Pre-1990.
- Engine Power Rating (HP) – larger engine HP is an indication of a higher fuel usage and NOx emissions, and therefore corresponds to a higher potential for replacement.

The second step involved specifying the Single Value Attribute Function (SAVF) for the MODA system. SAVFs are used to translate the value of a key parameter into a number indicating how desirable that parameter value is for the desired application (i.e., replacement) as perceived by the decision maker. High and low bounds for each key parameter were determined from the database. The bisection technique was used to determine the bisection point or the mid-value point. Using these values, parameter values were translated into a criterion score in the next steps. Table 1 shows the low, high, and bisection point values for the key parameters.

Table 1. Low, High, and Bisection Points for Key Parameters.

Parameter	Low	Bisection point	High
Usage (h) 2016–2018 Total	2	181	532
Fuel Consumption (gal) 2016–2018 Total	0.02	10	100
Down Time (h) 2016–2018 Total	3	395	2502
Model Year Group	Before 1990	2000-2004	2010 or newer
Engine Power Rating (HP)	40	48	94

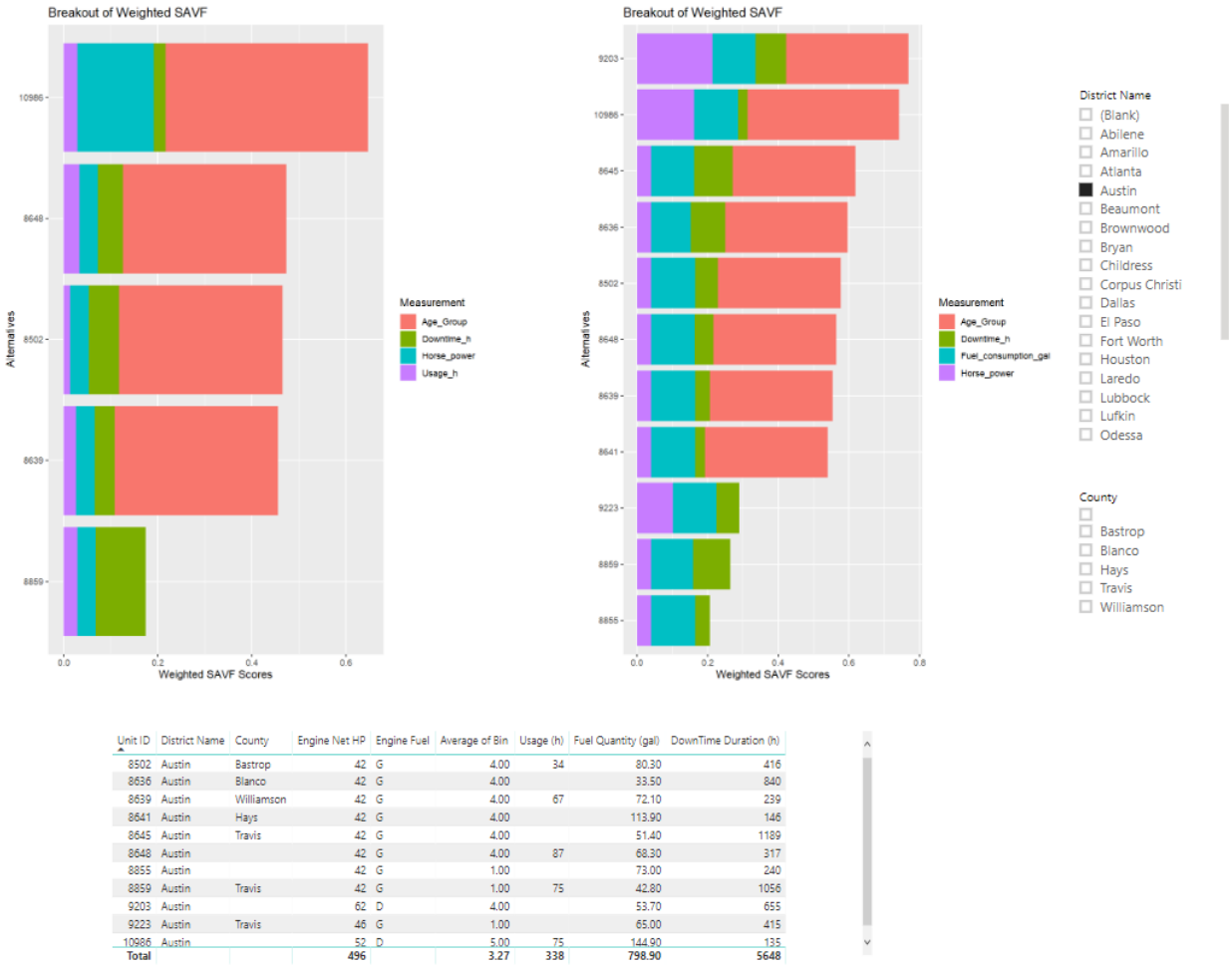
In the third step, weights were assigned to different parameters. These weights represent the perceived importance of the parameter for the desired application (i.e., replacement). TTI staff selected these values based on their experience with emissions estimation for on-road and non-road equipment. These weights can be easily adjusted to reflect alternative perspectives:

- Usage (h): 0.125
- Fuel Consumption (gal): 0.125
- Down Time (h): 0.125
- Model Year Group: 0.500
- Engine Power Rating (HP): 0.250

The final step in implementing a MODA system for identifying TxDOT forklifts was to calculate the Multi Attribute Value Function (MAVF) score. This can be done using various methods, the simplest being the use of a weight vector that multiplies each attribute's SAVF by a relative measure of importance. The weights vector is normalized so that the sum of weights is equal to one. This method was used in this analysis. Using the MAVFs, a multicriteria ranking was established and an interactive visual dashboard was developed as shown in the Figure 4. Fuel or usage hours information were missing

for some pieces of equipment. To address this limitation, two separate MODA systems were established: one with usage (h) and the other one with fuel consumption (gal).

Using the visual dashboard, one can quickly identify and rank the forklifts that are eligible for replacement in VW mitigation program's priority areas. The dashboard can be easily adjusted and expanded to include other types of equipment for other funding programs such as Texas Emissions Reduction Plan (TERP).



Unit ID	District Name	County	Engine Net HP	Engine Fuel	Average of Bin	Usage (h)	Fuel Quantity (gal)	DownTime Duration (h)
8502	Austin	Bastrop	42	G	4.00	34	80.30	416
8636	Austin	Blanco	42	G	4.00		33.50	840
8639	Austin	Williamson	42	G	4.00	67	72.10	239
8641	Austin	Hays	42	G	4.00		113.90	146
8645	Austin	Travis	42	G	4.00		51.40	1189
8648	Austin		42	G	4.00	87	68.30	317
8855	Austin		42	G	1.00		73.00	240
8859	Austin	Travis	42	G	1.00	75	42.80	1056
9203	Austin		62	D	4.00		53.70	655
9223	Austin	Travis	46	G	1.00		65.00	415
10986	Austin		52	D	5.00	75	144.90	135
Total			496		3.27	338	798.90	5648

Figure 4. Interactive Dashboard for Identifying Potential TxDOT Forklifts for Replacement under the VW Mitigation Program.