



Spreadsheet-Based Engine Data Analysis Tool - User's Guide

Project 0-6626

Project Title: Fleet Equipment Performance Measurement Preventive Maintenance Model

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16. Abstract The concept of preventive maintenance is very important in the effective management and deployment of vehicle fleets. The Texas Department of Transportation (TxDOT) operates a large fleet of over 17,000 pieces of on-road and off-road equipment. Newer engines and vehicles are equipped with on-board diagnostic systems that can provide data on engine operation—including engine speed and throttle position (an indication of load value). There is the possibility of tracking these parameters to refine predictions for when equipment maintenance should be performed. Project 0-6626 aimed to provide a proof of concept for this idea by developing an algorithm that can be used to recommend appropriate oil change intervals based on engine data collected through on-board diagnostic systems. This product is a spreadsheet-based analysis tool developed as part of Project 0-6626, which can be used for logging, analyzing, and characterizing engine data for heavy-duty fleet vehicles in the TxDOT fleet of the selected test vehicle type.					
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Disclaimer

This research was performed in cooperation with the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA). The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the FHWA or TxDOT. This report does not constitute a standard, specification, or regulation. The engineer in charge of the project was Tara Ramani, P.E. #113224. The United States Government and the State of Texas do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

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Introduction

This spreadsheet-based engine data analysis tool was developed as part of the Texas Department of Transportation (TxDOT) research project 0-6626, *Fleet Equipment Performance Measurement Preventive Maintenance Model*. This tool can be used for logging, analyzing, and characterizing engine data for heavy-duty fleet vehicles in the TxDOT fleet that conform to the Society of Automotive Engineers (SAE) J1939 protocol.¹ Project 0-6626 specifically deployed the data collection for Sterling LT9500 dump trucks with a Mercedes-Benz MBE-4000 diesel engine in the TxDOT fleet. However, this tool can be used with any heavy-duty vehicles in the fleet that conform to the SAE J1939 protocol.

This user's manual is intended to assist the user in collecting and analyzing data and using the spreadsheet-based tool. This tool is in the form of a Microsoft Excel[®] workbook. It is intended for use by TxDOT's vehicle fleet manager, or others who may be interested in logging and characterizing the fleet vehicle activity, specifically for applications such as studying engine loads and idling characteristics. The software is designed for use with data files (in .log format) produced by specific data logging equipment, as discussed in the next chapter. The tool can be used on any computer that has Microsoft Excel[®] and from which the required data files can be extracted.

The final project report, 0-6626-1, <http://tti.tamu.edu/documents/0-6626-1.pdf> contains further information on the research findings and background on the development of this analysis tool. For further information about this software, please contact:

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¹ Society of Automotive Engineers Standards Serial Control and Communications Heavy Duty Vehicle Network – SAE J1939

Data Logger Setup and Data Collection

DATA LOGGER SETUP

The initial step for collecting and analyzing data is to set up and install the data logger required for recording the data from fleet vehicles. As mentioned in the introduction, this analysis tool is designed for the analysis of .log format data files generated by data loggers used in Project 0-6626. Data logging is done by installing a J1939/1708 data logger manufactured by IOSiX LLC. While data loggers from other manufacturers can be used to collect and analyze data, the macros contained in this spreadsheet tool are based on the data/file format used by IOSiX (i.e., this tool will work only in the case of data logging devices that output data following the SAE J1939 Protocol in files of .log format). The device, shown in Figure 1, is the standard 9-pin used for SAE J1939 communications.

This section describes the setup of the data loggers, including the configuration files that can be included on the memory cards. This section is only relevant in the case of new memory cards or new data loggers being used; the data loggers deployed in project 0-6626 already contain memory cards with appropriate configuration files that may directly be used without additional data logger setup being required.



Figure 1. IOSiX Data Logger.
(Source: <http://www.iosix.com/j1939.html>)

Prior to installation in the vehicle, the data loggers must be configured to properly log the data that are required by the user. Each data logger comes with a micro-SD card that stores the configuration file as well as all the recorded data. The data logger will accept any micro-SD card up to 2 GB in size (the data logger will not recognize cards of larger size). By default, if there is no configuration file on the micro-SD card the data logger will record all data at the highest speed/frequency. While this is acceptable for short-term data logging sessions, the memory card can quickly fill up, and each file becomes very large, in the absence of a configuration file. In order to configure the data logger to only record the necessary data, and use the necessary time between logging data, the user must supply a configuration file to the data logger. This is done by putting a file named config.txt on the main directory of the micro-SD card. The data logger will check for this file and if one is found it will use the information on the configuration file during each data logging session. The configuration file consists of two types of entries, parameters to log and the logging frequency. Each entry in the configuration file is separated by a “|” symbol. The first entries are always the entries telling the configuration file which parameters to log. Each of these entries is in the form of PXXXXXXXX, where the XXXXXXXX is replaced by the identifier of the parameter to log. The identifiers are found in the SAE J1939 protocol and are written in hexadecimal format. The final entry in the configuration file is the logging frequency entered in the form JXXXXXXXX. The value here is represented by a hexadecimal number where 1 = 10 MS. To log data every second the entry would be J00000064.

The following represents a sample config.txt file for the data logger.

```
P0000FEF1|P0000FEEE|P0000F003|P0000F004|P0000FEDF|P0000FEEF|P0000FEF2|P0000FEF6|P0000FEE0|J00000064
```

DATA LOGGER INSTALLATION

Once the data logger has been setup it must be installed on the test vehicle to record data. As seen in Figure 1 the data logger has a standard 9-pin SAE J1939 connector. Most heavy duty vehicles will support this connector via a diagnostic port and the data logger can simply be plugged into this port. Most vehicles have the port located somewhere under the steering wheel, while others are on the floor next to the driver’s seat.

It was discovered during the project that certain Sterling LT9500 trucks, which were used in this study, did not contain all the wiring needed to support the “plug and play” option to log

the J1939 data. This may also be the case on other vehicles within the TxDOT fleet. In order to use the data logger on these vehicles, a small jumper cable had to be assembled and connected to the vehicle. Figures 2 and 3 illustrate this additional wiring needed. The additional jumper cable would connect the Vehicle Control Unit (VCU) directly to the data logger via terminals on the VCU and data logger. The terminals on VCU end must be connected to the 19th and 21st (19 = J1939+, 21 = J1939-) pins on the 21-pin vehicle interface harness shown in the figures. The pins terminating at the diagnostic connector must be connected in the C and D (C = J1939+, D = J1939-) ports of the connector. Once the connection has been made the data logger will record the SAE J1939 data normally.

DATA COLLECTION

After being installed on a vehicle, the data logger will record data each time the ignition of the vehicle is turned on. The data loggers operate on power from the vehicle, so no additional source of power or batteries are required for the loggers. The data will be stored as .log files in the SD card, which can then be removed from the data logger and transferred to a computer using an SD card reader once sufficient amount of data has been logged.

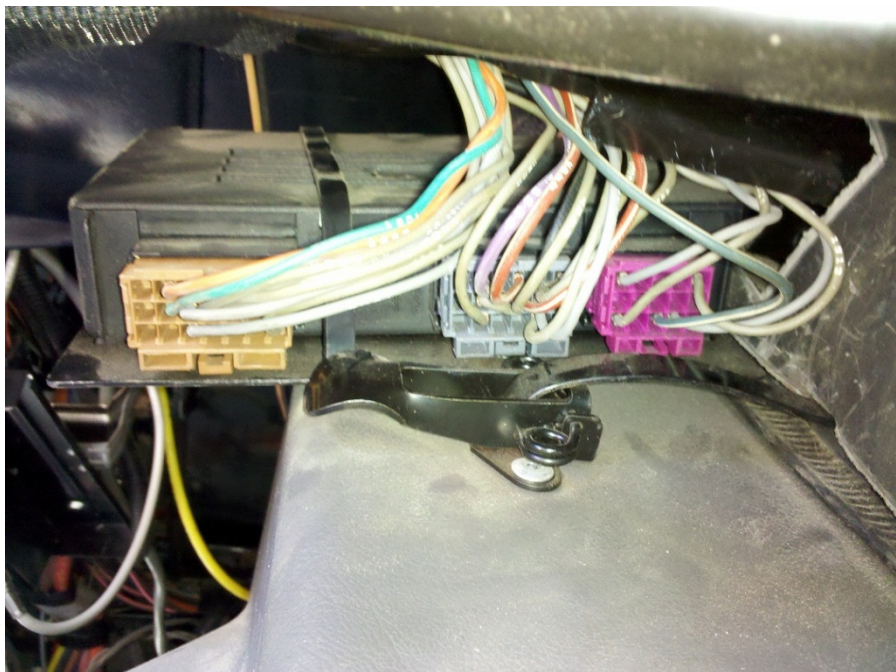


Figure 2. VCU Connector on Sterling Vehicle.

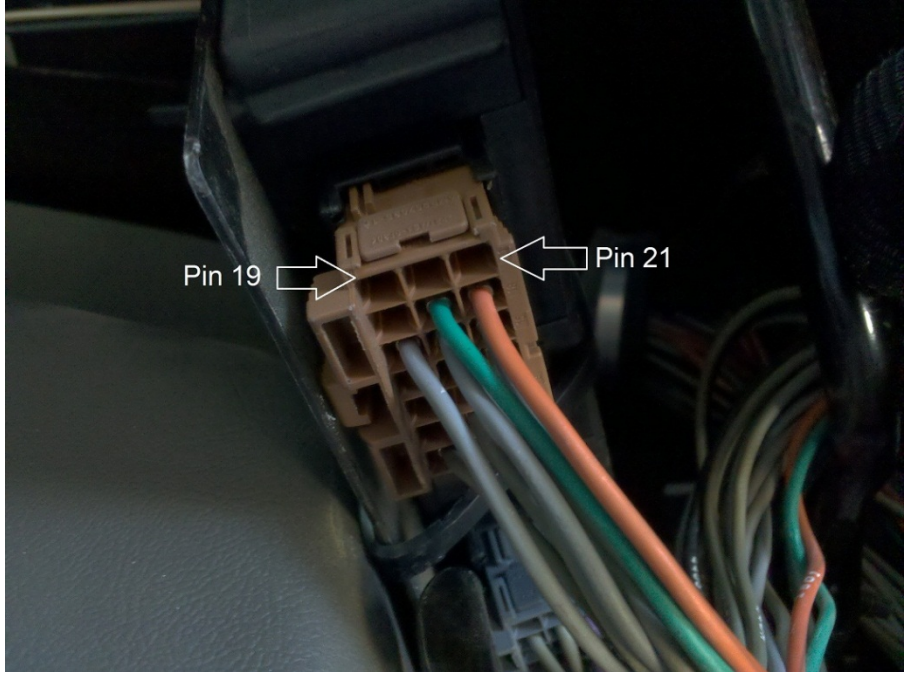


Figure 3. Location of SAE J1939 Pins.

Overview of Analysis Tool

INSTALLATION AND GETTING STARTED

The analysis tool is in the form of a standalone Microsoft Excel® workbook, which is available along with this user manual and a sample data file (titled 0_6626_ExampleData.log). Any data files (in .log format) produced by the J1939 data loggers used in research project 0-6626 can be analyzed using this format. The data files and the workbook can both be saved onto any location on a computer for use.

It is recommended that the user save a copy of the workbook onto a local drive on their computer before starting. The user will need to open the analysis tool workbook and enable macros to allow for full functionality. Figure 4 shows a screenshot of the main screen on the tool that the user will see on opening the workbook. From this page the user can navigate through each of the worksheets using either the hyperlinks or the tabs at the bottom of the sheet. The worksheets are categorized and colors coded, and also include basic instructions for the user.

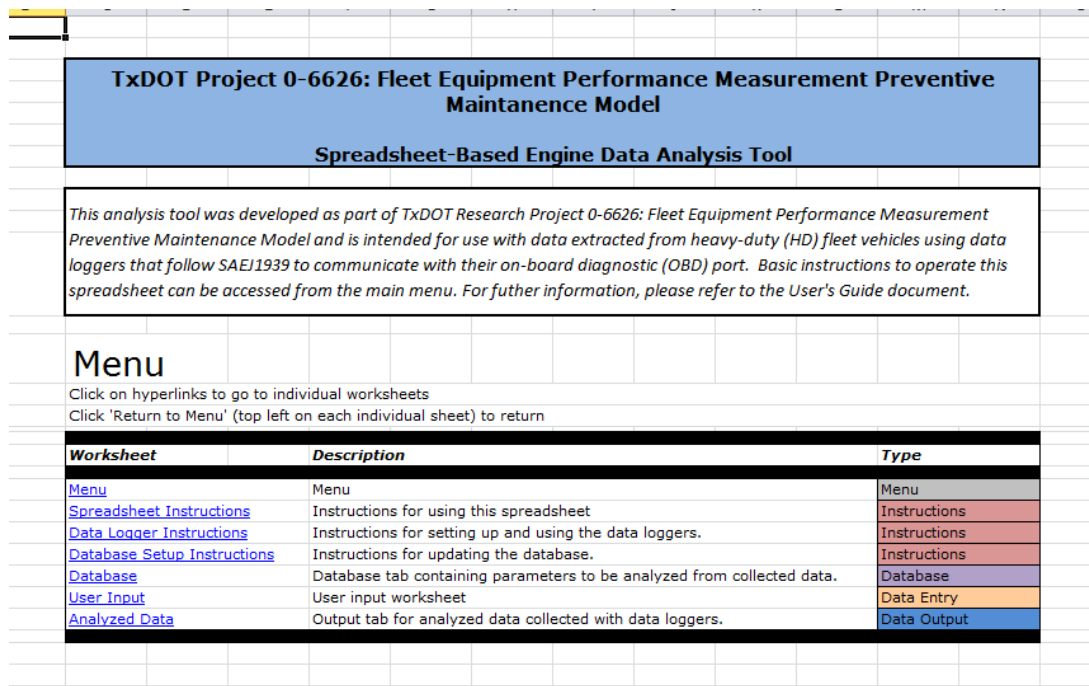


Figure 4. Main Menu for Excel Tool.

SECURITY

This analysis tool requires that macros be enabled in order to function. To check this select Tools->Macro->Security and ensure that either Low or Medium is selected. It is recommended that you use Medium. If you have Very High or High setting selected, you must reopen the spreadsheet to allow the changes to take effect.

The file is password protected and does not allow any changes to be made except for analyzing and saving data. If users wish to make other modifications, the password (“6626”) can be entered to unlock the spreadsheet.

DATABASE SETUP

The database setup feature allows advanced users to modify the database if desired, though it is not recommended unless the user has sufficient understanding of the database and how to modify it. While users are able to change the data, or add data to the database, note that if the data are changed, or entered incorrectly, it could affect the accuracy of the tool as it analyzes the collected data.

The tool contains a default database of over 100 engine characteristic parameters that may be logged by the data logger. Note that because they are supported by SAE J1939 not all parameters will be available or reported by every vehicle. Vehicles may only support and implement a subset of the entire database, as therefore the data logger may not log all the requested parameters if the vehicle does not support it. There are nine different parameters for each entry in the database. These parameters are required for each entry into the database or the tool will not function properly. All information in the database comes from the SAE J1939 protocol that the data logger uses to record data. The parameters are explained below in Table 1.

Table 1. Database Parameters.

Name	This parameter is the name of each variable that will be decoded from the raw data. The name is only used by the Macro as a reference, so it does not have to be the exact name of the parameter as used in J1939.
PID	The PID is the SAE J1939 hexadecimal identifier of the parameter. Based on the structure of the protocol there can be multiple variables that share the same PID.
Byte	The byte parameter indicates to the Macro which byte within a SAE J1939 data packet the variable is located at. Each SAE J1939 message contains 8 bytes worth of data, so the byte parameter will be a number between 1 and 8.
Bit	The bit parameter indicates to the Macro which bit within a SAE J1939 data packet the variable is located at. The bit number refers to a bit with the byte identified by the byte parameter. Each byte contains 8 bits of data, so the bit parameter can be between 1 and 8.
Length	The length parameter indicates to the Macro the length, in bits, of the variable's data is within a packet. The length can be between 1 and 64, the number of bits in one SAE J1939 data packet recorded by the data logger.
Scale	The scale is a multiplier that is used by the Macro to calculate the value of the variable. After converting the hexadecimal data recorded by the data logger to a number that number is multiplied by the scale to get a new value.
Offset	The offset is a number that is used by the Macro to calculate the value of the variable after it has been converted from hexadecimal to a number and then multiplied by the scale. This allows for numbers to be shifted, if necessary, one way or another to produce the final value of the variable.
Units	The units are only used by the calculator as a reference for the output from the Macro. If the units are entered incorrectly the macro will display the incorrect units in all proceeding calculations.
Output	The output parameter tells the Macro which parameters the user would like to see analyzed. If the output parameter is one the Macro will convert all raw data for that variable into a number and display it in the 'Analyzed Data' worksheet. If the output is 0 the Macro will ignore all data in the raw data file for that parameter.

Using the Analysis Tool

OPENING AND ANALYZING DATA FILES

This section describes the use of the analysis tool to analyze data files. After completing the database setup (if desired), the user can begin analyzing collected data. For this, the user will need to navigate to the ‘User Input’ worksheet from the main menu shown in Figure 4. Figure 5 shows the layout of the User Input section of the analysis tool.

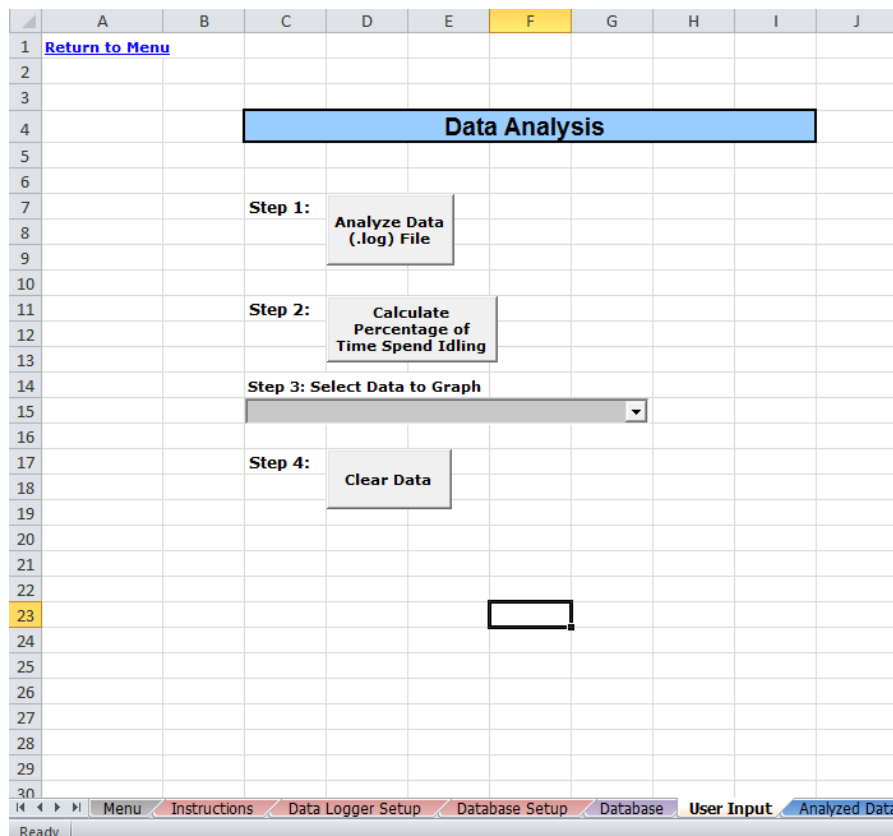


Figure 5. User Input Section.

This tab allows users to select what they would like to do with the collected data. The first step, however, is to select and analyze the data file by clicking on the “Analyze Data” button. Clicking this button will ask the user to browse and select a data file (.log file). The user

may select the appropriate data file obtained from the SD card on the data loggers. An example data file has been included along with the spreadsheet tool as a reference for users who are interested in using the tool but do not yet have access to data logged from the fleet vehicles. The example results shown in this section make use of this data file.

Once the user selects a file, the tool will use the database settings to analyze the raw data. The analyzed data will then be shown on the ‘Analyzed Data’ worksheet. Some raw data files are very large and the tool might take a few minutes to complete the analysis, depending on the speed of the computer. The tool may appear frozen or non-responsive during this time.

Following this step, users can calculate idle time of the logged data by clicking on the “Calculate Percentage of Time Spent Idling” button. In this case, idling is defined as the ratio of time where vehicle speed is zero, while engine RPM is not zero to the total time where engine RPM is not equal to zero. The resultant idle time for the analyzed data file will be displayed as a pop-up message, as shown in Figure 6.

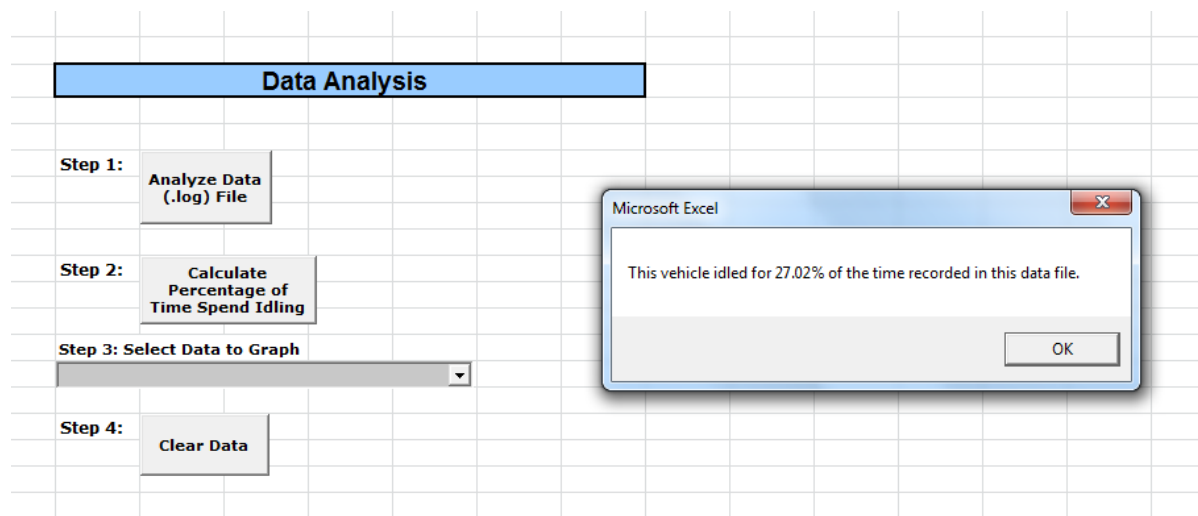


Figure 6. Example Idle Time Output.

The drop down menu of the data analysis section (Figure 7) allows the user to select and graph various data parameters over time. Each graph selected by the user will be created as a separate tab at the end of the workbook. The user can return to the data analysis sheet by navigating on the tabs at the bottom of the sheet. Figure 8 shows an example of the graphed data (in this case, the wheel-based vehicle speed). The user can also use the “clear data” button to remove all current analyses outputs, after which a new data file can be selected and analyzed using the same steps described above.

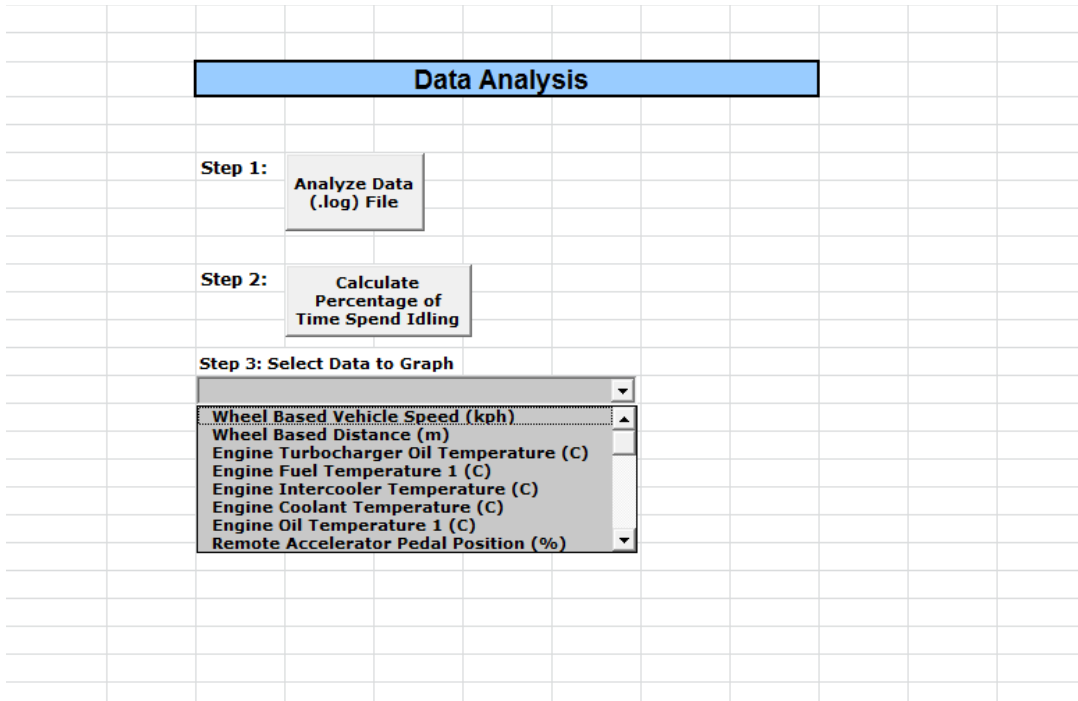


Figure 7. Drop-Down Menu for Graph Options.

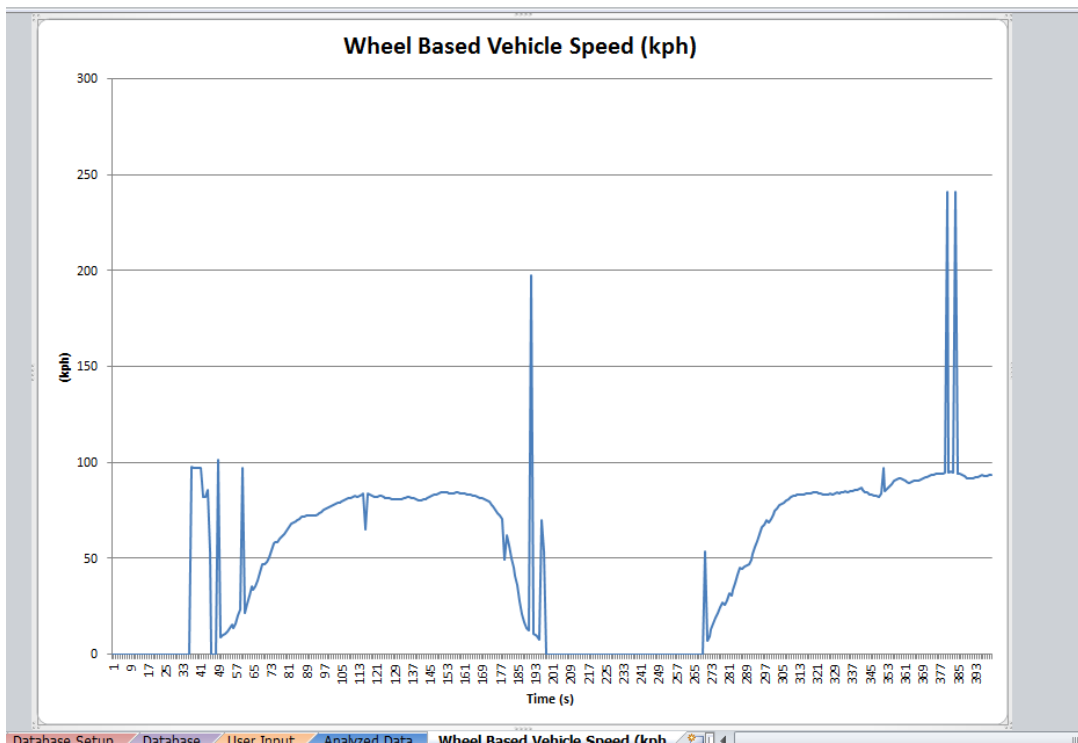


Figure 8. Example Output Graphs.

SAVING ANALYZED DATA

As mentioned in the previous section, the analysis tool has an option to clear all output data on completion of the analysis. Therefore, to avoid losing results of the data analysis, users are encouraged to save copies of the entire workbook (including results/graphs generated) using the “save as” command. Once this is done, users can clear data from the original workbook and repeat the analysis for other data files.

TROUBLESHOOTING

Some common errors/problems that may occur are explained below:

- The analysis tool appears frozen or non-responsive – This is likely due to large sized raw data files for which the tool might take a few minutes to complete the analysis.
- Message of “No Speed Data Found” appears when the user clicks on the “Calculate Percentage of Time Spent Idling” button – This happens when Step 1 has not been completed (i.e., no data file has been analyzed).
- Graphing options do not appear on the drop-down menu – As above, if the graphing options do not appear, it is also because there is no data file analyzed. The user should select and analyze the data file as a first step.
- Graphs generated do not appear to have data on them or analyzed data file is missing a specific engine parameter – As stated previously, certain vehicles may not log all engine parameters that are in the database. This is a function of the vehicle itself and cannot be modified by modifying the database or configuration file. In such cases, a parameter that is in the database but not reported by the vehicle will appear as a blank or flat graph. Another possible reason is that the configuration file was modified to exclude a parameter that is still being logged by the database. Such a case will also result in engine parameters that are in the database not having any data associated with them in the analyzed data file.