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TRUCK IDLING SCOPING STUDY

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SUMMARY

Truck idling is a significant source of air pollution and contributes to potential health risks, higher operating costs, and greater fuel consumption. Although information exists on truck emissions while idling, recent data on the time that trucks spend idling are anecdotal or speculative. This limited information may not adequately reflect the variability across all types of trucking operations, vehicle models, or regional tendencies. Enhanced datasets could help to better characterize the variability of the contributing factors in truck idling activity across all truck classes and operations.

The objective of this research is to develop a plan for decisionmakers that provides the scope, methods, and cost estimates for obtaining national and regional datasets for the time spent and fuel consumed by on-road trucks while idling. The datasets will include truck characteristics, operation types, and idling causes. The plan will be used as part of a follow-on study to provide guidance on how to apply and supplement the idling estimates at the local level.

The research team developed a comprehensive plan for profiling truck idling characteristics associated with Class 2b through Class 8 truck operations within the United States. The overall approach included researching existing idling reports, identifying idling data sources, developing comprehensive data parameters, and segmenting the commercial vehicle market.

The research of existing truck idling data identified a wide range of idling times and data collections methods. Previous reports used driver surveys, engine control module downloads, vehicle instrumentation, and onsite observations. The driver survey provided the largest sample size, but relied on the respondents to provide accurate answers. Vehicles with installed instrumentation provided the most accurate idling times, but had the smallest sample size. A review of the overall findings found idling times as low as 6 hours per week and as high as 5 hours per day. This research helped to identify three considerations required to provide a robust truck idling scoping plan:

- The proposed test plan will outline a data collection method that represents all commercial vehicles, Class 2b through Class 8.
- The proposed test plan will recommend downloading idling data from existing electronic control units or installed vehicle monitoring equipment.
- The proposed test plan will use various data sources to obtain a statistically significant sample size. The sample size will represent a diverse fleet of vehicles, including local fleets, motor coaches, and long-haul tractors.

To provide an economical, but extensive, idling test plan, several key factors were identified. The final database must encompass vehicles across the United States; provide a large, diverse sample vehicle composition; use proven technology to collect the data; monitor vehicles remotely; and use previously installed equipment. Software companies have developed the capability to remotely monitor vehicle status, including idling, mileage, and so on. The information allows tracking of vehicle routing, idling time, and other data requested by the fleet. An investigation into remote vehicle monitoring (RVM) companies identified several sources for idling data. Using a combination of companies, the test plan is

capable of providing a national snapshot of commercial truck idling. The size of the test fleet can be adjusted by adding or removing participating RVM companies.

The truck idling scoping database is only as strong as the data collected. Key data variables were identified for monitoring idling time, location, and fuel consumption. In addition, the variables will be used for the vehicle segmentation scheme. Working with the RVM companies, a list of recommended data variables was developed (see Table S-1).

Table S-1. Test plan data variables.

Variable	Examples	Source
Vehicle Characteristics	Model Year, Manufacturer, Model Name, Engine Family Name[1], Fuel Type, GVWR, Cab Type	Vehicle identification number (VIN)
	Vehicle Vocation[1]	Fleet Records
Time Spent Idling	Engine Speed, Vehicle Speed, Engine Run Time	Vehicle Data Bus
Idling Location	Vehicle Time, Vehicle Longitude/Latitude	GPS Receiver
PTO-Enabled	PTO Status	External Sensor
Fuel Usage	Fuel Usage	Calculated Value

[1]Provided, if available.

Using the parameters identified in the table, the test plan has the capability for extensive vehicle segmentation. The segmentation will allow the database users to characterize idling based on vehicles with similar idling characteristics. The test plan identified several parameters to segment vehicles into appropriate subgroups: power take-off (PTO)-enabled, cab type, gross vehicle weight rating (GVWR), vehicle vocation, and vehicle model year. A form will provide a selectable user interface for scaling and filtering the idling data.

The test plan includes three categories—data collection, data storage, and database development. For data collection, the RVM companies will work with their fleets to identify willing participants. The RVM companies will work with the data in their existing database to extract idling data, perform data integrity checks, strip data of fleet identifiers, and produce an idling report. The RVM companies will run existing algorithms to define global positioning system (GPS) locations according to predetermined subcategories (e.g., distribution center, rest area, roadside). The data will be transferred to the test facilitator and uploaded to a server for storage.

The expansive requirements for this study require significant storage capabilities for the idling data. The team estimates the need for up to 1.4 terabytes (TB) of data for a year-long test period. The storage requirements are based on storing idling events, not a continuous data stream, for a 1-year period. To meet these requirements, the test plan identified a computer server with the capability to store 8 TB of data. Data analysis would be conducted on this server using a relational database management system (Microsoft's SQL Server program). Although Microsoft Access has been used for past projects, SQL Server is recommended to handle a database of this size. The test facilitator would develop a database to upload the RVM data into preset categories and develop a user interface for data queries, vehicle segmentation, and report generation.

The cost estimation for conducting this study is based on the parameters established above. Several price contributors were identified during the report that could increase or decrease the cost of the overall project (e.g., number of RVM companies, number of vehicles surveyed, and length of vehicle monitoring). Using the parameters, the estimated cost to complete a full-scale project would be $70,000. The cost estimate provides the funding to purchase the idling data, to purchase the computer hardware and software, and to develop the idling database. Additional costs will be incurred to provide data analysis and a final report, if desired.

CHAPTER 1

Background

1.1 Study Context

Medium-duty and heavy-duty trucks idle for various reasons including occupant comfort, occupant safety, and auxiliary power equipment operation. However, truck engine idling contributes to air pollution, increases greenhouse gas emissions, and consumes precious fossil fuel resources. With approximately nine million Class 2b through Class 8 trucks operating in the United States, the combined idle time and fuel used can be a significant source of pollution and "wasted" energy. However, the extent of this problem is not well-documented, as most of the truck idling characteristics are anecdotal or based on small-sample research studies. By defining the magnitude of truck idling, the data generated by this study will assist policymakers, truck manufacturers, and other key stakeholders in prioritizing the truck idling issue and in gauging the impact (benefits) of technologies and operational strategies for reducing idle time.

1.2 Study Objective and Scope

The objective of this research study is to develop a plan that provides decisionmakers with the scope, methods, and cost estimates for obtaining national and regional datasets for the time spent and fuel consumed by on-road trucks while idling. The plan will be used in a follow-on study to provide guidance on how to apply and supplement the idling estimates at the local level.

This study may be a key resource in helping shape national, regional, and local policies and strategies for reducing truck idle operations. Idling, fuel consumption, and emissions are believed to be a function of engine technology, vehicle equipment, freight operations, vehicle vocation, driver comfort, and safety. Advances in engine control modules and GPS have the potential to provide a new perspective. Enhanced datasets could help to better characterize the variability of the contributing factors in truck idling activity across all truck classes and operations.

CHAPTER 2

Research Approach

The research approach required knowledge in four key areas to support the final truck idling scoping plan. The preliminary work included the following tasks:

- Research existing truck idling reports,
- Identify and evaluate new truck idling sources,
- Identify truck idling data elements and sources, and
- Develop a vehicle segmentation scheme.

2.1 Research Existing Truck Idling Reports

Previously, few researchers attempted to evaluate the frequency and duration of idling events under real-world conditions. Instead, they made educated guesses about idling behavior or applied general rules of thumb that assumed a particular number of idling hours for a specific timeframe for a specific truck type or application. Although the estimates are useful in assessing the general magnitude of the idling issue, it is difficult to assess the accuracy of these estimates without validation by empirical data. As a result, several recently published reports have attempted to evaluate idling events under real-world conditions.

For this task, the research team conducted an analysis of those truck idling reports to document the methodology of collecting idling data, the idling times recorded, and the advantages and disadvantages of each method. The analysis identified 11 reports published within the past 10 years. The reports estimated truck idling using one of three methods—driver surveys, onsite observations, or engine control module downloads. The idling estimates varied widely between each report, from 5 hours per day to 6 hours per week. Some variations were attributed to the type of vehicle surveyed (e.g., sleeper berth versus day cab). Other variations were attributed to the data collection method. For example, the driver surveys monitored an individual driver's idle time, but the onsite observations monitored the idle time per parking space. A review of the data found that the driver surveys provided the largest data source (55,000 trucks). For the test using the engine control module download, the scope and purpose of the test limited the sampled vehicles to 270, which is too small to scale to a national representation. Larger downloads, however, can be achieved with minimal effort.

The research identified three considerations for the development of the truck idling scoping plan:

- *Vehicles Surveyed:* The reviewed plans did not represent a diverse vehicle set. None of the plans included vehicles in Class 2b through Class 7, which represent two-thirds of the commercial market. *The proposed test plan will outline a data collection method that represents all commercial vehicles, Class 2b through Class 8.*

- Data Collection Methods: Two-thirds of the reviewed reports used surveys, data loggers, or estimations to calculate idling time. Each of these methods introduces its own set of complications. Surveys are only as accurate as the responses provided. Drivers may mask their actual idle time in fear of repercussions from employers. Data loggers are limited by project cost. As the sample size is increased, additional equipment and installation costs are incurred. Finally, estimations are only as accurate as the original data source. If the estimation is based on limited source data, the accuracy of the idling time decreases. *The proposed test plan will recommend downloading idling data from existing electronic control units or installed vehicle monitoring equipment. The researchers have identified sources for obtaining idling data.*
- Sample Size and Distribution: With the exception of one report, the sample sizes of the idling reports represented less than 1/20 of a percentage of registered commercial vehicles. The sample sizes did not include a diverse commercial fleet; Class 8 vehicles were represented. *The proposed plan will use various data sources to obtain a statistically significant sample size. The sample size will represent a diverse fleet of vehicles, including local fleets (e.g., plumbing companies, utility companies, local delivery fleets), motor coaches, and long-haul tractors.*

2.2 Identify and Evaluate New Truck Idling Sources

In field studies, data acquisition and collection is a critical component of the effectiveness of the study. The types of required data must be clearly identified, and the methods that will be used to calculate the idle time of the vehicles must be determined before the test begins. The amount of data must be limited to prevent data overload in the analysis phase and to reduce the resource requirements on the fleet and personnel.

The use of existing in-vehicle communications networks minimizes the test's cost implications and expands the field of available vehicles. Existing communication networks include the On-Board Diagnostic II (OBDII) for medium-duty vehicles and the SAE J1939 for heavy-duty vehicles. Software companies specializing in RVM and maintenance services work directly with interested fleets to monitor these communication networks. For a fee, the RVM companies wirelessly download data from the in-vehicle communication networks and aftermarket sensors. The RVM companies analyze the data and provide reports to the fleet. Examples of monitored data include vehicle idle time, vehicle speed, and vehicle location.

In considering the sources for the truck idling data, the research team identified several key factors to ensure compilation of a diverse idling database. The factors include:

- *Access to vehicles distributed across the United States*—The National Cooperative Freight Research Program (NCFRP) has requested that the idling scoping study includes datasets at regional and national levels.
- *Access to a large, diverse vehicle composition*—The dataset must represent the current distribution of commercial vehicles in the United States.

- *Use of proven technology recognized within the industry*—The field test will not be used as a test to validate prototype technologies. The data must be obtained using recognized practices to ensure that industry experts accept the study findings.
- *Remote monitoring of the vehicle dataset*—To minimize the study cost, the monitored vehicles must be monitored remotely to reduce the interaction with the vehicles to obtain the datasets.
- *Previously installed monitoring equipment*—To minimize the study cost, the vehicles selected for the study must have the monitoring equipment installed. The study does not include the instrumentation of the vehicles.

Taking these factors into consideration, the team determined that the best sources of data for the truck idling scoping project would be RVM companies with existing fleet contracts. The pool of RVM companies can be expanded to match the commercial vehicle distribution. To initiate the search, the team identified several existing companies with the capability for remote vehicle monitoring. Table 1 identifies these sources. A combination of the potential idling sources identified in the table can provide a dataset that is representative of the current commercial vehicle breakdown.

Table 1. Potential sources of idling data.

Idling Source	Data Available
Telogis, Inc.	• Commercial vehicles, mostly Classes 2b to 7 • Approximately 100,000 vehicles • Tracks—Idle Time, Run Time, Mileage, Location, PTO engaged, etc. • Monitors J1939
The Volvo Group	• All Volvo and Mack commercial vehicles with software installed (10,000+ vehicles) • Monitors engine control unit • Tracks—Idle Time, Fuel Usage, Mileage, PTO engaged, etc.
Cadec Global	• Commercial vehicles, including motor coaches • Approximately 1,500 motor coaches currently monitored • Tracks—Idle Time, Run Time, Mileage, Location, etc.
GPS Insight	• Approximately 25,000 vehicles, all classes • Tracks—Idle Time, Run Time, PTO engaged, vehicle weight class, etc.
Networkfleet	• Offers vehicle monitoring services similar to

	Telogis and GPS Insight
Malone Specialty Inc. *Fleet Logix*	• Independently installed by fleets • Does not offer central database of parameters across several fleets

2.3 Identify Truck Idling Data Elements and Sources

Conducting an idle reduction study requires more than simply compiling the total time a vehicle is at idle. The reasons for the idle events are of great importance to understanding the requirements for idling each particular vehicle's engine and to determining the best technical solutions for idle reduction in each application. Therefore, additional data elements are required to gain an understanding of the nature of truck idling.

The NCFRP requested a dataset that monitored idling time of on-road commercial vehicles and their corresponding fuel consumption. NCFRP requested additional variables to characterize the idling, including truck characteristics, operation type, and idling cause. Using this information, the research team recommends the variables shown in Table 2 for analysis.

Table 2. Recommended data variables.

Variable Name	Description
Vehicle Model Year	Year of Manufacture
Vehicle Manufacturer	
Vehicle Model Name	
Vehicle GVWR	Pounds
Cab Type	Sleeper, Day Cab
Vehicle Class	Classes 2b through 8
Engine Family Name	
Vehicle Vocation	Parcel, Long-Haul, Delivery
Vehicle Fuel Type	Gasoline, Diesel, Propane, Natural Gas (Compressed and Liquid)

Time Spent Idling	Per Event
Idling Location	Storage Yard, Intersection
PTO-Enabled	Time Off/On
Fuel Consumption	Calculated per Idling Event

These variables will be collected by the RVM companies using a variety of sources including on-board communications networks (J1708, J1939, and OBDII), GPS receivers, and existing sensors on the vehicle. No additional sensors will be added to the vehicle.

2.4 Develop a Vehicle Segmentation Scheme

The idling scoping study will provide datasets for the time spent and corresponding fuel consumed by on-road trucks while idling. The findings are to be scaled from the available dataset to mimic the vehicle distribution at the regional or national level. Therefore, the dataset must represent the distribution of commercial vehicles in the United States. An industry analysis (see Table 3) estimated that nine million Class 2b through Class 8 vehicles are registered in the United States. As shown in the table, the final dataset should be broken down into 33 percent Class 8 vehicles and 67 percent Class 2b through Class 7 vehicles.

Table 3. Distribution of registered commercial vehicles.

Class 8 Tractor	Units	Comments / Examples
Less-than-Truckload (LTL)	508,000	UPS, Yellow Roadway, Ryder, FedEx
Truckload (TL)	1,044,000	J.B. Hunt, Schneider, Swift
Owner Operators	365,000	N/A
Private Fleets	415,000	Walmart, Tysons Food, Sysco Corp.
Total Class 8 tractors	**2,332,000**	
Large Buses		
Public Transit Buses	80,000	Operated by Local Government Transportation Agencies
Motor Coach	48,000	Greyhound, Trailways, etc.
Private Shuttles (e.g., Airports)	16,000	
Total Large Buses	**144,000**	
Vocational Class 8		
Fire Trucks	84,000	
Refuse Haulers	140,000	
Armored Car	12,000	
Concrete Mixers	79,000	
Dump & Misc. Class 8	170,000	
Total Vocational Class 8	**485,000**	
Total Class 8	**2,961,000**	
Vocational Classes 2b through 7	**Units**	**Comments / Examples**
School Buses	512,000	
Cable TV & Telecommunications	245,000	
Courier & Overnight Delivery	495,000	FedEx, UPS, USPS
Tow Trucks (or Straight Flatbed)	145,000	
Plumbing, Heating, AC Contractors	745,000	
Other Trades	638,000	Electricians, Painters, Misc. Repairs
Shuttle Buses (Non Class 8)	196,000	Paratransit Fleets; Shuttles; Airport Buses
Misc. Private Fleets	770,000	Local Private Fleets: Bottle, Bread, Box Vans, Furniture, and Other Commodities
Local Contract Delivery	335,000	Local Delivery Service (Non USPS, Non Overnight)
Ambulances, Emergency Response	43,000	
Roads, Parks, & Construction Related	485,000	Dump, Rack, Flatbeds, etc.
Government (Misc)	652,000	Misc. Trucks Used by Federal, State, & Local Government Not Falling into Other Categories; Includes Classes 2b through 7 Trucks Used on Military Bases
Total Classes 2b through 7	**6,051,000**	
Total Class 2b through Class 8	**9,012,000**	

Class	**Units** (1000s)
2b	2,790
3	1,142
4	396
5	376
6	910
7	437
Total 2b - 7	**6,051**

Source: Based on the Booz Allen team analyses of numerous sources including the 2002 truck inventory and use survey; estimated growth in segments; data accumulated by the Booz Allen team in completing assignments for private-sector clients; and information provided by numerous industry trade associations.

The vehicle segmentation scheme provides the ability to categorize the idling data from the vehicles into subgroups with similar idling characteristics. The data will have the ability to be segmented by up to five characteristics—PTO-enabled, GVWR, vehicle vocation, vehicle model year, and cab type.

PTO-enabled will be the most significant segmentation characteristic, which will define whether the vehicle is idling due to on-board equipment operation. It will separate the vehicles that were identified as idling due to the operation of the PTO equipment. These idling statistics, although significant, are not as vital as the idling of vehicles during load/unload operations, required hours of service (HOS) breaks, and so on. Idling during PTO operation is required to operate the auxiliary equipment. Vehicles with PTO capability, which are idling without the PTO enabled, will be grouped with the non-PTO-enabled vehicle data.

The remaining segmentation characteristics can be used alone, or in combination, to provide a discrete idling dataset. The remaining characteristics are:

- *GVWR*—GVWR provides the weight and class of the vehicle.
- *Vehicle Vocation*—Describes the primary role of the vehicle (e.g., long-haul, delivery, trades).
- *Model Year*—The year of the vehicle manufacture. The model year can help to identify levels of emissions regulated by the US Department of Energy (e.g., a 2007 engine versus a 2010 engine).
- *Cab Type*—For long-haul vehicles, the cab could be a sleeper cab or a day cab.

2.5 Data Collection Process

Figure 1 outlines the flow of idling data from the participating fleets to the test facilitator.

The test facilitator will collect idling data from fleets that the RVM companies have identified as being willing to share anonymous vehicle data. The RVM companies outfitted each vehicle with GPS equipment and wireless modems. The GPS equipment tracks vehicle location, idle time, and route optimization. The RVM companies extract data from the vehicle’s electronic control module (ECM) to track engine operation, fuel usage, and vehicle fault codes. The wireless modem transfers the GPS and ECM data to a central database.

The RVM companies perform data integrity checks on the uploaded data to ensure the data is within the proper ranges. Erroneous data is flagged, fixed, or discarded. Using the validated data, the RVM companies generate reports for the participating fleets to outline vehicle usage, fuel economy, and upcoming maintenance activities. In addition, the fleets are provided with any alerts that were generated as a result of the vehicle operation, such as operation outside of service range, excessive speed, or heavy braking.

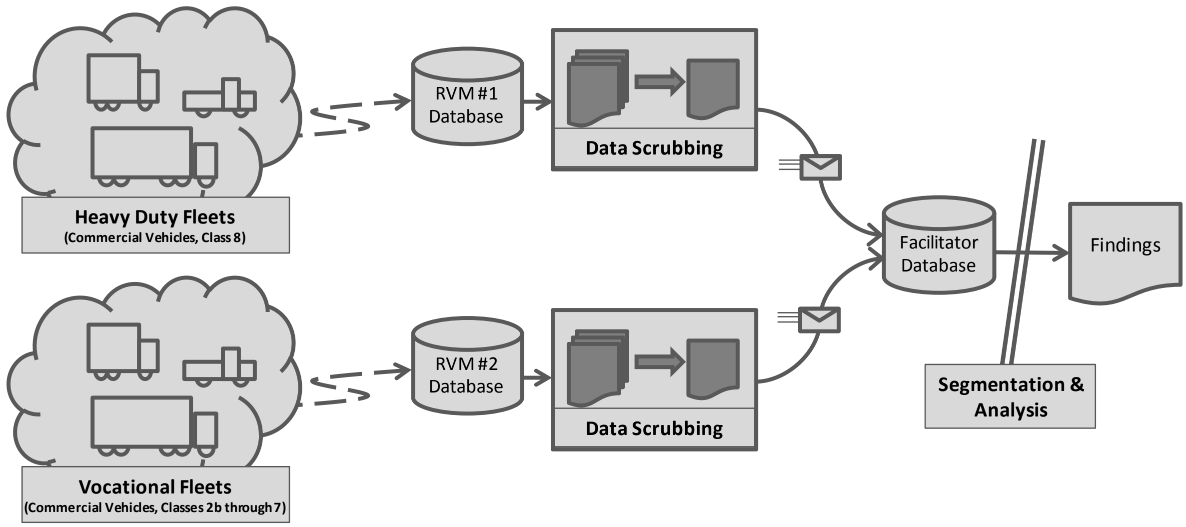


Figure 1. Data collection process.

For the idling scoping study, the test facilitator will work with the RVM companies to define the parameters for the data extraction. The facilitator will set the minimal idling time and the date range for the report. An ideal data extraction would exclude idling times less than 90 sec, which is the standard queuing time for red lights. The date range is expected to cover a year-long period established by the NCFRP. These parameters will assist in the filtration of data from the RVM database.

Using these parameters, the RVM companies will extract a fleet's data from the database. The findings will be scrubbed to ensure the anonymity of the participating fleets and manipulated to meet the requirements of the idling scoping study, including post-processing of the geospatial data. The RVM companies should be able to provide location names for the GPS idling locations to reduce post-processing by the test facilitator. The ability of the RVM companies to complete this task will reduce the need for the test facilitator to produce algorithms to predict and name idling locations. The final product will be saved in a comma delimited text file (*.CSV) for ease of transfer between the RVM companies and the test facilitator.

As the .CSV file is not expected to exceed the file size limitations of an email server, the data will be transferred to the test facilitator via email. If the file exceeds the limitations of an email server, a file transfer protocol (FTP) site will be established for transferring the data file from each RVM company. Upon receipt of the file, the test facilitator will validate, scrub, and parse the data into the established data categories (see Table 2). The test facilitator will export the data into normalized database tables. A case study showed that the database would likely require only two tables (see Figure 2). The first table stores the information for each truck monitored during the study. The second table stores all idling events during the study period.

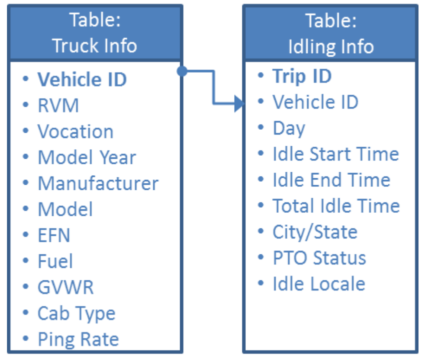


Figure 2. Database tables.

To ensure anonymity, the researchers recommend developing database tables that do not differentiate the source of the idling data. During the case studies, strong assurances were provided that the idling data would not identify specific fleets or drivers. In the final study, the test facilitator must ensure the database does not provide unique identifiers for each idling event or monitored truck. Therefore, although the study currently recommends logging the monitoring of each truck, this information must be either (a) locked from public access, or (b) eliminated from the database.

2.6 Hardware Requirements

The hardware requirements were estimated on the basis of the final storage requirements of the database, the minimum operational characteristics of the server, and the ability to expand the storage and/or memory.

Minimum Idling Data Storage Calculations

The storage requirements for the final idling database depend on several factors—total number of vehicles monitored, total length of the test period, and total number of idling events. With a population estimated at 9,012,000, a confidence level of 99 percent and confidence interval of 2 requires a sample size of 4,158. The research team recommends monitoring the idling characteristics of 9,000 vehicles, which represents 0.1 percent of the registered commercial vehicles. The sample size was chosen to represent a reasonable amount of data collection effort and to provide an estimate of the software and hardware requirements required for the task. A test period of approximately 365 days will provide idling events for vehicles under most operating conditions (i.e., winter, summer, spring, fall, extreme temperatures). Finally, it was assumed that each vehicle averages four idling events per day.

After conducting the case study, the researchers confirmed that the RVM companies provide datasets as individual events versus a continuous data stream to be analyzed by the recipient. This knowledge significantly reduces the hardware requirements for the database. To estimate the hardware requirements for the database, the field names, field types, and field sizes for each table in the database were outlined (see Table 4).

Table 4. Projected data fields.

Table Name	Field Name	Field Units	Field Type	Field Size (Byte)
Truck Info	ID (Primary Key)	*Numeric*	int	4
Truck Info	Vehicle ID	*Numeric*	int	4
Truck Info	RVM	*Alphanumeric*	char	20
Truck Info	Vehicle Vocation	*Numeric*	char	20
Truck Info	Model Year	*Numeric*	smallint	2
Truck Info	Manufacturer	*Alphanumeric*	char	20
Truck Info	Model Name	*Alphanumeric*	char	20
Truck Info	Engine Family Name	*Alphanumeric*	char	20
Truck Info	Fuel Type	*D, G, P, CNG, LNG*	char	3
Truck Info	Vehicle GVWR	*Pounds*	int	4
Truck Info	Cab Type	*S, D*	bit	1
Truck Info	Ping Rate	*Minutes*	tinyint	1
Idling Info	Trip ID (Primary Key)	*Numeric*	int	4
Idling Info	Vehicle ID	*Numeric*	int	4
Idling Info	Day	*Numeric*	int	4
Idling Info	Idle Start Time	*H-min-S*	time	3
Idling Info	Idle End Time	*H-Min-S*	time	3
Idling Info	Total Idle Time	*H-Min-S*	time	3
Idling Info	City	*Alphanumeric*	char	40
Idling Info	PTO Status	*0-1*	bit	1
Idling Info	Location	*Alphanumeric*	char	20

Idling Info	Fuel Consumed	*Gallons*	real	4

Using the field size data assigned in Table 4, the researchers calculated the storage requirements for the database. The findings, combined with the hardware requirements for the operating system, will determine the minimum requirements for the file server. The minimum database size was determined using the variables shown in Table 5.

Table 5. Database size calculation.

	Truck Info	**Idling Info**
Number of Rows	9,000	13,140,000
Number of Columns	12	10
Fixed Data Size	16	26
Number of Variable Columns	6	2
Maximum Size of Variable Column	103	60
Null Bitmap	4	4
Variable Data Size	117	66
Row Size	141	100
Rows Per Page	56	79
Number of Pages	161	166,330
Table size (bytes)	1.3 MB	1.36 TB
Total Database Size	1.4 TB	

The first variable assigns the number of rows to be stored in each table. For the Truck Info table, each row represents the vehicle information for each vehicle tested. For the Idling Info table, each row represents a single idling event. The table will record all idling events, regardless of data source. To calculate the size of the Idling Info table, the researchers assumed that a tractor averages four idling events per day. For a year-long field test, the test facilitator can anticipate approximately 13 million rows of idling data. The remaining variables were assigned based on information outlined in Table 4 and formulas generated by SQL Server (the anticipated database program). In conclusion, the research team recommends a file server with the capability to store at least 8 TB of idling data. The recommendation is for a hard drive capable of storing four times the minimum storage requirements (1.4 TB) to ensure efficient operation of the server and to allow additional expansion, if desired.

Hardware Recommendations

Using this information as a baseline, the research team conducted an extensive study of the hardware and software requirements to identify potential equipment that would meet the needs of the project from capacity, performance, and budget standpoints. The Dell PowerEdge T610 server was identified as a quad-processor unit that will serve three main functions: (1) as a SQL database server to coordinate and organize the data, (2) as a hard drive to store the idling data locally, and (3) as a processor to perform the data analysis and reporting. The latter operation will require some significant processing capabilities along with a large amount of memory. The server can store up to 24 TB of data among eight internal hard drives. If necessary, internal memory can be expanded to 192 gigabytes (GB). These hardware specifications exceed the minimum requirements to operate the preferred database program. The unit, as priced, contains the following features:

- PowerEdge T610 - Tower Chassis for up to eight, 3.5" Hard Drives,
- Windows Server 2008 R2 SP1, Standard Edition, Includes 5 CALS
- Memory up to 192 GB (priced with 12 megabyte [MB] of RAM)
- Maximum Internal Storage: Up to 24 TB (priced with 12 TB of hard drive space)
- Eight additional drive bays (priced with four hard drives of 2 TB each)

2.7 Database Development

In past programs with the Federal Motor Carrier Safety Administration (FMCSA), the research team has found that Microsoft Access was capable of handling large amounts of data and sufficiently flexible to be tailored for the specific needs of the project. The team has also been successful in writing visual basic code to integrate graphical presentation software into the database. However, the performance needs of this project are significantly higher; it requires a more powerful software development environment and a larger database storage capacity. Therefore, the research team recommends the use of Microsoft's SQL Server as the database engine for several reasons: (1) it is a powerful, low-cost database alternative; (2) the team is familiar with its use; and (3) it is flexible and quick to implement. Alternatives to the SQL Server include Oracle (which cost more than the SQL Server), Dbase (which has different size and performance parameters), and Access (which also has different size and performance parameters).

A user interface could be generated to perform data queries and generate reports (see Figure 3). As shown, the user interface has selectable fields to narrow the data into manageable segments. The selectable fields are based on the segmentation scheme discussed above. The user would also be able to generate a report on the entire database by leaving all fields within the form blank. The user would select one of two display options for the final report—on-screen or export. The on-screen report will provide the segmented data according to the selected fields, but the user will not be able to manipulate the data for analysis. The second option, an export to a spreadsheet (such as Microsoft Excel), will allow the user to manipulate and analyze the data.

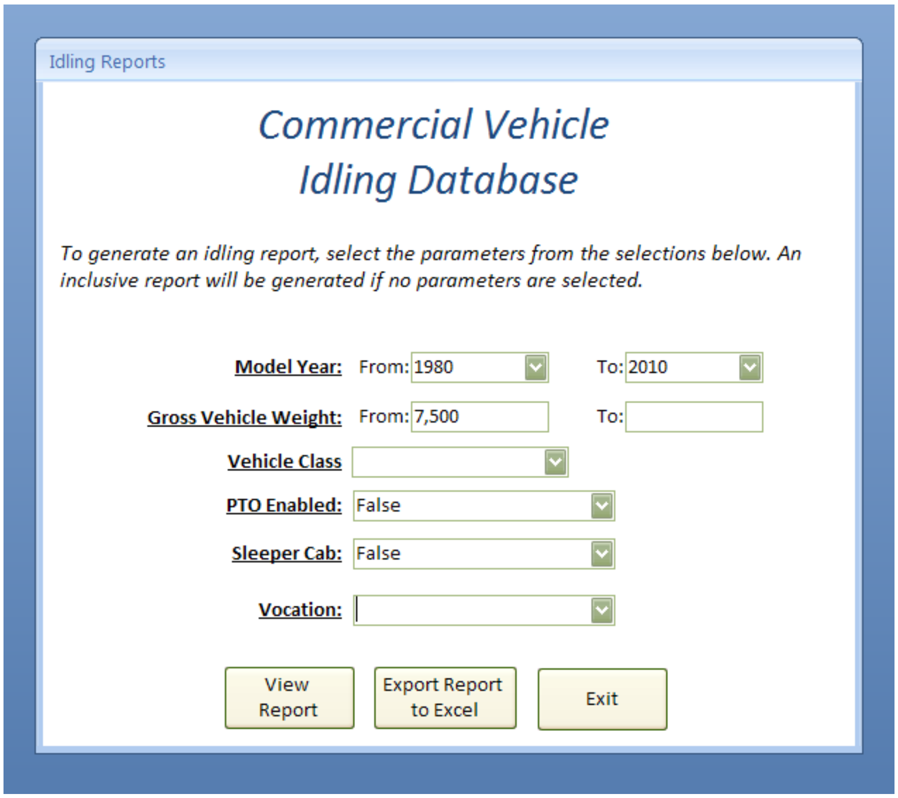


Figure 3. Database user interface.

CHAPTER 3

Findings and Applications

The research team developed a comprehensive plan for profiling truck idling characteristics associated with Class 2b through Class 8 truck operations in the United States. Upon approval of the draft, the team conducted a series of case studies to validate the plan as outlined. The objective of the case study was to test the proposed methodology, to identify issues that may arise in real-world implementation, and to generate enhancements or modifications to the original plan.

Similar to the test plan, the case study included three crucial phases for developing a truck idling database. First, the team identified participants willing to provide idling data. Second, the team coordinated with the participants to identify dataset and delivery methods. Finally, the team developed a database to store the collected data.

NCFRP requested three case studies to ensure that the test plan adequately addresses all vehicles in the commercial market. The researchers recommended tracking a Class 8 commercial truck with a sleeper cab, a Class 8 vocational truck, and a local fleet comprising vehicles in Classes 2b through 7.

3.1 Participant Identification

During the development of the test plan, the research team contacted several companies that provided RVM capabilities to commercial fleets. The services provided real-time and historical data on the operation of the fleet's vehicles, including idling times, routes driven, and speeding events. The team identified participants that used the Software as a Service (SaaS) concept. SaaS allows the participants to poll the entire customer platform and pull data locally. If the participant required its customers to store their own data, the data collection method outlined in the test plan would require a significantly higher number of participants. For the case study, the researchers contacted two SaaS-capable participants who expressed an interest in the study and a willingness to participate in a small data-gathering exercise: Telogis, Inc. and the Volvo Group.

Telogis, Inc. was founded in 2000 and is headquartered in Irvine, California, with a development center in Christchurch, New Zealand. It operates a wireless fleet management platform for a variety of fleets. Its capabilities include fleet productivity, vehicle tracking, route optimization, and vehicle maintenance monitoring. The company serves construction and building products, distribution, food and beverage distributors, fuel jobbers, HVAC service, plumbing, waste hauling, steel manufacturers, security patrol, towing and salvage, carpet cleaning and restoration, telecommunications, packaging, less-than-truckload (LTL) carriers, real estate inspection, health care, property management, utilities, pest control, landscaping, water delivery, and retail distribution industries. Telogis customers are dispersed across the United States and operate vehicles in each of the vehicle classes.

The Volvo Group is headquartered in Gothenburg, Sweden, and is the world's second-largest manufacturer of heavy-duty trucks. Volvo Group manufactures heavy-duty vehicles used for long-haul, regional transport, and construction operations under the Volvo, Mack, and Renault logos. Volvo Group offers *Volvo Link Sentry* as a fleet management tool for fleets and owner/operators. *Volvo Link Sentry* continuously monitors a truck's systems and fault codes, and automatically sends that data via satellite to a central facility called Volvo Action Service. The technology supports the download of specific datasets for further analysis.

3.2 Data Collection

For the case study, each participant provided the data variables shown in Table 6. The researchers requested each participant to provide idling data for a month-long period, identify the appropriate vehicles, and obtain the necessary client approvals to share the data.

Table 6. Requested data variables.

Variable Name	
Time Spent Idling	Per Event
Idling Location	Storage Yard, Intersection
PTO-Enabled	Time Off/On
Vehicle Fuel Type	Gasoline, Diesel
Vehicle Class	Classes 2b through 8
Cab Type	Sleeper, Day Cab
Vehicle Vocation	Parcel, Long-Haul, Delivery
Vehicle GVWR	Pounds
Model Year	Year of Manufacture
Vocation	Long-Haul, Trades
Fuel Consumption	Calculated per Idling Event

The first participant provided idling information for two separate case studies. The first case study monitored two long-haul commercial trucks with sleeper cabs. Each vehicle operated in a different region of the United States. The second case study monitored the idling events for a single Class 8 vocational truck operating in the state of Pennsylvania. The participant downloaded idling data for the case studies and forwarded it, in its raw form, to an outside contractor. The contractor sorted the raw data identifying idle events, noting idling locations, and scrubbing fleet identifiers. The data from this participant offered varying degrees of information. For example, the software ping rate varied between tractors, at either 15 or 30 min. In addition, the vocational truck did not provide specific city/state information for idling location in order to eliminate potential identifiers based on the construction site.

The researchers worked with the second participant for a period of 2 months. During the initial rounds of communication, the researchers spoke with a marketing representative who expressed ongoing interest in the project. Several follow-up discussions during the course of the test plan development solidified the company's interest in the project. By the time approval had been given to move forward with the case study, the marketing representative had moved onto a new position. Although the researchers continued to communicate with a vice president of the company, interest in the case study waned and the participant never delivered the promised data. The researchers opted to move forward with the case study and attempt to secure additional idling data from alternate sources.

For the third case study, additional participants, including actual RVM companies, commercial truck fleets, and a commercial motor coach manufacturer, were contacted for idling data. Due to the time constraints, researchers were unable to secure an additional data provider. With additional time, it is believed that another RVM company could have been identified to participate in the third case study.

Upon reviewing the needs for the case study, the research team determined that two case studies would provide sufficient data to validate the test plan. This decision was based on several assumptions:

- The researchers developed a methodology to gather electronic data from central databases. The data collected from these sources can be manipulated into identical datasets, regardless of the source.
- The monitoring of a significant number of vehicles in the case study would not enhance the validation of the test plan. By using idling data from an electronic database, the test facilitator receives datasets that meet the specific request. The case study can be validated using a single vehicle, as the data received would be consistent across all fleets/vehicles. Additional vehicles would only increase the size of the database for the case study.
- The elimination of the second RVM company would not diminish the assessment of the proposed test plan. The use of electronic data would standardize the information received from all sources, regardless of fleet size. The researchers contacted a small local fleet to review the data provided by the RVM company. The idling reports matched the information that the researchers received from the other two case studies.

3.3 Database Development

Upon reviewing the data provided for the case study, the research team modified the expected storage requirements for a full study. The initial review based the data requirements on a streaming dataset, including idling and non-idling events. The case study showed the idling reports are pared down to single events. In other words, the data received from the RVM company will not be streaming data, but will detail a single idling event, including total idling time and idling location. As a result, the data storage requirements for a single tractor were modified.

A relational database, consisting of two data tables, was developed using the data parameters discussed previously. As shown in Figure 4, the database contains a Truck Info table and an Idling Info table. The Truck Info table stores the truck-specific information, including truck vocation, truck model year, truck manufacturer, and cab type. The Idling Info table stores individual idling events. The table contains the vehicle's identification number, the total idling time, and the idling location.

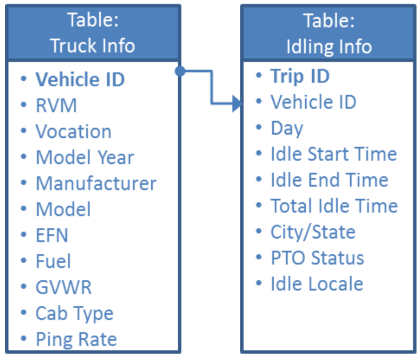


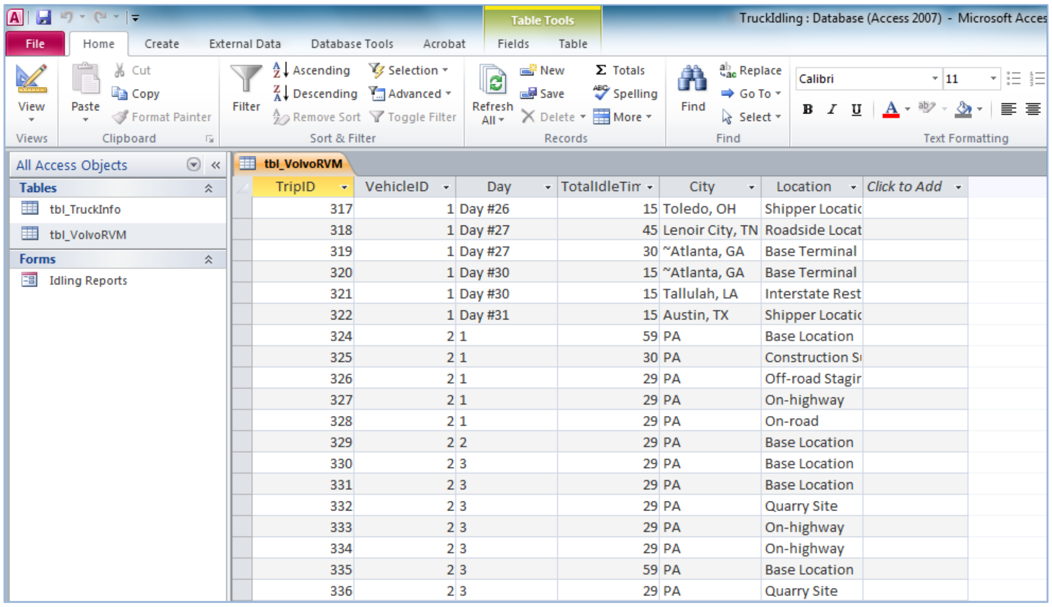
Figure 4. Database tables.

Using these tables, various reports can be generated based on the user's needs. Reports can be sorted by vocation, model year, cab type, region, idle locale, or PTO status. The reports can be developed to summarize total idling, idling with PTO active, and so on.

3.4 Case Study Analysis

During negotiations with the RVM companies to collect idling data, the research team agreed to suppress the truck-level identifiers to ensure complete anonymity. As a result, the analysis below does not detail specific truck-level idling events, but provides a high-level analysis to demonstrate the capabilities of an idling database.

The two case studies track idling events for three vehicles during a month-long period (June 2011). The first case study monitors idling data for two long-haul trucks; the second case study monitors a vocational truck. Figure 5 provides a screenshot of the database used to store the idling events. The database was developed in two steps. First, the Truck Info table was generated to store pertinent information for each truck in the study. Second, the Idling Info table was generated to store all idling events during the month-long study.



TripID	VehicleID	Day	TotalIdleTim	City	Location	Click to Add
317	1	Day #26	15	Toledo, OH	Shipper Locatic	
318	1	Day #27	45	Lenoir City, TN	Roadside Locat	
319	1	Day #27	30	~Atlanta, GA	Base Terminal	
320	1	Day #30	15	~Atlanta, GA	Base Terminal	
321	1	Day #30	15	Tallulah, LA	Interstate Rest	
322	1	Day #31	15	Austin, TX	Shipper Locatic	
324	2	1	59	PA	Base Location	
325	2	1	30	PA	Construction Si	
326	2	1	29	PA	Off-road Stagir	
327	2	1	29	PA	On-highway	
328	2	1	29	PA	On-road	
329	2	2	29	PA	Base Location	
330	2	3	29	PA	Base Location	
331	2	3	29	PA	Base Location	
332	2	3	29	PA	Quarry Site	
333	2	3	29	PA	On-highway	
334	2	3	29	PA	On-highway	
335	2	3	59	PA	Base Location	
336	2	3	29	PA	Quarry Site	

Figure 5. Screenshot of database (Microsoft Access).

The research team generated a map to outline the idling locations for the long-haul trucks (see Figure 6). The exhibit shows that one truck traveled exclusively in the Southwest of the United States. The idling events for this truck may have been more significant due to the temperatures experienced in this region during the data collection period (June 2011). The truck did not show a pattern for idling locations. The driver traveled to several different shippers, and did not regularly return to the same location for rest stops. The second truck traveled within the Midwest, with minimal idling events. The data showed this driver attempted to minimize idling events, incurring only one event that exceeded 15 min. In addition, this driver frequented the same break locations during his deliveries. The vocational truck was not tracked to a specific city/state. The RVM company stated the city/state information would allow users of the database to identify the driver/company. A review of this data showed that all the vocational truck's idling occurred within the state of Pennsylvania.

It is important to note that the individualized view of the idling events for this discussion will not be available for the final study. Agreements were made with the RVM companies to suppress individualized idling information for anonymity. As such, the final idling study would be able to pinpoint a high-level location for the idling for all vehicles, but would not provide a localized view of the location. In this way, the users of the database are prevented from reporting drivers for idling infractions (based on time and/or location).

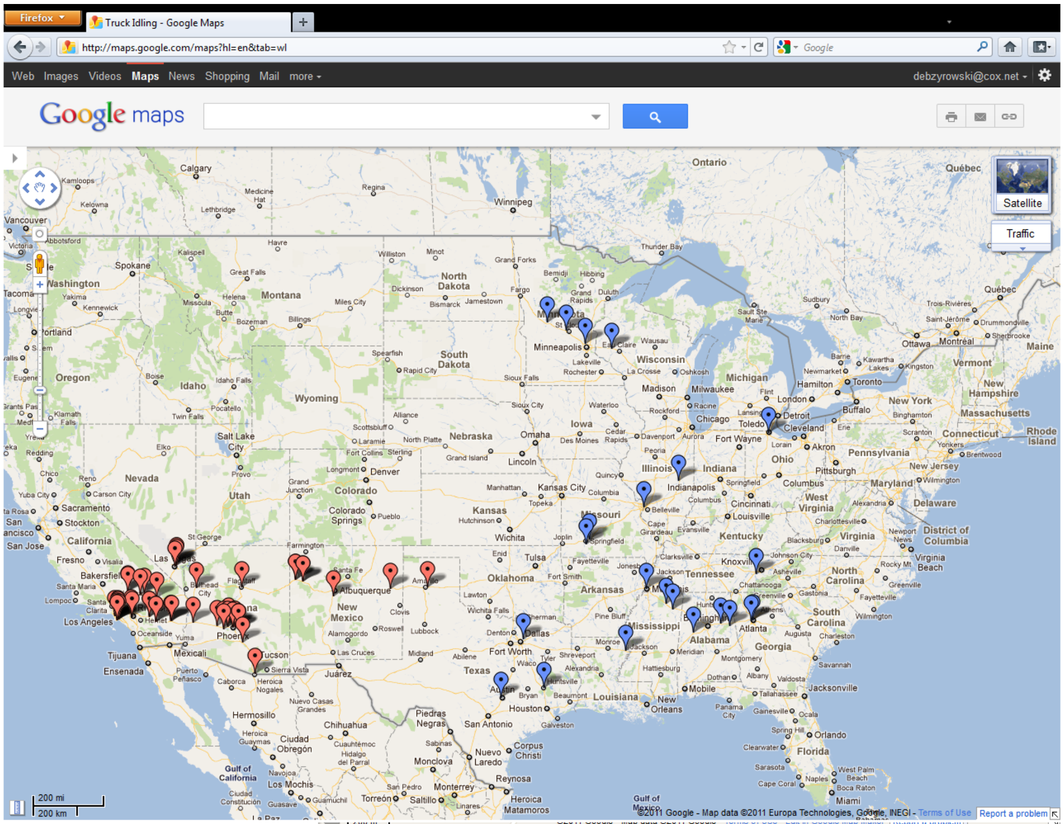


Figure 6. Idling locations (Truck 1 and Truck 3).

The analysis of the idling events showed the vocational truck idled twice as long as a single long-haul truck. As shown in Table 7, the long-haul trucks tended to idle during their rest periods (i.e., rest areas, truck stops, and shippers). The long-haul trucks attempted to minimize all idling events. On average, most idling events did not exceed a single ping rate. For the idling event that reached 180 min, the truck was parked at a shipping yard in Las Vegas, Nevada, during the middle of the day. In comparison, the vocational truck idled frequently. A review of the data suggests the truck's engine ran during the entire trip. Though the average idle time mirrors the time calculated for the long-haul tractors, the vocational tractor had twice the idling events. This can be attributed to the vocational truck operating continuously between two or three locations during a single trip.

Table 7. Summary of total idling events.

Idling Location	Total Idling Time (min)	Total Idling Events	Average Idling Time	Max Idling Time
Long-Haul (2 vehicles)				
Base Terminal	480	16	30	60
Interstate Rest Area	45	3	15	15
Off-road Rest Area	180	5	36	60
On-ramp	30	1	30	30
Roadside	300	12	25	45
Roadside Rest Area	60	2	30	30
Shipper	2277	62	37	180
Traffic	195	7	30	30
Truck Stop	360	11	33	60
Long-Haul Grand Total	**3927**	**119**	**33**	**180**
Vocational (1 vehicle)				
Base Terminal	1839	55	33	89
Construction Support Facility	30	1	30	30
Gas Station	59	2	30	30
Off-road	923	21	44	179
Off-road Staging Area	146	4	37	59
On-highway	353	11	32	60
On-road	1103	24	46	240

Quarry Site	234	8	29	30
Vocational Grand Total	**4687**	**126**	**37**	**240**
Grand Total	**8614**	**245**	**35**	**240**

The case study suggests several things. First, the driver of the first long-haul tractor tried to minimize idling. The driver tended to idle for no more than 15 min in a single location. During the longer idling events, the idling location tended to be in hotter climates during the peak hours of the day. Second, vocational trucks experience longer and more frequent idling events due to the nature of the job. The vocational truck tended to idle for at least an hour, and frequently left the engine running during an entire shift. Third, idling times are affected by the weather conditions and operating locations. The driver of the second long-haul tractor had varying degrees of idling. This trucker frequently traveled through Arizona and Nevada. The driver tended to idle at shipper locations, with some idle events reaching 90 min. The trucker conducting business in the Southwest would be exposed to high temperatures during layovers at the shipping yards.

CHAPTER 4

Conclusions and Suggestions

The test plan, as outlined, ensures minimal impact to the fleets under test. The proposed layout of the test plan retrieves information from the RVM companies' databases and does not require the installation of any additional equipment by the test facilitator.

4.1 Observations

The case studies presented several elements to consider during the full idling study.

The research team understands the importance of identifying reliable sources for the data. The team has conducted several other field tests that required extensive interaction with the participants to obtain valid test data. The team understood the need to secure willing participants early in the test plan development. Due to the time constraints with the case study, the researchers continued to work with the other participant while trying to secure additional data sources. The procurement of data from the commercial industry, outside of Class 8 vehicles, may prove to be difficult. Small RVM companies may not have a vested interest in assisting in an industry study of idling. As a result, the research team could not secure a participant for the Class 2b through Class 7 fleets. The team recommends directly contacting Class 2b through Class 7 fleets and requesting their data. The fleets may be more willing to provide data, and the RVM companies will be required to provide the data, if requested by their clients.

The location data for the case study was obtained by reviewing a map for each individual idling instance and assigning an appropriate designation for each idling event. The process proved to be labor intensive and impractical for larger datasets. The research team reviewed the data available from other RVM companies and determined idling reports would provide an approximate address for the idling location. Similarly, the data would require manipulation to standardize idling locations. Therefore, the researchers recommend that a locational database be developed during the initial stages of the idling project. The database would be developed as the developer assigns idling locations. As found during a review of the case study data, drivers frequently return to specific locations to idle, such as rest areas, shippers, and base terminals. As the location database is populated, the location parameter in the idling table can be populated through a standard "find and replace" function.

The case study corrected the estimated cost to implement the final idling study. The original cost estimate for equipment was based on a streaming set of idling data. As a result, the research team projected the need for more than 2 GB of data per tractor, and more than 20 TB of data storage. If the datasets are provided as individual idling events, the researchers estimate that the data storage needs will be reduced to 1.4 TB. This level of storage can be accomplished via simple external hard drives with the current state of memory storage technology.

During the review of the case study idling data, the research team noted high ping rates for some vehicles. The review showed that longer ping rates on the vehicles tended to falsely represent total idling time. For example, the vocational truck had a ping rate of 30 min. For tractors with the higher ping rate, the team found it difficult to determine if a tractor had been idling continuously between the 30 min ping times. A continuous idling event was noted if the tractor had not moved from a location during the previous 30 min. In some instances, the truck would be idling at each 30-min interval, but a review of the idling location showed the vehicle had moved. As a result, the team recommends requesting ping rates of approximately 10 min. The team researched other RVM companies and noted they were able to monitor the client's vehicles on a varying scale, down to 1-min intervals. The ping rate is essential for collecting accurate idling data. The idling time cannot be estimated any lower than the minimum ping rate. For example, each time the vocational truck idled, the database noted 30 min of idling. RVM companies recommended interviewed fleets monitor vehicles for idling in excess of 10 min. Therefore, a similar ping rate is recommended.

4.2 Cost Estimation

Table 8 presents the cost for the study. The cost breakdown is based on the information provided within this report. Costs will increase or decrease based on the equipment purchased, the sample size, and the number of RVM companies used.

Data collection results in the largest cost element. The table provides approximate values for the collection and storage of data for 9,000 vehicles for 365 days.

Table 8. Truck idling scoping study price breakdown.

		Price	Unit	Total
Data Collection*				
	Data files (distributed among three vendors)	$10,000	3	$30,000*
Data Storage				
	Server – Dell Power Edge T610, Enhanced	$5,359	1	$ 5,359*
	Software – Microsoft SQL Server 2008 RS	$2,500	1	$ 2,500
Database Development				
	Database Development	$150	200	$ 30,000
Total				$67,859

Note: Items marked with an asterisk (*) indicate cost is dependent on final sample size.

4.3 Conclusion

The goal of this study is to provide a detailed roadmap for the collection of truck idling data that can then be implemented as needed. Because this study includes case studies that are designed to validate and refine the proposed methodology, the applicability of results to practice has been indicated. This study will generate data about an activity (truck idling) that is poorly understood, but has implications on key issues including climate change, energy security, and the economic health of the freight transport sector. This study is also unique in scale (addressing the full range of trucks, from Class 2B to Class 8) and in its data collection methods, which will rely on data collected from RVM companies versus driver interviews or onsite observations.

The information gleaned from the database should be useful for various entities of the trucking industry, including academic researchers, nonprofit organizations (especially those active in the environmental and energy arenas), government agencies (local, state, and federal), industry associations, and private corporations (including manufacturers of truck engines, chassis, and powertrain components). In addition to implementing this test plan, the test facilitator could perform a series of queries on the idling database (additional costs to be incurred). Examples of idling analyses that could be performed include the following:

- Average number of hours of idling, by class,
- Average number of hours of idling, by idling location,
- Average number of hours of idling, by cab type, and
- Average number of hours of idling, by region.

At the completion of the database development, and the suggested analysis, the trucking industry should have a de facto standard for trucking idling. Researchers may continue to analyze the database to develop further idling suggestions. Future research can be based on a real-world understanding of idling, and any number and variety of tests could be performed on the database.

Acronyms and Abbreviations

ECM	electronic control module
FMCSA	Federal Motor Carrier Safety Administration
FTP	file transfer protocol
GB	gigabyte
GPS	global positioning system
GVWR	gross vehicle weight rating
HOS	hours of service
LTL	less-than-truckload
MB	megabyte
PTO	power take-off
RVM	remote vehicle monitoring
SaaS	Software as a Service
TB	terabyte
VIN	vehicle identification number

Appendix A: Truck Idling Sources

Report Title	Issuer	Year Published	Collection Method	Sample Size	Hours Idle
Idle Reduction Technology: Fleet Preferences Survey	ATRI for NY State Energy Research & Development Authority & DOE Clean Cities Program	2006	Survey	55,000	28 (Sleeper) / wk 6 (Day cab) / wk
Estimation of Fuel Use by Idling Commercial Trucks	Argonne National Laboratory for DOE	2006	Estimated	See ATRI Report	
Demonstration of Integrated Mobile Idle Reduction Solutions	ATRI	2009	Sat Comm	19 105 96	1,032 / yr 1,567 / yr 470 / yr
Analysis of heavy-duty diesel truck activity and emissions data	UC-Riverside for CARB	2005	ECM d/l	270	Total Hours
HDDV Idling Activity and Emissions Study, Phase 1	Texas Transportation Institute, for TCEQ	2003	Combo		
HDDV Idling Activity and Emissions Study, Phase 2	Texas Transportation Institute, for TCEQ	2004	Combo		
Heavy-Duty Truck Activity Data	Battelle for FHWA	1999	Data logger	140	C8 - 1.5 / day
Truckers Idling Reduction Program - Case Study	Canadian Centre for Pollution Prevention	2005			
Heavy-Duty Truck Idling Characteristics, Results from a Nationwide Truck Survey	UC-Davis	2004	Survey	365	5.69 / day
Benchmark roundwood delivery cycle-times and potential efficiency gains in the southern United States.	Louisiana Tech for Wood Supply Research Institute	2003			excessive
Heavy-Duty Truck Population Activity & Usage Patterns	Jack Faucett Associates, for CARB	1998	Instrument Data	5	5.71 min / trip
Mobile Idle Reduction Technology Project: A Case Study by NC State and Volvo Technology of America	NCSU with Volvo, for EPA	2008	ECM d/l	20	2,130 / yr (single) 770 / yr (team)

Review of the Incidence, Energy Use and Costs of Passenger Vehicle Idling	GW Taylor Consulting for Office of Energy Efficiency, Natural Resources Canada	2003	Survey		13% to 23% of operating time

Appendix B: Specifications for Dell Server

PowerEdge T610: Tower Chassis for Up to 8, 3.5" Hard Drives	T61WT3	1	[224-8474]	1
Shipping: PowerEdge T610 Shipping	SHIPGRP	1	[330-4119]	2
Primary Processor: Intel® Xeon® X5647 2.93GHz, 12M Cache, 5.86 GT/s QPI, 4C	X5647	1	[317-6156]	6
Memory: 12GB Memory (6x2GB), 1333MHz Single Ranked LV RDIMMs for 1 Proc, Optimized	12LVR1O	1	[317-0266] [317-0266] [317-0266] [317-0266] [317-0266] [317-0266] [317-7355]	3
Additional Processor: Single Processor Only	1P	1	[311-3928] [317-0342]	7
Operating System: Windows Server 2008 R2 SP1, Standard Edition, Includes 5 CALS	WS8S5C	1	[421-5425]	11
Internal Controller: SAS 6/iR Integrated	SAS6IR	1	[341-9136]	9
Hard Drive Configuration: No RAID for H200 or SAS 6/iR Controllers	MSN	1	[341-8774]	27
Hard Drives: 2TB 7.2K RPM Near-Line SAS 3.5in Hotplug Hard Drive	2TBA3H	4	[342-2100]	1209
Power Supply: Energy Smart Power Supply, Non-Redundant, 570W	NRDPSUE	1	[330-3548]	36
Power Cords: NEMA 5-15P to C13 Wall Plug, 125 Volt, 15 AMP, 10 Feet (3m), Power Cord	125V10F	1	[310-8509]	106
Embedded Management: iDRAC6 Express	IDRCEX	1	[467-8649]	14
Network Adapter: Intel® Gigabit ET NIC, Quad Port, Copper, PCIe-4	IGBQP	1	[430-0657]	13
Microsoft SQL Server: Microsoft®SQL Server™2008R2 Standard w5 CALs, OEM, NFI, w/Media	SR2S5C	1	[421-3600]	39
Rails: Tower Chassis, No Rails Required	TOWER	1	[330-4120]	28
Internal Optical Drive: DVD-ROM, SATA, Internal	DVD	1	[313-9100] [330-4219]	16
System Documentation: Electronic System Documentation and OpenManage DVD Kit	EDOCS	1	[330-3554]	21
1st Hard Drive: HD Multi-Select	HDMULTI	1	[341-4158]	8
Power Cords: No Additional Power Cord	NOPWRCD	1	[310-9057]	38
Feature Upgrades for Embedded NIC				