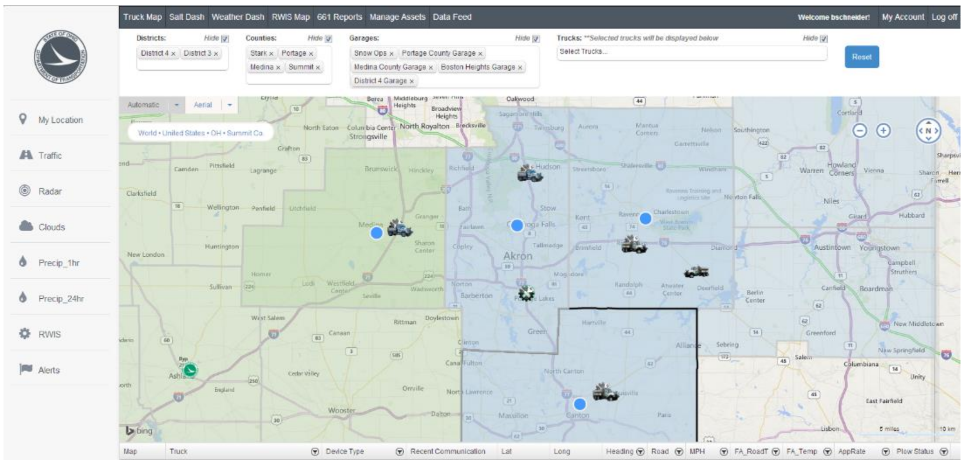
EVALUATION OF THE GPS/AVL SYSTEMS FOR SNOW AND ICE OPERATIONS RESOURCE MANAGEMENT



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16. Abstract		
Snow and ice management is the single largest expenditure in the maintenance budget for the Ohio Department of Transportation (ODOT) with an annual cost including labor, equipment, and materials reaching approximately $86 million (ODOT, 2013). One method to increase the efficiency of operations is the implementation of a Global Positioning System (GPS) and Automatic Vehicle Location (AVL) resource management system. Phase One of the project, was to implement 22 trucks with systems that work with the hydraulic system on the truck. During this phase, the research team was able to implement one system that works with both primary hydraulic systems in the ODOT fleet. With success in Phase One, Phase Two was developed to scale-up the fleet from 22 to 187 trucks throughout the state. The deliverables of this project are the details of installing and troubleshooting the system and the website developed for ODOT and with ODOT. The website allows real-time data and historical data for the truck location and road conditions. The website is able to rely various data platforms depending on what ODOT wants to implement. The cost of the systems will vary depending on the level of detail the end users would like to receive. More sensors requires more capital, maintenance and calibration cost.		
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Customary Unit	SI Unit	Factor	SI Unit	Customary Unit	Factor
Length			Length		
inches	millimeters	25.4	millimeters	inches	0.039
inches	centimeters	2.54	centimeters	inches	0.394
feet	meters	0.305	meters	feet	3.281
yards	meters	0.914	meters	yards	1.094
miles	kilometers	1.61	kilometers	miles	0.621
Area			Area		
square inches	square millimeters	645.1	square millimeters	square inches	0.00155
square feet	square meters	0.093	square meters	square feet	10.764
square yards	square meters	0.836	square meters	square yards	1.196
acres	hectares	0.405	hectares	acres	2.471
square miles	square kilometers	2.59	square kilometers	square miles	0.386
Volume			Volume		
gallons	liters	3.785	liters	gallons	0.264
cubic feet	cubic meters	0.028	cubic meters	cubic feet	35.314
cubic yards	cubic meters	0.765	cubic meters	cubic yards	1.308
Mass			Mass		
ounces	grams	28.35	grams	ounces	0.035
pounds	kilograms	0.454	kilograms	pounds	2.205
short tons	mega grams	0.907	mega grams	short tons	1.102

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LIST OF ACRONYMS

ODOT – Ohio Department of Transportation

LOS – Level of Service

Mph – miles per hour

GPS – Global Positioning System

AVL – Automatic Vehicle Location

RWIS – Roadside Weather Information Systems

HMA – Highway Maintenance Administrator

IP – Internet Protocol

TA – Transportation Administrator

TM – Transportation Manager

IR – Infrared

NVR – Network Video Recorder

APN – Access Point Name

API – Application Program Interface

UDP – User Datagram Protocol

PPLM – Pounds per Lane-Mile

PE – Percent Error

PS – Platform Scale Weight

ITS – In-Truck Scale Weight

CHAPTER I INTRODUCTION

Snow and ice management is the single largest expenditure in the maintenance budget for the Ohio Department of Transportation (ODOT) with an annual cost including labor, equipment, and materials reaching approximately $86 million (ODOT, 2013). Given the current financial climate, it is essential to minimize costs while simultaneously maximizing efficiency, especially for maintenance operations. The goal of snow and ice control is to provide an adequate level of service (LOS) to the motoring public, which is measured by regain time, or the amount of time to recover, after a snow event and by increasing the vehicle speed to within 10 miles per hour (mph) of the expected speed limit within three hours of a winter event ending. In a recent survey of winter maintenance professionals, Global Positioning System (GPS) and Automatic Vehicle Location (AVL) was found to be a top item of interest in the industry. Of interest is the ability of the system to increase productivity, quality of work, and environmental stewardship while maintaining or increasing LOS (Fay et. al., 2010). Additional benefits have been recognized such as monitoring material usage while not adding additional duties to the operators and the ability for real time responses to issues that may arise (Henry, 2007). Others have found that the route optimization enhances the operations by knowing where vehicles are located and where they should travel to (Allen, 2006). Previously, ODOT District 12 Cuyahoga County implemented a GPS/AVL resource management system. The initial results of this study were favorable, encouraging ODOT to pursue further research into implementing a more widespread GPS/AVL asset management system versus ODOT's normal procedures for snow and ice removal. ODOT brought in the University of Akron to study the various systems on the market and how they will work with ODOT's fleet.

The research team has identified five factors in order to increase the effectiveness and efficiency of snow and ice removal operations:

- Resource and asset management,
- Automated resource reporting,
- Vehicle tracking and route optimization,
- Real time LOS and regain time, and
- Historical records of snow plow locations and usage rates.

The combination of all these factors will allow ODOT to effectively manage its winter operation fleets and increase safety on the roadways.

1.1 Objectives and Goals of the Study

During this research project, the research team and ODOT discussed multiple options for continuing GPS/AVL system within its entire fleet. Once Phase One data concluded, ODOT moved forward with a Phase Two to gather more and new information. The goals and objectives from Phase One to Phase Two are presented in the follow sections.

1.1.1 Phase One

This research team proposed that three objectives be met to ensure that Phase One of this project would be considered a success. These three objectives were:

- Objective One: Maintain a high Level-of-Service (LOS) for traffic using the ODOT network during winter weather conditions,
- Objective Two: Quantify the regain time associated with County or District level performance, and
- Objective Three: Optimize asset management including but not limited to: equipment, personnel, and salt.

In order to successfully meet these objectives, the research team would have to meet the following goals and guidelines for Phase One of this study:

- Incorporation of the GPS/AVL system with Roadside Weather Information Systems (RWIS),
- Reliance on District 3, District 4, and District 10 personnel expertise and input on tasks during the project,
- Reliance on existing District 3 and District 4 data collection methods (e.g. M&R 661, material application rates and properties, real time travel speeds, and real-time weather), and
- Project Deliverables (i.e. GPS/AVL system) that would meet the system features while tracking the required information to provide effective resource management for ODOT.

1.1.2 Phase Two

With the success of meeting the goals and objectives of Phase One, the research continued on with a Phase Two. The objectives for Phase Two were:

- Objective One: Scale-up from 22 trucks (Phase One) to approximately 175 trucks (whole fleets in seven counties) with location and visual applications only,
- Objective Two: Determination of how well ODOT garage managed this system in-house, and

- Objective Three: Continue to gather and implement feedback from ODOT personnel on the system and website.

In order to successfully meet these objectives, the research team would have to meet the following goals and guidelines for Phase Two of this study:

- Training of ODOT staff on installation,
- Equipment field-hardening,
- Data analysis of field data,
- Web support, and
- ODOT information technology communication.

The research team continued to communicate regularly with ODOT on the process of the project to ensure the success of Phase Two.

1.2 Benefits from this Research

There are several benefits from this research. One immediate benefit of this system is the managers' ability to utilize real-time data of their fleet. Another benefit is the storage of historical data which may be helpful if claims are made about the winter maintenance operations. Additionally, the same data may be used to assist with training new operators as well as allowing managers to see the road conditions of the routes that they maintain.

1.3 Out-of-State Survey

There are several different applications and methodologies that are possible when implementing and utilizing a GPS/AVL system. The research team contacted every state outside of Ohio to survey if or how they decided to utilize the system. The complete list of questions and responses to questions are displayed in Appendix F. Displayed below in Table 1.1 are key questions that highlight questions of major importance.

Table 1.1: Brief Summary of Vital Survey Questions.

Question Number in Survey	Questions and Responses	Total	Count 26	Percentage
Question 1	Installed on Any Trucks			
	Yes		25	96.2%
	No		1	3.8%

Note: The remaining questions were pertaining to states with the system installed on a portion of their fleet. One state answered no to question one therefore have been removed from the analysis of the remainder of the survey.

Question Number in Survey	Questions and Responses	Total	25	
Question 5	Off the Shelf or Self-Built			
	Off the Shelf		22	88.0%
	Self-Built		1	4.0%
	Did not know		2	8.0%
Question 11	Data Acquisition			
	Tier 1		10	40.0%
	Tier 2		3	12.0%
	Tier 3		8	32.0%
	Tier 4		3	12.0%
	Did not answer		1	4.0%
Question 13	Cameras Accessible via network			
	Yes		7	28.0%
	No, but camera is installed		3	12.0%
	No		14	56.0%
	Did not answer		1	4.0%
Question 18	Real Time Data			
	Real Time		21	84.0%
	No		3	12.0%
	Did not answer		1	4.0%

Note: Tier 1 refers to trucks with strictly vehicle location and speed, Tier 2 is location data and camera data. Tier 3 refers to trucks tying in hydraulics and often road temperature, Tier 4 refers to all included in Tier 1 through 3 and another data source. Often seen to be plow on/off or up/down, but engine diagnostics and harsh breaking/acceleration were also seen.

A majority (88%) of the 25 states with systems installed decided to utilize off the shelf systems due to the ease of implementation. ODOT chose to self-build their system to allow for additions in the future as well as create the system around wants and needs. For data acquisition, 40% of the states were considered Tier

1 as they only receive vehicle location and speed. ODOT may be considered Tier 3 due to the amount of additional sensors such as road temperature, bed scales, and plow sensors that were installed onto the system. Of the states surveyed, 56% reported that they did not have cameras installed within their fleet at all. ODOT currently has cameras installed within all truck utilizing the system; all of which are accessible and are capable of streaming live video in addition to taking pictures. Real time data are a category a majority of states find to be imperative as 84% report in real time. This time frame ranges from two seconds to ten minutes. ODOT sends reports every ten seconds which may be considered one of the shortest delays possible.

As seen in the brief survey summary above, there are various different methodologies implemented nationwide for GPS/AVL systems. The system integrated with ODOT's fleet is very unique and customizable for the end user to receive various types of data from various sensors. The system and website capabilities are summarized.

1.4 Organization of this Report

This report is divided into five chapters. Chapter One is the introduction of the topic and a statement of the research objectives. Chapter Two presents the project time and setting, as well as the equipment tested in Phase One and Phase Two of the project. Chapter Three contains a summary of the deliverables which are the website and GPS/AVL system. Chapter Four displays data collected from various sensors integrated into the GPS/AVL system. Chapter Five discusses implementation of the GPS/AVL system.

CHAPTER II PROJECT INFORMATION

This chapter presents the timeline and locations of the project as well as the details about the equipment being tested in Phase One and Phase Two of this project. The following sections outline this chapter:

- Section One: Data flow through system,
- Section Two: Project timeline,
- Section Three: Phase One setting and equipment, and
- Section Four: Phase Two setting and equipment.

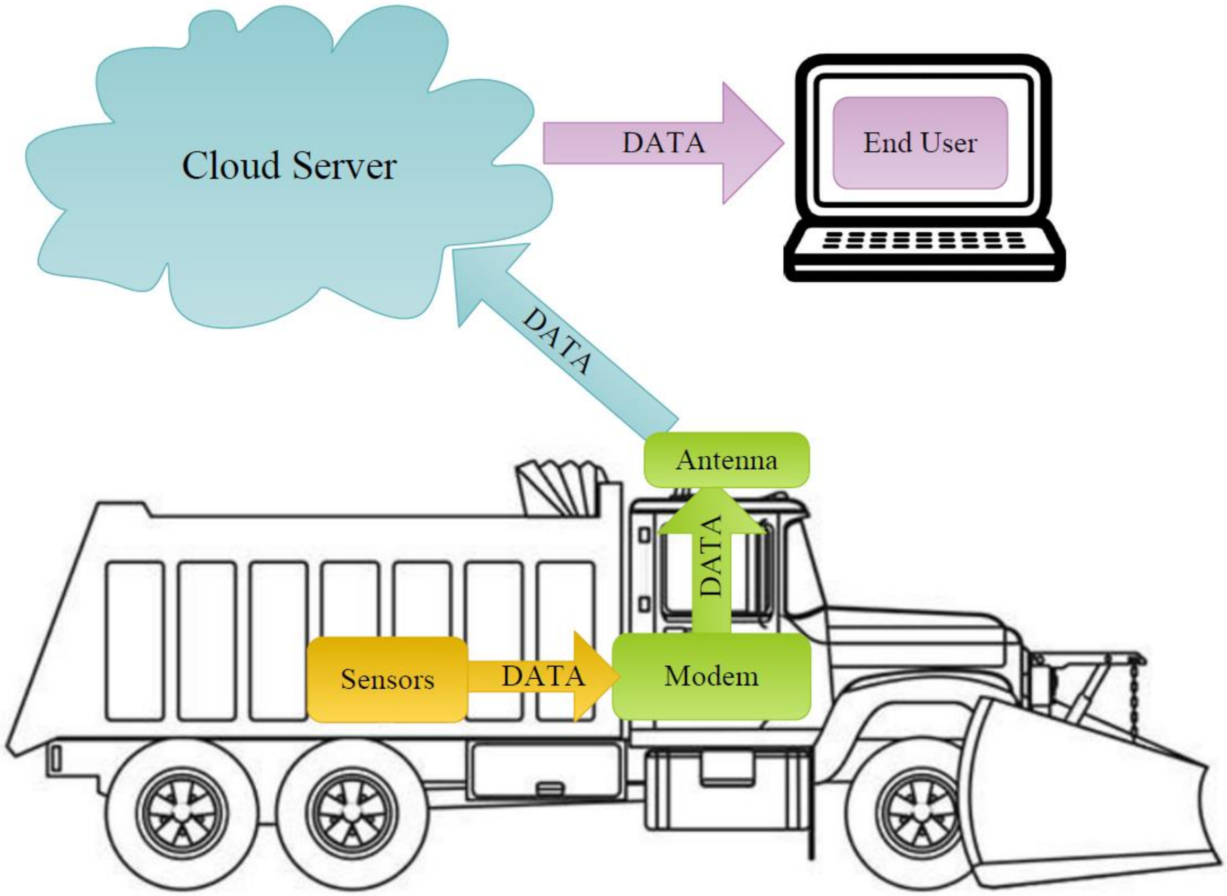
These sections provide readers with details on the project background information of this research project.

2.1 Data Flow Through System

This research project requires integrating a system that is compatible with multiple brands of equipment currently implemented throughout ODOT's fleet. There are four main levels at which the data flow throughout the GPS/AVL system:

- Data from truck equipment to modem,
- Modem to antenna,
- Antenna to cloud server, and
- Cloud server to end users.

Note that data processing may occur on the truck via the gateway or once data moves into the cloud server. These four levels are shown in Figure 2.1.



(References: www.kidsplaycolor.com & www.freepik.com)
Figure 2.1: Data Flow Throughout the GPS/AVL System

As presented in Figure 2.1, any data from the truck go through the modem. The antenna is required to move the data to a data server (a cloud server) and may then be accessed by the end user. For the successful implementation of this system and regardless of hydraulic control system each section of the data flow must work accurately to maintain an efficient system.

2.2 Timeline of Project

This research project began in December of 2012. Phase Two began in the summer of 2015. Figure 2.2 presents a timeline of milestones for Phases One and Two of this project.

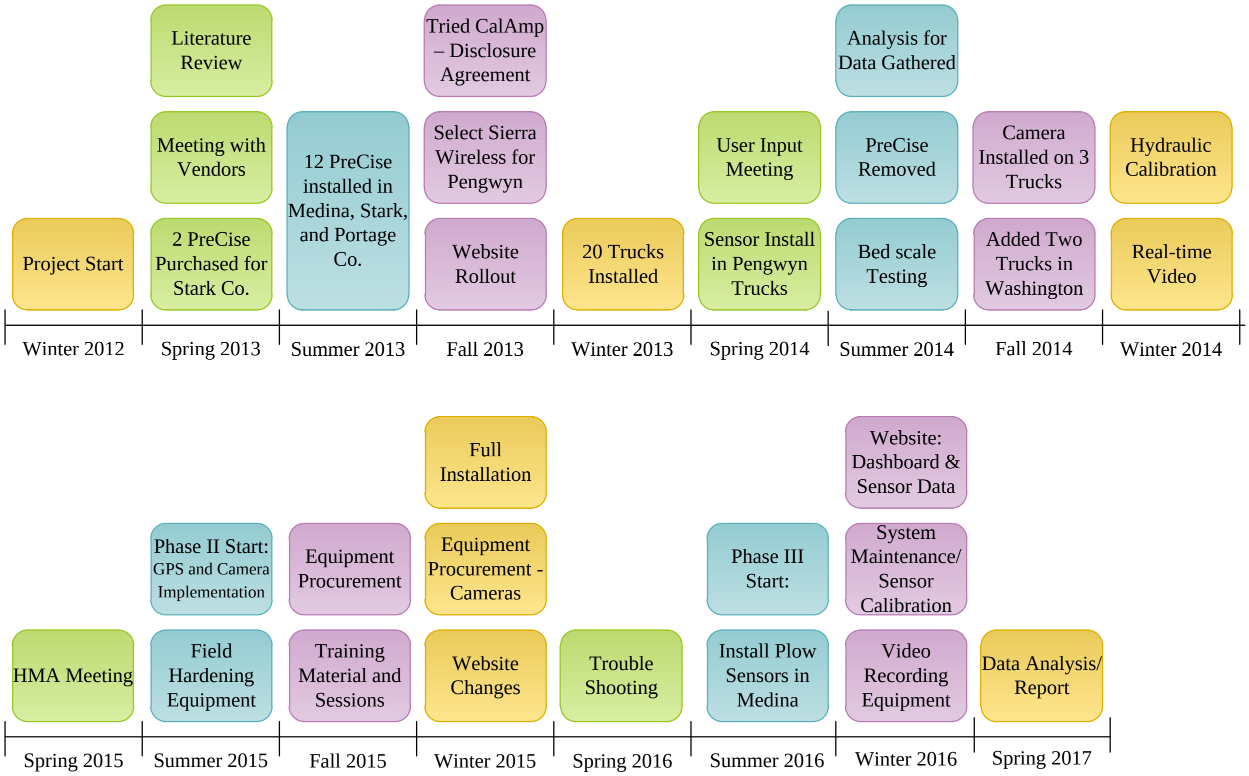
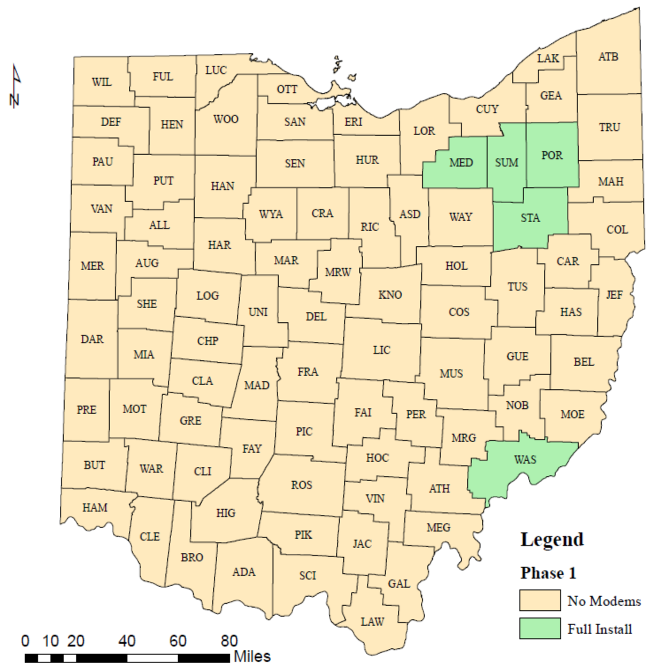


Figure 2.2: Milestones of Phases One and Two of the Project

Figure 2.2 shows just some of the highlights from the project. As seen in spring 2015, after Phase One, the research team met with the Highway Maintenance Administrators (HMAs) to discuss the project. From this meeting, ODOT moved forward with tracking the trucks and road conditions through pictures.

2.3 Phase One Information

The first phase of this project was conducted in Districts 3 (D3) and 4 (D4) in the first winter season. During the second winter season in Phase One, the research was extended to District 10 (D10). Figure 2.3 presents the counties that were equipped with the GPS/AVL system in Phase One.



County	**Device Type**	**Number of Trucks**
Medina	Force America	3
Portage	Force America	5
Stark	Force America	7
Summit	Pengwyn	5
Washington	Pengwyn	2 (Year Two)

Figure 2.3: Counties Involved in Phase One

As presented in Figure 2.2, Medina (D3), Summit (D4), Portage (D4), Stark (D4), and Washington (D10) Counties were involved in Phase One of the project. These counties were in possession of 22 trucks equipped with the GPS/AVL for testing purposes. Multiple types of equipment were tested and evaluated during Phase One of this project. These subsections will introduce the equipment evaluated and the lessons learned while conducting this phase of the research.

2.3.1 Equipment

The equipment for Phase One consists of: the modem, antennas, cameras, and sensors. The system may be as simple as a modem and antenna which allow the truck to be tracked. The camera and sensors are optional for additional data as shown in Figure 2.4.

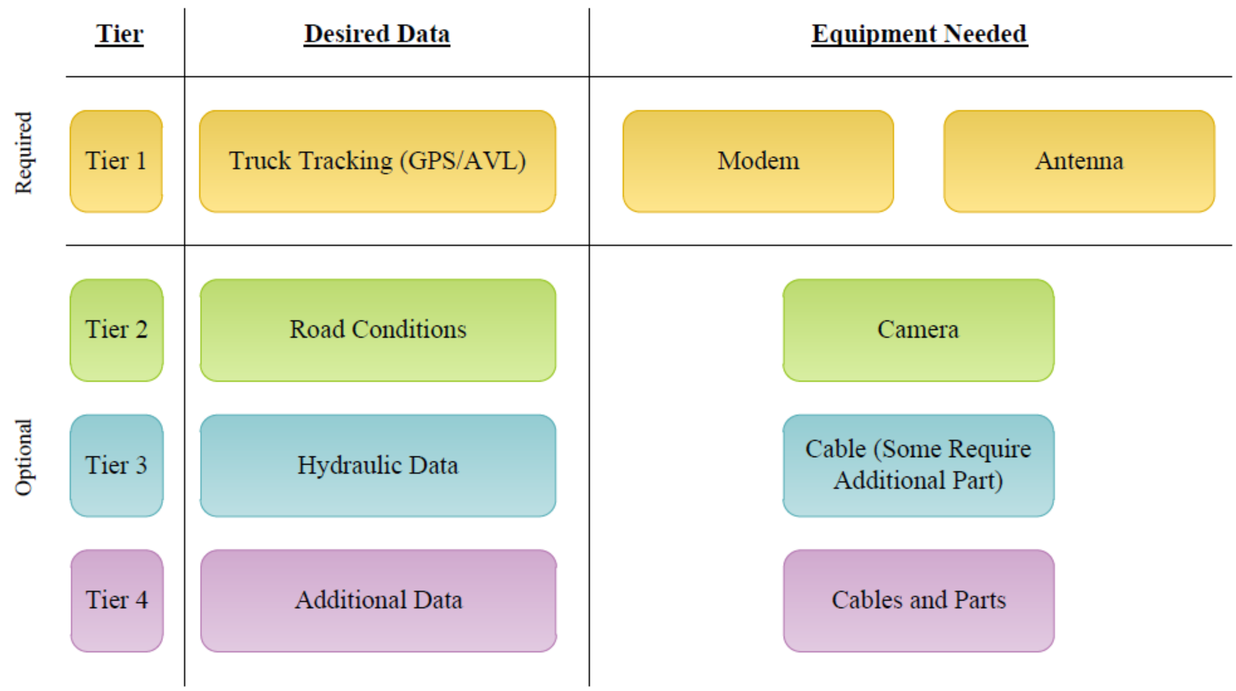


Figure 2.4: Equipment Components for GPS/AVL Systems

Note that the modem may change depending on the amount of additional data desired. Additional information is provided in Appendix A.

Gateway

The first step of the system is the selection of the modem. A modem manufactured by Sierra Wireless was selected for its multiple input/output ports, RS-232 ports, and the ability to send data to and from the truck. In addition to the necessary ports, this modem is sturdy enough for mobile applications and may be placed in any truck despite its hydraulic system. The Sierra Wireless GX440 modem is pictured in Figure 2.5.

Figure 2.5: Sierra Wireless GX440 Modem.

During the second winter of Phase One of this project, there was an integration of the Sierra Wireless modems and the Force America hydraulic system. Until this integration, all of the Force America systems had relied on the PreCise MRM modem. One major benefit of the Sierra Wireless modem is that the data streams are sent directly to the ODOT cloud server at intervals specified by the research team. The data are processed once it reaches the cloud server and relayed to the end user.

Antennas

During Phase One of the project, an external double magnet mount antenna was implemented as recommended by Sierra Wireless. These modems are shown in Figure 2.6.

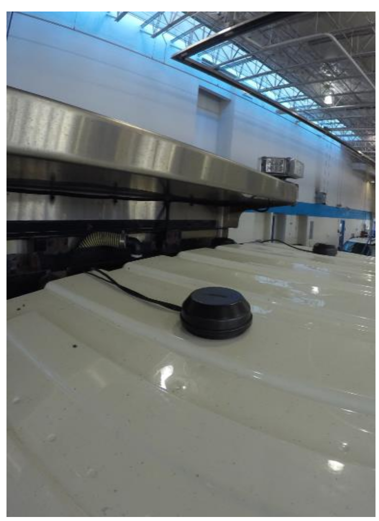


Figure 2.6: External Double Magnet Mounted Antenna

These antennas are wired through a back vent on the cab or a drilled hole which allows cables to be run into the truck. There are multiple variations on installing the antennas. Therefore, it is important to discuss what the mechanics, transportation administrators (TA), and transportation managers (TM) are comfortable with when running external cables into the cab because of the risk of corrosion. Installation through the pre-existing hole in the bottom of the cab would be used for this install in the future. This would require an antenna with a longer cable.

IP Cameras

During the second year of Phase One, Internet Protocol (IP) cameras were installed on three trucks for proof of concept. These cameras allow ODOT personnel to see road conditions from the vantage point of the operator. Each camera was installed inside the cab as presented in Figure 2.7.

Figure 2.7: Mounted IP Camera

The cameras are programed to take a picture every five minutes; the website users also have the ability to take a picture manually. Figure 2.8 presents a sample of the IP camera picture.

Figure 2.8: Sample Picture of Road Conditions from IP Camera in Truck

The time interval may be set to any frequency ODOT desires. The pictures are accessed on the website (more information about accessing the pictures is discussed in Section 3.2.2 and Appendix F). In addition, the cameras may be accessed from the website to view real-time video. However, real-time video requires a large amount of bandwidth and will increase the cellular cost associated with the modems. The research team has been experiencing hardware failures within the cameras selected. This failure is typically a power short that causes the camera to completely fail. This is most likely due to the lifespan of the cameras as well as the cheap cost at which they are available. To resolve this issue, utilizing a more field hardened camera with an increased lifespan is recommended.

Sensors

There are multiple sensors that were tested through Phase One of the project, which include:

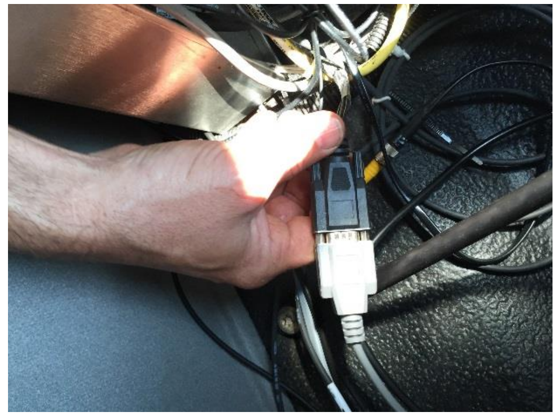
- Hydraulic: Provides data on how much salt is being applied (according to the control) as well as the spinner settings,
- Plow Up/Down: Indicates that the front plow is being utilized (down) or not (up),
- Plow On/Off: Allows managers to know if there is a plow attached and works alongside the Plow Up/Down sensor,
- Road Temperature: Provides road surface temperature data, and
- Bed Scales: Relays the weight of the load in the bed of the truck, in this case, salt quantity.

Hydraulic Sensor

As previously discussed, there are two primary types of hydraulic systems being used throughout the ODOT garages: Force America and Pengwyn. In addition to the two types, there are various models, i.e.

Force America 6100 and Force America 5100. The data are relayed to the modem through the serial port on the back, and only one cable is needed (note that there is a different cable for the Pengwyn and Force America, which is the only difference in the installation). Figure 2.9 presents the hydraulic cable to communicate with the modem.

(a) Pengwyn 485 Series Hydraulic Hook-up



(b) Force America RS-232 Hook-up

Figure 2.9: Connection for Hydraulic Data – (a) Pengwyn, (b) Force America

The Force America 5100 requires a fob key to download the data logging program which may only be used one time. The Force America 6100 requires a different administrative fob key to program the system which may be used on multiple system; however, in order to use a non-PreCise system, an additional part must be purchased for each truck. More detail regarding the hydraulic connection may be found in Appendix A.

Plow Up/Down and On/Off Sensor

Figure 2.10 presents the front plow sensors.

(a) Plow Up/Down Sensor

(b) Plow Attached or Detached Sensor

Figure 2.10: Plow Sensors – (a) Up/Down, (b) On/Off

The wiring and additional information for these sensors is presented in Appendix A.

Road Temperature

ODOT primarily uses RoadWatch sensors to allow operators to see what the pavement temperature is as they are driving. These sensors may be connected to the modems in order to communicate temperature readings to the data server. Figure 2.11 presents the convert box to hook up to the modem.

Figure 2.11: RoadWatch, Road Temperature Connection

The research team reviewed other road temperature sensors which may hook-up with the same RS-232 cable. More details about the installation of the road temperature sensor is provided in Appendix A.

Bed Scale

Bed scales are used to collect data on the weight of the truck and hence the weight of the salt in each truck. The scale is affixed to the axles of the truck to measure the strain. Figure 2.12 presents the bed scale for a single axle truck.

Figure 2.12: The Single Axle Bed Scale

The bed scale data may be viewed in the cab of the truck as the data were sent through the modem. The bed scales utilize the Ethernet port on the modem. In the initial setup, an IP camera was not able to be used when a bed scale is installed on the truck.

2.3.2 Lessons Learned

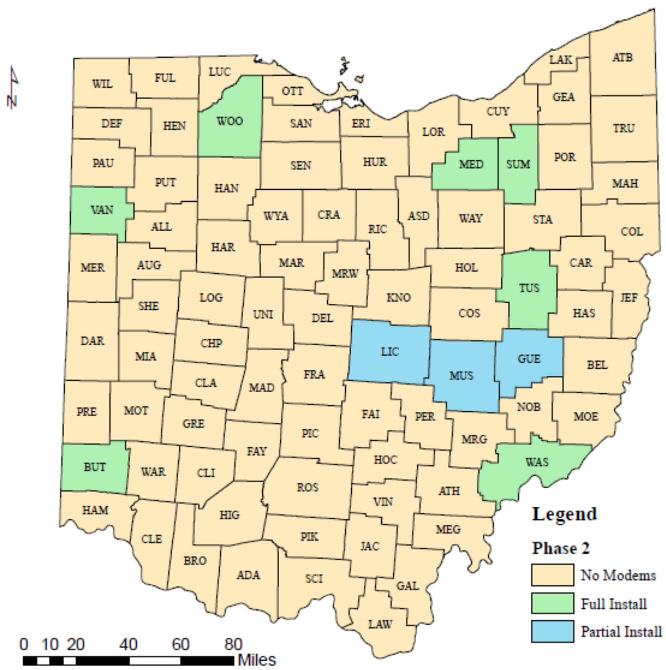
The major lesson learned during Phase One of this research is that having one GPS/AVL system to work in all the ODOT trucks despite the variations in truck and hydraulic type is very valuable to ODOT. When trying to integrate multiple systems onto one website, there were issues of lag time since the data were sent through multiple servers instead of going directly to the cloud sever developed for ODOT.

In addition, the sensors reviewed during Phase One required frequent calibrating, and more evaluation to determine the accuracy and life span is needed. Furthermore, all the Pengwyn hydraulic systems tested in Phase One are the 485 models; therefore, older Pengwyn models need to be evaluated. During the installation of the cameras in Phase One, one of the cables was being rubbed on the edge of a piece of hard plastic, which resulted in a short in the wiring. The research team avoided pitch points and provided a cover to any areas that may comprise the wiring.

At the conclusion of Phase One, the research team and HMAs (as well as other ODOT personnel) met to discuss the accuracy of the additional sensors implemented in Phase One. Many of the sensors, especially the ones that produce hydraulic data, require consistent calibration and therefore, the data from the hydraulic control may not be the same as the amount of salt coming out of the truck. ODOT eventually moved forward with the data they were comfortable with, which are the truck tracking and IP cameras for road conditions.

2.4 Phase Two

ODOT decided to move forward with a larger implementation of GPS tracking of the trucks and road condition visual pictures in seven counties across the state, as presented in green on Figure 2.14.



County	District	Number of Trucks
Van Wert	D1	16
Wood	D2	23
Medina	D3	30
Summit	D4	25
Guernsey	D5	10
Licking	D5	9
Muskingum	D5	10
Butler	D8	19
Washington	D10	24
Tuscarawas	D11	21

Figure 2.13: Counties and Trucks Involved in Phase Two

Phase Two consisted of a larger scale implementation of the Sierra Wireless modem in comparison to Phase One. As presented in green on Figure 2.13, Van Wert (D1), Wood (D2), Medina (D3), Summit (D4), Butler (D8), Washington (D10), and Tuscarawas (D11) Counties have their complete fleet installed. An extra inventory was installed in a few trucks in Guernsey (D5), Licking (D5), and Muskingum (D5) Counties to assist with another ODOT research project. As seen in Figure 2.13, there are 187 trucks equipped with the Sierra Wireless modems for Phase Two of the project. More details about the modem installation may be found in Appendix A. Having one system in all the trucks allows data to be sent by the modems in each truck to the Azure server quickly. The capability to send data to the truck is very important as the number of units in the field increases. This will allow the researchers to send updates for the entire system at the same time without having to physically connect to each modem in the field.

2.4.1 Equipment

After Phase One, ODOT developed Phase Two, in which more trucks were equipped with the modem, antenna, and IP camera in order to track its trucks and see the road conditions through the pictures and live video. The research team added the hydraulic cable in case ODOT chose to further pursue hydraulic data. Please note that if ordering or installing any of equipment discussed, all input/output (I/O) pin configurations, fuse size, voltage size, and an additional information should be verified and discussed with the proper ODOT personnel.

Modem

The Sierra Wireless GX450 modem is installed in all trucks in Phase Two. This modem is a newer model for the GX440. The differences are minor. The GX450 has a shorter boot-up time than the GX440, and one of the ports has a different pin configuration. Details of these systems are introduced in Section 2.3.1, and installation information may be found in Appendix A.

One objective of Phase Two was to field harden the system. One step was to protect the modem by enclosing it in a plastic case since the modem was originally fully exposed to the elements as presented in Figure 2.14a. The enclosing case is presented in Figure 2.14b.

(a) Phase One Modem Installed on Passenger Side Seat

(b) Enclosure to Protect Modem

Figure 2.14: Modem Installation – (a) Phase One, (b) Phase Two

The mechanics secured the boxes between the two seats as seen in Figure 2.14b or under the passenger-side seat as presented in Figure 2.15a. Some of the newer truck cabs do not have enough space to install the enclosure, but the mechanics still managed to protect the modem as best they could, as presented in Figure 2.15b.

(a) Mounted Under the Passenger-side Seat

(b) Mounted by Passenger-side Seat without Enclosure

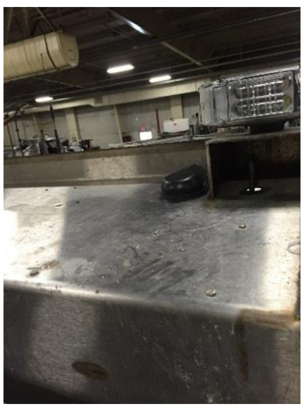
Figure 2.15: Mounting Options - (a) With Enclosure, (b) Without Enclosure

Ideally, ODOT would consider moving to a custom-made enclosure for the new trucks. In addition to the protective enclosure, the cables are designed to be field hardened compared to the ones implemented in Phase One.

Antenna

During Phase Two, the double antennas seen in Figure 2.6 on page 11 were consolidated to a single antenna. In addition, ODOT purchased two other types of antennas to implement. Table 2.2 below presents the initial overview of the antennas in Phase Two.

Table 2.2: Antennas Being Tested in Phase Two.

Equipment	**Potential Positives**	**Potential Negatives**
	Internal Mount	
	• Low cost • Easy to install	• Signal strength may be an issue
	Exterior Mount with Sticky Mount	
	• Antenna may have improved signal capabilities over the internal antenna. • Double antennae may increase signal strength which may be important in more rural areas such as Washington County.	• Need to drill a hole through the cab of the truck or an external metal flashing such as the light bar. • Longer time to install • Road salt moisture may seep underneath the rubber flashing and destroy the sticky pad
	External Mount Magnet	
	• Recommended by Sierra Wireless vendor. • Double antennae may increase signal strength which may be important in more rural areas such as Washington County.	• More expensive than the internal antenna. • Magnetic mount is not permanent and may fall off the vehicle over time. • Some of the new cabs are not compatible with the magnetic mount.

The research team allowed the garage mechanics to select the antenna. In the end, the mechanics selected the internal and the external magnetic mount antenna. Not all cabs are magnetic; therefore, the sticky exterior mounted antennas may be needed in areas where the internal antennas may not be strong enough to properly work. No garage selected the sticky exterior mount antenna; however, Van Wert was willing to test these on their fleet. The research team concluded that the external antennas were more reliable and transmit a stronger GPS signal versus the internal mount. During an event of continuous streaming for approximately two weeks, all trucks used the external mounts due to their increased signal strength and reliability. The research team found this to be appropriate due to the security concerns and increased website traffic.

<u>IP Camera</u>

During Phase One, the nighttime pictures from the IP cameras showed a large, bright globe as presented in Figure 2.16a.

(a) IP Camera in Phase One – IR On

(b) IP Camera in Phase Two – IR Off

Figure 2.16: IP Camera Night shot (a) Phase One IR On, (b) Phase Two IR Off

This bright light that appeared in the night shot (seen in Figure 2.16a) was due to the infrared (IR) lights reflecting off the windshield. During Phase Two the research team first covered the lights with electrical tape and, with the help of the manufacturer, developed an upgrade to the software which allowed the IR to be turned off as seen in Figure 2.16b. As a result, the picture was relying on the outside lights, i.e. the truck's headlights, for illumination. This particular camera has a 3 megapixel lens that is capable of generating an image with effective pixels of 1280x960. As discussed above, the camera has IR capabilities as well as the capability to turn off the IR option. The camera has rustproof high quality metal for increased durability in adverse conditions. It is also capable with multiple smartphones and also allows multiple users to access the image or stream at once.

2.4.2 Camera System Capabilities

The system that the research team implemented is not only able to take pictures and video, but also creates the opportunity to install Network Video Recorders (NVR), which may record and store video on board. So, live video may be accessible via the website while being stored at the same time. This system may be useful if an incident occurs and review is necessary to determine exactly what happened. These cameras are multi-versatile and may be installed at any vertical or horizontal orientation to ensure the proper field of view is captured. During a special event, the research team was able to capture and store over one terabyte of data and video for security monitoring purposes. This was completed at the request of ODOT officials. During this event, few issues arose with the desired fleet. The research team was capable of resolving any issue within an acceptable time frame. The system capabilities were truly tested during this two week time period as continuous video streaming occurred. Additionally, multiple users were able to access the network at once. The camera picture time frame was updated to capture an image every minute versus every five that is typical for the system.

2.4.3 Lessons Learned

The research team expected to see new issues as the project scaled from 22 trucks to 187 trucks. The two primary lessons learned concerned issues with:

- Equipment acquisition, and
- Network connection.

The first issue, a delay in equipment acquisition, occurred at the beginning of the project. In order to prevent this in the future, it is recommended that installation begin in the spring and summer to prepare for the winter months. Researching the equipment and vendors is also recommended to improve equipment purchasing.

The second main issue was that the modem was not able to connect to the network. Approximately 10% of the modems were having this issue and therefore were not reliable. The research team switched the internal antennas to the external antennas but did not fix the issue. The research team worked with Sierra Wireless and changed the access point name (APN) associated with the problem modems. This new APN address seemed to have permanently fixed the issue. A troubleshooting manual was developed and provided in Appendix D.

2.5 System Capabilities Summary

Throughout the duration of this project, the research team was able to implement various technologies into the GPS/AVL system. The desired capabilities are outlined throughout this report. These technologies have also been implemented into the website. The website collected, analyzed, and summarized key information back to the end user. Many of the data outputs received by the website are capable for viewing in real-time; meaning the end user was able to see the data after a short delay of approximately ten seconds.

CHAPTER III DELIVERABLES

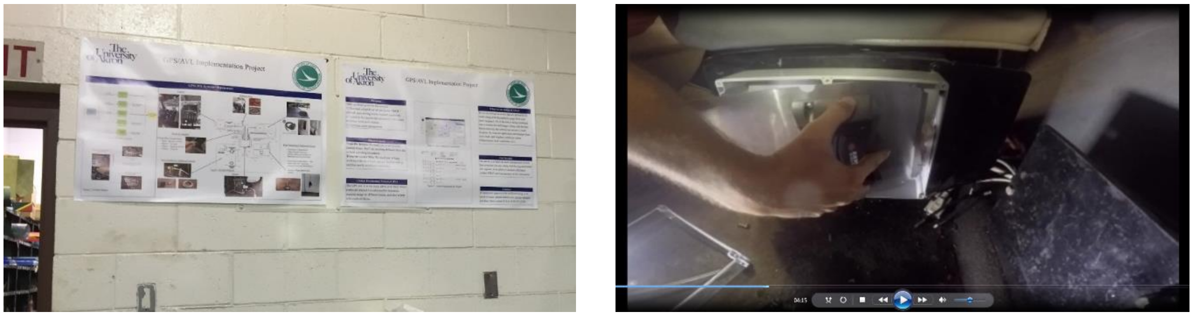
This chapter provides an overview of the deliverables. The first deliverable is the installation of the system which includes all the necessary documentation ODOT needs to install the system by its own staff. In addition to the installation guide, a website was created with and for ODOT to display the real-time data and to retrieve the historical data. System and website capabilities are summarized and discussed as well to visually represent all that may be done with the GPS/AVL system.

3.1 Installation of the System

For the installation of the system, there are multiple resources to assist in the process. The research team conducted the installation of the Sierra Wireless modems in Phase One of the project. As part of Phase Two, the research team conducted training sessions with ODOT mechanics on the installation process, as shown in Figure 3.1.

Figure 3.1: Training Session with ODOT Mechanics

One of the goals of Phase Two of this project was to pass the GPS/AVL installation and maintenance to the ODOT garage to determine if this was realistic for future implementation. The training session consisted of a sit-down introduction of the system, system components, and installation process. Then the mechanics in each garage at the session went through the installation process on one or two of their trucks with the research team there to answer questions. At the end of the training, the mechanics all gathered for questions and comments about the system. In addition, the research team provided the mechanics with a video of the installation process, informational posters about the project to display in the garages for operators to review (provided in Appendix C), an installation packets with more detail about each component (provided in Appendix A), and wiring diagrams (provided in Appendix B). Samples of the posters and video are shown in Figure 3.2.



(a) Posters Displayed in Garage (b) Installation Video

Figure 3.2: Training Material Developed for ODOT Mechanics – (a) Posters, (b) Video

Once the training was complete, ODOT and the research team scheduled the full installation of the system as the equipment was acquired. Figure 3.3 shows the fully installed system.

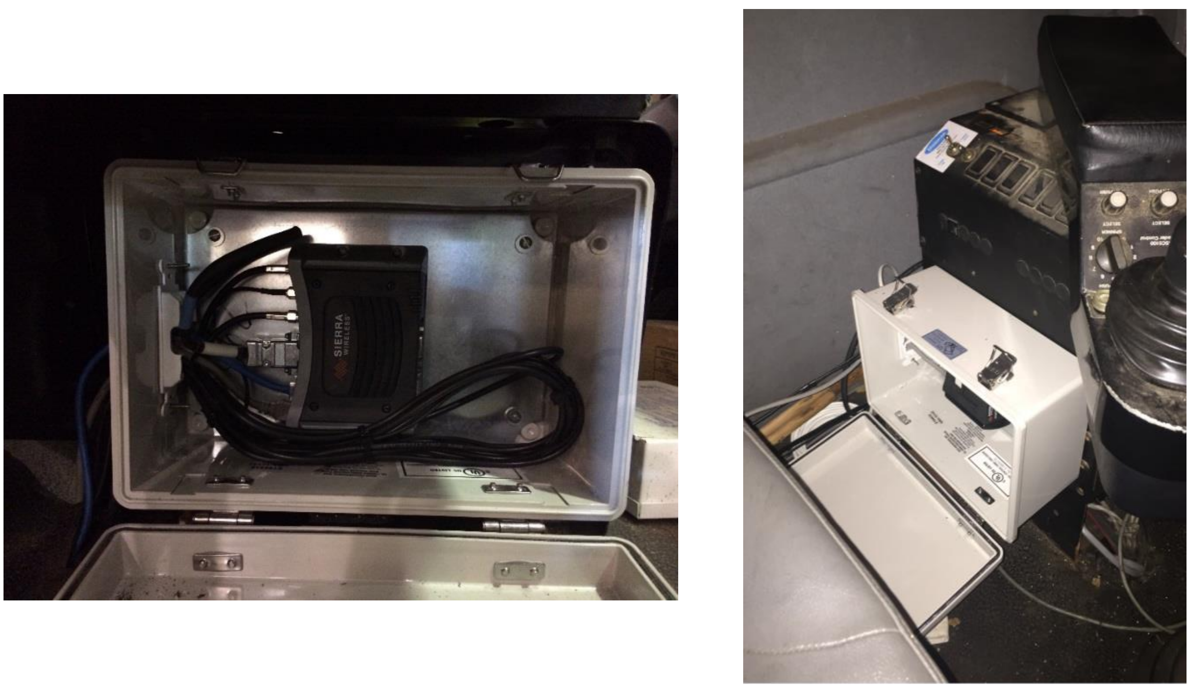


Figure 3.3: Fully Installed GPS/AVL System

Please note that as mentioned in Section 2.3, Phase Two installation consisted of the modem, antenna (for GPS tracking), and IP cameras (for road condition visualization). The research team provided hydraulic cables as well in the event ODOT decides to move forward with hydraulic data.

In addition to the training material for the installation of the system, the researchers developed a troubleshooting manual for the Sierra Wireless modem, presented in Appendix D. As expected, as the number of trucks increased from 22 in Phase One to 187 trucks in Phase Two, there were issues observed in the field. Appendix D presents solutions to the issues encountered. The research team assisted the ODOT garages with questions, problems, or concerns during Phase Two.

3.2 Website Development

One key component of GPS/AVL systems is the platform for users to view data. The objective of Phase One, which continued into Phase Two, was the development of a website with ODOT input. The website must be structured to hand over to ODOT and must be secure. The following subsection provides an overview of the website structure and some of its features.

3.2.1 Website Structure

The website utilizes a Microsoft Windows Azure cloud server. Azure supports multiple operating systems, programming languages, tools, databases, frameworks, and devices. This server may be scaled up and down depending on the amount of data it receives from the field. That is, as more trucks are out sending data, the server scales up, but when trucks are turned off and not being used, the server scales down. Figure 3.4 presents the application infrastructure of the GPS/AVL website.

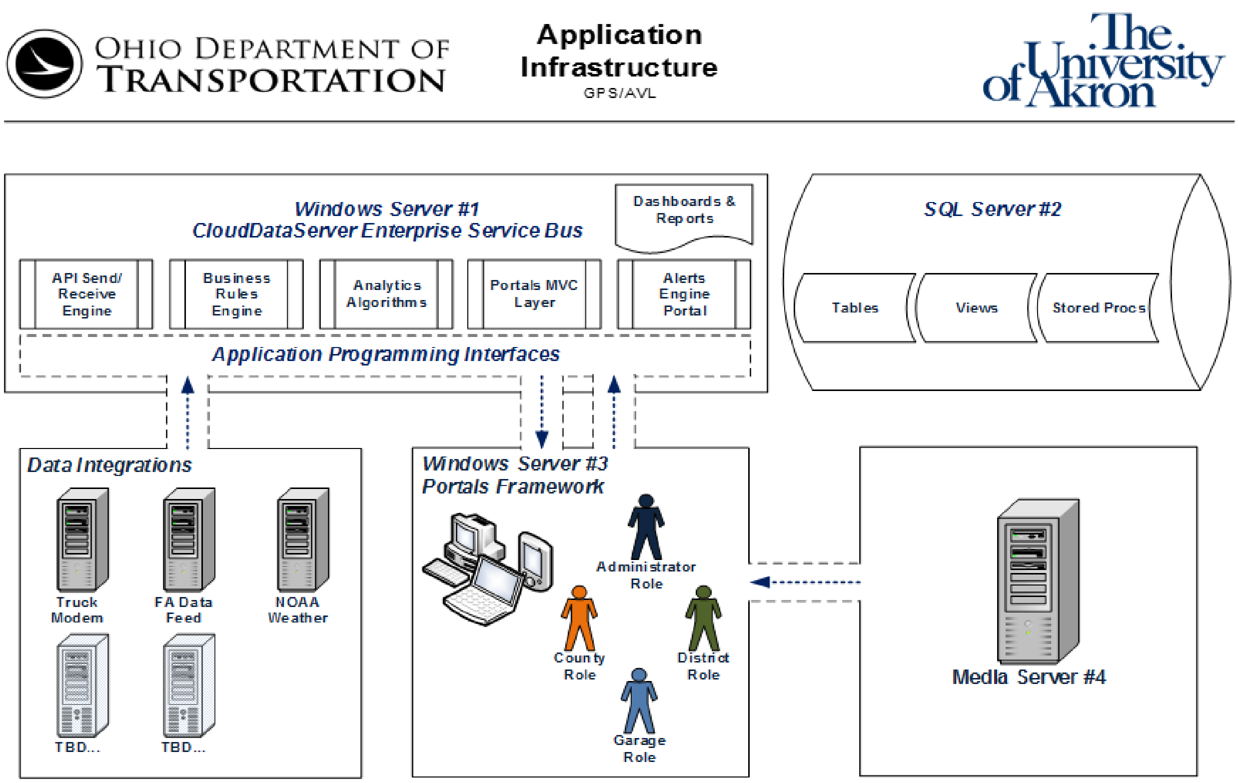


Figure 3.4: The Application Infrastructure for the Website

As presented in Figure 3.4, the data (modem, traffic, and weather data) are sent to the cloud sever which is then securely relayed to the end user. In addition, the data are stored on a SQL server for future retrieval. The media server shown in Figure 3.4, is for the storage of potential video data. Figure 3.5 presents more details about the data moving onto the cloud data server.

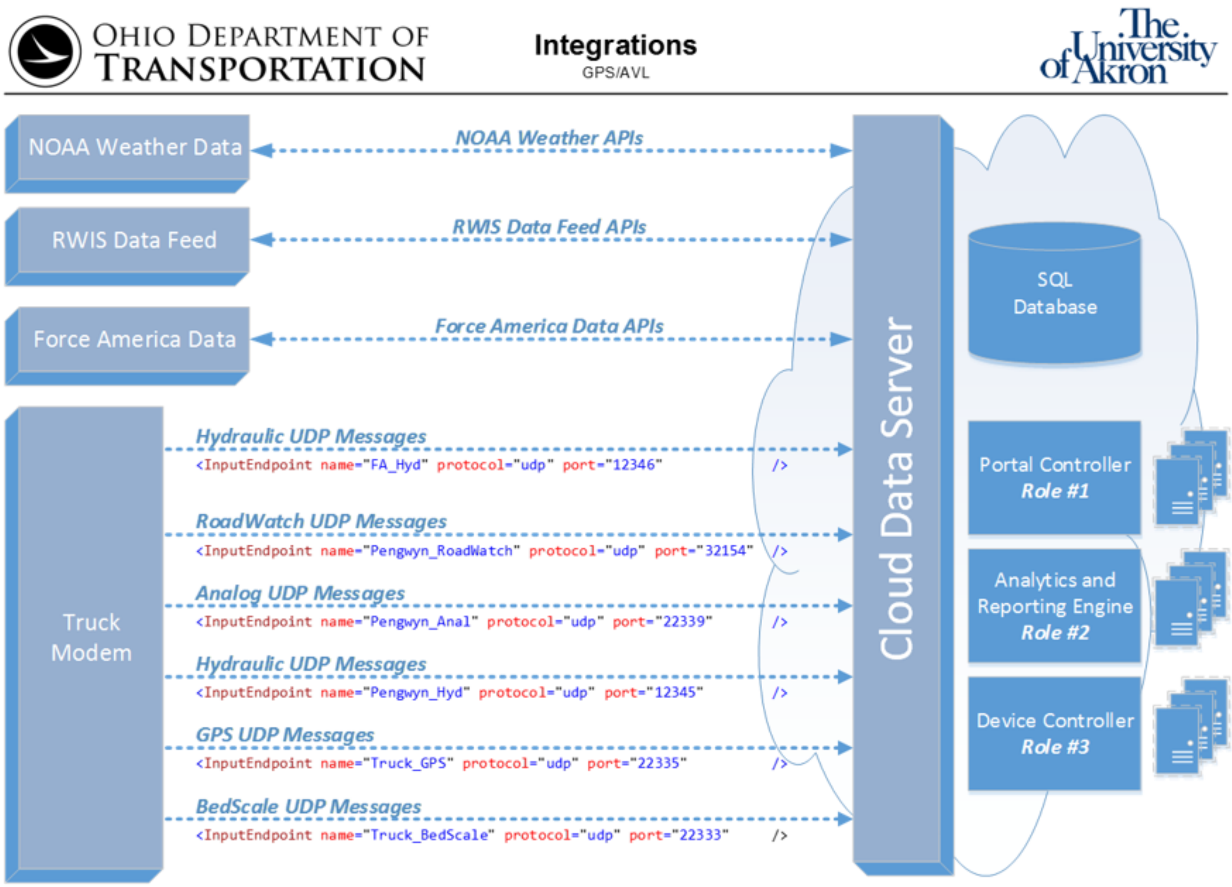


Figure 3.5: Integrations of Data to Cloud Server

The third-party data (i.e. weather data and Force America data when the PreCise system was utilized) use an application program interface (API). An API is a set of protocols and tools for software applications. The data coming from the truck through the modem use a user datagram protocol (UDP), which is another form of protocols. Figure 3.6 presents additional information about the website structure.

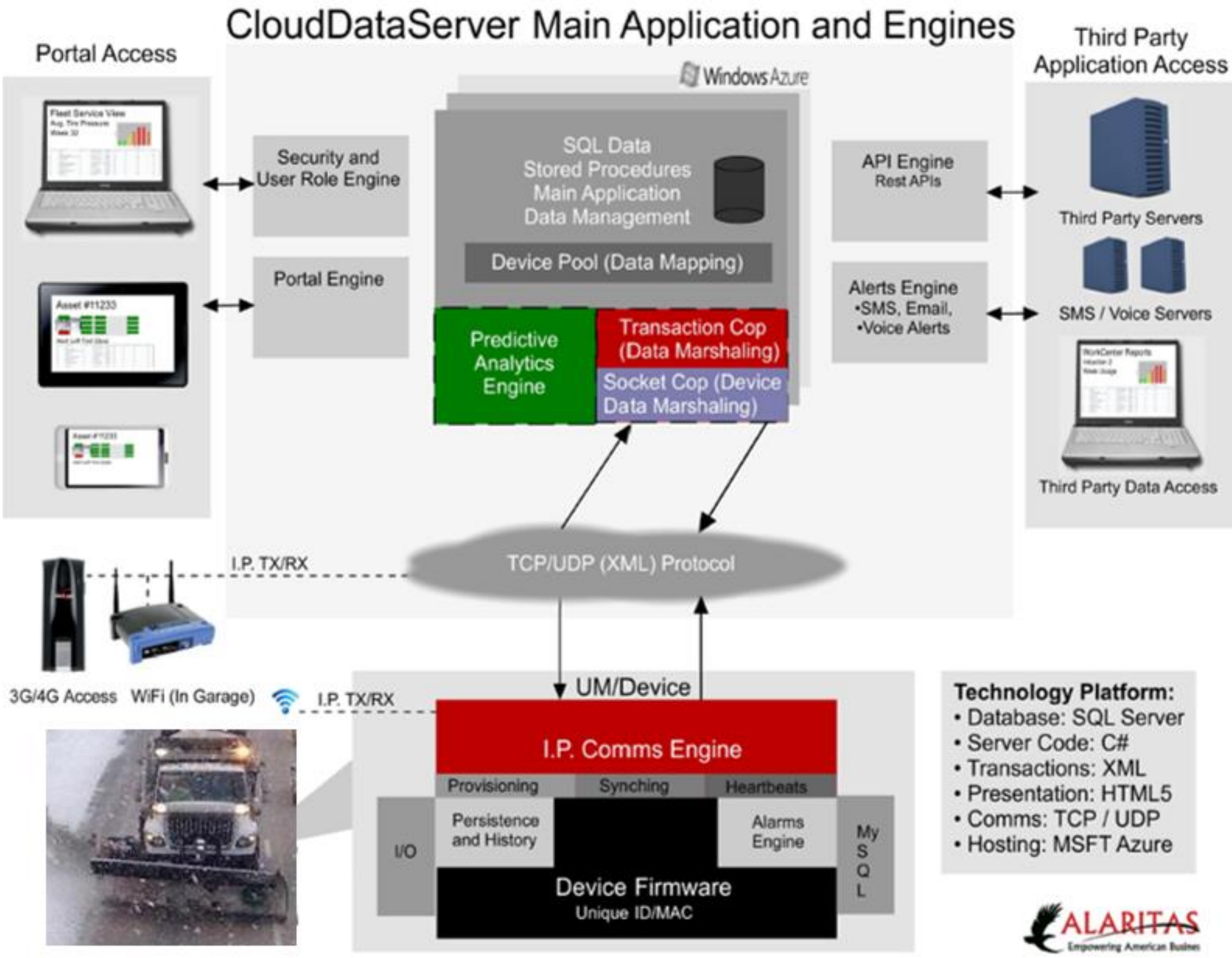


Figure 3.6: The Cloud Data Sever Main Application and Engines

The main application and engines are used for the website to perform core and essential functions. For more details about the website structure please refer to Appendix E of this report.

3.2.2 *Website Features*

The website was developed for and alongside ODOT. This section introduces some of the key features of the website. More details of the website and how to use it is presented in Appendix F. Figure 3.7 presents an outline of the website features.

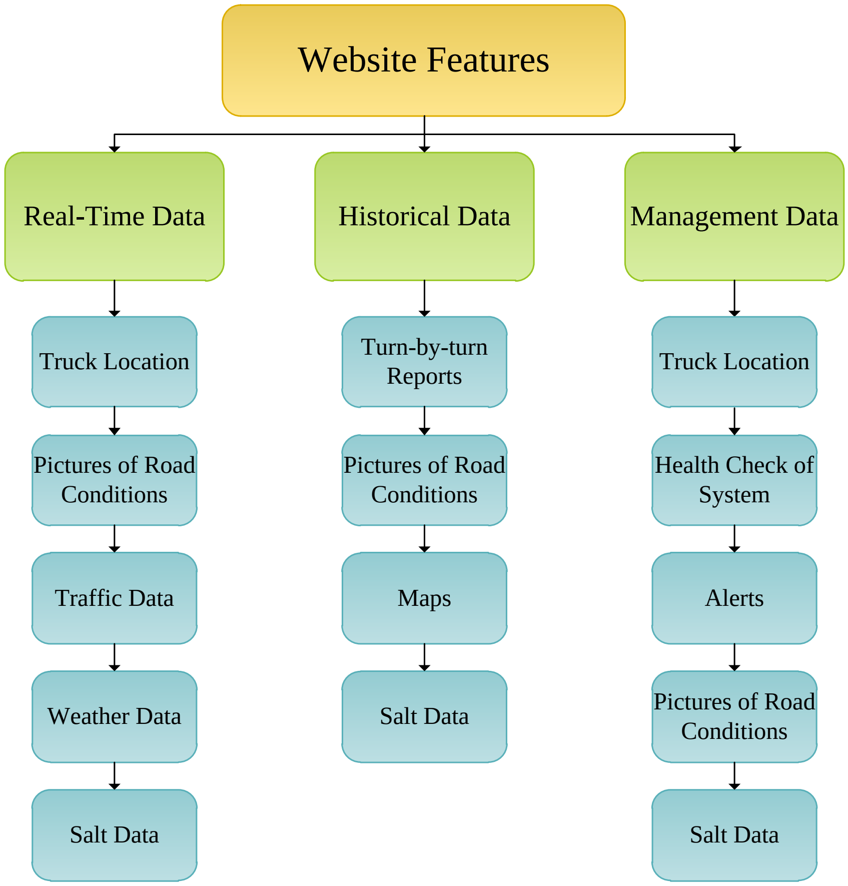


Figure 3.7: Website Features Outline

The website contains real-time, historical, and management data which provide ODOT personnel with additional tools to increase the efficiency of their winter maintenance operations.

Real-Time Data

The website requires a user name and password to access it. Once accessed, the website opens to a real-time truck map, as presented in Figure 3.8.

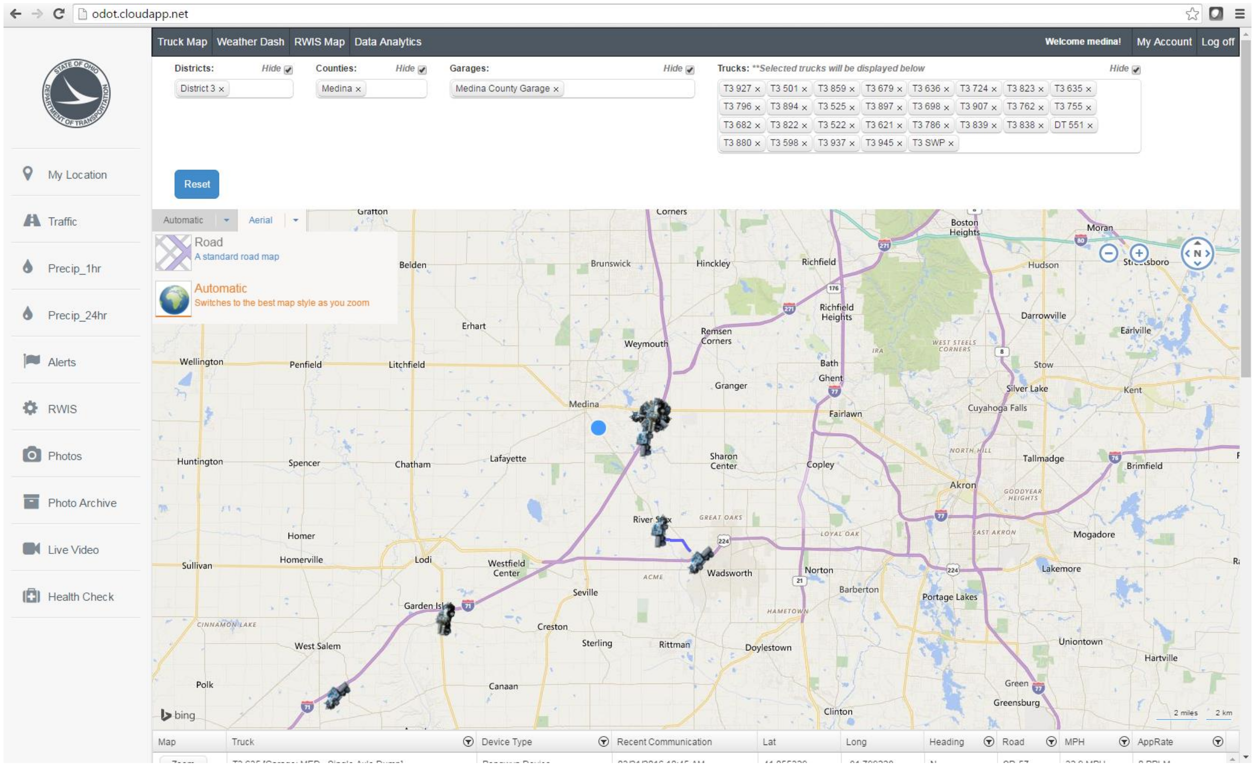


Figure 3.8: Real-time Truck Map

The view of the website may be changed from road to aerial in the upper left hand corner of the map. This feature assists in finding trucks relative to existing land marks, as shown in Figure 3.9.

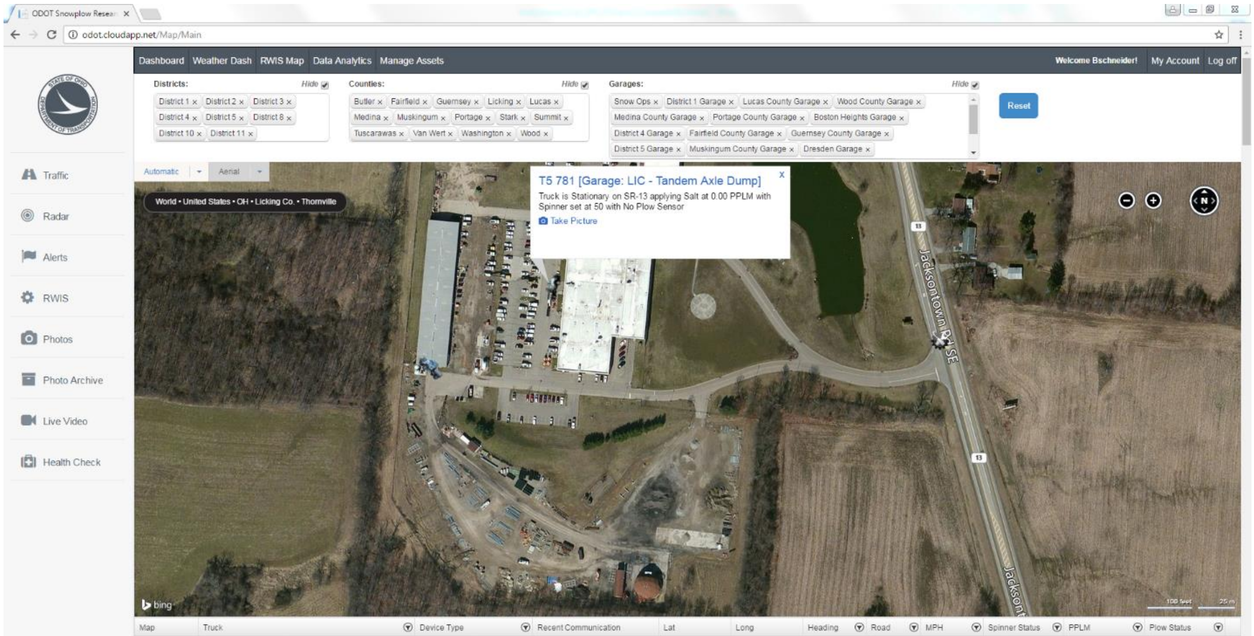


Figure 3.9: Aerial Feature for Real-time Truck Map

When clicking or hovering on a truck on the real-time map, more detailed data are provided as shown in Figure 3.10

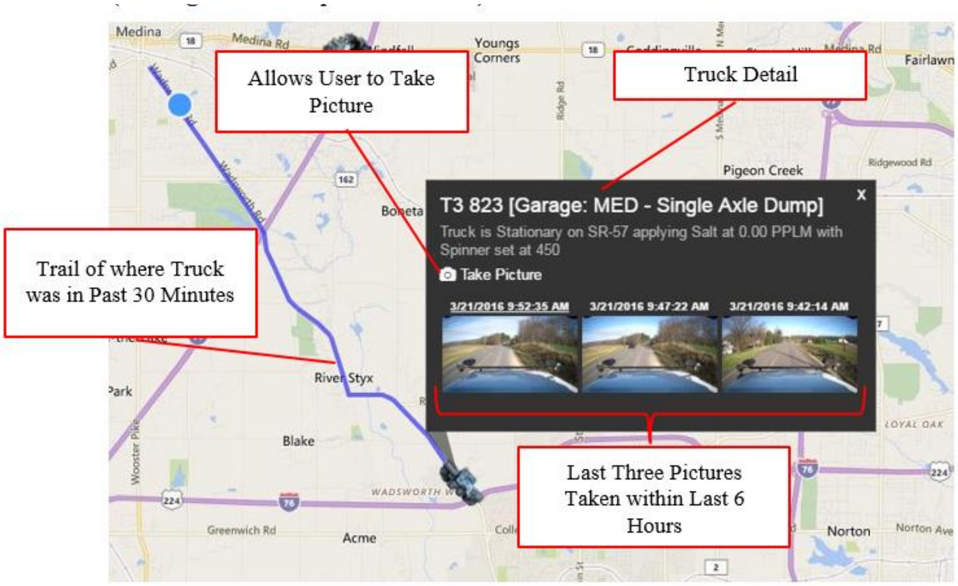


Figure 3.10: Hovering Truck Details on Real-time Map

Beside trucks' locations and details, traffic and weather data may also be added to the real-time map to allow users to see the traffic conditions (green, yellow, and red indicators) on main roadways and the precipitation radar. RWIS station locations and data may also be accessed on the real-time map.

Real-time and historical data may also be viewed on the dashboard tab as seen in

Figure 3.11, located on the left-hand side of the website.

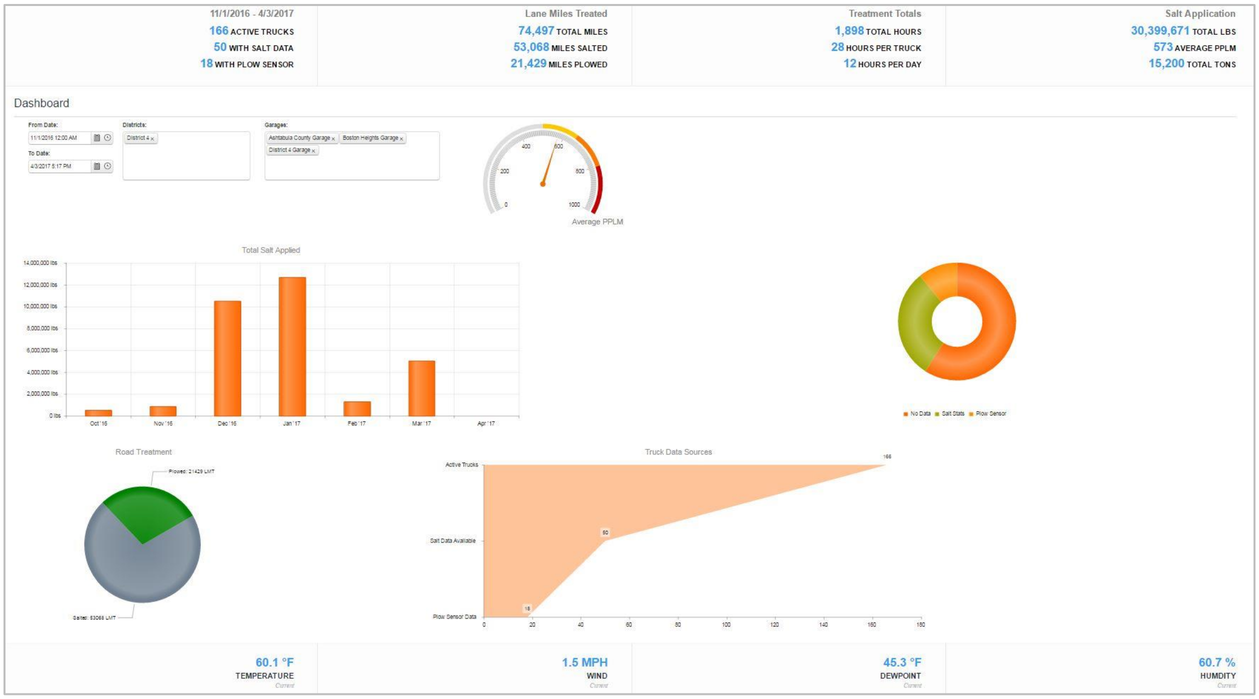
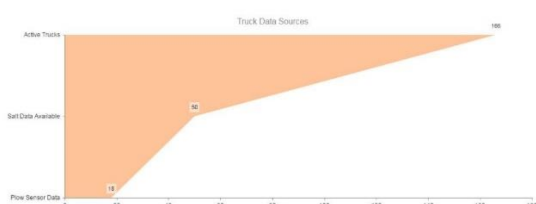


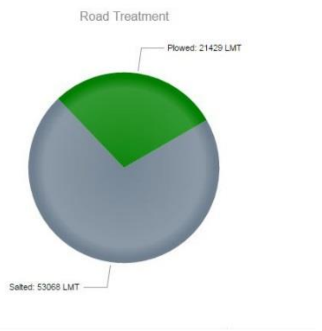
Figure 3.11: Full Dashboard

The full dashboard show in

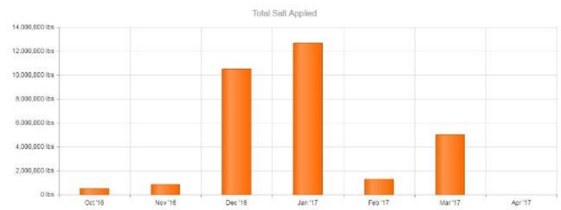
Figure 3.11 gives a visual representation of what will appear when the end user wishes to see the dashboard. For visual clarity, each individual aspect of the dashboard are outlined below in Table 3.1.

Table 3.1: Website Components and Descriptions.

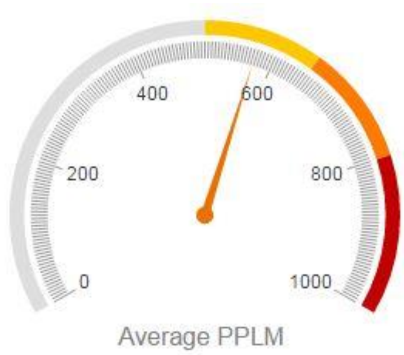
Website Component	**Description**
	This graph displays the amount of trucks that have plow sensor data available and number of trucks that have salt data available compared to the amount of trucks that are currently available.
	This figure breaks down the amount of trucks that are sending plow sensor data, salt stats, as well as no data. This may allow the end user to identify trucks with faulty equipment.



This figure specifically compared the number of lane miles that are treated via plow versus the lane miles that are salted. These statistics are able to be analyzed for specific storms by simply changing the calendar days the end user wishes to analyze.



The amount of salt applied is able to be viewed by month, day, or even hour based on the needs of the end user. The amount of salt applied per unit time is displayed in pounds.



This figure averages the amount of trucks that are sending salt data and generates an average PPLM amount for the amount of trucks sending these data.

Various weather conditions are displayed on the salt dashboard such as temperature, wind speed, dew point, and humidity level. These data are received from the RWIS station that correlates directly to the area that the end user is analyzing.

Historical Data

Along with the real-time data, the historical data may be accessed on the website through the *Data Analytics* Command. The historical data consists of a turn-by-turn report, a map of where a truck has traveled, and the pictures taken during a trip, as presented in Figure 3.12 and Figure 3.13.

Report Start 4/7/2016 12:00:00 AM	Truck T3 927	Mileage Start 8088.42	Legacy PPLM 0.00
Report End 4/7/2016 11:50:38 PM	Driver ,	Mileage End 8120.89	Actual PPLM 0.00
	Fuel 0.00	Mileage Total 32.47	Salt Mileage Total 0.00

Road Condition and Operation Report

Time On	Time Off	Route	From	To	Condition	Treatment	Salt	Calcium	Brine	Abrasives	Mileage	PPLM
4/7/2016 10:22:18 PM	4/7/2016 10:48:08 PM	SR-18	Cnty Num: 15.06	Cnty Num: 15.42	0 = Undefined	0 = Undefined	0.00	0.00	0.00	0.00	0.84	0.00
4/7/2016 10:48:08 PM	4/7/2016 11:02:18 PM	IR-71	Cnty Num: 16.7	Cnty Num: 7.52	0 = Undefined	0 = Undefined	0.00	0.00	0.00	0.00	9.97	0.00
4/7/2016 11:02:18 PM	4/7/2016 11:06:28 PM	US-224	Cnty Num: 15.5	Cnty Num: 13.92	0 = Undefined	0 = Undefined	0.00	0.00	0.00	0.00	1.57	0.00
4/7/2016 11:06:28 PM	4/7/2016 11:11:48 PM	US-224	Cnty Num: 13.9	Cnty Num: 12.22	0 = Undefined	0 = Undefined	0.00	0.00	0.00	0.00	1.93	0.00
4/7/2016 11:11:48 PM	4/7/2016 11:16:58 PM	US-224	Cnty Num: 12.19	Cnty Num: 11.33	0 = Undefined	0 = Undefined	0.00	0.00	0.00	0.00	1.13	0.00
4/7/2016 11:16:58 PM	4/7/2016 11:19:58 PM	US-224	Cnty Num: 11.28	Cnty Num: 9.95	0 = Undefined	0 = Undefined	0.00	0.00	0.00	0.00	1.35	0.00
4/7/2016 11:19:58 PM	4/7/2016 11:24:18 PM	US-224	Cnty Num: 9.95	Cnty Num: 8.42	0 = Undefined	0 = Undefined	0.00	0.00	0.00	0.00	1.59	0.00
4/7/2016 11:24:18 PM	4/7/2016 11:30:38 PM	US-224	Cnty Num: 8.39	Cnty Num: 6.6	0 = Undefined	0 = Undefined	0.00	0.00	0.00	0.00	2.78	0.00
4/7/2016 11:30:38 PM	4/7/2016 11:32:58 PM	US-42	Cnty Num: 2.31	Cnty Num: 3.04	0 = Undefined	0 = Undefined	0.00	0.00	0.00	0.00	1.07	0.00
4/7/2016 11:32:58 PM	4/7/2016 11:36:58 PM	US-224	Cnty Num: 6.92	Cnty Num: 6.33	0 = Undefined	0 = Undefined	0.00	0.00	0.00	0.00	0.65	0.00
4/7/2016 11:36:58 PM	4/7/2016 11:37:58 PM	US-42	Cnty Num: 3.03	Cnty Num: 2.79	0 = Undefined	0 = Undefined	0.00	0.00	0.00	0.00	0.31	0.00
4/7/2016 11:37:58 PM	4/7/2016 11:49:08 PM	US-224	Cnty Num: 6.54	Cnty Num: 2.48	0 = Undefined	0 = Undefined	0.00	0.00	0.00	0.00	4.62	0.00
4/7/2016 11:49:08 PM	4/7/2016 11:50:38 PM	SR-301	Cnty Num: 2.8	Cnty Num: 2.7	0 = Undefined	0 = Undefined	0.00	0.00	0.00	0.00	0.31	0.00

Salt Total 0.00 Cal. Total 0.00 Brine Total 0.00 Abr. Total 0.00

Comments:

Figure 3.12: Turn by Turn Report Information

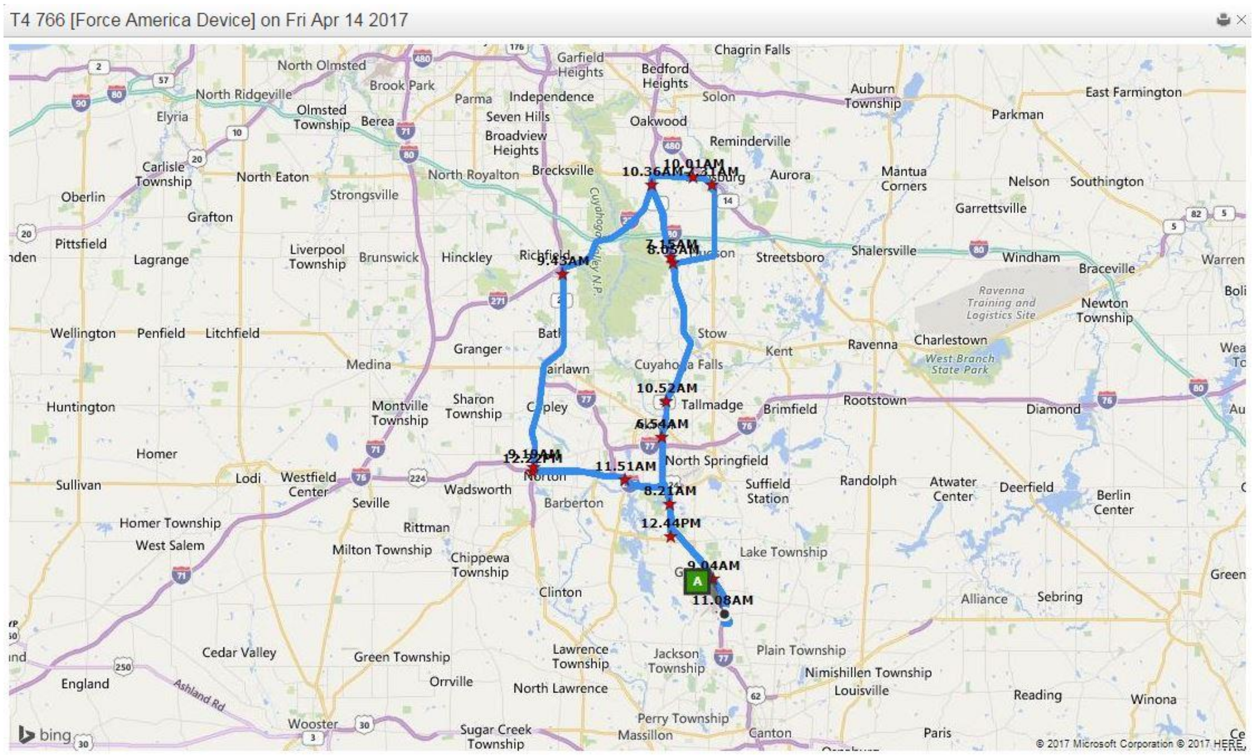


Figure 3.13: Map of Historical Data

The historical data are updated at 2:00 AM daily. This time was selected arbitrarily and may be switched to any time(s) throughout the day. Users may print or review the data each day or create a custom report where they may select a specific time and/or day. The pictures are accessed through these reports and through the *Photo Archive*. The pictures are organized by date and the last 100 pictures are retrievable. The video is currently not stored on the system, but the system is capable of storing video by storing on-board with a NVR/Digital Video Recorder (DVR) or sending the video to be stored on the server which requires a large amount of bandwidth and cost. The video may be viewed in real-time or downloaded to the server. To access the live video, a password is required. The live video is presented in Figure 3.14.

Figure 3.14: Live Video Interface

A box with the truck number (when the truck is turned on) will appear, and the user may click to see the real-time video. This video will time out after a couple of minutes to prevent an increase in cellular usage to save cost.

Management Data

A health check page on the website is an effective tool that gives the end user the ability to monitor the GPS/AVL system. The health check page shows truck information, the date/time and latitude/longitude of the last time the GPS communicated with the website, the last time a picture was taken, the total number of pictures taken by the camera, and hydraulic communication data (when activated). Figure 3.15 presents the health check page.

District	County	Truck	Id	Device Type	IP Address	Last GPS	Lat	Long	Last Picture	Total Pics	La
District 3	Medina	T3 796 [Garage: MED - Single Axle Dump]	124	Force America	166.165.59.122	04/05/2016 03:44 PM	41.406349	-81.780320	04/05/2016 03:41 PM	7270	
District 3	Medina	T3 636 [Garage: MED - Single Axle Dump]	117	Pengwyn	166.165.59.129	04/05/2016 03:44 PM	41.010084	-81.753309	04/05/2016 03:41 PM	4460	
District 3	Medina	T3 838 [Garage: MED - Single Axle Dump]	127	Force America	166.165.59.99	04/05/2016 03:44 PM	41.009949	-81.753251	04/05/2016 03:41 PM	3631	
District 3	Medina	T3 927 [Garage: MED - Tandem Axle Dump]	132	Force America	166.165.59.98	04/05/2016 03:44 PM	40.990352	-81.729719	04/05/2016 03:41 PM	4843	
District 3	Medina	T3 525 [Garage: MED - Single Axle Dump]	114	Force America	166.165.59.128	04/05/2016 03:42 PM	40.990362	-81.729723	04/05/2016 03:41 PM	7380	
District 3	Medina	T3 635 [Garage: MED - Single Axle Dump]	116	Pengwyn	166.165.59.125	04/05/2016 03:18 PM	41.135411	-81.802897	04/05/2016 03:15 PM	5062	
District 3	Medina	T3 724 [Garage: MED - Single Axle Dump]	120	Pengwyn	166.165.59.132	04/05/2016 03:15 PM	41.135389	-81.802948	04/05/2016 03:10 PM	7949	02
District 3	Medina	T3 621 [Garage MED - Tandem Axle Dump]	210	Force America	166.165.59.92	04/05/2016 03:03 PM	41.135450	-81.802447	04/05/2016 03:00 PM	5712	
District 3	Medina	T3 945 [Garage MED - Tandem Axle Dump]	215	Certified Power	166.165.59.93	04/05/2016 02:55 PM	41.135676	-81.802780	04/05/2016 02:55 PM	762	
District 3	Medina	T3 679 [Garage: MED - Single Axle Dump]	118	Pengwyn	166.165.59.130	04/05/2016 02:49 PM	41.135690	-81.802590	04/05/2016 02:45 PM	4573	
District 3	Medina	T3 598 [Garage: MED - Tandem Axle Dump]	109	Force America	166.165.59.85	04/05/2016 02:35 PM	41.135273	-81.802977	04/05/2016 02:25 PM	7163	
District 3	Medina	T3 937 [Garage: MED - Tanker]	111	None	166.165.59.101	04/05/2016 02:12 PM	41.134517	-81.803028	04/05/2016 02:10 PM	2764	
District 3	Medina	T3 897 [Garage: MED - Single Axle Dump]	13	Force America	166.165.59.83	04/05/2016 01:26 PM	41.135896	-81.802846	04/05/2016 01:24 PM	5430	03
District 3	Medina	T3 894 [Garage: MED - Single Axle Dump]	131	Force America	166.165.59.97	04/05/2016 12:56 PM	41.099471	-81.511610	04/05/2016 12:54 PM	7830	
District 3	Medina	T3 859 [Garage: MED - Single Axle Dump]	130	Pengwyn	166.165.59.95	04/05/2016 12:40 PM	41.135205	-81.802791	04/05/2016 12:03 PM	490	
District 3	Medina	T3 682 [Garage: MED - Tandem Axle Dump]	119	Force America	166.165.59.133	04/05/2016 09:36 AM	41.135288	-81.802873	04/05/2016 09:36 AM	6050	
District 3	Medina	T3 839 [Garage: MED - Tandem Axle Dump]	128	Force America	166.165.59.119	04/05/2016 08:53 AM	41.135270	-81.802940	04/05/2016 08:50 AM	6940	
District 3	Medina	T3 823 [Garage: MED - Single Axle Dump]	126	Pengwyn	166.165.59.120	04/05/2016 07:31 AM	41.135557	-81.802783	03/31/2016 01:26 PM	7958	03
District 3	Medina	T3 522 [Garage: MED - Tandem Axle Dump]	113	Force America	166.165.59.84	04/04/2016 11:39 PM	41.406332	-81.780212	04/04/2016 11:36 PM	6868	

Figure 3.15: Health Check Page of the Website

The health check page is helpful when managing multiple GPS/AVL systems in various locations. This page is a tool to help determine if equipment is working properly. Sometimes trucks are not used for a long period of time for maintenance; therefore, first-hand communication with the mechanic is best for trouble shooting. This is just an additional tool for managing GPS/AVL systems.

As presented, the end user is able to access live video, analyze historical data, analyze salt data, and keep track of all trucks within the fleet and much more. This data may be useful in the future planning and operations ODOT may undertake.

3.3 Capabilities

Nationwide, states may be implementing technology similar to the system implemented within ODOT's fleet. To gather more information on these different capabilities, the research team surveyed multiple states to analyze what they are integrating with the GPS/AVL system. This survey may be seen in Chapter 1 CHAPTER I and Appendix F.

As seen from the out-of-state survey, states are selecting to utilize the system in a variety of ways. The GPS/AVL system in which the research team implemented carries a variation of different capabilities. All aspects of the system are outlined below in Table 3.2. These categories include the gateway, camera, cellular coverage, security, and others.

Table 3.2: GPS/AVL System Capabilities by Category.

System Capabilities	
Category	**Description**
Number and type of ports	1 10/100 Base-T RJ45 Ethernet Port, 1 RS-232 Serial Port on DB-9 Connector, 1 Digital I/O, 1 USB 2.0 Client, and 2 Cellular and 1 GPS Antenna Connectors.
IP Camera Capabilities	Ethernet Port may allow an IP camera to send data through system.
4G LTE Capability	4G LTE Compatible. 3G in Areas not 4G Capable.
Shock, Vibration, Temperature and Humidity Standards	Exceeds Military Spec MIL-STD-810G Specification.
Security	Port Filtering and Trusted IP.
Remote Access	Capable of Remote Access While in the Field Using Management Site.
Dimensions	5.6 x 3.9 x 1.6 in.
Weight	14 oz.

The systems capabilities outlined in Table 3.2 show that the gateway is able to send and receive different data through various ports such as an Ethernet and RS-232 connector. The gateway also exceeds military specifications for shock, vibration, temperature and humidity. The gateway has different security measures that enable the end user to safely acquire data. The camera specifications are displayed as well showing a 3 Megapixel lens with IR capabilities.

In order to effectively display the information the gateway and camera obtain, the research team developed a website to enable the end user to visually see different reports and data. The website capabilities are outlined by ODOT's needs and are able to expand based on wants if compatible. The website allows the end user to monitor the fleet in real time as well as view historical data. The website capabilities are shown in below in Table 3.3.

Table 3.3: GPS/AVL Website Capabilities by Category.

Website Capabilities	
Category	**Description**
Security	Requires Username and Password for Login. Video also Password Encrypted for Additional Security.
Timeouts	Video Times Out after 30 Seconds to Save Bandwidth and Cost.
Amount of Users	Any Amount of Users May Use Website.
Real Time Data Reporting	Active Trucks, Truck Location, Speed, Pictures, Live Video, Turn by Turn Reporting, Plow Status,

	Application Rate, RWIS, Traffic Reports, Weather Updates to Include Radar, Truck Alerts, Hydraulic Data.
Historical Data	Truck Location, Pictures, Turn by Turn Reporting, Lane Miles Treated, Salt Totals, Plow Status.
Dashboard Data	Lane Miles Treated, Treatment Totals, Salt Application, Average Application Rate, Plow Status Breakdown, Truck Data Sources.

When opening the page for the website, a prompt initiates asking for a username and password to login for security. In addition to the security measure, the website reports various data in real time such as live video, plow status, hydraulic data, weather, and even traffic reports. If the end user wishes to go back and look at data from a particular event they may do so. Historical Data is stored for locations, pictures, and turn by turn reporting. Also on the website, the end user may notice the dashboard data that is stored as well. The data within the dashboard includes lane miles treated, application totals, plow status break down, and truck data sources.

The GPS/AVL system implemented by the research team is multifaceted. The system is capable of various different data streaming to allow for a wide variety of results and possible analyses. The website contains different tabs allowing the end user to accomplish a multitude of tasks. The GPS/AVL system currently installed within ODOT's fleet is capable of capturing different data from a variety of data sources due to its adaptability and capabilities.

CHAPTER IV SENSOR DATA

GPS/AVL technology may be utilized in a variety of ways. As seen in the out of state survey in Chapter 1, states are selecting to implement this technology in numerous ways. Primarily, GPS/AVL systems consists of truck location, truck speed and occasionally hydraulic data. This chapter focuses on the integration of other sensors tested. These sensors were tested to improve the LOS to the public and ODOT's operations. The first section evaluates plow sensor data as well as event based activity relating to mechanical operation. The second section relates to general hydraulic information, salt calibration, and a third-party quality assurance quality control with chemical application. The third section speaks on the operational application that may result from the additional sensors.

Throughout these three sections, the data collection capabilities of the sensors, how ODOT could potentially use the data, and the compatibility with the current server are discussed. With these technologies, ODOT may utilize real-time and historical data to improve future operations through the GPS/AVL system.

4.1 Mechanical Application

4.1.1 Event Based Evaluation

With the integration of sensors, it is possible to track aspects of plowing snow such as speed, time spent plowing, and could aid with future training. As discussed in Chapter Two and Appendix A, plow on/off sensors were installed on various trucks along with plow up/down sensors to test the compatibility and reliability of the sensors. The collaboration of these two separate sensors may allow for the system to establish readings for plow attachment as well as plow position to the end user and ultimately allow ODOT to serve the public more efficiently.

Due to the importance and possible effects of the plow sensor, data were analyzed by the research team the sensors collected. An example of the raw data used by the website may be seen in Table 4.1. Among other information, this data contains the device number, IP address, plow position, and time of reported position. Depending on the data that the AirLink transmits to the website, there are only three readings that may be displayed for the website user. These readings are Plow Off, Plow On & Up, and Plow On & Down.

Table 4.1: Plow Sensor Raw Data Example.

Truck Number	Date	Time	Plow Status
T3-636	3/8/2017	12:46:32	Plow On & Down
T3-636	3/8/2017	12:46:16	Plow On & Down
T3-636	3/8/2017	12:46:00	Plow On & Down
T3-636	3/8/2017	12:45:44	Plow Off
T3-636	3/8/2017	12:45:28	Plow Off
T3-636	3/8/2017	12:45:12	Plow Off

These raw data are sent within intervals only seconds apart for each truck. The raw data may be processed to reach a better understanding of the information and fully utilize the plow sensors. Figure 4.1 is a figure that displays the plow positions relative to one another for seven trucks over a two-month time period allowing ODOT to analyze plow blade performance over a specified period of time.

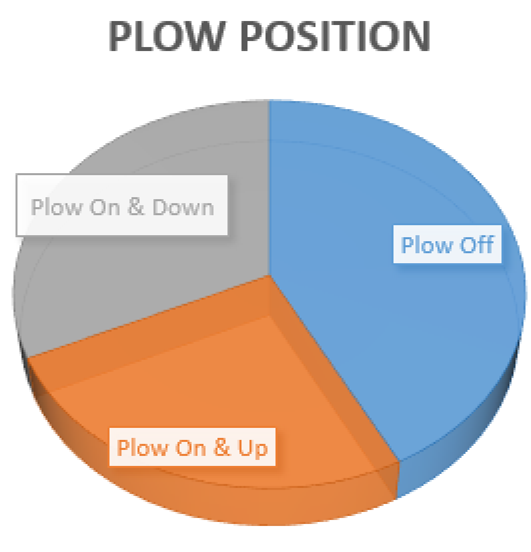


Figure 4.1: Plow Position Breakdown.

As shown in Figure 4.1, the raw data may be examined to find the distribution of plow location. This may aid ODOT in evaluating plow blade performances. The data displayed in Figure 4.1 are preliminary findings and more extensive testing and research may be required in order to validate the data shown.

An important aspect of any sensor is the reliability and accuracy. Raw data may be validated through video collected with the NVR’s or DVR’s to inspect these data points as accurate readings. An example of a truck with the reading “Plow Off” is shown below in Figure 4.2.

Figure 4.2: Example Image of Plow Off from DVR.

Throughout the winter season, operators routinely remove their plow and reattach as needed for snowfall events. Figure 4.3 displays what the end user's view may be when a plow is attached to the front end of a truck in the up position.

Figure 4.3: Example Image of Plow On and Up from DVR.

Although the plow may be visible when in the up position, it is much more difficult to spot when in the down position. Due to the light emitted from the headlights of the truck, the plow attachment is still visible in Figure 4.4 below during hours after nightfall.

Figure 4.4: Example Image of Plow On and Down for DVR.

In Figure 4.2, Figure 4.3, and Figure 4.4 are all images extracted from DVR systems installed within the fleet. These same images may be seen on the website for the end user to monitor and track. The research team experimented with two separate proximity sensors and received much better results with one compared to the other. One sensor resulted in a 50% success of sending data while the second sensor experienced an 80% success rate. The success rate differential may be due to a variety of things such as the sensing distance (distance needed to proper complete the circuit and send data). In addition to analyzing the data from these sensors on an event based scenario, it may be possible to examine them from a maintenance view as well, as discussed in the next section.

4.1.2 Maintenance

A standard flame-harden steel blades may cost approximately $540 per blade (Schneider et. al., 2015). However, innovate blades may cost up to $3,000 but may have longer life spans (Schneider et. al., 2015). With the plow blades possibly coming at a very high cost to ODOT, the ability to mitigate the wear and tear of these blades may help improve operations. When incorporating the plow sensor technology, it may be possible to track how many lane miles a truck has plowed when requiring maintenance to the plow blade. Data collected may aid ODOT in effectively implementing the best plow blade based on performance and price. The plow sensor data may also allow managers to monitor how quickly trucks may plow roadways utilizing different plow blades.

Along with general plow blade performance, other data points may be observed such as trouble spots. A trouble spot may be considered a point on the road that continually causes issues with the plow. Examples include bridge joints, road imperfections, or anything that may not allow the plow to perform optimally. The geographical locations of these problem spots may be provided to the operator to assist them in avoiding these imperfections which may increase the lifespan of the plow blade.

These data may also be broken down into daily lane miles plowed versus lane miles plowed for a season allowing for analysis for various time periods. In addition, if a plow blade is identified as wearing quicker than the norm, this may point to a counterbalance issue. At this point, the sensor may act as a preventive maintenance factor allowing ODOT to identify issues before other issues arise from the root problem.

4.1.3 Summary

With the increasing cost of maintenance every year, it is crucial to minimize expenses when it is possible. The integration of these plow sensors may allow ODOT to see savings in plow blade costs. The integration of a GPS/AVL system may also allow for real time updates as well as identify trouble spots in the road that may be damaging equipment. In addition, plow sensor data may also increase plow efficiency to increase the LOS for the public and keep the roads safe.

The output of the plow sensors may give the end user an accurate reading of the current status of a plow for a given truck at any time. These data may also be stored for historical data to view at any time. Another expense ODOT budgets for annually is salt. The research team also visited the hydraulic systems installed within ODOT's fleet.

4.2 Chemical Application

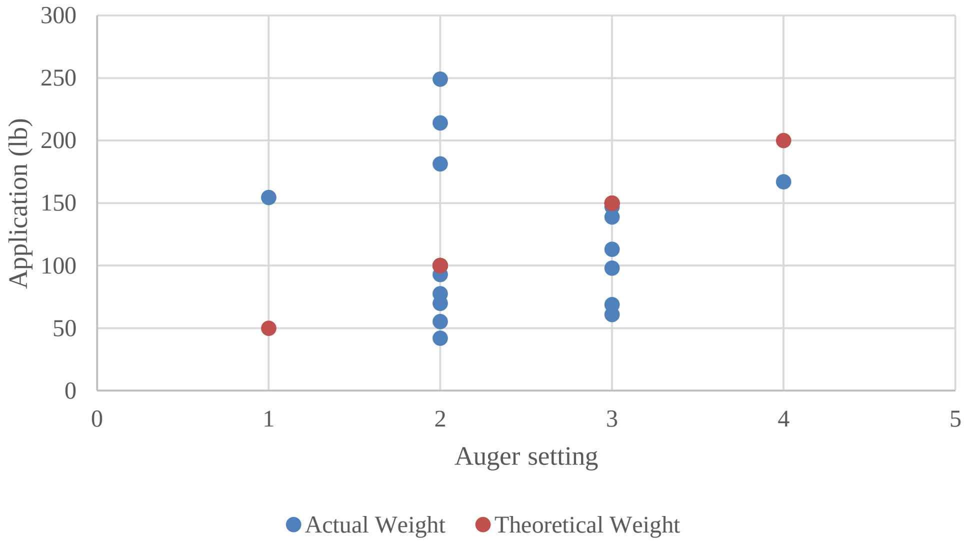
4.2.1 General

ODOT spent approximately $55 million for 889,871 tons of salt in 2015 (ODOT Salt Bid, 2015), it is imperative to operations and to budget as best as possible optimized and accurate. The GPS/AVL deployment was designed for the two primary hydraulic systems ODOT currently uses. With the amount spent on salt annually, it is even more important to track all applications of salt to minimize cost while maximizing efficiency. The hydraulic systems are used frequently throughout a winter season. Due to the frequent use of the hydraulic system throughout a season, it is not uncommon for the spreader to require calibration. This would mean the system is supposed to be applying at a predetermined rate but in reality, is applying at a different rate. The event of a truck coming out of calibration may cause for salt to be applied at a greater rate than anticipated therefore wasting salt. This particular issue may be avoided with regular calibrations of the hydraulic system.

4.2.2 Calibration

As discussed in the previous section, salt is a large portion of ODOT’s annual budget. This resource is a huge factor in providing safety to the traveling public. Therefore, it is imperative to optimize the methods in which salt is applied through the hydraulic system. Throughout the use of a hydraulic system, it is possible that the system may need calibrated or checked for calibration needs. This means that the auger is on a certain setting that had a predetermined application rate, but the system is applying more or less than the assumed value. This may lead to the driver anticipating an empty bed while there is still salt, or the opposite where they could anticipate there is salt in the bed when in fact they have none left. To alleviate this issue, calibrations are required on the hydraulic system. Multiple checks and calibrations were conducted on a series of trucks at the Summit County Boston Heights Garage located in District 4.

When comparing weights, the auger setting rate is the baseline for comparisons. These rates are identified with each auger setting. The settings, beginning with setting one, relates to 50 lb/ln/mi.; setting two relates to 100 lb/ln/mi.; and so on increasing in increments of 50 lb/ln/mi for every setting. After speaking with the operators, typically only setting one through six are used; setting four being the most frequently used. Throughout testing and calibration, this factor was considered and only settings one through four were tested to ensure the settings ODOT frequently uses are calibrated. Figure 4.5 is a visual representation of these tests.

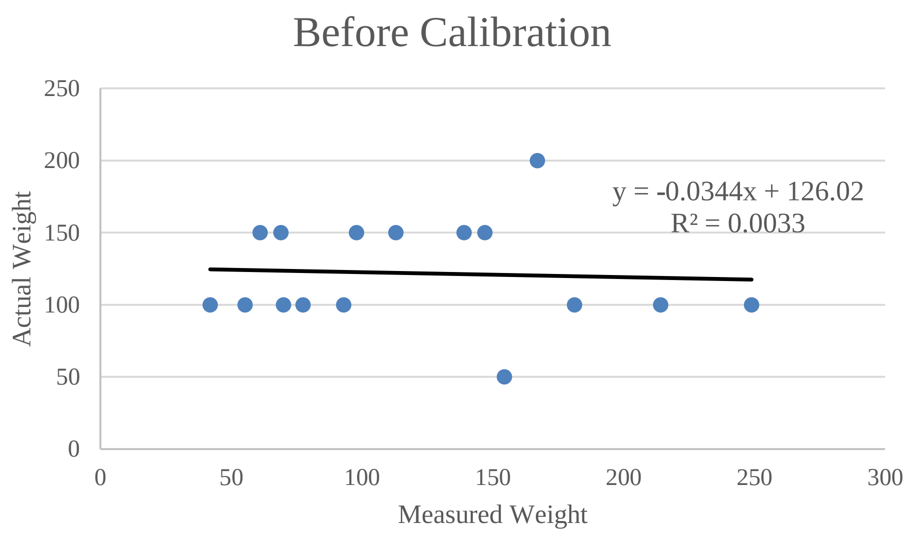


Note: The red theoretical weights are the weights that correspond to the auger setting. The blue weights correspond to what was measured. The difference between may show the need for calibration.

Figure 4.5: Auger Setting Weight versus Measured Weight of Salt.

As displayed in Figure 4.5, often the truck is not applying at the rate that the auger is set to.

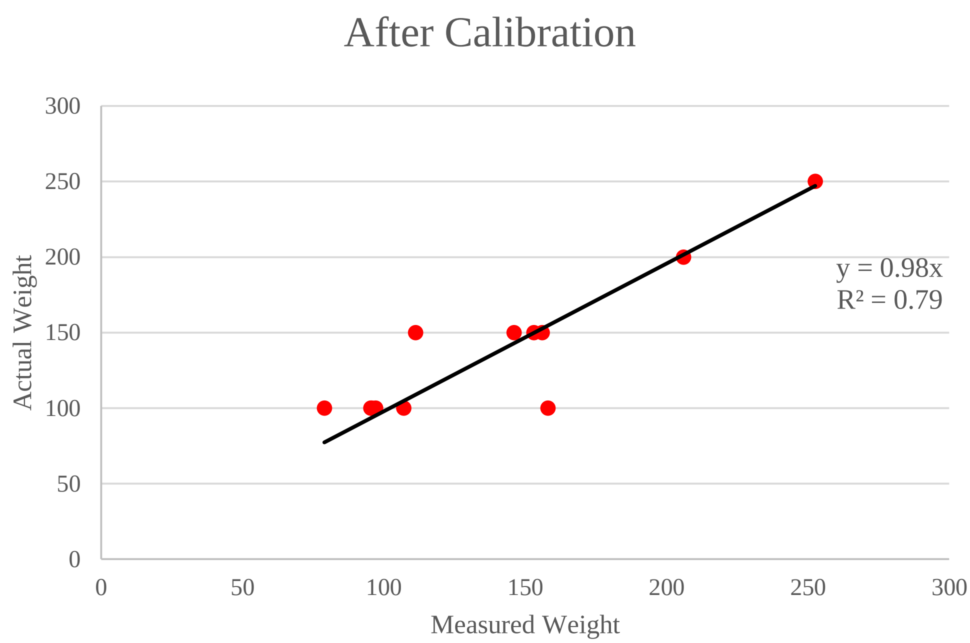
The need for hydraulic calibration relies on the operator to recognize there is an issue and communicate that to management to ensure that they are aware of the problem. The research team conducted tests to monitor the accuracy of the system to evaluate the need for calibrations. The initial results may be seen below in Figure 4.6. The R^2 value displayed for the before calibration measurements was 0.33%. This value being far off from one shows that the applied weights are not in line with the weights of the auger settings.



Note: The actual weight corresponds to the auger setting weight that correlates to that particular setting. The R^2 value is to represent how accurate the measured weights are compared to the actual. The closer the value is to one the more accurate the readings are.

Figure 4.6: Before Calibration Weight Comparison.

As seen above in Figure 4.6, the R^2 value is extremely low and not close to one, therefore the measured readings are different than the actual weights. These tests are preliminary and may need to be conducted more thoroughly for more accurate results. After these tests were concluded, the research team calibrated the group of trucks that were selected for this testing. Following the calibration, all trucks experienced a decrease in percent error as well as weight differential from the auger setting weight. The results of the calibration may be seen in Figure 4.7 displaying the actual weight of the auger setting versus the measured weight the system actually applied following the calibration.



Note: The actual weight corresponds to the auger setting weight that correlates to that particular setting. The R^2 value is to represent how accurate the measured weights are compared to the actual. The closer the value is to one the more accurate the readings are.

Figure 4.7: After Calibration Weight Comparison.

Through these tests, it may be determined that the need for calibrations of the hydraulic system may be needed. This may increase the efficiency of salt usage and ultimately decrease the amount of salt applied for the same type of events seen in the past. The comparison may be completed using historical data stored on the server for the end user to analyze. The application of salt may also be measured utilizing different sensors provided by a 3rd party entity.

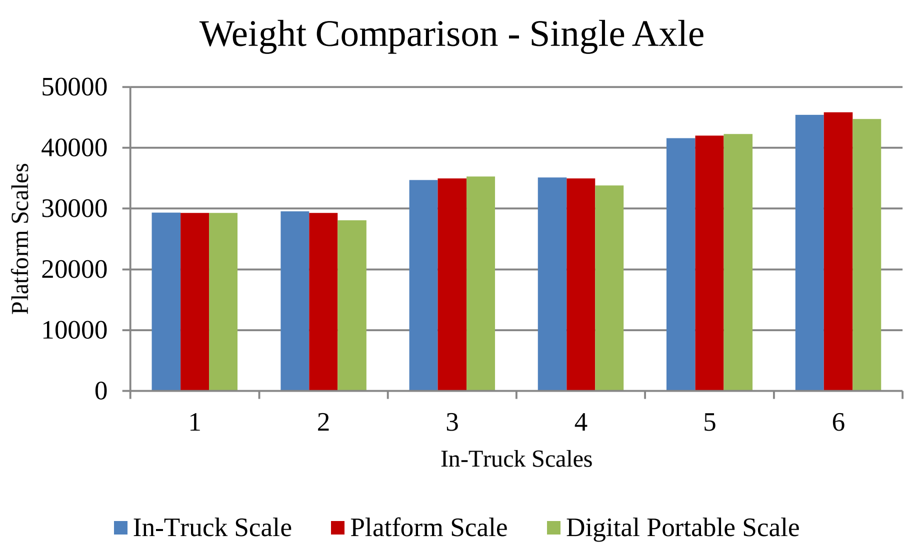
4.2.3 Third Party Quality Assurance Quality Control

With the amount of money ODOT spends annually on salt, it is vital to operations and budgeting to monitor salt usage. To calculate the amount of salt that is used throughout a shift, month, or even winter season, there are various different types of technology capable of calculating this information. This third-party entity may aid ODOT in monitoring salt usage down to the truck level allowing them to see the amount of salt every truck within their fleet applied if implemented in all trucks.

4.2.4 Evaluation

Bed scales were chosen to test the feasibility, durability, and accuracy of this type of technology. This particular brand of bed scales is compatible with both tandem axle and single axle trucks which may allow for implementation in virtually all plow trucks within ODOT's fleet. The tandem sensors use a system that measures deflection which calculates a weight, versus the single axle sensor that utilizes a wire and measures the tension that translates a weight. The sensors are installed directly on the trucks with a display located in the cab to allow for the operator to view the readings of the sensor.

Sensors of this variety vary in accuracy; most accurate up to the closest ten pounds. Throughout this section, the in-truck bed scales are compared to the platform scale at the District 4 Portage County Garage location. The bed scales may allow ODOT to identify calibration issues with an individual truck allowing them to apply salt more precisely. The bed scales were installed in Portage County as well as Summit County trucks due to the close proximity to the platform scale. This platform scale is assumed to be calibrated and display an accurate reading. The platform scale is assumed to be the actual weight of the truck and amount of material within the bed within the percent error outlined in the specifications. At some times during testing, other scales were used to validate the reading of both the bed scale as well as the platform scale. The Ohio State Patrol provided portable spring scales and ODOT provided portable digital scales that were utilized at different points during testing as a separate data source. Displayed in Figure 4.8 and Figure 4.10 below are two different testing results for two different trucks: one single axle test and one tandem axle test.



Note: The truck results displayed in this figure is T4-576. This is a single axle truck out of the Portage County Garage. The digital portable scales were provided by ODOT, the platform scale is the drive-up scale at the Portage County Garage, and the In-Truck Scale is the KiLoad sensor

Figure 4.8: Weight Comparison of In-Truck Scale, Platform Scale, and Digital Portable Scale.

Figure 4.8 shows that the in-truck bed scales read very similar to the platform scale. The values that are used in Figure 4.8 above are outlined in Table 4.2 below. Along with the weights, a percent error is shown comparing the weights. The readings were taken prior to the start of the winter 2014/2015 season. The Digital Portable scales were provided by ODOT Central Office as another data source as outlined in the section above. The percent error was calculated using the platform scale weight and the bed scale weight. Equation 4.1 below shows how the percent error was calculated.

$$PE = \frac{PS - ITS}{PS} \times 100 \qquad \text{Equation 4.1}$$

where: PE = Percent Error,
PS = Platform Scale Weight, and
ITS = In-Truck Scale Weight.

Table 4.2: Weights of Scales for Various Tests (Single).

In-Truck Scale Weight	**Platform Scale Weight**	**Digital Portable Scale Weight**	**Percent Error**
29330	29300	29280	0.10%
29550	29300	28060	0.85%
34700	34980	35300	-0.80%
35100	34980	33800	0.34%
41600	42000	42280	-0.95%
45450	45840	44760	-0.85%

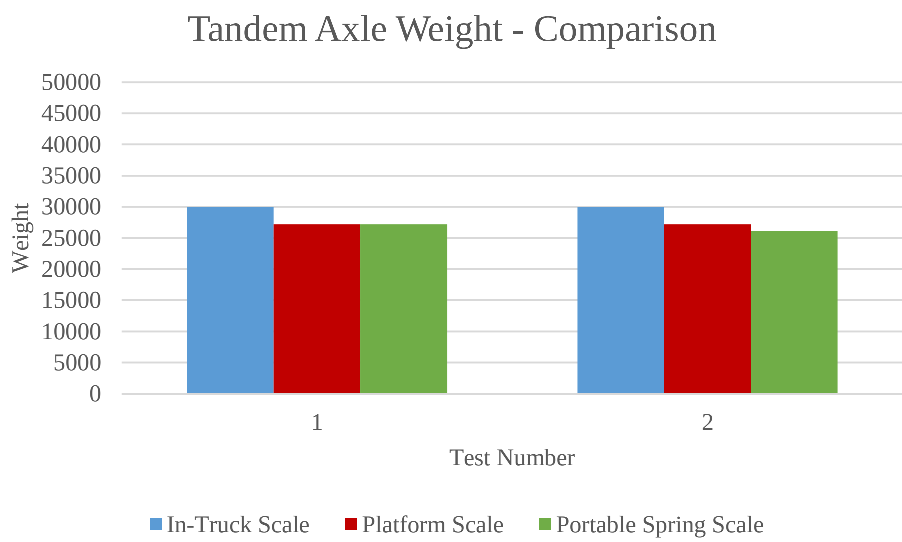
Note: The percent error is comparing the In-Truck Scale Weight to the Platform Scale Weight. All weights were manually recorded at the time the test was conducted.

The digital portable scales mentioned in Table 4.2 were provided by ODOT's Central Office to allow for another data point to validate other readings. These scales may be seen below in Figure 4.9.

Note: Placement of the scales must match with the particular truck as the scales are portable and must be set to the user's needs.

Figure 4.9: Digital Portable Scales Provided by ODOT's Central Office.

As seen in Figure 4.9, the scales must be placed the proper distance apart in order to have all of the truck on the scales. These tests may be completed for trucks with different capabilities such as tandem or single axle. Along with single axle sensors, tandem axle trucks are also compatible with this particular system. Due to the different method of reading the weights, both types are outlines in this report. Figure 4.10 below displays the weights for various tests conducted.



Note: Both the tests above were conducted on T4-642 which is a tandem axle truck. Tests were also completed with a bed that the operator considered to be a full load during the winter season of salt.

Figure 4.10: Full Weight Comparison of a Tandem Axle Truck with In-Truck Scale, Platform Scale, and Portable Spring Scale.

The weights for each test are displayed below in Table 4.3. The portable spring scales are analog scales that were provided by the Ohio State Patrol.

Table 4.3: Weights of Scales for Various Tests (Tandem).

In-Truck Scale Weight	Platform Scale Weight	Portable Spring Scale Weight	Percent Error
51100	48900	48300	7.06%
46390	43400	42800	7.66%

Note: The percent error is comparing the In-Truck Scale Weight to the Platform Scale Weight. All weights were manually recorded at the time the test was conducted.

Following the initial testing that proved the in-truck bed scales were accurate within an acceptable percentage, the research team monitored the scales throughout the season and remained in contact with the operators to assist in any issues that arose. At the conclusion of the season, the research team conducted another round of testing on all the in-truck bed scales test the accuracy after a full season of usage. The results the test yielded may be seen in Table 4.4.

Table 4.4: End of Year Bed Scale/Platform Scale Data and Differences.

Truck	Load	Platform (lb)	Bed Scale (lb)	% Error
973	Empty	22420	24310	-8%
	Half	31120	33830	-9%
	Full	40880	44760	-9%
	Material	18460	20450	-11%
732	Empty	31720	14810	53%
	Half	42020	24320	42%
	Full	50960	32800	36%
	Material	19240	17990	6%
806	Empty	34380	37460	-9%
	Half	39340	43290	-10%
	Full	44700	48930	-9%
	Material	10320	11470	-11%
605	Empty	32080	35140	-10%
	Half	40100	43300	-8%
	Full	48260	52400	-9%
	Material	16180	17260	-7%
924	Empty	22960	29200	-27%
	Half	33260	38300	-15%
	Full	41980	49130	-17%
	Material	19020	19930	-5%
642	Empty	35740	36500	-2%
	Half	44660	45500	-2%
	Full	54100	54850	-1%
	Material	18360	18350	0%
965	Empty	21820	10200	53%

Note: Truck 965 was not operating correctly. Troubleshooting techniques were utilized to identify the issue and was resolved.

As seen in Table 4.4, four out of the seven trucks with bed scales installed on the trucks are within a ten percent error. Two of the remaining scales experienced a greater percent error with the last scale malfunctioning. This may be due to trucks requiring calibration after a certain amount of usage through a season. Moving forward, there are many applications that ODOT could possibly use these scales for. Primarily, it would allow for management to view salt usage on an individual truck level more consistently. The data the scales received from the trucks was able to be transported through the gateway to the website for the end user to view real time data. This could allow for calibration issues to be identified displaying if the system is applying at the rate of the setting. An example of a graph generated from real time data collected on January 30th, 2015 is below in Figure 4.11.

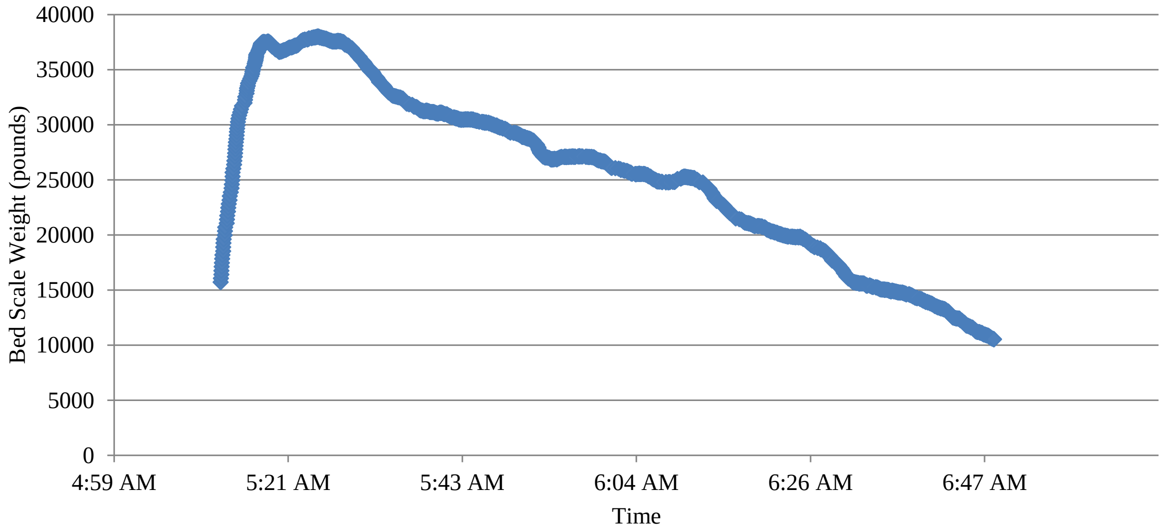


Figure 4.11: Real Time Data Tracking of Bed Scale Readings from January 30, 2015.

To validate that the measurements coming through correctly, data points must be collected directly from the display located inside the ODOT truck. The end user would be able to view any of the bed scales reading at the time they wish. An alternative approach discussed within the research group is the implementation of a platform scale at each individual garage. This method would require much less maintenance and calibration versus scales on each individual truck. Real time data would not be possible with this technique. In addition to enabling the manager to monitor salt usage, it will also develop a more accurate representation of salt usage. This may allow for ODOT to optimize their salt usage in greater detail to increase efficiency as well as create cost savings.

The research team attempted to gather data from the bed scales during Phase 3 but were unsuccessful. All but one of the trucks with installed bed scales were calibrated and able to be turned on to receive a reading. The last bed scale was operating incorrectly and trouble shot to solve the issue and identified as a faulty wire.

4.2.5 Summary

With the amount of money spent annually on salt by ODOT, it is important to track salt in the best way possible. Additionally, salt is the primary resource in keeping the roads safe for the public through winter storms. Salt is, therefore, one of the most important assets used by ODOT. One possible implementation method would be to utilize on truck bed scale systems. These systems may allow ODOT to monitor salt usage per truck. It may also allow ODOT to monitor where on the route more salt is being applied versus other positions. This may only be possible through the integration with a GPS/AVL system. The research team has proven these data may be received in real time to allow for managers to make operational decisions as well.

4.3 Operational Application

4.3.1 Road Temperature Sensor

In order to effectively treat roadways, pavement temperature is vital information to successfully remove snowfall from the pavement. An instrument often used to aid management are road temperature sensors installed on trucks throughout the fleet. When accurate and calibrated, these sensors give the operator a reading of the current surface temperature on roadways or bridge decks. Due to the level of importance of these data, the research team found it appropriate to test the accuracy of these sensors. ODOT leaves it up to the garage level to decide which road temperature sensors they wish to implement into their fleet. The research team came across three different sensors throughout the span of this project and tested both on their accuracy. Note that the tests provided preliminary data, and it is advised to further test each sensor. The three sensors are outlined below in Table 4.5.

Table 4.5: Road Temperature Sensor Specifications.

	Road Watch SS	RoadWatch Bullet	Vaisala
Price	Old Model. Discontinued by Vendor	$475	$1463
Components	N/A	M8 Connector, Bullet Sensor, 12 ft cable, and Digital Display	Vaisala Sensor, 12ft cable, and Digital Display with Serial Port
Road Temperature Accuracy	±2° F (23-41° F Ambient) ±6° F (-40-23° F Ambient) ±6° F (41-150° F Ambient)	±2° F (23-41° F Ambient) ±6° F (-40-23° F Ambient) ±6° F (41-131° F Ambient)	±0.5° F (32° F Ambient)
Road Temperature Display Range	-40° to 150° F	-40° to 150° F	N/A
Air Temperature Accuracy	±2° F (-40 - 131°F)	±2° F (-40 - 131°F)	±0.5° F (32°F Ambient)
Air Temperature Display Range	-40° to 131°F	-40° to 131°F	-40° to 160° F
Calibration	Pre-calibrated Maintenance Free	Pre-calibrated Maintenance Free	Adjustable in field ±5°F (32°F Ambient)
Source	Roadwatch.com	Roadwatch.com	Vaisala.com

Note: Quotes were received for single units. Price reductions may occur with larger orders.

As seen above in Table 4.5, the road temperature sensors are compared within various categories such as accuracy, display range, and calibration of the displayed sensors. An example of a road temperature sensor installed on a truck is displayed below in Figure 4.12.

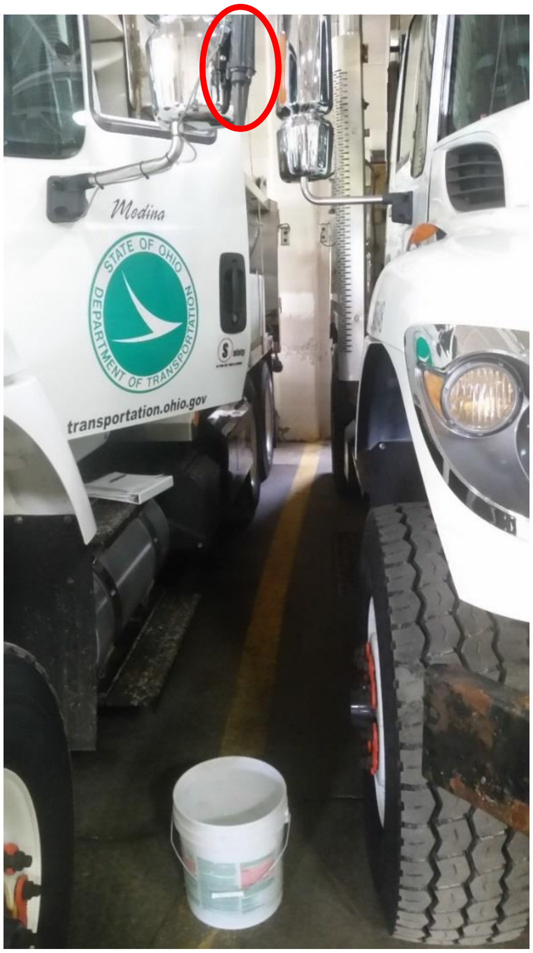


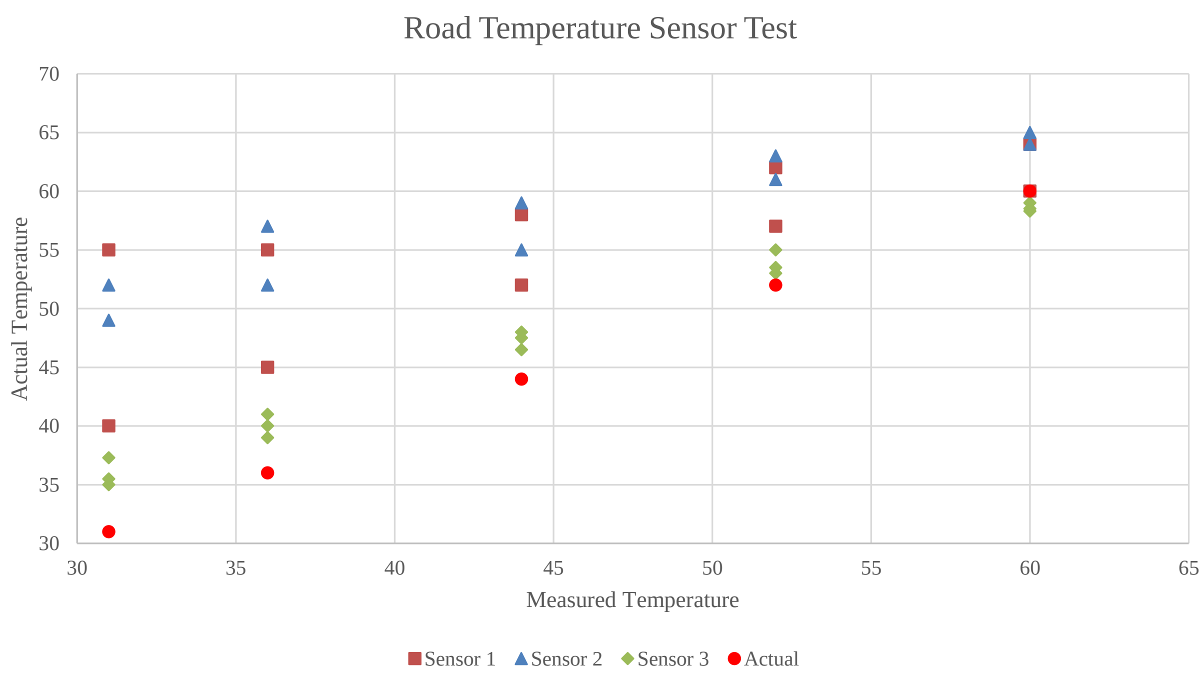
Figure 4.12: Example Temperature Sensor Installed on ODOT Truck.

These road temperature sensors are installed primarily on the driver's side view mirror to ensure that the pavement is captured without any disruption. Both sensors are installed in the same location on all trucks. For operator convenience and safety, the displays showing the readings of the sensor are shown inside the cab. The placement of the display is at the installers discretion based on available space within the truck. A road temperature sensor display is shown below in Figure 4.13 installed in a truck.

Figure 4.13: Road Temperature Sensor Display Installed in ODOT Truck.

These displays visually show the operator both the pavement temperature as well as the ambient temperature. The displayed temperature correlates to the temperature of the road surface as well as the air temperature respectively. It is important to note that the displays must be compatible with the system in order for the sensors information to be received in real time.

At ODOT's request, the research team tested the reliability and accuracy of the road temperature sensors. A series of tests were conducted on multiple sensors from both manufacturers. The tests were conducted with a bucket of water with varying temperatures. The temperatures were altered based on the amount of ice added to the water level. To ensure the tests may be evaluated, the same bucket of water with the same level of ice were used throughout a series of tests to have a constant temperature. The bucket was placed below the sensor to ensure that the sensor was capable of reading the desired temperature. All of the trucks chosen for the test had sensors that were installed so that the bottom of the sensor was at a height of six and a half feet above the pavement. The results of the test are shown below in Figure 4.14.



Note: The data series labeled actual in red use temperatures from the thermometer as an accurate reading of the water temperature. This test may require more iterations to accurately determine the road temperature sensor correctness. A compact digital thermometer was used with a temperature variation of 0.1 degrees Fahrenheit.

Figure 4.14: Road Temperature Sensor Tests.

As seen in Figure 4.14, the data points displayed in red are considered the actual temperature the sensor should display. This reading was taken with a thermometer to increase the accuracy of the recorded temperature. The measured temperatures, along with actual temperatures and percent error are shown below in Table 4.6. From these tests the accuracy of the road temperature sensors may be determined. For more accurate results, this test may be conducted on a wide variety and numerous trucks to validate the data.

Table 4.6: Road Temperature Sensor Test Data Readings.

Truck #	Sensor	Thermometer Temp	Road Temp	Percent Error	Average Percent Error
772	Sensor 2	31	52	67.7%	32.2%
	Sensor 2	60	64	6.7%	
	Sensor 2	36	52	44.4%	
	Sensor 2	44	55	25.0%	
	Sensor 2	52	61	17.3%	
737	Sensor 2	31	49	58.1%	36.0%
	Sensor 2	60	65	8.3%	
	Sensor 2	36	57	58.3%	
	Sensor 2	44	59	34.1%	
	Sensor 2	52	63	21.2%	
774	Sensor 1	31	55	77.4%	37.6%
	Sensor 1	60	64	6.7%	
	Sensor 1	36	55	52.8%	
	Sensor 1	44	58	31.8%	
	Sensor 1	52	62	19.2%	
897	Sensor 3	31	35.5	14.5%	6.6%
	Sensor 3	60	58.5	-2.5%	
	Sensor 3	36	39	8.3%	
	Sensor 3	52	53	1.9%	
	Sensor 3	44	46.5	5.7%	
598	Sensor 3	31	37.3	20.3%	9.6%
	Sensor 3	60	58.3	-2.8%	
	Sensor 3	36	41	13.9%	
	Sensor 3	52	53.5	2.9%	
	Sensor 3	44	47.5	8.0%	
907	Sensor 3	31	35	12.9%	8.1%
	Sensor 3	60	59	-1.7%	
	Sensor 3	36	40	11.1%	
	Sensor 3	52	55	5.8%	
	Sensor 3	44	48	9.1%	
679	Sensor 1	31	40	29.0%	16.4%
	Sensor 1	60	60	0.0%	
	Sensor 1	36	45	25.0%	
	Sensor 1	52	57	9.6%	
	Sensor 1	44	52	18.2%	

As seen in Table 4.6, some sensors may be more accurate than others. Sensor three may yield the most accurate measurements for this series of testing compared to sensor one and two. These tests may need more data in a variety of weather conditions to validate these claims.

Another group of trucks were tested at the Summit County Garage. This particular garage only carries one of the two road temperature sensors. Of the five available trucks, two either had blank displays, or temperatures over 107 degrees and were therefore deemed unfit to test. It has also been seen by the research team that sensors are to most often come calibrated. To calibrate the sensors a kit is required or the sensor must be shipped back to the manufacturer.

At a managerial level, these data are pertinent for the decision-making process during a storm or the hours leading up to a storm in preparation. These data, along with RWIS data, may allow management to aid operators in decisions such as type of material as well as amount of material that may be needed. Inexperienced drivers that may utilize managers input more often than experienced drivers may receive better input more swiftly with this implementation. To accomplish this, a system is needed to accommodate the data and ultimately display this in real time. The GPS/AVL system implemented by the research team has verified that road temperature sensor data may communicate to the system and display for the end user. This was only verified for the one of the road temperature sensors. It was discovered by the research team that a separate display was required for the second sensor to communicate with the system. It is also important to note that when moving forward, if ODOT wishes to implement this into the system, the compatibility may be tested prior to installations across the fleet. The outcome may be real-time data compatibility and accuracy increases.

4.3.2 Evaluation

When evaluating the two road temperature sensors, the research team utilized the percent error to monitor how far away from the actual temperature the sensor was reading. Sensor one and two that may be seen in Truck Numbers 772, 737, 774, and 679. These readings ranged from 16 percent to 38 percent away from the actual reading. Sensor three may be seen in Truck Numbers 897, 598, and 907 in Table 4.6 above. These readings ranged from six to ten percent away from the actual reading. These preliminary results yield that the first road temperature sensor may be slightly more accurate. For more accurate and reliable results, more tests such as the one above may be needed to come to a conclusion before implementation.

4.3.3 Summary

Pavement temperature is a vital aspect to effectively removing snow from roadways. To monitor this important facet, road temperature sensors may be implemented to allow operators and managers to receive this information. In order to ensure the temperatures are accurate, these sensors may be tested prior to implementation. Once implemented, this may allow operators to see the pavement temperature to make a decision on material application. The integration of sensors with a GPS/AVL system may allow managers to view the temperature of the pavement in real time and aid the operator in any decision such as material application or application rate. This may improve the LOS for roadways ODOT is responsible for creating a safer environment for the public. The research team has proven that these data may be viewed in real time by the end user of the system. This may yield greater results and ultimately allow ODOT to operate more effectively and efficiently.

CHAPTER V IMPLEMENTATION

An implementation plan was developed to aid with successfully implementing the results found within this report. Accordingly, this section is divided into eight sections.

- Section One: Recommendations for implementation of the GPS/AVL system,
- Section Two: Steps needed to implement the findings from this study,
- Section Three: Suggested time frame for implementation,
- Section Four: Expected benefits from implementation,
- Section Five: Potential risks and obstacles to implementation,
- Section Six: Strategies to overcome potential risks and obstacles,
- Section Seven: Potential users and other organizations that may be affected, and
- Section Eight: Estimated cost of implementation.

5.1 Recommendations for Implementation of the GPS/AVL System

There was a meeting held on February 11, 2015 towards the end of Phase One with the HMAs and other ODOT personnel to discuss the future of the research project. This meeting resulted in Phase Two of this research in which truck tracking and visual components were implemented into 187 trucks. This technology is relatively low-cost (capital and maintenance) and relatively easy to implement throughout all 88 counties of ODOT. However, there are many other ways to utilize the modems installed into the trucks with additional sensors sending various types of data. Figure 5.1 presents an overview of the various levels of options available to ODOT with a GPS/AVL system.

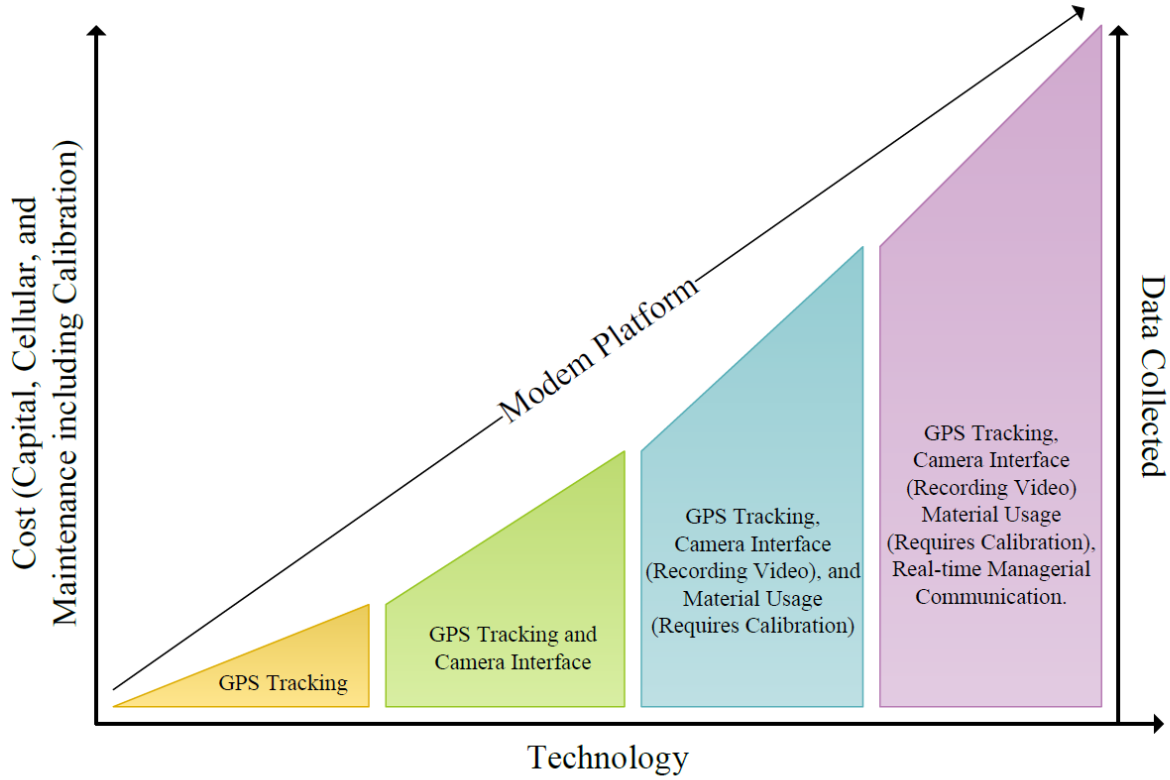


Figure 5.1: Multiple Options for Moving Forward with GPS/AVL Project

The lowest technology (gold) tier of Figure 5.1 presents the lowest cost and lowest data collection option. As the technology level increases (purple), the cost increases and the data collection increases. As more sensors and equipment are added to the GPS/AVL system, the overall cost to not only purchase, but maintain the system will increase as well. There are multiple advantages and disadvantages with each tier as shown in Figure 5.2.

Tier	Levels of GPS/ AVL Systems	Disadvantages	Advantages
Tier 1	Truck tracking and visualization	• No material tracking • No road conditions	• Low cost of implementation and maintenance • Managers know treated routes when watching system
Tier 2	Truck tracking and camera interface	• Maintenance of system required • Data bandwidth needs increased	• Real-time conditions of routes • Road conditions stored in form of pictures
Tier 3	Truck tracking, camera interface and material usage recording	• Maintenance of system required • Sensors need calibrated • Data bandwidth need increased • High costs	• Automated material usage reports • Managers know treated routes and how much material used on routes • Road conditions stored in form of pictures
Tier 4	Truck tracking, material usage recording, camera interface and real-time managerial communications	• High costs • Maintenance of system required • Sensors need calibrated • Data bandwidth needs increased • Distracted driving issues	• Automated material usage reports • Managers know treated routes and how much material used on routes • Road conditions stored in form of picture • Real-time route optimization • Interface for drivers showing weather conditions, material usage of all trucks, etc

Figure 5.2: Advantages and Disadvantages of each Tier of Implementation

These tiers of GPS/AVL functions are available to ODOT. However, ODOT must move forward with technology that provides useful data to balance the cost for purchasing and maintaining the technology. ODOT may find that some sensors are less useful than others.

5.2 Steps Needed to Implement the Findings from this Study

As seen in Phase Two, the second (green) tier of GPS/AVL system (truck tracking and cameras), the steps needed to implement consist of purchasing the modems, antennas, cameras, and enclosures as well as activating the modems on a cellular phone plan and configuring the cameras to the correct settings. Installation of the system takes approximately two hours per truck; therefore, each garage would need two to four days for installation depending on the number of trucks in the county. The website also needs to be updated with the truck information. Most importantly, ODOT must educate its employees on the GPS/AVL system to ensure operator buy-in. More details on the installation may be found in Appendix A.

If ODOT moves forward with additional sensors, the steps needed will vary in the amount of equipment that must be purchased as well as the time to install and calibrate the equipment. Some sensors may only require an additional cable run while others may require welding sensors to the outside of the truck and running wiring inside.

5.3 Suggested Time Frame for Implementation

If each garage is responsible for installing its own trucks, the current level of GPS/AVL system may be completed in a week's time. However, equipment acquisition may require additional time. There may need to be additional time to properly train mechanics, operators, and managers on the GPS/AVL system. The research team is only able to suggest the time frame for the current system tested in Phase Two of this research. Other types of GPS/AVL systems may vary.

5.4 Expected Benefits from Implementation

One immediate benefit of this system is ODOT's ability to utilize real-time data of its fleet. ODOT personnel may see exactly where each of the trucks are located. It may be useful if a truck breaks down while out in the field. Additionally, if one particular area of the county is getting more snowfall than another, trucks may be easily shifted to meet the needs of that county. This was seen firsthand during the project, when TAs and TMs were able better assist and manage drivers by seeing the roads via live video. Another benefit is the storage of historical data which may be helpful if claims are made about the winter maintenance operations. The system also allows for TAs and TMs to personally see what the operator is seeing to allow them to make a more informed decision based on the situation. If more sensors are added to the system, such as the sensor which produces hydraulic data, ODOT could gain additional knowledge of the amount of salt needed in each type of snow and ice event to optimize its operations. This system has also been featured on social media pages that display images of trucks treating roadways and giving the public a visual of the current road conditions.

5.5 Potential Risks and Obstacles to Implementation

Potential risks and obstacles to implementations would be the cost to operate (e.g., cellular plan) and maintain whichever type of system ODOT adopts. One of the biggest factors of cost would be the video streaming, as real-time video requires a larger amount of bandwidth and storage capacity. Additionally, systems with certain features, such as operators able to communicate to managers through the modem, may be seen as distracting driving. These features must be discussed with the proper ODOT personnel prior to implementation. Another potential obstacle is buy-in from the operators. If the operators are not properly educated, they may try to prevent this technology from working or being installed in the garages or trucks they work in. The research team did not see any issues with any operators tampering with equipment during this project.

5.6 Strategies to Overcome Potential Risks and Obstacles

Strategies to overcome some of the issues consist of educating the garages on the use, installation, and functions of the GPS/AVL system. The primary goal of this system is to provide an additional tool for the managers and operators to better treat roadways during snow and ice events. There are sample posters presented in Appendix C which may be hung in common areas of the garages to overview the purposes of the project and the different components. Operator buy-in is always a key to successfully implement new technology into the garages.

5.7 Potential Users and Other Organizations that may be affected

The users of this implementation consist of any ODOT personnel as a part of snow and ice maintenance efforts. The website is helpful for managers, operators, and mechanics as it provides detailed information on their operations. Other organizations may be interested in the outcome of the project to determine if it could be used within their own snow and ice maintenance garages.

5.8 Estimated Cost Effects

As presented in Figure 5.1, the cost will vary depending on the many of functions implemented on the GPS/AVL system. With a greater amount of data being collected, this requires a greater amount of sensors, memory, and a more developed gateway driving cost up. The system may be used to better train operators and better serve the traveling public, resulting in overall cost savings. Some managers have been able to log in to the website to check road conditions and call back the newly hired operator from continuing to treat the roads, hence, resulting in time and salt savings.

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APPENDIX A INSTALLATION GUIDE

DISCLAIMER: THIS IS TO BE USED FOR GUIDANCE. BEFORE ORDERING AND INSTALLING ANY COMPONENTS OF THIS SYSTEM, ALL CONNECTIONS, INPUTS/OUTPUTS PIN CONFIGURATIONS, FUSE, VOLTAGE, AND AMP SIZES MUST BE VERIFIED WITH THE PROPER ODOT PERSONNEL.

A.1 GPS/AVL SYSTEM

This chapter is to outline the different piece of equipment and how to install each one. There are two primary types of hydraulic system within the ODOT fleet, Pengwyn and Force America. The installation for the two systems is the exact same except for the cable for hydraulic data.

A.1.1 Introduction and Modem

The GPS/AVL installation for the ODOT Evaluation of a GPS/AVL System has several different installation procedures based on the types of equipment being instrumented and the type of equipment that is chosen to be installed on the vehicle. This installation guide is a step by step methodology on how to install all components associated with the project. While particular configurations may change from truck to truck, all of the possible installation information is contained within this installation guide. Additionally, there are drawings included in the appendix of the installation guide. These depict how all of the equipment connect to complete the various installations. Additionally, the general configuration may be seen in Figure A.1.

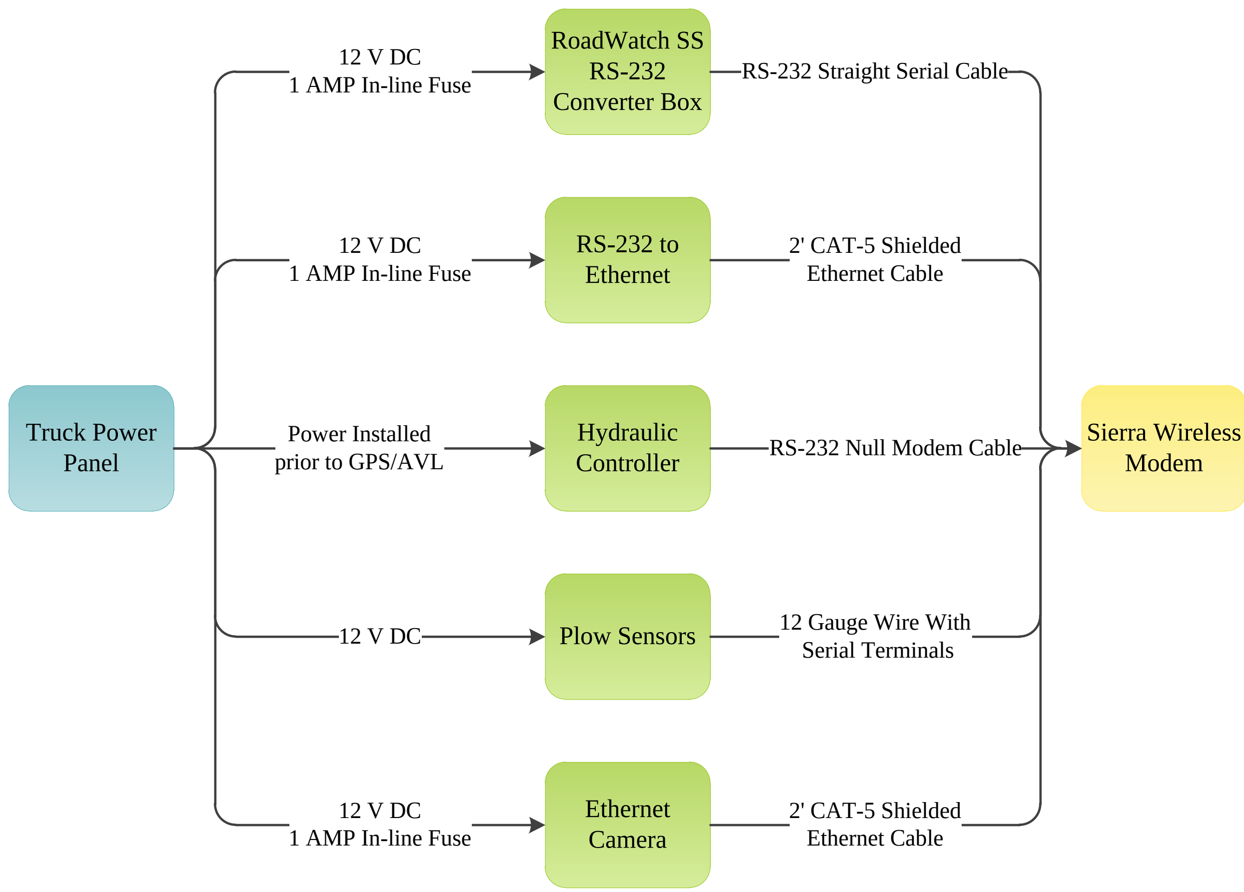


Figure A.1: General Layout for GPS/AVL System.

The modem is the first piece of equipment that is installed for all installations. Regardless of the hydraulic system installed on the truck, or the additional sensors that are to be installed, the modem will be the same; the Sierra Wireless GX 450 (the modem). The modem has GPS and cellular connectivity through Verizon Wireless. The box is roughly 5.5" by 4" allowing for it to be mounted easily in a variety of locations. The installations that works best with the additional equipment needed for the full installation is mounting to the door side of the passenger seat. The modem should be mounted such that the short (4") end is along the horizontal part of the metal seat frame. To attach, drill two holes approximately 1.57" apart to align with the holes in the modem, or the blue dimension in Figure A.2. The modem is shipped with four (4) number 8 sheet metal screws and lockout washers. These should be used to make sure that the modem does not vibrate as the truck is moving. The only difference in the installation of a system in a Pengwyn vs Force America hydraulic controller system is the hydraulic data cable, they both have an RS-232 male connection on one end but the other end varies depending on system.

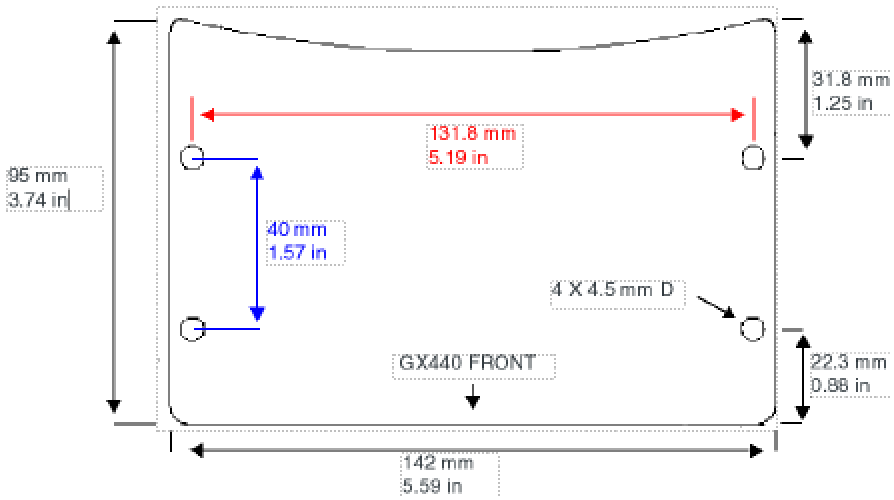


Figure A.2: Sierra Wireless GX 440 (or 450) Dimensions, Not to Scale. Note: Figure Courtesy of Sierra Wireless GX 440 Installation Manual.

Completed installations of the modem may be seen in Figure A.3. Note from the figure that the connecting wires have easy access to both sides of the modem when the longer sides are mounted vertically. In Figure A.3, installations to the back of the seat frame and side of the seat frames. While it the modem may be mounted to the back it may be seen that it is much more difficult to connect all of the sensor wires when the modem is mounted in this location.

Figure A.3: Sierra Wireless GX 440 Mounted to the Back of Passenger Seat (left) and Mounted to the Door Side of the Passenger Seat (right).

In Phase Two of the project, the modem was mounted inside of an enclosure for protection. As presented in Figure A.3.

Figure A.4: Modem Mounted under the Passenger Seat Inside of Enclosure.

Power is the first connection made to the modem. The supplied four wire power cord must be used for the power supply as it has a 4 pin connection made specifically for the modem on one end and the other end is an opened end. Trim the supplied cord so that there is enough wire to reach the fuse interior fuse panel on the passenger side of the truck. The wires should be terminated such that:

- The black wire is grounded,
- The red wire is connected to 12 volts DC battery power on a 10-15 amp fuse,
- The white wire is connected to 12 volts DC ignition or accessory power on a 10-15 amp fuse, and
- The green wire is not for power and is not used in this installation.

A.1.2 Antenna(s)

The next set of connections are the two or three antennae used by the modem; GPS, cellular, and diversity (if there are three connection). The installation procedures vary depending on the specific antenna mounting style. The recommended antenna types for this installation are the AP Double Cell and GPS, or the AP Cell/ GPS and Diversity combo. Both antennae systems offer three different mounting styles including threaded bolt, permanent adhesive, and magnetic mount. The magnetic mounted antenna offer the ability to change antenna location while providing excellent mounting strength. The key differences between the AP Double Cell and GPS and the AP Cell/ GPS and Diversity combo is the number of antennae that are mounted. The newer AP Double Cell and GPS contains three connections in one unite while the slightly older AP Cell/ GPS and Diversity has two (2) antenna to be mounted one of which contains the cell and GPS and the other containing the LTE diversity antenna. All antennas should be mounted to the roof of the truck cab, free of the truck bed and bezel. The antenna should also be mounted a minimum of 20 cm from all persons and other antennas. An example of magnetic mounted antennas may be seen in Figure A.5.

Figure A.5: Magnetic Mount Antennas.

In addition to the exterior antennas as presented in Figure A.5, less expensive interior mounted antenna was used. These antennas have a sticky pad that allows you to attach to a surface (ideally, the windshield). Some mechanics used Velcro encase the windshield needs replaced in the future.

Figure A.6: Interior Antenna.

All antenna wires should be run down the back of the cab free of all exhaust and moving truck bed parts. Run the wires into the cab either utilizing the existing wire chase built into the back of the cab or by creating one by drilling a hole and filling it with flexible conduit and a rubber gasket. The wires should remain tight without causing vibration that may cause wear to the wires. Note that despite the number of physical antennas mounted to the top of the cab (one or two) there will still be a total of three (3) antenna wires run into the cab. Ideally, ODOT personnel would like future installs to have the antenna cables run through the pre-existing hole located at the bottom of the cab and run under the floor mat inside.

A.1.3 Hydraulic Cables

The next connection is from the modem to the hydraulic control unit. Depending on which hydraulic system is installed in the truck, will vary which cable is needed. The Pengwyn hydraulic system uses a cable with a Male DE-9 (RS-232) connection on one side and a XLR 3-Pin Plug connector on the other. This cable is connected to the COM port on the back of the modem as seen in Figure A.7. A DE-9 (or DB-9) connection, or a serial connection, is a nine (9) pin plug that looks similar to a computer monitor plug. The serial port on the modem, for this connection, is located on the back panel between diversity antenna and Ethernet connections. Note, this is not the 15 pin connection on the front of the modem by the LED lights. That connection will be detailed later on. The COM port on the Pengwyn controller is a round metal hole in the back of the controller. The correct port sits above another round connection labeled "SPARE". The Spare port is not used in this installation. Examples of the correct connection to the hydraulic controller may be seen in Figure A.7.

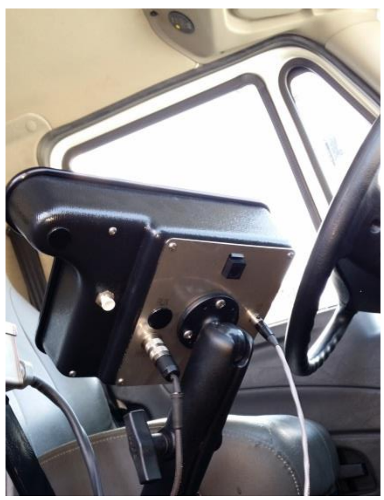


Figure A.7: Back of Pengwyn Hydraulic Controller.

The Force America System has an output Female DE-9 (RS-232 or DB-9) cable which a DE-9 cable may connect to in order to receive data. There are settings on the controller box which will need to be set in order to for the system to send data to the modem. The Force America 5100 require the purchase of a black fob key to download the software need to log data. The Force America 6100 require an additional part to be purchased to allow data to be logged, as presented in Figure A.8.

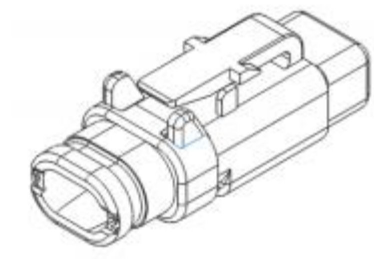


Figure A.8: 6100 Event Logging Authentication Module (Reference: Forceamerica.com)

Force America requires contractual agreements in order to acquire this additional part and therefore, ODOT and the University of Akron has not obtained one. This part is needed for any third party vendor to access the hydraulic data.

A.1.4 Road Temperature (Preliminary)

Most ODOT plow trucks are configured with a RoadWatch SS temperature sensor system. This system collects both the ambient temperature and the road surface temperature directly below the truck. This system is fitted with an adapter so that it may communicate with the modem. There are two types of RoadWatch systems currently used by ODOT, Generation1 and Generation 3 RoadWatch SS systems. The difference between the two generations is the connection type and may be identified by the color of the wire connecting the sensor to the digital temperature display. A white wire indicates a first generation sensor and a flat black cable indicates the third generation sensor. For the first generation systems, a splitter cable is inserted between the sensor and the digital display. This splitter requires no additional power and allows the sensor to connect to the modem via a 15 foot DE-9 (or DB-9) straight modem cable. The third generation requires an adapter box made by RoadWatch as shown in Figure A.9.

Figure A.9: RoadWatch SS DE-9 (DB-9, or RS-232) Converter Box.

The box is placed near the digital readout (permanent mounting is at the discretion of installer based on location.) The black flat cable on the back left side of the box (directly next to the orange and black power cables) connects to the RoadWatch SS sensor. The flat black cable on the back right of the box (alone from the three other cables) gets connected to the digital readout. The orange wire is connected to 12 V DC accessory or ignition power with a 1 amp inline fuse. The black wire is grounded. This adapted box also connects to the modem via a 15 foot DE-9 straight modem cable.

New temperature sensors systems are available on the market. ODOT has reviewed other road temperature sensors. If the road temperature sensor has a serial port available to connect the modem with the same DE-9 (DB-9) cable used for the RoadWatch setup, it may work with the Sierra Wireless modem but more research would be needed.

A.1.5 Plow Sensors (Preliminary)

There are two types of plow sensors that are connected to the modem to report whether or not the plow is attached and if the plow is up or down. The plow attached sensor is a proximity sensor made by Turck (Part No. NI15-M30-RP6X-H1143) and may be seen in Figure A.10. The installation of the sensor begins with mounting the steel bracket that holds the proximity sensor. The bracket will need to be modified for each truck depending on specific plow type and mounting type, but the main goal is to ensure that the sensor will be no further than 15 mm (.591 in) from the plow attachment hook. After the metal bracket is welded to the plow attachment frame, use the two nuts provided with the sensor to attach the threaded sensor to the mounting bracket. Note that the yellow portion of the sensor needs to be facing the plow attachment hook as seen in Figure A.10.

Figure A.10: Unmodified Mounting Bracket and Proximity Sensor (left). Proximity Sensor Mounted on Modified Bracket.

This sensor requires power and connection to the modem through the use of the supplied sensor wire and a five (5) pin relay. Connect the sensor wire (Turck Part No. RK 4T-10) to the small threaded plug of the proximity sensor, and run the wire along the frame. Drill a hole through the firewall on the passenger side of the cab to run the wires for the proximity sensor and the hydraulic sensor to the fuse box.

Once the hole is drilled, insert a rubber grommet to ensure that the wires will not wear and short. This may be seen in Figure A.11. Be sure to apply silicon to the hole to seal the cab.

Figure A.11: Drilled hole through fire wall into cab.

Now that the sensor wire is inside the cab, the provided five (5) pin relay may be installed within the fuse panel. This relay does not plug into the fuse panel and should be mounted securely within the fuse box to keep it free of salt and water. Installation may be achieved by using a sheet metal screw or zip-tie through the small hole in the tab of the relay. This relay receives no external power. Instead, the relay is powered only when the proximity sensor is activated, which then routes the power to the modem as an electronic signal. Take the blue wire from the sensor wire and ground it. The next step is to wire the relay. Every pin will be used except pin 87, this will be left open. Using spare wires and female spade connecters connect pins 85 and 30 to ground (if possible use blue for both wires since blue was ground in the sensor wire). Crimp a female spade connecter to the black wire from the sensor wire and connect it to pin 86. Using a spare wire crimp a female spade connector to the wire and connect it to pin 87a. Next, take the white/orange wire from the modem cable and connect the white/orange wire from the modem to the wire that is connected to pin 87a. The last step is to connect the black wire from the sensor wire to a working fuse to power the sensor. Using a small butt connector crimp the brown wire from the sensor wire to a connection for a fuse. Insert the fuse into a working slot for power. The finished wiring for the relay may be seen in Figure A.12.

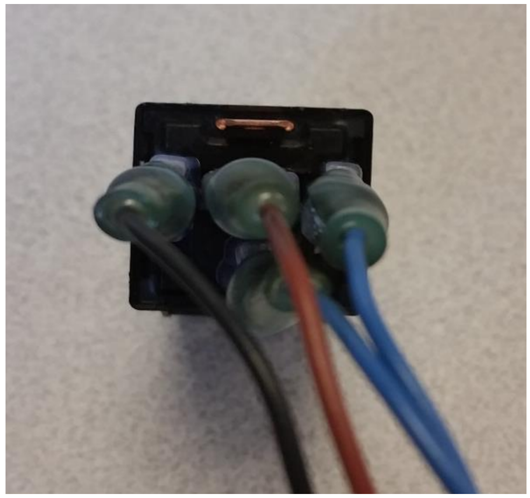


Figure A.12: Finished relay, pin 86 black from sensor wire, pins 30 and 35 blue grounded, pin 87a spare wire to orange/white modem cable.

Tape the rest of the wires from the modem cable down except for the orange and the white/orange wire. The orange wire will be used to install the hydraulic sensor. Connect the modem cable to a splitter then plug the splitter into the modem. Once everything is complete, the sensor should be checked. Turn the truck on and look at the proximity sensor. If the plow hook is not in front of the sensor, there should be an orange light. If the hook is in front of the sensor there should not be a light. Move the hook up and down and the light should turn on and off. The relay may also click when the hook is engaged and disengaged.

A.1.6 Plow Up/Down Hydraulic Sensor (Preliminary)

This hydraulic sensor determines the pressure of the hydraulic ram that controls the height of the plow. This is an adjustable sensor and requires calibration upon completion of entire GPS/ AVL installation. To begin installation, release pressure from front plow hydraulic ram (with vehicle on push plow control all the way down on hydraulic control unit.) Unscrew the lower hydraulic fluid line and insert stainless steel “T” (Figure A.13) with small intersecting threaded end facing up. This opening is for the sensor which is screwed in tightly to the “T”. The sensor may be seen in Figure A.14. Ensure that the terminals at the top of the sensor are clear of obstructions.

Figure A.13: Fluid Line Hydraulic Sensor.

The sensor is unique in that it has an adjustable screw. This screw needs to be available for adjustment, meaning that when this sensor is wired, it should be wired with that in mind. Using thick gauge (12 - 14 ga) shielded and weatherproof cable connect to the sensor as shown in the wiring diagram and as follows; wire pin 1 to ground (inside cab) using large weatherproof female spade terminal and dielectric grease, pin 3 to ground (inside cab) using large weatherproof female spade terminal and dielectric grease, and pin 4 to the modem using large weatherproof female spade terminal and dielectric grease. Run the wire to the modem. This wire is combined with the wire from the proximity sensor in a 9 pin terminal as described in 'Modem Sensor Connection Configuration'. Connect the wire from pin 4 to the orange wire from the modem cable. Tape the rest of the wires back besides the orange/white wire. This will be used for the proximity sensor.

Figure A.14: Sensor for Plow Up/Down.

The completed installation may be seen in Figure A.15.

Figure A.15: Completed Installation of Hydraulic Pressure Sensor.

A.1.7 Plow Sensors and Road Temperature Sensor Connection

The Sierra Wireless GX 440 (and GX 450) modem with the additional I/O card requires a specific splitter in order to make the best use of all the optional inputs available. For the field implantation of the Sierra Wireless modems, the research team developed a splitter specifically to make the most use of the available inputs. The 15 pin connection of the front of the modem contains the pins for one (1) RS-232 port, four (4) analogue inputs, and four (4) digital inputs. The configuration for the GX 450 may be seen in Figure A.16.

I/O X-Card 15-Pin Connector Description

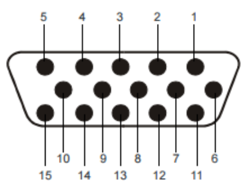


Figure 2-24: I/O X-Card 15-pin Connector Pin Diagram

Note: For better performance, signal pins on the I/O X-Card should be referenced to the ground pin on the I/O X-Card (pin 10).

Pin	Name	Description	Wire color (on optional I/O X-Card breakout cable)
1	TXD	Transmit Data	White/Black
2	CTS	Clear to Send	Red/Black
3	DIO[2]	Digital I/O 2	Green/Black
4	DIO[4]	Digital I/O 4	Orange/Black
5	RXD	Receive Data	Blue/Black
6	RTS	Request to Send	Blue
7	AIN[2]	Analog Input 2	Green
8	AIN[4]	Analog Input 4	Red
9	Reserved for future use		Black
10	GND	Ground	White
11	DIO[3]	Digital I/O 3	Orange
12	DIO[5]	Digital I/O 5	Blue/White
13	Reserved for future use		Green/White
14	AIN[1]	Analog Input 1	Red/White
15	AIN[3]	Analog Input 3	Black/White
Shield	Cable Shield		
This is not a VGA connector			

Note: Digital Input 1 in ACEmanager is reserved for Pin 4 on the power connector.

Figure A.16: Sierra Wireless GX 450 I/O Car Pin-Out. Note: Image Courtesy of Sierra Wireless

In order to accommodate the RS-232 from the RoadWatch SS temperature system, the hydraulic pressure sensor, and the plow attach proximity sensor a splitter must be made. When constructing the splitter it is necessary to terminate the specific wires from the two plow sensors with DB crimp-on or solder terminals. These terminals then get placed in specific ports of the DB 9 terminal, thus joining the two hydraulic sensors into one DB9 hood and plug. The terminals and final assembly may be seen in Figure A.17.

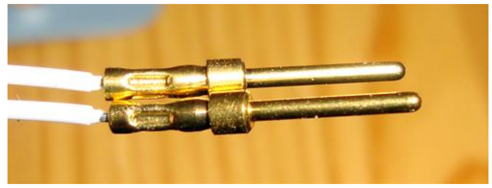



Figure A.17: DB9 hood (left) and standard size male crimped terminal (right bottom). Images courtesy of uk.rs-online.com.

The other side of the splitter uses D-sub compact crimp-on or solder pins inserted into a D-Sub 15 compact hood and plug that fits into the front of the Sierra Wireless GX 450 modem. The assembly and terminals of the 15-pin plug may be seen in Figure A.18.

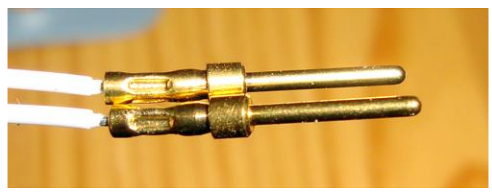



Figure A.18: D-Sub 15 hood (left) and compact size crimped terminal (right, top). Images courtesy of alibab.com and rv-7construction.com.

A.1.8 Ethernet to RS-232 Converter Box

This box is required only when a truck bed scale is installed in the vehicle. For truck bed scale installation, refer to specific scale installation manuals. Install the box by mounting to same seat frame that the modem is mounted on using two (2) sheet metal screws and lock washers. The Ethernet to RS-232 converter comes with an AC/DC converter connected to a barrel plug that will be used to power the box. The AC/ DC converter is not necessary as the converter requires 12 V DC and the vehicle power is 12 V DC. To use supplied power cable, first ensure that neither the barrel end nor the AC/DC adapter is connected to any power source. Next, cut the cable at the AC/DC converter. This should leave several feet of cable with the barrel power terminal at one end. Split the two wires that make up the cable enough to work with. The wire with the white marking along the sides will be the positive power for the converter and should be connected to 12 V DC ignition power with an inline 1 AMP fuse. The unmarked wire is to be connected to a ground. To connect the Ethernet box to the modem plug one side a shielded CAT 5 Ethernet cable (approx. 2 feet long) into the Ethernet port of the converter and the other side into the open Ethernet port of the modem. Green indicator lights will confirm proper power and data transfer for Ethernet to RS-232 converter. The completed installation of the Ethernet to RS-232 converter box may be seen in Figure A.19.

Figure A.19: Installed Ethernet to RS-232 switch.

A.1.9 Microseven IP Ethernet Camera – M7077

A HD 1080P IP camera is used for this research project. This IP camera is to be pre-configured per the GPS/AVL Device Configuration and Data Handling section of this installation manual prior to installation and should not be installed on a vehicle that is equipped with an Ethernet to RS-232 converter box. Begin the installation by mounting the camera to the plastic headliner directly above the rearview mirror just off of the windshield glass. Figure A.20 shows an Ethernet camera installed in the cab of a plow truck. Exact mounting technique is at the discretion of the installer, but using the screws provided is recommended. Before the final fix the camera should be checked for alignment and rotation. Adjust the camera by loosening the two small set screws in the bezel of the mount. Check alignment from the front of the vehicle and look to see that the camera points straight forwards at a spot on the ground roughly 50-75 feet from the front of the plow.

Figure A.20: Ethernet Camera Installed as Seen from in the Cab (left) and from in Front of the Vehicle (right).

Ensure that the picture is completely vertical by locating the IR receptor on the face of the camera and adjusting the lens so that this is at the very bottom of camera face. This small looking microchip is visibly different that the infrared bulbs that surround the camera lens. A close-up image of the infrared camera may be seen in Figure A.21.

Figure A.21: Face of Ethernet Camera. Note the infrared receiver at the bottom of the camera face. Image courtesy of MicroSeven.

To connect the camera to the modem plug one side a shielded CAT 5 Ethernet cable (approx. 15 feet long) into the Ethernet port of the converter and the other side into the open Ethernet port of the modem. Similarly to the Ethernet converter box, The Microseven IP Ethernet Camera comes with an AC/DC converter connected to a barrel plug that will be used to power the camera. The AC/ DC converter is not necessary as the camera requires 12 V DC and the vehicle power is 12 V DC. To use supplied power cable, first ensure that neither the barrel end nor the AC/DC adapter is connected to any power source. Cut the cable at the AC/DC converter. This should leave several feet of cable with the barrel power terminal at one end. Split the two wires that make up the cable enough to work with. The wire with the gold color metal will be the positive power for the converter and should be connected to 12 V DC ignition power with an inline 1 AMP fuse. The white metal wire is to be connected to a ground.

Figure A.22 and Figure A.23 presents the method needed to adjust the camera to get best shot when mounted at the top of the cab.

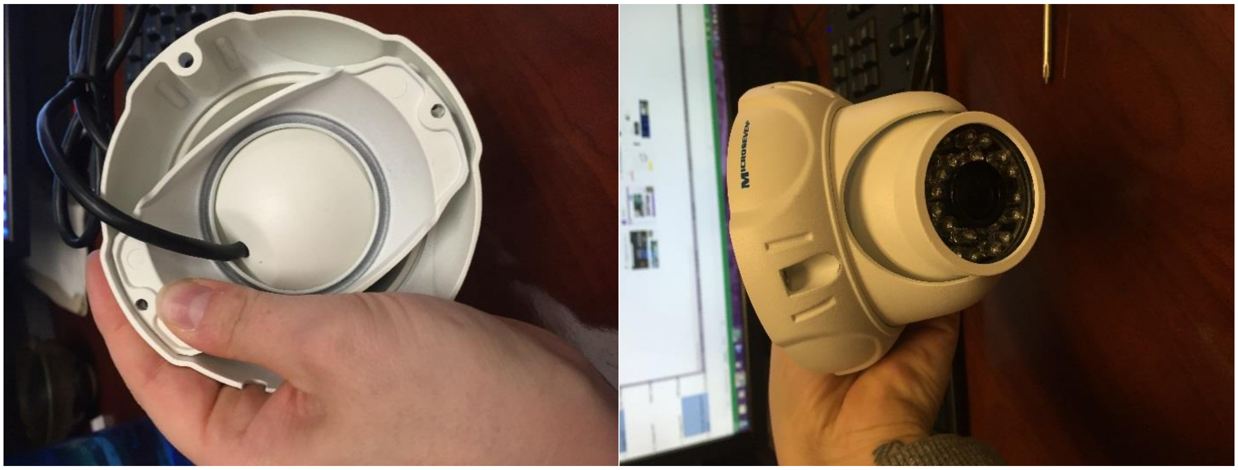


Figure A.22: Original Setup of the Camera.

This is the original setup. The cable prevents the camera from being moved completely up.

To fix this lack of mobility, the cable maybe moved outside of the mount. Once the mount is removed and the cable is moved to the outside, the mount should be loosely screwed back on. Next position the camera to the correct location and hold while completely tightening the two screws. This will allow the camera to be all the way up while still being held tight by the mount.

Figure A.23: Modified Camera Setup.

A.2 Calibration and Configuration

A.2.1 Calibration of the Hydraulic Pressure Sensor

After all systems have been installed and all software programed according to the GPS/AVL Device Configuration and Data Handling section, it is necessary to adjust the set screw at the top of the hydraulic sensor, as seen in Figure A.24, so that the sensor is activated when the plow is up or down. The easiest method is to have the entire system running and use the online interface to calibrate the plow sensors. Start the vehicle and allow it to run in order for the modem to communicate with the server. Once the truck is registered online, set the plow all the way to the ground. If the web portal indicates that the plow is still up turn the set screw at the top of the sensor counter clockwise as it is too sensitive. Raise the plow all the way. This should increase the pressure and the status should change to plow up. If the web indicates that the plow is still down, turn the set screw at the top of the sensor clockwise to increase the sensitivity of the sensor.

Figure A.24: Top of hydraulic pressure sensor. Note the set screw at the top.

A.2.2 Calibration of the Plow Attach Proximity Sensor

The proximity sensor near the plow attach hook has an effective range of 0.591 inches (15 mm). To test if the sensor is working, turn on the vehicle with the plow removed. Move the plow attachment handle down so that the hook is down (Figure A.25). An orange LED light near the base of the wire where it connects to the sensor should light up.

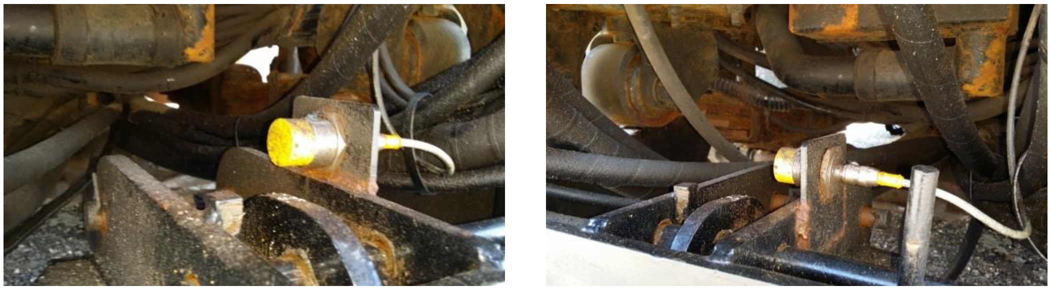


Figure A.25: Sensor and Plow Hook in the “Plow On” Position.

Move the plow attachment handle up so that the hook is in the "plow off" position, as seen in Figure A.26. The orange LED light should shut off. If the LED does not shut off, the sensor needs to be adjusted so that it is closer to the hook. If the LED does not turn on, the sensor needs to be moved further away from the where the hook resides in the "plow off" position.

Figure A.26: Sensor and Plow Hook in the "Plow Off" Position.

A.3 GPS/AVL Device Configuration and Data Handling

A.3.1 Sierra Wireless Modem

The Sierra Wireless AirLink GX modem contains a cellular transceiver, a GPS receiver, and various input/output ports. The AirLinks were configured by the manufacture for use with Verizon's cellular services, but other carriers were also available. The AirLink serves as the data router or gateway device that links all of the data obtained from the plow to the Internet.

The AirLink requires a cellular antenna in order for it to connect to the network, and the antennas used for this study were recommended and provided by Sierra Wireless. The cellular antenna attached to the roof of the truck cab via magnetic mount, and a coaxial cable connects the antenna to the modem located inside the cab. Once connected to the network, any device attached to the modem will be able to communicate over the Internet in exactly the same manner as a smart phone.

The built-in GPS receiver also requires an antenna, and the antenna enclosure that houses the cellular antenna also contains a GPS antenna, so the antenna mounted to the roof of the cab actually contains two cables; one for the cellular network and the other for GPS. A third, optional antenna was also used in this study. This antenna is also mounted to the cab roof several feet away from the cellular/GPS antenna and connected to the AirLink's AUX/Diversity port. This optional antenna is recommended by Sierra Wireless as a means to improve wireless reception.

The GPS data may be configured to provide a location reading on a time interval that is configurable by the user, and the data may be automatically sent to any machine(s) connected to the internet in a number of different industry standard GPS data formats. For this study, GPS measurements were taken every 10 seconds in the NMEA GGA+VTG format. These recording were forwarded to our server, and the latitude and longitude fields in each message were extracted from the GPS message and stored in a database.

The AirLink modems contain well over 1000 configuration parameters, but the configuration from one modem may be saved and copied to other devices through two different mechanisms. The first option is a manual configuration file transfer directly to each modem individually, which is still a cumbersome process. The second method is to use the AirVantage service offered by Sierra Wireless. AirVantage is a fee-based website that allows the user to manage all of their modems from a single interface. A configuration template may be created from any modem, and this template may be applied to any number of other modems with a few clicks. During this process, the website waits for each modem to “check-in” with AirVantage to report its status and to see if there are any changes to its configuration that need to be downloaded. Each modem is configured from the factory to check the AirVantage server periodically, so this process is not instantaneous. The website cannot “push” a configuration out to a modem.

A.3.2 Pengwyn Hydraulic Controller Interface

The Pengwyn hydraulic controller interfaces with the AirLink modem via RS-232 serial port interface. The controller’s data interface operates in a polled mode, meaning that the controller responds with the Pengwyn data every time that it receives an ASCII ‘G’ character. A software script running on the server generates and sends the ASCII polling characters to each AirLink via UDP, which is configured to forward the polling character to the controller. When the controller responds with data, the modem forwards it back to the server. The serial port settings on the AirLink that support this mode of operation are the UDP default dial mode and UDP auto answer. The serial port settings requires for the Pengwyn controller are listed in Table A.1, and the ASCII data message that is returned contains the following fields (each item is followed by a CR/LF):

- Unit ID
- Day of the Week
- Time of Day
- Current Speed
- Current Granular Spread Rate
- Spreader Alert On / Off (Displayed as 1 = On, 0 = Off)
- Auger On (Displayed as 1 = On, 0 = Off)
- Spinner On (Displayed as 1 = On, 0 = Off)
- Wetting On (Displayed as 1 = On, 0 = Off)

- Current Spinner Rate
- Current Wetting Spread Rate – Gallons per Mile
- Current Wetting Spread Rate – Gallons per Ton

Table A.1: Pengwyn Serial Port Settings.

Setting	**Value**
Baud Rate	9600
Data Bits	8
Parity	None
Stop Bits	2
Flow Control	None

A.3.3 Force America Hydraulic Interface

The Force America controller connects to the AirLink via RS-232 serial port. The serial port settings are configurable on the Force America unit, and the settings must match those configured on the AirLink. The settings used in this study are listed in Table A.2. The Force America controller must also be configured to transmit its data at specific time intervals over the serial port. These settings require the use of the proper key fob, and the reader is directed to the Force America manual for each specific model number for the configuration information.

The Force America controller features a second serial port that could be used to interface with a RoadWatch sensor. The controller will package the RoadWatch data with its own measurements, which allows for both devices to forward data through a single serial port connection to the AirLink. This feature is valuable due to the limited number of serial ports on the AirLink (2) versus the number of serial devices that require a serial port connection (3: controller, RoadWatch, and bed scale sensor).

Table A.2: Force America Serial Port Settings

Setting	**Value**
Baud Rate	19200
Data Bits	8
Parity	None
Stop Bits	1
Flow Control	None

A.3.4 RoadWatch Sensor Interface

The RoadWatch sensor is an RS-232 serial device that operates in the same manner as the Pengwyn controller with the serial port settings in Table A.3. Data is sent from the sensor whenever it is polled by an ASCII ‘T’ character, and the data is then forwarded to the server. The data messages from the

RoadWatch are ASCII text messages with the format of “%Q xxxx yyyy zzzz:DD” followed by a CR/LF character. The air temperature in degrees Fahrenheit may be found by converting the ‘xxxx’ field from hexadecimal to decimal form; the same applies for the road temperature, which is the ‘yyyy’ field.

Table A.3: RoadWatch Serial Port Settings.

Setting	**Value**
Baud Rate	9600
Data Bits	8
Parity	None
Stop Bits	1
Flow Control	None

A.3.5 Plow Up/Down Sensor Interface

The plow up/down sensor is a simple device that simply returns the states of two contact switches; one for the presence of a plow and the other for whether it’s up or down. The leads of the sensor connect directly to any digital I/O ports on the AirLink. The AirLink is configured to read the state of the switches every 15 seconds, which is configurable, and the sensor readings are forwarded to the server. The actual data that is sent is an ASCII ‘0’ or ‘1’, depending on the state of the switch.

To configure the modem to read and transmit this data, the Events Reporting feature must be utilized on the modem. This is a two-step process that entails the creation of an event and an action to respond to the event. In this case, the event is a simple timer. The action that responds to this timer is to send a UDP datagram to the server that contains the state of the digital I/O pins. Unfortunately, the remote configuration of the Events Reporting parameters via AirVantage was not supported during the performance period, so these settings needed to be manually changed on each modem.

A.3.6 Camera Interface

The camera setting maybe access and changed based on the camera’s manufacturer direction. Each camera is pre-programmed with a default settings. These settings must be changed before installing. The main settings that must be changed are the password and IP address. The password should be changed for security reasons. The IP must be changed to all the camera to work with the modem. Additional settings may be changed based on the user’s preferences, such as turning off the IR capability.

The on-board camera connects to the AirLink via power-over-Ethernet (PoE), which uses a single network cable for both power and data. The Ethernet port on the AirLink is used for the camera, which comes with the required power injector that connects to the plow’s power supply.

To allow the camera access to the Internet, port forwarding is configured on the modem. This allows a server application to access the camera remotely to change the camera configuration or to command the camera to take a snapshot. The particular model of camera from Microseven used in this study allowed for us to command and download a snapshot by simply requesting a specific URL located on the camera itself. For example, to request a snapshot from a camera located on a plow with an AirLink IP address of 123.234.345.456 and port forwarding on port 8088, the server simply needs to request the following URL: ‘http://123.234.345.456:8088/web/tmpfs/snap.jpg’. The cameras are also capable of supporting live video feeds using numerous protocols including RTSP, but it is important to remember that the uplink network throughput on cellular networks is limited, so it is important to set the video quality settings in the camera low enough so that the video feed remains intact.

A.3.7 Cleral Bed Scale Interface

The Cleral K2 bed scale sensor has serial port that is used for data recording and transmission. There are several different data transmission modes that are user-configurable on the sensor, but the default “Continuous V1” mode was used in this study. The serial port and Cleral message formats are given in Table A.4 and Table A.5. Cleral also provides a data interface manual that contains more details about the data produced by this sensor.

The main difficulty with processing the Cleral data is that the date is output from the serial port in binary, not ASCII. This requires a data conversion on the server so that the proper weights may be read from the messages.

For the plows that contain a Pengwyn controller and a RoadWatch sensor, a serial-to-Ethernet converter device had to be employed because a third serial port is not available on the AirLink. The device that was used in this study was a startech.com model, which is not recommended due to issues that we had with fragmentation of the bed scale measurement messages.

Table A.4: Bed Scale Serial Port Settings.

Setting	**Value**
Baud Rate	9600
Data Bits	8
Parity	None
Stop Bits	1
Flow Control	None

Table A.5: Cleral Bed Scale Data Format.

Bytes	**Description**
3	0xAAFF55 Identifier to mark the beginning of a message
1	Number of Weights
1	Weight ID
4	Integer Value of the Weight
1	‘p’ or ‘k’ for pounds or kilograms
1	Status Codes
1	Checksum
…	…repeat the previous 5 fields for each weight measurement
1	Carriage Return
1	Line Feed

APPENDIX B TRAINING POSTERS

GPS/AVL Implementation Project

Purpose

There are three goals for this project;

1.) Maintain a high level-of-service for ODOT network users during winter weather conditions.

2.) Quantify the regain time associated with county or district level performance.

3.) Optimize asset management.

What we need

From the drivers: We need you to drive your normal routes. Don't do anything different from the normal operating procedures.

From the county TA's: We need you to keep working with the website and get familiar with it, and then notify us of your experience.

Global Positioning System (GPS)

The GPS unit is in the truck allow us to track which routes are treated. It is also used to determine material usage on different routes, and also to help with court of claims.

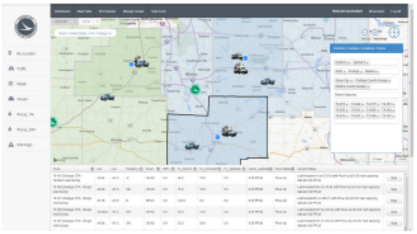


Figure 1. Snow Operations Screenshot

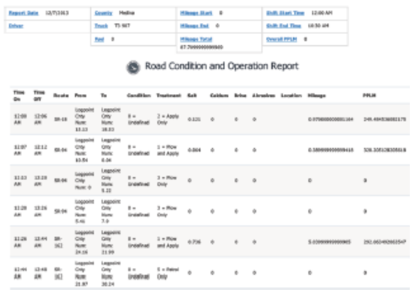


Figure 2. Sample Automated 661 Report

What we are doing at Akron

We are recording the routes that are driven by the trucks along with the material usage from each truck equipped. All of the data is being combined into a website for staff usage. Along with the data that is received, the website has access to truck location, the material application information from each truck, and weather conditions (radar, temperatures, road conditions, etc.)

End Results

The desire is to have an asset management system that everyone can use, along with having automated 661 reports, in an effort to increase efficiency within ODOT and transparency in the community.

Contact

If equipment appears to be malfunctioning or in need of repair, please inform your garage manager and have them contact UA at (330) 972-2150.

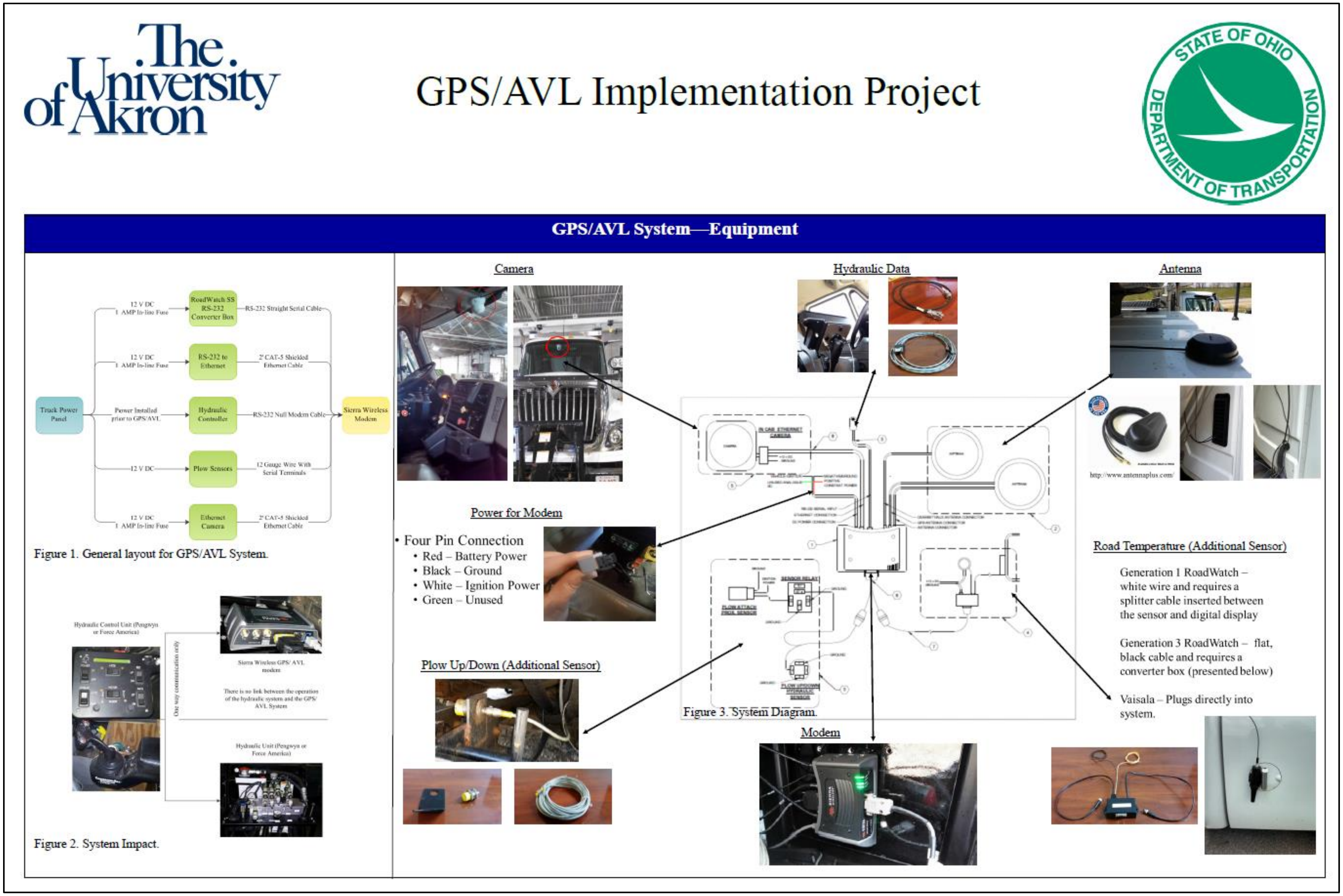


Figure 1. General layout for GPS/AVL System.

Figure 2. System Impact.

Figure 3. System Diagram.

APPENDIX C SIERRA WIRELESS MODEM

DISCLAIMER: THIS IS TO BE USED FOR GUIDANCE. BEFORE ORDERING AND INSTALLING ANY COMPONENTS OF THIS SYSTEM, CONTACT THE SIERRA WIRELESS TO VERIFY INFORMATION OR FOR QUESTIONS.

C.1 Hardware

This section will provide a brief overview of the hardware used in the ODOT GPS/AVL program. Its purpose is to provide a quick review of the device for reference. More detailed information is available from the manufacturer of the devices, Sierra Wireless.

Figure D.1: Sierra Wireless Airlink GX450 Modem.

The hardware used in the project consist of Airlink GX440 and Airlink GX450 LTE modems. Figure D.1 presents the Sierra Wireless GX450 Modem. They provide internet and GPS service to the vehicles they are installed in through the use of cell service. This project utilizes Verizon SIM cards and service.

Figure D.2: Airlink GX450 Modem Front Panel

The front of the device, shown in Figure D.2, contains a serial port, a reset button, and status LEDs. The serial port may be used to add additional sensors. The *Reset* button has two uses. To cycle the power on the device, briefly press and release the button. To return the device to factory defaults, press and hold the button for 7-8 seconds, until the LEDs flash yellow. There are four status LEDs on the device: Network, Signal, Activity, and Power. Their meanings are as follows:

- Network – Shows connection status to the network.
- Signal – Shows signal quality to the cellular network.
- Activity – Shows if cellular data is being transmitted over the air to or from the device. Blinks rapidly when data is being transmitted.
- Power – Shows the current on/off status of the device

LEDS light up one of three colors to indicate status. The different combinations of these status lights and their colors are covered in Section D.3.

The rear of the device, shown in Figure D.3, contains antenna connections, a serial port, an Ethernet port, a DC power port, and a micro USB type B port. The antenna connectors are used to connect the cellular antenna to the modem. The three connectors have the following uses:

- Cellular – Connect cellular antenna to provide cellular signal
- GPS – Connect GPS antenna to provide GPS location services
- Diversity / AUX - Connect secondary cellular antenna to provide increased signal strength

Figure D.3: Airlink GX450 Modem Rear Panel

On this project the rear serial port is used as a connection point for the hydraulic system. It allows the hydraulic system's data to be transmitted to the ODOT GPS/AVL website. The Ethernet port is used to connect the IP camera to the modem. The DC power port provides the unit power through the power cable. The Micro USB type B port is not used on this project, however while the modem is powered on it may be used as a power providing port for other devices. It also has the capability of being used to provide internet service to connected devices in lieu of Ethernet.

The SIM card is installed on the internal board of the modem. To have access to the internal board of the modem, the external shell must be removed. The external shell should only be removed if there is an issue with the SIM card. To remove the shell, remove all four Phillips head screws on the top of the device. Next remove the hexagonal head screws on both sides of the front facing serial port. Slide the top of the device towards the front to fully remove it. The screws required to be removed and the direction to slide the shell are shown in Figure D.4.

Figure D.4: Opening Procedure for GX450 Modem

C.2 Software

All hardware for this project is maintained through Sierra Wireless' AirVantage service. It allows the management of deployed hardware by allowing the user to check, manage, and update firmware, settings, device information, and status through a web interface. Through the use of over the air communications all of this is possible in real-time without requiring the hardware to be taken to a specific location.

This portion of the manual will briefly introduce the site and cover basic navigation and usage purposes. Detailed information on how portions of the site are used will be expanded on further in Section D.3. For more information on the uses for the site that are not explained, please visit the help section of the AirVantage site.

The AirVantage site is accessed by going to https://airvantage.net or https://airvantage.net/login. If using the former, press the red *Login* button at the upper-right hand corner of the page to be directed to the login page. To login, input the email and password to the account into their prospective fields, as shown in Figure D.5, and press the *Log In* button. If login fails, recheck that both the email and password are correct. If issues persist, check the server status by clicking the server status link. The server status page is shown in Figure D.6. If this page shows reports of server issues, wait until they have subsided and try again.

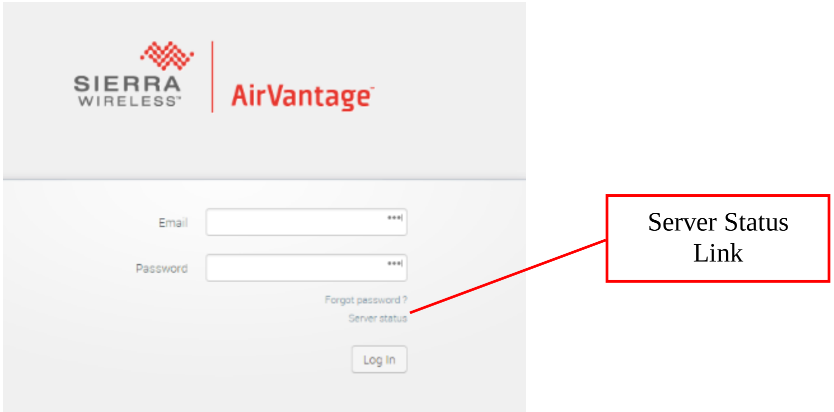


Figure D.5: AirVantage Login Page [1]

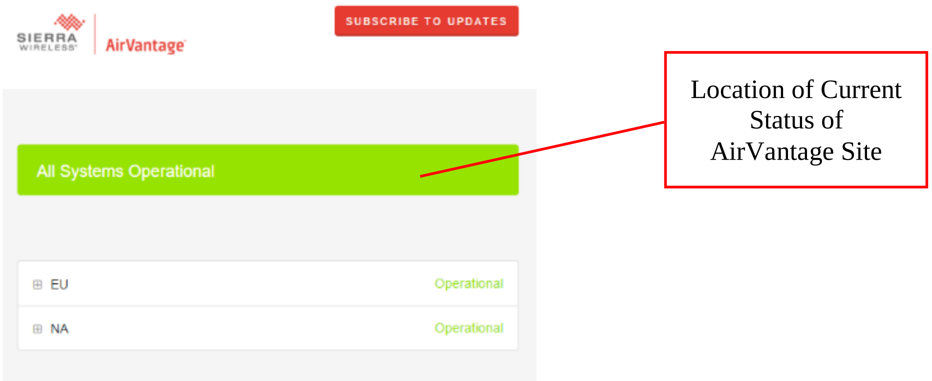


Figure D.6: AirVantage Service Status Page [1]

The AirVantage site is divided into five areas used for managing the hardware:

- Register: Used to register new hardware to the system.
- Inventory: Used to manage the hardware from a physical perspective.
- Monitor: Used to manage the hardware from a software perspective.
- Configure: Manages the templates, reports, alarms, and labels used on the AirVantage site.
- Develop: Used to develop templates and firmware modifications for the hardware.

These areas are navigated to through use of the headings on the navigation panel, shown in Figure D.7.

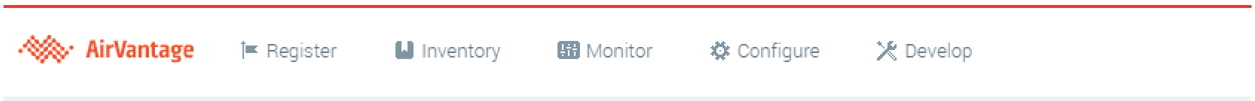


Figure D.7: Navigation Panel for the AirVantage Site [1]

C.3 Diagnosis and Troubleshooting

Diagnosis begins by first powering on the modem. Verify that the power and antenna cables are all securely attached to the device and wait for it to power on. In addition, be sure to verify that the SIM card in the modem is still activated by Verizon or whichever cell company is being used. The LED lights on top of the device will change from all red, then all yellow, then all green. The lights will then go through a series of patterns. The device is fully powered when the power LED changes yellow, then green, and remains steady.

Once the device is fully powered, examine the status LEDs and use the following table to determine the next step in diagnosis.

Power	Signal	Network	Proceed To
Off	-	-	Power
Yellow	-	-	Power
Red	-	-	Power
Green	-	Red	Sim Card
Green	Yellow-Flashing	Yellow	Antenna
Green	Green-Solid	Yellow	Connection
Green	-	Yellow-Flashing	Sim Card

Table D.1: Diagnosis Procedure for GX440/450 Modem

C.3.1 Power

No Light:

- Check the connection of the power cable to both the outlet and the modem. If necessary, remove and reattach the cable to verify full connection.
- If issue persists, attempt to use another power supply keeping the cable and modem the same. If the unit powers normally, then the initial power supply is non-functioning.

- If issue persists, use another power cable on the initial power supply. If the unit powers on normally, then the initial power cable is non-functioning.
- If the issue persists, use the new power cable on a second power supply. If the unit powers on normally, then both the initial power supply and power cable are non-functioning.

Yellow Light: The device is in lower power mode. Verify that the truck is powered on and delivering the full voltage to the connection point.

Red Light: The device is having severe issues with the power system. Contact Sierra Wireless technical support.

C.3.2 Sim Card

Red: Verify that the SIM card is fully inserted into the device by first removing the outer casing as shown in the Section D.1 and then removing and reinserting the SIM card.

Yellow-Flashing: Verify that the SIM card is fully inserted into the device by first removing the outer casing as shown in Section D.1 and then removing and reinserting the SIM card.

C.3.3 Antenna

- Verify that the antenna is properly connected into the antenna connectors on the back of the device. If necessary, disconnect all of the cables and reattach.
- If the signal status LED has changed from flashing-yellow to green then wait 5 minutes to see if the network status LED changes to green. If not, then proceed to Section D.3.4.
- If the signal status LED does not change from flashing-yellow, then relocate the antenna to a more open area in an attempt to increase signal strength. If the status LED does not change, then attempt to use another antenna that is known to provide a green signal LED in another device. Also, attempt to use the initial antenna on another device that is known to be capable of achieving full signal strength. If an alternative antenna changes the LED to green, and the initial antenna give continued issues on another device, then the antenna may need to be replaced.

C.3.4 Connection

Find the modem's information in the master list and copy the serial number for the device. On the AirVantage site, navigate under the monitor heading to the *Systems* subheading. Insert the serial number into the filters box, shown in Figure D.9, with the filter set to *Name*. Apply the filter by either pressing the

Enter key or the + button at the end of the box. The modem should appear in the list below as the only option.

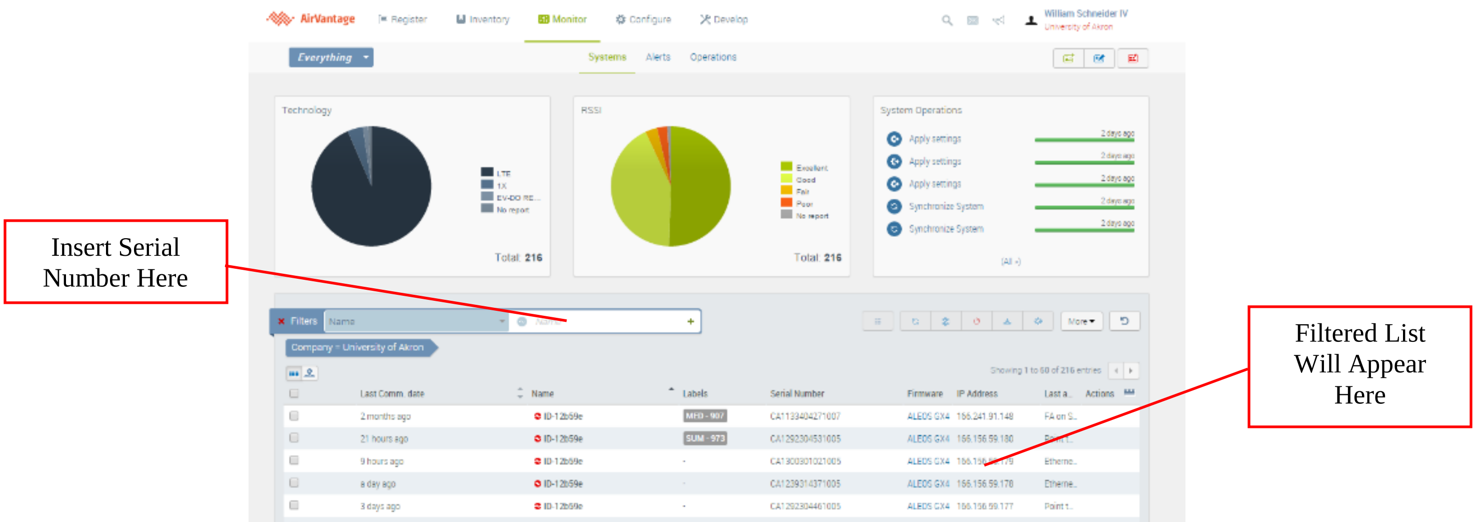


Figure D.8: Overview of AirVantage Monitor Page [1]

Click on the line containing the modems information to open the modem's detailed information page. First check the Communication Status indicator located near the top of the page. The color of the indicator represents the status of the device. Possible colors are shown in Figure D.10, where from left to right they represent: Unconfigured, OK, Warning, and Error. If the indicator is red, then proceed to Page 77 Paragraph 2. If the indicator is blue, this means that the device has not had its communication settings fully configured.

Figure D.9: Communication Status Icons [1]

To configure the communications of the device, press the *Configure Communication* button near the top right side of the page. The buttons in this area are shown in Figure D.11. From left to right the buttons are: Synchronize, Configure Communication, Reboot, Upgrade Firmware, Apply a Template

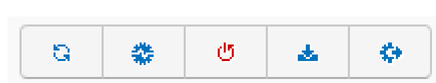


Figure D.10: Action Buttons Icons [1]

Verify that the Heartbeat and Status Report settings are switched to the *On* position. Set both the heartbeat and status report timing to 15 minutes, as these are the minimum allowable times. Open the configure warnings/error settings by pressing the *More* button located to the right of the heartbeat timing settings. Set the warning setting, the green to yellow setting, to 1 minute and the alert setting, the green to red setting, to 15 minutes. Properly configured communication settings are shown in Figure D.12.

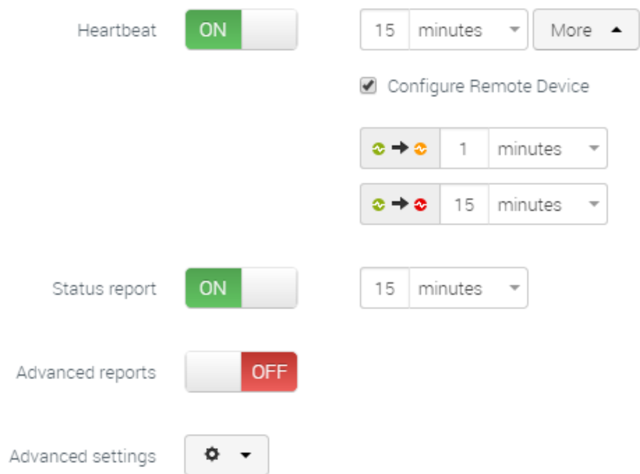


Figure D.11: Device with Properly Configured Communications [1]

Press the *Configure Communications* button at the bottom of the dialog to update the settings on the device.

If issues with connection persist, next verify that all of the information present in the device information panel, shown in Figure D.13, on the AirVantage site is correct.

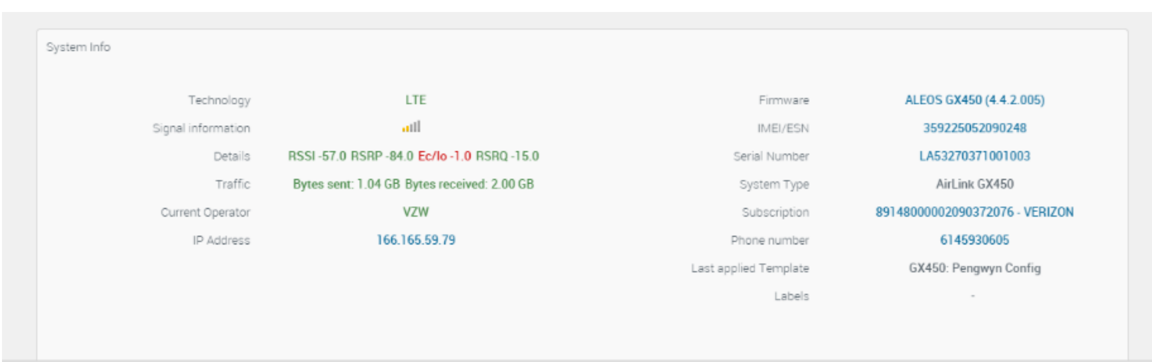


Figure D.12: Device Information Panel [1]

Check that the device's IP address, phone number, and template all match the information in the master list. If any of these items are not present or incorrect this may be the cause of the error. To update any of the information for the device, press the synchronize button at the top right corner of the page. Wait approximately 15-20 minutes for the device to synchronize with the system. To see if the device has successfully synchronized, go to the Monitor heading and select Operations. The operation will change from grey to green when completed. If the device does not update properly, or fails to synchronize after 15-20 minutes move onto the steps below. If the device's template is incorrect, due to being moved to another truck or not having a template applied initially, proceed to Section D.3.5.

The device has now failed to connect to the AirVantage site after having both the device's settings and the site's settings correct. Additional settings not accessible directly through the AirVantage site are able to be modified by using the modem as a connection point. To do this, first power on the modem and connect the antennas. Use an Ethernet cable to connect the modem to an Ethernet port on a computer. On the computer, open the network and sharing center by opening the start menu and typing *Network and Sharing Center*. In the top left of the window click on *Change Adapter Settings*, shown in Figure D.14

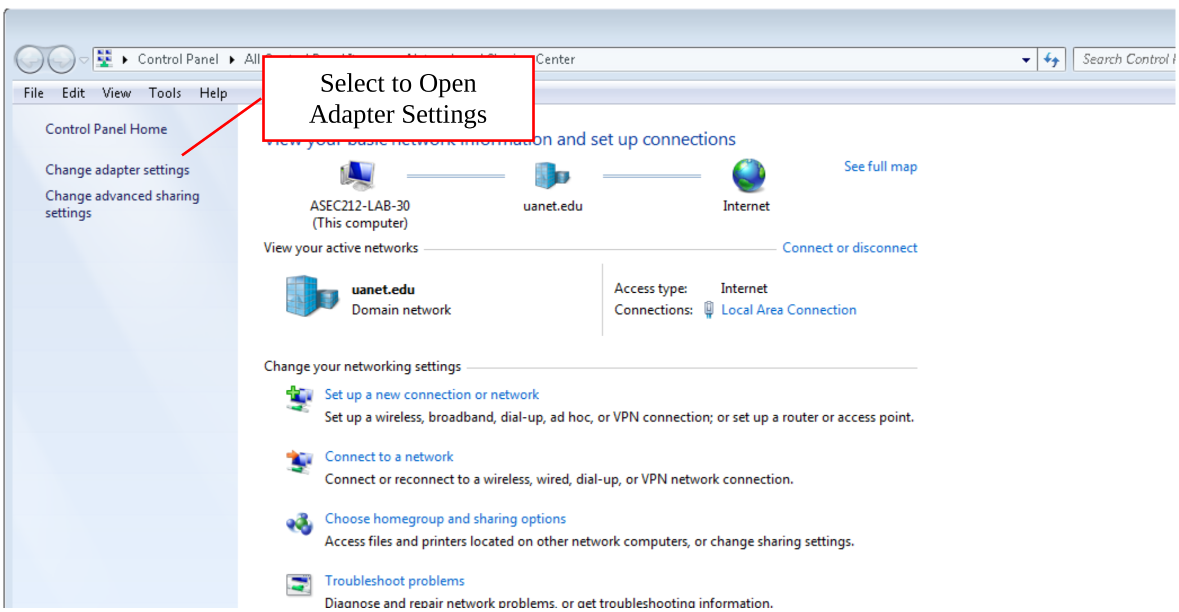


Figure D.13 Network and Sharing Center

Right click on the Local Area Connection associated with the computer. This may be recognized by checking that the second line of text on the icon. This line should contain the name of your local network and not a generic name. Choose the properties option from the menu. In the center of the dialog that opens, shown in Figure D.15, find and select the line titled *Internet Protocol Version 4 (TCIP/IPv4)*. Press the *Properties* button in the dialog.

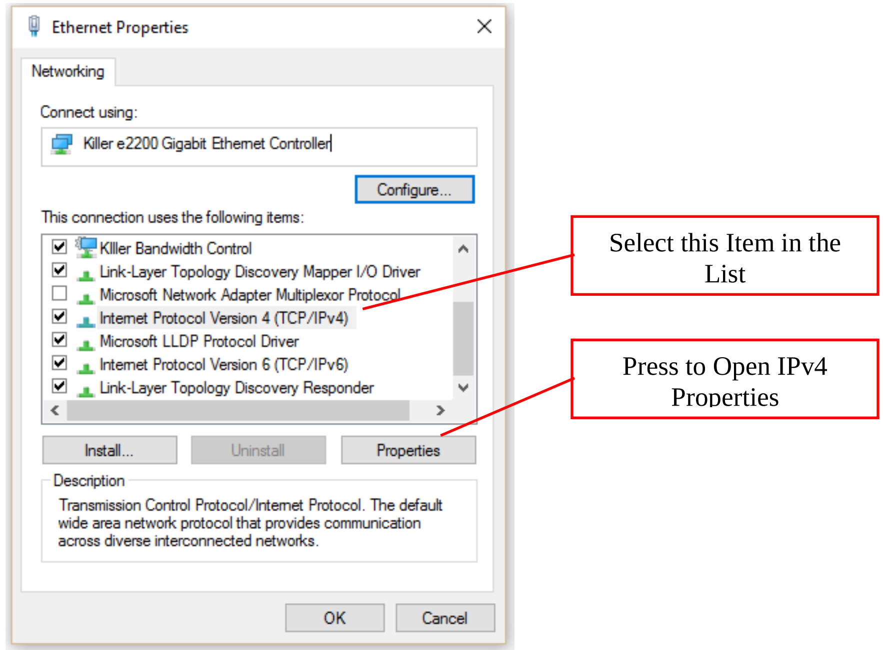


Figure D.14 Device Properties Dialog

In the newly opened dialog, shown in Figure D.16, select the *Use the following IP address:* option. Input the following information: IP address: 192.168.13.100, Subnet mask: 255.255.255.0, Default Gateway: 192.168.13.31. Press the *OK* button to close the dialog, followed by the second *OK* button to close the initial dialog. Open an internet browser and go to the following web address: 192.168.13.31:9191. If the website fails to load, verify that the information just inserted saved.

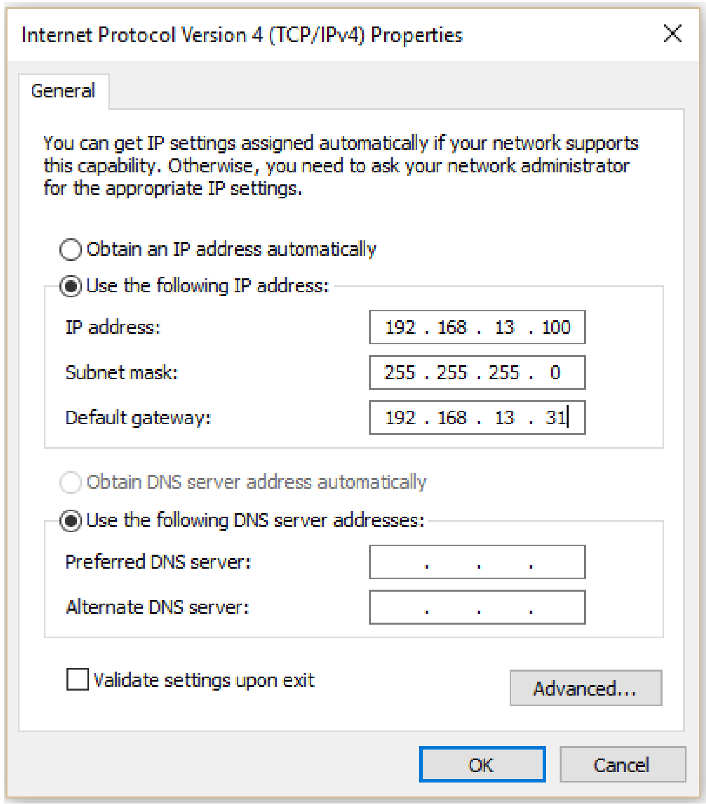


Figure D.15: Properly Configured IPv4 Properties

Upon successful loading of the page, the user will be presented with a login screen, shown in Figure D.17. Insert the following login information: User Name: user, Password: 12345. To finish logging in, press the *Log In* button. If login fails, recheck that both the user name and password were input correctly.

When logged in successfully, the user will be presented with the status page. Navigate to the WAN/Cellular tab by clicking on the heading, as shown in Figure D.18. On the WAN/Cellular tab check the line titled *APN in Use*. If this line contains no information or anything except *mw01.VZWSTATIC* than enter *mw01.VZWSTATIC* into the line below (Note that these APN addresses are for ODOT for this project), *User Entered APN*. To apply the new setting, press the *Apply* button in the top right corner of the page, followed by the *Reboot* button also in the top right corner of the page.

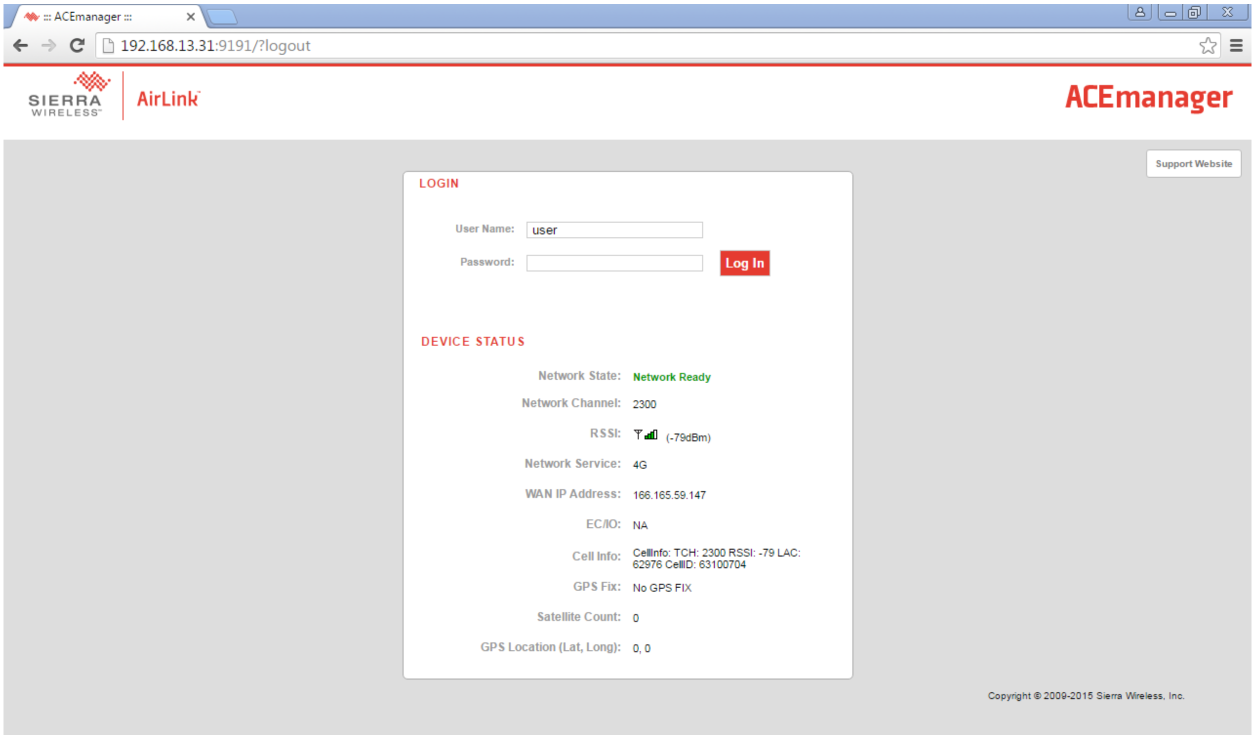


Figure D.16: Login Page for Modem Specific Settings [1]

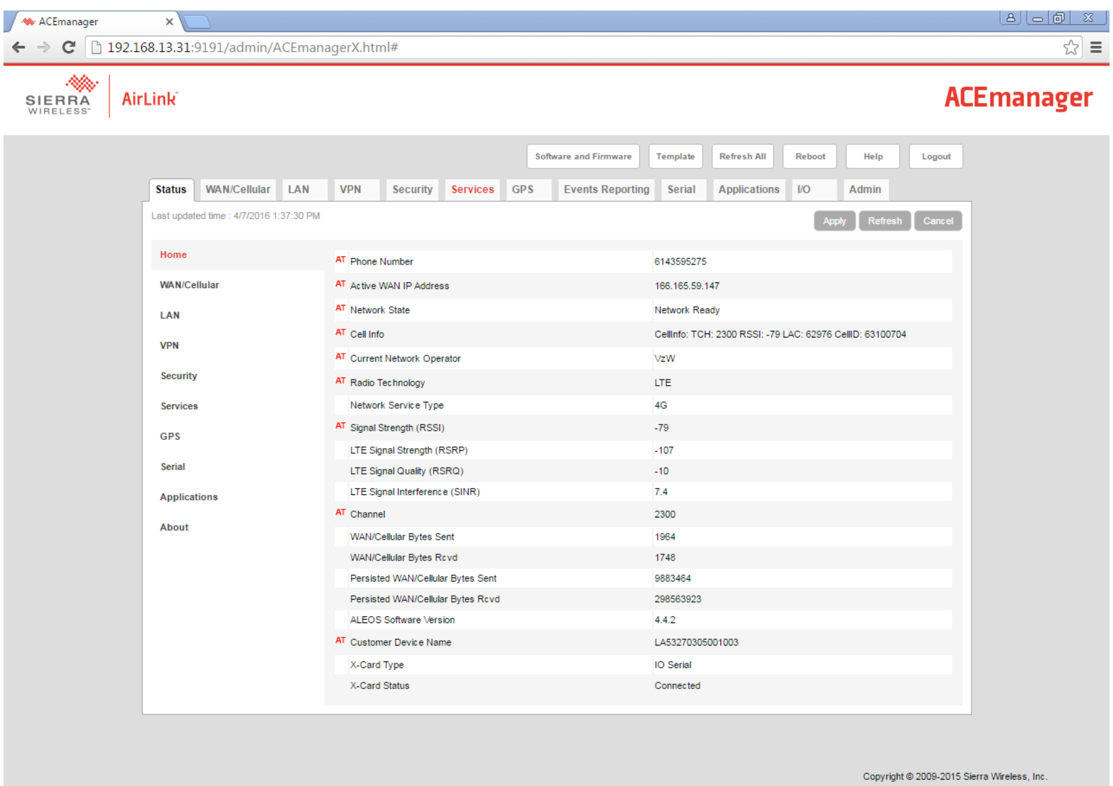


Figure D.17: Status Page for Modem Specific Settings [1]

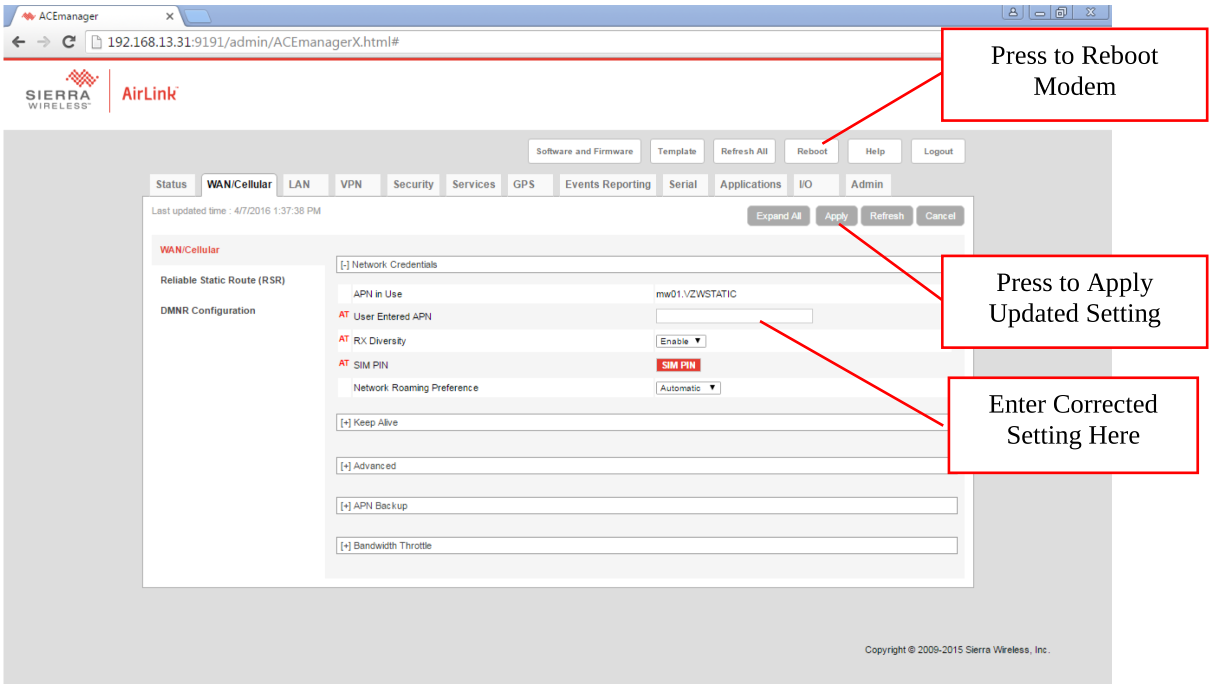


Figure D.18: WAN/Cellular Page for Modem Specific Settings [1]

After the device has fully rebooted, return to the WAN/Cellular tab and verify that the updated settings have been applied.

Once the device has rebooted, and the setting has been verified, the connection should complete. If the connection does not complete, contact Sierra Wireless technical support.

To revert the settings that allowed the user to change the modem specific settings, navigate back to the Change Adapter Settings window. Reopen the settings for the Local Area Connection. Reopen the *Internet Protocol Version 4 (TCIP/IPv4)* properties. Select the *Obtain IP Address Automatically* option. Press the *OK* button to close the dialog, followed by the second *OK* button to close the initial dialog.

C.3.5 No Template

If no template, or an incorrect template, is applied to a modem; a new template may be applied through the AirVantage site. Navigate to the modem's detailed information page following the filtering and selection procedure outlined in Section D.3.4. Press the *Apply a Template* button near the top right corner of the page. The dialog shown in Figure D.19 will open. Select the desired template from the drop down by first clicking into the drop down and then selecting the template.

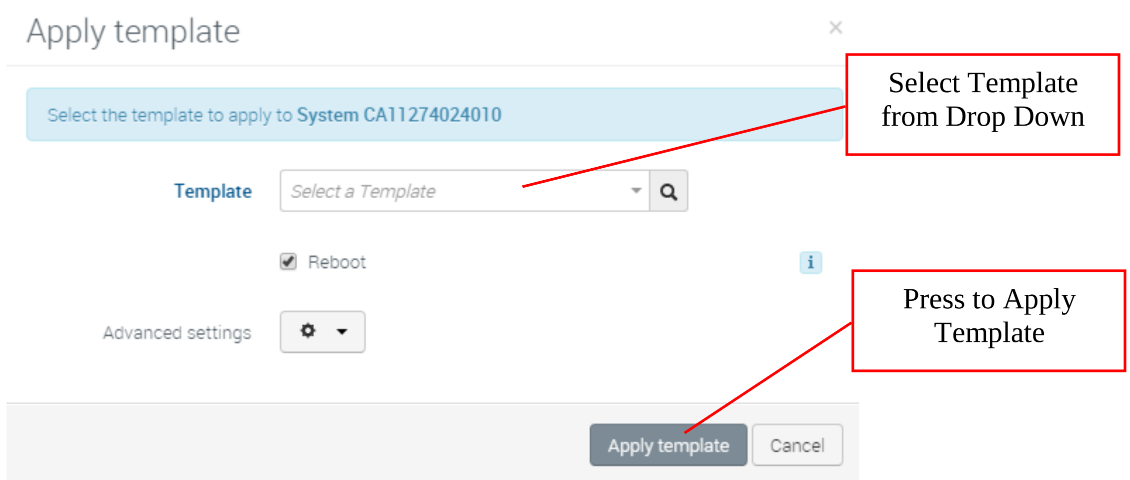


Figure D.19: Apply Template Dialog [1]

To finish applying to the template, press the *Apply Template* button at the bottom of the dialog. Wait for the device to completely reboot and apply the template. To verify that the process has completed successfully, reload the device's detailed information page and recheck the applied template.

APPENDIX D WEBSITE ARCHITECTURE DESIGN

Ohio Department of Transportation

Division of Information Technology

GPS/AVL

Software Architecture Design

Version 1.00

Updates to the document should be completed every iteration. If there are no updates, please note the date and indicate that there are "No updates for Iteration X". Example updates are included in the table.

Revision History				
Date	**Version**	**Iteration #**	**Description**	**Modified By**
5/26/15	1.0	1	Document Initial Version	Akron Team

D.1 Software Architecture Design

D.1.1 Purpose

The Software Architecture Design (SAD) Template is included within the Software Development Life Cycle (SDLC) to establish a consistent method for documenting a system or software design. The core purpose of documenting the software design is to communicate the design decisions and reasoning behind those decisions so other project team members may complete their tasks.

The development of this document is a collaborative effort between all information technology teams; however the document owner is the role of technical team lead. The technical team lead will facilitate the technical aspects and completion of the document with the project manager.

This document is expected to evolve over the life of the project, however certain components of the document should be completed within each phase of the project.

Important: The drafts of this document must be reviewed by the IT management team, starting with the first draft within two weeks after the kickoff meeting. This document is completed as a collaborative effort.

As the system evolves and changes over time, so too should this document. It is expected the document will be brought forward and updated as the system or software changes and should not be created from scratch for each phase after the initial phase unless deemed necessary.

D.1.2 Author(s)

The Technical Team Lead is the owner of this document; however creation of this document is a collaborative effort of the appropriate IT subject-matter experts. The IT subject-matter experts include system architect(s), database analyst(s), infrastructure engineer(s), and any other applicable IT SMEs. The Business Systems Analyst(s) should be consulted frequently during planning the implementation activities for clarification and alignment.

D.1.3 Audience

The individuals involved in creating and supporting the software or system. Also this document will serve as a reference for any future development, trouble shooting and support.

D.2 Basics

Application Name:	GPS/AVL System
Application Abbreviation:	GPS/AVL
Scope Document Location:	Akron University SharePoint Server
Tier (use table below)	Tier 1
Uptime (Definition below)	24/7
Maintenance Window (Definition below)	Non-Weather Event Day 10pm to 11pm
Access Scope	External – Internet Facing
Software Scope	Departmental/Back Office
Contributors to SAD	Bill Schneider, Casey Bakula, John Lurtz, Aaron Napier, & Will Holik

Tier Definitions

	Tier 1	*Tier 2*	*Tier 3*	*Tier 4*
Recovery Time *Unplanned*	Recovery time is 2 hours Unplanned 99.9%	Recovery time is 4 hours Unplanned 99.5%	Recovery time is 8 hours Unplanned 90.0%	Recovery time is 16 hours Unplanned (Best Effort)
Up Time	Defines the hours which the software needs to be running Example: 6 AM – 6PM or 24/7 This will be application specific – Enter values in table above			
Maintenance Window	Defines the hours in which the software can be offline in order to performance. Example: 6:01 PM – 5:59 AM This will be application specific – Enter values in table above.			

D.2.1 Technologies Used

Name of Technology	**Version**	**Description and/or Purpose of Technology**
SQL Server	2014	**Database Environment** [Azure SQL Server] ***-or-*** [2 CPU Core / 32GB of Ram / 2TBs of Rom]
Windows Server	2012 R2	**Web Application Environment** [Windows Azure Cloud Service] ***-or-*** [2 CPU Core / 8GB of Ram / 100GBs of Rom]
Windows Server	2012 R2	**Windows Service Integration Environment** [Windows Azure Cloud Service] ***-or-*** [2 CPU Core / 8GB of Ram / 100GBs of Rom]
Video Media Server [Wowza]	3.0	**Media Server for Video RTSP Relay** [Windows Azure Cloud Service] ***-or-*** [2 CPU Core / 16GB of Ram / 2TBs of Rom]
Bing Maps	Version 7+	Truck Map
NOAA Weather Feed	~	Truck Map
Microsoft .NET C#	~	Microsoft Server Coding Standard

HTML	~	Application FrontEnd Coding Standard
CSS	~	Application FrontEnd Coding Standard
JavaScript	~	Application FrontEnd Coding Standard
T- SQL Server	~	Database Coding Standard

D.2.2 Usage Patterns

Description	**Internal**	**External**
Total Number of Users	Less than 200 Users	N/A
Number of Concurrent Users	~20 Users	N/A
Peak Usage Times (Months, Days, Times)	Weather Events from October to March	N/A
SQL Server Records [Trucks]	~4k Daily Records per Truck during Weather Event	N/A
SQL Server Records [RWIS]	~1k Daily Records per RWIS Station	N/A

D.2.3 Audit Logging and Sensitive Data

This application will not have any confidential personal information or sensitive data.

D.2.4 Recovery and DR

Recovery will be 30 Minutes or less. This application is not mission critical and does not warrant DR planning.

D.2.5 Backup Information

Daily Full Database Backups & Real-Time SQL Server Mirroring.

D.2.6 Data Retention

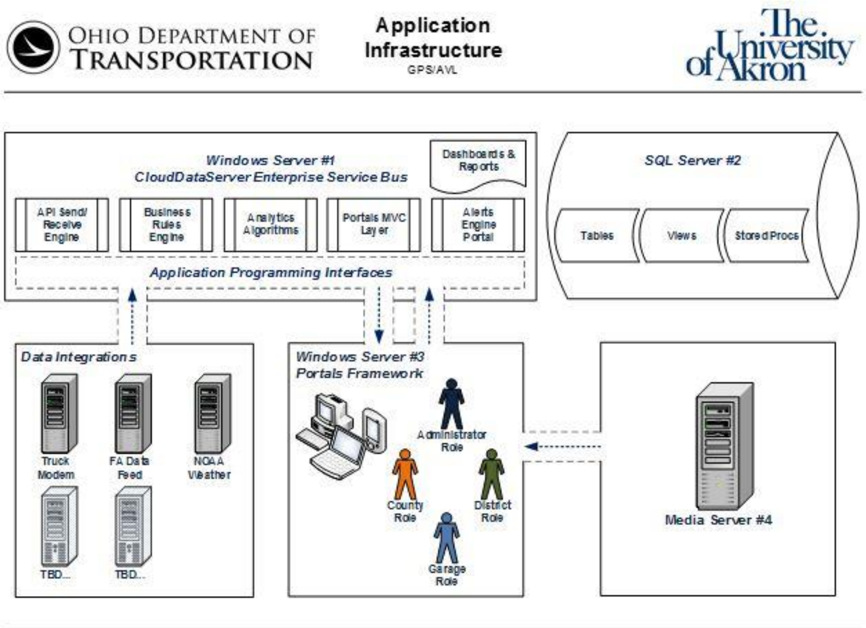
The system will retain the summary data for 10 years and detailed data for 2 years.

D.2.7 Data Archive

SQL Server Reporting Services will be used for reporting.

D.3 System Environment

D.3.1 Infrastructure



Application Layers	Components
CloudDataServer	Database Environment Web Application Environment Windows Service Integration Environment Media Server for Video RTSP Relay
OnTruckDataSource	Sierra Wireless Modem Verizon Wireless Cellular Modem
SensorDevice	Force America Sensor Pengwyn Sensor GPS Unit

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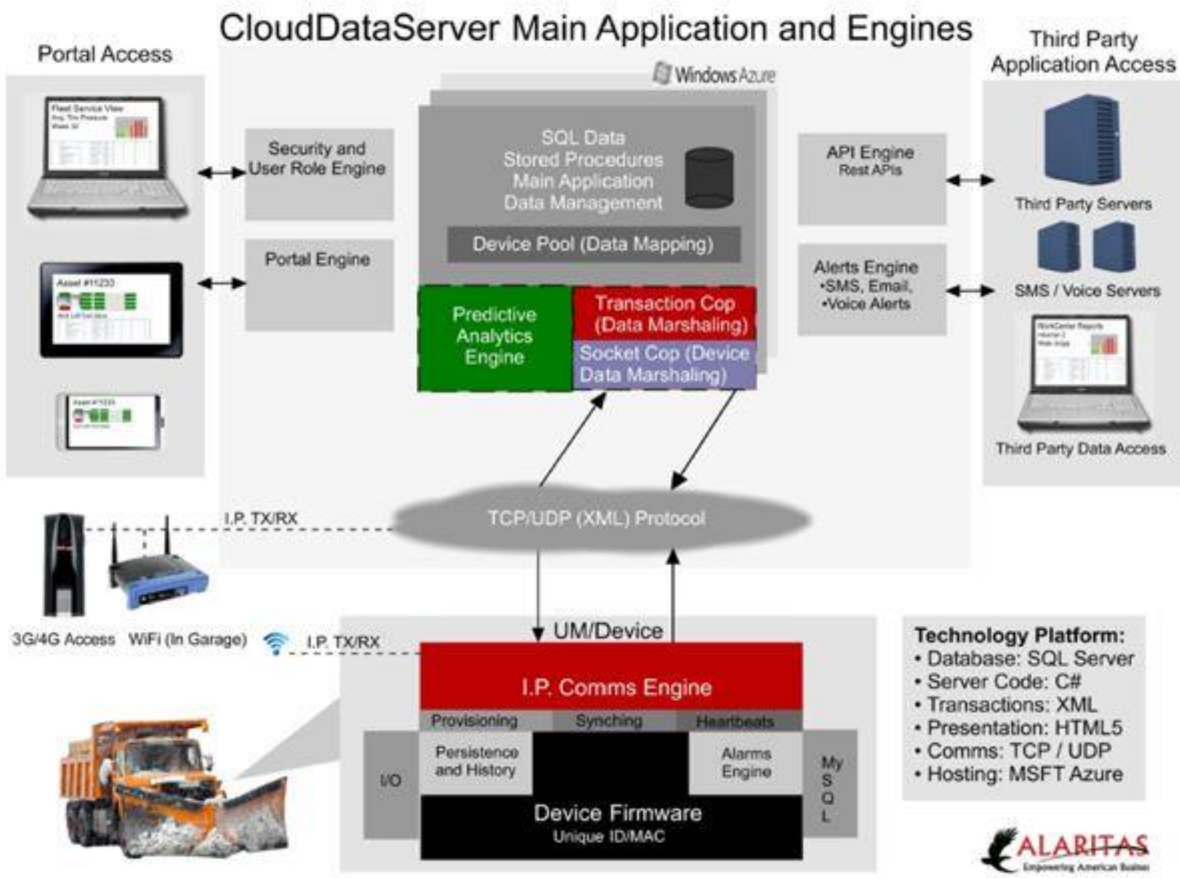


D.3.2 Monitoring

Area Monitored	Notification (role or person)
Database Server	On-Call Technical Analyst 24/7 Text Message Alerts
Web Application Server	On-Call Technical Analyst 24/7 Text Message Alerts
Integration Server	On-Call Technical Analyst 24/7 Text Message Alerts

D.3.3 Environment Information

Environment	Description
Development	**Local SQL Server:** SQL_DEV_01 [localhost::ODOT_TEST] **Local Web Server:** WEB_DEV_02 [http://localhost:8080] **Local Integration Server:** INT_DEV_03 [http://localhost:8088] **Media Server:** WOW_MED_04
Testing	**SQL Server:** SQL_TST_01 [cqavplg1xr.database.windows.net::ODOT_TEST] **Web Server:** WEB_TST_02 [http://test.odot.cloudapp.net:8080] **Integration Server:** INT_TST_03

	[http://test.odot.cloudapp.net:8088] **Media Server:** WOW_MED_04
Production	**SQL Server:** SQL_PRD_01 [cqavplg1xr.database.windows.net::ODOT] **Web Server:** WEB_PRD_02 [http://odot.cloudapp.net:8080] **Integration Server:** INT_PRD_03 [http://odot.cloudapp.net:8088] **Media Server:** WOW_MED_04

D.3.4 Web Site / Web Service Configurations

Type	Azure Cloud Service IIS7
SSL Needed	Azure Built-in SSL and TLS cryptography encrypt communications within and between deployments & on-premises datacenters.
SSL Cert Purchase	Provided
SSL Cert Expiration	Perpetual
SSL Cert Vendor (?)	Microsoft Azure
URL	http://odot.cloudapp.net
Domain Name Purchase	No
Host Headers	Truck_Analog, Truck_Hydraulic, Truck_GPS, Truck_BedScale
Ports	Web Server: 8080, 8088 Integration Server: 12346, 32154, 22339, 12345, 22335, 22333
Authentication	Device Authentication: 3-Level Authentication on MessageType, PORT, Private Algorithm Hash, & Custom Un-Pack Method. User Authentication: SHA-1

D.3.5 Windows Service / Windows Application

Display Name	ODOT.Worker [Integration Service Role]
Executable Name	ODOT.Worker.exe
Admin access required?	Yes

D.3.6 Network

D.3.6.1 Connection to Device

Application will communicate with on-board Truck Modems. Each Truck will have its own Modem(s) that will communicate to the Web Server via the Cellular Network.

D.3.6.2 Bandwidth requirements

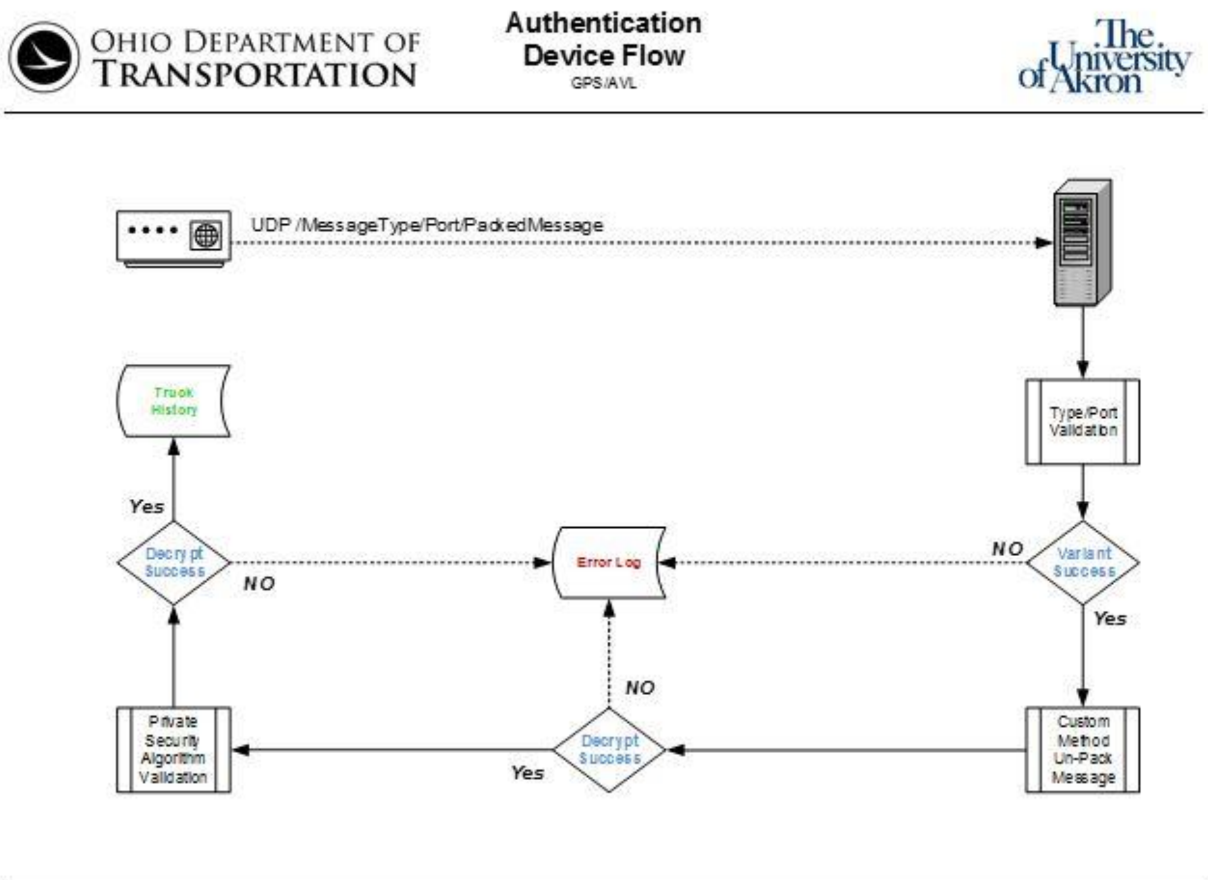
No special Bandwidth requirements.

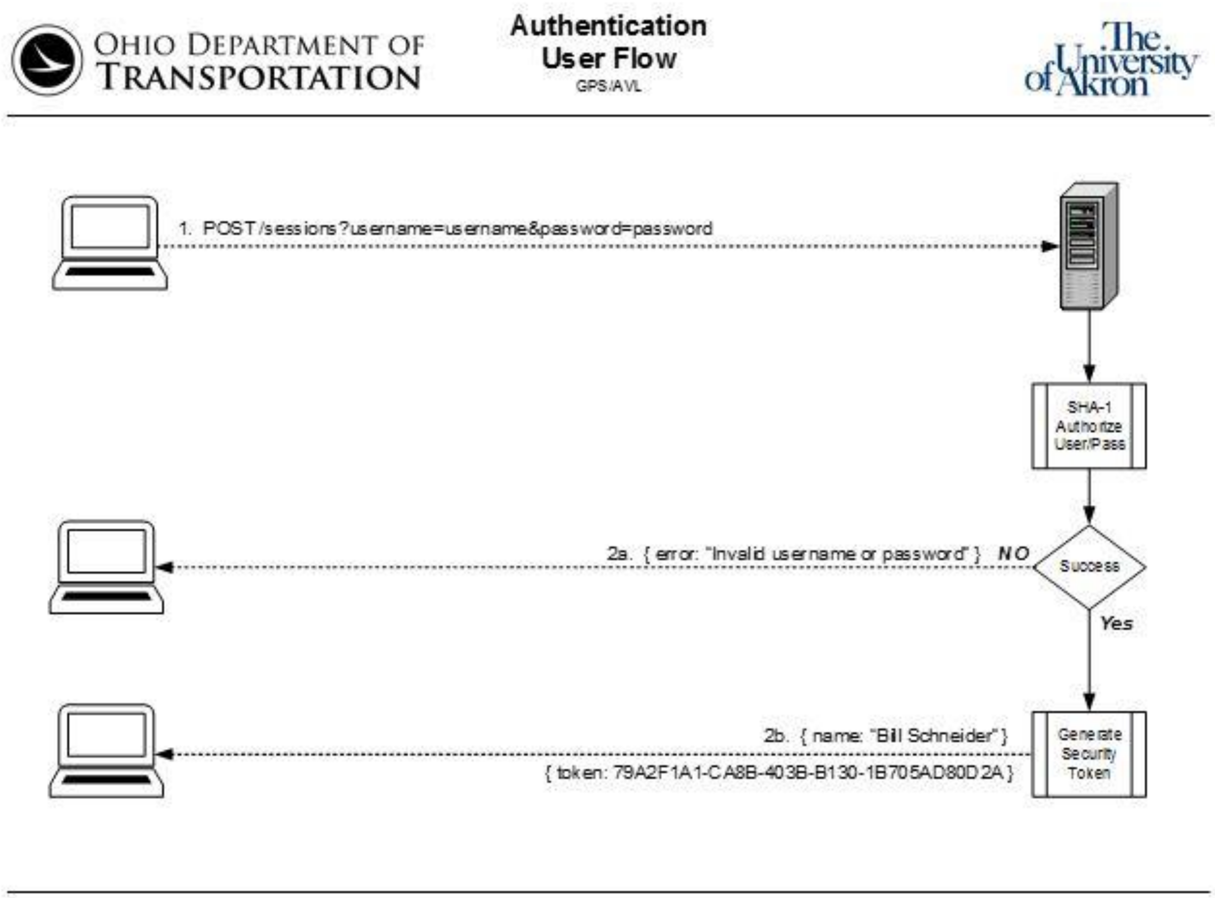
D.3.6.3 Phone/Voice Requirements

Not applicable.

D.3.7 Security

D.3.7.1 Authentication





D.3.7.2 Authorization

- Each Application System User is assigned a unique UserId & Password.
- The Password is one-way encrypted using SHA-1 hash.
- Upon successful logon the Server will create an assign a Session Token to the User that will expire after being idle for 30 minutes.
- Only the application itself will have access to the Database server. There is no direct access to the Database available to the User.
- When the User logs into the system they will have access to Districts, Counties, & Garages based on their assigned User Security Role.

D.3.7.3 Security Roles and Definitions

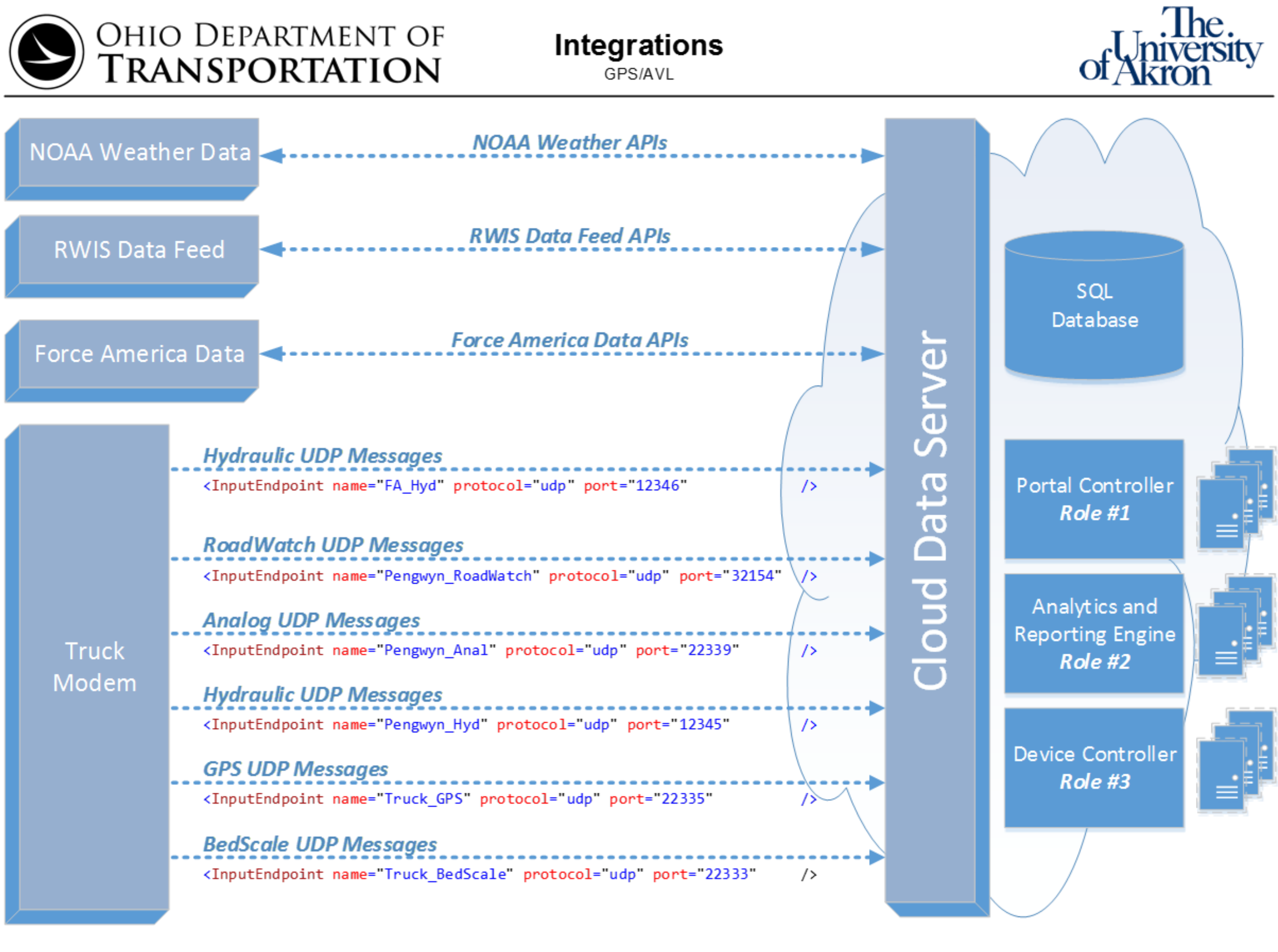
Role	**Definition**
Administrator	User has access to all System Functions and has the ability to add or change other User Profiles.
State Read-Only	User has access to view Trucks & Data in all Districts.
District Read-Only	User has access to view Trucks & Data in assigned District(s).
County Read-Only	User has access to view Trucks & Data in assigned County(s).
Garage Read-Only	User has access to view Trucks & Data in assigned Garage(s).
State Manager	User has access to view & edit Trucks & Data in all Districts.

District Manager	User has access to view & edit Trucks & Data in assigned District(s).
County Manager	User has access to view & edit Trucks & Data in assigned County(s).
Garage Manager	User has access to view & edit Trucks & Data in assigned Garage(s).

D.3.8 Specialty Services

The Microseven Video Cameras on the Trucks broadcast an RTSP video stream that is captured by a Media Server and the serviced to the web-site.

D.3.9 Interface to other Application(*s)*



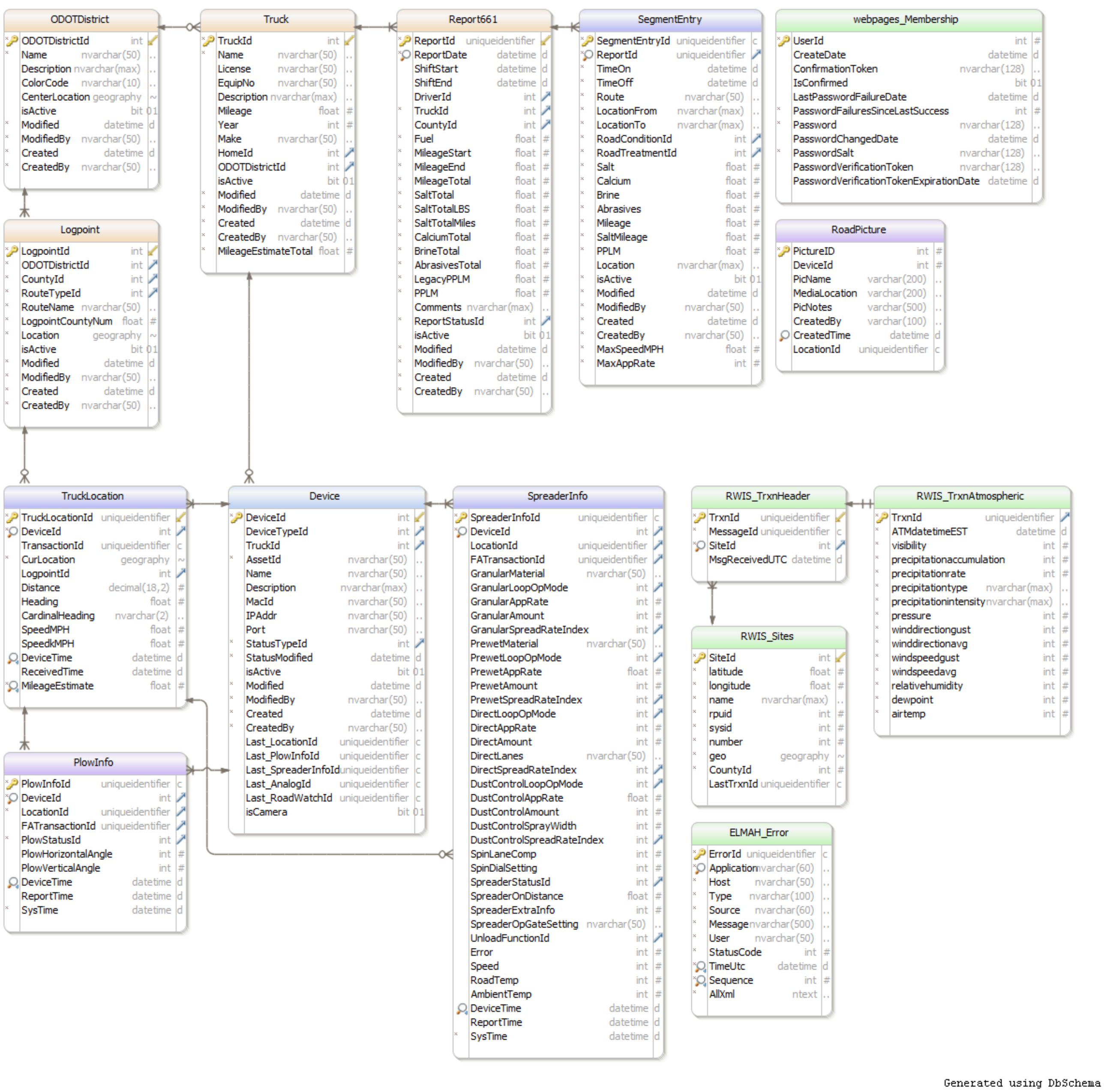
The Application Interfaces with:

- RWIS Data Feed
- Force America Data Feed
- Bing Maps
- NOAA Weather Feed
- Truck Modems [Pengwyn Data/Sensor Data/GPS Data]
- Wowza Media Server [Truck Camera]

D.3.10 Batch Processes

All Data Feeds run on a predefined cadence of every 5 minutes except for GPS data which is every 30 seconds.

D.4 Data Architecture



Database Entities
dbo.City
dbo.City_County
dbo.Country
dbo.County
dbo.County_State
dbo.Device
dbo.DeviceType
dbo.Driver
dbo.ELMAH_Error
dbo.FAAccumulator
dbo.FATransaction
dbo.Home
dbo.HomeType
dbo.Log
dbo.Logpoint
dbo.LogType
dbo.LoopOperation
dbo.ODOTCounty
dbo.ODOTDistrict
dbo.ODOTDistrict_County
dbo.Original_Report661
dbo.Original_SegmentEntry
dbo.PlowInfo
dbo.PlowStatus
dbo.PWAnalog
dbo.PWRoadWatch
dbo.PWSpreaderInfo
dbo.PWTransaction
dbo.Report661
dbo.ReportStatus
dbo.RoadCondition
dbo.RoadPicture
dbo.RoadTreatment
dbo.RouteType
dbo.RWIS_Messages
dbo.RWIS_Sensors
dbo.RWIS_Sites
dbo.RWIS_TrxnAtmospheric
dbo.RWIS_TrxnHeader
dbo.RWIS_TrxnLine
dbo.RWIS_TrxnLongbin
dbo.RWIS_TrxnNormalbin
dbo.RWIS_TrxnSnowice
dbo.RWIS_TrxnSurface
dbo.RWIS_TrxnTraffic
dbo.SegmentEntry
dbo.SpreaderInfo
dbo.SpreaderStatus
dbo.SpreadRateIndex
dbo.State
dbo.State_Country
dbo.statesprovinces
dbo.StatusType
dbo.tilestatesprovinces
dbo.tileuscounties
dbo.Truck
dbo.Truck_Driver
dbo.TruckLocation
dbo.UnloadFunction
dbo.Usage
dbo.uscounties
dbo.User_Home
dbo.UserProfile
dbo.webpages_Membership
dbo.webpages_OAuthMembership

dbo.webpages_Roles
dbo.webpages_UsersInRoles
dbo.ZipCode
dbo.ZipCode_City

D.5 Appendix

<u>Azure Platform Security Bullets:</u>

- **24 hour monitored physical security.** Datacenters are physically constructed, managed, and monitored to shelter data and services from unauthorized access as well as environmental threats.
- **Logging and monitoring.** Security is monitored with the aid of centralized monitoring, correlation, and analysis systems that manage the large amount of information generated by devices within the environment and providing timely alerts. In addition, multiple levels of monitoring, logging, and reporting are available to provide visibility to customers.
- **Virtual networks and firewalls.** Microsoft Antimalware is built-in to Cloud Services and can be enabled for Virtual Machines to help identify and remove viruses, spyware and other malicious software and provide real time protection. Customers can also run antimalware solutions from partners on their Virtual Machines.
- **Threat mitigation.** Intrusion detection and prevention systems, denial of service attack prevention, regular penetration testing, and forensic tools help identify and mitigate threats from both outside and inside of Azure.
- **Zero standing privileges.** Access to customer data by Microsoft operations and support personnel is denied by default. When granted, access is carefully managed and logged. Data center access to the systems that store customer data is strictly controlled via lock box processes.
- **Isolation.** Azure uses network isolation to prevent unwanted communications between deployments, and access controls block unauthorized users. Virtual Machines do not receive inbound traffic from the Internet unless customers configure them to do so.
- **Virtualization.** Enables multiple deployments to an isolated Virtual Network and allow those deployments to communicate with each other through private IP addresses.
- **Encrypted communications.** Built-in SSL and TLS cryptography enables customers to encrypt communications within and between deployments, from Azure to on-premises datacenters, and from Azure to administrators and users.
- **Secure remote access.** Customers can use ExpressRoute to establish a private connection to Azure datacenters, keeping their traffic off the Internet.
- **Data access control and encryption**. Azure offers a wide range of encryption capabilities up to AES-256, giving customers the flexibility to implement the methods that best meets their needs.
- **Identity and access management.** Azure Active Directory enables customers to manage access to Azure, Office 365 and a world of other cloud apps. Multi-Factor Authentication and access monitoring offer enhanced security.

Detailed Database Schema Documentation:

D.5.1.1.1	[dbo].[City]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	18802
Created	6:49:00 PM Thursday, January 2, 2014
Last Modified	1:11:10 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK C	CityId	int	4	False
	Name	nvarchar(max)	max	False

Indexes

Key	Name	Columns	Unique
PK C	PK__City__F2D21B76A6808334	CityId	True

SQL Script

```
CREATE TABLE [dbo].[City]
(
[CityId] [int] NOT NULL,
[Name] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL
)
GO
ALTER TABLE [dbo].[City] ADD CONSTRAINT [PK__City__F2D21B76A6808334] PRIMARY KEY CLUSTERED  ([CityId])
GO
```

Used By

[dbo].[City_County]
[dbo].[ZipCode_City]

D.5.1.1.2 [dbo].[City_County]

Properties

Property	Value
Row Count (~)	30016
Created	6:49:00 PM Thursday, January 2, 2014
Last Modified	1:11:20 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK FK	CityId	int	4	False
PK FK	CountyId	int	4	False

Indexes

Key	Name	Columns	Unique
PK	PK__City_Cou__99BAE2AFE35DD6F7	CityId, CountyId	True

Foreign Keys

Name	No Check	Columns
FK_City_County_City	True	CityId->[dbo].[City].[CityId]
FK_City_County_County	True	CountyId->[dbo].[County].[CountyId]

SQL Script

```
CREATE TABLE [dbo].[City_County]
(
[CityId] [int] NOT NULL,
[CountyId] [int] NOT NULL
)
GO
ALTER TABLE [dbo].[City_County] ADD CONSTRAINT [PK__City_Cou__99BAE2AFE35DD6F7] PRIMARY KEY CLUSTERED
([CityId], [CountyId])
GO
ALTER TABLE [dbo].[City_County] WITH NOCHECK ADD CONSTRAINT [FK_City_County_City] FOREIGN KEY ([CityId])
REFERENCES [dbo].[City] ([CityId])
GO
ALTER TABLE [dbo].[City_County] WITH NOCHECK ADD CONSTRAINT [FK_City_County_County] FOREIGN KEY ([CountyId])
REFERENCES [dbo].[County] ([CountyId])
GO
```

Uses

[dbo].[City]
[dbo].[County]

D.5.1.1.3 [dbo].[Country]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	1
Created	6:49:01 PM Thursday, January 2, 2014
Last Modified	1:11:20 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK C	CountryId	int	4	False
	Name	nvarchar(max)	max	False
	Abbr	nvarchar(3)	6	False

Indexes

Key	Name	Columns	Unique
PK C	PK__Country__10D1609F0EF9968A	CountryId	True

SQL Script

```
CREATE TABLE [dbo].[Country]
(
[CountryId] [int] NOT NULL,
[Name] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[Abbr] [nvarchar] (3) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL
)
GO
ALTER TABLE [dbo].[Country] ADD CONSTRAINT [PK__Country__10D1609F0EF9968A] PRIMARY KEY CLUSTERED  ([Country-
Id])
GO
```

Used By

[dbo].[State_Country]

D.5.1.1.4 [dbo].[County]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	1926
Created	6:48:52 PM Thursday, January 2, 2014
Last Modified	1:24:55 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK C	CountyId	int	4	False
	Name	nvarchar(max)	max	False

Indexes

Key	Name	Columns	Unique
PK C	PK__County__B68F9D9720B483C8	CountyId	True

SQL Script

```
CREATE TABLE [dbo].[County]
(
[CountyId] [int] NOT NULL,
[Name] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL
)
GO
ALTER TABLE [dbo].[County] ADD CONSTRAINT [PK__County__B68F9D9720B483C8] PRIMARY KEY CLUSTERED  ([CountyId])
GO
```

Used By

[dbo].[City_County]
[dbo].[County_State]
[dbo].[Home]
[dbo].[Logpoint]
[dbo].[ODOTCounty]
[dbo].[ODOTDistrict_County]
[dbo].[Original_Report661]
[dbo].[Report661]
[dbo].[uscounties]
[dbo].[vOhioDistrictCounty]

D.5.1.1.5 [dbo].[County_State]

Properties

Property	Value
Row Count (~)	3221
Created	6:49:01 PM Thursday, January 2, 2014
Last Modified	1:11:33 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK FK	CountyId	int	4	False
PK FK	StateId	int	4	False

Indexes

Key	Name	Columns	Unique
PK	PK__County_S__0AB43E24DB06B94B	CountyId, StateId	True

Foreign Keys

Name	No Check	Columns
FK_County_State_County	True	CountyId->[dbo].[County].[CountyId]
FK_County_State_State	True	StateId->[dbo].[State].[StateId]

SQL Script

```
CREATE TABLE [dbo].[County_State]
(
[CountyId] [int] NOT NULL,
[StateId] [int] NOT NULL
)
GO
ALTER TABLE [dbo].[County_State] ADD CONSTRAINT [PK__County_S__0AB43E24DB06B94B] PRIMARY KEY CLUSTERED
([CountyId], [StateId])
GO
ALTER TABLE [dbo].[County_State] WITH NOCHECK ADD CONSTRAINT [FK_County_State_County] FOREIGN KEY ([CountyId])
REFERENCES [dbo].[County] ([CountyId])
GO
ALTER TABLE [dbo].[County_State] WITH NOCHECK ADD CONSTRAINT [FK_County_State_State] FOREIGN KEY ([StateId])
REFERENCES [dbo].[State] ([StateId])
GO
```

Uses

[dbo].[County]
[dbo].[State]

D.5.1.1.6 [dbo].[Device]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	26
Created	5:57:46 PM Monday, January 27, 2014
Last Modified	11:52:18 PM Thursday, December 4, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls	Identity	Default
	DeviceId	int	4	False	1 - 1	
	DeviceTypeId	int	4	True		
	TruckId	int	4	True		
	AssetId	nvarchar(50)	100	False		('')
	Name	nvarchar(50)	100	True		
	Description	nvarchar(max)	max	True		
	MacId	nvarchar(50)	100	True		
	IPAddr	nvarchar(50)	100	True		
	Port	nvarchar(50)	100	True		
	StatusTypeId	int	4	False		((0))
	StatusModified	datetime	8	False		(getutcdate())
	isActive	bit	1	True		((1))
	Modified	datetime	8	False		(getutcdate())
	ModifiedBy	nvarchar(50)	100	False		('System')
	Created	datetime	8	False		(getutcdate())
	CreatedBy	nvarchar(50)	100	False		('System')
	Last_LocationId	uniqueidentifier	16	True		
	Last_PlowInfoId	uniqueidentifier	16	True		
	Last_Spreader-InfoId	uniqueidentifier	16	True		
	Last_AnalogId	uniqueidentifier	16	True		
	Last_RoadWatch-Id	uniqueidentifier	16	True		
	isCamera	bit	1	True		

Indexes

Key	Name	Columns	Unique
	PK__tmp_ms_x__49E1231190533FCA	DeviceId	True

Foreign Keys

Name	No Check	Columns
FK_Device_DeviceType	True	DeviceTypeId->[dbo].[DeviceType].[DeviceTypeId]
FK_Device_StatusType	True	StatusTypeId->[dbo].[StatusType].[StatusTypeId]
FK_Device_Truck	True	TruckId->[dbo].[Truck].[TruckId]

SQL Script

```
CREATE TABLE [dbo].[Device]
```

```
(
[DeviceId] [int] NOT NULL IDENTITY(1, 1),
[DeviceTypeId] [int] NULL,
[TruckId] [int] NULL,
[AssetId] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__tmp_ms_xx__-
Asset__190BB0C3] DEFAULT (''),
[Name] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[Description] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[MacId] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[IPAddr] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[Port] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[StatusTypeId] [int] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Statu__19FFD4FC] DEFAULT ((0)),
[StatusModified] [datetime] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Statu__1AF3F935] DEFAULT (getutcdate()),
[isActive] [bit] NULL CONSTRAINT [DF__tmp_ms_xx__isAct__1BE81D6E] DEFAULT ((1)),
[Modified] [datetime] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Modif__1CDC41A7] DEFAULT (getutcdate()),
[ModifiedBy] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__tmp_ms_xx__-
Modif__1DD065E0] DEFAULT ('System'),
[Created] [datetime] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Creat__1EC48A19] DEFAULT (getutcdate()),
[CreatedBy] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__tmp_ms_xx__-
Creat__1FB8AE52] DEFAULT ('System'),
[Last_LocationId] [uniqueidentifier] NULL,
[Last_PlowInfoId] [uniqueidentifier] NULL,
[Last_SpreaderInfoId] [uniqueidentifier] NULL,
[Last_AnalogId] [uniqueidentifier] NULL,
[Last_RoadWatchId] [uniqueidentifier] NULL,
[isCamera] [bit] NULL
)
GO
ALTER TABLE [dbo].[Device] ADD CONSTRAINT [PK__tmp_ms_x__49E1231190533FCA] PRIMARY KEY CLUSTERED  ([Device-
Id])
GO
ALTER TABLE [dbo].[Device] WITH NOCHECK ADD CONSTRAINT [FK_Device_DeviceType] FOREIGN KEY ([DeviceTypeId])
REFERENCES [dbo].[DeviceType] ([DeviceTypeId])
GO
ALTER TABLE [dbo].[Device] WITH NOCHECK ADD CONSTRAINT [FK_Device_StatusType] FOREIGN KEY ([StatusTypeId])
REFERENCES [dbo].[StatusType] ([StatusTypeId])
GO
ALTER TABLE [dbo].[Device] WITH NOCHECK ADD CONSTRAINT [FK_Device_Truck] FOREIGN KEY ([TruckId]) REFERENCES
[dbo].[Truck] ([TruckId])
GO
```

Uses

[dbo].[DeviceType]
[dbo].[StatusType]
[dbo].[Truck]

Used By

[dbo].[FATransaction]
[dbo].[PlowInfo]
[dbo].[PWAnalog]
[dbo].[PWRoadWatch]
[dbo].[PWSpreaderInfo]
[dbo].[PWTransaction]
[dbo].[SpreaderInfo]
[dbo].[TruckLocation]
[dbo].[spGenerateFASegment]
[dbo].[spProcessFATrans]
[dbo].[spProcessPWLocation]

D.5.1.1.7 [dbo].[DeviceType]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	2
Created	6:48:54 PM Thursday, January 2, 2014
Last Modified	1:24:56 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls	Default
	DeviceTypeId	int	4	False	
	Name	nvarchar(50)	100	False	
	Description	nvarchar(max)	max	True	
	Modified	datetime	8	False	(getutcdate())
	ModifiedBy	nvarchar(50)	100	False	('System')
	Created	datetime	8	False	(getutcdate())
	CreatedBy	nvarchar(50)	100	False	('System')

Indexes

Key	Name	Columns	Unique
	PK__DeviceTy__07A6C7F6C2F75F1F	DeviceTypeId	True

SQL Script

```
CREATE TABLE [dbo].[DeviceType]
(
[DeviceTypeId] [int] NOT NULL,
[Name] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[Description] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[Modified] [datetime] NOT NULL CONSTRAINT [DF__DeviceTyp__Modif__5629CD9C] DEFAULT (getutcdate()),
[ModifiedBy] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__DeviceTyp__-
Modif__571DF1D5] DEFAULT ('System'),
[Created] [datetime] NOT NULL CONSTRAINT [DF__DeviceTyp__Creat__5812160E] DEFAULT (getutcdate()),
[CreatedBy] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__DeviceTyp__-
Creat__59063A47] DEFAULT ('System')
)
GO
ALTER TABLE [dbo].[DeviceType] ADD CONSTRAINT [PK__DeviceTy__07A6C7F6C2F75F1F] PRIMARY KEY CLUSTERED
([DeviceTypeId])
GO
```

Used By

[dbo].[Device]

D.5.1.1.8 [dbo].[Driver]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	1
Created	6:49:01 PM Thursday, January 2, 2014
Last Modified	1:24:32 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls	Identity	Default
PK C	DriverId	int	4	False	1 - 1	
FK	UserId	int	4	True		
	FirstName	nvarchar(50)	100	True		
	LastName	nvarchar(50)	100	True		
	Email	nvarchar(50)	100	True		
	Phone	nvarchar(50)	100	True		
	Addr_Street	nvarchar(max)	max	True		
	Addr_City	nvarchar(50)	100	True		
	Addr_State	nvarchar(50)	100	True		
	Addr_Zip	nvarchar(50)	100	True		
	isActive	bit	1	True		((1))
	Modified	datetime	8	False		(getutcdate())
	ModifiedBy	nvarchar(50)	100	False		('System')
	Created	datetime	8	False		(getutcdate())
	CreatedBy	nvarchar(50)	100	False		('System')

Indexes

Key	Name	Columns	Unique
PK C	PK__Driver__F1B1CD04EB96371A	DriverId	True

Foreign Keys

Name	No Check	Columns
FK_Driver_UserProfile	True	UserId->[dbo].[UserProfile].[UserId]

SQL Script

```
CREATE TABLE [dbo].[Driver]
(
[DriverId] [int] NOT NULL IDENTITY(1, 1),
[UserId] [int] NULL,
[FirstName] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[LastName] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[Email] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[Phone] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[Addr_Street] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[Addr_City] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[Addr_State] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[Addr_Zip] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[isActive] [bit] NULL CONSTRAINT [DF__Driver__isActive__37703C52] DEFAULT ((1)),
[Modified] [datetime] NOT NULL CONSTRAINT [DF__Driver__Modified__3864608B] DEFAULT (getutcdate()),
[ModifiedBy] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__Driver__-
Modified__395884C4] DEFAULT ('System'),
[Created] [datetime] NOT NULL CONSTRAINT [DF__Driver__Created__3A4CA8FD] DEFAULT (getutcdate()),
```

```
[CreatedBy] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__Driver__Created-B__3B40CD36] DEFAULT ('System')
)
GO
ALTER TABLE [dbo].[Driver] ADD CONSTRAINT [PK__Driver__F1B1CD04EB96371A] PRIMARY KEY CLUSTERED  ([DriverId])
GO
ALTER TABLE [dbo].[Driver] WITH NOCHECK ADD CONSTRAINT [FK_Driver_UserProfile] FOREIGN KEY ([UserId])
REFERENCES [dbo].[UserProfile] ([UserId])
GO
```

Uses

[dbo].[UserProfile]

Used By

[dbo].[Original_Report661]
[dbo].[Report661]
[dbo].[Truck_Driver]

D.5.1.1.9 [dbo].[ELMAH_Error]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	4951
Created	6:48:50 PM Thursday, January 2, 2014
Last Modified	1:11:31 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls	Identity	Default
PK C	ErrorId	uniqueidentifier	16	False		(newid())
	Application	nvarchar(60)	120	False		
	Host	nvarchar(50)	100	False		
	Type	nvarchar(100)	200	False		
	Source	nvarchar(60)	120	False		
	Message	nvarchar(500)	1000	False		
	User	nvarchar(50)	100	False		
	StatusCode	int	4	False		
	TimeUtc	datetime	8	False		
	Sequence	int	4	False	1 - 1	
	AllXml	ntext	max	False		

Indexes

Key	Name	Columns	Unique
PK C	PK_ELMAH_Error	ErrorId	True
	IX_ELMAH_Error_App_Time_Seq	Application, TimeUtc, Sequence	

SQL Script

```
CREATE TABLE [dbo].[ELMAH_Error]
(
[ErrorId] [uniqueidentifier] NOT NULL CONSTRAINT [DF_ELMAH_Error_ErrorId] DEFAULT (newid()),
[Application] [nvarchar] (60) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[Host] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[Type] [nvarchar] (100) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[Source] [nvarchar] (60) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[Message] [nvarchar] (500) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[User] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[StatusCode] [int] NOT NULL,
[TimeUtc] [datetime] NOT NULL,
[Sequence] [int] NOT NULL IDENTITY(1, 1),
[AllXml] [ntext] COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL
)
GO
ALTER TABLE [dbo].[ELMAH_Error] ADD CONSTRAINT [PK_ELMAH_Error] PRIMARY KEY CLUSTERED  ([ErrorId])
GO
CREATE NONCLUSTERED INDEX [IX_ELMAH_Error_App_Time_Seq] ON [dbo].[ELMAH_Error] ([Application], [TimeUtc] DESC,
[Sequence] DESC)
GO
```

Used By

[dbo].[ELMAH_GetErrorsXml]
[dbo].[ELMAH_GetErrorXml]
[dbo].[ELMAH_LogError]

D.5.1.1.10 [dbo].[FAAccumulator]

Properties

Property	Value
Row Count (~)	2706125
Created	4:29:24 PM Wednesday, January 8, 2014
Last Modified	2:22:19 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls	Default
PK FK	FAAccumulatorId	uniqueidentifier	16	False	(newid())
	DeviceId	int	4	False	
FK	FATransactionId	uniqueidentifier	16	False	
	OdometerMeters	int	4	False	((0))
	OdometerMiles	float	8	False	((0.0))
	WindshieldTime	int	4	False	((0))
	IgnitionTime	int	4	False	((0))
	ReportTime	datetime	8	True	
	SysTime	datetime	8	False	(getutcdate())

Indexes

Key	Name	Columns	Unique
PK	PK__tmp_ms_x__B52D0467A512AB77	FAAccumulatorId	True
	FAAccumulator_DeviceId_OdometerMiles	OdometerMiles, DeviceId	

Foreign Keys

Name	No Check	Columns
FK_FAAccumulator_FATransaction	True	FATransactionId->[dbo].[FATransaction].[FATransactionId]

SQL Script

```
CREATE TABLE [dbo].[FAAccumulator]
(
[FAAccumulatorId] [uniqueidentifier] NOT NULL CONSTRAINT [DF__tmp_ms_xx__FAAcc__79C80F94] DEFAULT (newid()),
[DeviceId] [int] NOT NULL,
[FATransactionId] [uniqueidentifier] NOT NULL,
[OdometerMeters] [int] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Odome__7ABC33CD] DEFAULT ((0)),
[OdometerMiles] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Odome__7BB05806] DEFAULT ((0.0)),
[WindshieldTime] [int] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Winds__7CA47C3F] DEFAULT ((0)),
[IgnitionTime] [int] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Ignit__7D98A078] DEFAULT ((0)),
[ReportTime] [datetime] NULL,
[SysTime] [datetime] NOT NULL CONSTRAINT [DF__tmp_ms_xx__SysTi__7E8CC4B1] DEFAULT (getutcdate())
)
GO
ALTER TABLE [dbo].[FAAccumulator] ADD CONSTRAINT [PK__tmp_ms_x__B52D0467A512AB77] PRIMARY KEY CLUSTERED
([FAAccumulatorId])
GO
CREATE NONCLUSTERED INDEX [FAAccumulator_DeviceId_OdometerMiles] ON [dbo].[FAAccumulator] ([DeviceId]) INCLUDE
([OdometerMiles])
GO
ALTER TABLE [dbo].[FAAccumulator] WITH NOCHECK ADD CONSTRAINT [FK_FAAccumulator_FATransaction] FOREIGN KEY
([FATransactionId]) REFERENCES [dbo].[FATransaction] ([FATransactionId])
GO
```

Uses

[dbo].[FATransaction]

Used By

[dbo].[spProcessFATrans]

D.5.1.1.11 [dbo].[FATransaction]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	5633984
Created	6:48:55 PM Thursday, January 2, 2014
Last Modified	12:14:59 AM Friday, November 21, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls	Default
	FATransactionId	uniqueidentifier	16	False	(newid())
(3)	DeviceId	int	4	False	((1))
	AssetName	nvarchar(max)	max	True	
	RecordType	nvarchar(max)	max	True	
	TripData	nvarchar(max)	max	True	
	Misc	nvarchar(max)	max	True	
	isProcessed	bit	1	False	((0))
	isError	bit	1	False	((0))
(2)	ReportDateTime	datetime	8	True	
	ReportUniqueID	nvarchar(50)	100	True	
	ReceiptDateTime	datetime	8	False	(getutcdate())
	APICallStart	datetime	8	True	
	APICallEnd	datetime	8	True	

Indexes

Key	Name	Columns	Unique
	PK__FATransa__490C26B0D5E9644A	FATransactionId	True
	UC_FATransaction	DeviceId, ReportUniqueID	True
	IX_FATransaction_DeviceId	DeviceId	
	IX_FATransaction_ReportDateTime	ReportDateTime	
	IX_FATransaction_ReportDateTime_DESC	DeviceId, ReportDateTime	

Foreign Keys

Name	No Check	Columns
FK_FATransaction_Device	True	DeviceId->[dbo].[Device].[DeviceId]

SQL Script

```
CREATE TABLE [dbo].[FATransaction]
(
[FATransactionId] [uniqueidentifier] NOT NULL CONSTRAINT [DF__FATransac__FATra__6754599E] DEFAULT (newid()),
[DeviceId] [int] NOT NULL CONSTRAINT [DF__FATransac__Devic__68487DD7] DEFAULT ((1)),
[AssetName] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[RecordType] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[TripData] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[Misc] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[isProcessed] [bit] NOT NULL CONSTRAINT [DF__FATransac__isPro__693CA210] DEFAULT ((0)),
[isError] [bit] NOT NULL CONSTRAINT [DF__FATransac__isErr__6A30C649] DEFAULT ((0)),
[ReportDateTime] [datetime] NULL,
[ReportUniqueID] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[ReceiptDateTime] [datetime] NOT NULL CONSTRAINT [DF__FATransac__Recei__6B24EA82] DEFAULT (getutcdate()),
[APICallStart] [datetime] NULL,
```

```
[APICallEnd] [datetime] NULL
)
GO
ALTER TABLE [dbo].[FATransaction] ADD CONSTRAINT [PK__FATransa__490C26B0D5E9644A] PRIMARY KEY CLUSTERED
([FATransactionId])
GO
ALTER TABLE [dbo].[FATransaction] ADD CONSTRAINT [UC_FATransaction] UNIQUE NONCLUSTERED  ([DeviceId], [Report-
UniqueID])
GO
CREATE NONCLUSTERED INDEX [IX_FATransaction_DeviceId] ON [dbo].[FATransaction] ([DeviceId])
GO
CREATE NONCLUSTERED INDEX [IX_FATransaction_ReportDateTime] ON [dbo].[FATransaction] ([ReportDateTime])
GO
CREATE NONCLUSTERED INDEX [IX_FATransaction_ReportDateTime_DESC] ON [dbo].[FATransaction] ([ReportDateTime] DESC)
INCLUDE ([DeviceId])
GO
ALTER TABLE [dbo].[FATransaction] WITH NOCHECK ADD CONSTRAINT [FK_FATransaction_Device] FOREIGN KEY ([Device-
Id]) REFERENCES [dbo].[Device] ([DeviceId])
GO
```

Uses

[dbo].[Device]

Used By

[dbo].[FAAccumulator]
[dbo].[PlowInfo]
[dbo].[SpreaderInfo]
[dbo].[spProcessFATrans]

D.5.1.1.12 [dbo].[Home]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	221
Created	6:48:53 PM Thursday, January 2, 2014
Last Modified	1:24:55 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls	Identity	Default
PK	HomeId	int	4	False	1 - 1	
FK	HomeTypeId	int	4	False		
FK	ODOTDistrictId	int	4	False		
FK	CountyId	int	4	False		((1))
	Name	nvarchar(50)	100	False		
	Description	nvarchar(max)	max	True		
	Contact_Name	nvarchar(50)	100	True		
	Contact_Email	nvarchar(50)	100	True		
	Contact_Phone	nvarchar(50)	100	True		
	Addr_Street	nvarchar(max)	max	True		
	Addr_City	nvarchar(50)	100	True		
	Addr_State	nvarchar(50)	100	True		
	Addr_Zip	nvarchar(50)	100	True		
	Location	geography	max	True		
	WashBay	bit	1	False		((0))
	LaneMiles	int	4	True		
	SaltCapacity-Tons	int	4	True		
	isActive	bit	1	True		((1))
	Modified	datetime	8	False		(getutcdate())
	ModifiedBy	nvarchar(50)	100	False		('System')
	Created	datetime	8	False		(getutcdate())
	CreatedBy	nvarchar(50)	100	False		('System')

Indexes

Key	Name	Columns	Unique
PK	PK__Home__105D64C2B97C2A5A	HomeId	True

Foreign Keys

Name	No Check	Columns
FK_Home_County	True	CountyId->[dbo].[County].[CountyId]
FK_Home_HomeType	True	HomeTypeId->[dbo].[HomeType].[HomeTypeId]
FK_Home_ODOTDistrict	True	ODOTDistrictId->[dbo].[ODOTDistrict].[ODOTDistrictId]

SQL Script

```
CREATE TABLE [dbo].[Home]
(
```

```sql
[HomeId] [int] NOT NULL IDENTITY(1, 1),
[HomeTypeId] [int] NOT NULL,
[ODOTDistrictId] [int] NOT NULL,
[CountyId] [int] NOT NULL CONSTRAINT [DF__Home__CountyId__46E78A0C] DEFAULT ((1)),
[Name] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[Description] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[Contact_Name] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[Contact_Email] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[Contact_Phone] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[Addr_Street] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[Addr_City] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[Addr_State] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[Addr_Zip] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[Location] [sys].[geography] NULL,
[WashBay] [bit] NOT NULL CONSTRAINT [DF__Home__WashBay__47DBAE45] DEFAULT ((0)),
[LaneMiles] [int] NULL,
[SaltCapacityTons] [int] NULL,
[isActive] [bit] NULL CONSTRAINT [DF__Home__isActive__48CFD27E] DEFAULT ((1)),
[Modified] [datetime] NOT NULL CONSTRAINT [DF__Home__Modified__49C3F6B7] DEFAULT (getutcdate()),
[ModifiedBy] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__Home__Modified-
By__4AB81AF0] DEFAULT ('System'),
[Created] [datetime] NOT NULL CONSTRAINT [DF__Home__Created__4BAC3F29] DEFAULT (getutcdate()),
[CreatedBy] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__Home__Created-
By__4CA06362] DEFAULT ('System')
)
GO
ALTER TABLE [dbo].[Home] ADD CONSTRAINT [PK__Home__105D64C2B97C2A5A] PRIMARY KEY CLUSTERED  ([HomeId])
GO
ALTER TABLE [dbo].[Home] WITH NOCHECK ADD CONSTRAINT [FK_Home_County] FOREIGN KEY ([CountyId]) REFERENCES
[dbo].[County] ([CountyId])
GO
ALTER TABLE [dbo].[Home] WITH NOCHECK ADD CONSTRAINT [FK_Home_HomeType] FOREIGN KEY ([HomeTypeId])
REFERENCES [dbo].[HomeType] ([HomeTypeId])
GO
ALTER TABLE [dbo].[Home] WITH NOCHECK ADD CONSTRAINT [FK_Home_ODOTDistrict] FOREIGN KEY ([ODOTDistrictId])
REFERENCES [dbo].[ODOTDistrict] ([ODOTDistrictId])
GO
```

Uses

[dbo].[County]
[dbo].[HomeType]
[dbo].[ODOTDistrict]

Used By

[dbo].[Truck]
[dbo].[User_Home]
[dbo].[vHomeTruck]

D.5.1.1.13 [dbo].[HomeType]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	4
Created	6:48:52 PM Thursday, January 2, 2014
Last Modified	1:24:32 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls	Default
PK C	HomeTypeId	int	4	False	
	Name	nvarchar(50)	100	False	
	Description	nvarchar(max)	max	True	
	Modified	datetime	8	False	(getutcdate())
	ModifiedBy	nvarchar(50)	100	False	('System')
	Created	datetime	8	False	(getutcdate())
	CreatedBy	nvarchar(50)	100	False	('System')

Indexes

Key	Name	Columns	Unique
PK C	PK__HomeType__61EFC112F2D6E320	HomeTypeId	True

SQL Script

```
CREATE TABLE [dbo].[HomeType]
(
[HomeTypeId] [int] NOT NULL,
[Name] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[Description] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[Modified] [datetime] NOT NULL CONSTRAINT [DF__HomeType__Modifi__38996AB5] DEFAULT (getutcdate()),
[ModifiedBy] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__HomeType__-
Modifi__398D8EEE] DEFAULT ('System'),
[Created] [datetime] NOT NULL CONSTRAINT [DF__HomeType__Create__3A81B327] DEFAULT (getutcdate()),
[CreatedBy] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__HomeType__-
Create__3B75D760] DEFAULT ('System')
)
GO
ALTER TABLE [dbo].[HomeType] ADD CONSTRAINT [PK__HomeType__61EFC112F2D6E320] PRIMARY KEY CLUSTERED
([HomeTypeId])
GO
```

Used By

[dbo].[Home]

D.5.1.1.14 [dbo].[Log]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	198021
Created	6:48:58 PM Thursday, January 2, 2014
Last Modified	1:10:39 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls	Identity	Default
PK	LogId	int	4	False	1 - 1	
FK	LogTypeId	int	4	False		
	Text	nvarchar(max)	max	False		
	TimeStamp	datetime	8	False		(getutcdate())

Indexes

Key	Name	Columns	Unique
PK	PK__Log__5E5486482038EF35	LogId	True
	IX_Log_TimeStamp	TimeStamp	

Foreign Keys

Name	No Check	Columns
FK_Log_LogType	True	LogTypeId->[dbo].[LogType].[LogTypeId]

SQL Script

```
CREATE TABLE [dbo].[Log]
(
[LogId] [int] NOT NULL IDENTITY(1, 1),
[LogTypeId] [int] NOT NULL,
[Text] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[TimeStamp] [datetime] NOT NULL CONSTRAINT [DF__Log__TimeStamp__123EB7A3] DEFAULT (getutcdate())
)
GO
ALTER TABLE [dbo].[Log] ADD CONSTRAINT [PK__Log__5E5486482038EF35] PRIMARY KEY CLUSTERED  ([LogId])
GO
CREATE NONCLUSTERED INDEX [IX_Log_TimeStamp] ON [dbo].[Log] ([TimeStamp])
GO
ALTER TABLE [dbo].[Log] WITH NOCHECK ADD CONSTRAINT [FK_Log_LogType] FOREIGN KEY ([LogTypeId]) REFERENCES
[dbo].[LogType] ([LogTypeId])
GO
```

Uses

[dbo].[LogType]

Used By

[dbo].[spProcessFATrans]
[dbo].[spProcessPWLocation]
[dbo].[spProcessPWTrans]

D.5.1.1.15 [dbo].[Logpoint]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	2112897
Created	6:48:56 PM Thursday, January 2, 2014
Last Modified	12:15:11 AM Friday, November 21, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls	Identity	Default
PK FK	LogpointId	int	4	False	1 - 1	
FK	ODOTDistrictId	int	4	False		
FK	CountyId	int	4	False		
FK	RouteTypeId	int	4	False		
	RouteName	nvarchar(50)	100	False		
	LogpointCounty-Num	float	8	False		
	Location	geography	max	False		
	isActive	bit	1	True		((1))
	Modified	datetime	8	False		(getutcdate())
	ModifiedBy	nvarchar(50)	100	False		('System')
	Created	datetime	8	False		(getutcdate())
	CreatedBy	nvarchar(50)	100	False		('System')

Indexes

Key	Name	Columns	Type	Unique
PK	PK__Logpoint__D862E24138E9770C	LogpointId		True
	sidx_Logpoint	Location	spatial	

Spatial Indexes

Name	Tessalation Scheme	Grids	Cells Per Object
sidx_-Logpoint	GEOGRAPHY_-GRID	level_1=HIGH, level_2=HIGH, level_3=HIGH, level_4=HIGH	16

Foreign Keys

Name	No Check	Columns
FK_Logpoint_County	True	CountyId->[dbo].[County].[CountyId]
FK_Logpoint_ODOTDistrict	True	ODOTDistrictId->[dbo].[ODOTDistrict].[ODOTDistrictId]
FK_Logpoint_RouteType	True	RouteTypeId->[dbo].[RouteType].[RouteTypeId]

SQL Script

```
CREATE TABLE [dbo].[Logpoint]
(
[LogpointId] [int] NOT NULL IDENTITY(1, 1),
[ODOTDistrictId] [int] NOT NULL,
[CountyId] [int] NOT NULL,
[RouteTypeId] [int] NOT NULL,
[RouteName] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
```

```
[LogpointCountyNum] [float] NOT NULL,
[Location] [sys].[geography] NOT NULL,
[isActive] [bit] NULL CONSTRAINT [DF__Logpoint__isActi__74AE54BC] DEFAULT ((1)),
[Modified] [datetime] NOT NULL CONSTRAINT [DF__Logpoint__Modifi__75A278F5] DEFAULT (getutcdate()),
[ModifiedBy] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__Logpoint__-
Modifi__76969D2E] DEFAULT ('System'),
[Created] [datetime] NOT NULL CONSTRAINT [DF__Logpoint__Create__778AC167] DEFAULT (getutcdate()),
[CreatedBy] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__Logpoint__-
Create__787EE5A0] DEFAULT ('System')
)
GO
ALTER TABLE [dbo].[Logpoint] ADD CONSTRAINT [PK__Logpoint__D862E24138E9770C] PRIMARY KEY CLUSTERED
([LogpointId])
GO
CREATE SPATIAL INDEX [sidx_Logpoint] ON [dbo].[Logpoint] ([Location]) WITH (GRIDS = (HIGH, HIGH, HIGH, HIGH), CELLS_-
PER_OBJECT = 16)
GO
ALTER TABLE [dbo].[Logpoint] WITH NOCHECK ADD CONSTRAINT [FK_Logpoint_County] FOREIGN KEY ([CountyId])
REFERENCES [dbo].[County] ([CountyId])
GO
ALTER TABLE [dbo].[Logpoint] WITH NOCHECK ADD CONSTRAINT [FK_Logpoint_ODOTDistrict] FOREIGN KEY
([ODOTDistrictId]) REFERENCES [dbo].[ODOTDistrict] ([ODOTDistrictId])
GO
ALTER TABLE [dbo].[Logpoint] WITH NOCHECK ADD CONSTRAINT [FK_Logpoint_RouteType] FOREIGN KEY ([RouteTypeId])
REFERENCES [dbo].[RouteType] ([RouteTypeId])
GO
```

Uses

[dbo].[County]
[dbo].[ODOTDistrict]
[dbo].[RouteType]

Used By

[dbo].[TruckLocation]
[dbo].[fFA_Location]
[dbo].[fPW_Location]
[dbo].[spGenerateFASegment]
[dbo].[spProcessFATrans]
[dbo].[spProcessPWLocation]
[dbo].[spUpdateLocationLogpoints]
[dbo].[vFA_Location]
[dbo].[vPW_Location]

D.5.1.1.16	[dbo].[LogType]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	5
Created	6:48:58 PM Thursday, January 2, 2014
Last Modified	1:10:34 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK C	LogTypeId	int	4	False
	Name	nvarchar(50)	100	False

Indexes

Key	Name	Columns	Unique
PK C	PK__LogType__AE957494FCA864C2	LogTypeId	True

SQL Script

```
CREATE TABLE [dbo].[LogType]
(
[LogTypeId] [int] NOT NULL,
[Name] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL
)
GO
ALTER TABLE [dbo].[LogType] ADD CONSTRAINT [PK__LogType__AE957494FCA864C2] PRIMARY KEY CLUSTERED  ([Log-
TypeId])
GO
```

Used By

[dbo].[Log]

D.5.1.1.17 [dbo].[LoopOperation]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	3
Created	6:48:57 PM Thursday, January 2, 2014
Last Modified	6:49:14 PM Thursday, January 2, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK C	LoopOperationId	int	4	False
	Name	nvarchar(50)	100	False

Indexes

Key	Name	Columns	Unique
PK C	PK__LoopOper__28F13E0CC372C4DC	LoopOperationId	True

SQL Script

```
CREATE TABLE [dbo].[LoopOperation]
(
[LoopOperationId] [int] NOT NULL,
[Name] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL
)
GO
ALTER TABLE [dbo].[LoopOperation] ADD CONSTRAINT [PK__LoopOper__28F13E0CC372C4DC] PRIMARY KEY CLUSTERED
([LoopOperationId])
GO
```

Used By

[dbo].[SpreaderInfo]

D.5.1.1.18 [dbo].[ODOTCounty]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	88
Created	6:49:02 PM Thursday, January 2, 2014
Last Modified	1:24:55 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK	Abbr	nvarchar(3)	6	False
PK FK	CountyId	int	4	False

Indexes

Key	Name	Columns	Unique
PK	PK__ODOTCoun__15D5F512EF09F112	Abbr, CountyId	True

Foreign Keys

Name	No Check	Columns
FK_ODOTCounty_County	True	CountyId->[dbo].[County].[CountyId]

SQL Script

```
CREATE TABLE [dbo].[ODOTCounty]
(
[Abbr] [nvarchar] (3) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[CountyId] [int] NOT NULL
)
GO
ALTER TABLE [dbo].[ODOTCounty] ADD CONSTRAINT [PK__ODOTCoun__15D5F512EF09F112] PRIMARY KEY CLUSTERED
([Abbr], [CountyId])
GO
ALTER TABLE [dbo].[ODOTCounty] WITH NOCHECK ADD CONSTRAINT [FK_ODOTCounty_County] FOREIGN KEY ([CountyId])
REFERENCES [dbo].[County] ([CountyId])
GO
```

Uses

[dbo].[County]

D.5.1.1.19 [dbo].[ODOTDistrict]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	12
Created	6:48:52 PM Thursday, January 2, 2014
Last Modified	1:24:55 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls	Default
PK C	ODOTDistrictId	int	4	False	
	Name	nvarchar(50)	100	False	
	Description	nvarchar(max)	max	True	
	ColorCode	nvarchar(10)	20	True	
	CenterLocation	geography	max	True	
	isActive	bit	1	True	((1))
	Modified	datetime	8	False	(getutcdate())
	ModifiedBy	nvarchar(50)	100	False	('System')
	Created	datetime	8	False	(getutcdate())
	CreatedBy	nvarchar(50)	100	False	('System')

Indexes

Key	Name	Columns	Unique
PK C	PK__ODOTDist__A10F240B0A76280B	ODOTDistrictId	True

SQL Script

```
CREATE TABLE [dbo].[ODOTDistrict]
(
[ODOTDistrictId] [int] NOT NULL,
[Name] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[Description] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[ColorCode] [nvarchar] (10) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[CenterLocation] [sys].[geography] NULL,
[isActive] [bit] NULL CONSTRAINT [DF__ODOTDistr__isAct__403A8C7D] DEFAULT ((1)),
[Modified] [datetime] NOT NULL CONSTRAINT [DF__ODOTDistr__Modif__412EB0B6] DEFAULT (getutcdate()),
[ModifiedBy] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__ODOTDistr__-
Modif__4222D4EF] DEFAULT ('System'),
[Created] [datetime] NOT NULL CONSTRAINT [DF__ODOTDistr__Creat__4316F928] DEFAULT (getutcdate()),
[CreatedBy] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__ODOTDistr__-
Creat__440B1D61] DEFAULT ('System')
)
GO
ALTER TABLE [dbo].[ODOTDistrict] ADD CONSTRAINT [PK__ODOTDist__A10F240B0A76280B] PRIMARY KEY CLUSTERED
([ODOTDistrictId])
GO
```

Used By

[dbo].[Home]
[dbo].[Logpoint]
[dbo].[ODOTDistrict_County]
[dbo].[Truck]
[dbo].[vOhioDistrictCounty]

D.5.1.1.20	[dbo].[ODOTDistrict_County]

Properties

Property	Value
Row Count (~)	88
Created	6:49:00 PM Thursday, January 2, 2014
Last Modified	1:10:43 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK FK C	ODOTDistrictId	int	4	False
PK FK C	CountyId	int	4	False

Indexes

Key	Name	Columns	Unique
PK C	PK__ODOTDist__CA67DDD27CF090BE	ODOTDistrictId, CountyId	True

Foreign Keys

Name	No Check	Columns
FK_ODOTDistrict_County_County	True	CountyId->[dbo].[County].[CountyId]
FK_ODOTDistrict_County_-ODOTDistrict	True	ODOTDistrictId->[dbo].[ODOTDistrict].[ODOTDistrict-Id]

SQL Script

```
CREATE TABLE [dbo].[ODOTDistrict_County]
(
[ODOTDistrictId] [int] NOT NULL,
[CountyId] [int] NOT NULL
)
GO
ALTER TABLE [dbo].[ODOTDistrict_County] ADD CONSTRAINT [PK__ODOTDist__CA67DDD27CF090BE] PRIMARY KEY
CLUSTERED  ([ODOTDistrictId], [CountyId])
GO
ALTER TABLE [dbo].[ODOTDistrict_County] WITH NOCHECK ADD CONSTRAINT [FK_ODOTDistrict_County_County] FOREIGN
KEY ([CountyId]) REFERENCES [dbo].[County] ([CountyId])
GO
ALTER TABLE [dbo].[ODOTDistrict_County] WITH NOCHECK ADD CONSTRAINT [FK_ODOTDistrict_County_ODOTDistrict]
FOREIGN KEY ([ODOTDistrictId]) REFERENCES [dbo].[ODOTDistrict] ([ODOTDistrictId])
GO
```

Uses

[dbo].[County]
[dbo].[ODOTDistrict]

Used By

[dbo].[vOhioDistrictCounty]

D.5.1.1.21 [dbo].[Original_Report661]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	7
Created	7:04:48 PM Monday, January 13, 2014
Last Modified	1:24:55 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls	Default
	ReportId	uniqueidentifier	16	False	(newid())
	ReportDate	datetime	8	False	(getutcdate())
	ShiftStart	datetime	8	True	(getutcdate())
	ShiftEnd	datetime	8	True	(getutcdate())
	DriverId	int	4	True	
	TruckId	int	4	False	
	CountyId	int	4	True	
	Fuel	float	8	False	((0))
	MileageStart	float	8	False	((0))
	MileageEnd	float	8	False	((0))
	MileageTotal	float	8	False	((0))
	SaltTotal	float	8	False	((0))
	SaltTotalLBS	float	8	False	((0))
	SaltTotalMiles	float	8	False	((0))
	CalciumTotal	float	8	False	((0))
	BrineTotal	float	8	False	((0))
	AbrasivesTotal	float	8	False	((0))
	LegacyPPLM	float	8	False	((0))
	PPLM	float	8	False	((0))
	Comments	nvarchar(max)	max	True	('')
	ReportStatusId	int	4	False	((0))
	isActive	bit	1	True	((1))
	Modified	datetime	8	False	(getutcdate())
	ModifiedBy	nvarchar(50)	100	False	('System')
	Created	datetime	8	False	(getutcdate())
	CreatedBy	nvarchar(50)	100	False	('System')

Indexes

Key	Name	Columns	Unique
	PK__tmp_ms_x__D5BD48058A695847	ReportId	True
	IX_Original_Report611_ReportDate	ReportDate	

Foreign Keys

Name	No Check	Columns
FK_Original_Report661_County	True	CountyId->[dbo].[County].[CountyId]
FK_Original_Report661_Driver	True	DriverId->[dbo].[Driver].[DriverId]
FK_Original_Report661_ReportStatus	True	ReportStatusId->[dbo].[ReportStatus].[ReportStatusId]
FK_Original_Report661_Truck	True	TruckId->[dbo].[Truck].[TruckId]

SQL Script

```
CREATE TABLE [dbo].[Original_Report661]
(
[ReportId] [uniqueidentifier] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Repor__3C89F72A] DEFAULT (newid()),
[ReportDate] [datetime] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Repor__3D7E1B63] DEFAULT (getutcdate()),
[ShiftStart] [datetime] NULL CONSTRAINT [DF__tmp_ms_xx__Shift__3E723F9C] DEFAULT (getutcdate()),
[ShiftEnd] [datetime] NULL CONSTRAINT [DF__tmp_ms_xx__Shift__3F6663D5] DEFAULT (getutcdate()),
[DriverId] [int] NULL,
[TruckId] [int] NOT NULL,
[CountyId] [int] NULL,
[Fuel] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx___Fuel__405A880E] DEFAULT ((0)),
[MileageStart] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Milea__414EAC47] DEFAULT ((0)),
[MileageEnd] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Milea__4242D080] DEFAULT ((0)),
[MileageTotal] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Milea__4336F4B9] DEFAULT ((0)),
[SaltTotal] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx__SaltT__442B18F2] DEFAULT ((0)),
[SaltTotalLBS] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx__SaltT__451F3D2B] DEFAULT ((0)),
[SaltTotalMiles] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx__SaltT__46136164] DEFAULT ((0)),
[CalciumTotal] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Calci__4707859D] DEFAULT ((0)),
[BrineTotal] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Brine__47FBA9D6] DEFAULT ((0)),
[AbrasivesTotal] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Abras__48EFCE0F] DEFAULT ((0)),
[LegacyPPLM] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Legac__49E3F248] DEFAULT ((0)),
[PPLM] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx___PPLM__4AD81681] DEFAULT ((0)),
[Comments] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NULL CONSTRAINT [DF__tmp_ms_xx__-
Comme__4BCC3ABA] DEFAULT (''),
[ReportStatusId] [int] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Repor__4CC05EF3] DEFAULT ((0)),
[isActive] [bit] NULL CONSTRAINT [DF__tmp_ms_xx__isAct__4DB4832C] DEFAULT ((1)),
[Modified] [datetime] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Modif__4EA8A765] DEFAULT (getutcdate()),
[ModifiedBy] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__tmp_ms_xx__-
Modif__4F9CCB9E] DEFAULT ('System'),
[Created] [datetime] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Creat__5090EFD7] DEFAULT (getutcdate()),
[CreatedBy] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__tmp_ms_xx__-
Creat__51851410] DEFAULT ('System')
)
GO
ALTER TABLE [dbo].[Original_Report661] ADD CONSTRAINT [PK__tmp_ms_x__D5BD48058A695847] PRIMARY KEY
CLUSTERED  ([ReportId])
GO
CREATE NONCLUSTERED INDEX [IX_Original_Report611_ReportDate] ON [dbo].[Original_Report661] ([ReportDate])
GO
ALTER TABLE [dbo].[Original_Report661] WITH NOCHECK ADD CONSTRAINT [FK_Original_Report661_County] FOREIGN KEY
([CountyId]) REFERENCES [dbo].[County] ([CountyId])
GO
ALTER TABLE [dbo].[Original_Report661] WITH NOCHECK ADD CONSTRAINT [FK_Original_Report661_Driver] FOREIGN KEY
([DriverId]) REFERENCES [dbo].[Driver] ([DriverId])
GO
ALTER TABLE [dbo].[Original_Report661] WITH NOCHECK ADD CONSTRAINT [FK_Original_Report661_ReportStatus] FOREIGN
KEY ([ReportStatusId]) REFERENCES [dbo].[ReportStatus] ([ReportStatusId])
GO
ALTER TABLE [dbo].[Original_Report661] WITH NOCHECK ADD CONSTRAINT [FK_Original_Report661_Truck] FOREIGN KEY
([TruckId]) REFERENCES [dbo].[Truck] ([TruckId])
GO
```

Uses

[dbo].[County]
[dbo].[Driver]
[dbo].[ReportStatus]
[dbo].[Truck]

Used By

[dbo].[Original_SegmentEntry]

D.5.1.1.22 [dbo].[Original_SegmentEntry]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	321
Created	7:04:48 PM Monday, January 13, 2014
Last Modified	1:24:56 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls	Default
	SegmentEntryId	uniqueidentifier	16	False	(newid())
	ReportId	uniqueidentifier	16	False	
	TimeOn	datetime	8	False	
	TimeOff	datetime	8	False	
	Route	nvarchar(50)	100	False	('')
	LocationFrom	nvarchar(max)	max	False	('')
	LocationTo	nvarchar(max)	max	False	('')
	RoadConditionId	int	4	False	
	RoadTreatmentId	int	4	False	
	Salt	float	8	False	((0))
	Calcium	float	8	False	((0))
	Brine	float	8	False	((0))
	Abrasives	float	8	False	((0))
	Mileage	float	8	False	((0))
	SaltMileage	float	8	False	((0))
	PPLM	float	8	False	((0))
	Location	nvarchar(max)	max	True	('')
	isActive	bit	1	False	((0))
	Modified	datetime	8	False	(getutcdate())
	ModifiedBy	nvarchar(50)	100	False	('System')
	Created	datetime	8	False	(getutcdate())
	CreatedBy	nvarchar(50)	100	False	('System')
	MaxSpeedMPH	float	8	False	((0.0))
	MaxAppRate	int	4	False	((0))

Indexes

Key	Name	Columns	Unique
	PK__tmp_ms_x__62BBC06576AE851A	SegmentEntryId	True
	IX_Original_SegmentEntry_ReportId	ReportId	

Foreign Keys

Name	No Check	Columns
FK_Original_SegmentEntry_User_-Report661	True	ReportId->[dbo].[Original_Report661].[ReportId]
FK_Original_SegmentEntry_Road-Condition	True	RoadConditionId->[dbo].[RoadCondition].[Road-ConditionId]
FK_Original_SegmentEntry_Road-Treatment	True	RoadTreatmentId->[dbo].[RoadTreatment].[Road-TreatmentId]

SQL Script

```
CREATE TABLE [dbo].[Original_SegmentEntry]
(
[SegmentEntryId] [uniqueidentifier] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Segme__546180BB] DEFAULT (newid()),
[ReportId] [uniqueidentifier] NOT NULL,
[TimeOn] [datetime] NOT NULL,
[TimeOff] [datetime] NOT NULL,
[Route] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__tmp_ms_xx__Route__5555A4F4]
DEFAULT (''),
[LocationFrom] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__tmp_ms_xx__-
Locat__5649C92D] DEFAULT (''),
[LocationTo] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__tmp_ms_xx__-
Locat__573DED66] DEFAULT (''),
[RoadConditionId] [int] NOT NULL,
[RoadTreatmentId] [int] NOT NULL,
[Salt] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx___Salt__5832119F] DEFAULT ((0)),
[Calcium] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Calci__592635D8] DEFAULT ((0)),
[Brine] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Brine__5A1A5A11] DEFAULT ((0)),
[Abrasives] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Abras__5B0E7E4A] DEFAULT ((0)),
[Mileage] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Milea__5C02A283] DEFAULT ((0)),
[SaltMileage] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx__SaltM__5CF6C6BC] DEFAULT ((0)),
[PPLM] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx___PPLM__5DEAEAF5] DEFAULT ((0)),
[Location] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NULL CONSTRAINT [DF__tmp_ms_xx__Locat__5EDF0F2E]
DEFAULT (''),
[isActive] [bit] NOT NULL CONSTRAINT [DF__tmp_ms_xx__isAct__5FD33367] DEFAULT ((0)),
[Modified] [datetime] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Modif__60C757A0] DEFAULT (getutcdate()),
[ModifiedBy] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__tmp_ms_xx__-
Modif__61BB7BD9] DEFAULT ('System'),
[Created] [datetime] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Creat__62AFA012] DEFAULT (getutcdate()),
[CreatedBy] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__tmp_ms_xx__-
Creat__63A3C44B] DEFAULT ('System'),
[MaxSpeedMPH] [float] NOT NULL CONSTRAINT [DF__Original___MaxSp__76818E95] DEFAULT ((0.0)),
[MaxAppRate] [int] NOT NULL CONSTRAINT [DF__Original___MaxAp__7775B2CE] DEFAULT ((0))
)
GO
ALTER TABLE [dbo].[Original_SegmentEntry] ADD CONSTRAINT [PK__tmp_ms_x__62BBC06576AE851A] PRIMARY KEY
CLUSTERED  ([SegmentEntryId])
GO
CREATE NONCLUSTERED INDEX [IX_Original_SegmentEntry_ReportId] ON [dbo].[Original_SegmentEntry] ([ReportId])
GO
ALTER TABLE [dbo].[Original_SegmentEntry] WITH NOCHECK ADD CONSTRAINT [FK_Original_SegmentEntry_User_Report661]
FOREIGN KEY ([ReportId]) REFERENCES [dbo].[Original_Report661] ([ReportId])
GO
ALTER TABLE [dbo].[Original_SegmentEntry] WITH NOCHECK ADD CONSTRAINT [FK_Original_SegmentEntry_RoadCondition]
FOREIGN KEY ([RoadConditionId]) REFERENCES [dbo].[RoadCondition] ([RoadConditionId])
GO
ALTER TABLE [dbo].[Original_SegmentEntry] WITH NOCHECK ADD CONSTRAINT [FK_Original_SegmentEntry_RoadTreatment]
FOREIGN KEY ([RoadTreatmentId]) REFERENCES [dbo].[RoadTreatment] ([RoadTreatmentId])
GO
```

Uses

[dbo].[Original_Report661]
[dbo].[RoadCondition]
[dbo].[RoadTreatment]

D.5.1.1.23 [dbo].[PlowInfo]

Properties

Property	Value
Row Count (~)	1156020
Created	6:48:58 PM Thursday, January 2, 2014
Last Modified	10:18:00 PM Thursday, November 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls	Default
	PlowInfoId	uniqueidentifier	16	False	(newid())
	DeviceId	int	4	False	
	LocationId	uniqueidentifier	16	False	
	FATransactionId	uniqueidentifier	16	True	
	PlowStatusId	int	4	False	
	PlowHorizontalAngle	int	4	True	
	PlowVerticalAngle	int	4	True	
	DeviceTime	datetime	8	True	
	ReportTime	datetime	8	True	
	SysTime	datetime	8	False	(getutcdate())

Indexes

Key	Name	Columns	Unique
	PK__PlowInfo__EC50791E35D95889	PlowInfoId	True
	DeviceTime_DESC_PlowInfo	DeviceId, DeviceTime	

Foreign Keys

Name	No Check	Columns
FK_PlowInfo_Device	True	DeviceId->[dbo].[Device].[DeviceId]
FK_PlowInfo_FATransaction	True	FATransactionId->[dbo].[FATransaction].[FATransactionId]
FK_PlowInfo_TruckLocation	True	LocationId->[dbo].[TruckLocation].[TruckLocationId]
FK_PlowInfo_PlowStatus	True	PlowStatusId->[dbo].[PlowStatus].[PlowStatusId]

SQL Script

```
CREATE TABLE [dbo].[PlowInfo]
(
[PlowInfoId] [uniqueidentifier] NOT NULL CONSTRAINT [DF__PlowInfo__PlowIn__0C85DE4D] DEFAULT (newid()),
[DeviceId] [int] NOT NULL,
[LocationId] [uniqueidentifier] NOT NULL,
[FATransactionId] [uniqueidentifier] NULL,
[PlowStatusId] [int] NOT NULL,
[PlowHorizontalAngle] [int] NULL,
[PlowVerticalAngle] [int] NULL,
[DeviceTime] [datetime] NULL,
[ReportTime] [datetime] NULL,
[SysTime] [datetime] NOT NULL CONSTRAINT [DF__PlowInfo__SysTim__0D7A0286] DEFAULT (getutcdate())
)
GO
ALTER TABLE [dbo].[PlowInfo] ADD CONSTRAINT [PK__PlowInfo__EC50791E35D95889] PRIMARY KEY CLUSTERED  ([Plow-
InfoId])
GO
CREATE NONCLUSTERED INDEX [DeviceTime_DESC_PlowInfo] ON [dbo].[PlowInfo] ([DeviceId], [DeviceTime] DESC)
GO
```

```
ALTER TABLE [dbo].[PlowInfo] WITH NOCHECK ADD CONSTRAINT [FK_PlowInfo_Device] FOREIGN KEY ([DeviceId])
REFERENCES [dbo].[Device] ([DeviceId])
GO
ALTER TABLE [dbo].[PlowInfo] WITH NOCHECK ADD CONSTRAINT [FK_PlowInfo_FATransaction] FOREIGN KEY
([FATransactionId]) REFERENCES [dbo].[FATransaction] ([FATransactionId])
GO
ALTER TABLE [dbo].[PlowInfo] WITH NOCHECK ADD CONSTRAINT [FK_PlowInfo_TruckLocation] FOREIGN KEY ([LocationId])
REFERENCES [dbo].[TruckLocation] ([TruckLocationId])
GO
ALTER TABLE [dbo].[PlowInfo] WITH NOCHECK ADD CONSTRAINT [FK_PlowInfo_PlowStatus] FOREIGN KEY ([PlowStatusId])
REFERENCES [dbo].[PlowStatus] ([PlowStatusId])
GO
```

Uses

[dbo].[Device]
[dbo].[FATransaction]
[dbo].[PlowStatus]
[dbo].[TruckLocation]

Used By

[dbo].[fFA_Plow]
[dbo].[spProcessFATrans]

D.5.1.1.24 [dbo].[PlowStatus]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	4
Created	6:48:58 PM Thursday, January 2, 2014
Last Modified	1:02:27 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK C	PlowStatusId	int	4	False
	Name	nvarchar(50)	100	False

Indexes

Key	Name	Columns	Unique
PK C	PK__PlowStat__AE36823D6C19367C	PlowStatusId	True

SQL Script

```
CREATE TABLE [dbo].[PlowStatus]
(
[PlowStatusId] [int] NOT NULL,
[Name] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL
)
GO
ALTER TABLE [dbo].[PlowStatus] ADD CONSTRAINT [PK__PlowStat__AE36823D6C19367C] PRIMARY KEY CLUSTERED  ([PlowStatusId])
GO
```

Used By

[dbo].[PlowInfo]

D.5.1.1.25 [dbo].[PWAnalog]

Properties

Property	Value
Row Count (~)	887357
Created	3:57:07 PM Tuesday, January 21, 2014
Last Modified	5:57:47 PM Monday, January 27, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls	Default
PK/FK	PWAnalogId	uniqueidentifier	16	False	(newid())
FK	PWTransactionId	uniqueidentifier	16	False	
FK	DeviceId	int	4	False	
	Volt1	float	8	False	((0.0))
	Volt2	float	8	False	((0.0))
	Volt3	float	8	False	((0.0))
	Volt4	float	8	False	((0.0))
	ReceiptDateTime	datetime	8	False	(getutcdate())

Indexes

Key	Name	Columns	Unique
PK	PK__PWAnalog__2BD220C7408AD4BF	PWAnalogId	True

Foreign Keys

Name	No Check	Columns
FK_PWAnalog_Device	True	DeviceId->[dbo].[Device].[DeviceId]
FK_PWAnalog_PWTransaction		PWTransactionId->[dbo].[PWTransaction].[PWTransactionId]

SQL Script

```
CREATE TABLE [dbo].[PWAnalog]
(
[PWAnalogId] [uniqueidentifier] NOT NULL CONSTRAINT [DF__PWAnalog__PWAnal__7E57BA87] DEFAULT (newid()),
[PWTransactionId] [uniqueidentifier] NOT NULL,
[DeviceId] [int] NOT NULL,
[Volt1] [float] NOT NULL CONSTRAINT [DF__PWAnalog__Volt1__7F4BDEC0] DEFAULT ((0.0)),
[Volt2] [float] NOT NULL CONSTRAINT [DF__PWAnalog__Volt2__004002F9] DEFAULT ((0.0)),
[Volt3] [float] NOT NULL CONSTRAINT [DF__PWAnalog__Volt3__01342732] DEFAULT ((0.0)),
[Volt4] [float] NOT NULL CONSTRAINT [DF__PWAnalog__Volt4__02284B6B] DEFAULT ((0.0)),
[ReceiptDateTime] [datetime] NOT NULL CONSTRAINT [DF__PWAnalog__Receip__031C6FA4] DEFAULT (getutcdate())
)
GO
ALTER TABLE [dbo].[PWAnalog] ADD CONSTRAINT [PK__PWAnalog__2BD220C7408AD4BF] PRIMARY KEY CLUSTERED
([PWAnalogId])
GO
ALTER TABLE [dbo].[PWAnalog] WITH NOCHECK ADD CONSTRAINT [FK_PWAnalog_Device] FOREIGN KEY ([DeviceId])
REFERENCES [dbo].[Device] ([DeviceId])
GO
ALTER TABLE [dbo].[PWAnalog] ADD CONSTRAINT [FK_PWAnalog_PWTransaction] FOREIGN KEY ([PWTransactionId])
REFERENCES [dbo].[PWTransaction] ([PWTransactionId])
GO
```

Uses

[dbo].[Device]
[dbo].[PWTransaction]

D.5.1.1.26 [dbo].[PWRoadWatch]

Properties

Property	Value
Row Count (~)	106844
Created	4:26:31 PM Wednesday, November 19, 2014
Last Modified	4:26:32 PM Wednesday, November 19, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls	Default
PK	PWRoadWatchId	uniqueidentifier	16	False	(newid())
FK	PWTransactionId	uniqueidentifier	16	False	
FK	DeviceId	int	4	False	
	AmbientTempFaren	int	4	True	
	RoadTempFaren	int	4	True	
	DeviceTime	datetime	8	True	
	ReceiptDateTime	datetime	8	False	(getutcdate())

Indexes

Key	Name	Columns	Unique
PK	PK__PWRoadWa__CE3BD0B535F124F1	PWRoadWatchId	True

Foreign Keys

Name	No Check	Columns
FK_PWRoadWatch_Device	True	DeviceId->[dbo].[Device].[DeviceId]
FK_PWRoadWatch_PWTransaction	True	PWTransactionId->[dbo].[PWTransaction].[PWTransactionId]

SQL Script

```
CREATE TABLE [dbo].[PWRoadWatch]
(
[PWRoadWatchId] [uniqueidentifier] NOT NULL CONSTRAINT [DF__PWRoadWat__PWRoa__44B528D7] DEFAULT (newid()),
[PWTransactionId] [uniqueidentifier] NOT NULL,
[DeviceId] [int] NOT NULL,
[AmbientTempFaren] [int] NULL,
[RoadTempFaren] [int] NULL,
[DeviceTime] [datetime] NULL,
[ReceiptDateTime] [datetime] NOT NULL CONSTRAINT [DF__PWRoadWat__Recei__45A94D10] DEFAULT (getutcdate())
)
GO
ALTER TABLE [dbo].[PWRoadWatch] ADD CONSTRAINT [PK__PWRoadWa__CE3BD0B535F124F1] PRIMARY KEY CLUSTERED
([PWRoadWatchId])
GO
ALTER TABLE [dbo].[PWRoadWatch] WITH NOCHECK ADD CONSTRAINT [FK_PWRoadWatch_Device] FOREIGN KEY ([Device-
Id]) REFERENCES [dbo].[Device] ([DeviceId])
GO
ALTER TABLE [dbo].[PWRoadWatch] WITH NOCHECK ADD CONSTRAINT [FK_PWRoadWatch_PWTransaction] FOREIGN KEY
([PWTransactionId]) REFERENCES [dbo].[PWTransaction] ([PWTransactionId])
GO
```

Uses

[dbo].[Device]
[dbo].[PWTransaction]

D.5.1.1.27 [dbo].[PWSpreaderInfo]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	416974
Created	9:23:28 PM Thursday, January 16, 2014
Last Modified	4:25:01 PM Tuesday, January 28, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls	Default
PK	PWSpreaderInfoId	uniqueidentifier	16	False	(newid())
FK	PWTransactionId	uniqueidentifier	16	False	
FK	DeviceId	int	4	False	
	UnitId	nvarchar(50)	100	False	
	WeekDay	nvarchar(50)	100	False	
	Speed	float	8	False	
	SpreadRate	int	4	False	
	SpreadAlert	bit	1	False	
	AugerOn	bit	1	False	
	SpinnerOn	bit	1	False	
	WettingOn	bit	1	False	
	SpinnerRate	int	4	False	
	WetSpreadRateGPM	int	4	False	
	WetSpreadRateGPT	int	4	False	
	DeviceTime	datetime	8	True	
	ReceiptDateTime	datetime	8	False	(getutcdate())

Indexes

Key	Name	Columns	Unique
PK	PK__tmp_ms_x__5140309EFA7FEFC4	PWSpreaderInfoId	True

Foreign Keys

Name	No Check	Columns
FK_PWSpreaderInfo_Device	True	DeviceId->[dbo].[Device].[DeviceId]
FK_PWSpreaderInfo_-PWTransaction	True	PWTransactionId->[dbo].[PWTransaction].[PWTransaction-Id]

SQL Script

```
CREATE TABLE [dbo].[PWSpreaderInfo]
(
[PWSpreaderInfoId] [uniqueidentifier] NOT NULL CONSTRAINT [DF__tmp_ms_xx__PWSpr__72E607DB] DEFAULT (newid()),
[PWTransactionId] [uniqueidentifier] NOT NULL,
[DeviceId] [int] NOT NULL,
[UnitId] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[WeekDay] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[Speed] [float] NOT NULL,
[SpreadRate] [int] NOT NULL,
[SpreadAlert] [bit] NOT NULL,
[AugerOn] [bit] NOT NULL,
[SpinnerOn] [bit] NOT NULL,
```

```
[WettingOn] [bit] NOT NULL,
[SpinnerRate] [int] NOT NULL,
[WetSpreadRateGPM] [int] NOT NULL,
[WetSpreadRateGPT] [int] NOT NULL,
[DeviceTime] [datetime] NULL,
[ReceiptDateTime] [datetime] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Recei__73DA2C14] DEFAULT (getutcdate())
)
GO
ALTER TABLE [dbo].[PWSpreaderInfo] ADD CONSTRAINT [PK__tmp_ms_x__5140309EFA7FEFC4] PRIMARY KEY CLUSTERED
([PWSpreaderInfoId])
GO
ALTER TABLE [dbo].[PWSpreaderInfo] WITH NOCHECK ADD CONSTRAINT [FK_PWSpreaderInfo_Device] FOREIGN KEY
([DeviceId]) REFERENCES [dbo].[Device] ([DeviceId])
GO
ALTER TABLE [dbo].[PWSpreaderInfo] WITH NOCHECK ADD CONSTRAINT [FK_PWSpreaderInfo_PWTransaction] FOREIGN KEY
([PWTransactionId]) REFERENCES [dbo].[PWTransaction] ([PWTransactionId])
GO
```

Uses

[dbo].[Device]
[dbo].[PWTransaction]

Used By

[dbo].[fPW_Spreader]
[dbo].[spGenerateFASegment]

D.5.1.1.28 [dbo].[PWTransaction]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	5631382
Created	10:37:21 PM Friday, January 10, 2014
Last Modified	12:14:47 AM Friday, November 21, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls	Default
	PWTransactionId	uniqueidentifier	16	False	(newid())
(2)	DeviceId	int	4	False	
	RecordType	nvarchar(max)	max	False	
	Msg	nvarchar(max)	max	False	
	isProcessed	bit	1	False	((0))
	isError	bit	1	False	((0))
	ReceiptDateTime	datetime	8	False	(getutcdate())

Indexes

Key	Name	Columns	Unique
	PK__tmp_ms_x__8BB011D2E3E13B0C	PWTransactionId	True
	IX_PWTransaction_DeviceId	DeviceId	
	IX_PWTransaction_ReceiptDateTime_DESC	DeviceId, ReceiptDateTime	

Foreign Keys

Name	No Check	Columns
FK_PWTransaction_Device	True	DeviceId->[dbo].[Device].[DeviceId]

SQL Script

```
CREATE TABLE [dbo].[PWTransaction]
(
[PWTransactionId] [uniqueidentifier] NOT NULL CONSTRAINT [DF__tmp_ms_xx__PWTra__30242045] DEFAULT (newid()),
[DeviceId] [int] NOT NULL,
[RecordType] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[Msg] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[isProcessed] [bit] NOT NULL CONSTRAINT [DF__tmp_ms_xx__isPro__3118447E] DEFAULT ((0)),
[isError] [bit] NOT NULL CONSTRAINT [DF__tmp_ms_xx__isErr__320C68B7] DEFAULT ((0)),
[ReceiptDateTime] [datetime] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Recei__33008CF0] DEFAULT (getutcdate())
)
GO
ALTER TABLE [dbo].[PWTransaction] ADD CONSTRAINT [PK__tmp_ms_x__8BB011D2E3E13B0C] PRIMARY KEY CLUSTERED
([PWTransactionId])
GO
CREATE NONCLUSTERED INDEX [IX_PWTransaction_DeviceId] ON [dbo].[PWTransaction] ([DeviceId])
GO
CREATE NONCLUSTERED INDEX [IX_PWTransaction_ReceiptDateTime_DESC] ON [dbo].[PWTransaction] ([ReceiptDateTime]
DESC) INCLUDE ([DeviceId])
GO
ALTER TABLE [dbo].[PWTransaction] WITH NOCHECK ADD CONSTRAINT [FK_PWTransaction_Device] FOREIGN KEY ([Device-
Id]) REFERENCES [dbo].[Device] ([DeviceId])
GO
```

Uses

[dbo].[Device]

Used By

[dbo].[PWAnalog]
[dbo].[PWRoadWatch]
[dbo].[PWSpreaderInfo]
[dbo].[spProcessPWTrans]

D.5.1.1.29 [dbo].[Report661]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	2481
Created	7:53:12 PM Tuesday, January 7, 2014
Last Modified	1:24:56 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls	Default
	ReportId	uniqueidentifier	16	False	(newid())
	ReportDate	datetime	8	False	(getutcdate())
	ShiftStart	datetime	8	True	(getutcdate())
	ShiftEnd	datetime	8	True	(getutcdate())
	DriverId	int	4	True	
	TruckId	int	4	False	
	CountyId	int	4	True	
	Fuel	float	8	False	((0))
	MileageStart	float	8	False	((0))
	MileageEnd	float	8	False	((0))
	MileageTotal	float	8	False	((0))
	SaltTotal	float	8	False	((0))
	SaltTotalLBS	float	8	False	((0))
	SaltTotalMiles	float	8	False	((0))
	CalciumTotal	float	8	False	((0))
	BrineTotal	float	8	False	((0))
	AbrasivesTotal	float	8	False	((0))
	LegacyPPLM	float	8	False	((0))
	PPLM	float	8	False	((0))
	Comments	nvarchar(max)	max	True	('')
	ReportStatusId	int	4	False	((0))
	isActive	bit	1	True	((1))
	Modified	datetime	8	False	(getutcdate())
	ModifiedBy	nvarchar(50)	100	False	('System')
	Created	datetime	8	False	(getutcdate())
	CreatedBy	nvarchar(50)	100	False	('System')

Indexes

Key	Name	Columns	Unique
	PK__tmp_ms_x__D5BD480578DE566D	ReportId	True
	IX_Report611_ReportDate	ReportDate	

Foreign Keys

Name	No Check	Columns
FK_Report661_County	True	CountyId->[dbo].[County].[CountyId]
FK_Report661_Driver	True	DriverId->[dbo].[Driver].[DriverId]
FK_Report661_ReportStatus	True	ReportStatusId->[dbo].[ReportStatus].[ReportStatusId]
FK_Report661_Truck	True	TruckId->[dbo].[Truck].[TruckId]

SQL Script

```
CREATE TABLE [dbo].[Report661]
(
[ReportId] [uniqueidentifier] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Repor__50C5FA01] DEFAULT (newid()),
[ReportDate] [datetime] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Repor__51BA1E3A] DEFAULT (getutcdate()),
[ShiftStart] [datetime] NULL CONSTRAINT [DF__tmp_ms_xx__Shift__52AE4273] DEFAULT (getutcdate()),
[ShiftEnd] [datetime] NULL CONSTRAINT [DF__tmp_ms_xx__Shift__53A266AC] DEFAULT (getutcdate()),
[DriverId] [int] NULL,
[TruckId] [int] NOT NULL,
[CountyId] [int] NULL,
[Fuel] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx___Fuel__54968AE5] DEFAULT ((0)),
[MileageStart] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Milea__558AAF1E] DEFAULT ((0)),
[MileageEnd] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Milea__567ED357] DEFAULT ((0)),
[MileageTotal] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Milea__5772F790] DEFAULT ((0)),
[SaltTotal] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx__SaltT__58671BC9] DEFAULT ((0)),
[SaltTotalLBS] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx__SaltT__595B4002] DEFAULT ((0)),
[SaltTotalMiles] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx__SaltT__5A4F643B] DEFAULT ((0)),
[CalciumTotal] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Calci__5B438874] DEFAULT ((0)),
[BrineTotal] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Brine__5C37ACAD] DEFAULT ((0)),
[AbrasivesTotal] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Abras__5D2BD0E6] DEFAULT ((0)),
[LegacyPPLM] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Legac__5E1FF51F] DEFAULT ((0)),
[PPLM] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx___PPLM__5F141958] DEFAULT ((0)),
[Comments] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NULL CONSTRAINT [DF__tmp_ms_xx__-
Comme__60083D91] DEFAULT (''),
[ReportStatusId] [int] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Repor__60FC61CA] DEFAULT ((0)),
[isActive] [bit] NULL CONSTRAINT [DF__tmp_ms_xx__isAct__61F08603] DEFAULT ((1)),
[Modified] [datetime] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Modif__62E4AA3C] DEFAULT (getutcdate()),
[ModifiedBy] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__tmp_ms_xx__-
Modif__63D8CE75] DEFAULT ('System'),
[Created] [datetime] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Creat__64CCF2AE] DEFAULT (getutcdate()),
[CreatedBy] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__tmp_ms_xx__-
Creat__65C116E7] DEFAULT ('System')
)
GO
ALTER TABLE [dbo].[Report661] ADD CONSTRAINT [PK__tmp_ms_x__D5BD480578DE566D] PRIMARY KEY CLUSTERED
([ReportId])
GO
CREATE NONCLUSTERED INDEX [IX_Report611_ReportDate] ON [dbo].[Report661] ([ReportDate])
GO
ALTER TABLE [dbo].[Report661] WITH NOCHECK ADD CONSTRAINT [FK_Report661_County] FOREIGN KEY ([CountyId])
REFERENCES [dbo].[County] ([CountyId])
GO
ALTER TABLE [dbo].[Report661] WITH NOCHECK ADD CONSTRAINT [FK_Report661_Driver] FOREIGN KEY ([DriverId])
REFERENCES [dbo].[Driver] ([DriverId])
GO
ALTER TABLE [dbo].[Report661] WITH NOCHECK ADD CONSTRAINT [FK_Report661_ReportStatus] FOREIGN KEY ([ReportStatus-
Id]) REFERENCES [dbo].[ReportStatus] ([ReportStatusId])
GO
ALTER TABLE [dbo].[Report661] WITH NOCHECK ADD CONSTRAINT [FK_Report661_Truck] FOREIGN KEY ([TruckId])
REFERENCES [dbo].[Truck] ([TruckId])
GO
```

Uses

[dbo].[County]
[dbo].[Driver]
[dbo].[ReportStatus]
[dbo].[Truck]

Used By

[dbo].[SegmentEntry]
[dbo].[spCreateReport]
[dbo].[spCreateSpanReport]
[dbo].[spFinalizeReport]
[dbo].[spFinalizeSpanReport]

D.5.1.1.30 [dbo].[ReportStatus]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	7
Created	6:49:02 PM Thursday, January 2, 2014
Last Modified	1:24:55 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK C	ReportStatusId	int	4	False
	Name	nvarchar(50)	100	False

Indexes

Key	Name	Columns	Unique
PK C	PK__ReportSt__9683C1060BC7DA3B	ReportStatusId	True

SQL Script

```
CREATE TABLE [dbo].[ReportStatus]
(
[ReportStatusId] [int] NOT NULL,
[Name] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL
)
GO
ALTER TABLE [dbo].[ReportStatus] ADD CONSTRAINT [PK__ReportSt__9683C1060BC7DA3B] PRIMARY KEY CLUSTERED
([ReportStatusId])
GO
```

Used By

[dbo].[Original_Report661]
[dbo].[Report661]

D.5.1.1.31 [dbo].[RoadCondition]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	9
Created	6:49:04 PM Thursday, January 2, 2014
Last Modified	1:24:56 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK C	RoadConditionId	int	4	False
	Name	nvarchar(50)	100	False

Indexes

Key	Name	Columns	Unique
PK C	PK__RoadCond__D9DB3AC20512518B	RoadConditionId	True

SQL Script

```
CREATE TABLE [dbo].[RoadCondition]
(
[RoadConditionId] [int] NOT NULL,
[Name] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL
)
GO
ALTER TABLE [dbo].[RoadCondition] ADD CONSTRAINT [PK__RoadCond__D9DB3AC20512518B] PRIMARY KEY CLUSTERED
([RoadConditionId])
GO
```

Used By

[dbo].[Original_SegmentEntry]
[dbo].[SegmentEntry]

D.5.1.1.32 [dbo].[RoadPicture]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	11177
Created	2:05:23 AM Monday, November 10, 2014
Last Modified	4:24:06 PM Tuesday, January 27, 2015

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK C	PictureID	int	4	False
	DeviceId	int	4	True
	PicName	varchar(200)	200	True
	MediaLocation	varchar(200)	200	True
	PicNotes	varchar(500)	500	True
	CreatedBy	varchar(100)	100	True
	CreatedTime	datetime	8	True
	LocationId	uniqueidentifier	16	True

Indexes

Key	Name	Columns	Unique
PK C	PK_RoadPicture	PictureID	True
	IX_RoadPicture_CreatedTime_DESC	DeviceId, CreatedTime	

SQL Script

```
CREATE TABLE [dbo].[RoadPicture]
(
[PictureID] [int] NOT NULL,
[DeviceId] [int] NULL,
[PicName] [varchar] (200) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[MediaLocation] [varchar] (200) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[PicNotes] [varchar] (500) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[CreatedBy] [varchar] (100) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[CreatedTime] [datetime] NULL,
[LocationId] [uniqueidentifier] NULL
)
GO
ALTER TABLE [dbo].[RoadPicture] ADD CONSTRAINT [PK_RoadPicture] PRIMARY KEY CLUSTERED  ([PictureID])
GO
CREATE NONCLUSTERED INDEX [IX_RoadPicture_CreatedTime_DESC] ON [dbo].[RoadPicture] ([CreatedTime] DESC) INCLUDE
([DeviceId])
GO
```

D.5.1.1.33 [dbo].[RoadTreatment]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	6
Created	6:49:04 PM Thursday, January 2, 2014
Last Modified	1:24:56 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK C	RoadTreatmentId	int	4	False
	Name	nvarchar(50)	100	False

Indexes

Key	Name	Columns	Unique
PK C	PK__RoadTrea__4B5FF5B51576BFDD	RoadTreatmentId	True

SQL Script

```
CREATE TABLE [dbo].[RoadTreatment]
(
[RoadTreatmentId] [int] NOT NULL,
[Name] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL
)
GO
ALTER TABLE [dbo].[RoadTreatment] ADD CONSTRAINT [PK__RoadTrea__4B5FF5B51576BFDD] PRIMARY KEY CLUSTERED
([RoadTreatmentId])
GO
```

Used By

[dbo].[Original_SegmentEntry]
[dbo].[SegmentEntry]

D.5.1.1.34 [dbo].[RouteType]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	13
Created	6:48:56 PM Thursday, January 2, 2014
Last Modified	6:49:12 PM Thursday, January 2, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK C	RouteTypeId	int	4	False
	Name	nvarchar(50)	100	False
	Code	nvarchar(2)	4	False

Indexes

Key	Name	Columns	Unique
PK C	PK__RouteTyp__E5F9A5554AA20153	RouteTypeId	True

SQL Script

```
CREATE TABLE [dbo].[RouteType]
(
[RouteTypeId] [int] NOT NULL,
[Name] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[Code] [nvarchar] (2) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL
)
GO
ALTER TABLE [dbo].[RouteType] ADD CONSTRAINT [PK__RouteTyp__E5F9A5554AA20153] PRIMARY KEY CLUSTERED
([RouteTypeId])
GO
```

Used By

[dbo].[Logpoint]
[dbo].[fFA_Location]
[dbo].[fPW_Location]
[dbo].[spGenerateFASegment]
[dbo].[vFA_Location]
[dbo].[vPW_Location]

D.5.1.1.35 [dbo].[RWIS_Messages]

Properties

Property	Value
Row Count (~)	0
Created	4:59:01 AM Saturday, January 4, 2014
Last Modified	2:20:50 PM Monday, March 24, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK C	MessageId	uniqueidentifier	16	False
	MsgReceivedUTC	datetime	8	False
	MsgRawXML	xml	max	False
	MsgStatus	int	4	False

Indexes

Key	Name	Columns	Unique
PK C	PK__RWIS_Mes__C87C0C9CF0A562DE	MessageId	True

SQL Script

```
CREATE TABLE [dbo].[RWIS_Messages]
(
[MessageId] [uniqueidentifier] NOT NULL,
[MsgReceivedUTC] [datetime] NOT NULL,
[MsgRawXML] [xml] NOT NULL,
[MsgStatus] [int] NOT NULL
)
GO
ALTER TABLE [dbo].[RWIS_Messages] ADD CONSTRAINT [PK__RWIS_Mes__C87C0C9CF0A562DE] PRIMARY KEY
CLUSTERED  ([MessageId])
GO
```

D.5.1.1.36 [dbo].[RWIS_Sensors]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	502
Created	4:59:02 AM Saturday, January 4, 2014
Last Modified	5:03:27 AM Saturday, January 4, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK	SensorId	int	4	False
FK	SiteId	int	4	False
	id	int	4	False
	name	nvarchar(max)	max	False

Indexes

Key	Name	Columns	Unique
PK	PK__RWIS_Sen__D8099BFA528B529C	SensorId	True

Foreign Keys

Name	Columns
FK_RWIS_Sensors_ToTable	SiteId->[dbo].[RWIS_Sites].[SiteId]

SQL Script

```
CREATE TABLE [dbo].[RWIS_Sensors]
(
[SensorId] [int] NOT NULL,
[SiteId] [int] NOT NULL,
[id] [int] NOT NULL,
[name] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL
)
GO
ALTER TABLE [dbo].[RWIS_Sensors] ADD CONSTRAINT [PK__RWIS_Sen__D8099BFA528B529C] PRIMARY KEY CLUSTERED
([SensorId])
GO
ALTER TABLE [dbo].[RWIS_Sensors] ADD CONSTRAINT [FK_RWIS_Sensors_ToTable] FOREIGN KEY ([SiteId]) REFERENCES
[dbo].[RWIS_Sites] ([SiteId])
GO
```

Uses

[dbo].[RWIS_Sites]

Used By

[dbo].[RWIS_TrxnLine]

D.5.1.1.37 [dbo].[RWIS_Sites]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	178
Created	4:59:02 AM Saturday, January 4, 2014
Last Modified	1:09:40 AM Saturday, October 4, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls	Default
PK C	SiteId	int	4	False	
	latitude	float	8	False	
	longitude	float	8	False	
	name	nvarchar(max)	max	False	
	rpuid	int	4	False	
	sysid	int	4	False	
	number	int	4	False	
	geo	geography	max	False	
	CountyId	int	4	False	((0))
	LastTrxnId	uniqueidentifier	16	True	

Indexes

Key	Name	Columns	Unique
PK C	PK__RWIS_Sit__B9DCB963DCD0533B	SiteId	True

SQL Script

```
CREATE TABLE [dbo].[RWIS_Sites]
(
[SiteId] [int] NOT NULL,
[latitude] [float] NOT NULL,
[longitude] [float] NOT NULL,
[name] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[rpuid] [int] NOT NULL,
[sysid] [int] NOT NULL,
[number] [int] NOT NULL,
[geo] [sys].[geography] NOT NULL,
[CountyId] [int] NOT NULL CONSTRAINT [default_value] DEFAULT ((0)),
[LastTrxnId] [uniqueidentifier] NULL
)
GO
ALTER TABLE [dbo].[RWIS_Sites] ADD CONSTRAINT [PK__RWIS_Sit__B9DCB963DCD0533B] PRIMARY KEY CLUSTERED
([SiteId])
GO
```

Used By

[dbo].[RWIS_Sensors]
[dbo].[RWIS_TrxnHeader]

D.5.1.1.38 [dbo].[RWIS_TrxnAtmospheric]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	5917261
Created	4:59:03 AM Saturday, January 4, 2014
Last Modified	5:03:27 AM Saturday, January 4, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK FK	TrxnId	uniqueidentifier	16	False
	ATMdatetimeEST	datetime	8	False
	visibility	int	4	False
	precipitationaccumulation	int	4	False
	precipitationrate	int	4	False
	precipitationtype	nvarchar(max)	max	False
	precipitationintensity	nvarchar(max)	max	False
	pressure	int	4	False
	winddirectiongust	int	4	False
	winddirectionavg	int	4	False
	windspeedgust	int	4	False
	windspeedavg	int	4	False
	relativehumidity	int	4	False
	dewpoint	int	4	False
	airtemp	int	4	False

Indexes

Key	Name	Columns	Unique
PK	PK__RWIS_Trx__2374CFBEFA9A37AA	TrxnId	True

Foreign Keys

Name	Columns
FK_RWIS_TrxnAtmospheric_ToTable	TrxnId->[dbo].[RWIS_TrxnHeader].[TrxnId]

SQL Script

```
CREATE TABLE [dbo].[RWIS_TrxnAtmospheric]
(
[TrxnId] [uniqueidentifier] NOT NULL,
[ATMdatetimeEST] [datetime] NOT NULL,
[visibility] [int] NOT NULL,
[precipitationaccumulation] [int] NOT NULL,
[precipitationrate] [int] NOT NULL,
[precipitationtype] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[precipitationintensity] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[pressure] [int] NOT NULL,
[winddirectiongust] [int] NOT NULL,
[winddirectionavg] [int] NOT NULL,
[windspeedgust] [int] NOT NULL,
[windspeedavg] [int] NOT NULL,
[relativehumidity] [int] NOT NULL,
[dewpoint] [int] NOT NULL,
[airtemp] [int] NOT NULL
)
```

```
GO
ALTER TABLE [dbo].[RWIS_TrxnAtmospheric] ADD CONSTRAINT [PK__RWIS_Trx__2374CFBEFA9A37AA] PRIMARY KEY
CLUSTERED  ([TrxnId])
GO
ALTER TABLE [dbo].[RWIS_TrxnAtmospheric] ADD CONSTRAINT [FK_RWIS_TrxnAtmospheric_ToTable] FOREIGN KEY ([TrxnId])
REFERENCES [dbo].[RWIS_TrxnHeader] ([TrxnId])
GO
```

Uses

[dbo].[RWIS_TrxnHeader]

D.5.1.1.39 [dbo].[RWIS_TrxnHeader]

Properties

Property	Value
Row Count (~)	5950898
Created	4:59:03 AM Saturday, January 4, 2014
Last Modified	2:45:54 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK	TrxnId	uniqueidentifier	16	False
	MessageId	uniqueidentifier	16	False
FK	SiteId	int	4	False
	MsgReceivedUTC	datetime	8	True

Indexes

Key	Name	Columns	Unique
PK	PK__RWIS_Trx__2374CFBECC5634C3	TrxnId	True
	RWIS_TrxnHeader_TrxnId_MessageId_Msg-ReceivedUTC	TrxnId, MessageId, MsgReceived-UTC, SiteId	

Foreign Keys

Name	Columns
FK_RWIS_TrxnHeader_ToTable	SiteId->[dbo].[RWIS_Sites].[SiteId]

SQL Script

```
CREATE TABLE [dbo].[RWIS_TrxnHeader]
(
[TrxnId] [uniqueidentifier] NOT NULL,
[MessageId] [uniqueidentifier] NOT NULL,
[SiteId] [int] NOT NULL,
[MsgReceivedUTC] [datetime] NULL
)
GO
ALTER TABLE [dbo].[RWIS_TrxnHeader] ADD CONSTRAINT [PK__RWIS_Trx__2374CFBECC5634C3] PRIMARY KEY
CLUSTERED  ([TrxnId])
GO
CREATE NONCLUSTERED INDEX [RWIS_TrxnHeader_TrxnId_MessageId_MsgReceivedUTC] ON [dbo].[RWIS_TrxnHeader] ([Site-
Id]) INCLUDE ([MessageId], [MsgReceivedUTC], [TrxnId])
GO
ALTER TABLE [dbo].[RWIS_TrxnHeader] ADD CONSTRAINT [FK_RWIS_TrxnHeader_ToTable] FOREIGN KEY ([SiteId])
REFERENCES [dbo].[RWIS_Sites] ([SiteId])
GO
```

Uses

[dbo].[RWIS_Sites]

Used By

[dbo].[RWIS_TrxnAtmospheric]
[dbo].[RWIS_TrxnLine]
[dbo].[RWIS_TrxnSnowice]

D.5.1.1.40 [dbo].[RWIS_TrxnLine]

Properties

Property	Value
Row Count (~)	0
Created	4:59:03 AM Saturday, January 4, 2014
Last Modified	5:03:27 AM Saturday, January 4, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK	TrxnLineId	uniqueidentifier	16	False
FK	TrxnId	uniqueidentifier	16	False
FK	SensorId	int	4	False

Indexes

Key	Name	Columns	Unique
PK	PK__RWIS_Trx__2825DC720A7F2E79	TrxnLineId	True

Foreign Keys

Name	Columns
FK_RWIS_TrxnLine_ToTable	SensorId->[dbo].[RWIS_Sensors].[SensorId]
FK_RWIS_TrxnLine_ToTable_1	TrxnId->[dbo].[RWIS_TrxnHeader].[TrxnId]

SQL Script

```
CREATE TABLE [dbo].[RWIS_TrxnLine]
(
[TrxnLineId] [uniqueidentifier] NOT NULL,
[TrxnId] [uniqueidentifier] NOT NULL,
[SensorId] [int] NOT NULL
)
GO
ALTER TABLE [dbo].[RWIS_TrxnLine] ADD CONSTRAINT [PK__RWIS_Trx__2825DC720A7F2E79] PRIMARY KEY CLUSTERED
([TrxnLineId])
GO
ALTER TABLE [dbo].[RWIS_TrxnLine] ADD CONSTRAINT [FK_RWIS_TrxnLine_ToTable] FOREIGN KEY ([SensorId])
REFERENCES [dbo].[RWIS_Sensors] ([SensorId])
GO
ALTER TABLE [dbo].[RWIS_TrxnLine] ADD CONSTRAINT [FK_RWIS_TrxnLine_ToTable_1] FOREIGN KEY ([TrxnId])
REFERENCES [dbo].[RWIS_TrxnHeader] ([TrxnId])
GO
```

Uses

[dbo].[RWIS_Sensors]
[dbo].[RWIS_TrxnHeader]

Used By

[dbo].[RWIS_TrxnLongbin]
[dbo].[RWIS_TrxnNormalbin]
[dbo].[RWIS_TrxnSurface]
[dbo].[RWIS_TrxnTraffic]

D.5.1.1.41 [dbo].[RWIS_TrxnLongbin]

Properties

Property	Value
Row Count (~)	0
Created	4:59:04 AM Saturday, January 4, 2014
Last Modified	5:03:27 AM Saturday, January 4, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK FK	TrxnLineId	uniqueidentifier	16	False
PK	binnumber	int	4	False
	bincount	int	4	False

Indexes

Key	Name	Columns	Unique
PK	PK__RWIS_Trx__A82A923237475FC7	binnumber, TrxnLineId	True

Foreign Keys

Name	Columns
FK_RWIS_TrxnLongbin_ToTable	TrxnLineId->[dbo].[RWIS_TrxnLine].[TrxnLineId]

SQL Script

```
CREATE TABLE [dbo].[RWIS_TrxnLongbin]
(
[TrxnLineId] [uniqueidentifier] NOT NULL,
[binnumber] [int] NOT NULL,
[bincount] [int] NOT NULL
)
GO
ALTER TABLE [dbo].[RWIS_TrxnLongbin] ADD CONSTRAINT [PK__RWIS_Trx__A82A923237475FC7] PRIMARY KEY
CLUSTERED  ([binnumber], [TrxnLineId])
GO
ALTER TABLE [dbo].[RWIS_TrxnLongbin] ADD CONSTRAINT [FK_RWIS_TrxnLongbin_ToTable] FOREIGN KEY ([TrxnLineId])
REFERENCES [dbo].[RWIS_TrxnLine] ([TrxnLineId])
GO
```

Uses

[dbo].[RWIS_TrxnLine]

D.5.1.1.42 [dbo].[RWIS_TrxnNormalbin]

Properties

Property	Value
Row Count (~)	0
Created	4:59:04 AM Saturday, January 4, 2014
Last Modified	12:59:39 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK FK	TrxnLineId	uniqueidentifier	16	False
PK	binnumber	int	4	False
	bincount	int	4	False

Indexes

Key	Name	Columns	Unique
PK	PK__RWIS_Trx__618F508D79B85883	TrxnLineId, binnumber	True

Foreign Keys

Name	Columns
FK_RWIS_TrxnNormalbin_ToTable	TrxnLineId->[dbo].[RWIS_TrxnLine].[TrxnLineId]

SQL Script

```
CREATE TABLE [dbo].[RWIS_TrxnNormalbin]
(
[TrxnLineId] [uniqueidentifier] NOT NULL,
[binnumber] [int] NOT NULL,
[bincount] [int] NOT NULL
)
GO
ALTER TABLE [dbo].[RWIS_TrxnNormalbin] ADD CONSTRAINT [PK__RWIS_Trx__618F508D79B85883] PRIMARY KEY
CLUSTERED  ([TrxnLineId], [binnumber])
GO
ALTER TABLE [dbo].[RWIS_TrxnNormalbin] ADD CONSTRAINT [FK_RWIS_TrxnNormalbin_ToTable] FOREIGN KEY ([TrxnLine-
Id]) REFERENCES [dbo].[RWIS_TrxnLine] ([TrxnLineId])
GO
```

Uses

[dbo].[RWIS_TrxnLine]

D.5.1.1.43 [dbo].[RWIS_TrxnSnowice]

Properties

Property	Value
Row Count (~)	0
Created	4:59:05 AM Saturday, January 4, 2014
Last Modified	2:45:54 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK FK	TrxnId	uniqueidentifier	16	False
	SNWdatetimeEST	datetime	8	False
	adjsnowdepth	int	4	False

Indexes

Key	Name	Columns	Unique
PK	PK__RWIS_Trx__2374CFBE1892210E	TrxnId	True

Foreign Keys

Name	Columns
FK_RWIS_TrxnSnowice_ToTable	TrxnId->[dbo].[RWIS_TrxnHeader].[TrxnId]

SQL Script

```
CREATE TABLE [dbo].[RWIS_TrxnSnowice]
(
[TrxnId] [uniqueidentifier] NOT NULL,
[SNWdatetimeEST] [datetime] NOT NULL,
[adjsnowdepth] [int] NOT NULL
)
GO
ALTER TABLE [dbo].[RWIS_TrxnSnowice] ADD CONSTRAINT [PK__RWIS_Trx__2374CFBE1892210E] PRIMARY KEY
CLUSTERED  ([TrxnId])
GO
ALTER TABLE [dbo].[RWIS_TrxnSnowice] ADD CONSTRAINT [FK_RWIS_TrxnSnowice_ToTable] FOREIGN KEY ([TrxnId])
REFERENCES [dbo].[RWIS_TrxnHeader] ([TrxnId])
GO
```

Uses

[dbo].[RWIS_TrxnHeader]

D.5.1.1.44 [dbo].[RWIS_TrxnSurface]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	0
Created	4:59:05 AM Saturday, January 4, 2014
Last Modified	12:59:39 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK FK	TrxnLineId	uniqueidentifier	16	False
	SFCdatetimeEST	datetime	8	False
	waterlevel	int	4	False
	subsurfacetemp	int	4	False
	icepercent	int	4	False
	depth	int	4	False
	chemicalpercent	int	4	False
	chemicalfactor	int	4	False
	freezingtemp	int	4	False
	surfacetemp	int	4	False
	surfacecondition	nvarchar(max)	max	False

Indexes

Key	Name	Columns	Unique
PK	PK__RWIS_Trx__2825DC7224BD0E5C	TrxnLineId	True

Foreign Keys

Name	Columns
FK_RWIS_TrxnSurface_ToTable	TrxnLineId->[dbo].[RWIS_TrxnLine].[TrxnLineId]

SQL Script

```
CREATE TABLE [dbo].[RWIS_TrxnSurface]
(
[TrxnLineId] [uniqueidentifier] NOT NULL,
[SFCdatetimeEST] [datetime] NOT NULL,
[waterlevel] [int] NOT NULL,
[subsurfacetemp] [int] NOT NULL,
[icepercent] [int] NOT NULL,
[depth] [int] NOT NULL,
[chemicalpercent] [int] NOT NULL,
[chemicalfactor] [int] NOT NULL,
[freezingtemp] [int] NOT NULL,
[surfacetemp] [int] NOT NULL,
[surfacecondition] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL
)
GO
ALTER TABLE [dbo].[RWIS_TrxnSurface] ADD CONSTRAINT [PK__RWIS_Trx__2825DC7224BD0E5C] PRIMARY KEY
CLUSTERED  ([TrxnLineId])
GO
ALTER TABLE [dbo].[RWIS_TrxnSurface] ADD CONSTRAINT [FK_RWIS_TrxnSurface_ToTable] FOREIGN KEY ([TrxnLineId])
REFERENCES [dbo].[RWIS_TrxnLine] ([TrxnLineId])
GO
```

Uses

[dbo].[RWIS_TrxnLine]

D.5.1.1.45 [dbo].[RWIS_TrxnTraffic]

Properties

Property	Value
Row Count (~)	0
Created	4:59:06 AM Saturday, January 4, 2014
Last Modified	1:02:27 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK FK C	TrxnLineId	uniqueidentifier	16	False
	TRFdatetimeEST	datetime	8	False
	sfstate	int	4	False
	sftemp	int	4	False
	volume	int	4	False
	avgspeed	int	4	False
	occupancy	int	4	False

Indexes

Key	Name	Columns	Unique
PK C	PK__RWIS_Trx__2825DC726085C687	TrxnLineId	True

Foreign Keys

Name	Columns
FK_RWIS_TrxnTraffic_ToTable	TrxnLineId->[dbo].[RWIS_TrxnLine].[TrxnLineId]

SQL Script

```
CREATE TABLE [dbo].[RWIS_TrxnTraffic]
(
[TrxnLineId] [uniqueidentifier] NOT NULL,
[TRFdatetimeEST] [datetime] NOT NULL,
[sfstate] [int] NOT NULL,
[sftemp] [int] NOT NULL,
[volume] [int] NOT NULL,
[avgspeed] [int] NOT NULL,
[occupancy] [int] NOT NULL
)
GO
ALTER TABLE [dbo].[RWIS_TrxnTraffic] ADD CONSTRAINT [PK__RWIS_Trx__2825DC726085C687] PRIMARY KEY CLUSTERED
([TrxnLineId])
GO
ALTER TABLE [dbo].[RWIS_TrxnTraffic] ADD CONSTRAINT [FK_RWIS_TrxnTraffic_ToTable] FOREIGN KEY ([TrxnLineId])
REFERENCES [dbo].[RWIS_TrxnLine] ([TrxnLineId])
GO
```

Uses

[dbo].[RWIS_TrxnLine]

D.5.1.1.46 [dbo].[SegmentEntry]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	87945
Created	3:52:25 PM Monday, January 6, 2014
Last Modified	1:24:55 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls	Default
PK	SegmentEntryId	uniqueidentifier	16	False	(newid())
FK	ReportId	uniqueidentifier	16	False	
	TimeOn	datetime	8	False	
	TimeOff	datetime	8	False	
	Route	nvarchar(50)	100	False	('')
	LocationFrom	nvarchar(max)	max	False	('')
	LocationTo	nvarchar(max)	max	False	('')
FK	RoadConditionId	int	4	False	
FK	RoadTreatmentId	int	4	False	
	Salt	float	8	False	((0))
	Calcium	float	8	False	((0))
	Brine	float	8	False	((0))
	Abrasives	float	8	False	((0))
	Mileage	float	8	False	((0))
	SaltMileage	float	8	False	((0))
	PPLM	float	8	False	((0))
	Location	nvarchar(max)	max	True	('')
	isActive	bit	1	False	((0))
	Modified	datetime	8	False	(getutcdate())
	ModifiedBy	nvarchar(50)	100	False	('System')
	Created	datetime	8	False	(getutcdate())
	CreatedBy	nvarchar(50)	100	False	('System')
	MaxSpeedMPH	float	8	False	((0.0))
	MaxAppRate	int	4	False	((0))

Indexes

Key	Name	Columns	Unique
PK	PK__tmp_ms_x__62BBC0658E2A167C	SegmentEntryId	True
	IX_SegmentEntry_ReportId	ReportId	

Foreign Keys

Name	No Check	Columns
FK_SegmentEntry_Report661	True	ReportId->[dbo].[Report661].[ReportId]
FK_SegmentEntry_RoadCondition	True	RoadConditionId->[dbo].[RoadCondition].[RoadConditionId]
FK_SegmentEntry_RoadTreatment	True	RoadTreatmentId->[dbo].[RoadTreatment].[RoadTreatmentId]

SQL Script

```
CREATE TABLE [dbo].[SegmentEntry]
(
[SegmentEntryId] [uniqueidentifier] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Segme__3BCADD1B] DEFAULT (newid()),
[ReportId] [uniqueidentifier] NOT NULL,
[TimeOn] [datetime] NOT NULL,
[TimeOff] [datetime] NOT NULL,
[Route] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__tmp_ms_xx__-
Route__3CBF0154] DEFAULT (''),
[LocationFrom] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__tmp_ms_xx__-
Locat__3DB3258D] DEFAULT (''),
[LocationTo] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__tmp_ms_xx__-
Locat__3EA749C6] DEFAULT (''),
[RoadConditionId] [int] NOT NULL,
[RoadTreatmentId] [int] NOT NULL,
[Salt] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx___Salt__3F9B6DFF] DEFAULT ((0)),
[Calcium] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Calci__408F9238] DEFAULT ((0)),
[Brine] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Brine__4183B671] DEFAULT ((0)),
[Abrasives] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Abras__4277DAAA] DEFAULT ((0)),
[Mileage] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Milea__436BFEE3] DEFAULT ((0)),
[SaltMileage] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx__SaltM__4460231C] DEFAULT ((0)),
[PPLM] [float] NOT NULL CONSTRAINT [DF__tmp_ms_xx___PPLM__45544755] DEFAULT ((0)),
[Location] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NULL CONSTRAINT [DF__tmp_ms_xx__Locat__46486B8E]
DEFAULT (''),
[isActive] [bit] NOT NULL CONSTRAINT [DF__tmp_ms_xx__isAct__473C8FC7] DEFAULT ((0)),
[Modified] [datetime] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Modif__4830B400] DEFAULT (getutcdate()),
[ModifiedBy] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__tmp_ms_xx__-
Modif__4924D839] DEFAULT ('System'),
[Created] [datetime] NOT NULL CONSTRAINT [DF__tmp_ms_xx__Creat__4A18FC72] DEFAULT (getutcdate()),
[CreatedBy] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__tmp_ms_xx__-
Creat__4B0D20AB] DEFAULT ('System'),
[MaxSpeedMPH] [float] NOT NULL CONSTRAINT [DF__SegmentEn__MaxSp__7869D707] DEFAULT ((0.0)),
[MaxAppRate] [int] NOT NULL CONSTRAINT [DF__SegmentEn__MaxAp__795DFB40] DEFAULT ((0))
)
GO
ALTER TABLE [dbo].[SegmentEntry] ADD CONSTRAINT [PK__tmp_ms_x__62BBC0658E2A167C] PRIMARY KEY CLUSTERED
([SegmentEntryId])
GO
CREATE NONCLUSTERED INDEX [IX_SegmentEntry_ReportId] ON [dbo].[SegmentEntry] ([ReportId])
GO
ALTER TABLE [dbo].[SegmentEntry] WITH NOCHECK ADD CONSTRAINT [FK_SegmentEntry_Report661] FOREIGN KEY ([Report-
Id]) REFERENCES [dbo].[Report661] ([ReportId])
GO
ALTER TABLE [dbo].[SegmentEntry] WITH NOCHECK ADD CONSTRAINT [FK_SegmentEntry_RoadCondition] FOREIGN KEY
([RoadConditionId]) REFERENCES [dbo].[RoadCondition] ([RoadConditionId])
GO
ALTER TABLE [dbo].[SegmentEntry] WITH NOCHECK ADD CONSTRAINT [FK_SegmentEntry_RoadTreatment] FOREIGN KEY
([RoadTreatmentId]) REFERENCES [dbo].[RoadTreatment] ([RoadTreatmentId])
GO
```

Uses

[dbo].[Report661]
[dbo].[RoadCondition]
[dbo].[RoadTreatment]

Used By

[dbo].[spFinalizeReport]
[dbo].[spFinalizeSpanReport]
[dbo].[spGenerateFASegment]

D.5.1.1.47 [dbo].[SpreaderInfo]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	304621
Created	6:48:58 PM Thursday, January 2, 2014
Last Modified	10:19:45 PM Thursday, November 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls	Default
	SpreaderInfoId	uniqueidentifier	16	False	(newid())
	DeviceId	int	4	False	
	LocationId	uniqueidentifier	16	True	
	FATransactionId	uniqueidentifier	16	True	
	GranularMaterial	nvarchar(50)	100	True	
	GranularLoopOpMode	int	4	True	
	GranularAppRate	int	4	True	
	GranularAmount	int	4	True	
	GranularSpreadRateIndex	int	4	True	
	PrewetMaterial	nvarchar(50)	100	True	
	PrewetLoopOpMode	int	4	True	
	PrewetAppRate	float	8	True	
	PrewetAmount	int	4	True	
	PrewetSpreadRateIndex	int	4	True	
	DirectLoopOpMode	int	4	True	
	DirectAppRate	int	4	True	
	DirectAmount	int	4	True	
	DirectLanes	nvarchar(50)	100	True	
	DirectSpreadRateIndex	int	4	True	
	DustControlLoopOpMode	int	4	True	
	DustControlAppRate	float	8	True	
	DustControlAmount	int	4	True	
	DustControlSprayWidth	int	4	True	
	DustControlSpreadRate-Index	int	4	True	
	SpinLaneComp	int	4	True	
	SpinDialSetting	int	4	True	
	SpreaderStatusId	int	4	True	
	SpreaderOnDistance	float	8	True	
	SpreaderExtraInfo	int	4	True	
	SpreaderOpGateSetting	nvarchar(50)	100	True	
	UnloadFunctionId	int	4	True	
	Error	int	4	True	
	Speed	int	4	True	
	RoadTemp	int	4	True	
	AmbientTemp	int	4	True	
	DeviceTime	datetime	8	True	
	ReportTime	datetime	8	True	
	SysTime	datetime	8	False	(getutcdate())

Indexes

Key	Name	Columns	Unique
	PK__Spreader__87B79CC17373F4D7	SpreaderInfoId	True
	DeviceTime_DESC_SpreaderInfo	DeviceId, DeviceTime	

Foreign Keys

Name	No Check	Columns
FK_SpreaderInfo_Device	True	DeviceId->[dbo].[Device].[DeviceId]
FK_SpreaderInfo_Direct_Loop-Operation	True	DirectLoopOpMode->[dbo].[LoopOperation].[LoopOperationId]
FK_SpreaderInfo_Direct_Spread-RateIndex	True	DirectSpreadRateIndex->[dbo].[SpreadRateIndex].[SpreadRate-IndexId]
FK_SpreaderInfo_Dust_Loop-Operation	True	DustControlLoopOpMode->[dbo].[LoopOperation].[Loop-OperationId]
FK_SpreaderInfo_Dust_Spread-RateIndex	True	DustControlSpreadRateIndex->[dbo].[SpreadRate-Index].[SpreadRateIndexId]
FK_SpreaderInfo_FATransaction	True	FATransactionId->[dbo].[FATransaction].[FATransactionId]
FK_SpreaderInfo_Gran_Loop-Operation	True	GranularLoopOpMode->[dbo].[LoopOperation].[LoopOperation-Id]
FK_SpreaderInfo_Gran_Spread-RateIndex	True	GranularSpreadRateIndex->[dbo].[SpreadRateIndex].[Spread-RateIndexId]
FK_SpreaderInfo_TruckLocation	True	LocationId->[dbo].[TruckLocation].[TruckLocationId]
FK_SpreaderInfo_Prewet_Loop-Operation	True	PrewetLoopOpMode->[dbo].[LoopOperation].[LoopOperationId]
FK_SpreaderInfo_Prewet_Spread-RateIndex	True	PrewetSpreadRateIndex->[dbo].[SpreadRateIndex].[SpreadRate-IndexId]
FK_SpreaderInfo_SpreaderStatus	True	SpreaderStatusId->[dbo].[SpreaderStatus].[SpreaderStatusId]
FK_SpreaderInfo_UnloadFunction	True	UnloadFunctionId->[dbo].[UnloadFunction].[UnloadFunctionId]

SQL Script

```
CREATE TABLE [dbo].[SpreaderInfo]
(
[SpreaderInfoId] [uniqueidentifier] NOT NULL CONSTRAINT [DF__SpreaderI__Sprea__06CD04F7] DEFAULT (newid()),
[DeviceId] [int] NOT NULL,
[LocationId] [uniqueidentifier] NULL,
[FATransactionId] [uniqueidentifier] NULL,
[GranularMaterial] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[GranularLoopOpMode] [int] NULL,
[GranularAppRate] [int] NULL,
[GranularAmount] [int] NULL,
[GranularSpreadRateIndex] [int] NULL,
[PrewetMaterial] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[PrewetLoopOpMode] [int] NULL,
[PrewetAppRate] [float] NULL,
[PrewetAmount] [int] NULL,
[PrewetSpreadRateIndex] [int] NULL,
[DirectLoopOpMode] [int] NULL,
[DirectAppRate] [int] NULL,
[DirectAmount] [int] NULL,
[DirectLanes] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[DirectSpreadRateIndex] [int] NULL,
[DustControlLoopOpMode] [int] NULL,
[DustControlAppRate] [float] NULL,
[DustControlAmount] [int] NULL,
[DustControlSprayWidth] [int] NULL,
[DustControlSpreadRateIndex] [int] NULL,
[SpinLaneComp] [int] NULL,
[SpinDialSetting] [int] NULL,
[SpreaderStatusId] [int] NULL,
[SpreaderOnDistance] [float] NULL,
[SpreaderExtraInfo] [int] NULL,
[SpreaderOpGateSetting] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[UnloadFunctionId] [int] NULL,
```

```
[Error] [int] NULL,
[Speed] [int] NULL,
[RoadTemp] [int] NULL,
[AmbientTemp] [int] NULL,
[DeviceTime] [datetime] NULL,
[ReportTime] [datetime] NULL,
[SysTime] [datetime] NOT NULL CONSTRAINT [DF__SpreaderI__SysTi__07C12930] DEFAULT (getutcdate())
)
GO
ALTER TABLE [dbo].[SpreaderInfo] ADD CONSTRAINT [PK__Spreader__87B79CC17373F4D7] PRIMARY KEY CLUSTERED
([SpreaderInfoId])
GO
CREATE NONCLUSTERED INDEX [DeviceTime_DESC_SpreaderInfo] ON [dbo].[SpreaderInfo] ([DeviceId], [DeviceTime] DESC)
GO
ALTER TABLE [dbo].[SpreaderInfo] WITH NOCHECK ADD CONSTRAINT [FK_SpreaderInfo_Device] FOREIGN KEY ([DeviceId])
REFERENCES [dbo].[Device] ([DeviceId])
GO
ALTER TABLE [dbo].[SpreaderInfo] WITH NOCHECK ADD CONSTRAINT [FK_SpreaderInfo_Direct_LoopOperation] FOREIGN KEY
([DirectLoopOpMode]) REFERENCES [dbo].[LoopOperation] ([LoopOperationId])
GO
ALTER TABLE [dbo].[SpreaderInfo] WITH NOCHECK ADD CONSTRAINT [FK_SpreaderInfo_Direct_SpreadRateIndex] FOREIGN
KEY ([DirectSpreadRateIndex]) REFERENCES [dbo].[SpreadRateIndex] ([SpreadRateIndexId])
GO
ALTER TABLE [dbo].[SpreaderInfo] WITH NOCHECK ADD CONSTRAINT [FK_SpreaderInfo_Dust_LoopOperation] FOREIGN KEY
([DustControlLoopOpMode]) REFERENCES [dbo].[LoopOperation] ([LoopOperationId])
GO
ALTER TABLE [dbo].[SpreaderInfo] WITH NOCHECK ADD CONSTRAINT [FK_SpreaderInfo_Dust_SpreadRateIndex] FOREIGN KEY
([DustControlSpreadRateIndex]) REFERENCES [dbo].[SpreadRateIndex] ([SpreadRateIndexId])
GO
ALTER TABLE [dbo].[SpreaderInfo] WITH NOCHECK ADD CONSTRAINT [FK_SpreaderInfo_FATransaction] FOREIGN KEY
([FATransactionId]) REFERENCES [dbo].[FATransaction] ([FATransactionId])
GO
ALTER TABLE [dbo].[SpreaderInfo] WITH NOCHECK ADD CONSTRAINT [FK_SpreaderInfo_Gran_LoopOperation] FOREIGN KEY
([GranularLoopOpMode]) REFERENCES [dbo].[LoopOperation] ([LoopOperationId])
GO
ALTER TABLE [dbo].[SpreaderInfo] WITH NOCHECK ADD CONSTRAINT [FK_SpreaderInfo_Gran_SpreadRateIndex] FOREIGN KEY
([GranularSpreadRateIndex]) REFERENCES [dbo].[SpreadRateIndex] ([SpreadRateIndexId])
GO
ALTER TABLE [dbo].[SpreaderInfo] WITH NOCHECK ADD CONSTRAINT [FK_SpreaderInfo_TruckLocation] FOREIGN KEY
([LocationId]) REFERENCES [dbo].[TruckLocation] ([TruckLocationId])
GO
ALTER TABLE [dbo].[SpreaderInfo] WITH NOCHECK ADD CONSTRAINT [FK_SpreaderInfo_Prewet_LoopOperation] FOREIGN KEY
([PrewetLoopOpMode]) REFERENCES [dbo].[LoopOperation] ([LoopOperationId])
GO
ALTER TABLE [dbo].[SpreaderInfo] WITH NOCHECK ADD CONSTRAINT [FK_SpreaderInfo_Prewet_SpreadRateIndex] FOREIGN
KEY ([PrewetSpreadRateIndex]) REFERENCES [dbo].[SpreadRateIndex] ([SpreadRateIndexId])
GO
ALTER TABLE [dbo].[SpreaderInfo] WITH NOCHECK ADD CONSTRAINT [FK_SpreaderInfo_SpreaderStatus] FOREIGN KEY
([SpreaderStatusId]) REFERENCES [dbo].[SpreaderStatus] ([SpreaderStatusId])
GO
ALTER TABLE [dbo].[SpreaderInfo] WITH NOCHECK ADD CONSTRAINT [FK_SpreaderInfo_UnloadFunction] FOREIGN KEY
([UnloadFunctionId]) REFERENCES [dbo].[UnloadFunction] ([UnloadFunctionId])
GO
```

Uses

[dbo].[Device]
[dbo].[FATransaction]
[dbo].[LoopOperation]
[dbo].[SpreaderStatus]
[dbo].[SpreadRateIndex]
[dbo].[TruckLocation]
[dbo].[UnloadFunction]

Used By

[dbo].[fFA_Spreader]
[dbo].[spGenerateFASegment]
[dbo].[spProcessFATrans]

D.5.1.1.48 [dbo].[SpreaderStatus]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	10
Created	6:48:58 PM Thursday, January 2, 2014
Last Modified	12:59:39 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK C	SpreaderStatusId	int	4	False
	Name	nvarchar(50)	100	False

Indexes

Key	Name	Columns	Unique
PK C	PK__Spreader__ADFD91C1A29BC9CE	SpreaderStatusId	True

SQL Script

```
CREATE TABLE [dbo].[SpreaderStatus]
(
[SpreaderStatusId] [int] NOT NULL,
[Name] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL
)
GO
ALTER TABLE [dbo].[SpreaderStatus] ADD CONSTRAINT [PK__Spreader__ADFD91C1A29BC9CE] PRIMARY KEY CLUSTERED
([SpreaderStatusId])
GO
```

Used By

[dbo].[SpreaderInfo]

D.5.1.1.49 [dbo].[SpreadRateIndex]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	12
Created	6:48:58 PM Thursday, January 2, 2014
Last Modified	12:59:39 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK C	SpreadRateIndexId	int	4	False
	Name	nvarchar(50)	100	False

Indexes

Key	Name	Columns	Unique
PK C	PK__SpreadRa__89E28536525591E7	SpreadRateIndexId	True

SQL Script

```
CREATE TABLE [dbo].[SpreadRateIndex]
(
[SpreadRateIndexId] [int] NOT NULL,
[Name] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL
)
GO
ALTER TABLE [dbo].[SpreadRateIndex] ADD CONSTRAINT [PK__SpreadRa__89E28536525591E7] PRIMARY KEY CLUSTERED
([SpreadRateIndexId])
GO
```

Used By

[dbo].[SpreaderInfo]

D.5.1.1.50 [dbo].[State]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	59
Created	6:48:59 PM Thursday, January 2, 2014
Last Modified	1:10:39 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK C	StateId	int	4	False
	Name	nvarchar(max)	max	False
	Abbr	nvarchar(10)	20	False

Indexes

Key	Name	Columns	Unique
PK C	PK__State__C3BA3B3A2886E368	StateId	True

SQL Script

```
CREATE TABLE [dbo].[State]
(
[StateId] [int] NOT NULL,
[Name] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[Abbr] [nvarchar] (10) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL
)
GO
ALTER TABLE [dbo].[State] ADD CONSTRAINT [PK__State__C3BA3B3A2886E368] PRIMARY KEY CLUSTERED  ([StateId])
GO
```

Used By

[dbo].[County_State]
[dbo].[State_Country]
[dbo].[uscounties]

D.5.1.1.51 [dbo].[State_Country]

Properties

Property	Value
Row Count (~)	59
Created	6:49:08 PM Thursday, January 2, 2014
Last Modified	1:10:34 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK FK	StateId	int	4	False
PK FK	CountryId	int	4	False

Indexes

Key	Name	Columns	Unique
PK	PK__State_Co__22B72D33C2DE113A	StateId, CountryId	True

Foreign Keys

Name	No Check	Columns
FK_State_Country_Country	True	CountryId->[dbo].[Country].[CountryId]
FK_State_Country_State	True	StateId->[dbo].[State].[StateId]

SQL Script

```
CREATE TABLE [dbo].[State_Country]
(
[StateId] [int] NOT NULL,
[CountryId] [int] NOT NULL
)
GO
ALTER TABLE [dbo].[State_Country] ADD CONSTRAINT [PK__State_Co__22B72D33C2DE113A] PRIMARY KEY CLUSTERED
([StateId], [CountryId])
GO
ALTER TABLE [dbo].[State_Country] WITH NOCHECK ADD CONSTRAINT [FK_State_Country_Country] FOREIGN KEY ([Country-
Id]) REFERENCES [dbo].[Country] ([CountryId])
GO
ALTER TABLE [dbo].[State_Country] WITH NOCHECK ADD CONSTRAINT [FK_State_Country_State] FOREIGN KEY ([StateId])
REFERENCES [dbo].[State] ([StateId])
GO
```

Uses

[dbo].[Country]
[dbo].[State]

D.5.1.1.52 [dbo].[statesprovinces]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	3787
Created	6:48:50 PM Thursday, January 2, 2014
Last Modified	1:24:32 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls	Identity
PK C	ID	int	4	False	1 - 1
	OBJECTID	bigint	8	True	
	VertexCou	real	4	True	
	ISO	nvarchar(255)	510	True	
	NAME_0	nvarchar(255)	510	True	
	NAME	nvarchar(255)	510	True	
	VARNAME_1	nvarchar(255)	510	True	
	NL_NAME_1	nvarchar(255)	510	True	
	HASC_1	nvarchar(255)	510	True	
	TYPE_1	nvarchar(255)	510	True	
	ENGTYPE_1	nvarchar(255)	510	True	
	VALIDFR_1	nvarchar(255)	510	True	
	VALIDTO_1	nvarchar(255)	510	True	
	REMARKS_1	nvarchar(255)	510	True	
	Region	nvarchar(255)	510	True	
	RegionVar	nvarchar(255)	510	True	
	ProvNumber	int	4	True	
	NEV_Countr	nvarchar(255)	510	True	
	FIRST_FIPS	nvarchar(255)	510	True	
	FIRST_HASC	nvarchar(255)	510	True	
	FIPS_1	nvarchar(255)	510	True	
	gadm_level	real	4	True	
	CheckMe	int	4	True	
	Region_Cod	nvarchar(255)	510	True	
	Region_C_1	nvarchar(255)	510	True	
	ScaleRank	int	4	True	
	Region_C_2	nvarchar(255)	510	True	
	Region_C_3	nvarchar(255)	510	True	
	Country_Pr	nvarchar(255)	510	True	
	Shape_Leng	real	4	True	
	AREA	real	4	True	
	the_geo	geography	max	True	
	the_geom	geometry	max	True	

Indexes

Key	Name	Columns	Type	Unique
PK	PK_statesprovinces	ID		True
	the_geo_sidx	the_geo	spatial	
	the_geom_sidx	the_geom	spatial	

Spatial Indexes

Name	Tessalation Scheme	Bounding Box	Grids	Cells Per Object
the_geo_sidx	GEOGRAPHY_-GRID		level_1=MEDIUM, level_2=MEDIUM, level_3=MEDIUM, level_4=MEDIUM	16
the_geom_sidx	GEOMETRY_-GRID	xmin=-90, ymin=-180, xmax=90, ymax=180	level_1=HIGH, level_2=HIGH, level_3=HIGH, level_4=HIGH	16

Check Constraints

Name	Checked	On Column	Constraint
enforce_srid_geography_states-provinces	False	the_geo	([the_geo].[STSrid]=(4326))
enforce_srid_geometry_states-provinces	False	the_geom	([the_geom].[STSrid]=(4326))

SQL Script

```
CREATE TABLE [dbo].[statesprovinces]
(
[ID] [int] NOT NULL IDENTITY(1, 1),
[OBJECTID] [bigint] NULL,
[VertexCou] [real] NULL,
[ISO] [nvarchar] (255) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[NAME_0] [nvarchar] (255) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[NAME] [nvarchar] (255) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[VARNAME_1] [nvarchar] (255) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[NL_NAME_1] [nvarchar] (255) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[HASC_1] [nvarchar] (255) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[TYPE_1] [nvarchar] (255) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[ENGTYPE_1] [nvarchar] (255) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[VALIDFR_1] [nvarchar] (255) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[VALIDTO_1] [nvarchar] (255) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[REMARKS_1] [nvarchar] (255) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[Region] [nvarchar] (255) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[RegionVar] [nvarchar] (255) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[ProvNumber] [int] NULL,
[NEV_Countr] [nvarchar] (255) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[FIRST_FIPS] [nvarchar] (255) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[FIRST_HASC] [nvarchar] (255) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[FIPS_1] [nvarchar] (255) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[gadm_level] [real] NULL,
[CheckMe] [int] NULL,
[Region_Cod] [nvarchar] (255) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[Region_C_1] [nvarchar] (255) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[ScaleRank] [int] NULL,
[Region_C_2] [nvarchar] (255) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[Region_C_3] [nvarchar] (255) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[Country_Pr] [nvarchar] (255) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[Shape_Leng] [real] NULL,
[AREA] [real] NULL,
[the_geo] [sys].[geography] NULL,
[the_geom] [sys].[geometry] NULL
```

```
)
GO
ALTER TABLE [dbo].[statesprovinces] WITH NOCHECK ADD CONSTRAINT [enforce_srid_geography_states-provinces] CHECK
(([the_geo].[STSrid]=(4326)))
GO
ALTER TABLE [dbo].[statesprovinces] WITH NOCHECK ADD CONSTRAINT [enforce_srid_geometry_states-provinces] CHECK
(([the_geom].[STSrid]=(4326)))
GO
ALTER TABLE [dbo].[statesprovinces] NOCHECK CONSTRAINT [enforce_srid_geography_states-provinces]
GO
ALTER TABLE [dbo].[statesprovinces] NOCHECK CONSTRAINT [enforce_srid_geometry_states-provinces]
GO
ALTER TABLE [dbo].[statesprovinces] ADD CONSTRAINT [PK_statesprovinces] PRIMARY KEY CLUSTERED  ([ID])
GO
CREATE SPATIAL INDEX [the_geo_sidx] ON [dbo].[statesprovinces] ([the_geo]) WITH (GRIDS = (MEDIUM, MEDIUM, MEDIUM,
MEDIUM), CELLS_PER_OBJECT = 16)
GO
CREATE SPATIAL INDEX [the_geom_sidx] ON [dbo].[statesprovinces] ([the_geom]) WITH (BOUNDING_BOX = (-90, -180, 90, 180),
GRIDS = (HIGH, HIGH, HIGH, HIGH), CELLS_PER_OBJECT = 16)
GO
```

Used By

[dbo].[GetViewport]
[dbo].[usp_StatesByDistance]
[dbo].[usp_StatesByIntersection]

D.5.1.1.53 [dbo].[StatusType]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	7
Created	6:48:55 PM Thursday, January 2, 2014
Last Modified	1:24:56 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK C	StatusTypeId	int	4	False
	Name	nvarchar(50)	100	False

Indexes

Key	Name	Columns	Unique
PK C	PK__StatusTy__A84F3C73DFEAEE44	StatusTypeId	True

SQL Script

```
CREATE TABLE [dbo].[StatusType]
(
[StatusTypeId] [int] NOT NULL,
[Name] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL
)
GO
ALTER TABLE [dbo].[StatusType] ADD CONSTRAINT [PK__StatusTy__A84F3C73DFEAEE44] PRIMARY KEY CLUSTERED
([StatusTypeId])
GO
```

Used By

[dbo].[Device]

D.5.1.1.54 [dbo].[tilestatesprovinces]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	0
Created	6:49:08 PM Thursday, January 2, 2014
Last Modified	1:10:34 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK C	quadkey	nvarchar(50)	100	False
	tile	image	max	True

Indexes

Key	Name	Columns	Unique
PK C	PK_tilestatesprovinces	quadkey	True

SQL Script

```
CREATE TABLE [dbo].[tilestatesprovinces]
(
[quadkey] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[tile] [image] NULL
)
GO
ALTER TABLE [dbo].[tilestatesprovinces] ADD CONSTRAINT [PK_tilestatesprovinces] PRIMARY KEY CLUSTERED  ([quadkey])
GO
```

D.5.1.1.55 [dbo].[tileuscounties]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	0
Created	6:49:08 PM Thursday, January 2, 2014
Last Modified	1:10:34 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK C	quadkey	nvarchar(50)	100	False
	tile	image	max	True

Indexes

Key	Name	Columns	Unique
PK C	PK_tileuscounties	quadkey	True

SQL Script

```
CREATE TABLE [dbo].[tileuscounties]
(
[quadkey] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[tile] [image] NULL
)
GO
ALTER TABLE [dbo].[tileuscounties] ADD CONSTRAINT [PK_tileuscounties] PRIMARY KEY CLUSTERED  ([quadkey])
GO
```

D.5.1.1.56 [dbo].[Truck]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	1687
Created	6:48:54 PM Thursday, January 2, 2014
Last Modified	8:56:20 PM Saturday, February 7, 2015

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls	Identity	Default
PK	TruckId	int	4	False	1 - 1	
	Name	nvarchar(50)	100	False		
	License	nvarchar(50)	100	True		
	EquipNo	nvarchar(50)	100	True		
	Description	nvarchar(max)	max	True		
	Mileage	float	8	True		
	Year	int	4	True		
	Make	nvarchar(50)	100	True		
FK	HomeId	int	4	True		
FK	ODOTDistrictId	int	4	True		
	isActive	bit	1	True		((1))
	Modified	datetime	8	False		(getutcdate())
	ModifiedBy	nvarchar(50)	100	False		('System')
	Created	datetime	8	False		(getutcdate())
	CreatedBy	nvarchar(50)	100	False		('System')
	MileageEstimate-Total	float	8	False		((0.0))

Indexes

Key	Name	Columns	Unique
PK	PK__Truck__6632E97BB83FD287	TruckId	True

Foreign Keys

Name	No Check	Columns
FK_Truck_Home	True	HomeId->[dbo].[Home].[HomeId]
FK_Truck_ODOTDistrict	True	ODOTDistrictId->[dbo].[ODOTDistrict].[ODOTDistrictId]

SQL Script

```
CREATE TABLE [dbo].[Truck]
(
[TruckId] [int] NOT NULL IDENTITY(1, 1),
[Name] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[License] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[EquipNo] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[Description] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[Mileage] [float] NULL,
[Year] [int] NULL,
[Make] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[HomeId] [int] NULL,
[ODOTDistrictId] [int] NULL,
```

```
[isActive] [bit] NULL CONSTRAINT [DF__Truck__isActive__4F7CD00D] DEFAULT ((1)),
[Modified] [datetime] NOT NULL CONSTRAINT [DF__Truck__Modified__5070F446] DEFAULT (getutcdate()),
[ModifiedBy] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__Truck__Modified-
B__5165187F] DEFAULT ('System'),
[Created] [datetime] NOT NULL CONSTRAINT [DF__Truck__Created__52593CB8] DEFAULT (getutcdate()),
[CreatedBy] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__Truck__Created-
By__534D60F1] DEFAULT ('System'),
[MileageEstimateTotal] [float] NOT NULL CONSTRAINT [DF__Truck__MileageEs__2E90DD8E] DEFAULT ((0.0))
)
GO
ALTER TABLE [dbo].[Truck] ADD CONSTRAINT [PK__Truck__6632E97BB83FD287] PRIMARY KEY CLUSTERED  ([TruckId])
GO
ALTER TABLE [dbo].[Truck] WITH NOCHECK ADD CONSTRAINT [FK_Truck_Home] FOREIGN KEY ([HomeId]) REFERENCES
[dbo].[Home] ([HomeId])
GO
ALTER TABLE [dbo].[Truck] WITH NOCHECK ADD CONSTRAINT [FK_Truck_ODOTDistrict] FOREIGN KEY ([ODOTDistrictId])
REFERENCES [dbo].[ODOTDistrict] ([ODOTDistrictId])
GO
```

Uses

[dbo].[Home]
[dbo].[ODOTDistrict]

Used By

[dbo].[Device]
[dbo].[Original_Report661]
[dbo].[Report661]
[dbo].[Truck_Driver]
[dbo].[spProcessFATrans]
[dbo].[spProcessPWLocation]
[dbo].[vHomeTruck]
[dbo].[vUserTruck]

D.5.1.1.57 [dbo].[Truck_Driver]

Properties

Property	Value
Row Count (~)	2
Created	6:49:08 PM Thursday, January 2, 2014
Last Modified	1:10:39 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK FK	TruckId	int	4	False
PK FK	DriverId	int	4	False

Indexes

Key	Name	Columns	Unique
PK	PK__Truck_Dr__3929F5AB48AEDA77	TruckId, DriverId	True

Foreign Keys

Name	No Check	Columns
FK_Truck_Driver_Driver	True	DriverId->[dbo].[Driver].[DriverId]
FK_Truck_Driver_Truck	True	TruckId->[dbo].[Truck].[TruckId]

SQL Script

```
CREATE TABLE [dbo].[Truck_Driver]
(
[TruckId] [int] NOT NULL,
[DriverId] [int] NOT NULL
)
GO
ALTER TABLE [dbo].[Truck_Driver] ADD CONSTRAINT [PK__Truck_Dr__3929F5AB48AEDA77] PRIMARY KEY CLUSTERED
([TruckId], [DriverId])
GO
ALTER TABLE [dbo].[Truck_Driver] WITH NOCHECK ADD CONSTRAINT [FK_Truck_Driver_Driver] FOREIGN KEY ([DriverId])
REFERENCES [dbo].[Driver] ([DriverId])
GO
ALTER TABLE [dbo].[Truck_Driver] WITH NOCHECK ADD CONSTRAINT [FK_Truck_Driver_Truck] FOREIGN KEY ([TruckId])
REFERENCES [dbo].[Truck] ([TruckId])
GO
```

Uses

[dbo].[Driver]
[dbo].[Truck]

D.5.1.1.58 [dbo].[TruckLocation]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	7299952
Created	5:30:39 PM Thursday, November 20, 2014
Last Modified	1:02:00 AM Monday, February 9, 2015

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls	Default
	TruckLocationId	uniqueidentifier	16	False	(newid())
(2)	DeviceId	int	4	False	
	TransactionId	uniqueidentifier	16	True	
	CurLocation	geography	max	False	
	LogpointId	int	4	True	
	Distance	decimal(18,2)	9	True	
	Heading	float	8	True	
	CardinalHeading	nvarchar(2)	4	True	
	SpeedMPH	float	8	True	
	SpeedkMPH	float	8	True	
(2)	DeviceTime	datetime	8	True	
	ReceivedTime	datetime	8	True	
	MileageEstimate	float	8	False	((0.0))

Indexes

Key	Name	Columns	Unique
	PK__TruckLoc__A44F4F858B51BBD3	TruckLocationId	True
	IX_TruckLocation_DeviceId_DeviceTime_-MileageEstimate	DeviceId, DeviceTime, Mileage-Estimate	
	IX_TruckLocation_DeviceTime_DESC	DeviceId, DeviceTime	

Foreign Keys

Name	No Check	Columns
FK_TruckLocation_Device	True	DeviceId->[dbo].[Device].[DeviceId]
FK_TruckLocation_Logpoint	True	LogpointId->[dbo].[Logpoint].[LogpointId]

SQL Script

```
CREATE TABLE [dbo].[TruckLocation]
(
[TruckLocationId] [uniqueidentifier] NOT NULL CONSTRAINT [DF__TruckLoca__Truck__24134F1B] DEFAULT (newid()),
[DeviceId] [int] NOT NULL,
[TransactionId] [uniqueidentifier] NULL,
[CurLocation] [sys].[geography] NOT NULL,
[LogpointId] [int] NULL,
[Distance] [decimal] (18, 2) NULL,
[Heading] [float] NULL,
[CardinalHeading] [nvarchar] (2) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[SpeedMPH] [float] NULL,
[SpeedkMPH] [float] NULL,
[DeviceTime] [datetime] NULL,
[ReceivedTime] [datetime] NULL,
```

```
[MileageEstimate] [float] NOT NULL CONSTRAINT [DF__TruckLoca__Milea__25077354] DEFAULT ((0.0))
)
GO
ALTER TABLE [dbo].[TruckLocation] ADD CONSTRAINT [PK__TruckLoc__A44F4F858B51BBD3] PRIMARY KEY CLUSTERED
([TruckLocationId])
GO
CREATE NONCLUSTERED INDEX [IX_TruckLocation_DeviceId_DeviceTime_MileageEstimate] ON [dbo].[TruckLocation] ([DeviceId],
[DeviceTime], [MileageEstimate])
GO
CREATE NONCLUSTERED INDEX [IX_TruckLocation_DeviceTime_DESC] ON [dbo].[TruckLocation] ([DeviceTime] DESC)
INCLUDE ([DeviceId])
GO
ALTER TABLE [dbo].[TruckLocation] WITH NOCHECK ADD CONSTRAINT [FK_TruckLocation_Device] FOREIGN KEY ([DeviceId])
REFERENCES [dbo].[Device] ([DeviceId])
GO
ALTER TABLE [dbo].[TruckLocation] WITH NOCHECK ADD CONSTRAINT [FK_TruckLocation_Logpoint] FOREIGN KEY
([LogpointId]) REFERENCES [dbo].[Logpoint] ([LogpointId])
GO
```

Uses

[dbo].[Device]
[dbo].[Logpoint]

Used By

[dbo].[PlowInfo]
[dbo].[SpreaderInfo]
[dbo].[fFA_Location]
[dbo].[fFA_Spreader]
[dbo].[fPW_Location]
[dbo].[getTruckLocationEstMileage]
[dbo].[spGenerateFASegment]
[dbo].[spProcessFATrans]
[dbo].[spProcessPWLocation]
[dbo].[spUpdateLocationLogpoints]
[dbo].[vFA_Location]
[dbo].[vPW_Location]
[dbo].[vTruckLocationEstMileage]

D.5.1.1.59 [dbo].[UnloadFunction]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	3
Created	6:48:57 PM Thursday, January 2, 2014
Last Modified	6:49:15 PM Thursday, January 2, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK C	UnloadFunctionId	int	4	False
	Name	nvarchar(50)	100	False

Indexes

Key	Name	Columns	Unique
PK C	PK__UnloadFu__3A944836011194FD	UnloadFunctionId	True

SQL Script

```
CREATE TABLE [dbo].[UnloadFunction]
(
[UnloadFunctionId] [int] NOT NULL,
[Name] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL
)
GO
ALTER TABLE [dbo].[UnloadFunction] ADD CONSTRAINT [PK__UnloadFu__3A944836011194FD] PRIMARY KEY CLUSTERED
([UnloadFunctionId])
GO
```

Used By

[dbo].[SpreaderInfo]

D.5.1.1.60 [dbo].[Usage]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	0
Created	6:49:08 PM Thursday, January 2, 2014
Last Modified	1:10:39 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls	Default
PK C	AppUsageId	uniqueidentifier	16	False	
	UserName	nvarchar(50)	100	False	('Unknown')
	URL	nvarchar(max)	max	False	('Unknown')
	DTIn	datetime	8	False	(getutcdate())
	DTOut	datetime	8	True	

Indexes

Key	Name	Columns	Unique
PK C	PK__Usage__18EE977742A9B6AB	AppUsageId	True

SQL Script

```
CREATE TABLE [dbo].[Usage]
(
[AppUsageId] [uniqueidentifier] NOT NULL,
[UserName] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__Usage__User-
Name__14E61A24] DEFAULT ('Unknown'),
[URL] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__Usage__URL__15DA3E5D]
DEFAULT ('Unknown'),
[DTIn] [datetime] NOT NULL CONSTRAINT [DF__Usage__DTIn__16CE6296] DEFAULT (getutcdate()),
[DTOut] [datetime] NULL
)
GO
ALTER TABLE [dbo].[Usage] ADD CONSTRAINT [PK__Usage__18EE977742A9B6AB] PRIMARY KEY CLUSTERED  ([AppUsage-
Id])
GO
```

D.5.1.1.61	[dbo].[uscounties]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	92
Created	6:48:59 PM Thursday, January 2, 2014
Last Modified	1:10:43 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls	Identity	Default
PK	ID	int	4	False	1 - 1	
	AREA	numeric(26,5)	13	True		
	PERIMETER	numeric(26,5)	13	True		
	CO99_D00_	numeric(11,0)	9	True		
	CO99_D00_I	numeric(11,0)	9	True		
	STATE	varchar(2)	2	True		
	COUNTY	varchar(3)	3	True		
FK	StateId	int	4	False		((41))
FK	CountyId	int	4	False		((1641))
	NAME	varchar(90)	90	True		
	LSAD	varchar(2)	2	True		
	LSAD_TRANS	varchar(50)	50	True		
	the_geo	geography	max	True		
	the_geom	geometry	max	True		

Indexes

Key	Name	Columns	Type	Unique
PK	PK_USCounties	ID		True
	the_geo_sidx	the_geo	spatial	
	the_geom_sidx	the_geom	spatial	

Spatial Indexes

Name	Tessalation Scheme	Bounding Box	Grids	Cells Per Object
the_geo_sidx	GEOGRAPHY_-GRID		level_1=MEDIUM, level_2=MEDIUM, level_3=MEDIUM, level_4=MEDIUM	16
the_geom_sidx	GEOMETRY_-GRID	xmin=-90, ymin=-180, xmax=90, ymax=180	level_1=HIGH, level_2=HIGH, level_3=HIGH, level_4=HIGH	16

Check Constraints

Name	Checked	On Column	Constraint
enforce_srid_geography_USCounties	False	the_geo	([the_geo].[STSrid]=(4326))
enforce_srid_geometry_USCounties	False	the_geom	([the_geom].[STSrid]=(4326))

Foreign Keys

Name	No Check	Columns
FK_uscounties_County	True	CountyId->[dbo].[County].[CountyId]
FK_uscounties_State	True	StateId->[dbo].[State].[StateId]

SQL Script

```
CREATE TABLE [dbo].[uscounties]
(
[ID] [int] NOT NULL IDENTITY(1, 1),
[AREA] [numeric] (26, 5) NULL,
[PERIMETER] [numeric] (26, 5) NULL,
[CO99_D00_] [numeric] (11, 0) NULL,
[CO99_D00_I] [numeric] (11, 0) NULL,
[STATE] [varchar] (2) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[COUNTY] [varchar] (3) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[StateId] [int] NOT NULL CONSTRAINT [DF__uscountie__State__1BC821DD] DEFAULT ((41)),
[CountyId] [int] NOT NULL CONSTRAINT [DF__uscountie__Count__1CBC4616] DEFAULT ((1641)),
[NAME] [varchar] (90) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[LSAD] [varchar] (2) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[LSAD_TRANS] [varchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[the_geo] [sys].[geography] NULL,
[the_geom] [sys].[geometry] NULL
)
GO
ALTER TABLE [dbo].[uscounties] WITH NOCHECK ADD CONSTRAINT [enforce_srid_geography_USCounties] CHECK
(([the_geo].[STSrid]=(4326)))
GO
ALTER TABLE [dbo].[uscounties] WITH NOCHECK ADD CONSTRAINT [enforce_srid_geometry_USCounties] CHECK
(([the_geom].[STSrid]=(4326)))
GO
ALTER TABLE [dbo].[uscounties] NOCHECK CONSTRAINT [enforce_srid_geography_USCounties]
GO
ALTER TABLE [dbo].[uscounties] NOCHECK CONSTRAINT [enforce_srid_geometry_USCounties]
GO
ALTER TABLE [dbo].[uscounties] ADD CONSTRAINT [PK_USCounties] PRIMARY KEY CLUSTERED  ([ID])
GO
CREATE SPATIAL INDEX [the_geo_sidx] ON [dbo].[uscounties] ([the_geo]) WITH (GRIDS = (MEDIUM, MEDIUM, MEDIUM,
MEDIUM), CELLS_PER_OBJECT = 16)
GO
CREATE SPATIAL INDEX [the_geom_sidx] ON [dbo].[uscounties] ([the_geom]) WITH (BOUNDING_BOX = (-90, -180, 90, 180),
GRIDS = (HIGH, HIGH, HIGH, HIGH), CELLS_PER_OBJECT = 16)
GO
ALTER TABLE [dbo].[uscounties] WITH NOCHECK ADD CONSTRAINT [FK_uscounties_County] FOREIGN KEY ([CountyId])
REFERENCES [dbo].[County] ([CountyId])
GO
ALTER TABLE [dbo].[uscounties] WITH NOCHECK ADD CONSTRAINT [FK_uscounties_State] FOREIGN KEY ([StateId])
REFERENCES [dbo].[State] ([StateId])
GO
```

Uses

[dbo].[County]
[dbo].[State]

Used By

[dbo].[usp_CountiesByDistance]
[dbo].[usp_CountiesByIntersection]

D.5.1.1.62 [dbo].[User_Home]

Properties

Property	Value
Row Count (~)	6
Created	6:49:09 PM Thursday, January 2, 2014
Last Modified	1:10:40 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
	UserId	int	4	False
	HomeId	int	4	False

Indexes

Key	Name	Columns	Unique
	PK__User_Hom__268D1A0077E6A11E	UserId, HomeId	True

Foreign Keys

Name	No Check	Columns
FK_User_Home_Home	True	HomeId->[dbo].[Home].[HomeId]
FK_User_Home_UserProfile	True	UserId->[dbo].[UserProfile].[UserId]

SQL Script

```
CREATE TABLE [dbo].[User_Home]
(
[UserId] [int] NOT NULL,
[HomeId] [int] NOT NULL
)
GO
ALTER TABLE [dbo].[User_Home] ADD CONSTRAINT [PK__User_Hom__268D1A0077E6A11E] PRIMARY KEY CLUSTERED
([UserId], [HomeId])
GO
ALTER TABLE [dbo].[User_Home] WITH NOCHECK ADD CONSTRAINT [FK_User_Home_Home] FOREIGN KEY ([HomeId])
REFERENCES [dbo].[Home] ([HomeId])
GO
ALTER TABLE [dbo].[User_Home] WITH NOCHECK ADD CONSTRAINT [FK_User_Home_UserProfile] FOREIGN KEY ([UserId])
REFERENCES [dbo].[UserProfile] ([UserId])
GO
```

Uses

[dbo].[Home]
[dbo].[UserProfile]

Used By

[dbo].[vUserTruck]

D.5.1.1.63 [dbo].[UserProfile]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	6
Created	6:49:01 PM Thursday, January 2, 2014
Last Modified	1:11:33 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls	Identity	Default
PK C	UserId	int	4	False	1 - 1	
	UserName	nvarchar(50)	100	False		
	FirstName	nvarchar(50)	100	False		
	LastName	nvarchar(50)	100	False		
	Email	nvarchar(max)	max	False		
	Phone	nvarchar(50)	100	True		
	Addr_Street	nvarchar(max)	max	True		
	Addr_City	nvarchar(50)	100	True		
	Addr_State	nvarchar(50)	100	True		
	Addr_Zip	nvarchar(50)	100	True		
	isActive	bit	1	True		((1))
	LastLogin	datetime	8	False		(getutcdate())
	Modified	datetime	8	False		(getutcdate())
	ModifiedBy	nvarchar(50)	100	False		('System')
	Created	datetime	8	False		(getutcdate())
	CreatedBy	nvarchar(50)	100	False		('System')

Indexes

Key	Name	Columns	Unique
PK C	PK__UserProf__1788CC4CF6943C4E	UserId	True

SQL Script

```
CREATE TABLE [dbo].[UserProfile]
(
[UserId] [int] NOT NULL IDENTITY(1, 1),
[UserName] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[FirstName] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[LastName] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[Email] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[Phone] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[Addr_Street] [nvarchar] (max) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[Addr_City] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[Addr_State] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[Addr_Zip] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[isActive] [bit] NULL CONSTRAINT [DF__UserProfi__isAct__2FCF1A8A] DEFAULT ((1)),
[LastLogin] [datetime] NOT NULL CONSTRAINT [DF__UserProfi__LastL__30C33EC3] DEFAULT (getutcdate()),
[Modified] [datetime] NOT NULL CONSTRAINT [DF__UserProfi__Modif__31B762FC] DEFAULT (getutcdate()),
[ModifiedBy] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__UserProfi__-
Modif__32AB8735] DEFAULT ('System'),
[Created] [datetime] NOT NULL CONSTRAINT [DF__UserProfi__Creat__339FAB6E] DEFAULT (getutcdate()),
[CreatedBy] [nvarchar] (50) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL CONSTRAINT [DF__UserProfi__-
Creat__3493CFA7] DEFAULT ('System')
)
GO
```

```
ALTER TABLE [dbo].[UserProfile] ADD CONSTRAINT [PK__UserProf__1788CC4CF6943C4E] PRIMARY KEY CLUSTERED  ([User-
Id])
GO
```

Used By

[dbo].[Driver]
[dbo].[User_Home]
[dbo].[webpages_UsersInRoles]
[dbo].[vUserTruck]

D.5.1.1.64	[dbo].[webpages_Membership]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	6
Created	6:49:09 PM Thursday, January 2, 2014
Last Modified	1:10:43 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls	Default
PK C	UserId	int	4	False	
	CreateDate	datetime	8	True	
	ConfirmationToken	nvarchar(128)	256	True	
	IsConfirmed	bit	1	True	((0))
	LastPasswordFailureDate	datetime	8	True	
	PasswordFailuresSinceLastSuccess	int	4	False	((0))
	Password	nvarchar(128)	256	False	
	PasswordChangedDate	datetime	8	True	
	PasswordSalt	nvarchar(128)	256	False	
	PasswordVerificationToken	nvarchar(128)	256	True	
	PasswordVerificationToken-ExpirationDate	datetime	8	True	

Indexes

Key	Name	Columns	Unique
PK C	PK__webpages__1788CC4C56ADD8C7	UserId	True

SQL Script

```
CREATE TABLE [dbo].[webpages_Membership]
(
[UserId] [int] NOT NULL,
[CreateDate] [datetime] NULL,
[ConfirmationToken] [nvarchar] (128) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[IsConfirmed] [bit] NULL CONSTRAINT [DF__webpages___IsCon__1B9317B3] DEFAULT ((0)),
[LastPasswordFailureDate] [datetime] NULL,
[PasswordFailuresSinceLastSuccess] [int] NOT NULL CONSTRAINT [DF__webpages___Passw__1C873BEC] DEFAULT ((0)),
[Password] [nvarchar] (128) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[PasswordChangedDate] [datetime] NULL,
[PasswordSalt] [nvarchar] (128) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[PasswordVerificationToken] [nvarchar] (128) COLLATE SQL_Latin1_General_CP1_CI_AS NULL,
[PasswordVerificationTokenExpirationDate] [datetime] NULL
)
GO
ALTER TABLE [dbo].[webpages_Membership] ADD CONSTRAINT [PK__webpages__1788CC4C56ADD8C7] PRIMARY KEY
CLUSTERED  ([UserId])
GO
```

D.5.1.1.65 [dbo].[webpages_OAuthMembership]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	0
Created	6:49:09 PM Thursday, January 2, 2014
Last Modified	1:10:43 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK C	Provider	nvarchar(30)	60	False
PK C	ProviderUserId	nvarchar(100)	200	False
	UserId	int	4	False

Indexes

Key	Name	Columns	Unique
PK C	PK__webpages__F53FC0ED137D54D6	Provider, ProviderUserId	True

SQL Script

```
CREATE TABLE [dbo].[webpages_OAuthMembership]
(
[Provider] [nvarchar] (30) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[ProviderUserId] [nvarchar] (100) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL,
[UserId] [int] NOT NULL
)
GO
ALTER TABLE [dbo].[webpages_OAuthMembership] ADD CONSTRAINT [PK__webpages__F53FC0ED137D54D6] PRIMARY KEY
CLUSTERED  ([Provider], [ProviderUserId])
GO
```

D.5.1.1.66 [dbo].[webpages_Roles]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	6
Created	6:49:09 PM Thursday, January 2, 2014
Last Modified	1:10:43 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls	Identity
PK C	RoleId	int	4	False	1 - 1
	RoleName	nvarchar(256)	512	False	

Indexes

Key	Name	Columns	Unique
PK C	PK__webpages__8AFACE1A2FCDAFC9	RoleId	True
	UQ__webpages__8A2B6160001CC6FD	RoleName	True

SQL Script

```
CREATE TABLE [dbo].[webpages_Roles]
(
[RoleId] [int] NOT NULL IDENTITY(1, 1),
[RoleName] [nvarchar] (256) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL
)
GO
ALTER TABLE [dbo].[webpages_Roles] ADD CONSTRAINT [PK__webpages__8AFACE1A2FCDAFC9] PRIMARY KEY CLUSTERED
([RoleId])
GO
ALTER TABLE [dbo].[webpages_Roles] ADD CONSTRAINT [UQ__webpages__8A2B6160001CC6FD] UNIQUE NONCLUSTERED
([RoleName])
GO
```

Used By

[dbo].[webpages_UsersInRoles]

D.5.1.1.67 [dbo].[webpages_UsersInRoles]

Properties

Property	Value
Row Count (~)	6
Created	6:49:09 PM Thursday, January 2, 2014
Last Modified	1:10:43 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK FK C	UserId	int	4	False
PK FK C	RoleId	int	4	False

Indexes

Key	Name	Columns	Unique
PK C	PK__webpages__AF2760ADCAF2A134	UserId, RoleId	True

Foreign Keys

Name	No Check	Columns
fk_RoleId	True	RoleId->[dbo].[webpages_Roles].[RoleId]
fk_UserId	True	UserId->[dbo].[UserProfile].[UserId]

SQL Script

```
CREATE TABLE [dbo].[webpages_UsersInRoles]
(
[UserId] [int] NOT NULL,
[RoleId] [int] NOT NULL
)
GO
ALTER TABLE [dbo].[webpages_UsersInRoles] ADD CONSTRAINT [PK__webpages__AF2760ADCAF2A134] PRIMARY KEY
CLUSTERED  ([UserId], [RoleId])
GO
ALTER TABLE [dbo].[webpages_UsersInRoles] WITH NOCHECK ADD CONSTRAINT [fk_RoleId] FOREIGN KEY ([RoleId])
REFERENCES [dbo].[webpages_Roles] ([RoleId])
GO
ALTER TABLE [dbo].[webpages_UsersInRoles] WITH NOCHECK ADD CONSTRAINT [fk_UserId] FOREIGN KEY ([UserId])
REFERENCES [dbo].[UserProfile] ([UserId])
GO
```

Uses

[dbo].[UserProfile]
[dbo].[webpages_Roles]

D.5.1.1.68 [dbo].[ZipCode]

Properties

Property	Value
Collation	SQL_Latin1_General_CP1_CI_AS
Row Count (~)	42269
Created	6:49:09 PM Thursday, January 2, 2014
Last Modified	1:10:56 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK C	ZipCodeId	int	4	False
	ZipCode	nvarchar(10)	20	False

Indexes

Key	Name	Columns	Unique
PK C	PK__ZipCode__36DEF30943C7CD18	ZipCodeId	True

SQL Script

```
CREATE TABLE [dbo].[ZipCode]
(
[ZipCodeId] [int] NOT NULL,
[ZipCode] [nvarchar] (10) COLLATE SQL_Latin1_General_CP1_CI_AS NOT NULL
)
GO
ALTER TABLE [dbo].[ZipCode] ADD CONSTRAINT [PK__ZipCode__36DEF30943C7CD18] PRIMARY KEY CLUSTERED  ([Zip-
CodeId])
GO
```

Used By

[dbo].[ZipCode_City]

D.5.1.1.69	[dbo].[ZipCode_City]

Properties

Property	Value
Row Count (~)	41900
Created	6:49:09 PM Thursday, January 2, 2014
Last Modified	1:11:09 AM Monday, October 20, 2014

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK FK	ZipCodeId	int	4	False
PK FK	CityId	int	4	False

Indexes

Key	Name	Columns	Unique
PK	PK__ZipCode___49F3D2BE690D3D2C	ZipCodeId, CityId	True

Foreign Keys

Name	No Check	Columns
FK_ZipCode_City_City	True	CityId->[dbo].[City].[CityId]
FK_ZipCode_City_ZipCode	True	ZipCodeId->[dbo].[ZipCode].[ZipCodeId]

SQL Script

```
CREATE TABLE [dbo].[ZipCode_City]
(
[ZipCodeId] [int] NOT NULL,
[CityId] [int] NOT NULL
)
GO
ALTER TABLE [dbo].[ZipCode_City] ADD CONSTRAINT [PK__ZipCode___49F3D2BE690D3D2C] PRIMARY KEY CLUSTERED
([ZipCodeId], [CityId])
GO
ALTER TABLE [dbo].[ZipCode_City] WITH NOCHECK ADD CONSTRAINT [FK_ZipCode_City_City] FOREIGN KEY ([CityId])
REFERENCES [dbo].[City] ([CityId])
GO
ALTER TABLE [dbo].[ZipCode_City] WITH NOCHECK ADD CONSTRAINT [FK_ZipCode_City_ZipCode] FOREIGN KEY ([ZipCode-
Id]) REFERENCES [dbo].[ZipCode] ([ZipCodeId])
GO
```

Uses

[dbo].[City]
[dbo].[ZipCode]

APPENDIX E WEBSITE GUIDE

Appendix B will walk ODOT users through the functions of the GPS/AVL website. This guide is a beginning step for users. The research team feels that the best way to understand the website is to spend time exploring all features on it. Please note that this website was designed to be scaled up for other features; therefore there may be features that are nonfunctioning at this time. The website address is odot.cloudapp.net.

E.1 Login

In order to visit the website, a user must enter a *Username* and *Password* field. Figure E.1 presents the login page of the website.

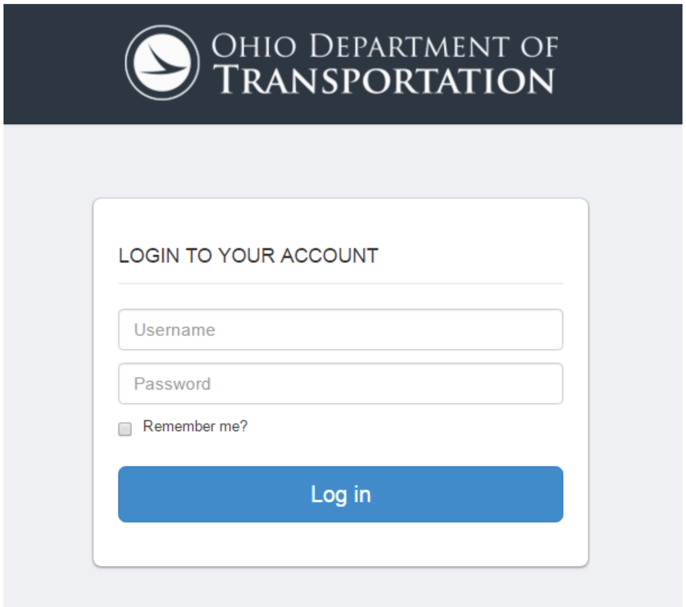


Figure E.1: Login Page for the Website.

Checking the *Remember me?* box below the login inputs will automatically log the user in upon revisiting the site from the same computer. Once you have input your account information, press the *Log in* button.

The next screen, which will be prompted automatically after the login, is the *Site Usage Disclaimer*, seen in Figure E.2. Read and understand the disclaimer in its entirety. If there are questions, please contact Scott.Lucas@dot.ohio.gov as stated at the bottom of the disclaimer.

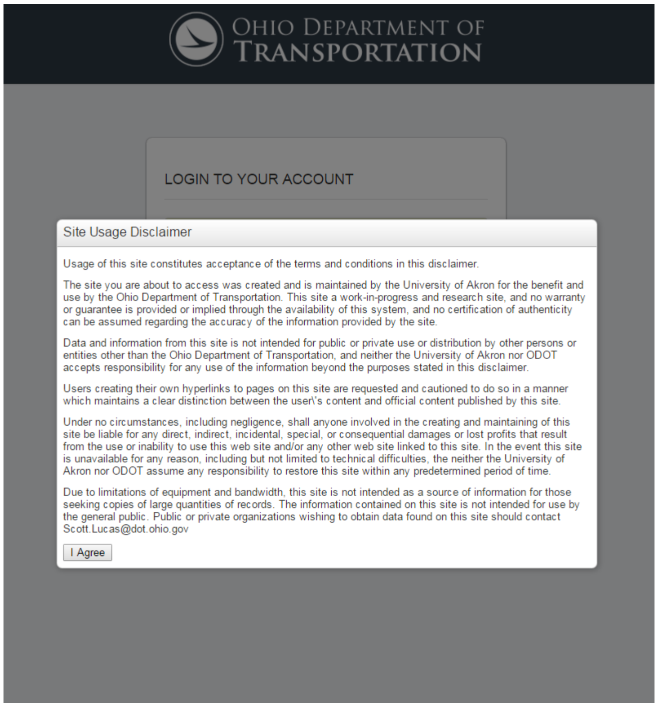


Figure E.2: Site Usage Disclaimer

Once the disclaimer is understood, press the *I Agree* button located in the bottom left of the dialog. .

If the account information is not correct, Figure E.3 will be presented on the site.

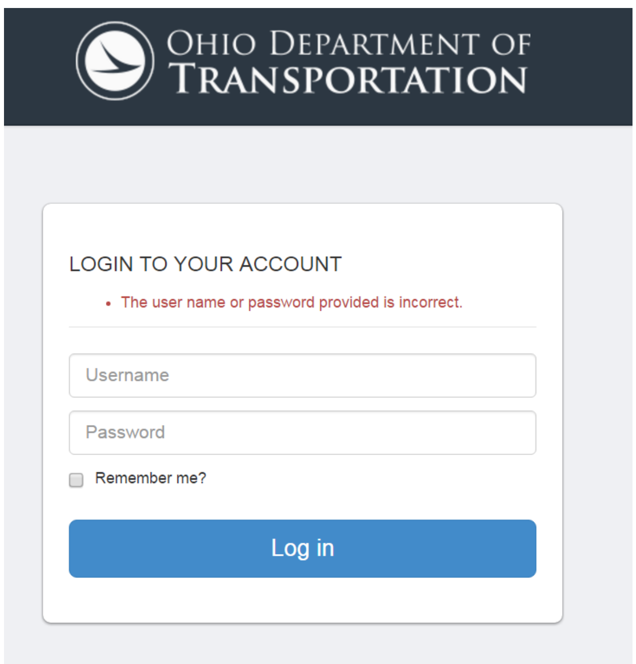


Figure E.3: Invalid Username or Password Prompt.

Be sure to make sure that the Caps Lock is not on while logging into the website, as this could cause the invalid username and/or password prompt.

Once successfully logged in, the real-time truck map will be presented as shown in Figure E.4.

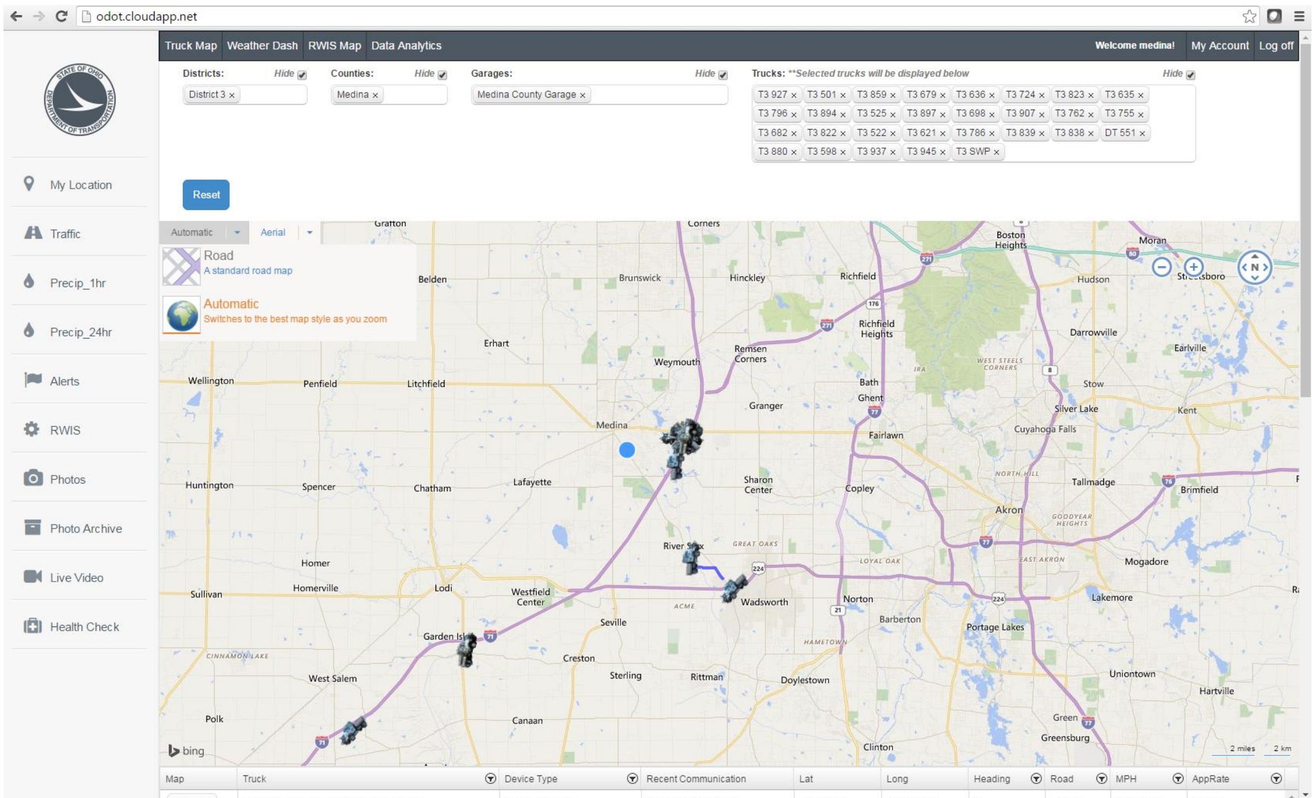


Figure E.4: Initial Display of Website after Successfully Logging In.

When logging in with a county login username, the website will zoom to and automatically filter only the trucks in that county.

E.2 Home Page Overview

The home page presents a truck (real-time) map, truck map tools, a top toolbar, left toolbar, and real-time truck details as presented in Figure E.5.

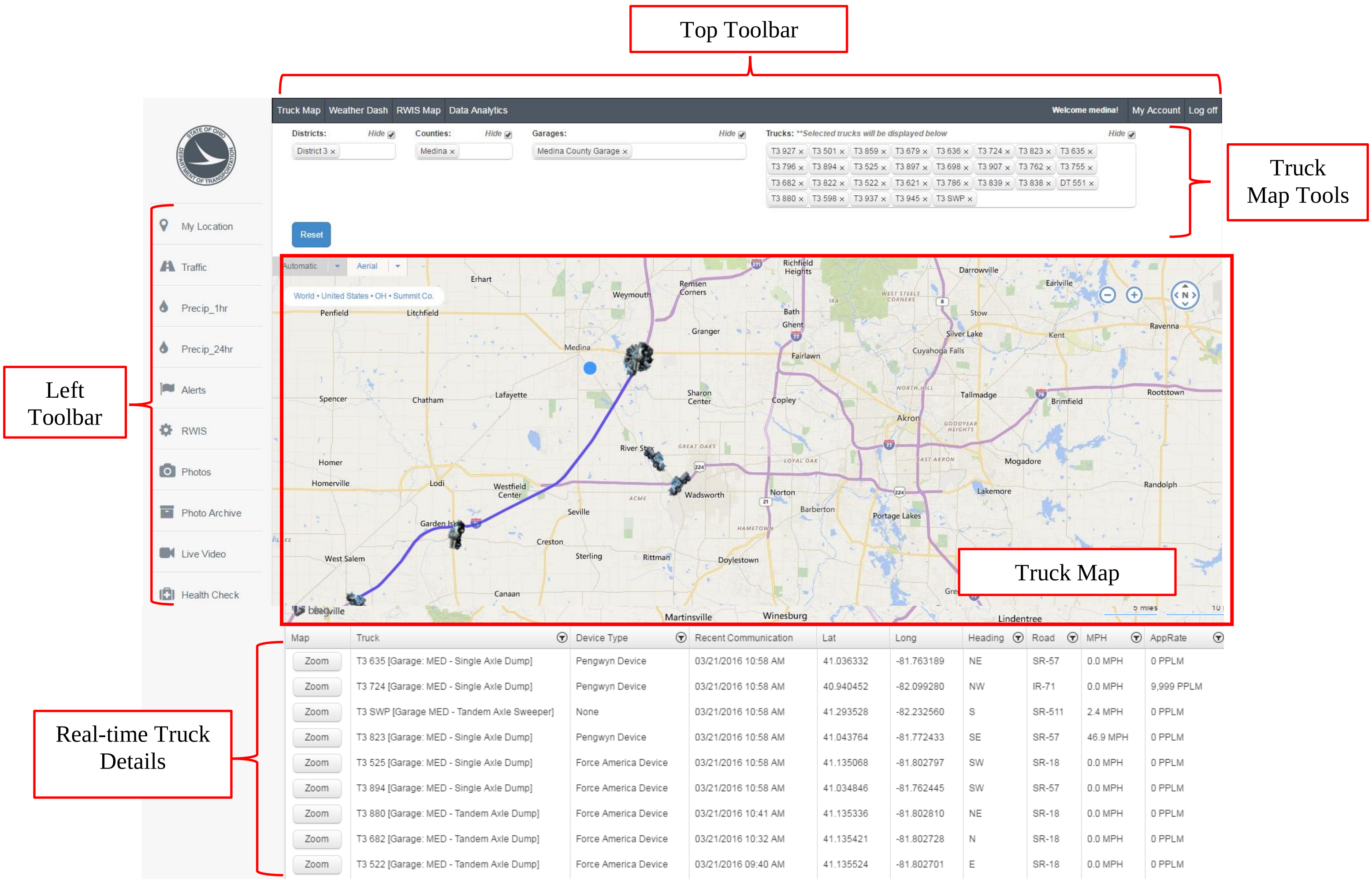


Figure E.5: Website Feature on Home Page (Truck Map).

The next three sections will explore the elements presented in red on the home page of the website in Figure E.5.

E.3 Real-time Truck Map

The truck map displays the location of trucks in real-time. The trucks may be seen moving on this map as they are out driving. Figure E.6 present the truck map.

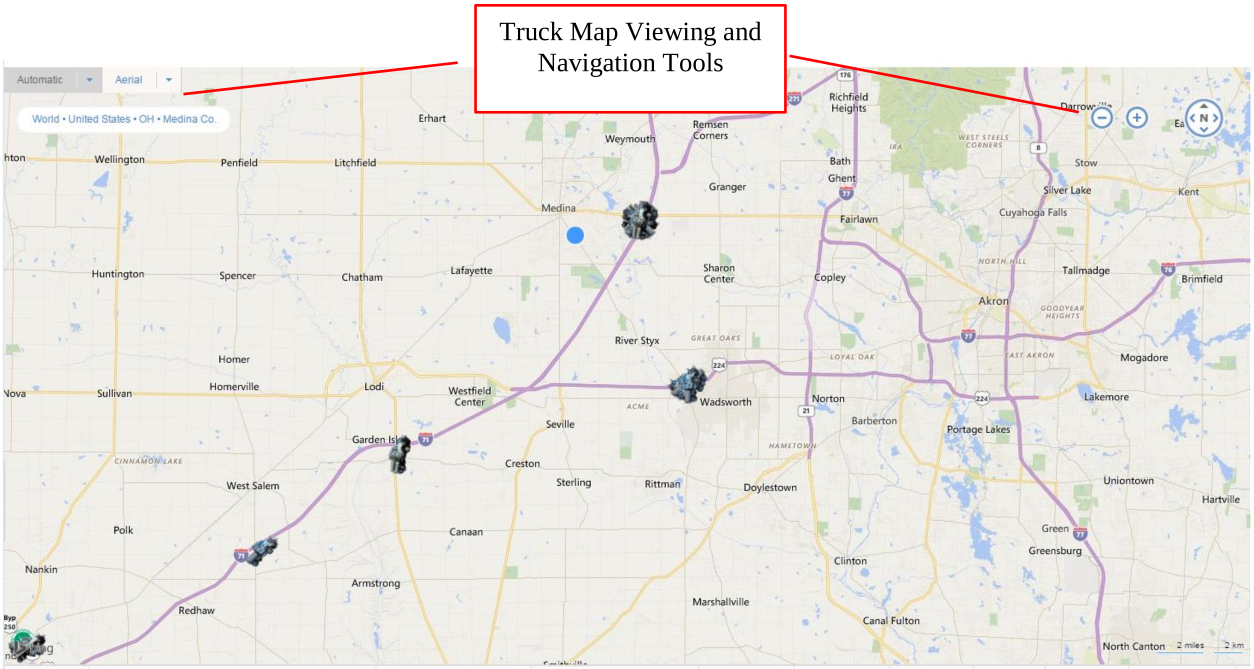


Figure E.6: The Real-time Truck Map.

By default the map will be set to the automatic view style. This style will be a roadmap view at large scales (zoomed out) and will transition to an aerial view at smaller scales (zoomed in). To change this style, hover over the style names at the top left corner of the map.

Navigating the map may be done through two methods: the mouse and the navigation buttons. Mouse controls for the map consist of holding the left mouse button down and moving the mouse to pan the view. In addition the scroll wheel on the mouse may be used to zoom the view. Alternatively there are navigation buttons located in the top right corner of the map. The plus and minus buttons zoom the map in and out respectively. To pan around the map, left click in the center of the directional circle, and drag in the desired direction. Also, pressing any of the directional arrows will move the map in that direction.

There are icons implemented into the truck (and RWIS) map to represent ODOT locations and assets. Figure E.7 presents images are used to represent the selected items in the truck map tools.

County	ODOT District	ODOT Garage	Tandem Axel Truck	Single Axel Truck	RWIS Site

Figure E.7: Icons Used on the Live Map.

Hovering over any of the visible icons will show contextual information about the item. If the user clicks the icon, the contextual information will remain open until closed by pressing the *X* in the top right corner of the information pop-up. Figure E.8 presents the information that will appear when hovering over a truck icon (clicking will leave open until closed).

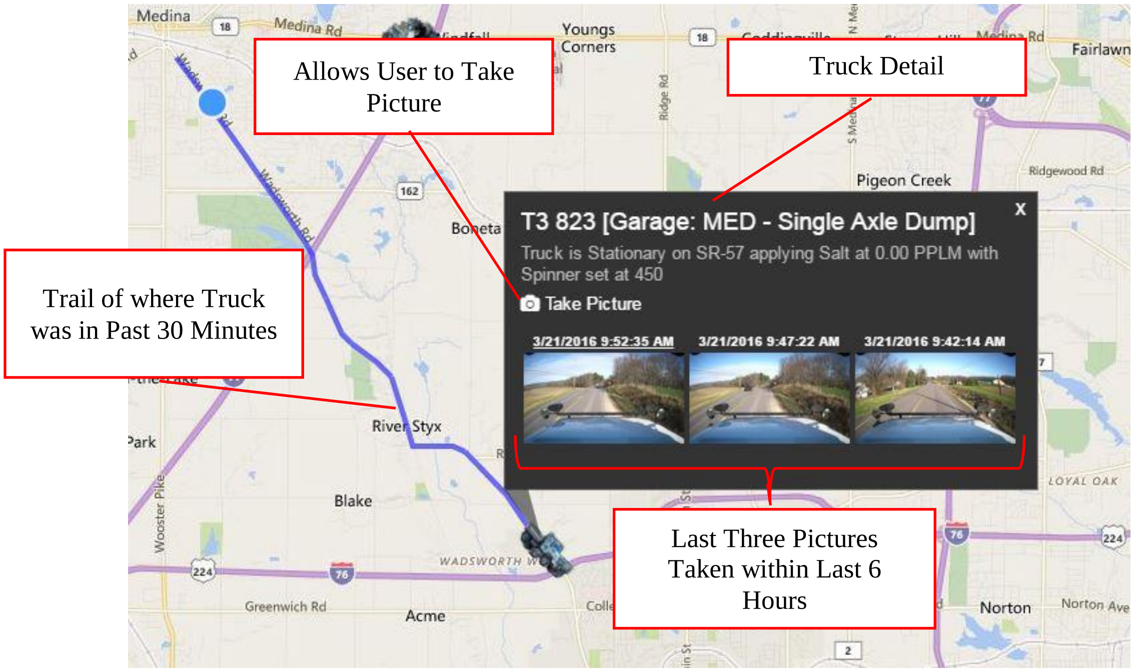


Figure E.8: Contextual Information for Selected Truck.

As presented in Figure E.8, when hovering or clicking on a truck, the truck data are presented at the top of the pop-up box, including location detail and hydraulic data (if hydraulic data is implemented). In addition, the user has the ability to take a photo using the *Take Picture* button on the pop-up, and view the last three pictures that were taken within six hours. In addition to the pop-up box, when hovering over or clicking on the truck, a blue line will appear behind the truck to indicate where the truck has traveled in the last 30 minutes. Note that no blue line would indicate that the truck was stationary over the last 30 minutes.

E.3.1 Truck Map Tools

As presented on Page 195, Figure E.5, the truck map tools above the real-time map allows the user to narrow down the visible items on the truck map. Selection is done by first selecting desired ODOT districts, then the relevant counties, garages, and trucks in the relevant boxes. By default most options will be automatically displayed (county logins will only present that counties fleet and information). To remove objects, simply click the *X* located on the right side of the name, as presented in Figure E.9.

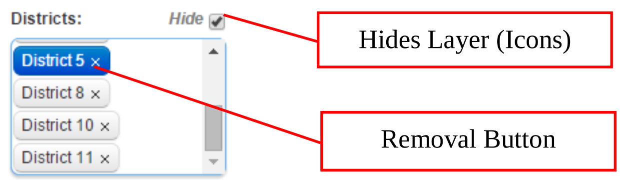


Figure E.9: Truck Map Tools.

To add objects to the current selection set, click into the desired category. This will open a selection menu with the options that may be added, as presented in Figure E.10.

Figure E.10: Selection Set Drop Down.

Available selections are limited by the options selected in the previous tier. The tiers are arranged as seen in Figure E.11.

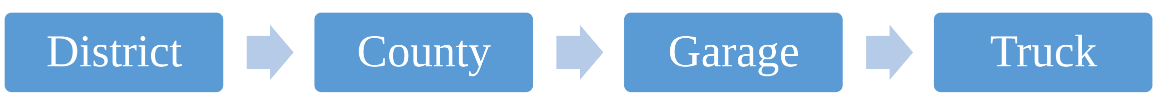


Figure E.11: Tiered Selection Explanation for the Filtering Data on Maps.

For example, as shown in Figure E.12, if District 4 is the only district selected; only its relevant counties will be available for selection in the county box. This tiered selection method applies for all selection boxes.

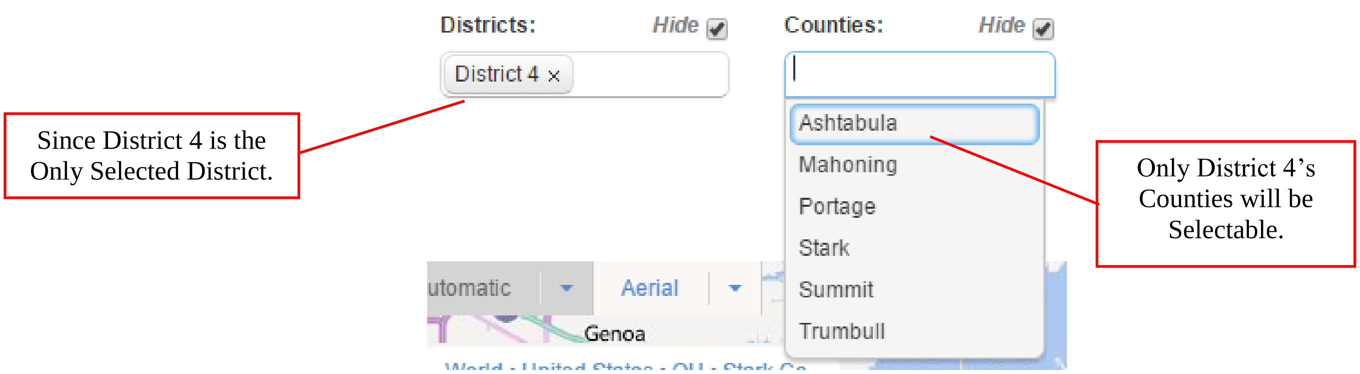


Figure E.12: Example of Tiered Selection Options.

Pressing the *Reset* button located on the left bottom section of the truck map tools will restore the default selections to all four categories.

E.3.2 Real-time Truck Details

The real-time truck details panel provides information for the selected trucks. Information readily available in this area is the Truck ID, device type, time of most recent communication, latitude, longitude, heading, road, speed in mile per hour, and the ability to zoom to the truck on the map.

Map	Truck	Device Type	Recent Communication	Lat	Long	Heading	Road	MPH
Zoom	T1 621 [Garage: VAN - Single Axle Dump]	Force America Device	12/22/2015 12:06 PM	40.887357	-84.581433	E	US-224	0.0 MPH
Zoom	T5 619 [Garage: MUS - Tandem Axle Dump]	Pengwyn Device	12/22/2015 12:06 PM	39.974756	-81.830624	W	US-22	20.8 MPH
Zoom	T4 697 [Garage: SUM - Single Axle Dump]	Pengwyn Device	12/22/2015 12:06 PM	41.042202	-81.662045	S	SR-21	0.0 MPH
Zoom	T5 551 [Garage: GUE - Single Axle Dump]	Pengwyn Device	12/22/2015 12:06 PM	40.235026	-81.854414	SE	SR-83	47.9 MPH
Zoom	T1 540 [Garage: VAN - Single Axle Dump]	Pengwyn Device	12/22/2015 12:06 PM	40.886481	-84.582920	N	US-127	0.0 MPH

Figure E.13: Detailed Information Panel for the Truck Map

These data may be sorted or filtered by clicking on any of the headings. The first selection will sort the data in alphabetic order, A-Z, or numeric order, 1-10. A second selection will reverse the order to Z-A or 10-1 respectively. A third click will remove any sorting. Data may only be sorted one column at a time. There are many filter options, clicking the circular icon located at the right edge of the column will open a drop down. In this dialog, the user may input filter terms and filter type. Available options include 'starts with', 'is equal to' and 'is not equal to' for non-numeric columns. Figure E.14 presents the filtering options available.

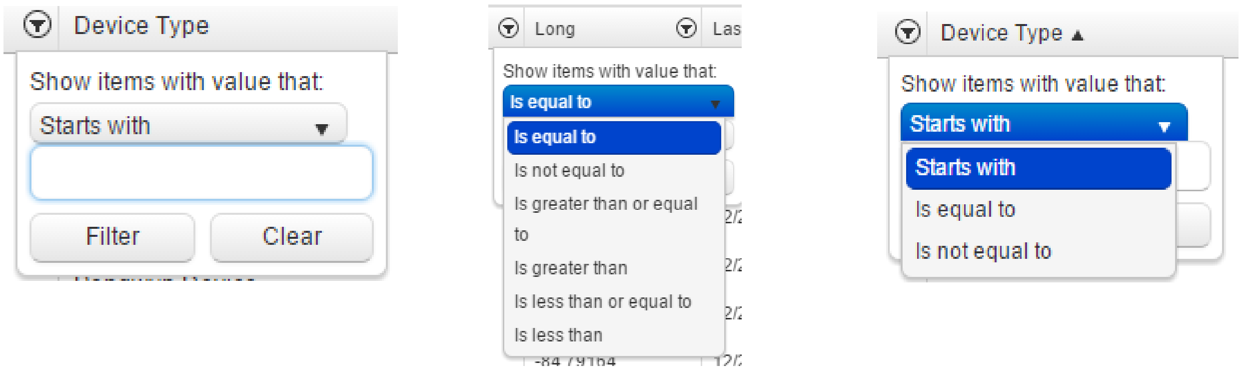


Figure E.14: Filtering Options.

Numeric columns have additional options. Filtering will limit the visible options to only those that match the chosen filter. To activate the filter, click on the *Filter* button. To clear the filter, click on the *Clear* button. Filters may be combined across columns. For example, a user may filter the Truck ID column to trucks starting with “T4”, while also filtering the device type column to those having a Pengwyn device.

Selecting the *Zoom* button for a truck will zoom the live map to the most recent location of the chosen truck.

E.3.3 Top Toolbar

The top toolbar, presented in Figure E.5 on page 195, remains constant regardless of the user’s location on the site. It allows navigation between the site’s different tools: the truck map, discussed in Section F.3, the weather dashboard, the RWIS map, data analytics, and for administrators, the asset manager. Clicking any of the headings will open the selected tool. The right portion of this toolbar consists of the user’s account information. It displays a *Welcome ‘username’!* in addition to the *My Account* and Log *Off* options.

E.4 Weather Dashboard

The weather dashboard tool is used to view weather information from RWIS sites located statewide. The tool is divided into five major areas: current conditions, weather dashboard tools, temperature history, weather forecast, and left toolbar as shown in Figure E.15.

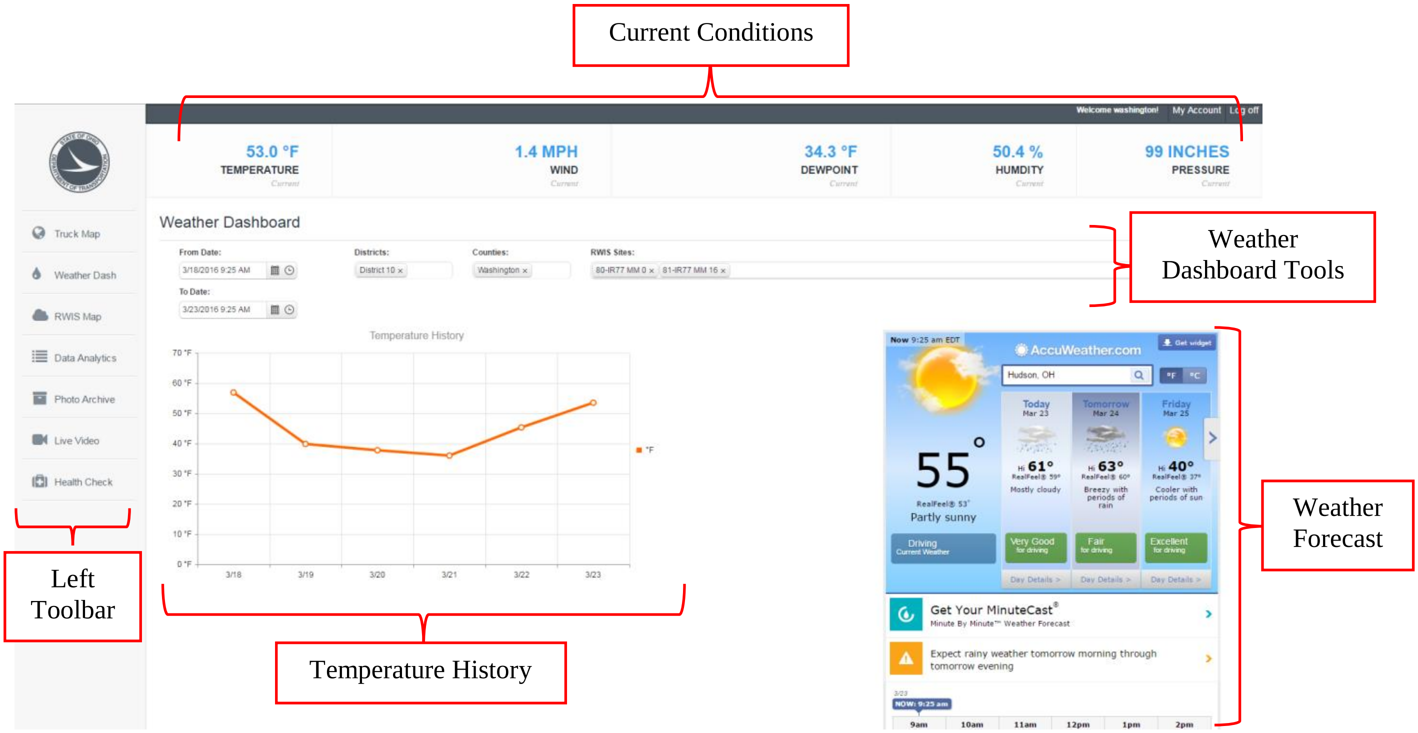


Figure E.15: Overview of the Weather Dashboard

The current conditions panel provides information regarding current weather conditions. These data are an average of the RWIS sites selected on the weather dashboard tools. The available information is temperature, wind speed, dew point, humidity, and air pressure.

The weather dashboard tools allow the user to add and remove the information sampled for the temperature history and current condition portion of the page. The selectable fields include: Start and End dates and times, District, County, and RWIS sites. This allows RWIS data to be found for a specific location(s) and/or for a specific time span. Start and end dates may be selected by either by changing the date and time displayed by typing, or by using the date and time selection tools. To use the tools, click on either the calendar or clock icon. This will open a date selection dialog or time selection drop down respectively. Choose the desired date or time and the changes will be applied. Information on how to add and remove data to the remaining fields may be found in Section F.3.1 on Page 197-199 in Figure E.9 through Figure E.12.

The temperature history panel displays a graph showing the average temperature for the duration of the selected time period for the RWIS sites selected in the weather dashboard tools. The chart will automatically update based on the selected time period and selected RWIS sites. It will automatically scale both axis to properly display the desired information.

The weather forecast panel consists of weather forecast information polled from Accuweather.com. To change the search location, type the desired city into the search box at the top of the panel. This will update the below information to the new location. Clicking on the data in the weather forecast will open Accuweather.com in a new tab. Details about the left toolbar are discussed in Section F.7.

E.5 RWIS Map

The RWIS map tool is used to view the current weather information sampled by the RWIS stations across the state of Ohio. It allows the user to filter the data by ODOT District as well as view detailed information from each station. The tool is divided into five areas: the selection area, the left toolbar, the top toolbar, live RWIS map, RWIS map tools, and the real-time RWIS details as shown in Figure E.16.

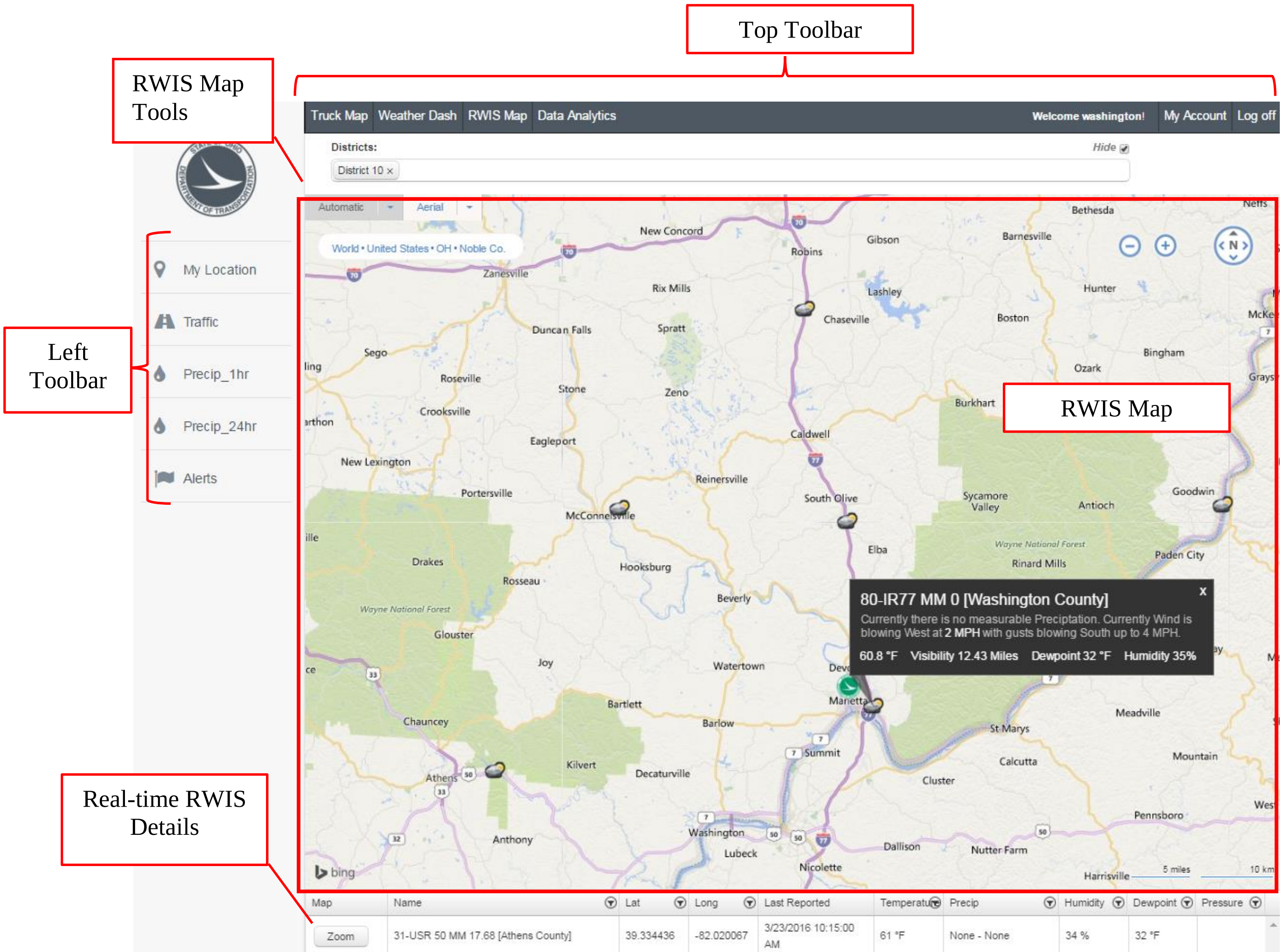


Figure E.16: Overview of the RWIS Map

The top toolbar is discussed in Section F.3.3. The details for the left toolbar are presented in Section F.7. The RWIS map presents the RWIS sites and is navigated similar to the real-time truck map. By default the map will be set to the Automatic view style. This style will be a roadmap view at large scales and will transition to an aerial view at smaller scales. To change this style, hover over the style names at the top left corner of the map. Navigation on the map may be done through two methods: the mouse and the navigation buttons. Mouse controls for the map consist of holding the left mouse button down and moving the mouse to pan the view. In addition the scroll wheel may be used to zoom the view. Alternatively users may use the navigation buttons located in the top right corner of the map. The plus and minus buttons zoom the map in and out respectively. To pan around the map, left click in the center of the directional circle, and drag in the desired direction. Also, pressing any of the directional arrows will move the map in that direction. The RWIS map tools allow the user to add and remove the information displayed on the real-time map. Selection and removal of items is done by the same methods detailed in Section F.3.1 on Page 197-199 in Figure E.9 through Figure E.12.

Hovering over any of the visible icons will show contextual information about the item. If the user clicks the icon, the contextual information will remain open until closed by pressing the *X* in the top right corner of the information pop-up as presented in Figure E.17.

Figure E.17: Contextual Information for the Selected RWIS Station

If any of the current alerts have been triggered, the alert causing statistic will be highlighted in red. Managing and editing alerts is discussed in Section F.7. The RWIS map tools allow the user to add and remove RWIS sites to the map. Information on how to add and remove data may be found in Section F.3.1 on Page 197-199 in Figure E.9 through Figure E.12. The real-time RWIS details are below the map and are similar to the truck map details. These details include the name of the RWIS site, latitude, longitude, last report time, temperature, precipitation, humidity, dew point, and pressure. These data may be filtered and sorted by following the same method detailed in Section F.3.2 on Page 199-200 in Figure E.14.

E.6 Data Analytics

The data analytics tool allows the user to view, print, and download historical data. The data are organized by each trip logged by the system. The tool allows the user to search automatically generated data sets as well as generate their own report. The tool is divided into four major areas: data selection tools, data details, left toolbar, and the data report creator as shown in Figure E.18.

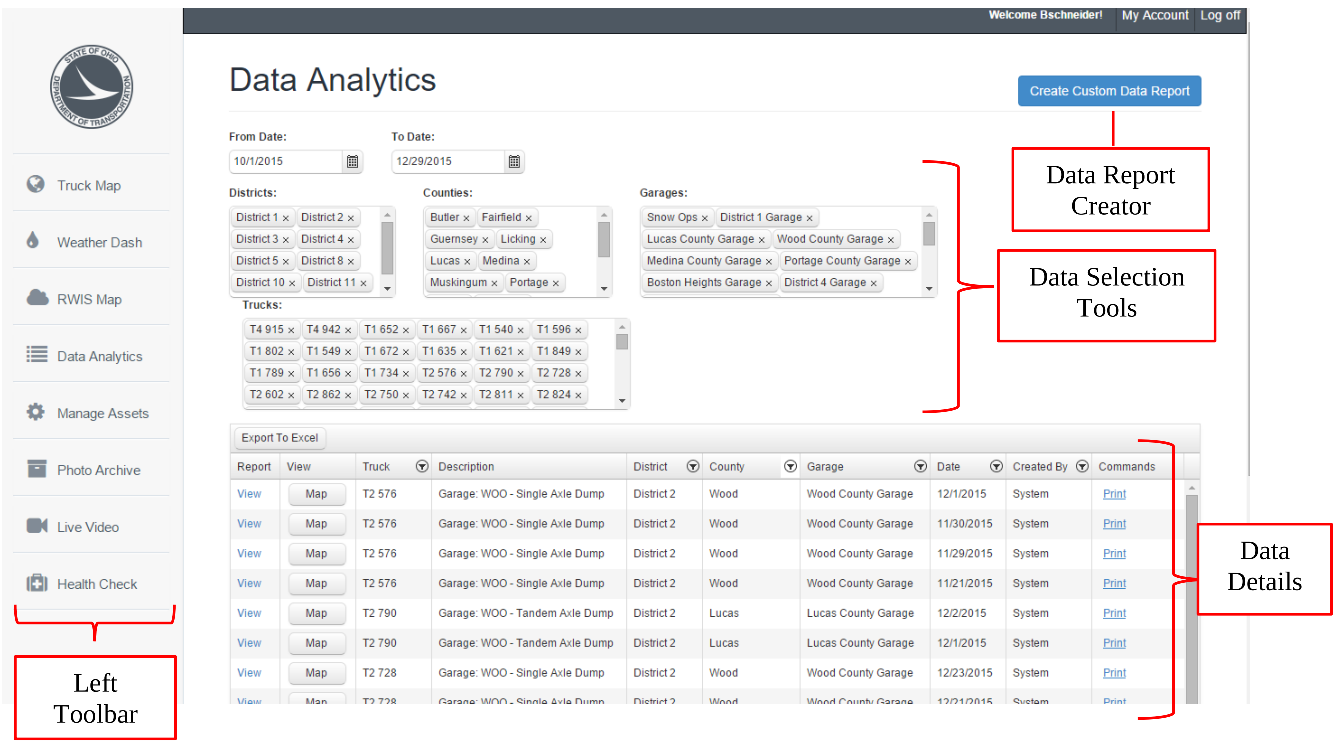


Figure E.18: Overview of the Data Analytics Tool

The data selection tools allows the user to add and remove data displayed in the data details area of the page. The selectable fields include: Start and End dates and times, District, County, Garage, and Truck. This allows data to be found for a specific location(s), specific truck(s), and/or for a specific time span. Start and end dates may be selected by either by changing the date and time displayed by typing, or by using the date and time selection tools. To use the tools, click on either the calendar or clock icon. This will open a date selection dialog or time selection drop down respectively. Choose the desired date or time and the changes will be applied. Information on how to add and remove data to the remaining fields may be found in Section F.3.1 on Page 197-199 in Figure E.9 through Figure E.12.

The data details area allows the user to further sort and filter the data selected. It also allows the user to view and print generated reports. Filtering and sorting is done following the procedure detailed in Section F.3.2 on Page 199-200 in Figure E.14. If the selected data in the data selection tools result in more than 15 (by default) reports, the reports will be displayed on multiple pages. Buttons to navigate between pages are located at the bottom of the page. To navigate to a specific page, press the desired page number. To move forward or backward one page, press the triangular buttons located next to the page numbers. To move to the first or last page, press the outermost buttons. To change the number of reports shown per page, open the drop down by pressing the downward arrow and selecting the desired number of reports.

Pressing the *Print* button will begin a download of a printer friendly PDF version of the chosen report. Pressing the *Map* button will open a dialog showing a map of the selected route as shown in Figure E.19. To close the dialog, press the *X* in the top right corner of the dialog. Pressing the printer icon in the top right corner of the dialog will open the printer dialog. The resulting print will be only of the displayed map. The map displays the beginning location, shown by the green A, the traveled route, shown by the blue line, and locations at specified times, shown by red stars with time stamps above them.

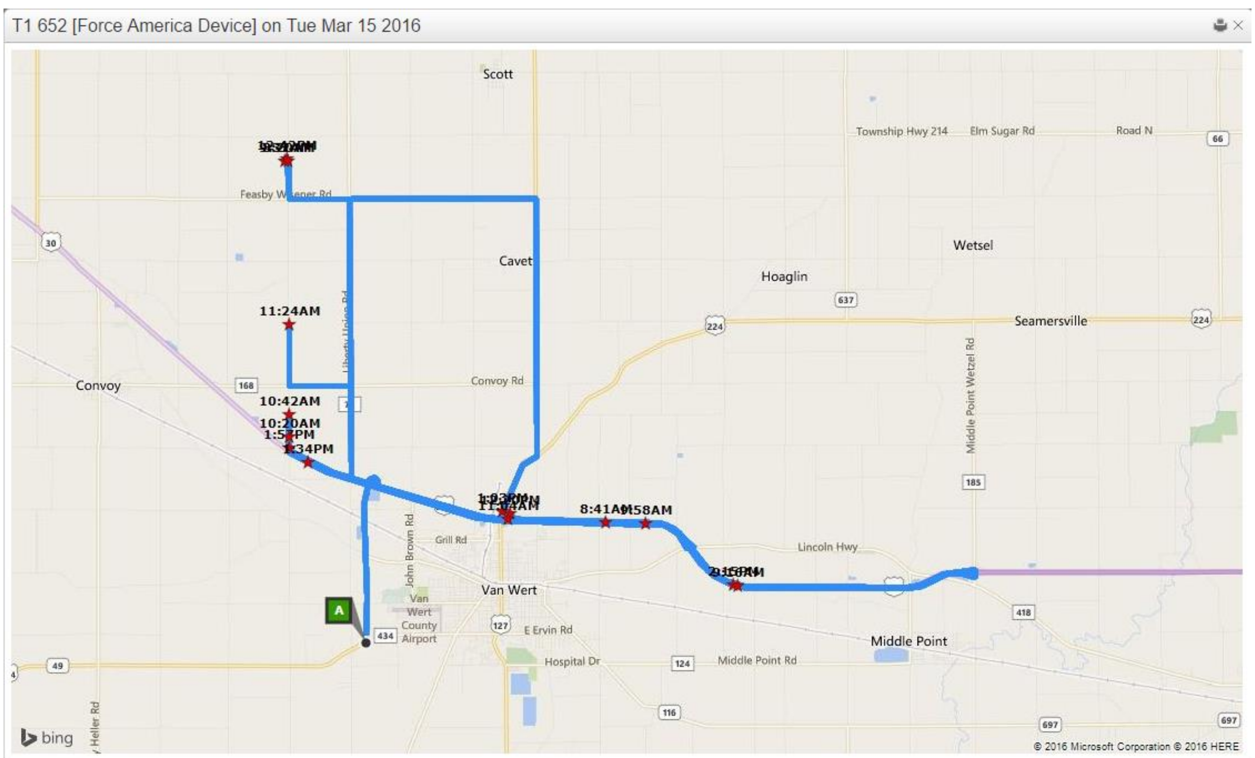


Figure E.19: Map Presented by the Data Analytics Tool

Pressing the *Export to Excel* button will begin a download of an Excel file containing all of the information currently displayed in the data details area. Pressing the *View* button in the data details area will open the detailed report.

The detailed report page displays in-depth information about the report selected from the data analytics page. Included in the report are the start and end times, the driver, truck, and starting and ending mileage.

In addition, the route taken during the report period is logged. The route data may be sorted and filtered following the procedure detailed in Section F.3.2 on Page 199-200 in Figure E.14. Pressing the *Map* button will open a dialog displaying a map of the portion of the route logged in the selected line of the report. Controls and Symbology for this map are the same as described previously on Page 205. To display a map of the entire logged route, press the *Map Report* button located in the top right corner of the page.

The data report creator allows the user to generate a detailed report for a truck over a specified time period. It is divided into two areas: the data selection tools and the data preview, as shown in Figure E.20. The user may use the upper portion of the form to select a time frame for the report. The methodology for selecting a time period is the same as described Section F.4 on Page 200. The user may also select a specific truck following the same methodology described in Section F.3.1 on Page 197-199 in Figure E.9 through Figure E.12. Once the two selections have been made, the lower portion of the form will display the logged movements that match the selections. Pressing the *Generate* button on the top right of the page will create the report. Once the report has been generated it may be found on the Data Analysis page.

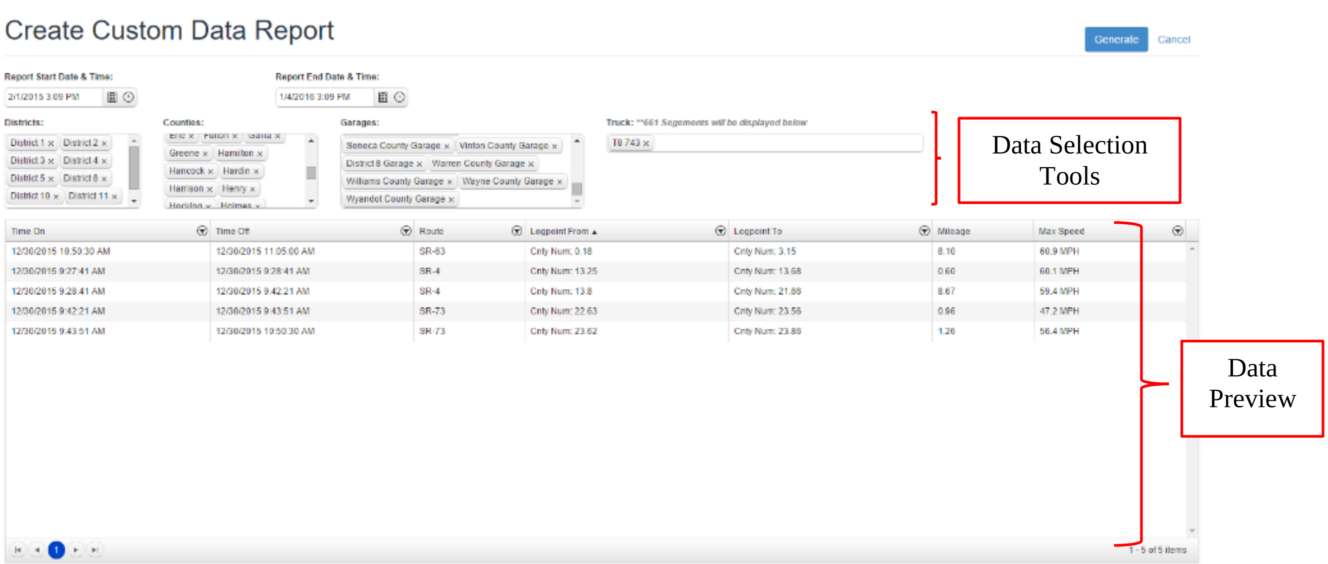
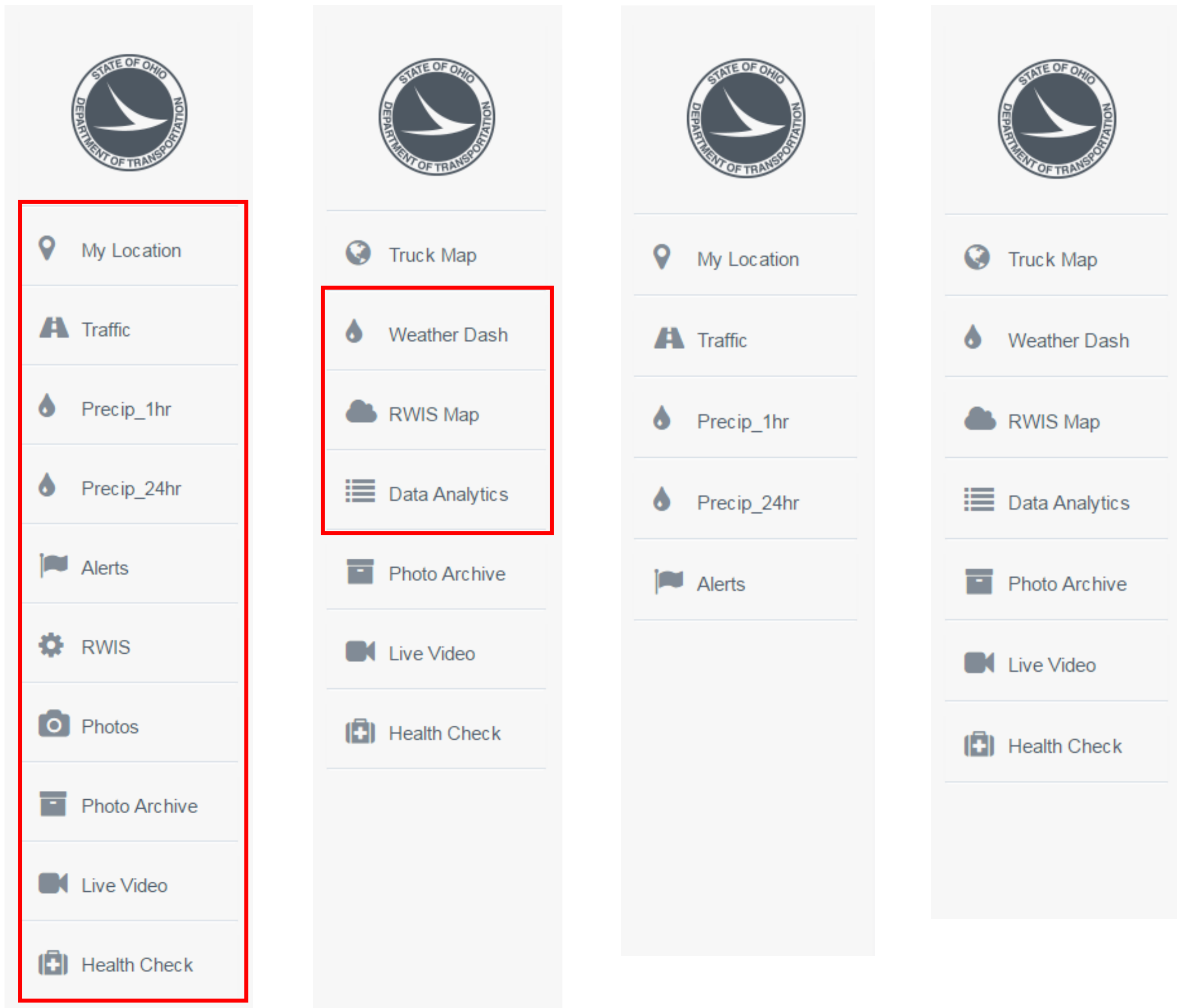


Figure E.20: Overview of the Data Report Creator.

E.7 Left Toolbar

The left toolbar is present on all pages of the site. It presents more features in addition to a universal home button. Clicking the ODOT logo at the top of any toolbar will return the user to the real-time truck map.



Truck Map Toolbar | Weather Dash Toolbar | RWIS Toolbar | Data Analytic Toolbar

Figure E.21: All Versions of the Left Toolbar on the Site.

Presented in Figure E.21 are all versions of the left toolbar used on the site. Options on the toolbars repeat, resulting in only 13 unique options. In Figure E.21 the unique options are outlined in red.

Use of the *My Location* feature requires the user to accept a prompt to allow their browser to use their location. If the user does not accept this prompt, the feature will not function. If the user accepts the prompt the live map will be centered on the user's location with a blue circle indicating their approximate location.

Enabling the *Traffic* feature makes the current traffic speeds on roadways visible. This information, generated by Microsoft for Bing Maps shows the current speed on a relative scale. Speeds are denoted as follows: green - normal speed, yellow - below normal speed, orange - much below normal speed, and red

- greatly below normal speed. Choosing the *Hide Traffic* option when this feature is enabled will remove this information from the live map.

Enabling the *Precip_1hr* feature makes precipitation that has occurred in the past hour visible on the live map. Enabling the *Precip_24hr* feature makes precipitation that has occurred in the past 24 hours visible on the live map.

Clicking the A*lerts* option on the toolbar opens the alert dialog box as presented in Figure E.22. This dialog allows for alerts to appear on the live map when certain criteria are met for either trucks or weather. Initially the dialog opens showing the current settings for alerts. To edit the current settings, press the *Edit* button for the desired alert. This allows the user to change the criteria and whether or not the alert will show when it occurs. Once the desired setting has been configured, press the *Update* button to apply changes. Alternatively press the *Cancel* button to abort any changes.

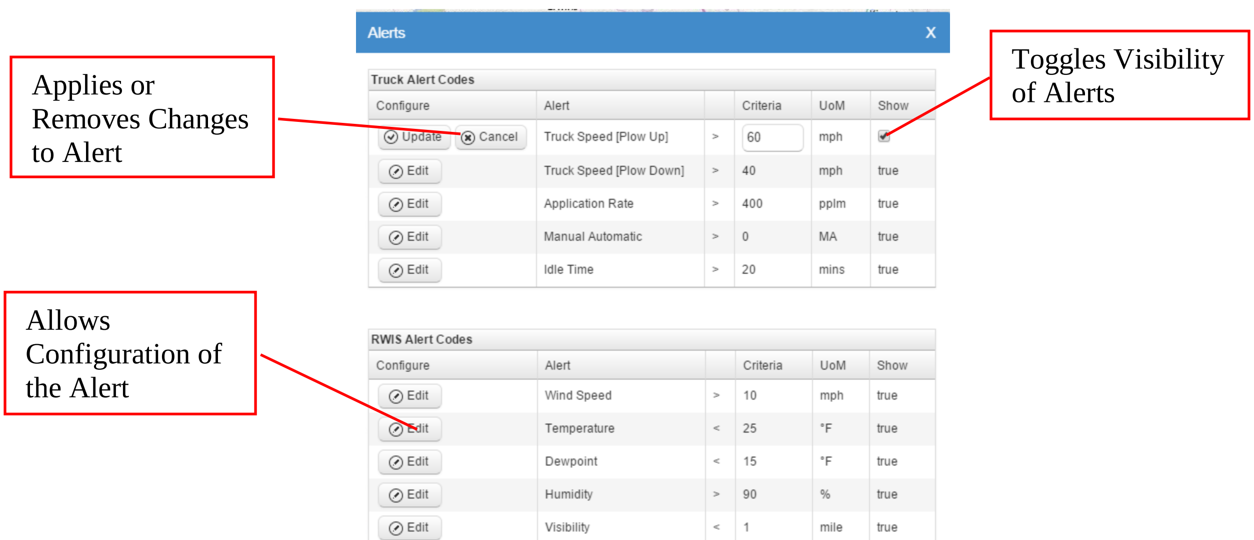


Figure E.22: Alert Configuration Dialog.

Alerts will appear by making the icon of the alert causing object to be red as shown in Section F.5 in Figure E.17.

Enabling the *RWIS* option makes the RWIS stations visible on the map. In the same manner as trucks, garages, counties, and districts covered in Section F.3; these icons may be hovered over to view current information, as well as selected to permanently display this information. To disable this feature, click the *Hide RWIS* option that has replaced the *RWIS* option.

The *Photo* option changes the icons of trucks equipped with live-update cameras to the most recent image taken by the camera. These icons function the same way as the icons they replace. To disable this option, click the *Hide Photo* option that has replaced the *Photo* option.

The *Photo Archive* option takes the user to the photo archive portion of the site. This feature allows users to select a specific truck and view its history of photos. To choose a vehicle, select the first drop down. This will contain options for all trucks containing photo capabilities. Once the desired vehicle is chosen, by default, the last 100 photos will be displayed. If a specific photo or time period is desired to be viewed, the second drop down contains all dates that photos were taken on. Choosing a date will filter the displayed photos to those that were taken on the selected date. To take a new photo, the user may press the *Take Picture* button. This image will then be viewable at the top of the *Last 100 Photos* sort.

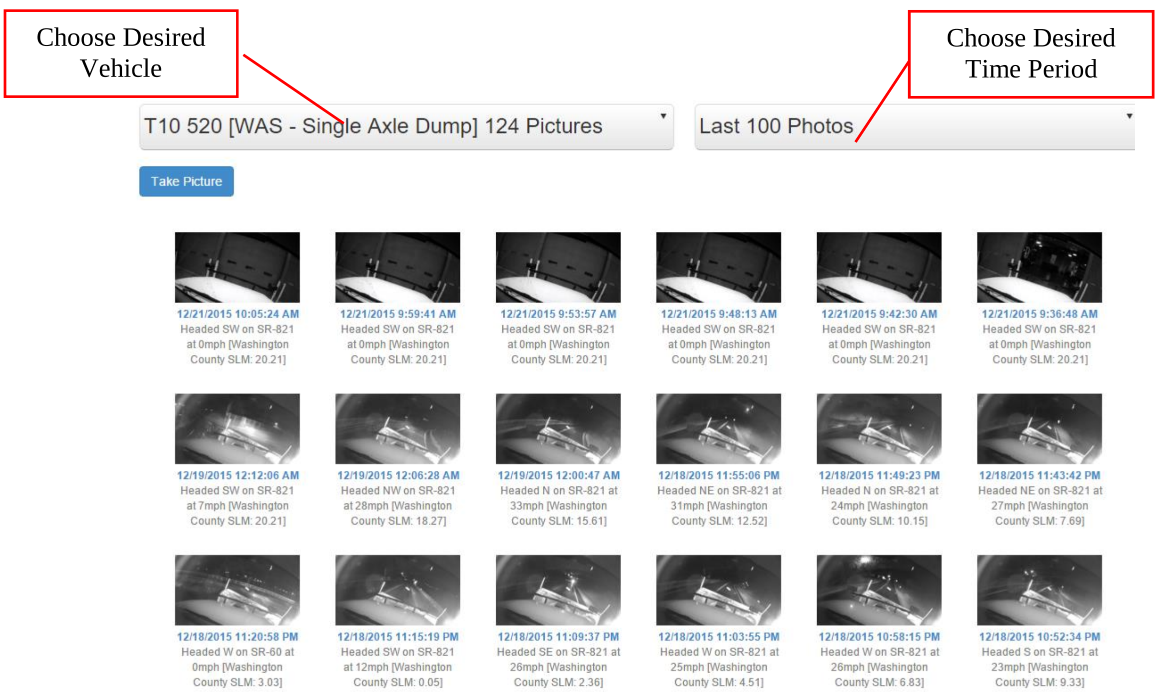


Figure E.23: Photo Archive

The *Live Video* option takes the user to the live video portion of the site. To use this feature, the user must input a password for the live video service into the password prompt shown in Figure E.24.

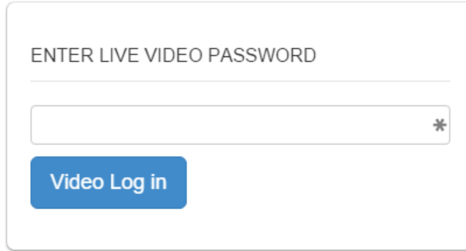


Figure E.24: Live Video Password Screen

The *Health Check* option takes the user to the health check portion of the site. This feature allows users to view detailed information for all ODOT trucks registered on the site. Available information includes: District, County, Truck, ID, Device Type, IP Address, Last GPS, Latitude, Longitude, Time of Last Picture, Total Photo count, Last Hydraulic, and Last RoadWatch. These data may be sorted and filtered using the same procedure detailed in Section F.3.2 on Page 199-200 in Figure E.14.

E.8 Asset Manager

The asset manager allows administrators to create and modify the application's locations, trucks, and devices. It also contains tools to manage the drivers that use the trucks as well as users that use the application.

The asset manager is divided into five areas, one for each of the categories that may be managed. The categories consist of Locations, Trucks, Devices, Drivers, and Users as shown in Figure E.25. To navigate to an area, left click on the categories name. In addition, hovering over the names will open a drop down menu containing a direct link to create a new asset for the corresponding category. The truck heading drop down menu also contains links to 'All trucks' and 'Active Trucks'. These options will take the user to the asset manager, only showing the chosen options assets.

Figure E.25: Navigation Bar for the Asset Manager

All areas of the asset manager function in the same way. Each area will display the relevant information, with the ability to sort, edit, and create entries.

Upon selecting an area of the asset manager, the user will be brought to the main page of that area. This page functions in the same manner as the data details area on other pages throughout the site. The information may be sorted and filtered using the same procedure detailed in Section F.3.2 on Page 199-200 in Figure E.14.

If the selected data contains more than 20 entries (by default), the data will be separated into multiple pages. Buttons to navigate between pages are located at the bottom of the page. To navigate to a specific page, press the desired page number. To move forward or backward one page, press the triangular buttons located next to the page numbers. To move to the first or last page, press the outermost buttons. To change the number of reports shown per page, open the drop down by pressing the downward arrow and selecting the desired number of reports.

To edit an entry, press the *Edit* button located in the rightmost column, shown in Figure E.26. This will bring you to a page containing all of the data associated with an entry. Change any of the desired information by using the associated drop down or input field. To save your changes, press the *Save* button at the bottom of the page. To discard any changes made to the entry during your current session, press the *Cancel* button at the bottom of the page. These buttons and an example field are shown in Figure E.27.

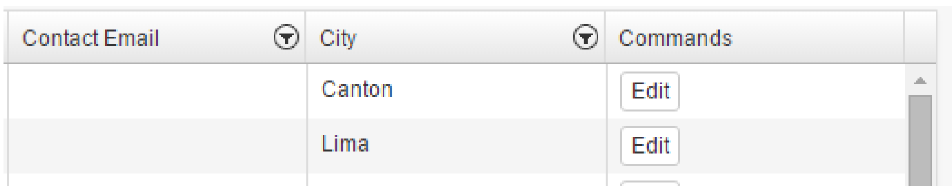


Figure E.26: Edit Button

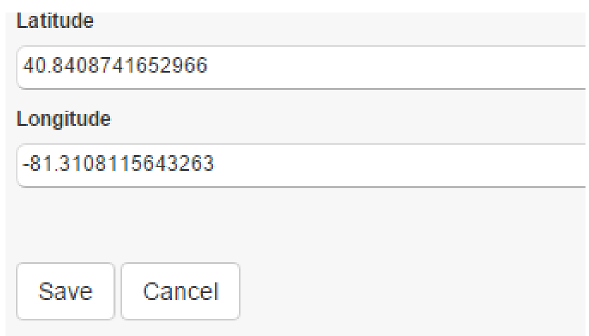


Figure E.27: Save Button

To create a new entry, press the *Create New 'X'* button located at the top of the associated page. Alternatively, hover over the asset type at the top of the page, and press the *New 'X'* drop down. This will bring you to a page containing input fields and drop downs for all data types associated with the new entry you are creating. Once all of the desired fields have been filled out, press the *Create* button at the bottom of the page. To discard the new entry, press the *Cancel* button at the bottom of the page. This procedure is shown below in Figure E.28.

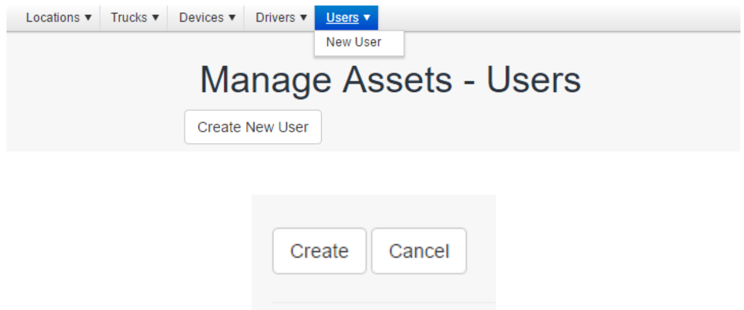


Figure E.28: Create New Entry Procedure

In the event that a user has forgotten their password, an administrator may reset the user's password using the asset manager. To reset a user's password, navigate to the user portion of the asset manager. Locate the user in the information area. Press the *Reset Pwd* button in the rightmost column, as shown in Figure E.29, for the associated user.

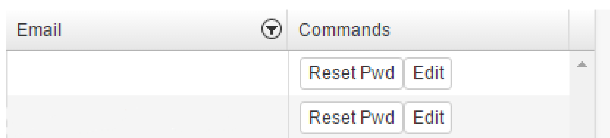


Figure E.29: Reset Password Button

APPENDIX F OUT-OF-STATE SURVEY

F.1 GPS/AVL Out-of-State Survey Questions

GPS/AVL Survey

1. Do you currently have GPS/AVL technology installed on any trucks in your fleet?
2. What is the current size of your fleet?
3. How much of your fleet currently has the system installed?
    a. Where are they installed if not in the entire fleet?
4. What brand of software and equipment do you have?
5. Is it off the shelf or a self-built system?
6. Have you always used the same system or have you tried others?
    a. What was the conclusion on the other systems?
7. How did you choose which trucks to install them in?
    a. Random or high priority routes?
8. How much time does it take to install a system on one truck?
9. Who is responsible for completing the installs?
10. What is the cost per truck for the hardware and monthly cost per vehicle for cellular?
11. What data do you get from the GPS/AVL system other than truck location?
    a. Application rate, chemicals, on/off, up/down, road temp, etc.
    b. What are the lifespans of the sensors that record the data?
12. Who designed the website to track data?
    a. Were you able to personalize anything or was it a template?
13. Are there cameras in the trucks that are accessible via the network?
14. Do you have an interactive interface for the operator?
    a. Do they input any of the data themselves versus the system being calibrated?
    b. How often does it need calibrated?
15. Did the GPS/AVL system have any effect on your hydraulic system selection?
16. Did the GPS/AVL system influence the implementation of different technology or truck selection?
17. Who is your current cellular provider?
    a. Do you have any issues with cellular signal in rural or congested areas?
18. Is it a real time data? How long of a delay?
19. Do you save any of the data?
    a. For how long?
    b. Is it a cloud server or regular server?
20. Who has access to the data?
21. Do you subcontract anything to other vendors? If so who? What are they responsible for?
22. How often do you experience network or hardware malfunctions?
23. Who is responsible for these malfunctions?
24. How much of your budget is allocated towards the GPS/AVL technology?
    a. Annual and Total
25. Has there been discussion of advancing the technology? If so, how?

26. Are there other phases of the project already emplaced? What do these other phases consist of?
27. What are your thoughts on the current technology of the system?
28. What are some advantages and disadvantages you have noticed?
29. Has there been a cost analysis done on the project?
30. Is there someone I can speak with at the garage level that can answer these questions?
31. Are there any reports or resources that are available? Would you be able to email me them?

F.2 Out-of-State Survey Response

Organization	Person Contacted	1	2	3		4
Vermont DOT	Ken Valentine	Yes	700	Roughly 275 trucks	Single and Tandem Axle Dump Trucks	Software: InterFleet Hardware: InterFleet
Iowa DOT	Bob Younie	Yes	900 plow trucks, and several freight trucks	Entire Fleet	N/A	Software: Skyhawk Hardware: Skyhawk
Illinois DOT	Steve Jackson	Yes	1,750	A few trucks in one district.	Snow and Ice Vehicles	Hardware: CompassCom
Wisconsin DOT	Mike Sproul	Yes	754 county-owned trucks	Approximately 600	Snow and Ice Vehicles	Software: Precise Hardware: Force America
Idaho DOT	Steve Spoor	Yes	N/A	409 snow plow trucks	Snow and Ice Vehicles	Software: Data Smart Hardware: Cirus modem, Garmin puck
Maine DOT	Brian Burne	Yes	400 Trucks	Approximately 250	Single and Tandem Axle DumpTrucks; Striping trucks	Software: Certified Cirus Hardware: Cirus
Missouri DOT	Tim Chojnacki	Yes	Approximately 1500	Approximately 300	N/A	N/A
New Hampshire DOT	Caleb Dobbins	Yes	Approximately 1500	89	N/A	Software: Cypress from Skyhawk
Oregon DOT	Patti Caswell	Yes	Approximately 450	27	Single and Tandem Dump Trucks	Software: LTI website Hardware: LP6 modem
Virginia DOT	Allen Williams	Yes	1,700	Approximately 850	Snow and Ice Vehicles	Software and hardware are provided through NetworkFleet by Verizon
West Virginia DOT	Jeff Pifer	Yes	Approximately 1000	536	Single and Tandem Axle Dump Trucks	Software: Tremble
Wyoming DOT	Cliff Spoonemore	Yes	358 vehicles	Entire Fleet	N/A	Software: CompassTrack by CompassCOM Hardware: Self built by GIS dept.

Organization	5	6		7	
Vermont DOT	Off the Shelf	3-4 Previous Vendors	The primary focus was on integrating with the spreader system	Based on priority	High Priority
Iowa DOT	Vendor Determined	LTI Vendors	Proof of concept	N/A	N/A
Illinois DOT	Off the shelf	Old analog system installed in District 1	Conclusion of the system is that it was beneficial but must be updated to a more capable system	Emergency Traffic Patrols (Metro-areas), snow and ice fleet	High prioity routes
Wisconsin DOT	Off the shelf	Same System	N/A	Trucks on Interstate Routes	High prioity routes
Idaho DOT	Off the Shelf	Previous Pilot Study with Force America	Proof of concept	Installed on Plow Trucks	High prioity routes
Maine DOT	Off the shelf	Other Vendors	N/A	Based on the age of the truck	N/A
Missouri DOT	Self Built	2 previous pilot studies	N/A	N/A	Random
New Hampshire DOT	Off the shelf	2 previous pilot studies	N/A	High traffic areas and watershed/wellhead areas	High Priority
Oregon DOT	Off the shelf	Same System	N/A	Random	Random
Virginia DOT	Off the Shelf	Same System	N/A	Winter Maintenance Trucks	High Priority
West Virginia DOT	Off the shelf	Same Hardware system. Previously used a different software system	Contract changed to Tremble	Dump Trucks	High Priority
Wyoming DOT	Off the shelf software and hardware by vendor, internal mapping software is self built	Same System	N/A	Full fleet deployed	

Organization	8	9	10
Vermont DOT	1.5 hours per truck	Initially by InterFleet Technicians Currently by Hyd Controller vendor	Hardware $1,300 per truck Cellular: $32/month/truck
Iowa DOT	2 trucks per day per technician	DOT personnel	N/A
Illinois DOT	N/A	Motorolla technicians	Hardware: $4,000-$6,000 Communications: $55/month/truck
Wisconsin DOT	Half Day	Initially by FA Technicians Currently by DOT personnel	Hardware: Unknown Cellular: $25/month/truck
Idaho DOT	10-11 hours	Cirus Technicians	Installation :$6,000 Hardware: $8,000
Maine DOT	Several Hours	Installed by HP Fairfield Vendor Currently by DOT personnel	Hardware: $5,000 for entire system Software: $200/year/truck
Missouri DOT	2-5 Hours	DOT personnel	Hardware : $2000-$3000 Cellular: $12-50/month/truck
New Hampshire DOT	2-3 hours	Skyhawk Technicians	Hardware : $932.23/year/truck Cellular: $373.08/year/truck
Oregon DOT	Half Day (4 hours at the most)	Initially by system vendor Currently by DOT personnel	Hardware: $400 per truck Cellular: $6/month/truck
Virginia DOT	Several Hours	DOT personnel	N/A
West Virginia DOT	1-2 hours	DOT personnel	Hardware:$250/month/truck Cellular: $25/month/truck
Wyoming DOT	Half Day	CompassCOM Technicians	No cellular fees; WyoLink radio used to transmit data

Organization	**11**		**12**	
Vermont DOT	Application rate, material type, plow on/off and up/down sensor, road temperatures	Up to 15 Years	N/A	Verizon Network Fleet
Iowa DOT	N/A N/A	N/A	System Vendor	N/A
Illinois DOT	Status ranking of road conditions	N/A	System Vendor	N/A
Wisconsin DOT	Application rate, chemicals, plow up/down and on/off, road temperatures, and all vehicle telematics	Unknown	Precise; data imported into MDSS (Iteris Company)	No personalization
Idaho DOT	Application rate, total volume, plow on/off, operator ID, air/road temp, location, truck number	Unknown	System Vendor	No personalization
Maine DOT	Application rate, spinner speed, type of material, on/off, speed, road/air temp	N/A	System Vendor	N/A
Missouri DOT	Application rate, plow on/off and up/down.	Unknown	N/A	No personalization
New Hampshire DOT	Road temp, solid and liquid spread rate, plow up/down, spreader error messages, geofence information, harsh breaking, harsh acceleration, idle time	Unknown	System Vendor	Able to add pictures and logos
Oregon DOT	Road temp, plow position, application rate, type of material	Unknown	System Vendor	No personalization
Virginia DOT	Currently the only data pulled is the truck location, speed, and idle time but no hydraulic data obtained	N/A	System Vendor	No personalization
West Virginia DOT	Capture the spreader rate through spreader controller. Road temps are captured in newer trucks by sensors. Neither of these systems are tied into the GPS/AVL system	Unknown	Tremble	Options to set up alerts
Wyoming DOT	Tracks the location, speed, heading, vehicle number	N/A	Internal mapping was developed by GIS department; CompassTrack software was developed by vendor	None for Compass Track; Personalization for Internal Mapping Software

Organization	13	14			15
Vermont DOT	No	No	No; spreader rate set by driver	Calibrated annually	No
Iowa DOT	Yes, but independent of the GPS/AVL system.	Yes, public one (TrackAPlow) and one for internal operations	N/A		Systems independent
Illinois DOT	Yes, but not network accessible	Yes, implemented via tablets	Yes. Roadway status reports are sent back and forth	N/A	No
Wisconsin DOT	No, updating sytems to allow them	Yes, through the MDSS system	Yes. The operator is capable of changing the weather forecast, recommended materials, and relaying the roadway conditions.	N/A	No
Idaho DOT	No	No	No	No	Systems independent
Maine DOT	No	No	No	N/A	Yes, only some hydraulic systems were compatible
Missouri DOT	Yes	Yes	No	When needed	Yes
New Hampshire DOT	No	No	No	N/A	No
Oregon DOT	No	No	No	N/A	No
Virginia DOT	No, several cameras were installed during test phase	No	No	N/A	No
West Virginia DOT	No	No	N/A	N/A	No
Wyoming DOT	No	No; plow location relayed by Road Reporting App	No	N/A	No

Organization	16	17		18
Vermont DOT	No	AT&T	Yes	Real-time
Iowa DOT	No	US Cellular	No	Real-time
Illinois DOT	Yes	None; system utilizes statewide Motorolla Wi-Fi	N/A	No; data transferred at garage
Wisconsin DOT	No	Verizon	Yes; all trucks and refilling stations have backup Wi-Fi	Real-time. Updated every 2 min
Idaho DOT	No	None; system based on Wi-Fi	N/A	No; data transferred at garage
Maine DOT	No	None; system based on Wi-Fi	N/A	No; data transferred at garage
Missouri DOT	Yes	Varies by price	Yes	Yes
New Hampshire DOT	No	US Cellular	Unknown	15 second delay
Oregon DOT	No	Sprint	Yes	Near real-time
Virginia DOT	No	Verizon	Yes	1-2 minute delay
West Virginia DOT	No	Unknown	Yes	Near Real Time
Wyoming DOT	No	N/A	N/A	Near Real Time based on Wifi connection

Organization		19		20	21
Vermont DOT	Yes	Stored for several years	N/A	DOT and Vendor	Yes, responsible for the website interface, installation and data storage
Iowa DOT	Yes	Stored indefinitely by Iowa State University	Regular Server	DOT, Iowa State University	Yes, vendor who gets RFP is responsible for the web design and building the system
Illinois DOT	Yes	Stored indefinitely	Regular Server	DOT Admin Only	Yes, two vendors to manage the hardware and data/software
Wisconsin DOT	Yes	Stored indefinitely	N/A	Iteris Company	No
Idaho DOT	Yes	Stored for two years; WARS data stored for 30 days	Regular Server	DOT and Cirus	Yes, Data Smart software and installation
Maine DOT	Yes	Stored for two years	Cloud	DOT	Yes, installations (HP Fairfield)
Missouri DOT	Yes	Stored for several years	Cloud	DOT Admin Only	No
New Hampshire DOT	Yes	Stored for length of contract	Cloud	DOT Admin Only	No
Oregon DOT	Yes	Stored indefinitely	Cloud	DOT	N/A
Virginia DOT	Yes	N/A	Regular Server	DOT Admin Only	No
West Virginia DOT	Yes	Unknown	N/A	DOT Admin Only	No
Wyoming DOT	Yes	Stored for two years	Regular Server	DOT Admin Only	No

Organization	22	23	24	
Vermont DOT	Network: Never Hardware: Occasionally	DOT unless under warranty	Less than 0.2% of the operations budget.	Approximately $110,000 per year
Iowa DOT	Network: Occasionally	IT Department.	N/A	N/A
Illinois DOT	N/A	N/A	N/A	N/A
Wisconsin DOT	Network: Never Hardware: Never	Network: Precise Hardware: Force America	N/A	N/A
Idaho DOT	Network: Never Hardware: Never	DOT unless under warranty	No capital money set aside. Cost of hardware buried in the cost of buying new trucks now	$150 per truck per year for software
Maine DOT	Network: Monthly Hardware:Less than 10% of the time	DOT unless under warranty	Approximately $40,000-45,000 licensing, hosting,etc. $15,000-20,000 for repairs, maintenance, installs	$55,000-$65,000
Missouri DOT	Network:Never Hardware: Never	DOT	N/A	N/A
New Hampshire DOT	Unknown	Vendor	N/A	N/A
Oregon DOT	Hardware: Frequent, as GPS systems did not match hydraulics	LTI	LTI charges 75 per month+ 1.85 per truck per month + 6per month per truck	N/A
Virginia DOT	Network: Occasional Hardware: Occasional	NetworkFleet	Budget built into winter maintenance budget	N/A
West Virginia DOT	Network: Minimal Hardware: Minimal	DOT	Unknown	Unknown
Wyoming DOT	Network: Never Hardware: Occasional	DOT unless under warranty	$25,000 plus additional equipment if needed	N/A

Organization	26	27	28
Vermont DOT	No	The current technology is still developing which has its challenges, but it is encouraging	Disadvantages: Repeating cost, maintaining the system as its complexity increases
Iowa DOT	No	Pleased with the current technology of the system, but looking into ways to increase the systems effectiveness.	Advantages: Managers can use it as an operational control. DOT embraces the public interest in the data.
Illinois DOT	Yes, statewide implementation of system proposed	The technology has a wide range of capabilities ,but will take time to properly implement and utilized in operations	Advantages: Sees that there is a benefit to have the tracking of trucks during snow and ice events
Wisconsin DOT	Yes, System updating to 3G cellular	Data presentation is extremely poor and a more data driven solution is needed	Advantage: Assist with storm management and roadway conditions Disavntage: Data presentation is poor
Idaho DOT	Yes, Pilot Study with Verizon Network (84 cars, light trucks, etc.)	DOT developed a Winter Automatic Reporting System (WARS) which uses the GPS/AVL system to help track all materials used and the stock pile in which they were taken from. Operators spend less time manually inputting the material usage, and tracking where the materials were taken from	Advantage: Reduce the expenditures and controlling the material applications
Maine DOT	No	More can be done with the technology pertaining to their specific system	Disadvantage: Software management and downloading system
Missouri DOT	Yes, pilot study	They could be helpful to manage operations. Reliable data at a good cost	N/A
New Hampshire DOT	No	Due to the fact the install are just now being completed, no opinion on the system and its effectiveness yet	N/A
Oregon DOT	No	Has potential to have a significant impact. The integration with the other systems is hard and there is a lack of consistency with the data	Advantage. Post storm analysis to review operations
Virginia DOT	None; current installations will continue through 2017	The system has been reliable but the system could provide more data than it currently does	Advantage: Useful data is obtained Disadvantage: Cellular coverage is poor due to geographics
West Virginia DOT	No	It is a dependable system but coverage is bad. The Tremble design is difficult to work	Advantage: Can use it to verify events Disadvantage: Tremble is difficult website to use
Wyoming DOT	No	The GPS/AVL system is extremely important to help track the operators and handle any situations that arise	Advantage: Useful to go back and verify events

Organization	29	30	31
Vermont DOT	No	Yes	Yes, RFP
Iowa DOT	Benefit Cost Analysis based on Clear Roads Methodology. No full cost analysis done yet.	Contact Craig Bargfrede	Contact Craig Bargfrede
Illinois DOT	No	No, garage level has had no interaction with the system yet	Not yet but an RFP should be published soon
Wisconsin DOT	Yes, in 2009	No, garage level is run by the counties	Not available
Idaho DOT	No	Spoke with mechanic	No, one report submitted for TRB can't send out yet
Maine DOT	No	N/A	Yes
Missouri DOT	No	No	N/A
New Hampshire DOT	No	N/A	N/A
Oregon DOT	No	N/A	N/A
Virginia DOT	No	Contacted	N/A
West Virginia DOT	No	Spoke with Travis	N/A
Wyoming DOT	No	Spoke with Ali Ragan	N/A

Organization	Person Contacted	1	2	3	
South Dakota DOT	Jason Humphrey	Yes	Approximately 587	121	Installed on snow and ice vehicles
Michigan DOT	Melissa Howe	Yes	Approximately 350	330	Installed on entire fleet
Maryland DOT	Russ Yurek	Yes	3000 Trucks & Dumps	600	N/A
Kentucky DOT	Michael Williams	Yes	N/A	10% of State Fleet 15% Contractor Fleet	Installed on snow and ice vehicles
Utah DOT	Kevin Griffin	Yes	500	All Plow Trucks	N/A
Alaska DOT	Ocie Adams	Yes	N/A	100 trucks installed w GPS 10 Trucks installed with HUD 2 Trucks with Hyd Controller Data	High Priority Districts
New Jersey DOT	Jim Schmidt	Yes	2500	Entire Fleet	N/A
California	Dale Greep	Yes	7750	Entire Fleet	N/A
South Carolina	David Cook	Yes	3098	>10	Installed in trucks for investigative purposes (for drivers)
Texas	Toby Towery	Yes	27000	Approximately 23000	High Priority Districts
Oklahoma	Ronnie Bruce	Yes	600 Trucks	100	N/A
New Mexico	John Kraul	Yes	6000	400	High Priority Districts
Mississippi	Julie Ettridge	Yes	1777	Entire Fleet	N/A

Organization	4	5	6		7	
South Dakota DOT	Maintenance Data Collection (MDC) System provided by Iteris Company	AVL system is off the shelf, additional sensors are self built	Previous pilot studies	Needs were not fulfilled	Random	Random
Michigan DOT	Software: Parsons Hardware: Parsons	Off the shelf	Same	N/A	Full fleet deployed	
Maryland DOT	AT&T	Off the shelf	Previously used Tellnab	Bad networking	Emergency response	High Priority
Kentucky DOT	Software: Webtech Hardware: Webtech	Off the shelf	Same system	N/A	Type of Hydraulic Controller	Random
Utah DOT	Software: Verizon Hardware: Verizon	Off the shelf	Tested others	Needs were not fulfilled	Full fleet deployed	
Alaska DOT	Software: Verizon. Hardware: Samsung/Motorolla phones; University of Minnesota HUD units	Off the Shelf	Same System	N/A	High Priority Locations/Conditions	Hihg Priority
New Jersey DOT	Software: Motorolla Marvelous Hardware: Motorolla Marvelous	Off the Shelf	Same System	N/A	All trucks	N/A
California	Software: Verizon Network Fleet Hardware: Verizon Network Fleet	Off the shelf	Previous pilot studies	N/A	Issued with Driver	N/A
South Carolina	N/A	N/A	N/A	N/A	Trucks with bad drivers	N/A
Texas	Software: Verizon Network Fleet Hardware: Verizon Network Fleet	Off the Shelf	Same System	N/A	Random	Random
Oklahoma	LG tablets, Muncy hyd	Off the shelf	Same System	N/A	High Priority Routes	High Priority Routes
New Mexico	Software: Verizon Hardware: Verizon	Off the Shelf	Tested Others	Needs were not fulfilled	Requested trucks	High Priority Routes
Mississippi	Hardware: AT&T Fleet Complete Software: AT&T Fleet Complete	Off the Shelf	Same System	N/A	Full fleet deployed	

Organization	8	9	10		11	
South Dakota DOT	N/A	DOT personnel	Hardware: $6,000/truck Cellular: $50/month/truck	Road/air temperatures, plow up/down, application rate, type of materials, chemicals, and camera images		Seven Years
Michigan DOT	Approximatlely 4 hours	Initially by system vendor, Currently by DOT personnel	Hardware:$3100-3500/ truck. Cellular: $15-27.50/truck/month	Road/air temperatures,plow up/down, towplow deployed, wind blade up/down, engine code data, spreader information such as materials, application rate		Unknown
Maryland DOT	1-2 hours	Initially by system vendor, Currently by DOT personnel	Hardware: $500 Cellular: $20-30/truck/month	Plow up/down		N/A
Kentucky DOT	3-4 hours	Contracted Fleet: WebTech State Fleet: DOT	Hardware: $2,200/truck Cellular:	Plow up/down, air/road temps, and spreader information such as application rate, materials		Unknown
Utah DOT	30-60 min	Vendor Technicians and DOT personnel	Total system: $150,000 annually	Location and Diagnostics		N/A
Alaska DOT	1 hour	DOT for GPS; University of Minnesota for HUDs	Hardware: GPS-$600 per truck; HUD systems-$50,000 per truck	Road temp, Windshield Wipers, Hydraulic Controller Info		6 years for GPS, 12 years for HUDs
New Jersey DOT	2-2.5 Hours	Motorolla technicians	Hardware: $2280/truck	Body up & down, Safety lights, plow up & down, spreader on & off)		Unknown
California	30-60 min	Verizon Network Fleet Techs	Hardware: $200/truck Software: $17/month/truck	Safety Lights/Sirens in some trucks. Ignition on/off	No	Unknown
South Carolina	N/A	DOT	N/A	Camera, Blade engagement for Mowers	No	N/A
Texas	20-60 min	Truck Dealers	N/A	Alerts, Mileage, Speed	No	Unknown
Oklahoma	2.5 hours	DOT	N/A	Camera, Video, HYD controller, PPLM amount	HYD controller, PPLM amount	Unknown
New Mexico	5 minutes	DOT	N/A	No	No	N/A
Mississippi	10 min	DOT	N/A	PS, veh on/off, (Alerts including speeding, braking, etc.	No	Brand New System, not sure about lifespan yet

Organization	12		13	14		
South Dakota DOT	Iteris Company	Customizable	Yes, on some systems but not all	Yes there is an interface that relays information back and forth	Yes, plow up/down, road conditions and type of material	Never
Michigan DOT	System Vendor	Customizable	Yes	No	No	Never
Maryland DOT	Webtech	Certain reports customizable	Yes, on some systems but not all	Yes	N/A	N/A
Kentucky DOT	Webtech was	Certain reports customizable	No	No	N/A	N/A
Utah DOT	Verizon	N/A	Yes	No	N/A	N/A
Alaska DOT	Weather Cloud	Customizable	Yes, on some systems but not all	No	No	N/A
New Jersey DOT	Motorolla	Customizable	No	No	N/A	N/A
California	Verizon Network Fleet	Template	No	No	No	N/A
South Carolina	N/A	N/A	N/A	N/A	N/A	N/A
Texas	Verizon Network Fleet	Template	No	No	N/A	N/A
Oklahoma	University of Oklahoma Students	N/A	Yes	Yes	Drivers can send 3 second videos	N/A
New Mexico	Verizon	Template	No	No	N/A	N/A
Mississippi	Fleet Complete	Customizable	No	No	N/A	N/A

Organization	15	16	17		18
South Dakota DOT	No	No	AT&T	Yes	Real Time
Michigan DOT	No	No	Verizon	Signal strength fluctuates	Real Time
Maryland DOT	No	No	ATT	N/A	Real Time
Kentucky DOT	Yes; Webtech equipment is only capable of working with Force America and Dicky John hydraulic systems	Yes, selected trucks have control point controllers	AT&T	Yes	Real Time
Utah DOT	No	No	Verison	No	30 sec
Alaska DOT	No	No	Verizon	Yes	Real Time
New Jersey DOT	No	No	No cellular (radio used)	No	Real Time
California	Yes; Muncy spreaders are chosen due to their ability to transmit data	No	Verizon	Yes; satellite modems used in bad locations	Real Time
South Carolina	N/A	N/A	N/A	N/A	N/A
Texas	No	No	ATT/Verizon	Yes	Real Time
Oklahoma	N/A	N/A	AT&T, Verizon, Pines Wireless,	N/A	No, data sent every 10 minutes or stored
New Mexico	No	No	Verizon	Signal Strength fluctuates	Yes
Mississippi	No	No	ATT	No	Real Time

Organization		19		20	21
South Dakota DOT	Yes	Stored for 48 hours; can be stored longer	N/A	DOT Admin and Vendor	No
Michigan DOT	Yes	Images stored for 72 hours, other data stored indefinitely	Cloud	DOT Admin	Some winter maintenance subcontracted to firms without GPS/AVL systems
Maryland DOT	Yes	Stored for two years	N/A	State highway only	No
Kentucky DOT	Yes	Stored indefinitely	N/A	DOT Admin and Vendor	No
Utah DOT	Yes	Stored for two years	N/A	N/A	No
Alaska DOT	Yes	Stored for 48 hours	Weather Data goes to cloud, all other data goes to hard server	DOT Admin and Vendor	No
New Jersey DOT	Yes	Stored indefinitely	Hard Server	DOT Admin and crew supervisors	N/A
California	Yes	Stored indefinitely	Cloud	DOT Admin and crew supervisors	Installs and repairs by network fleet techs
South Carolina	N/A	N/A	N/A	N/A	N/A
Texas	Yes	Stored for 21 days	cloud	DOT Admin	Installs through dealers
Oklahoma	Yes	N/A	Cloud	DOT Admin	No
New Mexico	Yes	Stored when needed	Cloud	DOT Admin	No
Mississippi	Yes	Stored indefinitely	Cloud	DOT Admin	No

Organization	22	23	24		25
South Dakota DOT	Hardware: Malfunctions periodically Network: minimal issues	DOT or Vendor	Budget part of winter maintenance budget	$30,000 per year for replacement	Yes
Michigan DOT	Network: issues around three times a season, usually due to cameras	Parsons	$750,000 per year		Yes, using electronic data collection to reduce paper usage
Maryland DOT	Network: No issues Hardware: periodic issues	DOT	$800,000-1.2 Million Total		No
Kentucky DOT	Hardware: Occasional issues Network: Occasional issues	Hardware: DOT Network:Webtech	$200,000 - 250,000 Total		Yes
Utah DOT	Hardware: No issues Network: No issues	Verizon	1%	$150,000 Total	Yes, add sensors
Alaska DOT	Hardware: Occasional issues Network: One major incident; no other issues	Hardware: DOT Network: Software Engineers	$30,000 Annually		No
New Jersey DOT	Hardware: Minimal Issues Network: Minimal Issues	Motorolla	$330,000 Annually	17 mil Total	Yes, cameras and road temperature sensors
California	Hardware: Frequent issues due to poor installations Network Issues: Frequent due to browser "cacheing"	Verizon, DOT software engineers	$3,000,000 Annually		Yes, plow sensors and cameras
South Carolina	N/A	N/A	N/A	N/A	N/A
Texas	Hardware: Minimal Issues Network: Minimal Issues	DOT	N/A	N/A	No
Oklahoma	Hardware: Minimal Issues Network: Minimal Issues	N/A	N/A	N/A	N/A
New Mexico	Rarely	DOT	N/A	N/A	No
Mississippi	Unknown	DOT	N/A	N/A	No

Organization	26	27	28	29	30
South Dakota DOT	No	The system is another tool that assists with helping the operator be as effective as possible	Advantage: The data can be utilized to get a better understanding to help improve operations during specific storm conditions	Yes	Spoke with mechanic
Michigan DOT	There is a pilot study on using the GPS/AVL system for herbiside spraying trucks used in the summer.	Feels that the technology is great in assisting with operational processes and automates some of the processes	Disadvantage:The system requires constant monitoring	No	Not at this time
Maryland DOT	No	Evolving Project	N/A	N/A	dmanley@sha.state.md.us
Kentucky DOT	No	It proves as a vaulable tool to help with salt conservation	Advantage: The capability to have application rates of materials based on the roadway conditions.	No	Complete
Utah DOT	No	System Reliable	Advantage: Protects DOT from public's complaints Disadvatage: Difficult transition period to new system	No	Jeff Caspere 801-2432129
Alaska DOT	No	Works Well	Advantage: Weather data improves National Weather Service forecasts	No	N/A
New Jersey DOT	No	Works Well	N/A	N/A	Not necessary
California	No	System is inefficient; website software poor and software engineers unhelpful; installations difficult and inefficient		Yes, not available to us	
South Carolina	N/A	N/A	N/A	N/A	N/A
Texas	No	Works Well	Disadvantage: Bad signal in rolling terrain	No	No
Oklahoma	N/A	Works Well	Advantage: Truck locations and road condition monitoring helpful	N/A	N/A
New Mexico	No	Works Well	N/A	No	No
Mississippi	No	Works Well	N/A	No	N/A