

Utilization of AVL/GPS Technology Case Study: Utah Department of Transportation

Clear Roads Project 16-01: Utilization of AVL/GPS Technology: Case Studies



May 15, 2018

Technical Report Documentation Page

1. Report No. CR 16-01	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle Utilization of AVL/GPS Technology Case Study: Utah Department of Transportation		5. Report Date May 15, 2018	
		6. Performing Organization Code:	
7. Author(s) Ming-Shiun Lee, Dan Nelson		8. Performing Organization Report No.	
9. Performing Organization Name and Address AECOM 800 LaSalle Avenue, Suite 500 Minneapolis, MN 55402		10. Work Unit No.	
		11. Contract or Grant No.	
12. Sponsoring Agency Name and Address Clear Roads Pooled Fund Study Lead State: Minnesota Department of Transportation Research Services Section 395 John Ireland Boulevard, MS 330 St. Paul, MN 55155		13. Type of Report and Period	
		14. Sponsoring Agency Code	
15. Supplementary Notes Project completed for Clear Roads Pooled Fund program, TPF-5(218). See www.clearroads.org .			
16. Abstract <p>Winter road maintenance accounts for roughly 20 percent of state DOT maintenance budgets. State and local agencies spend over \$2.3 billion on winter operations annually. As such, effective winter maintenance operations incorporating smart uses of methods, techniques, technologies, equipment and materials becomes essential. Among various winter maintenance technologies, automated vehicle location (AVL) and global positioning systems (GPS) have been widely used by transportation agencies to monitor vehicle locations and equipment operational status for winter road maintenance operations.</p> <p>This document is one of the six case studies conducted for the Clear Roads project entitled <i>Utilization of AVL/GPS Technology: Case Studies</i>. This case study report summarizes Utah Department of Transportation's experiences and lessons learned in using AVL/GPS technologies for winter maintenance. The case study took a broad view, examining agencies' decision-making processes; implementation steps; difficulties and lessons learned; and documented benefits and costs for different tiers of AVL/GPS implementation.</p>			
17. Key Words Automated Vehicle Location (AVL), Global Positioning Systems (GPS), Maintenance, Technology		18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161. http://www.ntis.gov	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 37	22. Price

Table of Contents

1.	Overview of Utah DOT Winter Maintenance Operations	1
1.1	Case Study Background	1
1.2	Agency Characteristics	1
1.3	Agency Interviews	3
2.	Degree of AVL/GPS Implementation	4
2.1	AVL/GPS Project Background	4
2.2	Size of AVL/GPS Implementation	4
2.3	AVL/GPS Vendor Solution	4
3.	Level of System Integration	5
3.1	Vehicle Hardware	5
3.2	System Software	7
3.3	Additional Software Interfaces	8
3.4	Vehicle-to-Center Communications	10
4.	Decision Making Process	10
4.1	Level of Management Involved	10
4.2	Factors Considered	11
5.	Data Collection and Management	11
5.1	Data Collection	11
5.2	Data Accuracy	11
5.3	Staffing and Resources	12
5.4	System Data Usage	12
5.5	Agency Policy and Agreements for Data Sharing	15
6.	System Implementation Process	16
6.1	Implementation Steps	16
6.2	Procurement Methods and Process	16
7.	System Benefits and Costs	17
7.1	Implementation Costs	17
7.2	Costs for Operations and Maintenance	17
7.3	Benefits	17
8.	System Issues and Challenges	18
8.1	Institutional Issues	18
8.2	Technology Issues	19
8.3	Procurement and Implementation Issues	19
8.3.1	Procurement Issues	19
8.3.2	Implementation Issues	19
8.4	Operations and Maintenance Issues	19
9.	Lessons Learned	20
	Appendix A Survey Response	21
	Appendix B UDOT 2014 Request for Information	25
	Appendix C UDOT Work Order for Snow Plow Location Reporting on Traffic Information Webpage and Mobile App	31

Figures

Figure 1. UDOT Regions.....	2
Figure 2. UDOT Snow Plow Vehicle	3
Figure 3. Verizon NetworkFleet GPS Fleet Tracking Product.....	5
Figure 4. Location of Verizon NetworkFleet 5500 Model in UDOT Snow Plow	5
Figure 5. Interior Picture of UDOT Snow Plow and Placement of Equipment.....	6
Figure 6. Additional Technology on UDOT Snow Plow (Left: Air and Surface Temperature Sensor; Right: Wing Plow Camera).....	7
Figure 7. Screenshot of Verizon NetworkFleet Software Interface for Vehicle Tracking	8
Figure 8. PC-Based Image from UDOT Traffic Information Webpage with Snow Plow Locations	9
Figure 9. Mobile Device Image of UDOT Traffic Information Page with Snow Plow Locations	9
Figure 10. UDOT Snow Plow Dashboard (Under Development).....	15

Tables

Table 1. Agency Interview Dates / Times	3
Table 2. Hardware, Installation, and Training Costs of UDOT AVL/GPS System	17
Table 3. Monthly Service Charges for First Year of System Operations	17

1. Overview of Utah DOT Winter Maintenance Operations

This section provides an overview of this Case Study report detailing how the Utah Department of Transportation (UDOT) has implemented Automated Vehicle Locator (AVL) / Global Positioning Systems (GPS) technologies on its winter maintenance vehicles for use in monitoring the operations of snow plow vehicles.

1.1 Case Study Background

This research project is being funded through the Clear Roads pooled fund program to develop Case Study Reports documenting how multiple State DOTs have implemented AVL/GPS technologies to support their winter maintenance programs. While the main function of the system is to provide automated vehicle location tracking for dispatchers and maintenance supervisors, AVL/GPS systems can also provide valuable information on vehicle diagnostics to maintenance supervisors. Furthermore, AVL/GPS systems can be integrated with existing vehicle components used for snow plow operations, such as spreader controllers and plow blades to provide reports to maintenance supervisors on plow usage and material applied by snow plow operators.

The purpose of the Case Study reports is to help other state DOTs make more informed decisions with respect to the implementation of AVL/GPS technology for winter maintenance activities. The case study report is intended to bring to light more nuanced issues related to the use of AVL/GPS technology for winter maintenance. The Case Study report also highlights the types of issues other state DOTs / agencies should consider prior to system procurement, provides guidance for successful implementation of the technology, and serves as a possible template for agencies to get the best value out of different levels their AVL/GPS applications.

In the spring of 2017, a survey was distributed to multiple state DOTs to gather basic, high-level information regarding each agency's level of AVL/GPS implementation, as well as detailed information on the planning, processes, steps, and results observed by agencies with their respective systems. Based on the survey responses, agencies were categorized into the following three levels of AVL/GPS implementation:

- Tier 1: Basic Location Tracking/Monitoring with or without collection of vehicle diagnostic data
- Tier 2: Medium implementation with basic location tracking, with limited additional data collection, equipment integration, and system reporting features
- Tier 3: High implementation with added, more complex data collection, integration, and reporting features

Upon a review of these survey responses, six agencies representing various tiers of implementation were selected to more in-depth interviews and for case studies. The Utah DOT was categorized into Tier 1 and ultimately selected for further in-depth interviews to gather more information on how their AVL/GPS system is implemented and utilized. UDOT's survey responses are also included in Appendix A of this Case Study.

1.2 Agency Characteristics

UDOT is divided into four regional offices. Personnel in each region oversee administration, construction, and maintenance of all state roads, highways and freeways within their areas. A map of the four regions is presented in Figure 1.

For winter maintenance operations, each Region is further divided into multiple Areas, and within each Area, a number of Stations house and maintain UDOT snow plows and maintenance equipment. UDOT

maintains a fleet of 508 snowplow trucks, in addition to 11 self-propelled snowblowers and 13 TowPlows statewide.¹

On average, Utah experiences more than 25 winter storms annually, and UDOT crews in different areas of the state see different conditions. For example, the snow plow crews at Logan Summit in Region 1 clear snow nearly 40 percent of the year, while the St. George crew in Region 4 clears snow only a few times a year.²

Within each region, UDOT winter maintenance staff are structured into the following general positions:

Region District Engineer: Responsible for overseeing all Areas within the region in terms of response to winter storms. This supervisor may be responsible for allocating some of the region's resources to other regions of the state in the event of severe weather impacting that specific region.

Area Supervisor: Responsible for monitoring how multiple Maintenance Stations within their respective area have allocated resources to plow roads within a specific area of that region. Reports to District Engineer and communicates with Station Supervisors as needed during winter events.

Station Supervisor: Responsible for overseeing multiple snow plow drivers performing along their assigned snow plow routes within that part of the Area within the Region.

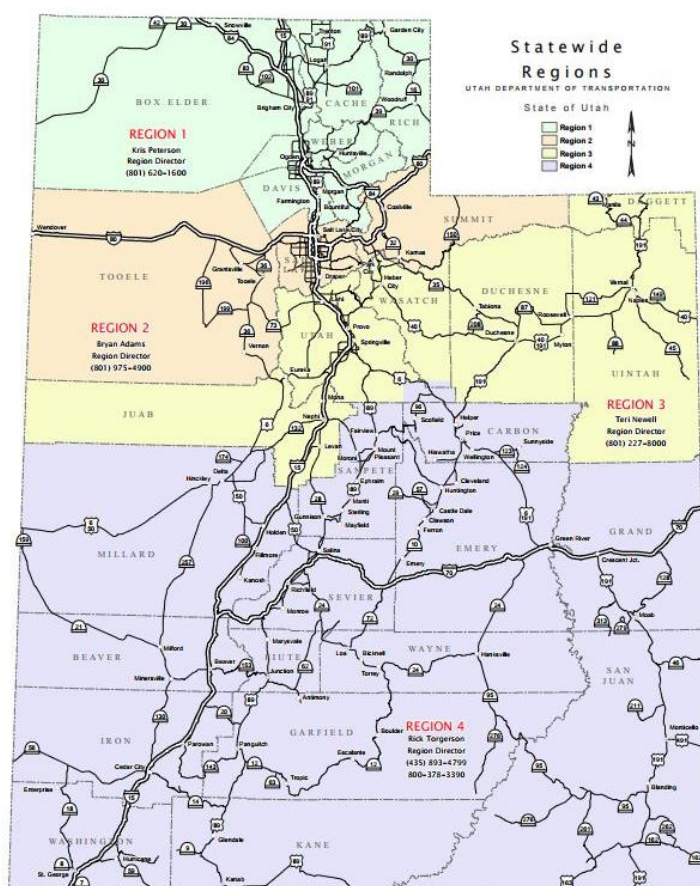


Figure 1. UDOT Regions³

¹ Source: <https://www.udot.utah.gov/main/f?p=100:pg:0:::1:T,V:2,70433>

² Source: <https://www.udot.utah.gov/main/f?p=100:pg:0:::1:T,V:2,70433>

³ Source: <https://www.udot.utah.gov/main/f?p=100:pg:0:::1:T,V:38>,

1.3 Agency Interviews

Agency interviews were conducted on November 27th and 28th, 2017. Table 1 contains a listing of the staff interviewed and the subjects discussed in those meetings.

Table 1. Agency Interview Dates / Times

Staff Interviewed	Date / Time	Subjects Discussed
Jason Davis , Director of Operations Kevin Griffin , Director of Maintenance Tim Ularich , Deputy Maintenance Engineer Brandon Klenk , Methods Engineer	Nov. 27 th / 1:00pm	Decision-making process Procurement process Data collection policy Data sharing policy Overall experience
Tim Ularich , Deputy Maintenance Engineer Jeff Casper , Equipment Operations Manager Rodney Andrews , Equipment Specialist Troy Starley , Equipment Specialist Nicole Godfrey , Equipment Systems Specialist CJ Connor , Maintenance Programs and Contracts Manager	Nov. 27 th / 2:30pm	Implementation and Integration Decisions Hardware and Software Selection Data Collection, Utilization and Management Communications Implementation Issues Operations Issues Procurement Costs and Benefits Recommendations and Lessons Learned
Tim Ularich , Deputy Maintenance Engineer Adam Radel , GIS Program Manager Kaitlin Marousis , GIS Analyst	Nov. 28 th / 9:00am	IT & Data Management
Tim Ularich , Deputy Maintenance Engineer CJ Connor , Maintenance Programs and Contracts Manager Greg Searle , District Engineer Michael Cole , Area Supervisor Chad Hansen , Station Supervisor	Nov. 28 th / 1:00pm	Hardware Installation Technology Issues and Testing Operations Maintenance



Figure 2. UDOT Snow Plow Vehicle

2. Degree of AVL/GPS Implementation

This section of the report outlines the extent to which AVL/GPS technology has been deployed for UDOT winter maintenance operations.

2.1 AVL/GPS Project Background

UDOT determined in 2014 to install AVL/GPS technology in winter maintenance vehicles primarily to increase the public transparency of their operations to the general public by providing snow plow locations to the general public via a public UDOT traffic information page. In addition to vehicle location tracking, UDOT would like to implement a system that would be integrated with spreader controllers and other sensors and equipment on snowplows to report on air temperature, pavement temperature, spread rate, liquid application rate, speed, direction, plow up/plow down, and operator road condition and weather condition inputs.

As part of the AVL/GPS procurement process, UDOT sent out a Request for Information (RFI) in 2014 to industry providers of AVL equipment requesting information on system costs, types of technology, and other items of interest. UDOT's RFI is included in Appendix B of this case study report. The responses to the RFI related to costs indicated that UDOT would not be able to deploy the AVL systems on a statewide basis as desired from the outset given the available project budget. However, through the RFI process, UDOT learned about the possibility of using a pre-negotiated contract through the Western States Contracting Alliance (WSCA), which is currently managed by the National Association of State Procurement Officials (NASPO), to procure an AVL/GPS system via Verizon to perform basic vehicle location tracking that fulfills the primary need for public transparency. Verizon had entered into a contract in 2011 through the WSCA, and UDOT was able to leverage for the deployment of the Verizon AVL system on UDOT winter maintenance vehicles throughout the state within the available project budget.

2.2 Size of AVL/GPS Implementation

UDOT has procured and installed AVL/GPS equipment on all 508 Class 8 winter maintenance vehicles throughout the state. In addition to snowplows, UDOT has also implemented the AVL/GPS on its Incident Maintenance Trucks (IMTs) that assist motorists involved in incidents along UDOT roads and highways.

2.3 AVL/GPS Vendor Solution

In the months of December 2014 and January 2015, UDOT requested Verizon to perform a demonstration of its AVL system on approximately 50 winter maintenance vehicles. Verizon performed the hardware installations on the UDOT vehicles and demonstrated the functionality and reliability of the system over a two-month period for UDOT. Verizon provided a software package (NetworkFleet) allowing UDOT staff to monitor vehicles and use features of the software to confirm that the system was functioning properly.

Upon successful completion of the demonstration, UDOT purchased additional Verizon hardware that was then installed by a Verizon team of subcontractors in all 508 Class 8 winter maintenance vehicles prior to the 2015-2016 winter season. Since that time, additional UDOT maintenance equipment and IMTs (UDOT Safety Service Patrol vehicles) have been equipped with Verizon hardware units. UDOT staff have been trained on the installation of Verizon hardware on new winter maintenance vehicles and other maintenance equipment (i.e. sweepers, loaders, skid steers, mini-excavators, graders, etc.).

3. Level of System Integration

This section details the Verizon AVL/GPS system equipment that was installed for the Utah DOT and the level of integration with other technology on winter maintenance vehicles.

3.1 Vehicle Hardware

The vehicle hardware component of the UDOT AVL/GPS is the Verizon NetworkFleet Model 5500 unit that is installed within the vehicle and placed behind the vehicle dashboard. This model is compatible with light-duty and heavy-duty vehicles with an On-Board Diagnostics (OBD-II) link connector (cars and light trucks manufactured since 1996) or SAE J1708 / SAE J1939 6-pin or 9-pin diagnostic link connector (heavy trucks manufactured since 1988).

Within the hardware device, there is an internal GPS antenna used for position determination, as well as an internal cellular antenna used for communicating the vehicle's position to the central Verizon NetworkFleet software package that allows for automated vehicle location monitoring in real-time. Figure 3 illustrates the hardware and cabling used by UDOT staff for installation.



Figure 3. Verizon NetworkFleet GPS Fleet Tracking Product

The hardware is approximately 5 inches long, by 3 inches wide by one inch tall, and weighs about 5 ounces. The small size and weight allow for the hardware unit to be installed in a location behind the vehicle's dashboard where it can be safely mounted as shown in Figure 4.



Figure 4. Location of Verizon NetworkFleet 5500 Model in UDOT Snow Plow

UDOT staff noted that they have connected the diagnostic link connector shown in Figure 5 to their maintenance vehicles. This allows pre-defined vehicle codes to be sent as alerts through the NetworkFleet software package to alert UDOT staff that vehicle maintenance is needed in a specific area. UDOT staff receive automated alerts when these codes are detected, which provides valuable information on the appropriate maintenance actions needing to be taken. This has been proven to be valuable for regular preventative maintenance required on snow plow vehicles before a vehicle would break down during snow plow operations. This capability was noted as a major benefit of the system by UDOT managers and supervisors when discussing how they have used the NetworkFleet software.

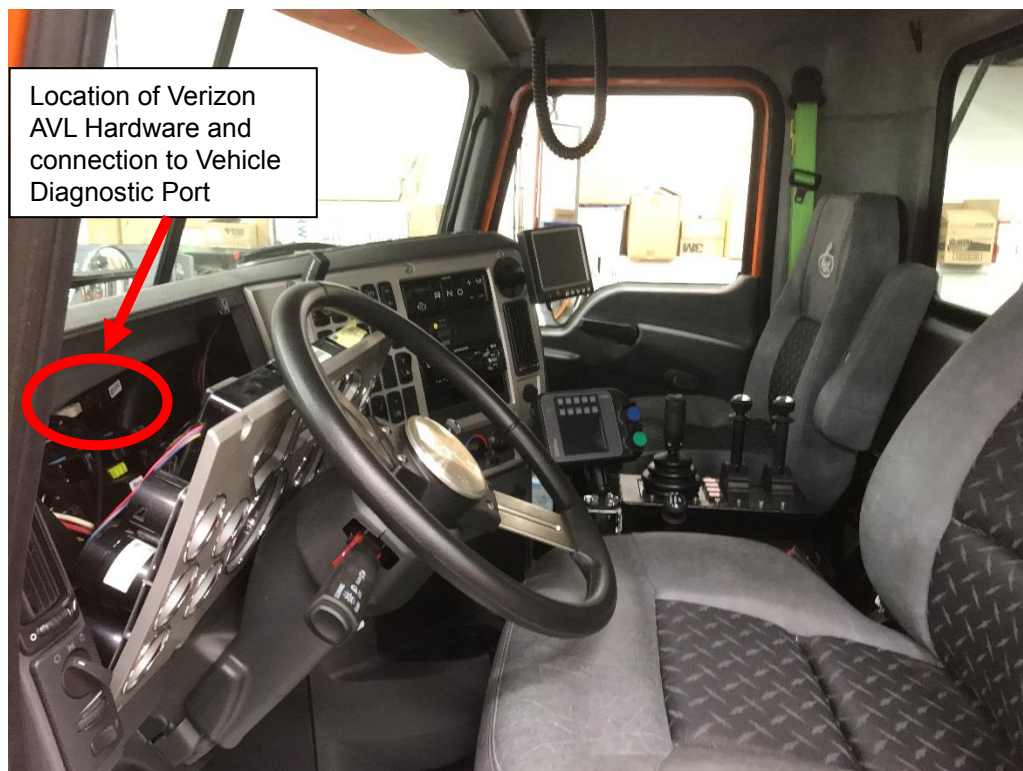


Figure 5. Interior Picture of UDOT Snow Plow and Placement of Equipment

In the cases where drivers do stop operating the vehicle in the field to report that an engine diagnostic code is being presented on their dashboard, UDOT staff can also use the data to remotely diagnose and correct the issue if that can be addressed remotely. If issues cannot be addressed remotely, the data allow UDOT maintenance technicians to ensure appropriate tools, parts and equipment are gathered prior to making a trip to the field for any repairs. Given the long distance of some snow plow routes that travel through remote areas on UDOT highways, supervisor / maintenance staff sometimes have to travel for multiple hours to address an issue that may be reported from a vehicle stranded on the side of the road. Prior to the use of the diagnostic reporting, staff would have to make one trip to verify the problem that needed correcting, and then a second trip with the correct equipment for repair.

It was noted that in some cases, the diagnostic error codes have saved maintenance technicians from having to make any trips to the field because of the type of vehicle error codes presented on the vehicle dashboard could be addressed remotely.

UDOT has not integrated the Verizon AVL hardware with the vehicle's spreader controller or other on-board equipment due to budget constraints. With the recent acquisition of Telogis by Verizon, UDOT

continues exploring the possibility of integration of the AVL/GPS system with spreader controllers and other equipment on winter maintenance vehicles with Verizon as well as other vendors.

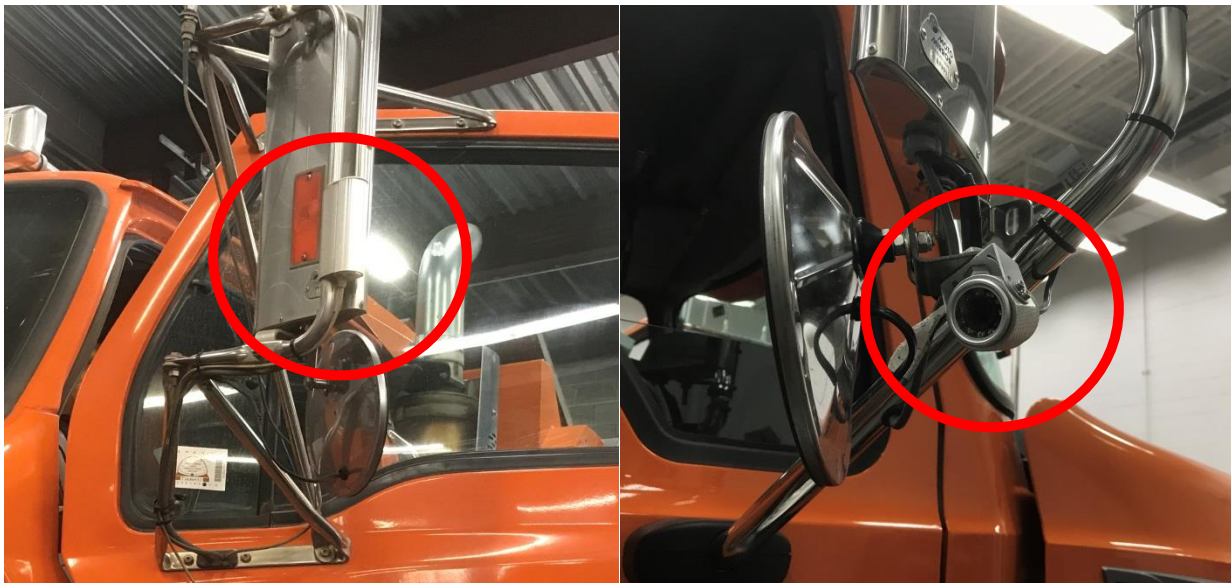


Figure 6. Additional Technology on UDOT Snow Plow (Left: Air and Surface Temperature Sensor; Right: Wing Plow Camera)

3.2 System Software

UDOT utilizes the Verizon NetworkFleet software interface to manage their vehicle fleet equipped with the Verizon AVL system. The NetworkFleet software allows for access of multiple users and can assign different levels of privileges for access to different features of the system. UDOT staff that are designated as Administrators within the software can assign other UDOT staff to certain levels as Supervisors, Managers, Technicians, and other levels. Multiple UDOT staff are then able to access the portions of the NetworkFleet software with a specific username and password that they need to perform their activities related to snow plow operations and maintenance. All data that is reported from UDOT vehicles to the NetworkFleet software resides on a Verizon server. However, UDOT does download select data from the Verizon server to backup and store in its GIS database.

One of the primary features of the software is the ability to generate automated alerts as desired by UDOT maintenance staff for items of interest. These alerts can be configured to be sent via email to the appropriate maintenance staff. UDOT Maintenance Supervisors can also use the NetworkFleet software package to have automated reports generated for specific system users on items of concern, namely vehicle idling for extended periods of time or high speeds of travel in excess of pre-defined speed values on specific routes. These reports can be presented by supervisors to specific drivers as informational reports, which have had an observed positive impact on driver behavior. The information can also be used for training, retraining and coaching of new or targeted drivers.

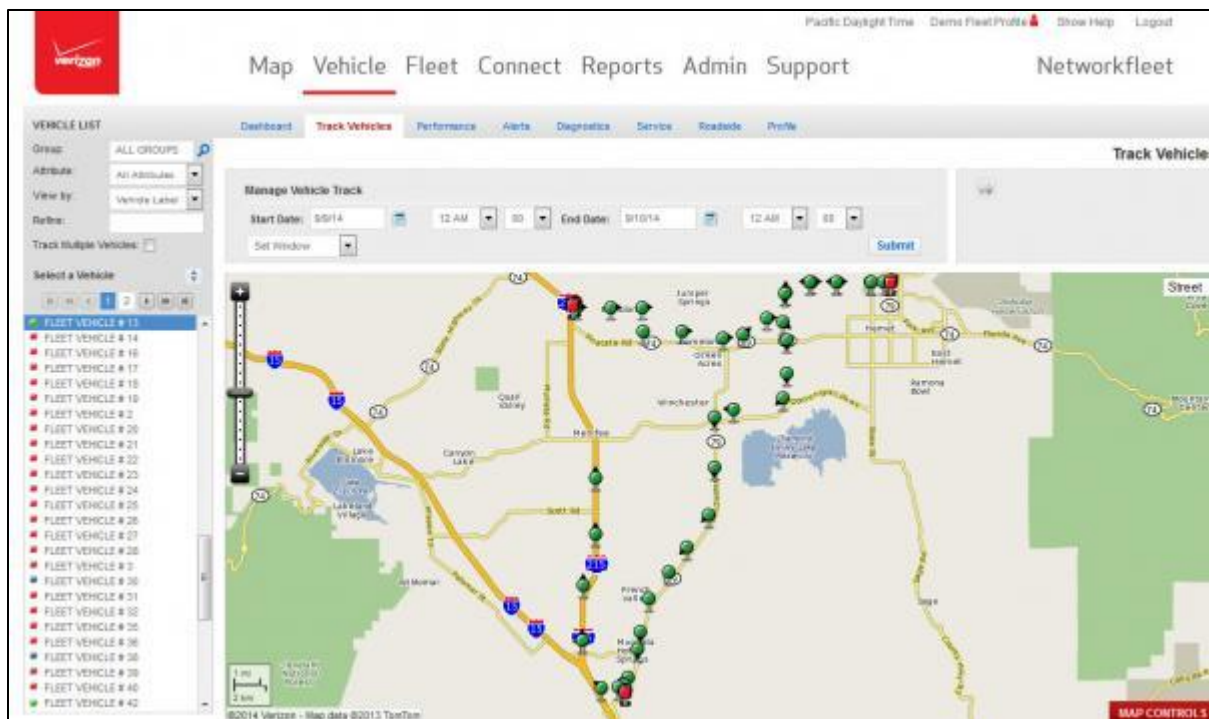


Figure 7. Screenshot of Verizon NetworkFleet Software Interface for Vehicle Tracking

3.3 Additional Software Interfaces

UDOT staff noted that Verizon was one of the few AVL/GPS vendors that was willing to provide them with access to the Application Programming Interface (API) designed by Verizon for the reporting of data from vehicle hardware to the Verizon servers for viewing the NetworkFleet software package.

The availability of the API allows for UDOT staff to download select portions of raw vehicle data reported to the Verizon server and store the data on a UDOT GIS database. For example, UDOT GIS staff are able to capture data attributes reported to Verizon on UDOT vehicle latitude and longitude coordinates at a sufficient frequency (once every 30 seconds during winter months, and 2 minutes during summer as plow locations are turned off for the public interface). These latitude and longitude points can then be used to display the vehicle location on the UDOT traffic information webpage and mobile app. Snow plow vehicle locations can be viewed on the UDOT traffic information webpage, as shown in Figure 8, at the following web address: <http://udottraffic.utah.gov/RoadWeatherForecast.aspx>. Figure 9 displays the vehicle locations on the UDOT traffic information mobile app.

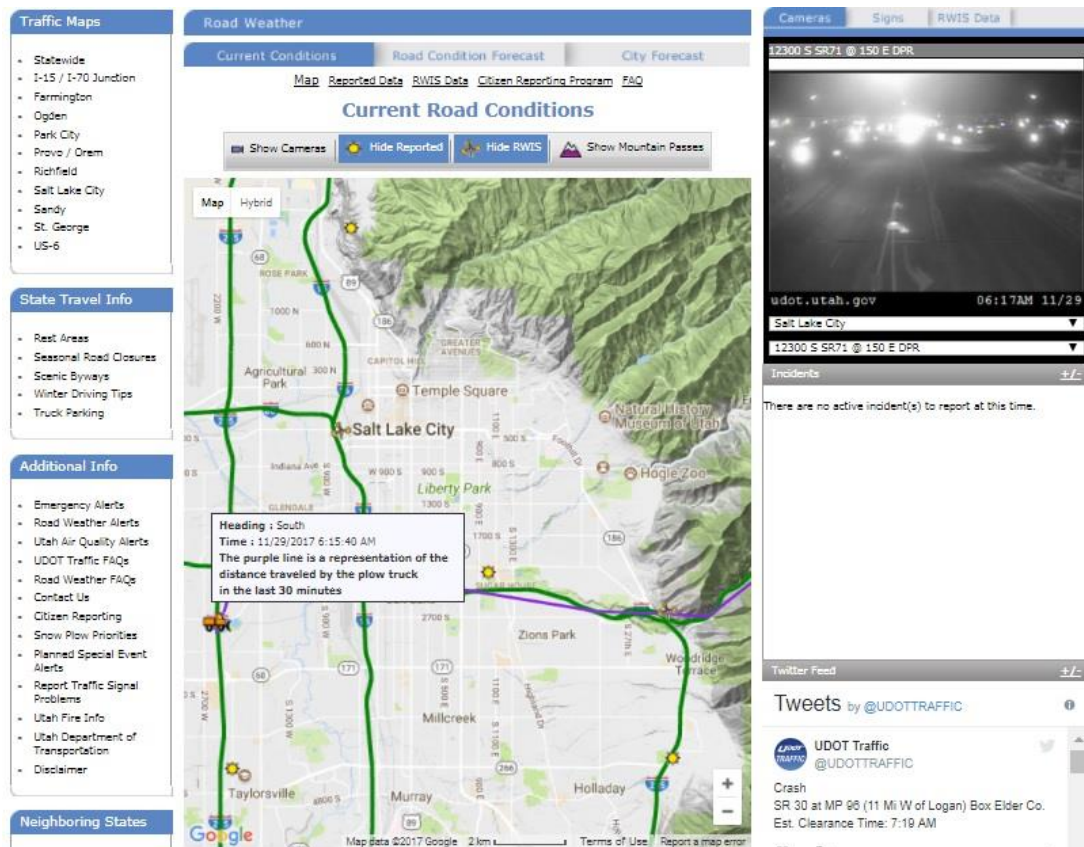


Figure 8. PC-Based Image from UDOT Traffic Information Webpage with Snow Plow Locations

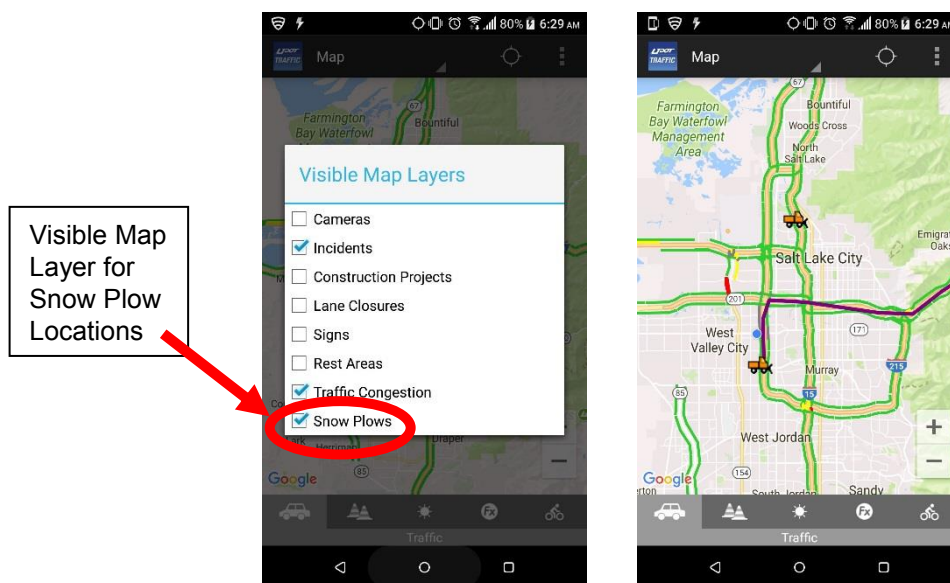


Figure 9. Mobile Device Image of UDOT Traffic Information Page with Snow Plow Locations

3.4 Vehicle-to-Center Communications

Cellular communications over the Verizon wireless network is the center-to-vehicle communications method for transmission of vehicle data to a central server. All data from UDOT vehicles is initially stored on the Verizon server. Through the use of the API provided by Verizon, UDOT then downloads select portions of the raw data from the Verizon server to a UDOT server and stores the data in its GIS database.

UDOT noted that Verizon provided good cellular coverage of snow plow routes throughout the state despite some gaps that are acceptable. In the event of loss in cellular coverage, vehicle hardware stores data that cannot be communicated until it returns to cell coverage to forward that information to the Verizon servers.

4. Decision Making Process

4.1 Level of Management Involved

As noted previously, UDOT determined in 2014 to install AVL/GPS technology in winter maintenance vehicles primarily to increase the public transparency of their operations to the general public by providing snow plow locations to the general public via a public UDOT traffic information page.

This overall objective was communicated from the executive director to Utah DOT maintenance staff for investigating how best to achieve the objective through on-board vehicle technology. UDOT had previously tested a pilot program with a Precise AVL/GPS system in 2012. Some issues encountered at that time related to sensor reliability and internal resources to make beneficial use of the data.

In order to gain a better knowledge of the overall capabilities of AVL/GPS systems and technology and develop a budgetary estimate for the deployment of an AVL/GPS system, UDOT sent out a Request for Information (RFI) in 2014 to industry providers of AVL equipment requesting information on system costs, types of technology, and other items of interest. General questions posed by UDOT in the RFI are bullet listed below:

- Connectivity Type Questions / Subjects
 - Cellular / Wi-Fi / Satellite connectivity
 - How system handles areas of no coverage
 - Experience sending information in real-time
 - Transmitting real-time images through vehicle cameras
- Data Collection / Storage / Hosting Questions / Subjects
 - Database configuration
 - Physical location of database servers
 - Provision of interactive webpage / smartphone application
 - Data retainage period
- Sensor Function Options Questions / Subjects
 - Integration of sensors from proposed system
 - Transferability of system equipment from one vehicle to another
- Cost Estimate Questions / Subjects
 - O&M System costs
 - Ongoing communications costs

4.2 Factors Considered

The responses to the RFI related to costs indicated that UDOT would not be able to deploy a comprehensive AVL/Materials usage systems on a statewide basis as desired from the onset. Due to financial constraints, UDOT had to find a balance between the collection of plow location data vs. the gathering of material usage data through integration with existing vehicle spreader controllers and other equipment/devices. Given the priority of increasing public transparency of winter maintenance operations, UDOT desired to proceed with the Verizon AVL/GPS system as Verizon was the most cost-effective way to get statewide coverage of all Class 8 snow plows. Verizon also offered an API to migrate data to a public interface and provided vehicle diagnostics to help UDOT with vehicle maintenance and repairs.

UDOT was able to leverage a pre-negotiated contract that Verizon had entered into in 2011 with the Western States Contracting Alliance (WSCA), which is currently managed by the National Association of State Procurement Officials (NASPO). The state of Utah was a member of the WSCA and utilized that contract to purchase the associated hardware and software required for their AVL/GPS system. With this contract, UDOT did not need to release an RFP to solicit vendors for AVL/GPS solutions.

5. Data Collection and Management

This section provides details on the data collection and management of the AVL/GPS system by UDOT.

5.1 Data Collection

All data from UDOT vehicles is initially stored on Verizon servers communicated from UDOT winter maintenance vehicles. Through the use of the API provided by Verizon, UDOT then downloads select portions of the raw data from the Verizon server to a UDOT server and stores the data in its GIS database. Verizon stores UDOT AVL data on its server for one year.

The following types of data are collected by UDOT at 30 second intervals for storage and review on their database:

- Vehicle Identification Number (VIN)
- Fleet Identification Number
- Message Timestamp
- Vehicle Latitude and Longitude
- Vehicle Ignition Status
- Vehicle Speed (MPH)
- Vehicle Odometer

5.2 Data Accuracy

The following general issues with data accuracy were identified by UDOT staff. Any data inaccuracies that have been observed are was mainly due to the following:

- Downtown areas due to urban canyons
- Canyon areas where cellular coverage was spotty
- Data was not detailed enough with a 2-minute polling rate, so the polling rate was reduced to 30-seconds
- Vendor's mobile application was poorly designed, hence UDOT staff decided to use the UDOT mobile traffic application when in the field

5.3 Staffing and Resources

UDOT is supported internally by GIS staff resources for developing and maintaining the GIS interfaces and database. Most of the resources were dedicated to the initial development of the GIS database and making vehicle location information available on the webpage. UDOT had a team of two to three GIS staff members working on integrating the AVL data with the GIS database as well as developing additional products and analysis tools to assist with winter maintenance operations and performance management. UDOT noted the level of support from GIS staff was sufficient.

5.4 System Data Usage

Given the overall objective of increasing public transparency of winter maintenance operations, UDOT utilizes the data that they pull from the Verizon API for sharing UDOT snow plow locations through the UDOT traveler information webpage and UDOT Traffic mobile app. UDOT contracted with the Narwhal Group to assist with making the AVL data available on the UDOT webpage and mobile app as well as making additional enhancements. The Work Order related to the web and mobile app enhancements is included in Appendix C.

UDOT Maintenance staff utilize the NetworkFleet software primarily for monitoring vehicle locations, operational analysis, and for post-storm analysis purposes. District Engineers and Area Supervisors use the software package on a more frequent basis than Station Supervisors, who also are active in plowing snow during winter weather events. Area Supervisors noted the ability to monitor vehicle locations to enable sharing and relocating resources was extremely useful. In addition to monitor vehicle locations, Area Supervisors felt the system was very useful for:

- Verifying snow maintenance activities
- Coupled with UDOT cameras, verifying and confirming pavement conditions

In addition, UDOT uses the AVL system data for the following performance monitoring activities:

- Snow and Ice Dashboard, which integrates AVL data with RWIS data and data from non-invasive “roadway grip” sensors to determine effectiveness of plowing operations.
- New GIS based dashboards that are currently being developed to provide additional information and performance measures for the public facing web page.
- Using records from past storms to observe past performance and identify contributing factors (e.g. types of material and equipment used), worth noting practices and lessons learned.

UDOT has developed a Snow and Ice Performance Dashboard that has real-time statistics. UDOT maintenance crews utilize the real-time statistics to determine how effective they were at maintaining good road conditions during a storm. Several metrics go into creating the performance measure, including the intensity of the storm, length of time the storm is ongoing, resources allocated to the maintenance station covering the geographic area, field instrumentation on the RWIS units, and AVL data. The resulting information is utilized to measure storm performance, identify best practices and possibly re-allocate resources to better cover areas in need.

Figure 10 below shows the dashboard when snow plows pass an RWIS station installed along US 6 at Soldier Summit. Figure 11 presents a statewide view of winter storm statistics and overall performance. Figure 12 presents a display of storm performance reports that can be filtered by UDOT Region and along specific UDOT routes.

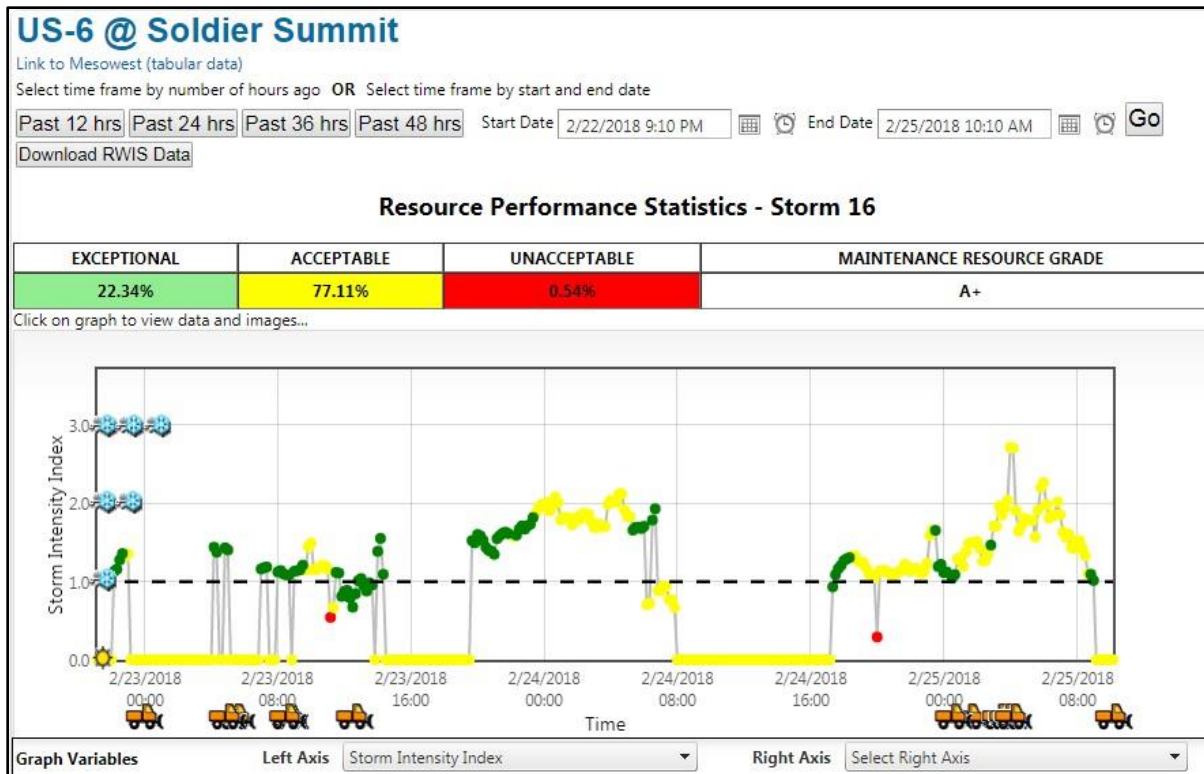


Figure 10. UDOT Snow and Ice Performance Dashboard at RWIS Station

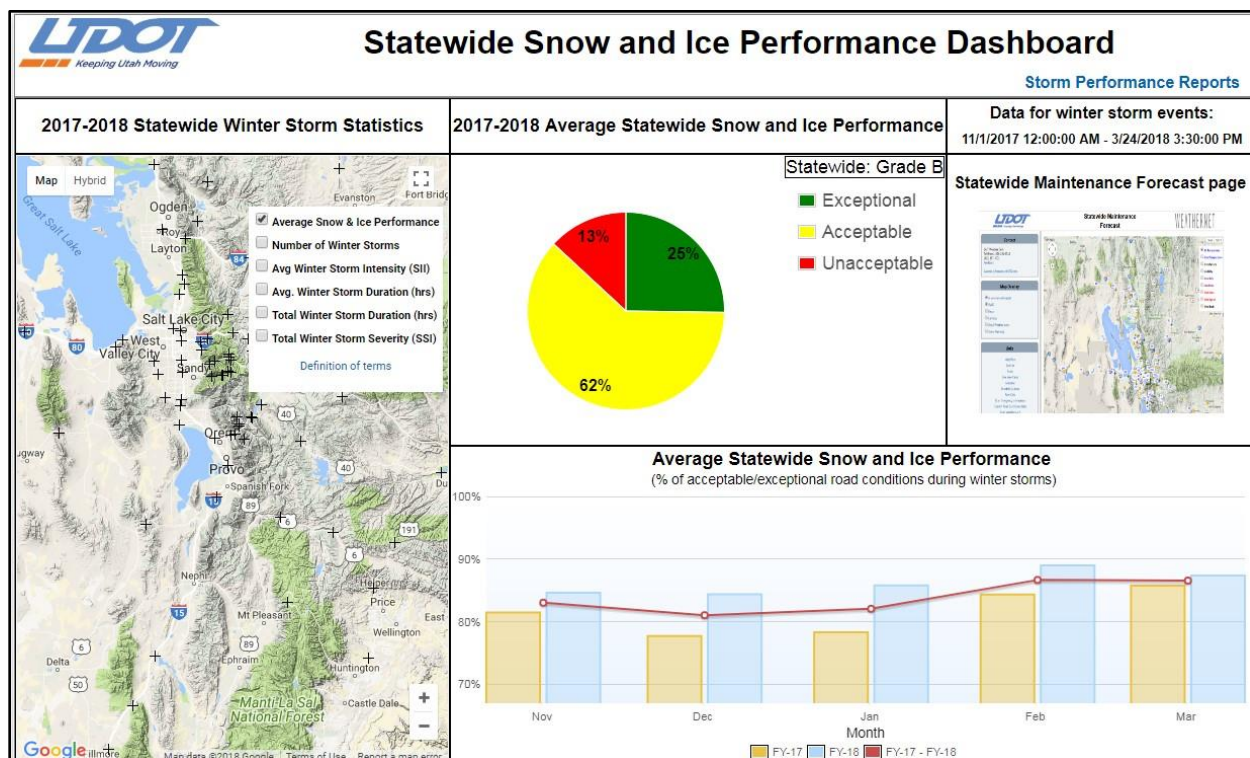


Figure 11. UDOT Snow and Ice Performance Dashboard Statewide View

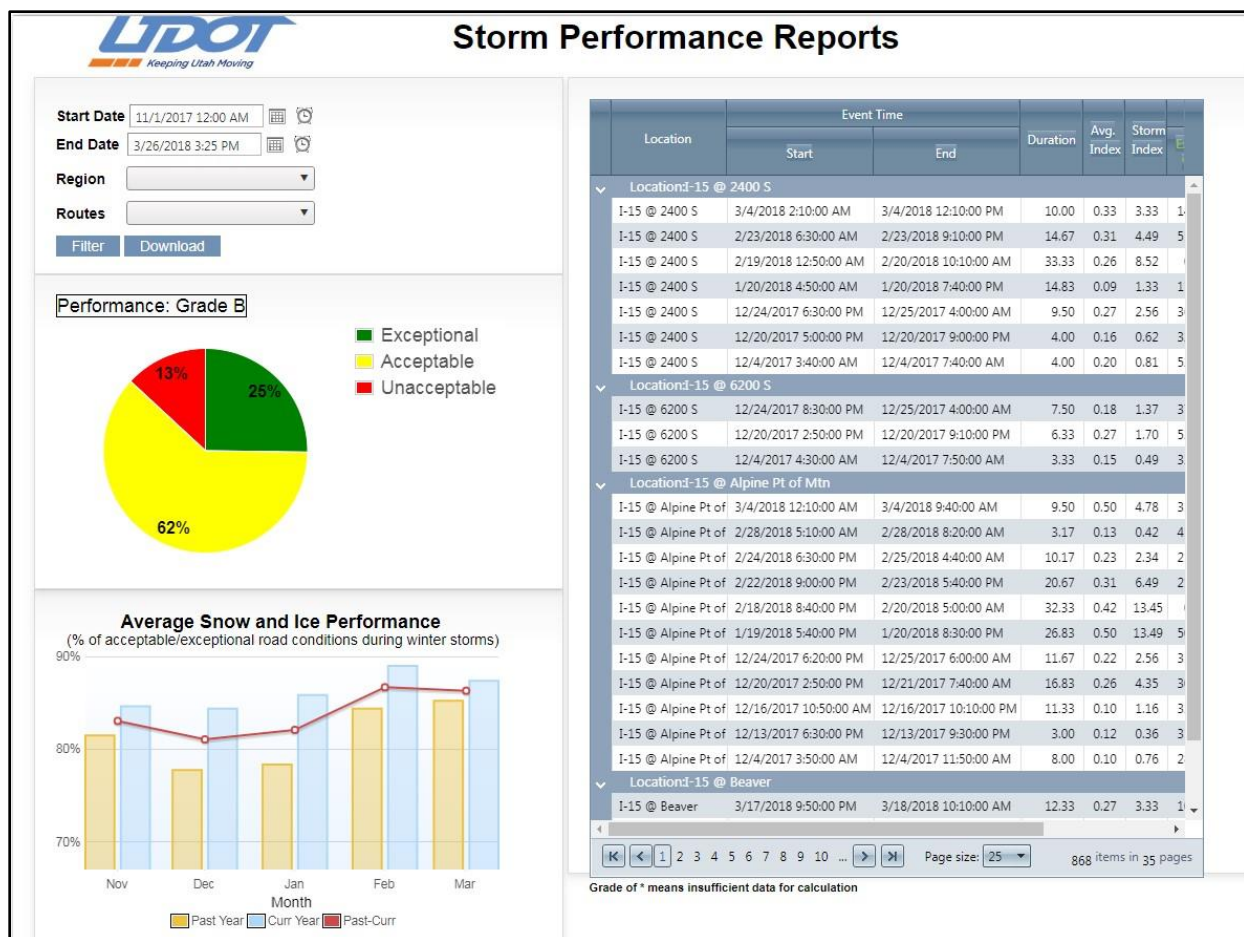


Figure 12. UDOT Snow and Ice Performance Dashboard Storm Performance Reports

UDOT GIS staff is currently developing a Snow Plow Tracking Dashboard, as presented in Figure 10. The dashboard draws from AVL data stored in the UDOT GIS database and shows the current UDOT snow plow locations, last plowed roadway segments, and additional metrics on the active plows. The interface is internal to UDOT Supervisors and Managers and can provide an overall snapshot of storm response on a statewide or regional scale. UDOT is also working on developing additional products and analysis tools for use by UDOT Supervisors and Managers in the coming year.

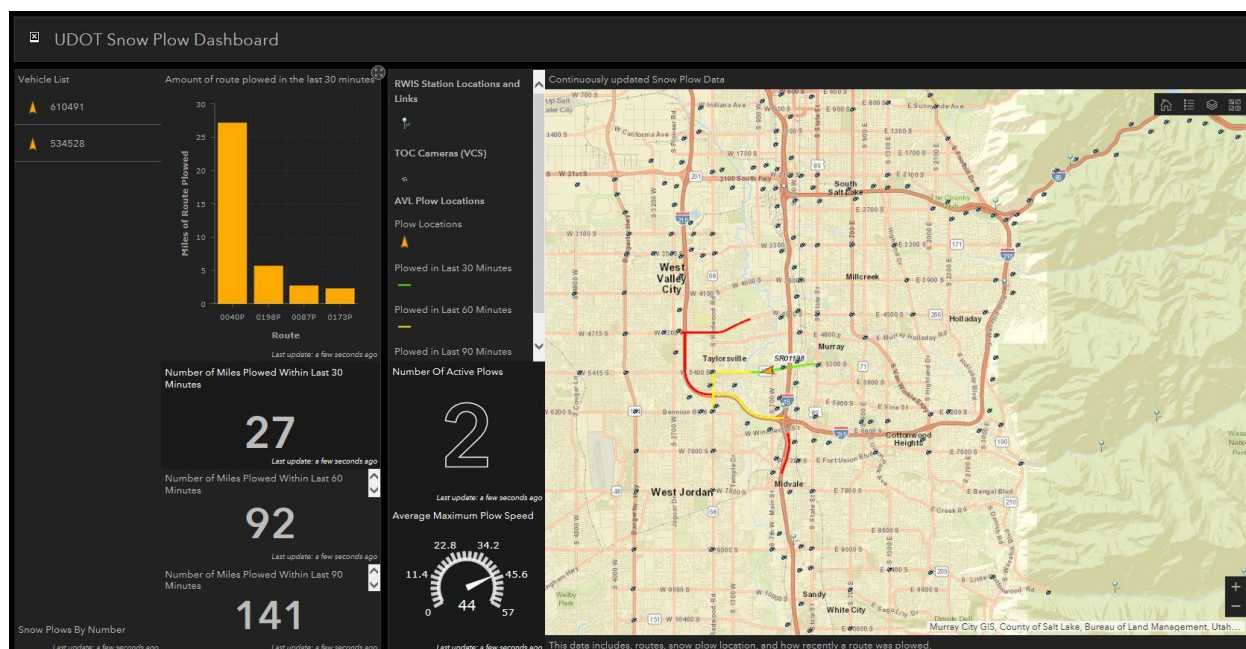


Figure 13. UDOT Snow Plow Dashboard (Under Development)

UDOT District Engineers and Area Supervisors noted that they are able to use the NetworkFleet system and the “bread crumb” trail reports to address public complaints about the lack of snow clearance on specific roads or reported damage to parked vehicles by snow plows.

UDOT supervisors are able to quickly run a report in a specific area over the range of time that the public complaint was received. UDOT can then respond to the public complaint by presenting an image of when the snow plows had cleared snow along a specific roadway, or whether they were present along a roadway when damage had occurred to a parked vehicle. It was noted that the general public has been pleased with UDOT’s responsiveness to the public’s complaints, even in cases where a UDOT snow plow was found to be liable for damage caused to a parked vehicle. The ability to use the AVL data and bread crumb trail of where vehicles have been in past snow storm events has also helped to accomplish the overall goal of increasing public transparency with respect to winter maintenance operations.

UDOT GIS staff are currently developing an algorithm that would automate the process of using the NetworkFleet software package to gather a bread crumb trail that would be used to respond to public complaints about either a lack of snow plowing along roadways or potential damage to parked vehicles caused by UDOT snow plows. Currently, this is a manual process where District Engineers or Area Supervisors will access the NetworkFleet software and search for bread crumb trails around the location and time of the complaint about winter maintenance operations. The automated process will reduce the amount of time spent by UDOT staff in searching for information to be used in responding to public complaints.

5.5 Agency Policy and Agreements for Data Sharing

Regarding the sharing of vehicle locations on the UDOT traffic information webpage, additional steps are taken by UDOT to delay the reporting of vehicle location on the webpage by 2-3 minutes to alleviate driver concerns that real-time vehicle location could be used by individuals to plan specific attacks on the snow plow vehicles.

When the general public accesses the traffic information page either through a computer or mobile device, they are also presented with the following disclaimer which helps users to understand why there may be some observed inaccuracies in the route taken by snow plow vehicles:

“The snowplow location feature on the UDOT Traffic displays information about actively working UDOT-only snowplows throughout the state of Utah. Plow location information is updated every 3-5 minutes. This information is provided to help travelers make smarter decisions about where and when to travel. Please note that areas without cellular phone coverage will not show plow movements, even though plows may be working. Plow location information is provided for awareness and is not intended to redirect plow resources. Every attempt has been taken to ensure the data is as accurate as possible, however data discrepancies may appear at any time.”

6. System Implementation Process

6.1 Implementation Steps

Upon selecting Verizon as the provider of the AVL/GPS system, UDOT requested Verizon to perform the installation of vehicle AVL/GPS hardware on UDOT snow plows. Verizon performed the hardware installations on the vehicles and demonstrated the functionality and reliability of the system over a two-month period for UDOT. The vehicles were monitored by UDOT through the software package (NetworkFleet) by UDOT staff and features of the software were observed to confirm that the system was functioning properly.

Upon successful completion of the demonstration, UDOT purchased additional Verizon hardware that was then installed by a Verizon team of subcontractors in about 90% of all UDOT winter maintenance vehicles prior to the 2015-2016 winter season.

Since that time, all other UDOT maintenance vehicles have been equipped with Verizon units, and UDOT staff have been trained to perform the installation of Verizon hardware on new winter maintenance vehicles.

UDOT technicians also install Verizon AVL hardware on roadside safety service patrol vehicles, referred to as Incident Management Team (IMT) vehicles, in the same manner as they do for UDOT snow plow vehicles. IMT vehicles provide roadside assistance to stranded motorists or other vehicle incidents along UDOT roadways throughout the state.

6.2 Procurement Methods and Process

UDOT was also able to leverage a pre-negotiated contract that Verizon had entered into in 2011 with the Western States Contracting Alliance (WSCA), which is currently managed by the National Association of State Procurement Officials (NASPO). The state of Utah was a member of the WSCA and utilized that contract to purchase the associated hardware and software required for their AVL/GPS system. With this contract, UDOT did not need to release an RFP to solicit vendors for AVL/GPS solutions.

7. System Benefits and Costs

7.1 Implementation Costs

A summary of the Verizon AVL equipment costs provided to UDOT in 2015 are provided in the table below. Note that unit cost prices were drawn from the pre-existing contract through the Western States Contracting Alliance (WSCA) entered into by Verizon.

Table 2. Hardware, Installation, and Training Costs of UDOT AVL/GPS System

Items	Quantity	Unit Cost	Total Cost
Hardware			
GPS only	191 vehicles	\$85.00	\$16,235.00
Diagnostics and GPS	309 vehicles	\$85.00	\$26,265.00
Accessories			
Sensor Harnesses	500 vehicles	\$10.00	\$5,000.00
Pin Harness	309 vehicles	\$35.00	\$10,815.00
Universal Pin Harness	191 vehicles	\$10.00	\$1,910.00
Alternate Power Adaptor	180 vehicles	\$20.00	\$3,600.00
Installation Cost	500 vehicles	\$65.00	\$32,500.00
Training	1 day	\$150.00	\$150.00
Sum of Hardware, Installation, and Training			\$96,475.00

7.2 Costs for Operations and Maintenance

The monthly cellular service costs for the various vehicle types are presented in the table below. Note that the prices below were also drawn from the pre-existing contract through the Western States Contracting Alliance (WSCA) entered into by Verizon.

Table 3. Monthly Service Charges for First Year of System Operations

Items	Quantity	Unit Cost	Total Cost
Service Charges			
GPS only	191 vehicles	\$18.95 / month	\$43,433.40 / year
Diagnostics and GPS	309 vehicles	\$19.95 / month	\$73,974.60 / year
Sum of Monthly Service Charges for One Year			\$117,408.00

In addition to the AVL/GPS system costs, UDOT also budgeted for the internal development required to pull AVL system from Verizon servers and present vehicle locations on the UDOT traffic information page for both PC and mobile devices. The estimated development time for the traffic information web page and mobile application was approximately 10 weeks with an estimated cost of \$55,362.00.

7.3 Benefits

UDOT staff provided many of the key benefits through the interviews conducted in November 2017. These benefits are summarized below.

- Ability to provide records of plow locations and activities, which help achieve public transparency.
 - Achieved through sharing of Verizon API with UDOT for reporting of vehicle locations.

- AVL data helps address liability issues and resolve tort claims.
 - “Bread crumb” trail reports help address public complaints about the lack of snow clearance on specific roads or reported damage to parked vehicles by snow plows.
- AVL data provides assistance in route planning and prevents gaps in plowing routes.
 - Verizon software package used by District Engineers / Area Supervisors for monitoring locations of snow plow equipment during winter storm events.
 - The system allows for more efficient resource sharing and relocation to fight major (particularly localized) storms.
- AVL data with RWIS data provides real-time road conditions information. Data are integrated in UDOT’s Snow and Ice Performance Dashboard.
- The system facilitates better resource sharing and cross-regional coordination.
 - District Engineers / Area Supervisors are able to request assistance from neighboring areas in the event of large storms impacting only a certain portion of the state.
- AVL data supports performance management. AVL data enables UDOT to make performance measures available to the public, which in turn promotes public trust.
 - UDOT GIS staff support the use of the AVL system and data through development of snow plow vehicle sharing information on public-facing webpages, as well as internal UDOT dashboard for monitoring overall storm response.
- Vehicle diagnostics have helped UDOT mechanics optimizing their time by allowing for remote access of truck error codes to perform a preliminary diagnostic on mechanical issues.

8. System Issues and Challenges

8.1 Institutional Issues

UDOT noted the biggest barrier for their AVL implementation was funding. Due to financial constraints, UDOT had to find a balance between basic plow location tracking vs. more sophisticated features such as collecting material usage data. The need for public transparency on plow locations outweighed tracking of material usage and other features through AVL.

The adoption of AVL/GPS systems by state DOTs in recent years has generally caused “Big Brother” concerns from snow plow drivers about the use of the system by supervisors to discipline drivers. Concerns may be questions raised about a vehicle was stopped at a given location for an extended period of time or why it was not on an assigned route.

UDOT staff noted that these concerns have lessened over time as drivers realize that the system is not used in this manner by District Engineers or Area supervisors. Drivers have found that the AVL/GPS system has also been able to exonerate them from public complaints about potential damage they may have caused through the use of the “bread crumb” trail reporting feature that supervisors can use to confirm where UDOT snow plows were in relation to the public complaint.

Although it was noted by UDOT staff that there are still “Big Brother” concerns from drivers, it is anticipated these concerns will continue to lessen over time.

Involvement from Districts and Regions is key to success. Exposing technology to people helps buy-in and implementation. UDOT worked with staff in each region to gain buy-in to the system. In addition to

providing continued training, UDOT holds monthly meetings with District Engineers to identify and discuss innovations.

8.2 Technology Issues

UDOT staff did not note any technological issues with the functionality of the AVL/GPS system from the vendor of equipment, or with the installation of the equipment by vendor staff.

8.3 Procurement and Implementation Issues

8.3.1 Procurement Issues

UDOT staff did not report any procurement issues with the AVL/GPS system. The ability to leverage a pre-existing contract through WSCA as noted previously expedited the overall procurement process given that UDOT did not need to release a Request for Proposals (RFP) as they had initially planned in 2014.

8.3.2 Implementation Issues

Installation of the system was smooth, and UDOT didn't experience any issues. Verizon staff performed the hardware installations on the vehicles during the initial demonstration and then utilized a team of subcontractors to complete installations in about 90% of all UDOT winter maintenance vehicles prior to the 2015-2016 winter season. UDOT staff have since been trained to perform the installation of Verizon hardware on new winter maintenance vehicles.

Additional wires and customized installation, however, was required on older trucks that did not have ODB-II ports. UDOT didn't experience any issues with maintenance of the system either. UDOT noted some issues with other equipment on the snow plows:

- UDOT experienced issues with plow sensors and gate sensors due to rusty or loose connections of wires. However, the sensors were very reliable with approximately 2 to 3 failures over more than 500 units over the past years.
- There were still gaps with cellular coverage. Verizon had the best coverage, but it was noted at about 75% to 80% of the state. It is anticipated that coverage will expand over time to remaining gaps.

8.4 Operations and Maintenance Issues

UDOT staff did not note any operations and maintenance issues with the overall system. Vehicle hardware has been reliable in terms of its operation, and UDOT staff noted that Verizon has been responsive to questions regarding the use of NetworkFleet as a software package by UDOT District Engineers / Area supervisors.

9. Lessons Learned

The following lessons learned are offered based on the UDOT case study.

- The ability to monitor winter maintenance vehicle locations enables improved resource sharing and allocation as well as cross-regional coordination.
- AVL data supports winter maintenance performance monitoring and management. Integrating AVL data with RWIS data and other real-time road conditions information helps better situational awareness and facilitates improved winter maintenance practices. Coupled with UDOT cameras, real-time road conditions information help verify and confirm pavement conditions.
- Involvement from leadership at District and Region levels is key to buy-in and implementation success. In addition to providing continued training to gain buy-in to the system in each region, UDOT holds monthly meetings with District Engineers to identify and discuss innovations, best practices, etc.
- Making vehicle location data and associated performance measures available to the public promotes public trust.
- Showing the vehicle locations on the public webpage doesn't create issues or damages to drivers, which helps alleviate drivers' "Big Brother" concern.
- Delaying vehicle location reporting on the public webpage by 2-3 minutes alleviates driver concerns that real-time vehicle location could be used by individuals to plan specific attacks on the snow plow vehicles.

UDOT noted their future plan related to expanding the system capabilities to winter operations. The future plan includes:

- Integrating AVL system with spreader controllers to gather material usage data.
- Further development and enhancement of performance measures and management program.
- Investigating and implementing connect vehicle technologies.
- Equipping DSRC to snow plows to help with signal priority and I2V communications.

Appendix A Survey Response

Name	Title	Agency	Phone	Email
Brandon Klenk	Methods Engineer	Utah DOT	801.965.4094	bklenk@utah.gov
AVL/GPS System				
1. Are you currently using an AVL/GPS system to automatically collect data for your winter mail				
			Yes	
2. Does your agency have plans to implement or expand AVL/GPS technologies on your winter maintenance vehicles in future years?				
			Yes	
If yes, please describe the anticipated implementation or expansion:				
			We will be expanding into plow up/down sensors and hopefully amount of material applied	
3. Approximately how many vehicles are in your winter maintenance fleet?				
			505	
4. How many of your winter maintenance vehicles are equipped with AVL/GPS technology?				
			505	
5. Who is your contracted AVL / GPS vendor?				
			Verizon	
6. What modem / GPS brand(s) does your agency utilize?				
			Verizon	
7. Who performed the installation of your AVL/GPS system? Was it the system vendor or DOT agency staff?				
			System Vendor	
8. Who is maintaining the AVL/GPS system after installation? Is there a maintenance contract with the system vendor, or is it maintained in house by DOT agency staff?				
			DOT Agency Staff	
9. Were there any issues with the installation of your AVL/GPS system?				
			No	
If yes, please describe:				
Integration				
10. What auxiliary equipment and sensors are installed on the vehicles and integrated with your AVL system? Please check all that may apply.				
			Spreader controller	No
			Plow controller	No
			Plow position sensor	Yes
			Mobile data terminal/computer	No
			Pavement temperature sensor	No
			Air temperature sensor	No
			Humidity Sensor	No
			Dashcam	No
			Other (describe below)	No
			If you indicated "Other" in the question above, please describe below.	
11. Have you experienced difficulty integrating above equipment or sensors into your AVL/GPS system? If so, please describe.				
			No	
12. What brand(s) of spreader controller does your agency use?				
			Force America	

Name	Title	Agency	Phone	Email
Brandon Klenk	Methods Engineer	Utah DOT	801.965.4094	bklenk@utah.gov
Data Management				
13. What types of data other than vehicle location are being captured with your AVL system? What is the data capture frequency? Please check all that may apply				
	Plow position		Not captured	
	Material application rate		Not captured	
	Type of material applied		Not captured	
	Mobile data terminal messages		Not captured	
	Pavement temperature		Not captured	
	Air temperature		Not captured	
	Humidity		Not captured	
	Surface friction		Not captured	
	Dashcam		Not captured	
	Engine diagnostics		Less than 5 min.	
	Other, please describe below		Not captured	
	If you indicated "Other" above, please describe below.			
14. Where does the AVL system data reside after it is transmitted from the vehicles?			Verizon	
15. Do you use the AVL system data to perform any of the following items? Please check all that may apply.				
	Vehicle location tracking / fleet monitoring		Yes	
	Route/operational planning and optimization		Yes	
	Material usage tracking and analysis		No	
	Treatment recommendations		No	
	Providing data to a maintenance decision support system (MDSS)		No	
	Operational analysis, evaluation and performance reporting		No	
	Collection of vehicle diagnostic data		Yes	
	Sharing of vehicle location through agency traveler information webpage		Yes	
	Road weather condition reporting		No	
	Staffing analysis and management		No	
	Other, please describe		No	
16. Does your agency share data collected through the AVL system internally with other divisions or offices within the department?			Yes	
If yes, what do those divisions/offices use the data for (e.g., operational analysis, planning, performance reporting, budgeting, etc.)?			Traffic for the public info page	
17. Does your agency share AVL system data externally with other public agencies?			No	
18. Does your agency share AVL system data externally with any private agencies, such as private weather service providers?			No	
19. Does your agency share AVL system data with the general public?			Yes	
If yes, please describe what AVL system data is being shared with the general public.			We show the public a bread crumb trail of where our plows have been for the past 30 min	

Name	Title	Agency	Phone	Email
Brandon Klenk	Methods Engineer	Utah DOT	801.965.4094	bklenk@utah.gov
Communications				
20. What type of communications does your AVL/GPS system use to transfer data? Please check all that apply.				
Cellular network				
21. How would you rate the coverage of your communications system?				
Covers most of maintenance areas with acceptable gaps				
Operational and Procurement Aspects				
22. Do you have a distributed approach to tracking vehicle locations (i.e. by district or geographic boundaries)? Or is there a centralized method of tracking all vehicles within the agency boundaries? Or do you use a mix of both approaches?				
Distributed approach				
23. Is your agency's AVL system equipment provided by a single vendor or multiple vendors?				
Single vendor				
24. Does your agency utilize a web-based interface accessible over the internet to access operational information?				
Yes				
If yes, how is the data that can be extracted from the interface utilized to improve upon winter maintenance operations?				
We are working on that. It isn't used for much of anything other than tracking right now				
25. Does your agency extract data from the AVL / GPS system and / or web-based interface for separate analyses to improve upon winter maintenance operations after winter weather events?				
No				
If yes, please describe how the data is utilized by your agency.				
26. What was the procurement process used for your AVL/GPS system (i.e. Request for Proposals (RFP), Invitation for Bids (IFB))?				
Used existing contract				
Was a demonstration of the system included as part of the evaluation of respondents?				
No				
27. Does your agency move your AVL/GPS vehicle units to different trucks or equipment for use during summer maintenance operations?				
No				
Costs and Benefits				
28. Do you have cost information associated with your AVL system?				
Not sure				
29. What cost information would you be able to provide?				
AVL equipment costs				
Yes				
Installation & integration costs				
Yes				
Costs associated with on-going operations (staffing, communications, software licensing, etc.)				
Yes				
Maintenance costs				
No				
Other costs, please describe				
No				

Name	Title	Agency	Phone	Email
Brandon Klenk	Methods Engineer	Utah DOT	801.965.4094	bklenk@utah.gov
30. Has there been any formal or informal benefits assessment or benefit-cost analysis performed on your AVL system and/or other technology for winter maintenance operations?				
Yes				
Deployment Experience				
31. Please share any general lessons learned in the deployment of AVL/GPS technologies below that would assist agencies considering a future deployment of these technologies.				
The diagnostic function has saved our technicians a lot of time since they don't have to make 2 trips to fix a problem. We also used the info from storms in our plow route optimization.				
32. May we contact you with follow-up questions about your system(s)?				
Yes				

Appendix B UDOT 2014 Request for Information

State of Utah

Bid DOT140317DB

Utah Department of Transportation Request for Information DOT140317DB Automatic Vehicle Location (AVL) services

I. Purpose of this RFI:

The Utah Department of Transportation (UDOT) is releasing this Request For Information (RFI) in an effort to gather information for the development of a budgetary estimate for Automatic Vehicle Location (AVL) services for its fleet of snow plows and other vehicles.

In addition to the questions in Section II of this RFI, vendors are encouraged to provide any additional information, as an attachment, that will help UDOT identify the current state of practice, cost benefit and pricing options for AVL services.

This RFI will not result in a contract award. Information obtained in response to this RFI may or may not be used in a future solicitation.

A. Background:

UDOT is looking to retrofit its fleet of approximately 500 snow plow vehicles with an AVL system that is capable of providing real-time and/or time delayed information during their winter snow removal activities. The entire snow plow fleet currently uses the Force America 6100 and 6200 spreader controls and infrared surface temperature sensors. Other vehicles may be considered during the final procurement process (sweepers, supervisor vehicles, etc.), based on features and cost.

On the most basic level, UDOT would like to provide a web/app based interface for the general public to help with transparency and improve understanding of snow removal operations. This may be integrated into the UDOT Traffic App and other systems. On more technical level, UDOT envisions using both real-time and stored data to analyze it's efficiency and effectiveness to provide a "score card" of snow removal activities. Collected data may also allow for better weather condition reporting, performance measures, analysis of response and other beneficial uses.

Each of the question categories in Section II will provide a general overview of why the questions are being asked. Each vendor should feel free to expand on the questions in areas UDOT may have overlooked.

B. Issuing Office and Reference Number:

The State of Utah Department of Transportation is the issuing office for this document and all subsequent addenda relating to it. The reference number for this RFI is Solicitation DOT140317DB. This number must be referred to on all correspondence and documentation relating to the RFI.

C. Submitting the Response:

1. The preferred method of submitting your proposal is electronically through BidSync. Electronic responses may be submitted through a secure mailbox at Bid Sync (www.bidsync.com) until the date and time indicated in this document. It is the sole responsibility of each "Company" to ensure that its response reaches Bid Sync before the closing date and time. There is no cost to the "Company" to submit electronic responses to this RFI via Bid Sync.
2. Electronic responses may require the uploading of electronic attachments. The submission of attachments containing embedded documents is prohibited. All documents should be attached in separate files.
3. If you choose to submit the response in hardcopy, the response must be delivered to the State of Utah Department of Transportation, 4501 South 2700 West, Salt Lake City, Utah, 84114 (attention: Debra Boulton) by the due date and time. The RFI reference number and due date must appear on the outside of the envelope. Responses received after the due date may or may not be considered for review.
4. Responses sent by fax will not be considered.

D. Response Preparation Costs:

Response preparation costs are the sole responsibility of the submitting company.

E. Questions; Addenda to RFI:

All questions regarding this RFI must be submitted through Bid Sync. All answers to questions will be posted on Bid Sync and will be considered addenda to the RFI. All addenda to the RFI will be posted on Bid Sync. No contact shall be made with any State employee or official in regard to this RFI.

F. Confidentiality:

1. All submissions pursuant to this RFI become the property of the UDOT and are generally subject to the Government Records Access Management Act (GRAMA).

2. GRAMA provides that if a person submits trade secrets, commercial information, or non-individual financial information to a governmental entity, the person may request that the information be classified as a protected record. A person making such a request must submit to the governmental entity a written claim of business confidentiality, which must contain the information required by Utah Code Ann. §63G-2-305(1) and (2) and §63G-2-309 (the "Required Information").
3. A claim of Business Confidentiality Form is attached hereto as Attachment "A." To request that any portion of a submission be classified as a protected record, use Attachment "A" or its equivalent and provide a detailed explanation. If the "Company" chooses to use an equivalent document, do so on a separate page and indicate conspicuously that the "Company" is using that document to claim confidentiality. Clearly identify the specific information for which the protected classification is requested. Failure to provide the required information risks having the entire submission be considered a public record. An entire submission may not be protected under the claim of business confidentiality.
4. Cost information, including any proposed fee or cost arrangement, will be public.

See GRAMA for additional information about Utah's governmental records laws.

G. GOVERNING LAWS AND REGULATIONS:

The Utah Procurement Code, Title 63G, Ch. 6, Utah Code; Submissions made pursuant to this RFI are also generally subject to GRAMA. (To the extent those provisions conflict with GRAMA, they are superseded by GRAMA.)

H. SUBSEQUENT SOLICITATION(S):

Information submitted will be considered by the State of Utah. If the State determines that the information received provides for a viable option, a subsequent solicitation will be issued.

I. RESPONSE TO THIS RFI NOT MANDATORY:

Failure to respond to this RFI in whole or in part **will not** disqualify any company from participation in any subsequent solicitation by UDOT regarding this matter.

II. INFORMATION SOUGHT BY THIS RFI:

In order to help evaluate the various options and develop a planning budget, the below questions are being asked of each Vendor. The questions are grouped into general categories to help UDOT build a comparison/benefit matrix once all information is collected. Vendors may provide additional supporting information (brochures, references, etc.) as an attachment to their response to the questions.:

Connectivity Type:

As technology continues to change, the options for network coverage and real-time data collection become increasingly affordable for DOT's. UDOT wishes to determine the current spectrum of communication options and flexibility of deploying them in various combinations. These may include WiFi hot spots at maintenance station locations for uploading data, cellular push of data at intervals, and satellite communication for cellular network dead zones. Note that Radio communications is not an option.

- Q1: Does your system offer Cellular, WiFi, and/or Satellite connectivity?
- Q2: How does your system handle areas of no coverage?
- Q3: Do you have experience with sending system information in real-time (i.e. two way communication), and if so, what equipment do you prefer to deploy (off the shelf such as tablet computers/smart phones or proprietary interface)? What additional cost should UDOT expect?
- Q4: If your system offers multiple connectivity types, can a blend of these be used to provide a cost effective solution for the Owner?
- Q5: If using Cellular or Satellite, what is a typical data plan (i.e. Verizon, Iridium Satellite, etc.) required to provide real-time data collection/transmission? Have you negotiated a package pricing, and what should UDOT expect for these?
- Q6: Follow Up to Q5: Do you have any experience with transmitting real-time images (such as forward plow cameras), and if so what resolution(s) and how does this impact the cost of operation? What value have other customers derived from live images? What are some limitations (i.e. quality, moisture on lenses, etc.)
- Q7: Follow Up to Q5: If your company offers data plans, can these be used seasonally to save money?

Data Collection/Storage/Hosting:

As stated in the background, UDOT is focused on providing both a public interface as well as internal data analysis for snow removal operations (and possibly other maintenance activities). The following questions are intended to provide UDOT an understanding of what type of public interface is possible, as well as how collected data can be utilized to provide other benefits to UDOT and the tax payers of Utah. UDOT operates several systems during snow events that help provide weather data and road conditions to staff and the public. It is important that the AVL system provide a value added to these systems as part of an operational tool set.

- Q8: What is the configuration of your database and application servers? (i.e. Oracle/Java, .Net, XML, HTML5, ESRI, etc.)
- Q9: Is your database and application servers protected? Where are they physically located? What is your typical/preferred method of sharing data? (web services, database views, etc.).
- Q10: What experience do you have with enterprise data reporting with multiple users? What Experience do you have with data analysis and reporting?
- Q11: Do you provide an interactive web page and smart phone app? Are there ongoing costs for data/web page maintenance, and if so, what budgetary figures should UDOT assume (i.e. Monthly, yearly, one time)?
- Q12: How long will the collected data be retained if not at UDOT? How can UDOT access the data? Can it be downloaded to our database servers? Real-time or Post Processed? Who owns the Data once collected?

Sensor/Function Options:

As stated in the background, UDOTs entire fleet is equipped with Force America 6100 and 6200 spreader controllers and infrared surface temperature sensors.

UDOT envisions a system with automatic location reporting, cookie crumb trails, and sensor reporting (air temp, road temp, spread rate, liquid application rate, speed, direction, plow up/plow down, periodic operator road condition input, and periodic operator weather condition input).

- Q13: Which functions/sensors does your system provide? What other functions are available from you system?
- Q14: Do you use proprietary equipment/sensors or "off the shelf" or a balance of both? Please explain the reason and how this is the most cost effective approach.
- Q15: Can your base system be taken from one vehicle to another with minor changes? (For example the system is on a snow plow during winter months, then a mechanical broom during the offseason.)

Cost Estimate:

In order to help establish a planning budget, some general cost information will help UDOT determine the most appropriate system for implementation. Implementation may be in one season, or it may be over a period of two to three years. It is understood that there are upfront costs related to implementation and deployment of equipment. It is also understood that there are O&M costs related to the continued use and maintenance of the system.

- Q16: What type of equipment and associated costs should UDOT plan for when initially deploying your system? If more than one system option is available, please provide enough detail to help determine potential budget needs.
- Q17: Can your system be operated during only portions of the year (i.e. snow season)? What is the related cost impact?
- Q18: Does your company offer a Lease option where equipment depreciation can help lower the cost of service to UDOT?
- Q19: Does your company offer a complete turnkey package with maintenance and equipment repair, such that UDOT only pays operational installs?

PLEASE ATTACH ADDITIONAL SHEETS IF FURTHER RESPONSES ARE DESIRED (References, Brochures, etc.).

Appendix C UDOT Work Order for Snow Plow Location Reporting on Traffic Information Webpage and Mobile App

Software Task Work Order Task WO 13003.55 – AVL\Snow Plow Location

Task Description: AVL\Snow Plow Location Map Layers

UDOT has recently acquired new AVL (Automatic Vehicle Location) equipment and plans to install these devices on 500 of their snow plow trucks by fall 2015. The Verizon cellular network is used to handle communications between the AVL device and the central servers. The AVL units report on various statuses of the snow plows, including the current latitude and longitude. UDOT wants to use this location data to display snow plow positions on the UDOT Traffic website and UDOT Traffic mobile application maps.

The purpose of this work order is to access the AVL data using the web services provided by Verizon and store it in the central database. The intent of this project is to only keep enough data on hand for creating the comet tails, and then purging any remaining data from the database older than a predefined time interval. Storing any permanent historical AVL data will be the responsibility of the UDOT Maintenance Division.

Both the UDOT Traffic website and UDOT Traffic mobile applications will access this data using the existing infrastructure when displaying snow plow icons and line segments on their respective maps. Since snow plow locations are only relevant during the winter season, the new snow plow icons will be added to the weather map layers. The weather map layers are disabled during the non-winter months, and then become enabled during the winter season automatically. On the UDOT Traffic website, when a user hovers their mouse cursor over a snow plow icon, a line segment ("comet tail") will be displayed on the map representing the route the plow has driven over a period of time. The UDOT Traffic Mobile apps will always display the comet tail when the snow plow layer is on, as there are no mouse hover events to capture on a mobile device.

The comet tail will be created by connecting a series of points retrieved from the Verizon web service for each snow plow truck. The ability to toggle on/off the displaying of the comet tail in all maps and defining the time period for gathering snow plow previous location points will be configurable at the system level and will affect all users.

The data retrieved from the Verizon web service will include data sent from out of service snow plow trucks or trucks that are currently not plowing roads. The UDOT Maintenance Division is currently working with Verizon to modify the data stream to include an out of service flag. This modification will not be available within the time frame of this project. The Narwhal Group will investigate, and if possible, will limit the number of out of service vehicles displayed on the map using the current data values provided by the Verizon web service.

A new link will be added to the Additional Info box on the UDOT Traffic website which will display information about primary and secondary snow plow routes. This information will be presented within the UDOT Traffic website similar to how the current Road Weather FAQs and Citizen Reporting links display information.

This work order will also cover required changes for iOS version of the UDOT Traffic App. Apple requires all apps submitted to the Apple App Store after June 1, 2015 to be both iOS 8.0 and 64 bit compliant.

Scope of Work

Primary functions to be provided as part of this task will include:

- Update KML generator to create a new snow plow KML file.
- Create service for gathering snow plow AVL data using the Verizon web services.
- Add snow plow map icons to the weather layer on the UDOT Traffic website traffic map.
- Add snow plow map icons to the "Show Reported" layer on the UDOT Traffic website road condition map.
- Add snow plow map layer to the UDOT Forecast View website map.
- Add snow plow map icons to the weather layer on the UDOT Traffic mobile application traffic map.
- Add snow plow map icons to the UDOT Traffic mobile application road conditions map.
- Update the iOS version of the UDOT Traffic mobile application to be iOS 8.0 and 64 bit compliant.
- Implement the vehicle layer on the ATMS map for displaying snow plow locations.
- Add "Snow Plow Route Priority" link to Additional Info box on UDOT Traffic website.
- Create design document.
- Create and execute acceptance test plans.

Test Plan

All application changes and additions will be tested in the staging environment. In order to effectively test the snow plow AVL data retrieved from the Verizon web service, UDOT will need to provide Verizon with adequate data through the AVL equipment. This may require driving snow plow trucks or other vehicles outfitted with functioning AVL devices along various plow routes. If no data is available, then artificial data will be inserted into the local database for the purpose of testing the map layers, but testing the retrieval of AVL data from Verizon will be dependent on such data being present.

Staging versions of the UDOT Traffic mobile application will be provided for both iOS and Android for the purpose of testing the new map layer functionality.

Installation Plan

Narwhal will assist DTS in running the prescribed update scripts against the production database, deploying the installation to the required servers and on a select number of workstations as directed by DTS staff.

Staffing Plan

The following staff categories and billing rates will be assigned to the project:

Position	Hours Estimate
Principal	28
Subject Matter Expert	
Systems Engineer IV	438

Deliverables

- Installation application, updated installation instructions, and release notes.
- Design document and acceptance test plans.

Schedule

The estimated completion time will be 10 weeks from the starting date. Start and completion dates are based upon priorities set by UDOT and/or DTS and the availability of snow plow data from Verizon.



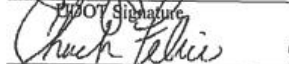
Cost Estimate

\$55,362

Assumptions

- Contract type will be fixed price.
- UDOT will provide network access from the staging and production environments to Verizon servers in order to pull the data and integrate it into the system.
- UDOT will provide updated icons and images for the snow plow map layers and mobile application compliance within their respective app stores.
- UDOT will provide all information regarding snow plow primary and secondary routes displayed in the UDOT Traffic website.
- UDOT will provide necessary access to the UDOT system and related equipment including AVL units, mobile application development licensing and VPN access from off-site.
- UDOT will provide data to Verizon through the AVL equipment for testing the web sites and services.
- Access will be granted to perform software updates and testing on-site.

Authorization to Proceed

 DTS Signature	5/4/15 Date	Rudy Zamora / IT Manager I DTS Name/Title (print)
 UDOT Signature	4/29/15 Date	Rob Clayton / TOC Manager UDOT Name/Title (print)
 UDOT Signature	4/29/2015 Date	Chuck Felice / Project Manager UDOT Name/Title (print)