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Utilization of AVL/GPS Technology Case Study: Nebraska 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: Nebraska 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

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.

This document is one of the six case studies conducted for the Clear Roads project entitled *Utilization of AVL/GPS Technology: Case Studies*. This case study report summarizes Nebraska 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.

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 51	22. Price

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1. Overview of Nebraska DOT Winter Maintenance Operations

This section provides an overview of this Case Study report detailing how the Nebraska Department of Transportation (NDOT) 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 of 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 NDOT was categorized into Tier 3 and ultimately selected for further in-depth interviews to gather more information on how their AVL/GPS system is implemented and utilized. NDOT's survey responses are also included in Appendix A of this Case Study.

1.2 Agency Characteristics

NDOT is divided into eight Districts, and NDOT winter maintenance staff within each District are structured into the following general positions:

District Engineer: Responsible for overseeing all winter maintenance and other construction activities within the District.

District Operations and Maintenance Manager (DOMM): Responsible for monitoring how multiple Superintendents within the District are responding to winter weather with winter maintenance operations. Reports to District Engineer and communicates with Superintendents as needed during winter events. Uses MDSS software interface for observing weather and treatment recommendations.

District Superintendent: Responsible for overseeing multiple District Supervisors within the District and keeping in touch with them about MDSS treatment recommendations and responses to winter weather.

District Supervisor: Responsible for overseeing one or multiple Crew Chiefs and winter maintenance workers that plow snow along pre-defined routes within that part of the District.

District Crew Chiefs: Responsible for communicating with and overseeing other snow plow drivers, and for reporting to District Supervisors / Superintendents and DOMM's as needed.

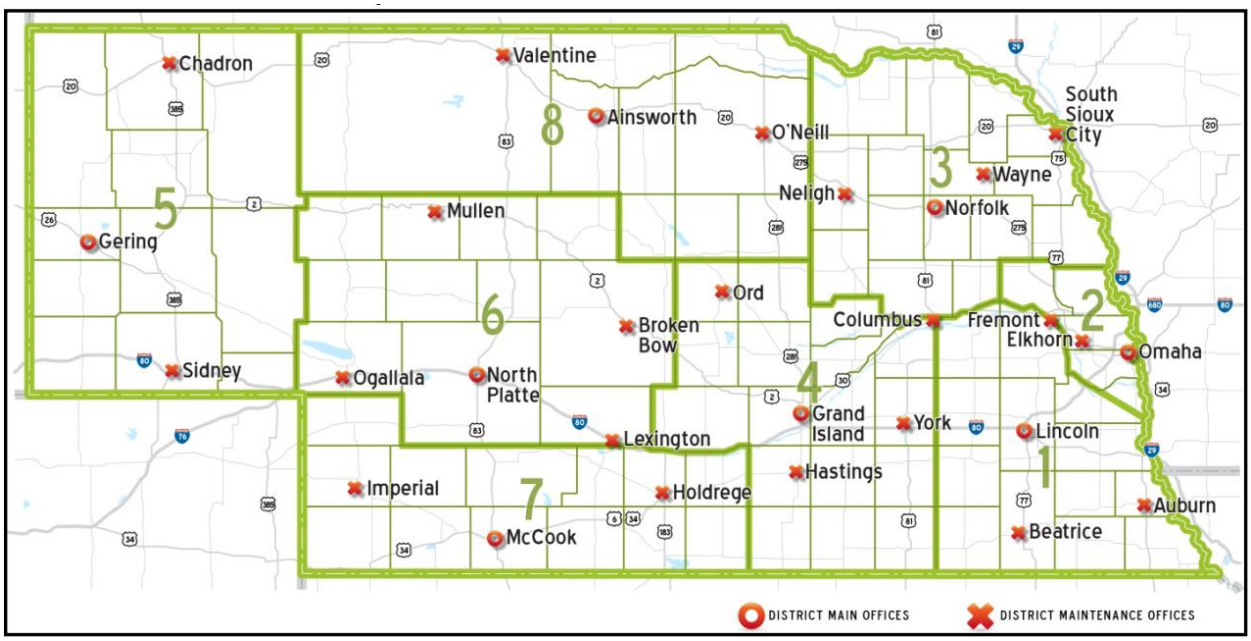


Figure 1. Nebraska DOT Districts

1.3 Agency Interviews

NDOT staff were interviewed over a two-day period between Dec. 13th and Dec. 14th, 2017 at an NDOT office in Lincoln, NE. Table 1 lists those individuals that were interviewed for the project.

Table 1. Agency Interview Dates / Times

Staff Interviewed	Date / Time	Subjects Discussed
Mike Mattison, Nebraska DOT **Larry Simmons**, Parsons **Sean Mulligan**, Parsons	Dec. 13th / 10:00am	• Communications • Software and interfaces • Data storage and management
Mike Mattison, Nebraska DOT **Snow Plow Operators,** Districts 1 and 2 **Snow Plow Crew Chief,** District 2	Dec. 13th / 1:00pm	• Hardware installation • Technology issues and testing • Operations • Maintenance
Mike Mattison, Nebraska DOT **Dale Butler,** District Operations Maintenance Manager (District 2) **Kelly Doyle**, District Operations Maintenance Manager (District 7) **Rita Kucera,** Nebraska DOT Procurement Specialist	Dec. 14th / 9:00am	• 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
Kyle Schneweis, Nebraska DOT Director **Moe Jamshidi**, Nebraska DOT Deputy Director, Operations **Tom Sands**, Nebraska DOT Operations Manager	Dec. 14th / 1:00pm	• Decision-making process • Procurement process • Data collection policy • Data sharing policy • Overall experience

2. Degree of AVL/GPS Implementation

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

2.1 AVL/GPS Project Background

NDOT had initially installed an AVL/GPS system on a few test vehicles for vehicle location tracking, prior to becoming involved with the Maintenance Decision Support System (MDSS) pooled fund study. Over time, additional AVL hardware was installed in NDOT vehicles. In 2009, NDOT procured approximately 100 AVL/GPS hardware units for installation in NDOT snow plows in seven of eight districts throughout the state. The installation included integration of the AVL/GPS equipment with the Iteris MDSS to provide treatment recommendations to NDOT District Supervisors and snow plow operators.

Problems were reported by some of the NDOT Districts with respect to the performance and reliability of the AVL hardware. Problems with respect to the accuracy of the winter weather forecasts and treatment recommendations through MDSS were reported as well.

Given the issues that were encountered, drivers and supervisors in some districts that had tried to use MDSS stopped using the AVL/GPS and MDSS systems altogether. The NDOT Districts that continued to use the system despite some of the early problems were District 2 (Omaha), District 6 (North Platte), and District 7 (McCook).

In 2014, NDOT followed a Systems Engineering process to determine how best to move forward with a new AVL/GPS system. This effort included interviews with NDOT Districts to review the past issues with the older AVL system, and determine what requirements could be developed for a new AVL/GPS system that might also include MDSS for treatment recommendations and vehicle dashcams for capturing vehicle images of roadway conditions.

NDOT released an RFP in April 2016 for the installation of an AVL/GPS system and vehicle dashcams in all NDOT Districts. The RFP also included providing a MDSS to NDOT Districts 2, 6, and 7 with flexibility for future expansion to all remaining NDOT districts.

2.2 Size of AVL/GPS Implementation

NDOT installed an AVL/GPS system prior to the 2016-2017 winter season. Approximately one-third of the fleet (about 225 vehicles) was equipped with the AVL System in 2016, and nearly all of the remaining vehicles had AVL hardware installed in 2017. Some of the older NDOT maintenance vehicles would be phased out in the near future. AVL hardware was not installed on those vehicles.

2.3 AVL/GPS Vendor Solution

The Parsons Team, led by Parsons with Iteris and other vendors, was hired by NDOT through a competitive process in 2016 to manage the installation of all AVL hardware, as well as to provide MDSS services. To address the AVL hardware installations, Parsons hired a local sub-contractor to travel through the state and perform the installation and integration of the hardware with existing spreader controllers, plow controllers, and air / pavement temperature sensors. Vehicle dashcams were also installed and integrated with the AVL hardware to provide still images of road conditions once every 60 seconds back to the AVL and MDSS software interfaces. NDOT's contract for AVL/MDSS system procurement, installation and integration was very similar to that of Michigan DOT.

3. Level of System Integration

3.1 Vehicle Hardware

The vehicle hardware component of the NDOT AVL/GPS system is the Parsons MDC-004 mobile data computer. The AVL/GPS system includes a touch screen in cab that can display weather radar images, locations of other trucks, MDSS treatment recommendations, material application rates, among others. An in-vehicle view of an NDOT snow plow equipped with the Parsons AVL/GPS system is shown in Figure 2. In new trucks, the mobile data computer hardware was mounted between the driver and passenger seat area behind the driver, as shown in Figure 3. Older trucks used different mounting locations. The hardware was installed so that wiring could be accessible to maintenance staff as needed from the passenger seat location.

Figure 2. NDOT Snow Plow In-Vehicle Equipment

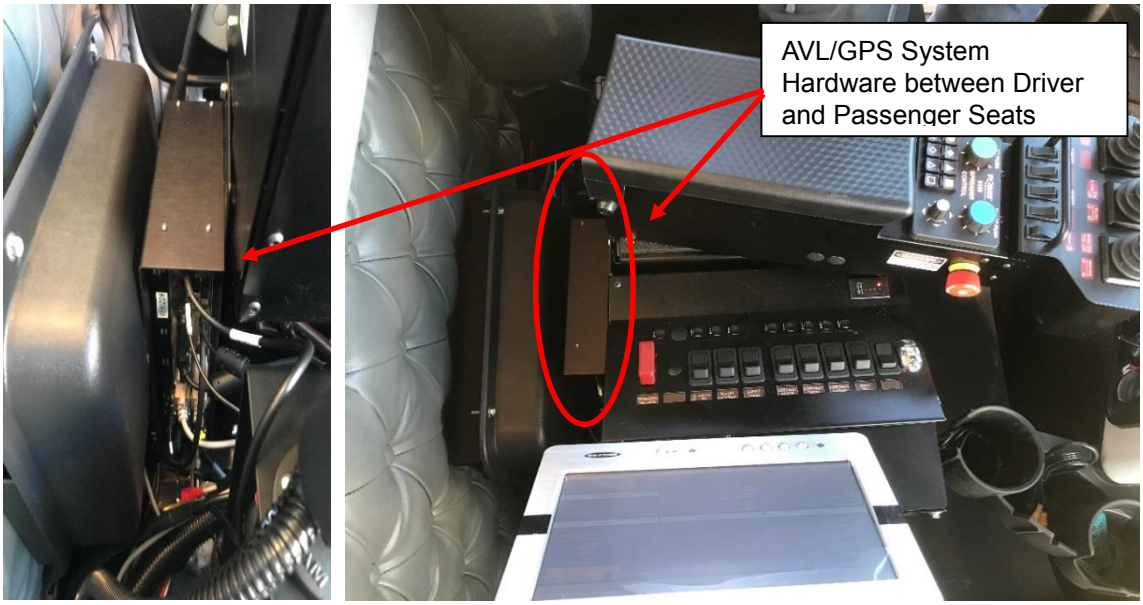


Figure 3. Location of NDOT AVL/GPS System Hardware

The mobile data computer screens are further illustrated in Figure 4 below. The main screen, as shown on the left in Figure 4, had the following options as large touch buttons: Device Settings, Camera, Diagnostics, Vehicle Data, and Change Password, with the Main Menu button at the bottom. The Vehicle Data screen, pictured at the right in Figure 4, shows data on spreader material and rate of application, weather conditions, and other vehicle characteristics on speed, direction, and vehicle location.

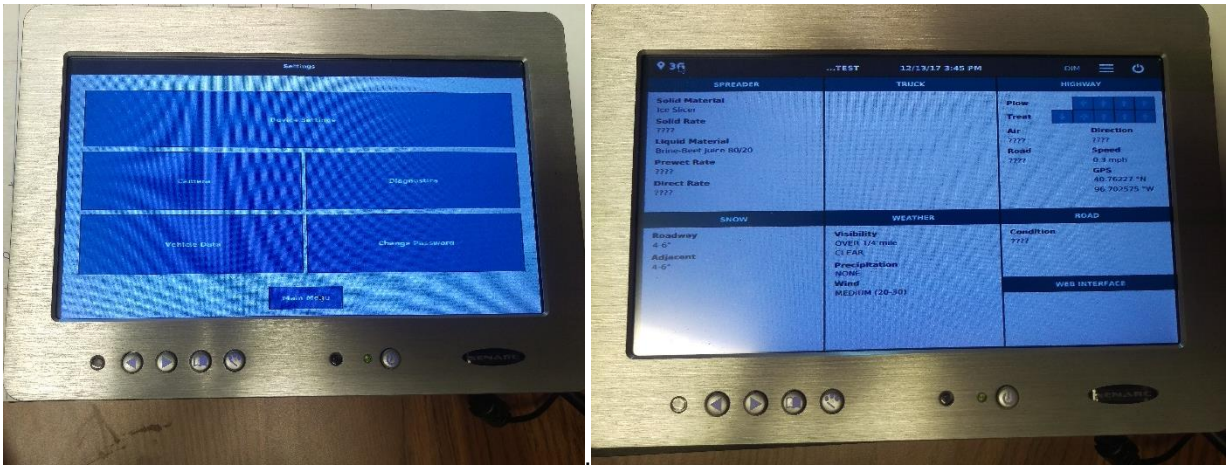


Figure 4. NDOT AVL System Touch Screen Images of Main Screen and Vehicle Data Screen

The AVL/GPS hardware was integrated with the following equipment and services:

- Spreader controllers
- Plow controllers
- RoadWatch pavement temperature sensors
- Front-facing vehicle dash-cams
- On-Board Diagnostics (OBD-II) port
- MDSS services

NDOT's winter maintenance trucks were not equipped with plow position sensors.

Spreader/plow controllers on NDOT's winter maintenance trucks were from various manufacturers, including: Force America, Certified Power, Cirus, Monroe and Raven. All spreader controllers were integrated with the AVL/GPS system with the exception of Monroe MC840 controllers which was no longer supported. An image of the Force America spreader controller interface is presented in Figure 5, with the material type and application rate presented in the upper left part of the screen. Force America controllers were readily integrated. Certified Power controllers required costly data conversion hardware and different settings for a variety of spreader types and firmware versions. It has proven to be very challenging to get consistent data from Certified Power controllers.

Figure 5. Force America Spreader Controller Screen in NDOT Snow Plow

Figure 6. NDOT Snow Plow Spreader Equipment and Spray Tank

NDOT has installed RoadWatch air and pavement temperature sensors and mounted them on the exterior of the vehicle with wires tied to side view mirror. Cabling is run through the vehicle and into the vehicle where it connects with the spreader controller. The AVL hardware then accepts temperatures through the spreader controller.

Figure 7. NDOT RoadWatch Air / Pavement Temperature Sensor Location on Plows

NDOT has also installed front-facing vehicle dashcams within the vehicle to capture images of road conditions for sending back through the AVL hardware for viewing by NDOT supervisors. The images are captured once per minute and communicated through the AVL hardware for viewing. NDOT uses Microsoft LifeCam Studio for the dashcams. Figure 8 illustrates a NDOT vehicle dashcam and its mounting location.

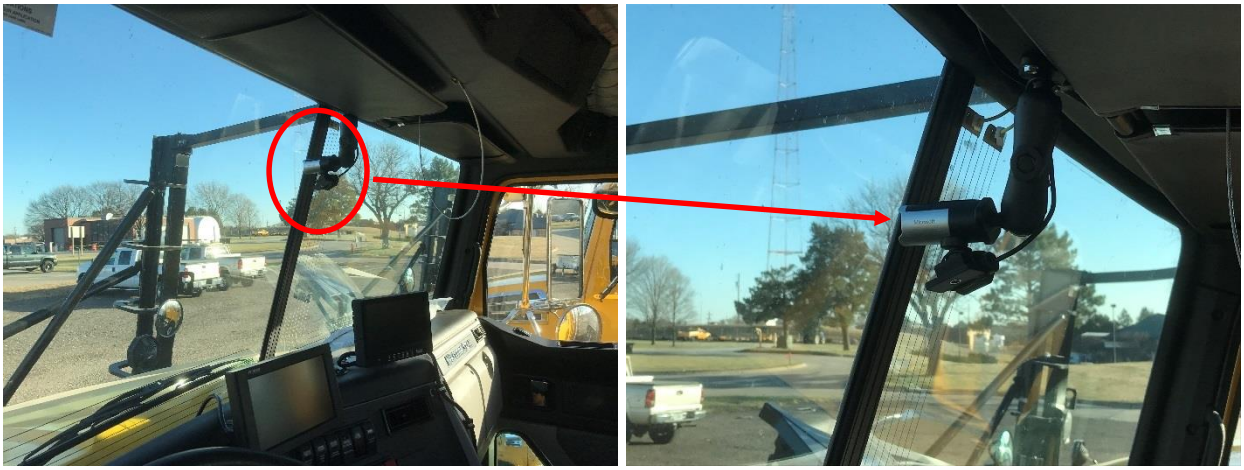


Figure 8. NDOT Snow Plow Dashcams

The AVL/GPS system has three antennae: GPS, cellular and Wi-Fi. The antennae are all combined into a single device pictured in Figure 9. The antennae were mounted above the cab on the heavy steel cab protector.

Figure 9. Location of NDOT AVL/GPS System Antennae on Snow Plow Vehicle

NDOT also integrated the AVL hardware with the snow plow vehicle's OBD-II port to gather vehicle diagnostic data, which allows pre-defined vehicle codes to be sent through the AVL system interface to alert NDOT staff of maintenance/repair needs on specific vehicles. The location of the connection is pictured in Figure 10.

Figure 10. Location of NDOT Snow Plow Vehicle Diagnostic Connection with AVL/GPS System

3.2 System Software

NDOT utilizes two separate software packages for the AVL/MDSS services: one for the AVL/GPS system provided by Parsons, and a separate software interface for MDSS provided by Iteris.

3.2.1 AVL/GPS System Software

The AVL software package, known as Parsons ATMS software, presents a map-based interface that allows NDOT staff to view the locations of snow plow vehicles. The interface allows for selecting specific vehicles on the map and viewing information about that specific vehicle.

The AVL software can generate automated reports that assist maintenance staff to identify when issues occur with the AVL hardware and vehicles. The reports can be custom-developed to provide alerts on

items of interest for maintenance staff, which can assist in preventative maintenance of the vehicles. Through the software, NDOT staff can use a filter to view snow plow vehicles at specific garages and then view the date and time stamps of specific data elements. The absence of any data in the software reported from a vehicle is often a quick way to identify loss of cellular coverage, antenna problems, or malfunctioning AVL hardware. NDOT maintenance staff can then review that specific vehicle and perform the needed repairs, or request assistance from the AVL vendor as needed if replacement parts are required.

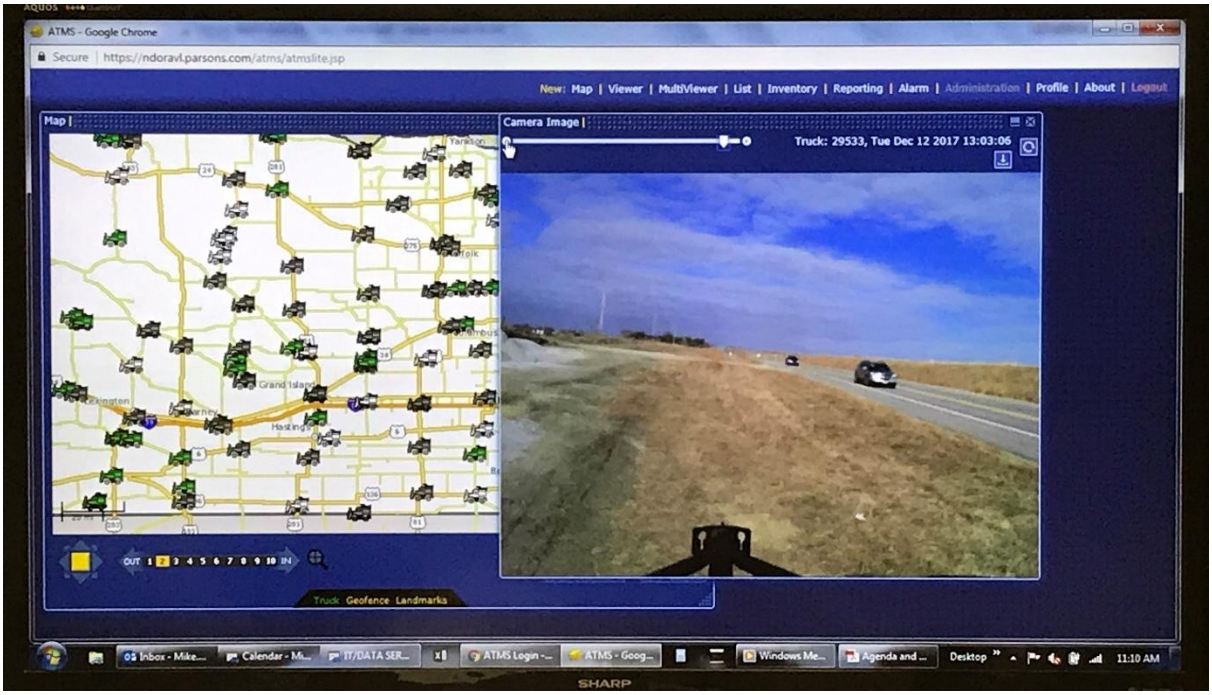


Figure 11. NDOT AVL/GPS System Software Interface

3.2.2 MDSS Software

The MDSS software interface provided by Iteris is used for monitoring weather forecasts and determining roadway treatment strategies in terms of times, locations, type and amount of material to use. Multiple types of alerts can be presented on weather, road conditions and blowing snow, along with winter maintenance treatment recommendations. The MDSS software interface can also be used to track and display vehicle locations and winter maintenance activities. Images from in-vehicle dashcams can also be viewed via the MDSS interface.

3.3 Vehicle-to-Center Communications Methods

NDOT's AVL/GPS system utilizes cellular communications. There are gaps in cellular coverage in parts of the rural areas. NDOT chose cellular carriers based on coverage by area with inputs from NDOT Districts. Cellular communications for the system is currently provided by three carriers, Verizon, Viaero, and US Cellular.

4. System Decision Making Processes

4.1 Level of Management Involved

Upon the initial pilot installation and utilization of AVL and MDSS systems in three NDOT districts (Districts 2, 6 and 7), NDOT Deputy Directors in Operations met with DOMMS from all districts to review the results and collectively decided to move forward with statewide implementation. The decision gained support from NDOT's Director.

In 2014, NDOT followed a Systems Engineering process to determine how best to move forward with a new AVL/GPS system. This effort included interviews with NDOT Districts to review the past issues with the older AVL system, and determine what requirements could be developed for a new AVL/GPS system that might also include MDSS treatment recommendations and vehicle dashcams for reporting vehicle images of roadway conditions. Upon completion of the Systems Engineering analysis, NDOT began the RFP development.

Given the potential challenges with managing multiple contractors/vendors for implementing and integrating various systems desired for the AVL and MDSS services, NDOT developed an RFP that requested one prime vendor to serve as a single point of contact for managing the installation of in-vehicle hardware (AVL/GPS and vehicle dashcams), the integration of the AVL/GPS system with other in-vehicle technology, and the provision of MDSS services.

4.2 Factors Considered

NDOT performed a Systems Engineering Analysis to identify needs and potential solutions to address those needs. High priority needs identified by NDOT District Operations and Maintenance Manager (DOMM) and other maintenance personnel included:

- An AVL system that is capable of:
  - Providing vehicle locations
  - Enables 2-way communications between supervisors and vehicle operators
  - Providing historical information for post-storm reviews
  - Being reliable in terms of operational uptime
  - Providing mobile access to users through mobile applications
- Dashcams that are capable of:
  - Capturing forward-looking snapshot images of driving conditions to check field conditions against weather reports
  - Sending snapshot images at least once every 5 minutes to a central server
  - Capturing accurate day-time and night-time images
  - Reporting location of camera image taken, the direction of travel and a timestamp
- A system that can provide real-time data report of application rates from spreaders
- A system that can capture historical application rates data from spreaders
- A system that can capture historical data of the amount of material used from spreaders
- A MDSS system that is capable of:
  - Providing treatment recommendations based on current air temperature, road temperatures, precipitation rate, wind speeds, previous maintenance actions transmitted by AVL hardware, operator road and weather condition reports, and the roadway level-of-service
  - Maintaining historical data on treatment recommendations for post-storm reviews

Those high priority needs formed the basis for the system requirements definition and RFP development.

5. Data Collection and Management

5.1 Data Collection

NDOT collects the following data through the AVL/GPS system installed in its vehicles:

- Vehicle locations, speeds and headings
- Material application rate
- Type of material applied
- Pavement and air temperatures
- Dashcam images
- Engine diagnostics, including engine hours, odometer, speedometer, RPM, coolant temperature, fuel level, trip fuel, oil pressure, battery voltage, engine error codes, and idle time

The data polling rates for the AVL/GPS and the MDSS software interfaces were every 1 minute and 2 minutes, respectively.

In terms of data storage and retention, NDOT stores AVL/GPS system and MDSS data for varying periods of time as noted below:

- Parsons keeps all AVL/GPS System data for the life of the contract with NDOT
- Two years of data archiving period upon request by NDOT to Parsons
- Two-weeks of AVL/GPS system data available for immediate access by NDOT staff through software interface
- Dashcam images are kept for a 24-hour period
- Iteris MDSS stores all data provided to MDSS, and NDOT has immediate access to the last 72 hours of data
- Per NDOT's request, MDSS can save data on large winter storms for a longer period than the last 72 hours (i.e. the life of the contract).

NDOT does not store data on its server and relies on vendor to provide data storage solution. NDOT felt the key benefit is saving NDOT resources for developing and maintaining a data storage system. The decision of saving dashcam images for no longer than 24 hours was to limit exposure of NDOT to tort claims.

5.2 Data Accuracy

The accuracy of spreader controller data was an issue for NDOT. NDOT noted that additional research would be desired to determine the data accuracy prior to NDOT reviewing and analyzing material usage reports. NDOT planned to compare material usage reports completed manually by snow plow drivers with the material usage data from the AVL/GPS system. NDOT noted that neither sources could be considered accurate until further research is completed.

As for MDSS, NDOT District Supervisors noted that they were responsible for data entry regarding roadway characteristics to allow MDSS algorithms to provide better and more accurate outputs related to treatment recommendations. These data entry inputs included daily traffic volumes, pavement types, and hours of operation for NDOT snow plow operators. NDOT noted the importance of such data entry as those inputs are factored into the type and amount of materials recommended as well as timing for roadway treatments through MDSS.

5.3 Staffing and Resources

NDOT relies on vendor to provide data storage solution for the AVL/GPS and MDSS systems. NDOT felt this arrangement provides NDOT savings on staffing and resources required to developing and maintaining a data management and storage system.

5.4 System Data Usage

NDOT's primary interaction with the system is through MDSS in which they can view the locations of the snow plow vehicles overlaid on the MDSS software interface. District supervisors also use Parsons AVL/GPS software interface to confirm AVL data was being downloaded to MDSS. NDOT district supervisors and crew chiefs noted the AVL system is helpful for resource identification and relocation which helps improving winter maintenance efficiency. Vehicle locations can be viewed on the touch screen inside the snow plow. Crew chiefs use the information to identify available resources and make adjustments to route assignments and/or maintenance strategies based on field conditions, forecast weather, recommended treatment, and progress of winter maintenance activities.

NDOT district supervisors also use the system data to check and monitor material application rates and usage. NDOT noted that the practice of using MDSS treatment recommendations varies by District. Some Districts were more receptive to the MDSS recommendations; while others still tended to use staff's own judgement. NDOT District 2 was one of the Districts more receptive to MDSS. Material application rates for the District 2 drivers were determined by maintenance supervisors. District 2 supervisors used a combination of the MDSS treatment recommendations and crew inputs to determine application rates.

Dashcam images are used by supervisors to observe field conditions. NDOT maintenance supervisors noted dashcam images were very helpful for observing field conditions, making winter maintenance decisions, and adjusting strategies.

In addition, weather radar information was displayed on the touch screens inside the vehicles. NDOT snow plow drivers noted the information was useful from drivers' perspective. It allowed drivers to observe storm paths and upcoming weather conditions, which helps them better understand winter maintenance instructions and decisions provided by supervisors.

NDOT supervisors have not utilized the vehicle diagnostics collected through the AVL/GPS system extensively, but they will monitor when vehicle codes were provided through the AVL/GPS software.

As for the potential use of the AVL system in the future, NDOT is considering the integration of backup cameras with on-board touchscreen display. NDOT would also consider using the AVL/GPS system that provides location and weather information for summer maintenance operations such as for striping, pavement sealing, etc. Other potential uses of the system included: providing coordinates of locations with problems (e.g. locations where snow fences are needed) and for asset inventory (e.g. locations of guardrails).

NDOT acknowledged that there were still many areas and potentials related to data utilization that NDOT has yet to explore and learn. NDOT envisions the use of data analytics in future years to compare the system's treatment recommendations for the winter season and various winter storms against manual reports completed by supervisors on material usage. This will provide a first real data point that NDOT can use to evaluate how the AVL/GPS and the MDSS systems have had an impact on material usage and overall operations efficiency. Additional winter seasons will also need to be evaluated to determine what effect the technology has on material usage. It was noted that the Winter Severity Index (WSI) would be used as a baseline to compare winter storms against one another, since some storms are more severe and require more material than others. NDOT also plan to include other performance measures, including staff resource usage, operations costs, consistency between treatments, etc.

NDOT envisions the AVL/GPS system data will be used to support operations strategies and resource allocation. The data will be able to help NDOT identify best practices and facilitate better discussion regarding winter maintenance. NDOT could also use the data to study optimal locations for salt storage/loading facilities and for route optimization.

5.5 Agency Policy and Agreements for Data Sharing

NDOT does not currently share the snow plow location information to the public. NDOT staff noted that the uncertainty regarding public interpretation of the vehicle locations has been the primary concern for not sharing the images. The concern includes potential questions that may come from the general public related to why NDOT has so many snow plows, or why some snow plows are not moving on the road, or why they are in garages during a snowstorm.

However, NDOT noted that they may share vehicle locations in real-time on the state 511 traffic information page along with vehicle dashcam images in the coming years to increase public transparency of winter maintenance operations. NDOT would like to look into restricting the reporting of images so that the general public does not see an image of the truck parked in a garage, or stopped at a location off the roadway. Another general concern raised was with respect to data storage and retention of vehicle dashcam images. The Iowa DOT was noted as a model to follow in the sharing of vehicle locations and images.

6. System Implementation Process

6.1 Implementation Steps

As noted earlier, NDOT followed a Systems Engineering process to determine how best to move forward with a new AVL/GPS system in 2014. NDOT maintenance staff from all districts were involved in the process to determine and prioritize designed system requirements. Upon completion of the Systems Engineering analysis, NDOT began the RFP development. The RFP was released in April 2016. NDOT then selected Parsons in May 2016 as the prime contractor to provide AVL/GPS hardware and manage Iteris as a sub-contractor responsible for providing the MDSS services.

NDOT noted that the arrangement of contractors worked very well for the project, and that they had received excellent support from Parsons and Iteris throughout the implementation. NDOT and Parsons had conference calls on a weekly basis from the beginning of the contract to ensure a smooth implementation and to identify and resolve any issues that might occur. About 225 snow plow vehicles were equipped for the 2016-2017 winter season, and since then, nearly all of the NDOT snow plow fleet (approx. 600 vehicles) have been equipped with AVL hardware and vehicle dashcams for the 2017-2018 winter season.

Installations of the AVL and other hardware were performed by a local contractor hired by Parsons. Parsons managed the installation schedule by coordinating with NDOT districts and the installation contractor and ensured all hardware and parts were ordered and in place prior to installation. The mounting location of the mobile data computer (MDC) unit of the AVL/GPS system was determined by the installation contractor with guidance from Parsons. NDOT did not experience any issues with the locations and mounting methods of the MDC units. Parsons was also responsible to work with spreader controller manufacturers to perform integration with the AVL/GPS system.

NDOT also received training from Parson and Iteris. Parsons provided training to NDOT maintenance mechanics so they had the knowledge to perform basic maintenance on the system. Parsons also provided training to snow plow operators for the operations of the AVL/GPS system. Training on the

AVL/GPS software interface was also provided, covering how to use the interface to view vehicles and their status, view vehicle history and bread crumbs, and use the reporting features.

Three levels of MDSS training were provided to NDOT by Iteris at the beginning of the implementation:

- The basic user training covered the principles of MDSS, weather forecast basic, pavement condition forecasting and modeling, AVL and camera image viewing, and how to use the MDSS software interface to view data.
- The supervisor training provided more detailed instructions on how to use the MDSS software interface and tools to generate, customize and view reports and how to use MDSS on mobile devices.
- The supervisor advanced training covering advanced MDSS software interface features, including paying back historical events, interpreting treatment recommendations, revising recommendations to fit local conditions, and comparing recommended treatment actions with reported maintenance actions.

In addition, Parsons and Iteris provide a two-hour refresher training to NDOT maintenance supervisors annually.

NDOT chose cellular carriers based on coverage by area with inputs from NDOT Districts. Cellular communications for the system is currently provided by three carriers, Verizon, Viaero, and US Cellular.

NDOT noted the importance of buy-in and support on AVL/GPS and MDSS systems from executive management at top levels of an agency. Without the support from top levels, agency employees at other levels would be less apt to buy-in to the system, which would negatively impact the credibility and proper use of the system. Support from NDOT Director and other executive management staff was key to the success of their AVL and MDSS implementation.

Given the negative experiences that some NDOT Districts had previously in utilizing MDSS and AVL systems, NDOT envisions a gradual rollout of the MDSS implementation to Districts 1, 3, 4, 5, and 8 in the coming years. NDOT has developed a working group that is composed of project champions from each NDOT District who have bought into the positive impact that the weather forecasts and treatment recommendations from MDSS can have on snow plow operations. Those project champions can then communicate the positive impacts with others in their own District that might be skeptical of the technology from their previous experiences. To further facilitate buy-in and smooth implementation, NDOT has requested that at least one vehicle within each District follow the MDSS treatment recommendations during the 2017-2018 winter season. Additional snow plow operators may be asked to follow the MDSS treatment recommendations in future winter seasons upon positive findings and feedback from field options. NDOT has witnessed the positive impact that this arrangement has had on the gradual buy-in from those NDOT Districts with respect to the AVL/GPS and MDSS systems.

6.2 Procurement Methods and Process

NDOT released an RFP in April 2016 that requested one prime vendor to serve as a single point of contact for managing the installation of an AVL/GPS system and vehicle dashcams on snow plows in all NDOT Districts, the integration of the AVL/GPS system with other in-vehicle technology, and for providing MDSS services to NDOT Districts 2, 6, and 7 with flexibility for future expansion to other NDOT districts.

The RFP for the turnkey procurement included a detailed scope of work and system requirements for vendor provided equipment, installation, MDSS system, integration, communications, data hosting/storage, warranty, testing, operations and maintenance, training, and deliverables. NDOT also included in the RFP that oral interviews, presentations and/or demonstrations might be conducted as part of the evaluation process.

As part of the RFP, unit prices were requested for the following project items:

- Vehicle AVL Hardware
- On-Board Camera (Vehicle Dash-Cam)
- AVL Spreader Controller Interface (Integration with Vehicle AVL Hardware)
- AVL Touchscreen Displays (for Districts 2, 6, and 7 only)
- Installation costs were requested separate, along with MDSS and AVL software licensing fees

NDOT noted that asking AVL system vendors to price items / system components individually and provide unit prices gives the DOT flexibility for equipment and service selections.

Ongoing services and hosting costs were requested for each year of the 5 year contract. Optional items and services which NDOT could choose to select in each contract year were also requested as part of the bid from contractors.

To ensure receiving quality products as well as services, the contract was bid as a professional services contract, as opposed to a low-bid procurement. The contract was for a period of five years with an option to renew for five additional one-year periods. Vendor proposals were evaluated on three areas

1. Corporate Overview – vendor's qualifications and past performance;
2. Technical Approach (Including Matrix; and
3. Cost Proposal Bid Sheet.

Evaluation criteria are listed in Table 2, and the cost proposal scoring method is shown in Table 3.

Table 2. NDOT AVL/GPS and MDSS Services RFP Evaluation Criteria

Evaluation Criteria	Possible Points
Part 1 — Corporate Overview	250
Part 2 — Technical Approach	1150
Part 3 — Cost Proposal Points	1000
Total Points without Demonstration	2400
Demonstration	1000
Total Points with Demonstration	3400

Table 3. Cost Proposal Scoring Method

Formula		Sample	Sample	Sample
	Lowest Cost Submitted	$100,000	$100,000	$100,000
÷	Cost Submitted	$100,000	$200,000	$150,000
x	Maximum Possible Cost Points	1000	1000	1000
=	Points To Award	1000	500	666.7

6.3 Procurement Documents

A copy of the scope of work included within the NDOT RFP is included as Appendix B.

7. System Benefits and Costs

7.1 Implementation Costs

Implementation costs associated with NDOT's AVL/GPS system have not shared by NDOT.

7.2 Costs for Operations and Maintenance

NDOT costs for operations and maintenance include monthly cellular costs for data transmissions from NDOT snow plow vehicles. Costs associated with operations and maintenance of the AVL system were not shared by NDOT.

7.3 Benefits

Given the system was implemented on approximately 225 snow plow vehicles prior to the 2015-2016 winter and additional 600 vehicles were implemented before the 2017-2018 winter, NDOT would have sufficient system data for the first time to conduct a quantitative evaluation of the system. NDOT envisioned the use of data analytics in coming years to capture and evaluate performance measures.

NDOT was especially interested in comparing material usage data based on the MDSS treatment recommendations against hand-written reports completed by NDOT District Supervisors. The comparisons would evaluate material usages for the entire winter season as well as for specific winter storms. The comparisons would provide a first real data point that NDOT can use to evaluate how the AVL/GPS and the MDSS systems have had an impact on material usage and overall operations efficiency. NDOT also planned to use the system data to generate and assess other performance measures, including: staff resource usage, operations costs, consistency between treatments, etc.

Benefits of the system as observed by field operations staff, particularly from maintenance supervisors and crew chiefs, are:

- The system provided increased situational awareness to winter maintenance staff. Supervisors and crew chiefs could obtain vehicle location information in real time, which helps in resource planning and allocation.
- Camera images provided road condition information from snow plow drivers' perspective, which provided additional information for supervisors' situational awareness.
- The system allowed the ability to check and monitor material application rates and types of material used.
- The MDSS treatment recommendations were especially helpful to less experienced drivers.

8. System Issues and Challenges

8.1 Institutional Issues

Due to the lack of interest in using AVL and MDSS systems in certain NDOT districts from prior experience, NDOT took a gradual rollout approach for the current AVL and MDSS systems implementation. Outreach to and buy-in from districts previously opposing the use of AVL and MDSS systems was critical for successful implementation and consistent use of the systems on a statewide basis. As discussed in Section 6.1, NDOT has developed a working group with champions from each district to perform outreach and facilitate buy-in. NDOT has witnessed positive changes in winter maintenance culture in NDOT districts.

NDOT noted there were “big-brother” concerns during the initial deployment of the AVL system. NDOT snow plow operators from Districts 1 and 2 noted that these concerns gradually went away when drivers realized that the AVL system was not being used in a disciplinary manner.

8.2 Technology Issues

One of the main implementation challenges for NDOT was the integration of multiple brands of spreader controllers with the AVL hardware. NDOT snow plows were equipped with spreader controller from five different manufacturers: Force America, Certified Power, Cirus, Monroe and Raven. Some spreader controllers were no longer supported by the manufacturer that had provided them to NDOT, and some manufacturers could not provide the necessary support to assist in understanding how best to perform the integration of the spreader controllers with the Parsons AVL hardware.

Specifically, the integration with Force America controllers worked well. Certified Power GL400 controllers were older technology and were challenging to integrate. Customer service support was somewhat lacking as well. NDOT had about 40 trucks with Monroe controllers. The equipment was five years old and support has been discontinued. NDOT ended up replacing them with Force America controllers. In addition, NDOT had a smaller number of Raven controllers. Those controllers were about 15 years old and would likely be retired in the near future. As such, NDOT did not test out the integration on those controllers.

Another issue encountered was manufacturers had provided incorrect information on software version of controller boxes and chips. Parsons noted that a “Plug-and-Play” standard for communications and data exchange between an AVL/GPS system and other devices would be desired and could benefit all winter operations agencies.

Another issue experienced by NDOT was the low-band radio interference caused by MDCs. The issue was resolved by changing circuitry of the MDC board. However, signal-to-noise ratio was still an issue that reduced FM radio reception, and drivers were generally not happy about it. NDOT performed an informal, non-standard test and found signal degradation in some frequencies. This issue has not been resolved.

8.3 Procurement and Implementation Issues

8.3.1 Procurement Issues

NDOT did not experience any procurement issues and felt the contract organization and procurement process made the implementation smooth. NDOT noted that the potential challenges with the integration of an AVL system with multiple brands of spreader controllers were identified and considered in the RFP development process. The RFP for the AVL and MDSS procurement was written to ensure the selected

prime contractor would have ultimate responsibilities for resolving any issues and challenges encountered.

8.3.2 Implementation Issues

NDOT felt the implementation went rather smoothly. In addition to the challenges associated with the integration between the AVL system and multiple brands of spreader controllers, a main challenge encountered was scheduling for system installation. The installation contractor had challenges coordinating with NDOT districts to schedule for installation initially. Parsons stepped up and proactively engaging NDOT districts and installation contractor for schedule coordination. Parsons provided detailed schedule and equipment information to facilitate scheduling of installation and helped NDOT better understand the scope of the installation. Parsons also sent out reminders to NDOT districts prior to installation to ensure vehicle availability. The effort helped improve scheduling and getting system installed as planned.

8.4 Operations and Maintenance Issues

NDOT staff noted that the size of the touch screen buttons and the responsiveness of the buttons to touch were issues. Sometimes multiple touches would be needed to navigate the various portions of the interface. In some screens, the touch screen buttons were large enough, but in others, they were much smaller, making it difficult sometimes for drivers to use the system reliably during their vehicle shifts.

NDOT maintenance staff also shared a concern related to the in-vehicle dashcam that is used to capture images once every 60 seconds. In some instances, an image may appear to show that the vehicle was stopped at a location, when the vehicle was turning around on their plow route. The general concern was that these images might be questioned by maintenance supervisors if they felt it was necessary to be addressed with the drivers.

NDOT noted the cellular network for the AVL system covered most of the maintenance area with acceptable gaps. Substantial coverage gaps exist in NDOT District 5 which is located in the panhandle area in the western part of Nebraska.

9. Lessons Learned

Lessons learned gathered from the NDOT case study are presented below.

- Support from top level executives is critical.
- It is important to know how DOT intends to use the technology. Requirements and specifications should be developed based on needs identified by DOT winter maintenance staff.
- Requirements and specifications development takes time and should start with a systems engineering analysis. Taking time to engage district staff to understand their needs and go through systems engineering helps develop a better scope, which promotes project success.
- The RFP needs to clearly state the DOT's expectations of all aspects of the project, particularly related to integration of AVL and spreader controllers.
- Pilot projects help identify issues and opportunities.
- The turnkey contract mechanism reduces the needs for DOT resources for equipment installation, integration, and managing multiple vendors/manufacturers. The prime contractor will be the single point of contact for DOT and responsible for all issues.

- Including warranty in the contract is important.
- Expectations should be communicated to district winter maintenance staff well in advance and throughout the project.
- It is more effective having DOT winter maintenance staff to communicate benefits of the system to their peers. Similar communication from vendors may be viewed as sales pitches by DOT maintenance staff.
- A phased implementation may work well if some districts or maintenance areas are not ready to adopt the technology.
- Additional research is needed to improve the accuracy of spreader controller data gathered through spreader controllers and the AVL system.
- AVL/GPS implementation along with MDSS will bring major cultural changes to operational staff. It is important to identify the right people as champions, along with support from DOT management to support outreach, training and communication.

Appendix A Survey Response

Name	Title	Agency	Phone	Email
Mike Mattison	**Engineer IV**	**Nebraska Department of Roads**	**402-479-4878**	**mike.mattison@nebraska.gov**
AVL/GPS System				
1.Are you currently using an AVL/GPS system to automatically collect data for your winter maintenance operations?			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:			One third (225) of our plow truck fleet were equipped with AVL/GPS in the last 8 months. We intend to install AVL/GPS in all remaining plow trucks by before the next winter season.	
3.Approximately how many vehicles are in your winter maintenance fleet?			675	
4.How many of your winter maintenance vehicles are equipped with AVL/GPS technology?			225	
5.Who is your contracted AVL / GPS vendor?			Parsons	
6.What modem / GPS brand(s) does your agency utilize?			Parsons	
7. Who performed the installation of your AVL/GPS system? Was it the system vendor or DOT agency staff?			System Vendor subcontracted with in-state radio installers.	
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?			Third party	
9.Were there any issues with the installation of your AVL/GPS system?			No	
If yes, please describe:			Connection to spreader controller required additional hardware from controller manufacturers. Low-band two way radio transmit caused AVL/GPS to reboot/temporarily quit working. These problems are being addressed by the vendor.	
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			Yes	
Plow controller			Yes	
Plow position sensor			No	
Mobile data terminal/computer			Yes	
Pavement temperature sensor			Yes	
Air temperature sensor			Yes	
Humidity Sensor			No	
Dashcam			Yes	
Other (describe below)			Yes	
If you indicated "Other" in the question above, please describe below.			OBDII port (engine diagnostics) from truck is connected to the AVL/GPS.	

Name	Title	Agency	Phone	Email
Mike Mattison	**Engineer IV**	**Nebraska Department of Roads**	**402-479-4878**	**mike.mattison@nebraska.gov**
11.Have you experienced difficulty integrating above equipment or sensors into your AVL/GPS system? If so, please describe.			Spreader/Plow controller required additional hardware from controller manufacturer. Monroe MC840 controllers will not connect and are no longer supported.	
12.What brand(s) of spreader controller does your agency use?			Force America, Certified Power, Monroe, Cirrus, Raven	
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			Less than 1 min.	
Type of material applied			Less than 1 min.	
Mobile data terminal messages			Less than 1 min.	
Pavement temperature			Less than 1 min.	
Air temperature			Less than 1 min.	
Humidity			Not captured	
Surface friction			Not captured	
Dashcam			Less than 1 min.	
Engine diagnostics			Less than 1 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?			Third Party server	
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			No	
Material usage tracking and analysis			Yes	
Treatment recommendations			Yes	
Providing data to a maintenance decision support system (MDSS)			Yes	
Operational analysis, evaluation and performance reporting			Yes	
Collection of vehicle diagnostic data			Yes	
Sharing of vehicle location through agency traveler information webpage			No	
Road weather condition reporting			Yes	
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.)?			only observation at this time	
17.Does your agency share AVL system data externally with other public agencies?			No	

Name	Title	Agency	Phone	Email
Mike Mattison	**Engineer IV**	**Nebraska Department of Roads**	**402-479-4878**	**mike.mattison@nebraska.gov**
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?			No	
Communications				
20.What type of communications does your AVL/GPS system use to transfer data? Please check all that apply.			Cellular network, Hardware is wi-fi enabled, but we are not using it at this time.	
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?			Both	
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?			Vehicle location, material application rate, and camera images are used to evaluate maintenance practices and results relative to weather and road conditions.	
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?			Yes	
If yes, please describe how the data is utilized by your agency.			Vehicle location, material application rate, and camera images are used to evaluate maintenance practices and results relative to weather and road conditions.	
26.What was the procurement process used for your AVL/GPS system (i.e. Request for Proposals (RFP), Invitation for Bids (IFB))?			Request for Proposals (RFP)	
Was a demonstration of the system included as part of the evaluation of respondents?			Yes	
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?			Yes	
29.What cost information would you be able to provide?				
		AVL equipment costs	Yes	
		Installation & integration costs	Yes	

Name	Title	Agency	Phone	Email
Mike Mattison	**Engineer IV**	**Nebraska Department of Roads**	**402-479-4878**	**mike.mattison@nebraska.gov**
Costs associated with on-going operations (staffing, communications, software licensing,			Yes	
Maintenance costs			Yes	
Other costs, please describe			No	
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.			It is important to know how you intend to use the technology and what your needs are before writing specifications. Operators and managers should be informed well in advance and throughout the project what the expectations are. Problems should be addressed as quickly as possible. If possible do a pilot project in advance to identify issues and opportunities. Be open to possibilities for additional use of the technology. Look for all of the value that you can get. Learn from the experience of your peers in other organizations.	
32.May we contact you with follow-up questions about your system(s)?			Yes	

Appendix B Excerpts from the NDOT Scope of Work in 2016 RFP Document

IV. PROJECT DESCRIPTION AND SCOPE OF WORK

The bidder must provide the following information in response to this Request for Proposal.

A. PROJECT OVERVIEW

The State of Nebraska, Department of Roads (NDOR), is issuing this Request for Proposal, RFP Number R69-16 for the purpose of selecting a qualified Contractor to provide a Maintenance Decision Support System (MDSS) and Automatic Vehicle Location (AVL) System & Services, thereby upgrading winter maintenance vehicle operations throughout the eight (8) districts within the NDOR. The MDSS and AVL Systems proposed must meet the requirements defined in this RFP document. It is the expectation of the NDOR that full implementation/installation of the MDSS and AVL Systems shall be complete by October 15, 2016.

B. SOLUTION TYPE

NDOR will be accepting proposals for the following solution types:

1) Existing System built for another client that can be transferred and modified to support the primary objectives; or
2) Commercial Off-The-Shelf Solutions that can be configured, modified, or enhanced to support the primary objectives.

C. SOLUTION HOSTING

NDOR will be accepting proposals for Contractor hosted solutions for which the proposed solution's application hardware and infrastructure would be owned and maintained by the Contractor.

D. PROJECT OBJECTIVES

It is the objective of the NDOR to improve the efficiency of roadway winter maintenance operations through the deployment of the following MDSS applications:

1) ***Automated Vehicle Locator (AVL) System*** – Provides the position and other information from AVL-equipped winter maintenance vehicles in the field for viewing by NDOR staff. Location and other data shall be viewable in the office within five (5) minutes of the time it is generated in the vehicle.

2) ***Vehicle Camera*** – A forward-facing camera on the NDOR winter maintenance vehicles to provide a snapshot image and live video feed of road and weather conditions as they appear to drivers.

3) ***Application Rate*** – Communicates vehicle spreader application rates to a MDSS/AVL Server package for review by NDOR staff. The tool will allow users in the office to view current and historical application rate data via an MDSS/AVL Server package.

4) ***Weather/Pavement Conditions & Forecast*** – Communicates current and forecasted weather/pavement conditions for specific geographic areas and highway segments.

5) ***Desktop (GUI), Web-Based (WUI), and Mobile Applications –*** All of the MDSS data including that listed above in 1, 2, 3, and 4 will be displayed in views that clearly convey the information to NDOR staff. The detail may vary to accommodate the screen size available.

6) ***Treatment Recommendations*** – Treatment recommendations will be required for Districts 2, 6, and 7 with an estimated 150 routes within Districts 2, 6 & 7. However, the overall solution shall allow for future expansion to include an estimated 250 additional routes that may be added in subsequent years within the remaining districts. Recommended maintenance actions based on weather and pavement forecasts using current real-time weather data collected from roadside stations, airport weather stations, vehicle sensors, and other available sources of weather information. Recommendations will be customized for individual route segments based on current and forecasted pavement conditions and specified Level of Service. Current data shall be defined as within no more than fifteen (15) minutes of data collected by vehicle AVL and RWIS, and at least as frequent as updates are provided by the National Weather Service.

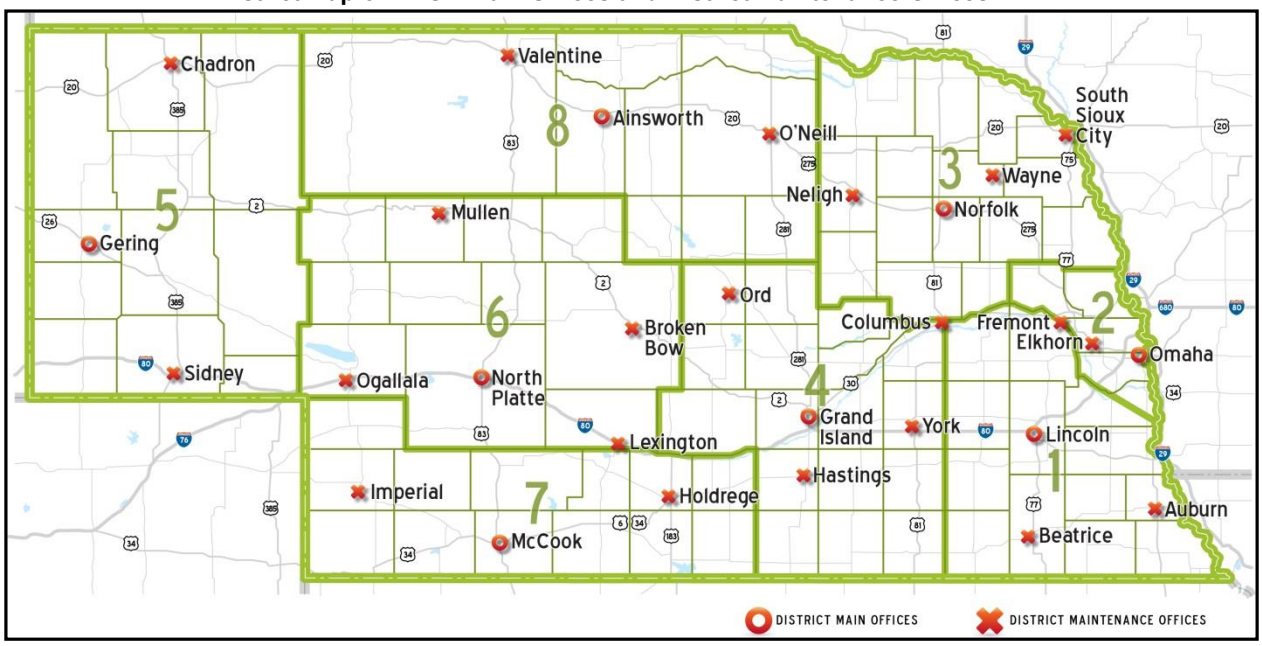
7) ***Vehicle Touchscreen Display*** – Vehicle Touchscreen Displays will be required for Districts 2, 6, and 7 with an estimated 150 displays within Districts 2, 6 & 7. However, the overall solution shall allow for future expansion to include additional displays that may be added in subsequent years within the remaining districts. Selected vehicles will be equipped with touchscreen displays that provide relevant information to operators and the ability to transmit information to the MDSS server. Touchscreen displays

will be disabled when the vehicle is in motion. Touchscreen display shall include ability to view treatment recommendations.

E. PROJECT ENVIRONMENT

There are eight (8) NDOR districts that manage winter highway maintenance. Districts may have different approaches to winter highway maintenance to fit the varying weather patterns, traffic levels, materials availability, and other factors.

District Map of NDOR Main Offices and District Maintenance Offices



F. SCOPE OF WORK

This section provides an overview of the various means by which the winter maintenance tools and MDSS applications will be installed for NDOR District staff. AVL hardware and cameras will be installed in approximately 650 winter maintenance vehicles across the state of Nebraska. *It is the expectation of the NDOR that full implementation/installation of the MDSS and AVL Systems shall be complete by October 15, 2016.*

Vehicle AVL hardware will include communications equipment that enables communication of data between vehicles and the MDSS/AVL Server. Additional equipment will also include forward-facing vehicle cameras for the purpose of capturing still images of driving conditions. Images will be captured and transmitted once every minute to be viewable by NDOR staff. Cameras will be capable of producing clear, well defined images captured in daylight as well as night conditions illuminated by vehicle headlights.

In the Districts that have chosen to receive treatment recommendations, NDOR staff must be able to view the recommendations from the AVL touchscreen in the winter maintenance vehicle, MDSS Graphical User Interface (GUI), Web User Interface (WUI), and Mobile Applications. The recommendations must account for the past and future events that affect the treatment needed to achieve the specified level of service. The recommendations are to be based on current and forecasted conditions and the specified level of service for the route.

A GUI, WUI, and Mobile Applications shall provide NDOR personnel with information including weather forecasts, pavement forecasts, current conditions, camera images, AVL data, reports, and treatment recommendations. These user interfaces will offer GIS map views that show all of the data in user configurable views.

NDOR has utilized the ITS Systems Engineering process in planning for the deployment of AVL and MDSS operations. Figure 1 below contains the Concept of Operations and System Requirements developed for winter operations. The Contractor shall complete the following work tasks under the direction of the NDOR

Project Manager. Contractor shall refer to Figure 1 which contains the system requirements for the equipment requested herein.

Figure 1 – Full System Winter Maintenance Tools and MDSS Applications

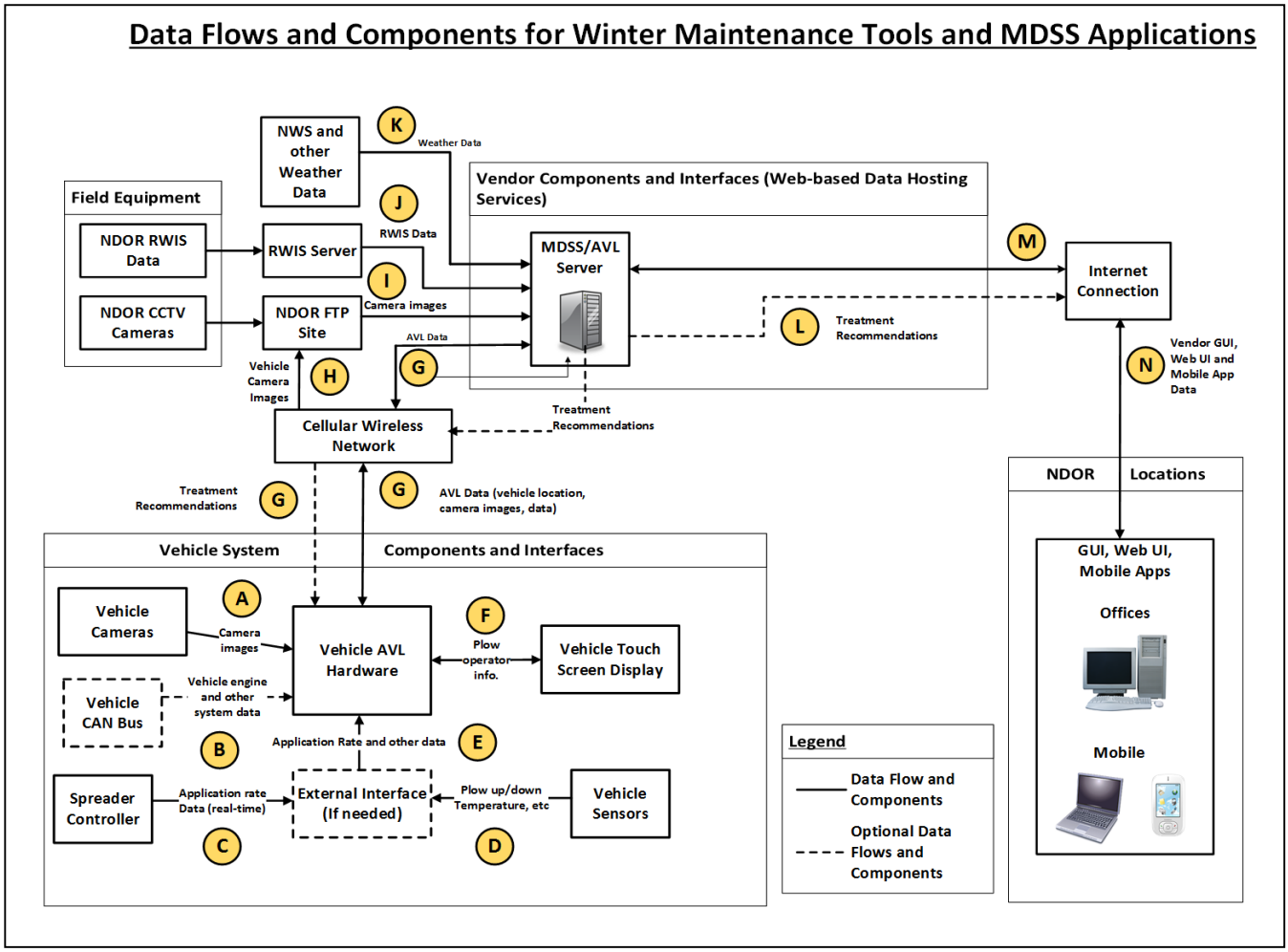


TABLE 1 – SYSTEM COMPONENT DEFINITIONS

System Component	Component Definition
Contractor-Provided Equipment	
Vehicle Cameras	Cameras installed in the vehicle to capture forward-looking images of roads during day and night-time conditions.
Vehicle AVL Hardware	Hardware that contains GPS technology and other integrated functions (i.e. cellular modem) to support vehicle location and other data reporting.
Vehicle Touchscreen Display	Touchscreen display within the vehicle that is used by operators to monitor current conditions, display recommendations, and communicate information to the MDSS/AVL Server on maintenance operations and conditions.
MDSS/AVL Server	A computer system operated and maintained by AVL system / MDSS Contractor(s)
Contractor GUI for NDOR	Graphical User Interface (GUI) that presents the MDSS and AVL information to NDOR personnel.
Cellular Wireless Network	Cellular wireless network utilized by vehicle AVL hardware to communicate information to the MDSS/AVL Server. NDOR will determine the network(s) to be utilized by Contractor(s) on the project.
Existing NDOR Winter Maintenance Vehicle Equipment	

Vehicle CAN Bus	On-board vehicle system that connects sensors and vehicle hardware
Spreader Controller	Existing spreader controllers on NDOR winter maintenance vehicles
Snow Plow	Existing snow plow equipment on NDOR winter maintenance vehicles
Vehicle Sensors	Various vehicle sensors on NDOR winter maintenance vehicles
Existing NDOR Equipment and Data	
NDOR RWIS	NDOR's Road / Weather Information Systems (RWIS) field equipment that gathers environmental data from fixed locations.
NDOR CCTV Cameras	CCTV cameras at fixed locations that are used by NDOR to monitor road and weather conditions.
AWOS	Airport Weather Observation Systems (AWOS) field equipment installed at airports to gather environmental data from fixed locations.
NDOR FTP Site	FTP site used by NDOR to store images from NDOR CCTV Cameras communicated from the field. FTP site will also need to receive and store images from vehicle cameras.
RWIS Server	A private company that manages RWIS Data communicated from fixed locations in the field.
NDOR Staff	NDOR personnel that will access the MDSS UI through an internet connection.

TABLE 2 –VEHICLE SYSTEM COMPONENTS AND INTERFACES

Label	Path Name	From	To	Description
A	Camera Images	Vehicle Cameras	Vehicle AVL Hardware	This represents the flow of images captured by forward-facing vehicle cameras and communicated through vehicle AVL hardware. Note that vehicle AVL hardware will require cellular modem to transmit images at one (1) minute intervals. Cameras will interface with vehicle AVL hardware via cable interface to be determined by Contractor.
B	Plow Operator Information	Vehicle AVL Hardware	Vehicle Touch Screen Display	This represents the flow of information gathered from the vehicle AVL hardware and presented on the Vehicle Touchscreen Display for winter maintenance vehicle operators to view in real-time. Vehicle AVL hardware will connect with Vehicle Touchscreen Display via cable interface to be determined by Contractor.
C	Requests for Data	Vehicle AVL Hardware	MDSS/AVL Server	This represents the communication of all data gathered by the vehicle AVL hardware (location, camera images, application rate, and others) to the MDSS/AVL Server. Vehicle AVL hardware will require cellular modem to transmit data in real-time.
D	Weather Data	NDOR RWIS	MDSS/AVL Server	This represents the sending of data from NDOR RWIS equipment directly to MDSS/AVL Server. Input from RWIS equipment will be displayed within GUI and also used to support treatment recommendations for NDOR Districts that choose to utilize them in winter maintenance operations.
G	Material Usage Data (Real-time)	Spreader Controller	AVL Hardware	This represents the flow of data to enable the measurement of application rates by NDOR District Staff. Spreader controller equipment will connect to the vehicle AVL hardware in a consistent format.
H	Vehicle Sensors	Vehicle	Vehicle CAN Bus or External Interface	This represents the optional flow of data to enable NDOR District Staff to monitor the status of sensors, including which will either be "up" or "down". Winter maintenance vehicle equipment will connect to the vehicle CAN Bus or external interface so that data could be communicated to the vehicle AVL hardware in a consistent format.
I	Weather Sensor Data (Real-time)	Vehicle Sensors	Vehicle CAN Bus or External Interface	This represents the optional flow of data to enable communication of weather data from the vehicle which will be an input into a treatment recommendations application. Weather sensors will connect to the vehicle CAN Bus or external interface so that data could be communicated to the vehicle AVL hardware in a consistent format.
J	Vehicle Status Info. (Real-time)	Vehicle CAN Bus or External Interface	Vehicle AVL Hardware	This represents the flow of all controller spreader, plow up/down or vehicle sensor data to the Vehicle AVL Hardware from the vehicle CAN bus or external interface. This enables the vehicle AVL hardware to communicate the various vehicle data in a consistent format that can be reported and logged by the MDSS/AVL Server.

G. INSTALLATION REQUIREMENTS

It is the expectation of the NDOR that full implementation/installation of the MDSS and AVL Systems shall be complete by October 15, 2016. NDOR is composed of eight (8) districts. Exhibit A lists all locations, contacts, and equipment that will have AVL's and cameras installed. Installation locations are split into Superintendent areas; however, if needed, additional installation locations may be chosen by mutual agreement by NDOR and the Contractor.

1. NDOR will be responsible for and provide:
   - **a.** The vehicles requiring installation will be at the specified location on a schedule arranged with the installer;
   - **b.** A heated indoor work bay, electrical power as needed, a table or bench for set up and placement of tools and equipment;
   - **c.** A checklist of essential installation procedures;
   - **d.** Contact information for arranging installation dates and times, and for questions related to the installation; and
   - **e.** Prompt inspection of finished installation, and notification to Contractor of any non-compliance that requires rework.

2. Contractor shall be responsible for and provide as part of their bid price, the following, at no additional cost to the Nebraska Department of Roads:
   - **f.** Labor and miscellaneous materials required to install AVL systems and cameras in compliance with the standard installation procedure;
   - **g.** Tools, instruments, and necessary equipment required to perform the installation;
   - **h.** Travel to and from the installation locations, to include lodging if needed;
   - **i.** Completed checklist and certification of installation according to standard procedures; and
   - **j.** Prompt rework of any noncompliance with the standard procedure.

H. MDSS SYSTEM REQUIREMENTS

The system requirements describe what the proposed winter operations solutions will do and how the various subsystems will function. These will primarily describe the functional capabilities of the proposed systems and how the subsystems will function. These requirements set the technical scope of the system to be built and serve as the basis for later verifying the installed systems meet the specified requirements.

System requirements are verifiable details that define what the MDSS applications will do when deployed in the field. They address either functional or performance / operational aspects of the MDSS applications.

Functional requirements are divided into two general categories: 1) Vehicle System Components and Interfaces, and 2) MDSS/AVL Components and Interfaces. These interfaces are illustrated within Figure 1 of this document.

1. VEHICLE SYSTEM COMPONENTS AND INTERFACES (1.0)

The Nebraska Department of Roads is requesting approximately 650 AVL system units to be installed in winter maintenance vehicles across the State. Contractor shall provide a fully functioning AVL system, to include, but not limited to: hardware, firmware, software, data collection, storage, transfer, manipulation, display and any other items relevant to the functionality of the system. All necessary materials for satisfactory performance of the AVL system shall be incorporated, including regularly advertised equipment/accessories as part of the equipment bid, whether or not they may be specifically mentioned. All equipment and accessories purchased will become property of the NDOR.

Contractor shall furnish and install vehicle system components and interfaces in approximately 650 NDOR winter maintenance vehicles as illustrated in Figure 1, according to Attachment A, and described in herein.

The vehicle hardware on NDOR winter maintenance vehicles must interface with other existing and planned on-board equipment to enable the successful operation of the MDSS applications described in this document. Table 1 defines the flows of information between vehicle components.

1.1 Automatic Vehicle Location (AVL) System

1.1.1 The AVL system shall allow district maintenance dispatchers the ability to locate the real-time position of AVL equipped winter maintenance vehicles in the field.

1.2 Hardware

1.2.1 Contractor shall include all necessary hardware and system requirements necessary to optimally effect the proposed solution.

1.2.2 Hardware shall include GPS technology and other integrated functions (i.e. cellular modem) to support vehicle location and other data reporting.

k. GPS

l. Communications

m. Data Interface

n. Touchscreen Display

1.3 Software

1.3.1 Contractor shall include any and all software required to properly operate the equipment and transfer the video from the device to a secure web location using an internet connected computer.

1.3.2 The Contractor shall maintain any and all software used in the functionality of the AVL system, at no additional cost to the NDOR.

1.3.3 Software versions and/or updates shall not prevent NDOR from using any functions, in whole or in part, or cause deficiencies or defects in the software within the system.

1.4 Vehicle Cameras

1.4.1 Vehicle cameras shall be forward facing cameras installed inside NDOR winter maintenance vehicles which would provide a snapshot image and live video feed of road and weather conditions as they appear to drivers.

1.4.2 Cameras must be capable of producing clear, well defined images captured in daylight, as well as night conditions illuminated by vehicle headlights.

1.4.3 NDOR will require camera images from trucks to be sent to an existing FTP site where existing fixed CCTV cameras currently send their images.

1.4.4 Images could be made available by NDOR on a webpage, or integrated into an existing webpage such as the NDOR511 page.

1.4.5 The general public would be able to access the images through an internet connection.

1.4.6 Integration with AVL Equipment:

a. Vehicle cameras shall take snapshot images as instructed by the vehicle hardware.
b. Vehicle cameras shal integrate with vehicle hardware for the purpose of sending images through vehicle hardware to a central database or other NDOR websites.
c. Vehicle cameras shall be able to send camera images taken at least once every minute via connection to vehicle hardware.
d. Vehicle cameras shall be configurable to send images less often as desired by NDOR staff.
e. Vehicle cameras shall be capable of streaming video.

1.4.7 Camera Functional Requirements:

a. Cameras shall be forward facing cameras, mounted to capture a forward looking image from the vehicle with no sight of the exterior vehicle hood or the top roof of the vehicle in the images captured. *Cameras shall be mounted in a manner as to not interfere with driver visibility.*
b. Cameras shall have a minimum 2 megapixel resolution.
c. Camera shall take snapshot images that have a minimum resolution of 640×480 pixels per file image.
d. Vehicle cameras shall capture images of roadway conditions in both daytime (light) and nighttime (dark) conditions.
   - Low light capability shall be minimum: 0.05 lux Color; 0.005 lux B&W.
   - May switch to B&W in low light to meet performance criteria.
e. Must be capable of capturing still view of roadway sufficiently clear to read a standard STOP sign at 250’ by day and 150’ at night lit by truck headlights only.
f. Cameras shall integrate with GPS in vehicle hardware and indicate the location of the image in the transmitted metadata.
g. Camera must be capable of streaming live video; streaming at not less than 1024x768 resolution.

1.5 Equipment Requirements

1.5.1 Equipment and accessories bid shall be of the latest manufacture in production as of the date of the RFP and be of proven performance and under standard design, complete as regularly advertised and marketed. All necessary materials for satisfactory performance of the video traffic data equipment shall be incorporated whether or not they may be specifically mentioned below.

1.5.2 Complete specifications, manufacturer’s descriptive literature and/or advertising data sheets with cuts or photographs may be required prior to an award and should be included with the bid on the

IDENTICAL items proposed. Literature should be complete and the latest published. Any information necessary to show compliance with these specifications not given on the manufacturer's descriptive literature and/or advertising data sheets should be supplied in writing on or attached to the bid document. If manufacturer's specifications sheets, descriptive literature, advertising data sheets or information necessary to show compliance with these specifications is not supplied in writing on or attached to the bid document, the bidder will be required to submit requested information within three (3) business days of a written request. Failure to submit requested descriptive literature or advertising data sheets may be grounds to reject the bid.

1.6 Gray Market Product Prohibition

1.6.1 The NDOR will not accept Gray Market Products for this solicitation. Gray Market is defined as the trade of a commodity through distribution channels which, while legal, are unofficial, unauthorized, or unintended by the original manufacturer. Gray Market items are not designed to be sold in a particular market and cannot be supported by the authorized importer because of various reasons. *Industries Regulation Act, Chapter 60, Article 14.*

1.7 Substitutions

1.7.1 Contractor will not substitute any item that has been awarded without prior written approval of the NDOR.

2. VEHICLE SUB-SYSTEM COMPONENT REQUIREMENTS (2.0)

2.1 Vehicle Hardware

2.1.1 Vehicle hardware shall include a GPS receiver that is accurate to within 2 meters for the purposes of vehicle location tracking.
2.1.2 Vehicle hardware shall include a cellular modem for communication of all data received by vehicle hardware inside the vehicle to MDSS/AVL Server.
2.1.3 Vehicle hardware shall be capable of storing 12 hours or 1 GB, whichever is greater, of information.
2.1.4 Vehicle hardware shall store data collected, including camera images, on the vehicle hardware while the vehicle is traveling out of communications coverage to MDSS/AVL Server and automatically forward stored information when back in coverage.
2.1.5 Vehicle hardware shall receive all data from, and communicate all data to, a MDSS/AVL Server.
2.1.6 GPS output interval on vehicle hardware shall be configurable to at least once every second.
2.1.7 GPS output interval shall be remotely configurable by NDOR staff.
2.1.8 Vehicle hardware shall begin receiving position and sensor data upon vehicle ignition and require no operator interface to begin this process.
2.1.9 Vehicle hardware shall have sufficient processor speed to handle all functions without noticeable delay.

2.2 AVL On-Board Integration

2.2.1 Vehicle hardware shall be able to interface with at least eight (8) digital sensor inputs, four (4) analog inputs, four (4) dedicated outputs, two (2) RS-232 communication Ports, two (2) USB Ports (2.0 or greater), and an Ethernet port.
2.2.2 Vehicle hardware shall be capable of integration with on-board vehicle diagnostic equipment.
2.2.3 Vehicle hardware shall have a hard-wired or wireless connection to the vehicle cameras.
2.2.4 Vehicle hardware shall have logic capable of instructing the vehicle cameras to capture an image at least once a minute.
2.2.5 Vehicle hardware shall instruct vehicle cameras to begin operating and capturing images upon vehicle ignition and require no operator interface to begin this process.
2.2.6 Vehicle hardware shall be integrated with on-board environmental sensors.
2.2.7 Vehicle hardware shall be integrated with vehicle spreader controllers.
2.2.8 Vehicle hardware shall be capable of integrating with the vehicle CAN bus.
2.2.9 Vehicle hardware shall be capable of processing material application information received from the vehicle CAN bus.

2.3 Equipment Reliability

2.3.1 Vehicle hardware shall maintain at least a 99% measure of operational uptime.
2.3.2 Vehicle hardware shall meet SAE J1455 environmental specifications and provide +/- 25 *g* shock rating.
2.3.3 Vehicle hardware shall operate within a temperature range from -40 F to 140 F and operating humidity up to 95%.
2.3.4 Vehicle hardware shall be solid state with no moving parts such as fans and all communication hardware shall be fully integrated into the housing with no openings.
2.3.5 Vehicle hardware shall be enclosed by a ruggedized case.
2.3.6 Vehicle hardware shall run on the vehicle's power system; typically 12VDC.
2.3.7 Vehicle hardware must be protected from voltage spikes and accommodate momentary drop in voltage during engine start without restarting or losing data.
2.3.8 Vehicle hardware shall include a power management feature or “sleep mode” and/or “charge guard” to ensure that vehicle battery is not discharged after the vehicle is turned off.
2.3.9 Vehicle hardware shall automatically report to the system upon vehicle ignition, without need for operator interface.
2.3.10 Vehicle hardware shall receive firmware/software updates via cellular communications equipment as "over-the-air" updates.
2.3.11 Vehicle hardware shall not produce RFI (Radio Frequency Interference) that negatively impacts the vehicle electronics including two-way radio communications.
2.3.12 Vehicle hardware shall not be negatively affected by RFI generated by the vehicle electronics including two-way radio communications.

2.4 Vehicle-To-Server Communications

2.4.1 Vehicle hardware shall communicate information to MDSS/AVL Server on vehicle locations, direction of travel, and speed at least once every 30 seconds.
2.4.2 Vehicle hardware reporting intervals shall be configurable to be more or less often as desired by NDOR staff.
2.4.3 Vehicle hardware shall include cellular communications technology that is dual mode – functional on 802.11 b/g and the latest LTE commercial protocols (must be backwards compatible to use 3G cellular services) -- and must include all necessary hardware items, processors, antennas, etc. (This provides the flexibility to use either 802.11 b/g wireless or GPRS to do automatic data downloads if necessary).
2.4.4 NDOR will specify the appropriate cellular provider for each NDOR vehicle.
2.4.5 Vehicle hardware shall communicate information to MDSS/AVL Server on material application rates at least once a minute and any time the rate of application changes.
2.4.6 Vehicle hardware shall communicate sensor data information to MDSS/AVL Server at least once every minute.
2.4.7 Vehicle hardware shall instruct vehicle cameras to transmit an image when the vehicle is moving or stationary, as measured by configurable vehicle speeds.
2.4.8 Vehicle AVL hardware shall transmit camera images via cellular connection at least once every minute to a central database.

2.5 Touchscreen Display

2.5.1 A display shall be available for presenting information on AVL and MDSS system operations to drivers within the cab of NDOR winter maintenance vehicles.
2.5.2 Display shall utilize a touch screen function for winter maintenance vehicle operator input of information.
2.5.3 Display shall be customizable with administrative credentials so that only relevant information is presented to winter maintenance vehicle operators, who would not be able to use the display for other purposes (i.e. social media, internet, etc.).
2.5.4 Display shall be sufficiently rugged to operate reliably in the cab of a winter maintenance vehicle.
2.5.5 Display screen shall be a minimum of six (6) inches tall by eight (8) inches wide. Overall size including enclosure shall be a maximum of eight (8) inches tall by ten (10) inches wide.
2.5.6 Operator controls presented by display screen shall only be allowed to function when the vehicle is stopped or traveling less than three (3) mph.
2.5.7 Information updates shall be communicated through the display at least once every five (5) minutes via cellular communications equipment installed as part of the AVL system.
2.5.8 Treatment recommendations shall be clearly visible to winter maintenance vehicle operators on the display during snowplowing operations for Districts who implement this application.
2.5.9 Display shall provide updates on an automated basis without the need for user intervention to retrieve updates.
2.5.10 Updates to information on the display, such as treatment recommendations, shall be provided with an audible tone to alert the driver that updated information has been displayed on the display.

2.5.11 Display shall be configurable with system administrative privileges to either enable or disable audible tone for drivers.
2.5.12 Display shall present short term forecast at all times when enabled.

2.6 Vehicle Equipment Data Transfer

2.6.1 AVL hardware shall integrate either the vehicle CAN bus or with an external interface on-board the vehicle.
2.6.2 AVL hardware shall provide an indication of when the spreader controller is not working or material is not being spread. The indication shall be visible on the MDSS GUI, and shall be stored for display in historical reports.

2.7 Fleet Management Reporting (OPTIONAL)

The following is not a base RFP requirement; if NDOR decides to implement Fleet Management Reporting, the following requirements shall apply.

2.7.1 AVL hardware shall collect engine data, available via OBD-II and the SAE standard J1708/1587, CANbus, and J1939 networks. Such information may include, but not be limited to:

- Engine Hours
- Odometer
- Speedometer
- RPM
- Coolant Temperature
- Transmission temperature
- Fuel Level
- Trip Fuel
- Oil Pressure
- Battery Voltage
- DTC – Trouble Codes
- Idle Time
- Plow up/plow down

2.7.2 The collected data shall be transmitted to a server and stored on a secure database.
2.7.3 NDOR shall access the data through a web interface or client application using a secure log-in.
2.7.4 Industry standard and customizable reports shall be available.
2.7.5 Data shall be downloadable by NDOR for use in other applications.

3. CONTRACTOR COMPONENTS AND INTERFACES (3.0)

Contractor shall furnish and install system software as illustrated in Figure 1 and described within this section. Table 3 defines the flows of information between Contractor components and interfaces.

TABLE 3 – CONTRACTOR COMPONENTS AND INTERFACES

Item	Path Name	From	To	Description
1	Location, Camera Images, Weather Data	MDSS/AVL Server	Contractor GUI for NDOR	This represents the communication of vehicle location data, camera images, and weather data to end users via the Contractor GUI. Camera images are also transmitted from the MDSS/AVL Server for purposes of viewing through a Contractor GUI by NDOR staff.
2	Contractor GUI Data	Contractor GUI for NDOR	NDOR District Staff	This represents the presentation of information gathered by the MDSS/AVL Server to NDOR Staff responsible for winter roadway operations and maintenance. Contractor GUI shall be provided to illustrate data on winter maintenance operations and be accessed via an Internet connection and mobile application.
3	Treatment Recommendations	MDSS/AVL Server	Contractor GUI for NDOR	This represents the presentation of treatment recommendations from MDSS/AVL Server to NDOR Staff responsible for winter roadway operations and maintenance. Contractor GUI shall be accessible to district supervisors via internet connection and mobile applications.
4	Treatment Recommendations	MDSS/AVL Server	Vehicle Hardware	This represents the presentation of treatment recommendations from MDSS/AVL Server to NDOR Staff responsible for winter roadway operations and maintenance. Contractor GUI shall be accessible to winter maintenance vehicle operators via mobile data computer in the vehicle.

NDOR district offices will require proper log-in credentials enabling NDOR staff to monitor winter maintenance vehicle locations and perform other central office functions as necessary. Vehicle hardware will be communicating information to a MDSS/AVL Server that can present the information on a graphical user interface that is accessible via an internet connection from any NDOR computer.

3.1 MDSS/AVL Server(s)

3.1.1 MDSS/AVL Server(s) shall be designed, owned and operated by the Contractor at a location of their choosing. Alternatively, the Contractor may use servers owned and operated by a disclosed Subcontractor.

3.1.2 All data stored on MDSS/AVL Server(s) shall be the property of the NDOR.

3.1.3 MDSS/AVL Server(s) shall be accessible to NDOR via the internet, using a standard web-browser using secure (i.e https) protocols.

3.1.4 MDSS/AVL Server(s) shall be accessible to NDOR users via an internet connection with a username and password allowing access to all information reported from vehicles.

3.1.5 MDSS/AVL Server(s) shall be able to provide access to the system for, and sustain, an estimated 1000 users.

3.1.6 Total concurrent users will be approximately 200.

3.1.7 MDSS/AVL Server(s) access shall be configurable to allow for diverse access, set by Administrative Users, according to level of staff responsibility.

3.1.8 MDSS/AVL Server(s) shall be in continuous operation 24 hours per day, 365 days per year.

3.1.9 MDSS/AVL Server(s) shall receive weather information reported from vehicle sensors on air and road temperatures.

3.1.10 MDSS/AVL Server(s) shall have a high degree of reliability with not less than 99.9% monthly uptime.

3.2 Data Archival Requirements

3.2.1 MDSS/AVL Server shall include the capability to selectively archive datasets and display archived data and products through GUI/WUI.

3.2.2 MDSS/AVL Server(s) shall allow for a means of automatic data archival and backup without system interruption.

3.2.3 All data within MDSS/AVL Server(s) shall be capable of being accessed, stored and archived by NDOR in a relational database.

3.2.4 MDSS/AVL Server(s) shall include a web services Application Programming Interface (API) to allow read only secured access for raw data retrieval for use in other relational database applications.

3.2.5 MDSS/AVL Server(s) shall store material application rate information by vehicle operator as historical information that can be reviewed by authorized software users.

3.2.6 MDSS/AVL Server(s) shall store the amount of material applied by vehicle operator as historical information that can be reviewed by authorized software users.

3.2.7 MDSS/AVL Server(s) shall store treatment recommendations provided to vehicle operators and authorized users as historical information that can be reviewed by authorized software users.

3.2.8 MDSS/AVL Server(s) shall include a short and long-term data storage capability, in which the process of saving data shall not interfere with the normal operation of the system.

a. Short-term archive shall consist of the latest fourteen (14) days of data.

b. Short-term archive shall be viewable by selecting the date and time of interest from the display interface.

c. The oldest stored data in short-term archive shall be overwritten by new incoming data, such that the integrity of incoming data is preserved.

d. Long-term archive shall consist of all system data to be archived for two (2) years by Contractor.

e. All data in long-term archive shall be accessible to NDOR staff through GUI for a period of up to two (2) years from date of collection.

f. Data beyond the two (2) year period shall be deleted on a quarterly basis.

3.3 Graphical User Interface (GUI)

3.3.1 GUI shall be designed to ensure that it can run on commercial-off-the-shelf hardware commonly available; that is, no special hardware development will be necessary.

3.3.2 MDSS/AVL Server shall present the locations of winter maintenance vehicles through a Graphical User Interface (GUI).

a. GUI shall include a base map that identifies all Nebraska roads and highways on which winter maintenance vehicles are traveling.

b. Base map shall use NDOR GIS map for an overlay to include viewable data provided by NDOR such as reference post data, district boundaries, superintendent areas, etc.

c. GUI shall be configurable to allow users to zoom to the appropriate region (e.g., state, city, county, etc.) that has input data necessary to support its operations.

d. GUI shall allow supervisors to click on winter maintenance vehicles identified in the GUI and gather information on the vehicle, including but not limited to:
   - Date / timestamps of locations reported
   - Direction of travel
   - Status of vehicle (moving or stationary)
   - Plow position (up / down)
   - Material application rate
   - Recommended application rate
   - Vehicle diagnostics

e. Supervisors shall be able to select winter maintenance vehicles identified in GUI and send text message information to one or multiple vehicles to be presented on the vehicle DISPLAY that is displayed only when the vehicle has stopped.

f. GUI shall provide the following functions to users through desktop / laptop computers:
   - Ability to view plan-view graphics
   - Animation of forecasts and weather information
   - Time selection whereby the user can select the time period for data viewing
   - Print function
   - Help function
   - Alert function
   - Ability to review historical data

- Ability to select viewing area
- Ability to toggle features, including but not limited to:
  - RWIS
  - CCTV cameras
  - AWOS
  - Weather backgrounds
  - Routes
  - Trucks (AVL)
  - Historical breadcrumb trail for trucks
  - Weather alerts
  - Pavement alerts
- Ability to view time-series information, including but not limited to:
  - Weather conditions
  - Pavement conditions
  - Maintenance actions
  - Maintenance recommendations
- Ability to combine data on time series plots
- Ability to configure data ranges (scale) for each time series plot
- Ability to overlay and combine graphical outputs from forecasts and observations

3.3.3 GUI shall include the capability to playback historical data between a configurable start and end date.

3.3.4 GUI shall present material application rate information between a configurable start and end date set by an authorized user of the MDSS/AVL Server for analysis purposes.

3.3.5 GUI shall present the amount of material applied by drivers between a configurable start and end date set by an authorized user of the MDSS/AVL Server for analysis purposes.

3.3.6 GUI shall present treatment recommendations provided to vehicle operators and authorized users between a configurable start and end date set by an authorized user of the MDSS/AVL GUI for analysis purposes.

3.3.7 All functionality shall be available on the GUI and/or the Web User Interface (WUI).

3.3.8 WUI shall be accessible via an Internet connection using the following versions of web browsers:

a. Internet Explorer Version 9 or Newer
b. Google Chrome Version 24 or newer
c. Firefox Version 18 or newer

3.4 Mobile Application

3.4.1 MDSS/AVL Server shall make data on winter operations available to NDOR users through a mobile application.

a. Mobile application shall be operable on the following platforms:
   - Android version 4.2.x or newer
   - iOS version 5.1.1 or newer
b. Mobile application shall allow supervisors to access vehicle locations presented on a map viewable on smartphone and tablet devices.
c. Mobile application shall be capable of displaying all AVL data, including but not limited to:
   - Date / timestamps of locations reported
   - Direction of travel
   - Status of vehicle (moving or stationary)
   - Plow position (up / down)
   - Material application rate
d. Route Treatment Recommendations
e. Current, past and future weather conditions
   - At least 24 hours previous and 24 hours future
f. Additional mobile application features:
   - Map view
   - Text forecast
   - Alerts
   - Routes
   - RWIS
   - AWOS
   - Camera images
g. User configurable dashboard.

3.5 Weather Forecasting Requirements

3.5.1 MDSS/AVL Server shall generate weather forecasts that are based on the following sources, including, but not limited to:
- a. National Weather Service (NWS)
- b. National Oceanic and Atmospheric Administration (NOAA)
- c. Road/Weather Information Systems (RWIS)
- d. Automated Weather Observation Stations (AWOS)
- e. Vehicle Sensors on-board NDOR winter maintenance vehicles

3.5.2 MDSS/AVL Server shall generate weather forecasts for zones or regions around the State as identified by the user (e.g., forecast zones, maintenance zones, etc.).

3.5.3 Weather forecasts shall take into account data reported from fixed Road/Weather Information Systems (RWIS) Stations and Automated Weather Observation Stations (AWOS), including but not limited to, air temperatures, precipitation rates and wind speeds.

3.5.4 Weather forecasts shall take into account data reported from mobile NDOR winter maintenance vehicle equipment, including but not limited to, air temperatures, and pavement temperatures.

3.5.5 Route weather forecasts shall be provided out to at least 24 hours.

3.5.6 Weather forecasts shall have a minimum resolution of at least one (1) hour.

3.5.7 Weather forecasts shall be updated no less than every three (3) hours, in which a new 24-hour forecast shall be provided every three (3) hours.

3.5.8 Weather forecasts shall be provided two (2) meters above ground level (AGL), unless otherwise noted with the following information:
- a. Surface air temperature in degrees Fahrenheit with time series information.
- b. Surface dew point in degrees Fahrenheit with time series information:
  - Surface relative humidity
  - Surface wind speed in miles per hour
  - Surface wind direction in degrees with respect to true north
  - Surface wind gust in miles per hour with time series information
- c. Precipitation type as Rain, Snow, Ice, or Mixed with time series information.
- d. Precipitation rate in inches per hour to a precision of a tenth of an inch with time series information.
- e. Snowfall accumulation in inches per hour to a precision of a tenth of an inch with time series information.

3.5.9 Ten (10) day forecast for the weather shall be provided.

3.5.10 Weather forecasts shall also provide the following NWS watches, warnings and advisories, including, but not limited to:
- a. Winter storm watches and warnings
- b. Flood watches and warnings
- c. Flash flood watches and warnings
- d. Severe thunderstorm watches and warnings
- e. Tornado watches and warnings
- f. High wind watches and warnings
- g. Special weather statements
- h. Freeze watches and warnings
- i. Winter weather advisories
- j. Dense fog advisories
- k. Snow advisories

3.6 Weather Alerts

3.6.1 Weather alerts will be required for all eight (8) districts; weather alerts will be for each Superintendent area as requested by NDOR.

3.6.2 Contractor shall provide an alert callout, two (2) hours in advance when weather conditions will cause a negative impact on the pavement; i.e., ice, snow or icing of roadway because of falling temperatures when wet pavements are present.

3.6.3 Weather alerts shall be provided to users via e-mail, SMS, and phone call; with the option for users to select which method(s) in which alerts will be received.

3.7 Weather Observation Requirements

3.7.1 MDSS/AVL Server shall provide weather observations that are based on the following sources:
- a. National Weather Service (NWS)
- b. National Oceanic and Atmospheric Administration (NOAA)
- c. Road/Weather Information Systems (RWIS)

d. Automated Weather Observation Stations (AWOS)
e. Manually entered reports by human observation
f. Vehicle Sensors on-board NDOR winter maintenance vehicles

3.7.2 MDSS/AVL Server shall provide weather observations for zones or regions around the State as identified by the user (e.g., forecast zones, maintenance zones, etc.).

3.7.3 Weather observations shall include the following parameters, where available:
a. Air temperature in degrees Fahrenheit
b. Relative humidity in percent
c. Dew point in degrees Fahrenheit
d. Wind speed in miles per hour
e. Wind direction in degrees with respect to true North

3.7.4 Weather observations shall update as new data arrives.

3.7.5 Weather observations shall have the following characteristics:
a. Observation data shall expire off the screen after a configurable number of minutes.
b. Expiration time shall be independently configurable for each observation.
c. Time series (text and graphical formats) shall be provided.

3.8 Route Configuration

3.8.1 Routes shall be configurable to fixed end points as specified by the NDOR.

3.8.2 Routes shall be configurable to match the physical properties of the highway segment(s) necessary to provide accurate pavement condition forecasts and current conditions.

3.8.3 Routes shall be configurable to match the available maintenance practices.

3.8.4 Routes shall be configurable to account for traffic volume on the highway segment(s).

3.8.5 Routes shall be configurable to account for the level of service on the highway segment(s).

3.9 Pavement Condition Forecasting Requirements

3.9.1 MDSS/AVL Server shall generate road condition forecasts that are based on the following sources, including, but not limited to:
a. Weather forecast data
b. Road/Weather Information Systems (RWIS)
c. Vehicle Sensors on-board NDOR winter maintenance vehicles

3.9.2 MDSS/AVL Server shall generate pavement condition forecasts for routes, zones or regions around the state as identified by the user (e.g. forecast zones, maintenance zones, etc.).

3.9.3 Pavement condition forecasts shall take into account data reported from mobile NDOR winter maintenance vehicle equipment, including, but not limited to, maintenance actions, air temperatures, and pavement temperatures.

3.9.4 Pavement condition forecasts shall be provided out to at least 24 hours.

3.9.5 Pavement condition forecasts shall have a minimum resolution of at least one (1) hour.

3.9.6 Pavement condition forecasts shall be updated no less than every one (1) hour, in which a new 24-hour forecast shall be provided every one (1) hour.

3.9.7 Pavement condition forecasts shall be presented graphically at each forecast location within configurable maintenance routes, and include the following parameters, where available:
a. Pavement temperature in degrees Fahrenheit
b. Snow depth on pavement in inches (to a tenth of an inch)
c. Blowing snow potential (likelihood reported as low, medium, high or as a percentage) at hourly increments
d. Pavement frost potential (likelihood reported as low, medium, high or as a percentage) at hourly increments
e. Chemical concentration on pavement (percent by weight)
f. Pavement condition as: Wet, Dry, Chemically Wet, Percent Coverage of Snow, and Snow / Frost / Ice Depth in inches

3.9.8 Snow depth forecast shall be based on the amount of snow forecasted to accumulate on a road surface without traffic.

3.9.9 Snow depth forecast shall be based on the forecasted precipitation type and rate, and forecasted pavement temperature to estimate the amount of snow that will accumulate on the road surface.

3.9.10 Snow depth forecast shall be based on treatment options including the amount of snow expected to accumulate on the pavement when:
a. No treatment is performed
b. The recommended treatment is performed
c. A user-defined treatment is performed

3.9.11 Blowing snow potential forecast shall be based on these minimum characteristics:
a. Recent snowfall characteristics

b. Forecasted precipitation type and rate
c. Predicted wind speed
d. Local topography
e. Predicted air temperature

3.9.12 Pavement frost potential forecast shall be based on these minimum characteristics:
a. Forecasted pavement temperature
b. Forecasted precipitation type and rate
c. Forecasted wind speed
d. Forecasted relative humidity (based on dew point / frost point)
e. Predicted air temperature

3.9.13 Pavement condition forecast shall be based on pavement conditions on the road when:
a. No treatment is performed
b. The recommended treatment is performed
c. A user-defined treatment is performed

3.10 Pavement Condition Observation Requirements

3.10.1 MDSS/AVL Server shall provide pavement condition observations that are based on the following sources:
a. Road/Weather Information Systems (RWIS)
b. Manually entered reports from human observation
c. Vehicle Sensors on-board NDOR winter maintenance vehicles

3.10.2 MDSS/AVL Server shall provide pavement condition observations for zones or regions around the State as identified by the user (e.g., forecast zones, maintenance zones, etc.).

3.10.3 Pavement condition observations shall include the following parameters, where available:
a. Pavement temperature in degrees Fahrenheit
b. Subsurface temperature in degrees Fahrenheit
c. Chemical concentration on pavement (percent by weight)
d. Freeze point temperature in degrees Fahrenheit
e. Pavement condition as: Wet, Dry, or Chemically Wet
f. Snow, frost, and ice depth in inches
g. Blowing snow (reported as yes/no)
h. Visibility in miles or fractions of miles
i. Friction or grip

3.10.4 Pavement condition observations shall update as new data arrives.

3.10.5 Pavement condition observations shall have the following characteristics:
a. Surface observation data shall expire off the screen after a configurable number of minutes.
b. Expiration time shall be independently configurable for each observation
c. Viewing of the observations shall be user selectable
d. Time series (text or graphical formats) shall be provided

3.11 Treatment Recommendation Requirements

Treatment recommendations shall be configured based on route segments provided by NDOR. NDOR will only be implementing Treatment Recommendations initially for Districts 2, 6, and 7 with an estimated 150 routes within Districts 2, 6 & 7. However, the overall solution shall allow for future expansion to include an estimated 250 additional routes that may be added in subsequent years within the remaining districts. Bidders should provide a price per route under "Optional Services" for possible further implementation of Treatment Recommendations for the remaining Districts in subsequent years.

Estimated quantities are not to be construed as either a minimum or maximum purchase quantity. Contractor shall not impose minimum order requirements.

NDOR staff must be able to view the recommendations from the MDSS GUI, Web UI and apps. The recommendations must account for past and future events that affect the treatment needed to achieve the specified level of service. The recommendations are to be based on current and forecasted conditions and the specified level of service for the route.

Treatment recommendations will specify the optimal application rate to achieve the specified level of service for the route at the lowest overall cost.

For each route where treatment recommendations are required, the following shall apply:

3.11.1 Winter maintenance rules of practice shall be based on the Manual of Practice for Effective Anti-Icing Program and NCHRP Report #526 - Snow & Ice Control: Guidelines for Materials and Methods, and be configurable, as necessary, to reflect local DOT practices.

3.11.2 MDSS/AVL Server shall provide treatment recommendations via the following configurations:
- a. Ability to view plan-view graphics
- b. Ability to view route-specific treatment recommendations
- c. Ability to view route-specific weather and pavement forecast

3.11.3 MDSS/AVL Server shall analyze roadway level-of-service information provided by NDOR staff in providing treatment recommendations to operators and authorized users of the MDSS/AVL Server.

3.11.4 MDSS/AVL Server shall generate summary reports that indicate amounts of material spread by one (1) or multiple vehicles that can be selected by supervisors with access to the MDSS/AVL Server.

3.11.5 Treatment recommendations shall include the following:
- a. Recommended initial treatment start time
- b. Recommended subsequent treatment start time
- c. Recommended treatment type (e.g., chemical, abrasives, plow)
- d. Recommended chemical type based on available chemicals as identified by the Department
- e. Recommended material rate (e.g., amount per lane mile)
- f. Recommended pre-treatment type (solid or liquid), where applicable

3.11.6 MDSS/AVL Server shall have a capability to incorporate constraints (configurable) for each route so that irrelevant treatment recommendations are not provided. For example, the use of NaCl should not be recommended if the user does not use that chemical. Constraints may include:
- a. Available materials (e.g., NaCl, MgCl2, CaCl2, abrasives etc.)
- b. Application rate limits (based on truck spreading limits)
- c. Route cycle limits (minimum turnaround time to repeat treatments)

3.11.7 Treatment recommendations shall be calculated, to the greatest extent possible, using a combination of current observational data on the state of the roadway and predicted weather and road conditions.

3.11.8 Treatment recommendation calculations should consider, to the greatest extent possible, factors that impact treatment effectiveness (e.g., chemical scatter, splatter, traffic impacts, spreader characteristics, etc.).

3.12 Management Reports

3.12.1 Management report capabilities shall be provided, which can be accessed and generated, as desired, by NDOR on the GUI/Web UI, used to study or evaluate the maintenance response to weather.

3.12.2 Provide access to archived weather, pavement condition, and maintenance data, and AVL reports.

3.12.3 Shall be scalable to single storm events, up to entire winter seasons.

3.12.4 Reports shall be viewable in multiple formats such as tabular form and displayed graphically on a map as selected by the user.

3.12.5 Reports shall be user configurable to allow users to select combinations of data and display the relationships between them.

3.12.6 Ability to enter NDOR winter severity index data and view winter severity index in tables, graphs, and maps.

3.12.7 Data shall include all captured winter weather data, forecasts, observations, and recommended and actual maintenance actions.

I. APPLICATION RATE (4.0)

1. SPREADER CONTROLLERS (4.1)

Contractor shall supply all necessary software and hardware required to connect to NDOR's spreader controllers. Application rates and material type (if available) will be transmitted to the AVL hardware and viewable on the GUI/WUI/Mobile App.

NDOR currently has the following existing controllers in use:

	GL400	FREEDOM 2	FREEDOM ACS	FORCE 5100	FORCE 6100	MONROE/ CIRUS	MC840	CIRUS	RAVEN	District Total
DISTRICT 1	24	5	21	10	9	4	5	4	11	**93**
DISTRICT 2	32		19	1	11		5			**68**
DISTRICT 3	21	1	10	37	4	11			17	**101**
DISTRICT 4	31	1	25	18	5	3	9	1	4	**97**
DISTRICT 5	20	5	23	13	5		10	3	10	**89**
DISTRICT 6	22	2	36	7			4		3	**74**
DISTRICT 7	16	3	27	5						**51**
DISTRICT 8	18	4	20	7	2		4		1	**56**
GRAND TOTAL	**184**	**21**	**181**	**98**	**36**	**18**	**37**	**8**	**46**	**629**

J. CELLULAR COMMUNICATIONS (5.0)

Contractor shall provide all cellular hardware for communication of data from vehicle system components to the MDSS/AVL Server. The communications technology for transmitted collected data shall be 4G LTE, where available, with fallback to 3G technology. Due to coverage limitations across the state, NDOR typically utilizes a data plans from Verizon, US Cellular and Viaero, depending on which carrier has the best coverage in a particular area. Cellular data plans will be provided by the NDOR prior to installation and cellular hardware must be compatible with the data plans supplied by NDOR.

K. HOSTING (6.0)

Contractor shall host all MDSS/AVL system components required to analyze data communicated from vehicle system components and present information via Graphical User Interface (GUI) that will be accessed by

NDOR staff through web-based internet connections. GUI shall be a consistent interface for all NDOR users throughout the State that presents information communicated from vehicles to the MDSS/AVL system components.

The Contractor shall be responsible for all contract requirements and activites related to hosting the proposed systems and ensure that any updates or transitions occur smoothly without disruption to the State.

L. STORAGE (7.0)

All data collected via the MDSS/AVL system by the Contractor on behalf of NDOR shall be stored by the Contractor for the entire life of the contract and must be readily accessible on website within two (2) business days of a request.

All data collected is the property of NDOR and shall be turned over to NDOR at the end of the contract.

M. WARRANTY (8.0)

Systems shall be warranted for a two (2) year period following installation and final acceptance of vehicle and MDSS/AVL system components as defined in the RFP.

Warranty to include all parts and services associated with the overall system, but may not require onsite service unless deemed necessary by both parties.

N. TESTING (9.0)

The Contractor shall define and document test requirements and a schedule for testing Vehicle hardware, firmware, and all software. Testing requirements shall include any compliance testing with the industry standards and regulations. The Contractor shall be responsible for carrying out unit, system, and integration testing for all programs, modules, and sub-systems throughout the development and management life cycles. The Contractor is responsible for successfully completing system and user acceptance testing prior to implementation.

The Contractor is responsible for certifying that each program, module, and sub-system meets or exceeds all of the functional, technical, and performance requirements prior to implementation. The Contractor shall be responsible for working with NDOR in structuring testing environments that mirror the production environment.

The Contractor is also responsible for the initial development of user test scenarios, establishing testing procedures and protocols, etc. Acceptance testing will include testing by users of all system functions, including, but not limited to, proper functioning of software, hardware and network components, as well as both data content, output, and connectivity components. It will offer the opportunity to test documentation, procedures, and business processes.

O. OPERATIONS & MAINTENANCE PHASE (10.0)

The following table contains the list of requirements and due dates expected of the contractor for the Operations and Maintenance (O&M) phase following the implementation of the solution. Details for these requirements follow in the narrative after the table.

	Phase	Requirements	Due Date
10.1	10.0 Operations and Maintenance	Operating Procedures Guide	Due dates to be determined in the Detailed Work Plan
10.2		Extended Hardware Services Warranty	Due dates to be determined in the Detailed Work Plan
10.3		On-Going Technical Support Services	Due dates to be determined in the Detailed Work Plan
10.4		On-Call On-Site Hardware Support Services	Due dates to be determined in the Detailed Work Plan

	Phase	Requirements	Due Date
10.5		Emergency On-Call Hardware Support Services	Due dates to be determined in the Detailed Work Plan
10.6		Problem Resolution Plan	Due dates to be determined in the Detailed Work Plan
10.7		Replacement Units	Due dates to be determined in the Detailed Work Plan

1. OVERVIEW

Operations & Maintenance (O&M) activities include, but are not limited to, the following:

a. Perform system maintenance, including testing, documentation, etc. Note: Maintenance shall be conducted as mutually agreed upon by both the NDOR and Contractor.

b. Record, track, and resolve system defects at no additional cost to the State.

c. Conduct necessary software/firmware updates.

d. Conduct maintenance of interfaces.

e. Provide technical support with predefined technical support prioritization levels.

f. Provide security management.

g. Support policy and process changes.

h. Keep GUI/WUI up to date.

i. Keep all written material, including all system documentation and scripts, up to date as changes occur.

2. OPERATING PROCEDURES GUIDE (10.1)

The Contractor shall develop and maintain documentation on operating procedures to assist technical staff in operation and maintenance of the MDSS/AVL Systems. These procedures help define and provide understanding of system operations and performance. The operations procedures will address all facets of the technical operation of both systems. The Operating Procedure Guide must be continuously updated to reflect the latest changes.

3. EXTENDED HARDWARE SERVICES WARRANTY (10.2)

Contractor shall provide cost information to allow NDOR the option to purchase up to three (3) one (1) year period warranty extensions beyond two (2) year base warranty period.

4. ON-GOING TECHNICAL SUPPORT SERVICES (10.3)

Contractor shall provide phone and/or online technical support at no additional cost to the Nebraska Department of Roads (NDOR) during the normal business hours of Monday through Friday, 8:00 a.m. to 5:00 p.m. CST for the duration of the contract or warranty period; whichever is later. The Contractor shall respond to calls/emails for assistance within one (1) hour or less. Technical support shall be defined as any equipment or technical issues for the entire system which may arise during the contract period to include, but not limited to:

a. Equipment operation;
b. Interpretation of data represented on GUI's;
c. Reporting issues;
d. Formatting issues;
e. Creating AVL and/or MDSS custom reports documenting maintenance operations;
f. Resolution of problems reported in production;
g. Modifications in design of application; These changes will be through the Change Management Process as defined in V.B.2;
h. Modification of components, vehicle hardware, design changes, and deployment of changes; These changes will be through the Change Management Process as defined in V.B.2;

i. The Contractor must commit to responsive communication with the NDOR District Managers or other staff responsible, assisting NDOR staff with individual support, mentoring and coaching capacity and providing status reports on the application;
j. Ongoing development services as defined in Change Management V.B.2;
k. Ongoing system maintenance;
l. Planning of system upgrades and enhancements as defined in Change Management V.B.2.

5. ON-CALL ON-SITE HARDWARE SUPPORT SERVICES (10.4)

During the warranty period, Contractor shall provide on-call on-site support services to NDOR maintenance facilities to repair and/or replace faulty hardware devices installed in the vehicles at no additional cost to the State. Support services shall be available during normal business hours Monday through Friday, 8:00 A.M – 5:00 P.M. Contractor shall be on-site within 48 hours maximum after the initial call for service. After the warranty period, on-call on-site support services will be provided at the hourly price listed on the Cost Proposal Bid Sheet.

6. EMERGENCY ON-CALL HARDWARE SUPPORT SERVICES (10.5)

On an as-needed basis during the warranty period, Contractor shall provide a certified technician for on-call emergency repair services after-hours, weekends and holidays at no additional cost to the State. Contractor's technician shall be on-site within 48 hours maximum after the initial call for service.

Emergency remote support shall also be provided by the Contractor via telephone and email for maintenance problems regarding the server software after hours and on weekends. Contractor must provide remote assistance within one (1) hour after notification. After the warranty period, emergency services will be provided at the hourly price listed on the Cost Proposal Bid Sheet.

7. PROBLEM RESOLUTION PLAN (10.6)

The Contractor shall establish procedures for receiving, recording, and tracking problem reports and modification requests from users, and providing feedback to users. Whenever problems are encountered, the problems shall be recorded and entered into the problem resolution process. The Contractor shall implement (or establish organizational interfaces with) the configuration management process for managing resolutions to the existing system.

The Contractor and NDOR will develop a mutually agreeable Problem Analysis and Resolution Plan prior to completion of the system implementation.

The Contractor shall provide a toll-free number and an email address for users to report system problems.

8. REPLACEMENT UNITS (10.7)

Contractor shall replace defective units within two (2) business days of being notified. During the warranty period, replacement units and installation services shall be provided at no additional cost to the NDOR. After the warranty period, replacement units will be provided at the unit price and hourly rate listed on the Cost Proposal Bid Sheet.

P. TRAINING (11.0)

1. AVL Technician Training (Equipment Installation and Maintenance) (11.1)

Contractor shall provide, at no additional cost to the State, on-site in-person hands-on training sessions for NDOR technical personnel in each NDOR district as follows:

a. Contractor shall submit training materials to NDOR project manager for approval at least two (2) weeks in advance of first session.
b. Contractor shall provide training sessions for NDOR technical personnel offering a complete overview of the hardware and software for the AVL, and detailed procedures for troubleshooting problems.
c. Contractor shall provide training at the following eight (8) district locations:

- Lincoln *(District 1)*
- Omaha *(District 2)*
- Norfolk *(District 3)*
- Grand Island *(District 4)*
- Gering *(District 5)*

- North Platte *(District 6)*
- McCook *(District 7)*
- Ainsworth *(District 8)*

d. Training shall be provided at each location after *at least* 25%, but not more than 75%, of AVL units for that corresponding district have been installed.

e. Training shall be provided for approximately three (3) to six (6) technicians per class.

f. Each training session shall be 6-8 hours in duration, including hands-on troubleshooting.

g. Training shall include hands-on work with the AVL hardware.

h. Contractor shall provide, at no additional cost to the State, six (6) operational service manuals for each class.

i. Contractor provided training shall include review of the operational service manual information.

j. Training shall include access to MDSS GUI with demonstrations of fully functioning AVL displaying data, and any applicable troubleshooting procedures.

k. Detailed instructions for obtaining technical support and warranty service will be provided at each session.

l. Training materials shall be given as hard copy and available electronically.

m. Contractor shall have all attendees sign in on a roster. A copy of the roster will be provided to the NDOR Project Manager within one (1) week of each training session.

2. AVL Touchscreen Training (11.2)

Contractor shall provide, at no additional cost to the State, on-site in-person hands-on training sessions for NDOR personnel as follows:

a. Contractor shall submit training materials to NDOR project manager for approval at least two (2) weeks in advance of first session.

b. Contractor shall provide training to NDOR personnel on the proper use of the touchscreen interface. This will be a train-the-trainer format.

c. Training shall be approximately one (1) hour in length and shall be provided at least once in each NDOR district where ten (10) or more touchscreen interfaces have been installed.

d. Training may be provided on the same day (before or after) MDSS user training.

e. Contractor shall have all attendees sign in on a roster. A copy of the roster will be provided to the NDOR Project Manager within one (1) week of each training session.

f. A video demonstrating and explaining the proper use of the touchscreen shall be provided.

- The video will be no more than twenty minutes in length.
- The video will be approved by the NDOR Project Manager.
- The video will be available within 90 days of the tenth (10^{th}) touchscreen installation.
- Twelve (12) copies on DVD will be provided.
- NDOR will be allowed to make unlimited copies and post on video websites such as YouTube or Vimeo for our own use.

3. MDSS/AVL Basic User Training (11.3)

Contractor shall provide, at no additional cost to the State, on-site in-person hands-on training sessions for NDOR personnel in each NDOR district as follows:

a. Contractor shall submit training materials to NDOR project manager for approval at least two (2) weeks in advance of first session.

b. GUI/WUI training for NDOR personnel will be provided during the month of October.

c. Contractor shall provide training sessions in the following eight (8) locations:

- Lincoln *(District 1)*
- Omaha *(District 2)*
- Norfolk *(District 3)*
- Grand Island *(District 4)*
- Gering *(District 5)*
- North Platte *(District 6)*
- McCook *(District 7)*
- Ainsworth *(District 8)*

d. Classes will be limited to 25 participants or less.

e. Up to four (4) sessions will be required at each location.

f. Training will be approximately two (2) hours in length including a ten (10) minute break near the midpoint.

g. A User Guide will be provided and referenced throughout the training.

h. Training will cover:

- The principles of MDSS
- Weather forecasting basics
- Pavement condition forecasting and modeling
- Factors affecting pavement condition
- AVL and camera image viewing
- How to use menus and tools to view MDSS data

i. Online reference materials, presentations and videos shall be available to all users.

j. Contractor shall have all attendees sign in on a roster. A copy of the roster will be provided to the NDOR Project Manager within one (1) week of each training session.

4. MDSS/AVL Supervisor Training (11.4)

Contractor shall provide, at no additional cost to the State, on-site in-person hands-on training sessions for NDOR Supervisors in each NDOR district as follows:

a. Contractor shall submit training materials to NDOR project manager for approval at least two (2) weeks in advance of first session.

b. GUI/WUI training for NDOR supervisory personnel will be provided during the month of November.

c. Contractor shall provide training in the five (5) following locations:

- Lincoln *(District 1)*
- Norfolk *(District 3)*
- Grand Island *(District 4)*
- Gering *(District 5)*
- Ainsworth *(District 8)*

d. Classes will be limited to 15 participants or less.

e. Up to three (3) sessions will be required at each location.

f. An Advanced User Guide will be provided and referenced throughout the training.

g. Training will cover:

- Review MDSS principles, weather forecasting and pavement condition modeling and forecasting
- Factors affecting pavement condition
- AVL and camera image viewing
- How to use menus and tools to view MDSS data
- How to generate, customize and view reports
- How to customize the GUI/WUI for preferred viewing
- Using MDSS on Mobile Devices

h. Online reference materials, presentations and videos shall be available to all users.

i. Contractor shall have all attendees sign in on a roster. A copy of the roster will be provided to the NDOR Project Manager within one (1) week of each training session.

5. MDSS/AVL Supervisor Advanced Training (11.5)

Contractor shall provide, at no additional cost to the State, on-site in-person hands-on training sessions for NDOR Supervisors in each NDOR district as follows:

a. Contractor shall submit training materials to NDOR project manager for approval at least two (2) weeks in advance of first session.

b. GUI/WUI training for NDOR personnel will be provided during the month of November.

c. Contractor shall provide training in the three (3) following locations:

- Omaha *(District 2)*
- North Platte *(District 6)*
- McCook *(District 7)*

d. Classes will be limited to 15 participants or less.

e. Up to three (3) sessions will be required at each location.

f. An Advanced User Guide will be provided and referenced throughout the training.

g. Training will cover:

- Review MDSS principles, weather forecasting and pavement condition modeling and forecasting
- Factors affecting pavement condition
- AVL and camera image viewing
- Using menus and tools to view MDSS data
- Generate, customize and view reports
- Customize the GUI/WUI for preferred viewing
- Play back historical events
- Interpret maintenance recommendations
- Revise maintenance recommendations to fit local conditions
- Compare recommended maintenance actions with reported maintenance actions
- Using MDSS on mobile devices

h. Online reference materials, presentations and videos shall be available to all users.

i. Contractor shall have all attendees sign in on a roster. A copy of the roster will be provided to the NDOR Project Manager within one (1) week of each training session.

6. MDSS/AVL Annual Supervisor Training (11.6)

Contractor shall provide, at no additional cost to the State, at least one (1) annual on-site in-person hands-on training session in each district for NDOR Supervisors as follows:

a. Contractor shall submit training materials to NDOR project manager for approval at least two (2) weeks in advance of first session.

b. GUI/WUI training for NDOR personnel will be provided.

c. Contractor shall provide training sessions in the following eight (8) locations:

- Lincoln *(District 1)*
- Omaha *(District 2)*
- Norfolk *(District 3)*
- Grand Island *(District 4)*
- Gering *(District 5)*
- North Platte *(District 6)*
- McCook *(District 7)*
- Ainsworth *(District 8)*

d. Classes shall be up to 25 participants.

e. One (1) session will be required at each location.

f. Training will be approximately two (2) hours in length including a ten (10) minute break near the midpoint.

g. Training will cover:

- All functionality that is made available to the NDOR through the Contractor's GUI.
- Any updates to the systems.

h. Online reference materials, presentations and videos shall be available to all users.

i. Contractor shall have all attendees sign in on a roster. A copy of the roster will be provided to the NDOR Project Manager within one (1) week of each training session.

7. On-Going Documentation (11.7)

The Contractor shall provide documentation to the NDOR any time significant changes to the system, hardware or software occur. The documentation may be provided via web portal, CD, or other mutually agreeable delivery method and be provided to NDOR at no additional cost to the State.