**Project 16-01: Utilization of AVL/GPS: Case Studies**

**Summary of Nebraska DOT In-Person Interviews**

*Overview*

Interviews were conducted by Ming-Shiun Lee and Dan Nelson of AECOM and coordinated with Ty Barger and Mike Mattison of the Nebraska Department of Transportation (NDOT) on December 13th and 14th, 2017.

*NDOT Staff Interviews*

Meeting attendees throughout the day on Wed. Dec. 13th included the following individuals:

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| * + *Mike Mattison, AVL/GPS Project Manager*   + *Sean Mulligan, Parsons Project Manager*   + *Larry Simmons, Parsons Project Support* | * + *NDOT District 1 (Lincoln) Plow Operators*   + *NDOT District 2 (Omaha) Plow Operators* |

Meeting attendees throughout the day on Thurs. Dec. 14th included the following individuals:

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| * + *Mike Mattison, AVL/GPS Project Manager*   + *Dale Butler, NDOT District 2 District Operations and Maintenance Manager*   + *Kelly Doyle, NDOT District 7 District Operations and Maintenance Manager* | * + *Kyle Schneweis, NDOT Director*   + *Moe Jamshidi, NDOT Deputy Director, Operations*   + *Tom Sands, NDOT Operations Manager*   + *Rita Kucera, NDOT Procurement Specialist* |

*NDOT IT Operations Level Interviews – Dec. 13th*

Group met at the NDOT Offices in Lincoln to discuss how NDOT currently operates and maintains its AVL / GPS system software packages. NDOT installed an AVL / GPS system from Parsons prior to the 2015-2016 winter season. Approximately one-third of the fleet (about 225 vehicles) was equipped with the Parsons AVL System in 2015, and nearly all of the remaining vehicles were then equipped with AVL hardware in 2016. Some of the older NDOT maintenance vehicles will be phased out of the fleet in the near future, and newer vehicles will come equipped with the Parsons AVL hardware.

The Parsons Team, led by Parsons with Iteris and other vendors, was hired by Nebraska DOT in 2015 to manage the installation of all AVL hardware, as well as to provide MDSS software for all maintenance vehicles. 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 software interface. NDOT’s contract for AVL system procurement, installation and integration was very similar to that of Michigan DOT.

NDOT felt the contract organization made the installation process smooth. It was challenging to schedule installation initially. The contractor (Parsons) stepped up to provide detailed schedule and equipment information to facilitate scheduling of installation, as well as reminders prior to installation to ensure vehicle availability. The effort helped improve scheduling and getting system installed as planned. NDOT left the AVL/GPS equipment mounting locations to the discretion of the installers with general guidance from Parsons.

Larry Simmons noted that one of the main challenges they encountered was the integration of multiple brands of spreader controllers with the AVL hardware. Some 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. Another issue encountered was manufacturers provided incorrect information on software version of controller boxes, chips, etc. Larry Simmons noted that a previous effort of the Clear Roads program to develop a “Plug-and-Play” standard for how in-vehicle electronics communicate data with other devices would alleviate this problem in future deployments that may occur in other states.

NDOT also experienced 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 teat that was not a standard type of test, and found signal degradation in some frequencies. This issue has not been resolved.

NDOT staff also noted their experience with integrating Parsons AVL/GPS system with various spreader controllers on their snow plows:

* Force America: worked pretty well. No substantial issues experienced.
* Certified Power: GL400 controller was an older technology and was very challenging to integrate. NDOT didn’t have good experience with customer services either.
* Monroe: 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.
* Raven: 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.

NDOT staff was also trained by Parsons to have the knowledge to perform basic maintenance on the system.

The AVL/GPS system has three antennae: GPS, cellular and Wi-Fi. 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.

In terms of data storage and retention, the NDOT system includes:

* Two years of data archiving period
* Two-week of data available for immediate access
* Parsons keeps all data for the life of the contract
* Dash cam 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.
* NDOT can store data for storms for longer period (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 dash cam images for no longer than 24 hours was to limit exposure to torte claims.

*NDOT Technician / Driver Level Interviews – Dec. 13th*

Group met at the NDOT Offices in Lincoln to discuss how NDOT District Crew Chiefs and snow plow drivers are impacted by the AVL system / MDSS operations, and to take pictures of NDOT snow plow vehicles. NDOT is split into eight Districts, and within each District, NDOT winter maintenance staff 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.

District Crew Chiefs discussed their overall experience with the AVL / GPS system, which mainly comes through their interaction with the MDSS interface in the vehicles. Trucks equipped with the AVL/GPS system have a touch screen in cab that can display weather radar images, locations of other trucks, MDSS treatment recommendations, material application rates, among others. The NDOT District 2 Crew Chief was supportive of the AVL system given his use of the MDSS treatment recommendations for understanding the proper amount of material for defined routes within the district. The AVL system also helped relocate available resources to improve efficiency of winter maintenance activities. Drivers also thought the weather radar information displayed on the touch screen was useful. The NDOT District 2 Crew Chief did note that the size of the touch screen buttons on the in-vehicle tablet provided for the purpose of entering inputs on existing weather conditions were not large enough so that only one touch would be needed to enter the information. In some areas, the touch screen buttons were large enough, but in others, they were much smaller.

District operators were asked about whether or not there were “big-brother” concerns during the initial deployment of the AVL system. The NDOT District 1 and 2 operators noted that these concerns gradually went away when drivers realized that the AVL system was not being used in a disciplinary manner.

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. NODT District 2 was one of the Districts more receptive to MDSS. Material application rates for the NDOT District 2 drivers were determined by supervisors using a combination of the MDSS recommendations and crew inputs. The NDOT District 2 crew chief noted that a driver might be questioned by a NDOT District Supervisor if the amount of material used on a route was significantly different from the MDSS recommendations for that route. Given that drivers are provided the flexibility to determine what the proper treatment should be, they can communicate reasons for the difference with their supervisor after the end of their shifts.

The NDOT District 1 Crew Chief noted other concerns related to the in-vehicle dashcam that is used to capture images once every 60 seconds and send the images back through the AVL system. 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. These images might be questioned by a NDOT District Supervisor if they felt it was necessary to be addressed with the drivers.

*NDOT Supervisor / Manager Level Interviews – Dec. 14th*

Group met at the NDOT Offices in Lincoln to discuss how NDOT District 2 and District 7 Supervisors interact with the AVL / GPS system. The NDOT District Supervisors interviewed noted that they felt the AVL/GPS system and the dashcam images were very useful. Their primary interaction with the system is through MDSS in which they can see the locations of the snow plow vehicles overlaid on the MDSS software interface. District supervisors use the system to check and monitor material application rates and usage. They will monitor long-term weather forecasts and log into MDSS when winter weather is forecasted within the next couple of days.

The group also reviewed the Parsons ATMS software and the MDSS software interfaces to illustrate the use of the system by District Supervisors. It was noted the data polling rates for the Parsons ATMS and the MDSS software were every 1 minute and 2 minutes, respectively. NDOT District Supervisors used the Parsons ATMS software to confirm AVL data was downloading and check dashcam images to observe field conditions. As for the MDSS software, NDOT District Supervisors noted that they were responsible for data entry regarding roadway characteristics to allow MDSS algorithms to provide better outputs. These data entry inputs included daily traffic volumes, pavement types, and hours of operation for NDOT snow plow operators. These inputs are all factored into the type and amount of materials recommended through the MDSS software package.

NDOT has integrated the on-board AVL hardware with the snow plow vehicle’s On-Board Diagnostics port (OBD-II) port, which allows pre-defined vehicle codes to be sent through the AVL software package to alert NDOT staff that vehicle maintenance is needed on specific vehicles. NDOT supervisors have not utilized this feature as extensively, but they do monitor when vehicle codes are provided for certain vehicles.

NDOT provided a brief history on their experience with AVL / GPS system installations. NDOT had initially installed an AVL / GPS system on a few test vehicles for vehicle location tracking, prior to becoming involved with the MDSS pooled fund study. Over time, additional AVL hardware would be installed in NDOT vehicles, and in 2009, NDOT procured approximately 100 AVL / GPS hardware units for installation in NDOT snow plows in all 8 NDOT Districts throughout the state. This installation included MDSS treatment recommendations that were being provided to NDOT District Supervisors and snow plow operators as well.

Problems were reported by some of the NDOT Districts with respect to the reliability of the AVL hardware and its performance in winter weather. Other problems were reported with respect to the accuracy of the winter weather forecasts, which negatively impacted the accuracy of the treatment recommendations. Given the issues that were encountered, drivers and supervisors that had tried to use the MDSS recommendations 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 treatment recommendations and vehicle dashcams for reporting vehicle images of roadway conditions.

NDOT then released an RFP in April 2016 that requested one prime vendor to serve as a single point of contact for managing the installation of all in-vehicle hardware (AVL / GPS and vehicle dashcams in all NDOT Districts) and for providing MDSS treatment recommendations to NDOT Districts 2, 6, and 7. NDOT also requested a demonstration of the AVL system prior to beginning with the procurement of AVL hardware for the entire fleet.

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. 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. Vendor proposals were evaluated on three areas: Vendor’s qualifications and past performance; technical approach; and costs. The contract was for a period of five years with an option to renew for five additional one year periods.

NDOT selected Parsons in May 2016 as the prime contractor that would eventually provide AVL / GPS hardware, and manage Iteris as a sub-contractor responsible for the MDSS treatment recommendations. A local sub-contractor managed the installation of all AVL hardware on NDOT snow plows. NDOT noted that the arrangement of contractors worked very well for the project, and that they had received excellent support from Parsons and Iteris during the training of NDOT staff. 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 coming 2017-2018 winter season.

NDOT noted the following benefits and lessons learned from this turnkey contract:

* The turnkey contract mechanism reduced the needs for NDOT resources for equipment installation, integration, and managing multiple vendors/manufacturers. Parsons was the single point of contact for NDOT and was responsible for all issues.
* Including warranty in the contract was important.
* Asking vendors to price items/system components individually and provide unit price gives DOT flexibility for equipment and service selections.
* The scope of work and requirements were developed based on needs identified from NDOT Districts. Scope and requirements development takes time and starts with systems engineering.
* 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.
* Due to some Districts were not ready for MDSS, a phased implementation for both equipment and software worked well.
* Accuracy of spreader controller data was still an issue. Additional research would be desired. NDOT planned to compare the data from material usage reports manually completed by NDOT staff with the data from the system. NDOT noted that neither sources could be considered accurate.

Given the negative experiences that some NDOT Districts had in the previous AVL system installation, NDOT envisions a gradual rollout of treatment recommendations to Districts 1, 3, 4, 5, and 8 over 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 treatment recommendations from MDSS can have on snow plow operations. These project champions from each District can then communicate the positive impacts with others in their own District that might be skeptical of the technology from their previous experiences with the older AVL system. 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 system and to MDSS treatment recommendations.

As for the potential use of the AVL system in the future, NDOT was considering the integration of backup cameras with on-board touchscreen display. NDOT would also consider using the 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 does not share the snow plow location information to the public currently. NDOT staff noted the uncertainty regarding public interpretation of the vehicle locations was the primary concern, such as questions related to why NDOT has so many snow plows; why snow plows are not moving or in garages when it is snowing, etc.

*NDOT Executive Level Interviews – Dec. 14th*

Group met at the NDOT Central Office in Lincoln on Thurs. Dec. 14th to review the history and processes followed in the installation of the AVL / GPS system for NDOT.

NDOT noted that a pilot was conducted in three NDOT Districts for a year. All trucks in those three Districts were equipped with AVL and MDSS. Upon completion of the pilot, NDOT executives met with DOMM’s from all districts and collectively decided to procure AVL and MDSS on a statewide basis. NDOT felt MDSS was especially helpful to less experienced drivers.

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 hand-written reports completed by NDOT District Supervisors on how much material was used by plow operators. 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 is having material usage by NDOT Districts. 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. Other performance measures could include: staff resource usage, operations costs, consistency between treatments, etc. NDOT also envisions the 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.

NDOT also discussed how the MDSS working group has had a positive effect on the gradual rollout of treatment recommendations to all NDOT Districts. The NDOT has requested that at least one vehicle within each District follow the treatment recommendations during the 2017-2018 winter season. Additional snow plow operators may request the use of the treatment recommendations in future winter seasons after hearing of positive reports on the system’s operations.

NDOT discussed 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 restrict 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.

One key lesson learned by NDOT was ensuring that the RFP written for the project is written well enough to ensure that any challenges encountered can be addressed by the project team. The issue of the difficult integration of multiple brands of spreader controllers with the AVL hardware was cited as one example, in which NDOT expected the Contractor (Parsons) to address the problem given their role as the overall project manager. NDOT was able to work with the Contractor and spreader controller manufacturers to resolve many of these issues.

NDOT also noted the importance of buy-in on AVL / GPS and MDSS systems from executive management at top levels of an agency, since that serves to support the operations of NDOT District Supervisors and other staff throughout an agency. Without buy-in from top levels, agency employees at other levels would be less apt to buy-in to the system as well, which would negatively impact the credibility of the system and use of data gathered from the system for data analytics efforts. In addition, NDOT identified a champion in each district to facilitate buy-in from district staff and help provide training.

NDOT Executives summarized the following key successes and lessons learned:

* AVL/GPS implementation along with MDSS will bring major cultural changes to operational staff. It is important to identify right people as champions along with support from District Engineers.
* Taking time to engage district staff to understand their needs and go through systems engineering helps develop a better scope, which promotes project success.
* It is more effective having NDOT staff to communicate benefits of the system to their peers. DOT staff may feel such communication from vendors as sales pitches.
* Support from top level executives is critical.