

## North/West Passage: Plow Camera and Location Sharing Practices

### Project Summary

November 20, 2018

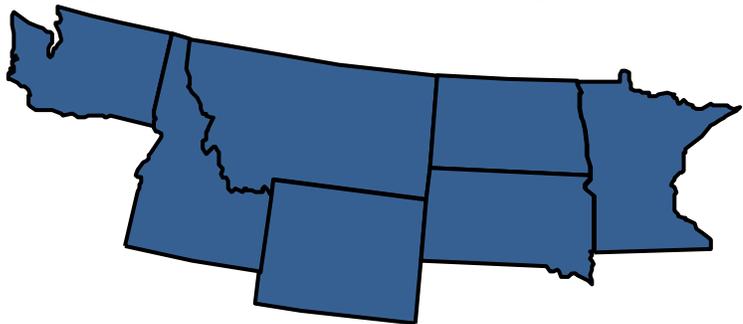
*Prepared by Athey Creek Consultants*

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### Background and Introduction

The [North/West Passage \(NWP\) Transportation Pooled Fund Study](#) focuses on cross-border Intelligent Transportation Systems (ITS) coordination along the I-90 and I-94 corridors through the states of Washington, Idaho, Montana, Wyoming, North Dakota, South Dakota, and Minnesota. See **Figure 1**.

The North/West Passage members were aware that there are states using plow cameras and location sharing to enhance traveler information and support winter operations. **The purpose of this project was to document current plow camera and location sharing practices for the North/West Passage members that are considering camera and locations sharing efforts or enhancing their current system.**



*Figure 1: North/West Passage Members*

To achieve the project purpose, the following six states were interviewed in early 2018.

- Idaho Transportation Department (ITD)
- Iowa DOT
- Minnesota DOT (MnDOT)
- Montana DOT (MD)
- North Dakota DOT (NDDOT)
- Pennsylvania DOT (PennDOT)

Four of these states are included within the North/West Passage corridor and two states are outside of the corridor. The discussion of the interviews focused on implementation, operations, technology and communications, and overall feedback. Based on the interviews two approaches were selected to highlight during a peer exchange webinar on August 16, 2018, the Minnesota DOT that utilizes plow cameras and Pennsylvania DOT that track plows but does not provide camera images. The webinar also provided an opportunity for the attendees to discuss specific points of interest around camera placement and display, camera mounts, image resolution, communication providers, and lessons learned.

The following pages provide the notes gathered during each interview and during the peer exchange webinar for each state. However, following are a few key overall items documented.

- Iowa DOT, MnDOT, and MDT provide snow plow camera images to the public.

- NDDOT and PennDOT provide only snow plow location and breadcrumbs to the public.
- No state that was interviewed streams video or has plans to stream video.
- ITD partnered with Idaho National Laboratory (INL), a national laboratory of the United States Department of Energy and a major employer in Idaho, to place a camera on two INL vehicles in addition to two ITD plows during their pilot project.
- MDT uses images taken every half mile by cameras installed on tow plows to update their 511 website and displays photos on the website for 30 minutes.
- NDDOT uses a GPS tracker with the traveler information map to show plow speed, time, and direction to the public and provide bread crumbs to identify the plow location for the last 15-20 minutes.
- Images taken by MnDOT snow plows interface with Minnesota's 511 map, MDSS website, and the weather data exchange.
- Iowa DOT uses color intensity bread crumbs on their 511 website to identify current road conditions and attaches this information to historic camera images from the last 24 hours.
- PennDOT installed AVL on all plows whether they were owned by the state or rented, provides plow location data to the public, and collects additional data including spreader rate, plow speed, and temperature for internal use.

## **Idaho Transportation Department (ITD)**

### Phone Interview Summary - February 26, 2018

ITD has AVL on a few plows. The AVL system collects location information but not plow position or whether product was applied.

In early 2018, ITD kicked off a pilot project with a limited scope in conjunction with Idaho National Laboratory (INL) to equip a few vehicles with cameras. A camera was placed on a plow in District 1 that travels on I-90 in the panhandle, a second camera was placed on a plow in District 4 in south-central Idaho, and the remaining 2 cameras were placed on INL vehicles, one scout vehicle and one bus. Camera images were to be collected every 10 minutes and transmitted with AVL data to their 511 contractor.

ITD initiated this pilot project for a more complete understanding and denser visual information of roadway conditions. In addition, the images will show the traveling public that the plows are out. This pilot project also provides information to INL to determine trouble spots to prepare drivers for a safer commute. ITD's internal pilot project webpage will also display a map of AVL data and camera images that can be accessed through bread crumb images.

ITD was concerned that nighttime images that used an infrared illuminator may create a hazard for drivers but no information substantiating this concern was found.

Plow drivers only need to turn on the system for the plow camera to activate. The system is designed to "set and forget." Data is primarily transmitted by cell, however, there are many dead spots within the state. When images are collected in the dead zone, they will be stored and downloaded when cell service is reestablished. ITD feels that plow camera images are best used as live information, so storage is short term. Though some post-event analysis may be beneficial, ITD will hold data only a few months at most.

An evaluation and summary of the pilot project is planned. Based on the results of the evaluation, future effort may include pulling the INL camera images into ITD's 511 web page to enhance the traveler information provided.

### Additional information gathered during the Peer Exchange Webinar - August 26, 2018

During the pilot, working with different 511, camera, and data service providers posed a significant challenge. ITD hoped the system would be fully functional in February but delays with camera and API issues resulted in the system not being available until May or June so ITD was not able to test the system with winter weather data. Currently ITD has a demo site that the camera and data service provider will continue. ITD also is working on an open bid for a camera and data provider for a fully functioning rollout.

ITD's Lesson Learned advice to other DOTs is that if a contractor does not have experience providing this type of service, don't assume it will happen quickly.

## Iowa DOT

### Phone Interview Summary - February 26, 2018

Iowa has 902 trucks in their fleet and all initially communicated AVL data including the GPS position through Sprint. Sprint coverage worked well within 20 miles from I-35 and I-80 but outside of that cell coverage was limited to national roaming. Getting data back was an issue because when the phone was not in a service area, the data didn't upload as it was supposed to when the phone returned to cell coverage.

In August 2013, the Director of the Iowa DOT tasked his staff to develop a way to take plow photos from the operator's perspective and then provide these photos to the public via a website. In the 60 days after this request, the Highway Division IT staff created an iPhone App that would automatically take a forward-facing photo every 5-10 minutes. The app would check to see if the truck was moving at least 8 mph and the truck location was within 20 ft of the centerline of one of the Iowa DOT's road segments. The photos were then pushed over the Verizon network to the IT Department for processing and posting to the Track a Plow website. Images remained on the website for 30 minutes.

The Iowa DOT utilized the built-in camera from an iPhone as it provided not only the camera, but the cellular service needed to send out the images. These iPhones were mounted forward facing in the cab of 100 of Iowa's 902 plows. Field staff decided which plows would be equipped to take photos from the plow.

The iPhone plow camera system was low cost (approximately \$70,000) on the Verizon data plan since the iPhones were free so the only costs were for mounts, chargers, and IT development. This worked well at first, but the frequent iOS updates required by Apple products affected the app. Also, mounts were a suction cup that frequently fell off the window from constant vibration and extreme temperatures. Since the iPhones repeatedly fell from their mounted position, drivers sometimes left them on the truck dash.

In 2015, Iowa DOT changed AVL providers and cellular service vendors to improve cell coverage and data quality. In Iowa, the best coverage is provided by Verizon and US Cellular. Iowa DOT found that even with the right cell provider they still experienced some problems along the Iowa-Minnesota border and the Iowa-South Dakota border. Iowa DOT eliminated the Verizon data cost by using a modem to transmit iPhone photos, determining that they needed 250 mb/truck, sharing data across fleet.

In 2017, Iowa DOT began research to replace the iPhones but found that most camera vendors were focused on taking video of the driver or taking video to the rear of the truck for crash and insurance claims purposes. Though streaming video may technically be possible, it is not practical since streaming that much video would pull down the cell network. Instead, they are managing expectations and relying on standard photos. Iowa DOT selected Axis Communications as their vendor and installed Axis 1065-L cameras in their snow plows to take forward facing still photos. This is the first full winter Iowa DOT has used Axis Communications and they have experienced few issues. Axis provided a mount for attaching camera into headliner and new cameras are mounted in the same general area as the iPhones but without the suction cup. There have been no issues with obstruction of view with these mounts.

Night photos with the new cameras default to black and white depending on the light but can be changed to always photograph in color though Iowa DOT has opted not to make that change because that would need to physically occur on each camera. Camera images are approximately 200 kb each and the photo quality is phenomenal, but camera images cannot be zoomed. Iowa DOT has stored the photos from the beginning and there have been instances where they have needed to retrieve the photos to address claims against the department.

Iowa maintains 2 different feeds. One filters in place, providing camera images every 15 minutes for the Track a Plow website, but the second feed is used internally and requires no filtering. Also, the Iowa 511 website includes color intensity bread crumbs to identify current road conditions and attaches this information to historic camera images from the last 24 hours. So far, Iowa DOT does not have any performance measures but there is a lot of interest in looking at the capabilities of plow cameras and the necessary budgets.

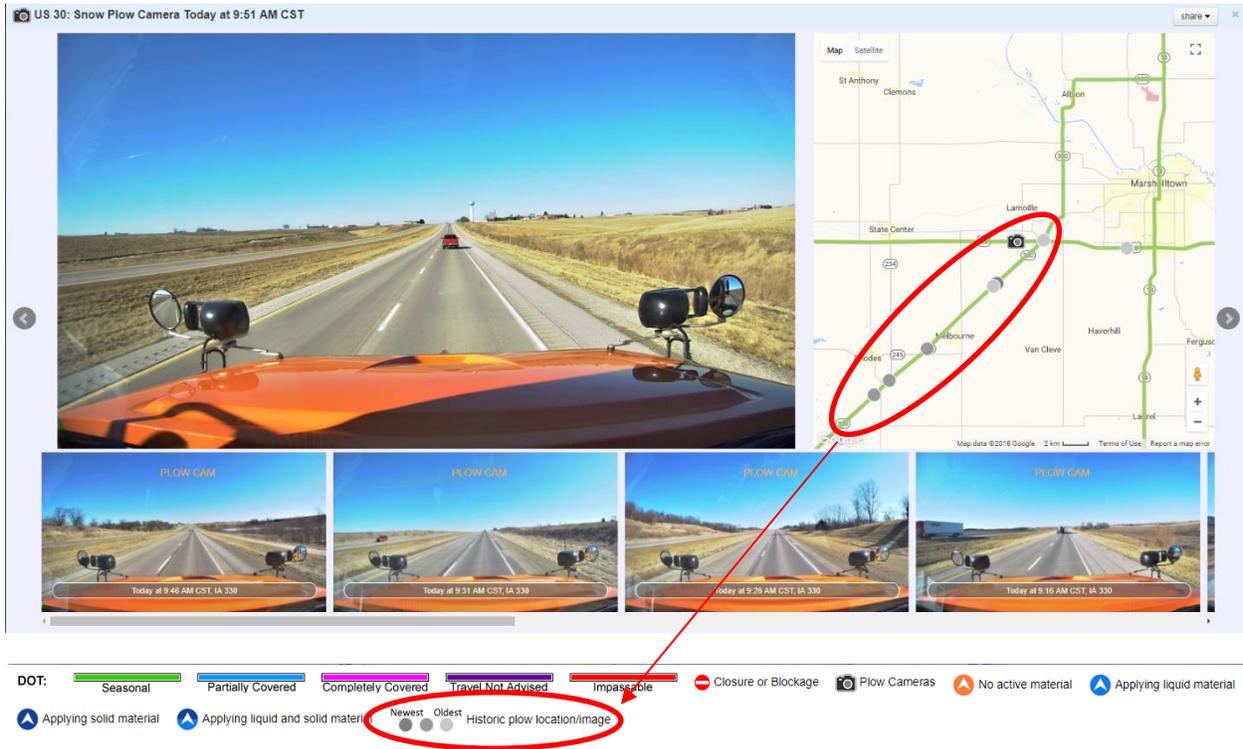
Initially, plow cameras were deployed at the request of the director to provide information for the public but the audience for the camera images has turned out to be so much more including the National Weather Service, tv station weather segments, and social media forecasts. Internally, camera images are beneficial to field staff who can look at the photos to get an idea about what is happening without having to physically drive the area. In addition to eliminating the need to drive the area, plow cameras allow managers to determine when to send staff out or bring them in, when materials need to be applied, and updating and validating road condition reporting for posting on the 511 website by looking at the photos, reducing the need for radio contact with the field.

Iowa DOT has used social media to monitor and collect public opinion on plow cameras. The public response has been outstanding. Many citizens have commented how well the plow cameras provide a good basic situational awareness of the road conditions and provides the traveling public with good information to make safe travel decisions.

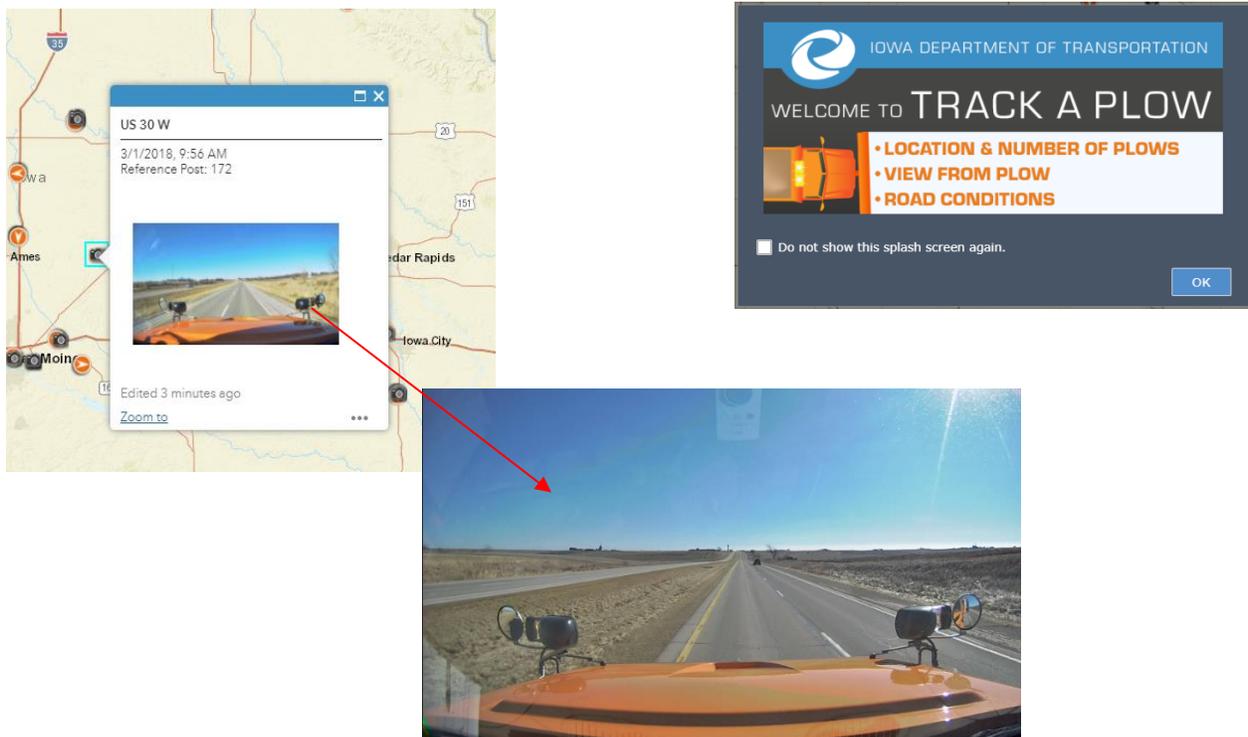
Iowa DOT is looking at plow cameras from an operational standpoint. Their recommendations include managing the expectations of management, selecting the cell provider with the best coverage statewide, and ensuring that no single party or stakeholder has total control over what or how traveler information is displayed.

Iowa provides plow camera images on two separate public facing websites: Iowa 511 and Track a Plow. Screenshots of each are shown below. In addition, the Track a Plow website includes camera images from some Minnesota snow plow cameras.

Screen shot of Plow Camera image from Iowa’s Traveler Information website:



Screenshot of Plow Camera Image from Iowa’s Track a Plow website:



## Minnesota DOT (MnDOT)

### Phone Interview Summary - February 28, 2018

Of Minnesota's 837 plow trucks (including both active and reserve trucks), 240 have cameras and 650 are equipped with AVL. All new trucks are fabricated and outfitted with AVL and trucks 2004 and later have been retrofitted with AVL. By 2019, Minnesota hopes to have AVL in all plows. Minnesota began integrating snow plows with cameras because they wanted a public interface for plow cameras. They selected cameras that would work with their existing AVL system and tried both dome and dash cameras depending on the type of vehicle and the mount available. The initial Phase 1 implementation involved 220 cameras and cost \$71,000. Minnesota DOT focused on interstates, choosing to implement cameras on snow plows in corridors that provide the best overall view of travel throughout the state. There was a concern that the camera images might be too good and not adequately depict the severity of the weather and road conditions because the cameras filtered some blowing snow. MnDOT has found the cameras are good for showing road conditions.

In Phase 2 of the implementation, MnDOT went live with snow plow photos on its 511 site. MnDOT uses snow plow photos to provide additional information to the public. The public interface required working with different providers: Castle Rock handles MnDOT's 511 system, AmeriTrak is the AVL provider, and Iteris is involved in forecasting. The public can access plow camera images through the 511 website after a filter has been applied. MnDOT can change how often photos are taken but the default is to have plow cameras take a photo every minute as long as the truck is traveling more than 10 mph and is less than 400 feet from the center line but only display images every 10 minutes. If the default parameters do not meet their needs, MnDOT can change the time and speed parameters. In addition, drivers can manually take a photo whenever they think it is necessary.

MnDOT's images are only available on state routes. The Minnesota 511 website displays the camera image and bread crumbs to show where the snow plow has been.

MnDOT's camera images are of high quality but are not zoomable. The images interface with the 511 map, MDSS website, and the weather data exchange. Information retained with the photos includes filename, location, date, truck name, address, and mile marker. MnDOT's photo retention schedule has been published. Photos are saved on the AVL system and internally. AVL and truck images are stored for 2 days. MnDOT stores internal AVL information for 14 days. MnDOT's internal MDSS website also hosts photos taken by snow plows. MnDOT advises states to get a camera system for future compatibility.

So far MnDOT has not installed more than 1 camera in a truck but they do have that potential if they choose to make a change. In addition, MnDOT has the potential for taking video but video will not be transferred through cellular to the DOT. MnDOT only saves video on the truck AVL. Videos must be manually initiated and are used to record general information, accidents, and work zones. Most videos will stay on the truck AVL for 4 days, however, videos flagged as accident videos will be saved until they are manually accessed and removed. Videos are not provided to the public on the 511 website. The 3G network does not provide enough bandwidth.

As future enhancements are made, Minnesota will move all cameras from dash mounts to ceiling mounts because it provides a better view of the road and dash mounts are more intrusive to operators. When there is a large snowfall, snow can build up on the hood of the plow and block the camera view. Ceiling mounts alleviate this problem.

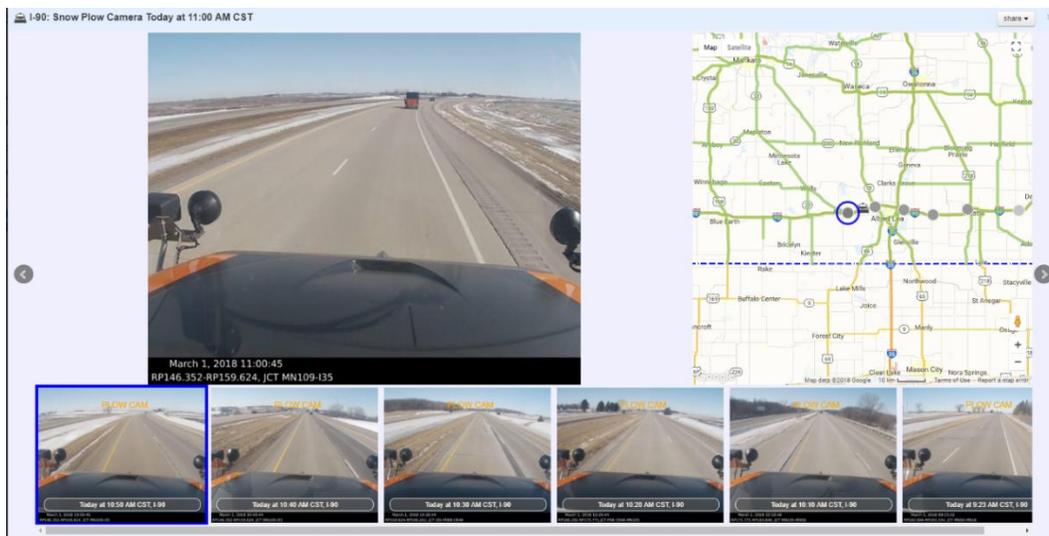
In 2017, Minnesota completed a research project on “Installing Snowplow Cameras and Integrating Images Into MnDOT’s Traveler Information System.” The final report and technical summary are available at: <http://dotapp7.dot.state.mn.us/projectPages/pages/projectDetails.jsf?id=18470&type=CONTRACT>. MnDOT has been sensitive to potential resistance to tracking plows and providing camera images so they surveyed operators, supervisors, and the public and included this information as part of the final project report found on MnDOT’s Research Services website. The survey showed few operators had concerns and found that most operators did not feel plow cameras posed a distraction. The 511 and communications offices reached out to the public through social media to get feedback. The public had a very positive response to the cameras. District offices also view plow cameras positively and would like additional cameras to expand the snow plow camera network.

Additional information gathered during the Peer Exchange Webinar - August 26, 2018

During the summer of 2018, MnDOT transferred over to WebMDSS to help counties and the DOT be more proactive. Currently mobile data is called in by the supervisor but MnDOT’s goal is to have an MDSS report sent to 511 directly. This would allow MnDOT to more easily introduce a system like Track a Plow that is currently not available.

MnDOT has experienced some challenges with communications, 511, and AVL providers not being on the same page but beyond software development they have not had a lot of issues. Different vendors working together takes time so that needs to be planned for.

**Screenshot of Plow Camera Image from Minnesota Traveler Information Website:**



DOT: ■ Normal ■ Partially Covered ■ Completely Covered ■ Travel Not Advised Plow Cameras

## Montana DOT (MDT)

### Phone Interview Summary - February 26, 2018

During the winter of 2015-16 Montana began a pilot project that added cameras to 10 of their 550 snow plows throughout the state. The idea for the pilot project occurred when MDT was looking into fixed camera locations and was contacted by a vendor who suggested plow cameras. The 10 camera installs are on tow plows spread across the state. These cameras and plows are still being used and MDT hopes to add 2 additional plow cameras soon, one in the northern portion of the state and one in the southern portion of the state. One issue that Montana has experienced is that not all their hardware is the same, making expansion more difficult.

Though Montana's plow trucks are equipped with AVL, MDT found that for their purposes it was better to track truck locations using GPS. Cameras and modems are activated when the truck ignition is turned on and the first image is posted to the website. There is no speed limit associated with the truck but if the truck is stationary, no second image is posted. Montana's plow cameras take a photo every ½ mile and are available on the website for 30 minutes. Images also include air temperature and surface temperature which has been beneficial to internal and external users. Montana has chosen not to archive images.

MDT uses both forward and rear facing cameras, but they have experienced some difficulty keeping the rear cameras clear. Montana's plow cameras are cell-based so MDT is dependent on their cell provider for connectivity. Images are automatically uploaded to the vendor server and pushed to the DOT. Though Montana does not have complete cell coverage border to border, when a plow is in an area with a coverage gap, the cameras store the images until the truck is back in cell service where they can do a data dump.

MDT's snow plow cameras are set up to take video, but the DOT does not stream the video and it is not stored. Instead, the video is received by the vendor and MDT logs into the vendor website to view videos. No video is provided to the public.

Though both forward and rear cameras are available, MDT only provides forward facing camera images to the public. The forward-facing cameras are mounted in the cab of the truck and hang from the visor by a suction cup on the passenger side. The photo quality is good and nighttime images seem to work well with just headlights. However, new cameras that are purchased will be upgraded and may have a new interface.

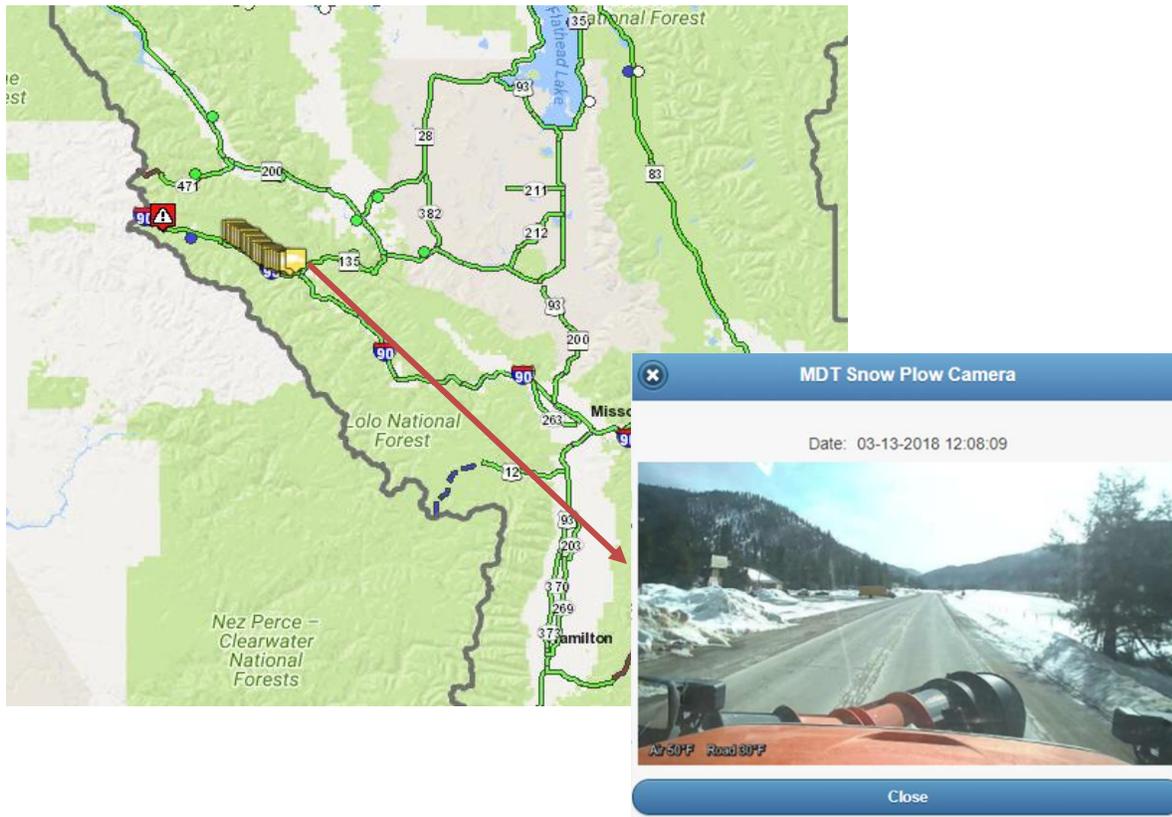
MDT first started collecting camera images for internal purposes and then invited the public to view the images on the pilot project beta site, not knowing if the existing system would handle the additional views and images. MDT received great public feedback and then migrated the images to the main traveler information site. This is the second winter MDT has provided snow plow images to the public.

There has been little feedback from snow plow drivers. Most felt the cameras were a useful tool. Only one driver seemed uncomfortable having the camera. In fact, some drivers even use the camera images to check to see where the plow has been when they start their shift to help them determine which part of their area to focus on.

Montana DOT feels they have had minimal issues with public perception, perhaps due to starting with a pilot project. In a few instances MDT has received a public inquiry because the individual did not understand that the plows were out even if there were no images were posted on the website since cameras were not installed on all plows. This has not been an overwhelming problem, perhaps since they told the public what to expect and how it works and accepted public feedback throughout the project.

Montana Department of Transportation acknowledges that people appreciate having access to the camera images so once a DOT starts providing plow camera images it must be willing to support the technology and consider expansion. Their advice to other DOTs would be to be proactive and ready to expand both for the public and internally for maintenance management.

**Screenshot of Plow Camera Image from Montana’s Traveler Information Website:**



## North Dakota DOT

### Phone Interview Summary - February 22, 2018

North Dakota launched a Track-A-Plow pilot program mid-January 2018. They implemented a GPS tracker on 47 of the state’s 350 plows to assure legislators and the public that the DOT was continuing to plow the roads and maintain the same level of service after closing 8 garages. The GPS tracker uses the North Dakota traveler information map to show plow speed, time, and direction to the public and provide bread crumbs to identify the plow location for the last 15-20 minutes.

Cellular service throughout the state is reliable and plows use cellular service to report back to North Dakota’s 511 map. If the plow is turned off or is moving at less than 3 mph it is not shown on the map. Data is pulled every 2 minutes. The GPS unit is not connected to the spreader, so they are not able to communicate to the public whether the plow has put down any material, but they are able to retrieve engine diagnostics for internal use. Historical information beyond a few days is not stored by NDDOT but Verizon’s Networkfleet software collects data for internal use such as creating geofences.

Since NDDOT has tested AVL for years, plow drivers were aware of what it could do for them and did not provide much resistance. There have been media reports on the Track-A-Plow pilot but with relatively few major winter events since the implementation, there has been little to drive public comment.

To provide the public with additional information when making driving decisions, cameras would have been a nice feature, however, cameras were not installed due to limitations of the contracted devices and the costs associated with installing and maintaining them. NDDOT plans to continue to use GPS trackers to provide traveler information and is in the process of adding 61 GPS trackers to plows this winter, equipping at least one plow in every garage with a GPS tracker.

### Screenshot of Track-A-Plow from North Dakota’s Traveler Information Website:

The screenshot shows a web browser window with the URL [www.dot.nd.gov/travelinfo/m/map?id=roads&id=severe&id=sections&id=snowplows](http://www.dot.nd.gov/travelinfo/m/map?id=roads&id=severe&id=sections&id=snowplows). The page header includes the ND ROADS logo and the text "Official Portal for North Dakota State Government".

On the left side, there are two main sections:

- Road Conditions:** Updated: 02/22/2018 11:11:01 AM. Road conditions updated daily from 5am to 10pm Central Time including holidays. A legend lists various conditions: No Travel Advised, Ice/Compacted Snow, Scattered Ice, Snow Covered, Scattered Snow Drifts, Frost, Scattered Frost, Wet/Slush, Scattered Wet/Slush, and Seasonal/Good.
- Track-A-Plow (Pilot Project):** Active Plows (1 reporting) and Plow Trails.
- Track-A-Plow Sections:** Sections.

The main map area shows a road network with several orange icons representing plows. A detailed view of plow **02 JAMESTOWN 9733** is shown below the map:

- Last Speed: 58 MPH
- Avg. Speed: 58 MPH
- Heading: 239°
- Last Update: Thu Feb 22 2018 11:28:26 GMT-0600 (Central Standard Time)

## **Pennsylvania DOT (PennDOT)**

### *Phone Interview Summary - February 22, 2108*

PennDOT explored plow cameras for video analytics but tabled that discussion because they did not have the technical expertise at the time. Instead, PennDOT has installed AVL on its nearly 3,000 plows to increase maintenance efficiencies and improve operations. A second reason for implementing AVL was to improve traveler information.

In 2014-15, PennDOT created a pilot project that equipped 700 plows with an AVL system that used in-truck technology to log and share data in real-time. The AVL system pilot was part of the Governor's Office of Transformation, Innovation, Management and Efficiency (GO-TIME) initiative to leverage interagency coordination and collaboration to maximize efficiency, modernize state government operations, and provide the highest-quality services. The pilot is expected to save \$1.4 million over the next four to six years based on reduced salt usage and better use of department equipment.

After the first year, the program expanded to improve the user experience and include all plows used by PennDOT, some owned by the state and some that were rented. Consequently, all plows used by PennDOT have AVL tracking. New plows are purchased integrated with AVL while older plows have been retrofitted with an aftermarket device. Each AVL unit sends a cellular signal that broadcasts the plow location, speed, and heading. New PennDOT-owned plows also can indicate if material is being spread from the truck. Additional data including spreader rate, speed, headings, and temperature is used internally and stored in the software history logs.

When the plow is turned on, PennDOT's AVL system is on. PennDOT's AVL system communicates information back to PennDOT using a cell phone every 30 seconds and location information is stored at PennDOT for at least 1 year to address operational issues and right to know requests. Occasionally plows may be in a dead zone or urban canyon but once they reconnect, the AVL system will do a large data dump to update the system. If a plow doesn't move for 30 minutes or is turned off, it will not appear on the 511 map. During the pilot, truck locations and breadcrumbs were provided with a 2-hour history, but by year 2, a 6-hour history was maintained to allow plows time to clear arterials. By 2017, a trip planning tool using Google API was used to show incidents, winter road conditions, plow locations, and historic plow information and a 12-hour history that used colored bands with bread crumbs was provided.

The public can view active plow trucks on interstates and expressways at PennDOT's 511 website. Using the AVL data for traveler information requires massaging the data although integration to the 511 website is primarily handled by the 511 vendor. Snow plow icons are date stamped with a plow location and direction and plows shown with numbers indicate the number of plows in the area. Selecting a plow on the map shows that plow's most recent information including a historical bread crumb trail.

PennDOT uses AVL to: monitor vehicle movement and plow-route coverage, monitor the system during winter storms or emergencies and direct trucks to locations as necessary, review data regarding the effectiveness of returning traffic to pre-storm conditions, review materials usage such as salt and anti-skid through the various stages of a weather event, and interface with other department technology to combine real-time weather and road conditions with corresponding material-usage rates.

There has been a lot of public response from the addition of the AVL technology, most of it positive. Prior to implementing the pilot project Pennsylvania had a mobile app that had been downloaded by 60,000 users. Two weeks after the launch of the plow tracking information on the 511 map, PennDOT gained 65,000 new users who downloaded the app. One and a half years later PennDOT reached 220,000 users, noting that one in three site visitors use the plow truck location feature.

Maintenance recommends talking to drivers early to help answer questions and minimize driver resistance. PennDOT worked with the plow drivers' union to reach an agreement prior to implementing the AVL system so most drivers responded either positively or neutrally. Built in 1-2 minute latency in the system seems to have addressed concerns with identifying employee locations in near-real time. In addition, a tv network researched whether three plows shown in the northern part of the state's 511 map were located where the map said they were. The network was able to find all 3 of the plows, resulting in a positive story.

*Additional information gathered during the Peer Exchange Webinar - August 26, 2018*

Going forward, PennDOT may try again to research using cameras to report winter road conditions now that they have the technology in place, but they will need to work with the union.

With the availability of third-party information from vendors such as Waze and HERE, PennDOT has experienced a change in how the public uses their 511 website – from traditional day-to-day traveler information to information primarily for winter weather and emergencies. This has changed how PennDOT views future enhancements to 511.

**Screenshot of Plow Tracked on Pennsylvania's Traveler Information Website:**

