

Installing Snowplow Cameras and Integrating Images into MnDOT's Traveler Information System

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LIST OF ABBREVIATIONS

AVL	Automated Vehicle Location
CARS	Condition Acquisition and Reporting System
DOT	Department of Transportation
FHWA	Federal Highway Administration
GPS	Global Positioning System
IMO	Integrating Mobile Observations
ITS	Intelligent Transportation Systems
MAW	Motorist Advisory Warning
MDC	Mobile Data Computer
MDSS	Maintenance Decision Support Systems
MnDOT	Minnesota Department of Transportation
NCAR	National Center for Atmospheric Research
PoE	Power over Ethernet
RWIS	Road Weather Information System
VDT	Vehicle Data Translator

EXECUTIVE SUMMARY

Need

Weather contributes to approximately 25 percent of vehicle crashes nationally every year. Minnesota motorists can attest to the danger of snowy or icy roads during the winter.

During inclement weather, drivers may know that conditions are generally worse than usual, but they still may make ill-advised decisions when presented with inaccurate, incomplete or vague weather advisories. More information about current and specific dangers can help drivers make better decisions about whether to travel.

Approach

The Minnesota Department of Transportation (MnDOT) sought to bridge the information gap between MnDOT staff in the field and the traveling public with respect to adverse road conditions. This project aimed to augment existing weather advisories with images of road conditions taken from MnDOT snowplows in the field. MnDOT planned to use its existing 511 travel information system—namely, the travel information website and 511 mobile app—to share this information with the public.

Prior to this project, MnDOT had deployed cameras on only 20 snowplows and with limited network infrastructure. Iowa Department of Transportation's (Iowa DOT's) success with a similar plow camera deployment informed MnDOT's approach to this project, although MnDOT's system used different equipment—the onboard mobile data computer/automated vehicle location (MDC/AVL) system—instead of Iowa DOT's cellular phone-based solution.

Deployment Overview

In 2015 and 2016, MnDOT installed network video dash cameras and ceiling-mounted cameras on 226 snowplows. This was approximately one-quarter of MnDOT's total snowplow fleet. The cameras were integrated with the onboard MDC/AVL equipment and automatically captured snapshots of road conditions during plowing. Images were sent to MnDOT's server and then imported in near-real-time to the MnDOT travel information website and MnDOT 511 mobile app for up-to-the-minute use by the traveling public.

After careful consideration of the capabilities and limitations of the cameras, the MDC/AVL system and MnDOT's back-end server, the following key operational features were ultimately selected and implemented:

- The dash cameras automatically recorded images whenever the MDC/AVL system was on.
- The cameras recorded an image of the road ahead of the plow.
- Images were taken once every five minutes and were only retained if the plow was moving at least 10 mph.

- The cameras were capable of taking operator-initiated snapshots and video clips.
- Video clips could be classified into three categories: accident, general interest or work zone.

Plow camera images and metadata (geolocation, plow, camera and conditions) were sent to a MnDOT server, which was upgraded to accommodate the data. MnDOT set a data retention schedule for mobile snapshots and video segments as well as the data server.

Plow images were incorporated into several aspects of MnDOT's 511 travel information system. These included the desktop website, the mobile website and the 511 app. The images were also incorporated into MnDOT's internal website called Condition Acquisition and Reporting System (CARS).

A custom filter was designed to specify whether the image qualified to be shared with the public. For example, images taken when a truck was not on a state highway or when a truck did not meet speed criteria would not appear on the 511 winter weather map layer. Images were plotted on the 511 map in 10-minute intervals, as shown in a detail of the MnDOT 511 website (Figure ES-1). The 511 app functioned in a similar manner.

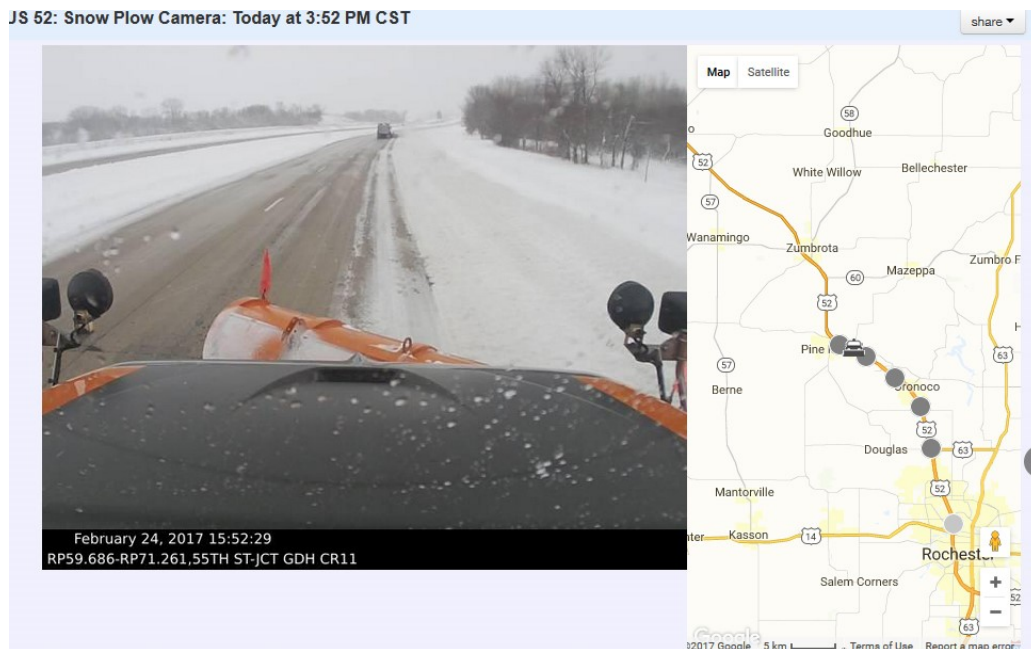


Figure ES-1. Detail of a plow image and map on MnDOT's 511 website.

Driver and Supervisor Perspectives

MnDOT reached out to snowplow drivers and their immediate supervisors using online surveys to learn about their experiences and perspective with respect to the cameras.

The surveys centered on ease of teaching or learning how to use the plow cameras. The general consensus was that the cameras were found to be easy to operate. Most found the cameras to not be a distraction, but a minority of drivers and supervisors were concerned with the distraction posed by

interrupted sightlines and a busier cab. One more prominent outcome was that it was found that the on-demand image and video clip recording were hardly used.

General opinions were also solicited through free-response questions. Drivers' reactions were a nearly even mix of positive, negative and neutral. Supervisors' reactions were much more positive than negative.

MnDOT also interviewed MnDOT managers responsible for the project implementation and gathered perspectives and lessons learned.

Beyond its own staff, MnDOT collected public input via Facebook and the agency's comment form on its website. Public response was largely, but not universally, positive.

Lessons Learned

Following are the significant recommendations drawn from the project and the people surveyed and interviewed:

1. Seek to receive feedback from all staff involved during the development of the project's scope, tying in all stakeholders as early as possible. This will help prevent "scope creep" and changes mid-program.
2. Perform outreach efforts to clearly communicate benefits to achieve broad buy-in from snowplow drivers. Provide training and follow-up instruction on use of the camera's features to encourage drivers to use the manual snapshot and video features.
3. Address drivers' concerns about privacy directly (i.e., "Big Brother is watching") and understand that these concerns have lessened over time. Supervisors should be advised not to react too quickly to these concerns.
4. Address concern about in-cab distraction issues by adjusting the system configuration or hardware. This might include making dash camera screens dimmable at the driver's option, or placing screens and cameras out of critical sightlines.

Final Recommendation

Although there is some room for improvement with this program, this project was judged almost unanimously to have been a success. The snowplow camera images provided significant benefit to MnDOT staff and the traveling public, and the efforts and expense spent in technical implementation were justified by the project outcomes.

It is recommended to install AVL cameras on additional snowplows in the state fleet as deemed necessary by district management and to continue to support the display of snowplow images on MnDOT's 511 system.

CHAPTER 1: INTRODUCTION

1.1 RESEARCH NEED

Weather contributes to approximately 25 percent of vehicle crashes nationally every year. Minnesota motorists can attest to the danger of snowy or icy roads during the winter.

During inclement weather, drivers may know that conditions are generally worse than usual, but they still may make ill-advised decisions when presented with inaccurate, incomplete or vague weather advisories. More information about current and specific dangers can help drivers make better decisions about whether to travel.

1.2 PROPOSED SOLUTION

The Minnesota Department of Transportation (MnDOT) sought to bridge the information gap between MnDOT staff in the field and the traveling public with respect to adverse road conditions. This project aimed to augment existing weather advisories with images of road conditions taken from MnDOT snowplows in the field. MnDOT planned to use its existing 511 travel information system—namely, the travel information website and 511 mobile app—to share this information with the public.

1.2.1 Potential Benefits

With near-real-time images of the actual road conditions encountered by snowplows, drivers can better understand the conditions they will encounter while on the road. Moreover, visually supplementing weather advisories can result in greater public confidence in the accuracy of the recommendations and lead to better, safer choices by road users.

1.2.2 Desired System Features

MnDOT set out to develop a program to acquire and disseminate road condition images from snowplows that included:

- Recording pictures and video.
- Transmitting images to a computer server.
- Disseminating images to the public.
- Promoting the availability of such images to the public as a supplement to posted travel advisories.

1.2.3 Agency Support

There was broad interest at MnDOT to expand the use of snowplow cameras for both internal use and traveler information. Support for this idea came from a diverse group, including the assistant commissioner, the division director, the district engineer, the Operations Management Group and the

Public Communications Group. Members of the Road Weather Technology Group visited with personnel from a variety of offices and districts to help ensure this idea was moved in a direction that best met MnDOT's needs.

1.3 PREVIOUS STATE OF PRACTICE

1.3.1 Iowa DOT

This project sought to replicate the success of a similar project in Iowa. Prior to the start of this project, the Iowa Department of Transportation (Iowa DOT) had installed mobile phones on the dashboards of its snowplows and developed an app that prompts the phones to take a snapshot at predetermined intervals when the trucks are in motion (over 10 mph).

Most of Iowa's snowplows were equipped with a mobile data computer/automated vehicle location (MDC/AVL) system, but did not have the communications bandwidth capacity to handle images. Since Iowa DOT uses cellular data for both MDC/AVL and the cellular phones (iPhones), each truck required two data plans with monthly charges. At a cost of \$30 to \$50 per data plan, this amounted to a significant sum when implemented fleetwide.

Iowa DOT also developed an internal process to gather and serve these images to maintenance managers and the general public over the Internet. Initially this was done on about 100 trucks for testing and evaluation purposes.

Iowa DOT's Track a Plow web service

([http://iowadot.maps.arcgis.com/apps/webappviewer/index.html?id=](http://iowadot.maps.arcgis.com/apps/webappviewer/index.html?id=3d5bc4ec8c474870a19c7e8f44b39c9c)

[3d5bc4ec8c474870a19c7e8f44b39c9c](http://iowadot.maps.arcgis.com/apps/webappviewer/index.html?id=3d5bc4ec8c474870a19c7e8f44b39c9c), Figure 1.1) proved popular with the public and news media, and Iowa DOT has now expanded the number of devices to include 300 snowplows, which is approximately 50 percent of its fleet.

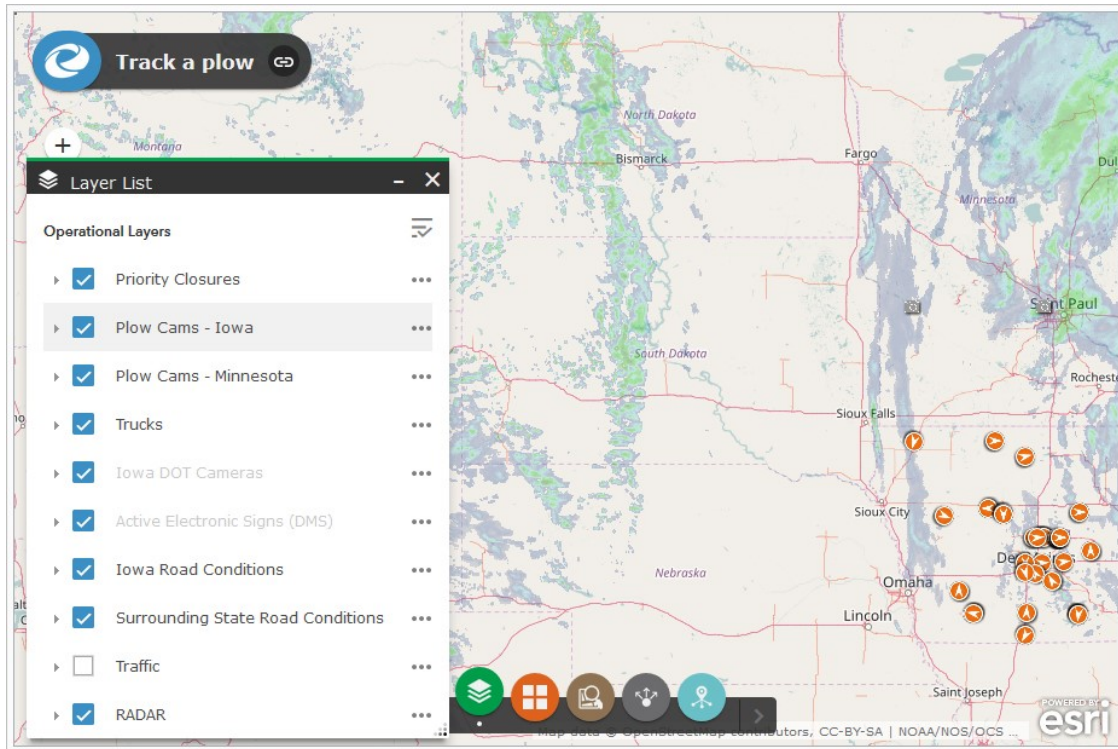


Figure 1.1. Iowa DOT Track a Plow interactive screen.

1.3.2 Minnesota DOT

MnDOT had been testing cameras connected to its snowplow MDC/AVL equipment for a few years preceding this project and had experienced good results. However, MnDOT had previously not made the images available to the public.

Approximately 20 snowplow cameras were deployed throughout the state, primarily in areas that requested them or ones involved with an ongoing Federal Highway Administration (FHWA) project, the Integrating Mobile Observations (IMO) project.

Images from the IMO snowplows were used to verify predicted road surface conditions produced by the National Center for Atmospheric Research (NCAR) Vehicle Data Translator (VDT) and Motorist Advisory Warning (MAW) systems.

1.3.2.1 Existing System Features

The equipment already in use by MnDOT and its collection/storage process was considerably different from Iowa DOT's. MnDOT designed its system to verify road conditions and provide images to select groups of internal users. By contrast, Iowa DOT's solution was designed to be quickly deployable for public use.

MnDOT's system relied on network video cameras connected to MDC/AVL systems installed in its snowplow fleet. The MDC/AVL systems were connected to the cameras via an Ethernet connection and were able to control the camera functions. Features included taking periodic and operator-initiated snapshots as well as recording and storing video.

At the start of this research project, MnDOT captured and transmitted one image per minute from these cameras and stored these images in a database for two weeks. This configuration worked well for testing purposes, but the server would not have been able to support this collection frequency and storage duration on a fleetwide basis without considerable modifications. MnDOT elected to change the collection frequency to one image every five minutes to reduce the server demands.

CHAPTER 2: DEVELOPMENT AND DEPLOYMENT

2.1 OVERVIEW

MnDOT's Office of Maintenance, together with its Operations Management Group and Communications Group, implemented the expanded collection and the display of camera images from MnDOT snowplows.

This project was conducted in two phases:

- Phase 1—Image collection and internal image viewer development. This work was conducted from April 2015 to November 2015.
- Phase 2—Development of the public 511 interface. This work was conducted from August 2015 to July 2016.

2.2 PHASE 1—IMAGE COLLECTION AND INTERNAL IMAGE VIEWER DEVELOPMENT

In 2015 and 2016, MnDOT installed network video dash cameras and ceiling-mounted cameras on 226 snowplows. This is approximately one-quarter of MnDOT's total snowplow fleet. The cameras were integrated with the onboard MDC/AVL equipment and automatically captured snapshots of road conditions during plowing. Images were sent to MnDOT's server and then imported in near-real-time to the MnDOT travel information website and MnDOT 511 mobile app for up-to-the-minute use by the traveling public.

The dash cameras interfaced with the MDC/AVL system already installed in these snowplows. The AVL/camera system has the ability to accommodate up to four cameras per vehicle.

The MDC/AVL system records snowplow locations, road conditions, weather conditions, sander controller data and other information, and then collects and transfers the information and dash camera images to a data server the maintenance supervisors can access.

Dash cameras were primarily used on high-volume roads, such as Interstate 35, Interstate 90 and Interstate 94. The cameras were evenly distributed around the state for constant coverage.

2.2.1 Operational—In-Vehicle

2.2.1.1 Considerations

During the course of project development, MnDOT considered the following key design issues related to the vehicle side of the system:

- **Streaming snapshots and video**—Streaming still images were an existing part of the project scope, but beyond that, MnDOT considered streaming video. Streaming video has become very

popular, and the AVL/camera system for this project was fully capable of supporting this feature.

However, cellular data transmission speed, storage and website bandwidth needs are higher for video compared to photos. MnDOT focused on developing a system that was affordable, useful to maintenance managers and useful to the public. MnDOT ultimately decided to allow video capture on the vehicle, but limited it to being downloaded manually rather than via network connection.

- **Automatic snapshots and manual snapshots and video**—MnDOT’s plan was to take snapshots at predetermined intervals and then use information from the Global Positioning System (GPS) to determine whether the vehicle was moving at least 10 mph; otherwise, the image would only be stored on the AVL system in the snowplow for four days and not be sent to the servers.

The system had the capability of adding a feature to the AVL touchscreen to allow the operator to select a snapshot on demand. For example, the operator could take a photo of a broken sign, a damaged guardrail or other roadside feature. These snapshots would be sent to the MnDOT server so maintenance crews could view them, but they would not be available to the public. The plow operators would also have the ability to capture live video if they wanted to record an accident or other problem. Upon the operator’s deciding to record a video clip, the camera would record and store the data on the MDC for later download.

To aid the operator in capturing video, the AVL screen would function as a viewer when recording. This would give the operator the ability to adjust truck or camera position to make sure the camera was recording what the operator intended to record.

- **Transmission frequency and image size**—For images that needed to be transmitted via network (typically for regular plowing operations), a balance was needed between data transmission rates, image size and frequency of transmission. When snowplows were operating in areas with poor or no cell service, the store-and-forward feature built into the MDC would keep the data and transmit when service quality became higher. However, in large areas with poor signal, the service was not able to catch up and transmit the other MDC/AVL data. In these cases, the MDC was individually configured to address this constraint.

2.2.1.2 Operational Specifications

The dash cameras automatically recorded images when the MDC/AVL system was on.

During its normal functioning, a camera recorded an image of the road ahead. Images were taken once every five minutes and were only retained if the plow was moving at least 10 mph.

The cameras were capable of taking operator-initiated snapshots.

The cameras were also capable of taking operator-initiated video. The data retention schedule (see the next section) allows time for downloading of the video to a laptop computer, if needed. Videos saved on

the onboard computer were marked as accident, general interest or work zone. Based on bandwidth considerations (see previous section), video streaming was not enabled.

2.2.1.3 Data Retention Policy

The retention policy for mobile image data stored on the MDC is as follows:

- Mobile snapshots:
 - The MDC will hold snapshots for two days.
 - Snapshots older than two days are automatically deleted.
- Mobile video segments:
 - The MDC will hold nonaccident video segments for four days.
 - The MDC will hold all accident video segments indefinitely, until they are manually downloaded.
 - After accident videos are manually downloaded by local Ethernet port and laptop, they will be marked as “offloaded,” then scheduled for deletion within the standard four-day automatic deletion cycle.
 - This will allow for second or third offload actions if the first attempt fails or if initially offloaded accident segments are misplaced.
 - Nonaccident video segments older than four days will be automatically deleted.

2.2.2 Operational—Server

2.2.2.1 Server Data Retention

MnDOT chose a time period that allowed users to retrieve images to resolve questions and troubleshoot issues while keeping storage demands at a manageable level.

The image retention policy for MnDOT’s server was decided as follows:

- The server will hold snapshots for two weeks (14 days).
- Snapshots older than 14 days are automatically deleted.

2.2.2.2 Internal Image Viewer

MnDOT needed to refine its internal interface so data could be quickly viewed and would not require a high user skill level. Online self-instruction materials were also needed, and it was desired that the system should remain a “one-stop shop,” allowing users to view all mobile data.

MnDOT improved the functionality of its existing image viewer to facilitate easier viewing of images by MnDOT personnel through MnDOT’s AVL website. MnDOT staff members were issued usernames and passwords upon request.

2.2.2.3 Data Transfer Mechanism

Realizing that the public, news outlets and other commercial entities might be interested in acquiring MnDOT's mobile data and images, a well-defined data dictionary and method of collection were established so that all parties could access this data according to their needs. This access could range from complete access to more limited access of what MnDOT chooses to make available (i.e., only the latest image, or only images that MnDOT feels would not give public viewers a misleading characterization of the roadway). One example of this would be to only serve up images taken when the snowplow is operating on a state highway, as there are many situations where a MnDOT vehicle is doing legitimate work that could look questionable when viewed only as a snapshot by people unfamiliar with MnDOT's operations.

2.2.3 Technical

2.2.3.1 In-Cab Camera Specifications

To meet the project needs, the minimum specification requirements for the in-cab fixed network camera were determined. Both the dash-mounted and dome-mounted camera models meet these specifications.

- **Network camera:**
 - Image sensor—Progressive scan RGB CMOS 1/2.7 inch.
 - Lens—2.8 mm, 80° view, F2.8, fixed iris, adjustable focus.
 - Minimum illumination/light sensitivity—1.5 lux.
 - Shutter time—1/8000 second to 1/16 second.
 - Network camera used:
 - Dash—**AXIS Communications brand, model M1025** (Appendix A and Figure 2.1).
 - Dome—**AXIS Communications brand, model M3004-V** (Appendix B and Figure 2.2).
- **Video:**
 - Resolution—640 x 360.
 - Compression—Motion JPEG.
 - Frame rate—30 frames per second.
- **Audio:** Not required.
- **Network:**
 - Security—Password protection, HTTPS encryption.
 - IP address—Assigned static IP address.
 - Supported protocols—IPv4/v6, QoS, HTTP, HTTPS, FTP, SMTP.
- **General:**
 - Casing—Dark color, IP42 water- and dust-resistant, IK08 impact- and vandal- resistant.
 - Memory—256 MB RAM, 128 MB Flash.
 - Power—Power over Ethernet (PoE) IEEE 802.3af/IEEE 802.3at Type 1 Class 1.

- Power source used—Air 802 brand, model PDCPOE1248DR (Appendix C).
- Operating conditions—0°C to 45°C, 15% to 85% RH (noncondensing).
- Weight—less than 2 pounds.
- Warranty—1 year full replacement, 3 year limited.
- **Accessories:**
 - PoE injector—IEEE 802.3af compliant, Mode B, 15W, 1-port, low-profile, mountable, plug-and-play.
 - Network cable—1-foot and 10-foot Ethernet Cat5 with coupler.



Figure 2.1. Dash-mount camera.



Figure 2.2. Dome-mount camera.

2.2.3.2 MDC Camera Specifications

The enhanced features of the MDC camera software are as follows:

- **Cameras:**
 - Up to four cameras may be attached to the MDC.
 - The first, or “default,” camera will always be facing out the front windshield.
 - The second, “optional,” camera will always look behind the vehicle.
 - It will be possible to attach two additional cameras, but their locations will not be preassigned.
- **Snapshots:**
 - The camera interface will automatically capture snapshots every five minutes as a default, or will be configurable.
 - Other snapshot capture rates will be available.
 - The camera interface will only send images that were acquired at-speed, unless the “At-Speed” threshold parameter is turned off.
 - The default “At-Speed” threshold will be 10 mph.
- **Snapshot Control page:**
 - In order to allow operators to change camera parameters, a “Snapshot Control” page will be implemented, accessible from the MDC’s “Main” page.
 - Operator-initiated (manual) snapshots will always be sent to the data center regardless of the “At-Speed” threshold setting.
 - This page will:
 - Display the currently acquired image.
 - Include the snapshot rate and “At-Speed” threshold parameters.
 - Include indicators that will flash green for one second when an image is acquired and flash green for one second when an image is sent to the data center.
 - Display various status information, such as the total number of cached images waiting to be sent.
 - Include a button that will allow operators to manually acquire snapshots.
 - Include a button that will allow operators to jump to a “Video Control” page.
 - Provide buttons that will allow operators to manually step through cached snapshots or return to the current snapshot.
- **Video:**
 - MnDOT has chosen a camera family that can also capture full-motion video.
 - When necessary, vehicle operators will be able to switch from snapshot mode to video mode.
 - Vehicle operators will be able to mark the content type of the video they are acquiring.
 - “Accident” will always be the most important marked category.
- **Video Control page:**
 - The “Video Control” page will contain buttons that will allow operators to start and stop the acquisition of full-motion video.
 - Video will be recorded in three-minute segments.
 - The operator must remain on this page to record video.

- Leaving this page will cause video recording to stop.
- An indicator will turn green when video is being recorded; otherwise, this indicator will be gray.
- Operators will be able to mark the type of video they are recording:
 - A “Mark Video” type selection page will be provided.
 - If no video type is selected, segments will be marked as “general interest.”
 - The most important video type will be “accident.”
- The “Video Control” page will always display the full-motion video being recorded.
- A button will be present on this page that will take the user to a “Video Offload” page.
- A “Done” button will allow operators to quickly leave this page.
- The MDC will notify the data center with a “Video Segment” message every time a new three-minute video segment begins recording.
- **Mark Video type selection page:**
 - The “Mark Video” type selection page will contain a collection of buttons that will allow operators to mark the type of video being recorded.
 - The following video types will be able to be marked:
 - General interest.
 - Accident.
 - Work zone.
 - No type selection is actually required; that is, the “Done” button may be selected. This will mark the video as “general interest.”
 - Selecting a video type or “Done” will cause video recording to begin.
- **Video Offload page:**
 - The “Video Offload” page will be password-protected.
 - Offloading video will involve selecting a time period that will contain the video segments of interest.
 - The “Video Offload” page will contain a button that will allow operators to offload selected video segments to a network-connected laptop.

2.2.3.3 Image Collection Server Specifications

Improvements to the image collection server included the following new features:

- Active metering of incoming image data rates.
- Real-time information about incoming image files in the production database.
- New extensions to the production relational database to keep track of received images—Database archival of each image’s metadata allows for faster selection of archived images for review. Some of the archived image information includes:
 - File name and location.
 - Date and time each image is received and removed.
 - Vehicle name.
 - Latitude, longitude, resolved address and nearest mile marker.

- Design image summary reports—The database extension for images allows reports to be generated against the collection of archived images. It also allows users to generate summary reports describing which vehicles are generating images, image count and image locations.
- Additional granularity in the file system structure—Unix file system granularity was added to the original file structure. This still keeps the file system relatively flat, but adds separation by vehicle. This still allows for fast file access, but adds convenience for manual searches.

2.3 PHASE 2—DEVELOP PUBLIC INTERFACE (511)

2.3.1 Public Information Considerations

At the project outset, MnDOT emphasized that operating transparently and becoming a trusted source of information play an important part in building support for MnDOT budgets and activities. MnDOT strived to ensure travelers have access to the valuable information the agency collects.

MnDOT's 511 system includes the 511 phone number; four websites (full-featured desktop, streamlined mobile, 3G mobile and a truckers' page); and apps for multiple mobile platforms. Since MnDOT's 511 system is already widely used, this project sought to incorporate data from MnDOT's Road Weather Information System (RWIS), fixed camera images and snowplow camera images into the existing websites and mobile applications.

2.3.2 MnDOT 511 Importer

MnDOT's 511 contractor built an importer to retrieve plow data (see specifications above) as well as the plow camera images from the main file system to create a new data layer for the MnDOT 511 displays. A custom filter was designed to specify whether the image qualified to be shared with the public. For example, images taken when a truck was not on a state highway or when a truck did not meet speed criteria would not appear on the 511 winter weather layer.

The snowplow AVL and photo feeds are updated approximately every minute. The importer polls for updated plow location data and images, with a polling rate selected at five minutes and a refresh rate selected at 10 minutes to best balance the need for fresh information on 511 with limitations on the server and network resources.

2.3.3 MnDOT 511 Features

The imported plow camera pictures were added to MnDOT's full-featured 511 website, its streamlined 511 website and its 511 app for mobile devices. The plow camera pictures are plotted on the map at the geolocations where the snowplows capture them.

In all deployment stages, controls were added to the legends and menus of the various websites to allow users easily to access the new information in conjunction with related data they might also require.

Figure 2.3 shows the interactive screen on the full-featured MnDOT 511 website. The interactive map at right shows the snowplow's route and the most recent location. The large picture at left shows the most recent snowplow camera image, with the smaller images below showing the most recent previous images.

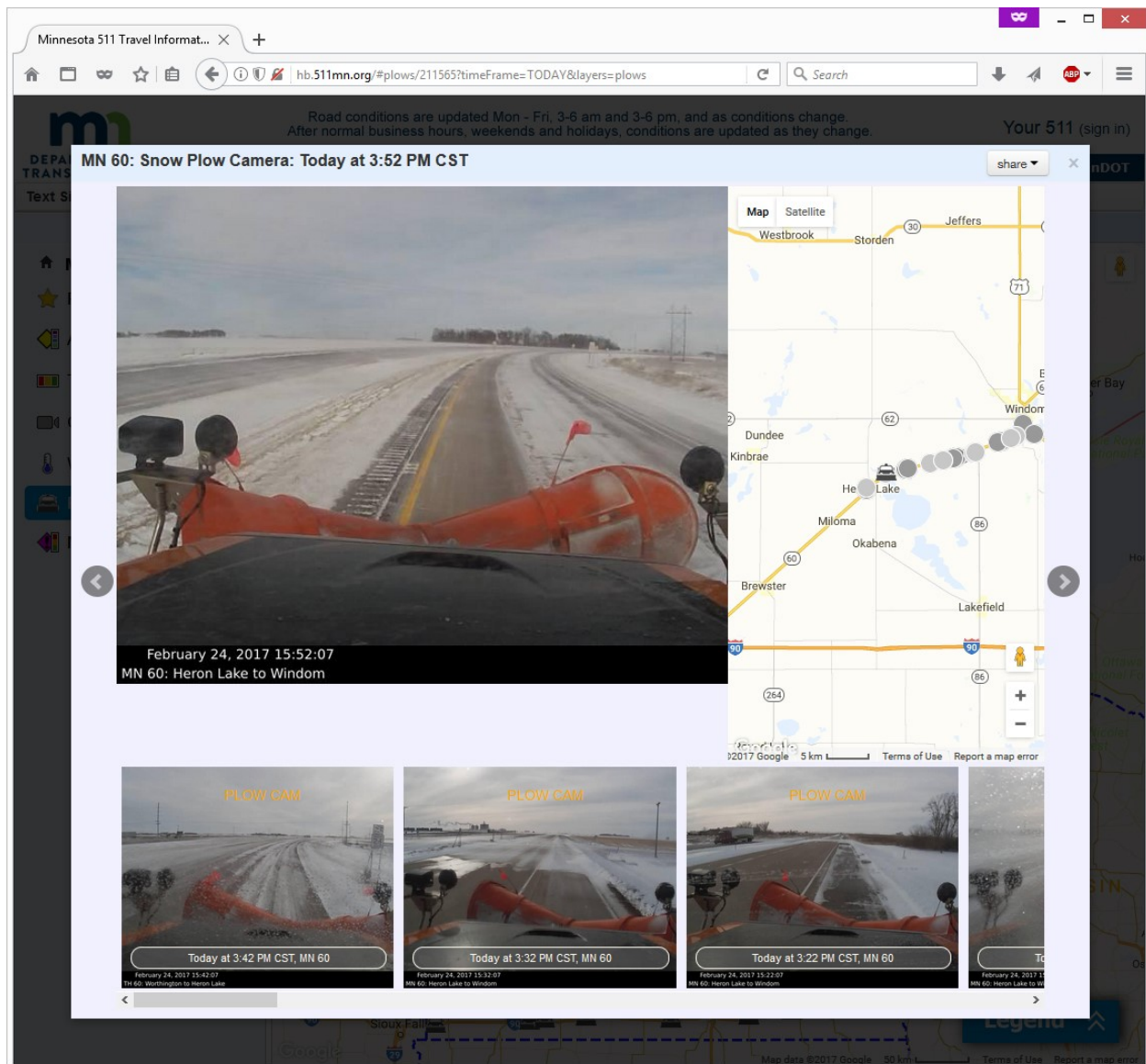


Figure 2.3. Accessing MnDOT 511 plow camera images via the web.

Plow camera images can be similarly accessed on the mobile app by using the “Layers” menu and selecting “Plow Cameras” (Figure 2.4).

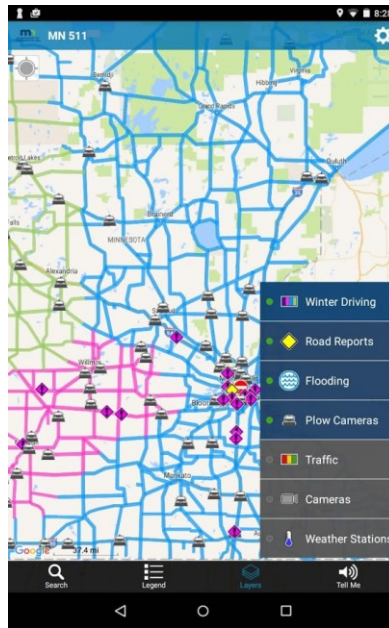


Figure 2.4. Accessing MnDOT 511 plow camera images via mobile app.

The plow camera pictures are also linked to the “Your 511” personalized route reports on the MnDOT 511 website. When users run personalized routes using “Your 511,” the results display plow camera pictures along with the event reports along that route.

2.3.4 Additional CARS Features

The plow camera pictures were also linked to the MnDOT internal website (Condition Acquisition and Reporting System, or CARS) to create “CARS-Segment” reports. When a MnDOT user opens “CARS-Segment” winter driving reports, the website displays current plow camera pictures along that route, lending a powerful visual to the winter driving report. These images may be displayed in a time series/motion video style, which automatically scrolls through the pictures taken along that roadway segment. Users also have the option of clicking through the photos at their own pace, in the linear order in which they were captured along the road.

CHAPTER 3: DRIVER AND SUPERVISOR SURVEYS

3.1 PURPOSE

The two groups of individuals at MnDOT with the most direct hands-on experience with the snowplow cameras were the snowplow drivers themselves and their immediate supervisors. MnDOT was interested in learning about these individuals' experiences and thoughts with respect to the plow camera systems. In May 2017, MnDOT reached out to each of these groups with the use of online surveys. Results follow below. Further analysis of both surveys may be found in Chapter 6, Analysis and Recommendations.

3.2 DRIVER SURVEY

3.2.1 Participants

MnDOT sent the online driver survey to all state maintenance supervisors (89 total) and asked each of them to forward it to three operators that are involved in using the snowplow cameras in the course of their normal maintenance operations.

Among the 267 invited participants, 57 drivers responded, a response rate of 21 percent.

3.2.2 Driver Responses and Analysis

The complete survey and detailed raw responses appear in Appendix D of this report. Following is a summary and analysis of driver responses.

3.2.2.1 Ease of Use

A majority of 47 driver respondents (37 respondents, or 79 percent) indicated that the AVL dash camera feature was easy to use. The remaining respondents (10 respondents, or 21 percent) indicated it was of average difficulty. None indicated that it was hard to use.

An additional nine respondents said by way of free response that they did not use the AVL dash camera, with one indicating that it "did not work properly most of the winter."

3.2.2.2 Nuisance or Distraction

Most of the 54 driver respondents (50 respondents, or 93 percent) indicated that the AVL dash camera was not a nuisance or distraction, and that it did not interfere with their regular duties operating the snowplow.

The remaining four respondents (7 percent) indicated that it was a nuisance or distraction. They offered free-response commentary that addressed privacy ("Felt like I was been being watched, like 'Big Brother' watching me to do something wrong. Felt a little nervous and anxiety like I had to do

everything perfect”; “It seems like it is an infringement of privacy”) and safety (“The camera that I first had in my truck was a safety hazard. It blocked the view of my front mirror that I use all the time when I’m plowing”; “The screen randomly comes on and is bright. The camera is another blind spot on the dash”).

3.2.2.3 Required Attention

Most of the 55 driver respondents (52 respondents, or 95 percent) indicated that using the AVL dash camera in automatic mode to collect regular images required little or no attention. A few (three people) indicated that it required either some attention or significant attention.

3.2.2.4 Snapshot and Video Features

Only three respondents indicated that they used the manual snapshot feature, and only two used the manual video feature. All respondents indicated that these features required either little or no attention or some attention.

3.2.2.5 Free Responses

A total of 23 individuals answered the free-response question that sought additional comments about use of the AVL dash camera feature. These comments can be categorized into four groups: positive, negative, neutral and suggestions. The distribution among positive, negative and neutral comments was fairly even.

- **Positive** comments (seven respondents) centered around how this feature will help the public. One respondent cited several neighbors who accessed the camera to see what the roads looked like before traveling. Another suggested that the still image and video features will also benefit MnDOT from a liability standpoint.
- **Negative** comments (six respondents) addressed the clutter and distraction from the screen and a dislike of having management or the public looking over the drivers’ shoulders. Two respondents stated that the cameras are a waste of money.
- **Neutral** comments (six respondents) generally indicated that drivers don’t pay attention to the camera once they start driving. “Sometimes I forget the dash camera is there.” Nevertheless, one respondent noted that it was still necessary to “keep up to date so you know how to run it when needed.”
- **Suggestions** (four respondents) touched on training, snapshot button placement and camera mounting location. These are reproduced here:
 - “Did not have any training on how to use the camera features. If you are plowing snow you don’t have the time to be playing with a camera. If it had a button on the wheel to take a picture that would be great but when you have to switch screens it takes your attention off what is important out there.”
 - “Have it mounted higher or from the headliner for better pictures of road conditions when snow, ice and road spray build up on the bottom part of the windshield.”

- “I would have to say not to mount them on the dash of the truck. If you do, I would at least talk to the operator and make sure it doesn’t affect his view of operating the truck.”
- “The camera on our 207556 is mounted on the dash, and when it snows the snow piles up right in front of the camera and all you get is a pic of snow. Maybe think about a new placement for that truck?”

3.3 SUPERVISOR SURVEY

3.3.1 Participants

MnDOT sent the online supervisor survey to all state maintenance supervisors (89 in total) and asked each of them to respond.

Among the 89 invited participants, 38 supervisors responded, a response rate of 43 percent.

3.3.2 Supervisor Responses and Analysis

The complete survey and detailed raw responses appear in Appendix E of this report. Following is a summary and analysis of supervisor responses.

3.3.2.1 Ease to Learn and Teach

All of the 35 supervisor respondents indicated that the AVL dash camera feature was easy to learn and teach (20 people, or 57 percent) or of average difficulty (15 people, or 43 percent). None indicated that it was hard to learn and teach.

3.3.2.2 Driver Concerns and Complaints

About a quarter of the 37 supervisor respondents (eight people, or 22 percent) reported that drivers expressed concerns or complaints.

In the free-response section, the most common reported concern was privacy and “Big Brother” watching (five responses). Another concern was screen brightness.

3.3.2.3 Driver Distraction

A minority of the 37 supervisor respondents (five people, or 14 percent) believed that operating the AVL dash camera distracted drivers from their primary duties.

Four respondents noted that the vehicle cab is already busy and any new feature requiring interaction is necessarily distracting. Another commented on screen brightness.

3.3.2.4 Burden on Regular Duties

A few among the 37 supervisor respondents (three people, or 8 percent) indicated that maintaining the AVL dash camera or external hardware added an undue burden to their regular duties of supervising snowplow operations.

One respondent was “having a hard time keeping up on this.” Another mentioned that the hardware restricted line of sight for shorter operators.

3.3.2.5 Free Responses

A total of 12 individuals answered the free-response question that sought additional comments about use of the AVL dash camera feature. These comments can be categorized into three groups: positive, negative and suggestions. These comments were largely positive (nine responses) rather than negative (two responses).

- **Positive** comments (nine respondents) centered around the usefulness of the 511 feature and the overall benefit of being able to see road conditions. Two respondents indicated a desire to see the cameras installed in all plow trucks.
- **Negative** comments (two respondents) indicated that the AVL dash cameras were not a good use of funding and that their benefit did not justify their expense. An already busy vehicle cab and concerns about driver distraction were again mentioned here.
- The **suggestion** (one respondent) was to “have a laminated cheat sheet on different operations of camera/video/storage information to refresh the drivers from year to year.”

CHAPTER 4: MANAGER EXPERIENCE

To gain a fuller perspective on the challenges of implementing AVL dash cameras and integrating the results into 511, interviews were conducted with four MnDOT managers closely involved with this project:

- MDSS/AVL/RWIS section manager.
- RWIS coordinator.
- Transportation program specialist 3, Freeway System Operations.
- Transportation operations supervisor.

Interviews appear in Appendix F of this report. Key findings are summarized in Chapter 6, Analysis and Recommendations.

CHAPTER 5: OUTREACH AND PUBLIC FEEDBACK

MnDOT's Communications Office publicized the snowplow camera feature on MnDOT 511 through a press release and a post on the agency's Facebook page.

5.1 PRESS RELEASE

The text of the press release follows:

Public can view road conditions from MnDOT snowplow cameras

January 25, 2017

<http://www.dot.state.mn.us/newsrels/17/01/25snowplowcameras.html>

ST. PAUL, Minn. – The public can now view winter road conditions from the Minnesota Department of Transportation's new "plow cams" available through the 511mn.org website. MnDOT announced today that some of the agency's 838 snowplows are equipped with cameras that show real-time road conditions along plow routes.

"The plow cams are another way for travelers to make good decisions about their travel plans during the snow and ice season," said Kelly Braunig, 511 program manager. "If they go on the 511 site and see that travel is not advised, they can actually see an image of the road the cameras take as the plow is traveling. Seeing is believing."

Travelers can already see road conditions on major highways from the Road Weather Information System, which is also part of 511. These are fixed cameras at 97 locations across the state that show live rotating photos. While the RWIS cameras show a small area of the road, the plow cams show real-time road conditions as snowplows plow their routes.

"The RWIS and plow cameras are both used for maintenance purposes, and the public also benefits," said Steve Lund, state maintenance engineer. "They give maintenance managers and supervisors a quick snapshot of what's going on in the field but the plow cams will show the road conditions from the driver's seat along a route."

The plow cams are available on the 511 website's full-featured and streamlined pages and the 511 app. They are also available on the "Personalize Your 511" feature, which is on the full-featured and truckers' pages.

To access the plow cams, go to www.511mn.org and click on "Plow Cameras" on the left menu. A window will open to show photos and a map where the plow is. Underneath the current photo and map is a "film strip," showing images every five minutes. The camera will activate when the plow is going at least 10 miles per hour or based on other filtering criteria.

Photos have captions that give the plow number, the date, time and location of the plow. Images will be displayed for two hours. If a new image is not taken for 15 minutes because, for

example, a snowplow has stopped to refuel, the snowplow icon will be removed from the map until the plow is active again.

The active trucks displayed on 511 only represent a portion of MnDOT's fleet for snow and ice and other maintenance activities. Not all of the cameras are fully implemented in the trucks, but 200 cameras were purchased for this winter season. MnDOT is in the testing stage this season, which will allow the agency to make decisions on whether to install additional cameras.

"All the new features we're putting on 511 come down to intelligent transportation," said Braunig. "We want to be on the cutting edge of that. If motorists can just pick one or two features to use, they can make better travel decisions."

For more information on other features of the 511 system go to www.511mn.org.

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Note that the "film strip" interval referenced above was later changed from five minutes to 10 minutes.

5.2 FACEBOOK

MnDOT's January 25, 2017, Facebook page is reproduced in Figure 5.1.

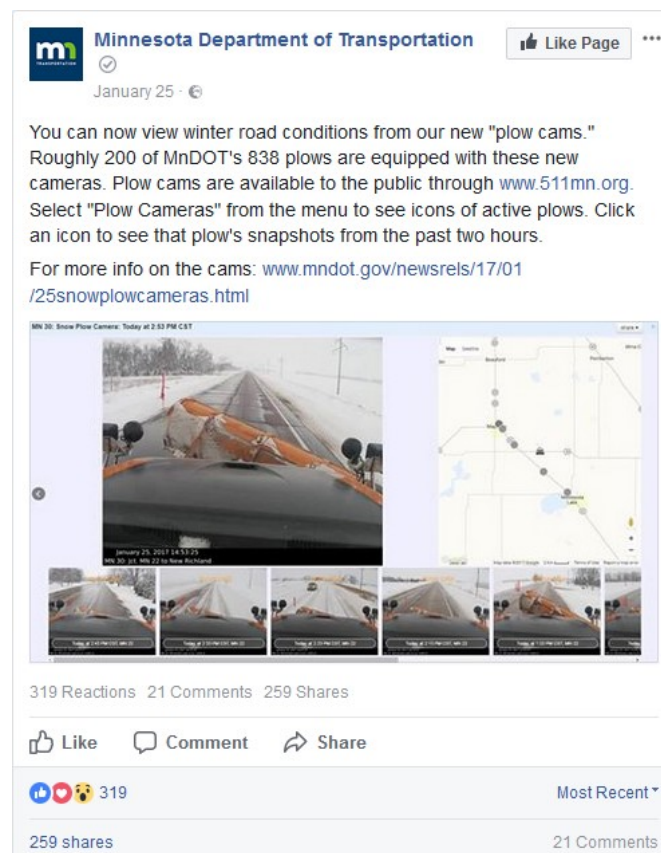


Figure 5.1. MnDOT's plow camera announcement on Facebook.

The text of the post reads:

You can now view winter road conditions from our new “plow cams.” Roughly 200 of MnDOT’s 838 plows are equipped with these new cameras. Plow cams are available to the public through www.511mn.org. Select “Plow Cameras” from the menu to see icons of active plows. Click an icon to see that plow’s snapshots from the past two hours.

For more info on the cams: www.mndot.gov/newsrels/17/01/25snowplowcameras.html

5.3 FEEDBACK FORM ON MnDOT’S WEBSITE

MnDOT also collected feedback on the snowplow camera feature on MnDOT 511 from its all-purpose web-based “Questions or comments” page, <http://www.dot.state.mn.us/information/submit.html>. Users may provide comments of any type in a free-response box labeled “Questions, comments or concerns.”

MnDOT received five responses through this web portal, discussed in the following section of the report.

5.4 ANALYSIS OF PUBLIC RESPONSE

Response statistics on Facebook indicate an extremely positive public response:

- As indicated in Figure 5.1, a total of 319 Facebook users responded using an emoticon, and all of these responses were positive (298 “like,” 12 “love” and nine “wow”; no responses of “sad” or “angry”).
- 259 Facebook users shared this link with others.
- Facebook’s internal metrics report to MnDOT indicated that this post had a reach to 53,676 users.

The public discussion thread about this post is reproduced in Appendix G to this report, with users’ profile photos and last names redacted. Comments collected both by Facebook and through MnDOT’s website, excluding extended Facebook exchanges, are compiled together in Appendix H.

The 20 comments in Appendix H can be categorized into three groups: positive, negative and technical issues. Among these, responses were overwhelmingly, but not universally, positive.

- Fourteen **positive** comments expressed that the plow cameras are “cool” or “slick,” and several individuals extended their thanks to drivers of the MnDOT snowplows. Some individuals noted that they make use of the camera images (“Useful today as I decided whether to venture out this evening in southwest Minnesota”; “This information helps ME make BETTER decisions about venturing out on state, county and Interstate highways on my daily commute of about 45 miles each way”).
- Two **negative** comments both centered on the snowplow cameras not being a good use of money. One person stated that the money could go toward cameras in police cars, and both recommended using the money to fund more plowing.

- Four **technical comments** about the images not being visible in the smartphone app were received shortly after the public announcement of this feature. These issues were quickly resolved.

Beyond the comments above, some additional Facebook comments represent Facebook users sharing MnDOT's post with others.

CHAPTER 6: ANALYSIS AND RECOMMENDATIONS

The following observations and recommendations are drawn from the project summary, the surveys and the interviews.

6.1 LIMITED USE OF ADVANCED FEATURES

The driver survey suggested that the system was on the whole easy to use, but was met with mixed reviews by drivers. The feature that allowed the driver to manually take snapshots and video was only used by a few of the snowplow drivers.

Moreover, some of the drivers who had a negative opinion of the cameras appeared not to have an understanding of the features and benefits.

RECOMMENDATION—*Perform additional outreach to clearly communicate the system’s benefits and foster broader buy-in from the drivers. Couple this with training and follow-up instruction on use of the camera’s features to encourage drivers to use the manual snapshot and video features when warranted.*

6.2 SUPERVISOR AND DRIVER ATTITUDES/CONCERNS

In comparison with the surveyed drivers, the surveyed supervisors had a more positive attitude toward the AVL dash cameras. The two most common concerns cited throughout the survey were drivers’ concerns about privacy and “Big Brother,” and a shared concern among drivers and supervisors alike about in-cab distraction.

Privacy issues were overcome to an extent with time during the project. This outcome is commonplace in other technologies that require relinquishing some level of privacy such as Internet cookies and the use of public spaces with persistent video recording.

RECOMMENDATION—*Address drivers’ concerns about privacy directly (i.e., “Big Brother is watching”) and understand that these concerns have lessened over time. Supervisors should be advised not to react too quickly to these concerns.*

RECOMMENDATION—*Address concern about in-cab distraction issues by adjusting the system configuration or hardware. This might include making dash camera screens dimmable at the drivers’ option, or placing screens and cameras out of critical sightlines.*

6.3 MANAGEMENT CONCERNS

A repeated concern about the plow camera images was that they present a misleading representation of the weather. This was caused because the camera’s shutter was not able to capture falling snow. Some felt this could represent a significant safety issue. To mitigate this potential issue, MnDOT used clear disclaimers about the nature of the images along with traditional weather reporting tools, and this aspect was generally considered to be resolved.

6.4 PROJECT SCOPE AND SCOPE CREEP

During this project, additional stakeholders were identified and involved at various times throughout the project. Because this project touched many different areas within MnDOT, these disparate perspectives were sometimes captured after decisions had been made.

RECOMMENDATION—*Solicit feedback during the development of the scope, tying in all stakeholders at the beginning of the project. Follow a systems engineering approach, such as is performed in the intelligent transportation systems (ITS) field.*

During technical projects, some scope change is expected including evolving customer needs. It is important to plan ahead for such scope variance to allow for acceptable scope creep.

6.5 FINAL RECOMMENDATION

Although there is some room for improvement with this program, this project was judged almost unanimously to have been a success. The snowplow camera images provided significant benefit to MnDOT staff and the traveling public, and the efforts and funds spent in technical implementation were justified by the project outcomes.

RECOMMENDATION—*Install AVL cameras on additional snowplows in the state fleet as deemed necessary by district management, and continue to support the display of snowplow images on MnDOT's 511 system.*

APPENDIX A

DASH-MOUNT CAMERA FACT SHEET

AXIS M1025 Network Camera

Smallest HDTV 1080p camera with HDMI™ and edge storage

AXIS M1025 is ideal for securing locations such as small businesses, restaurants or residences. It uses progressive scan technology to provide superior video quality in HDTV 1080p or 2 megapixel resolution in full frame rate, in multiple, individually optimized H.264 and Motion JPEG streams. The camera features an HDMI™ output (Micro) for live view streaming on a public monitor at HDTV 720p. It has a fixed lens with adjustable focus, and supports the Axis' Corridor Format that optimizes surveillance of long areas. AXIS M1025 can be powered either over Ethernet or with a 5 V DC input, and has support for an on-board memory card.

- > **HDTV 1080p/2 MP quality**
- > **Power over Ethernet**
- > **HDMI output (Micro) in HDTV 720p**
- > **Easy and flexible installation**



AXIS M1025 Network Camera

Camera		General	
Image sensor	1/2.7" progressive scan RGB CMOS	Casing	Color: White NCS S 1002-B Aluminium and polycarbonate
Lens	3.6 mm: 94° view ^a , F2.8, fixed iris, adjustable focus	Memory	256 MB RAM, 128 MB Flash
Light sensitivity	1.5-100000 lux, F2.8	Power	4.9-5.1 V DC, max. 2.4 W Power over Ethernet IEEE 802.3af/IEEE 802.3at Type 1 Class 1 (max. 3.84 W)
Shutter time	1/8000 s to 1/6 s	Connectors	DC jack, RJ45 10BASE-T/100BASE-TX Male RJ45 10BASE-T/100BASE-TX PoE, HDMI (Micro) - Video out compatible with DVI
Pan/Tilt/Zoom	Digital PTZ	Edge storage	Supports for microSD/microSDHC/microSDXC card Support for recording to dedicated network-attached storage (NAS) For SD card and NAS recommendations see www.axis.com
Video		Operating conditions	0 °C to 50 °C (32 °F to 122 °F) Humidity 20-80% RH (non-condensing)
Video compression	H.264 Main Profile (MPEG-4 Part 10/AVC), Motion JPEG	Approvals	EN 55022 Class B, EN 61000-3-2, EN 61000-3-3, EN 55024, FCC Part 15 Subpart B Class B, ICES-003 Class B, VCCI Class B, C-tick CISPR 22, KCC Class B, IEC/EN 60950-1 Power supply: EN 60950-1, cCSAus
Resolutions	1920x1080 (HDTV 1080p) to 320x240	Weight	144 g (0.32 lb)
Frame rate	H.264: 25/30 fps with power line frequency 50/60 Hz Motion JPEG: 15 fps with power line frequency 50/60 Hz	Included accessories	Power supply, Stand and clamp, Installation Guide, Windows decoder 1-user license
Video streaming	Multiple, individually configurable streams in H.264 and Motion JPEG Controllable frame rate and bandwidth, VBR/CBR H.264, MPEG-4 Part 2	Optional accessories	AXIS T8414 Installation Display
Image settings	Compression, Color, Brightness, Sharpness, Contrast, White balance, Exposure value, Backlight compensation, Text and image overlay, Privacy mask, Mirroring, Rotation including Corridor Format WDR-dynamic contrast, Text and image overlay and Privacy mask are not available with HDMI (HDTV 720p capture mode), Rotation: Only 180° for video stream over HDMI	Video management software	AXIS Camera Companion, AXIS Camera Station, Video management software from Axis' Application Development Partners available on www.axis.com/techsup/software
Network		Warranty	Axis 1-year warranty and AXIS Extended Warranty option see www.axis.com/warranty
Security	Password protection, IP address filtering, HTTPS ^b encryption, IEEE 802.1X ^b network access control, Digest authentication, User access log	a. Horizontal angle of view b. This product includes software developed by the OpenSSL Project for use in the OpenSSL Toolkit (http://www.openssl.org/), and cryptographic software written by Eric Young (eyay@cryptsoft.com).	
Supported protocols	IPv4/v6, HTTP, HTTPS ^b , SSL/TLS ^b , QoS Layer 3 DiffServ, FTP, CIFS/SMB, SMTP, Bonjour, UPnP TM , SNMPv1/v2c/v3 (MIB-II), DNS, DynDNS, NTP, RTSP, RTP, TCP, UDP, IGMP, RTCP, ICMP, DHCP, ARP, SOCKS		
System integration		More information is available at www.axis.com	
Application Programming Interface	Open API for software integration, including VAPIX [®] and AXIS Camera Application Platform; specifications at www.axis.com AXIS Video Hosting System (AVHS) with One-Click Connection ONVIF Profile S; specifications at www.onvif.org		
Analytics	Video motion detection, Active tampering alarm Support for AXIS Camera Application Platform enabling installation of AXIS Video Motion Detection 3, AXIS Cross Line Detection, AXIS Digital Autotracking and third-party applications, see www.axis.com/acap		
Event triggers	Intelligent video, Edge storage events		
Event actions	File upload: FTP, HTTP, network share and email Notification: email, HTTP and TCP Pre- and post-alarm video buffering Video recording to edge storage		
Data streaming	Event data		
Built-in installation aids	Pixel counter		

APPENDIX B

DOME-MOUNT CAMERA FACT SHEET

AXIS M3004-V Fixed Dome Network Camera

Fixed mini dome with HDTV 720p performance

The palm-sized AXIS M3004-V is an affordably priced, vandal- and dust-resistant indoor fixed dome camera that supports HDTV 720p and 1 MP resolution. The factory-focused camera is designed for quick and flexible installation. With its 3-axis camera angle adjustment, it can be mounted on walls or ceilings, and images can be easily leveled. AXIS M3004-V offers a horizontal viewing angle of 80° and supports Axis' Corridor Format for vertically oriented video streams of areas such as corridors, hallways or aisles. Support for AXIS Camera Application Platform enables the installation of intelligent video applications such as people counting. A microSDHC slot enables local video storage.

- > **Ultra-compact, vandal-resistant design**
- > **HDTV 720p/1 MP**
- > **Axis' Corridor Format**
- > **Edge storage**



AXIS M3004-V Fixed Dome Network Camera

Camera		Built-in installation aids	Pixel counter
Image sensor	1/4" progressive scan RGB CMOS	General Casing Color: White NCS S 1002-B (for repainting instructions of skin covers, contact your Axis partner), Encapsulated electronics, Captive screws (resitox 10) IP42 water- and dust-resistant, IK08 impact-resistant, polycarbonate/ABS casing PVC free	
Lens	M12 mount, F2.8, Fixed iris, Megapixel resolution 2.8 mm Horizontal angle of view: 80°		
Light sensitivity	1.5–100000 lux, F2.8		
Shutter time	1/8000 s to 1/6 s		
Camera angle adjustment	Pan ±175°, Tilt 56°, Rotation ±175°		
Video		Memory	256 MB RAM, 128 MB Flash
Video compression	H.264 Main Profile (MPEG-4 Part 10/AVC), Motion JPEG	Power	Power over Ethernet IEEE 802.3af/802.3at Type 1 Class 1, max. 2.2 W
Resolutions	1280x800 (1 MP) to 320x240	Connectors	Male RJ45 10BASE-T/100BASE-TX PoE on a 2 m (6.6 ft) network cable, warranty can be maintained even when cable is cut-for more information, contact your Axis partner
Frame rate	25/30 fps with power line frequency 50/60 Hz	Storage	Support for microSD/microSDHC/microSDXC card Support for recording to dedicated network-attached storage (NAS) For SD card and NAS recommendations see www.axis.com
Video streaming	Multiple, individually configurable streams in H.264 and Motion JPEG, Controllable frame rate and bandwidth, VBR/CBR H.264	Operating conditions	0 °C to 45 °C (32 °F to 113 °F) Humidity 15–85% RH (non-condensing)
Pan/Tilt/Zoom	Digital PTZ	Approvals	EN 55022 Class B, EN 55024, EN 61000-6-1, EN 61000-6-2, FCC Part 15 Subpart B Class B, ICES-003 Class B, VCCI Class B, C-tick AS/NZS CISPR 22 Class B, KCC KN22 Class B, KN24, IEC/EN/UL 60950-1 IEC/EN 60529 IP42, IEC/EN 62262 Class IK08
Image settings	Compression, Color, Brightness, Sharpness, Contrast, White balance, Exposure control, Backlight compensation, Wide dynamic range – dynamic contrast, Text and image overlay, Mirroring of images, Privacy mask Rotation: 0°, 90°, 180°, 270°, including Corridor Format	Dimensions	Ø 100 x 27 mm (Ø 4 x 1.1 in)
Network		Weight	200 g (0.44 lb)
Security	Password protection, IP address filtering, HTTPS ^a encryption, IEEE 802.1X ^a network access control, Digest authentication, User access log, Centralized Certificate Management	Included accessories	Installation Guide, Windows decoder 1-user license, Drill hole template, Torx L-key
Supported protocols	IPv4/v6, HTTP, HTTPS ^a , SSL/TLS ^a , QoS Layer 3 DiffServ, FTP, CIFS/SMB, SMTP, Bonjour, UPnP TM , SNMPv1/v2c/v3 (MIB-II), DNS, DynDNS, NTP, RTSP, RTP, TCP, UDP, IGMP, RTCP, ICMP, DHCP, ARP, SOCKS, SSH	Optional accessories	AXIS T94B01D Pendant Kit AXIS T94B01L Recessed Mount AXIS T94B01M J-Box/Gang plate AXIS T94B01S Mount Bracket AXIS T91A27 Pole Mount Accessory lenses, Skin covers (White/Black)
System integration		Video management software	AXIS Camera Companion, AXIS Camera Station and video management software from Axis' Application Development Partners (not included). For more information, see www.axis.com/products/video/software
Application Programming Interface	Open API for software integration, including VAPIX [®] and AXIS Camera Application Platform; specifications at www.axis.com AXIS Video Hosting System (AVHS) with One-Click Connection ONVIF Profile S, specification at www.onvif.org	Languages	German, French, Spanish, Italian, Russian, Simplified Chinese, Japanese, Korean, Portuguese
Analytics	Video motion detection, Active tampering alarm Support for AXIS Camera Application Platform enabling installation of AXIS Video Motion Detection 3, AXIS Cross Line Detection, AXIS Digital Autotracking and third-party applications, see www.axis.com/acap	Warranty	Axis 1-year warranty and AXIS Extended Warranty option, see www.axis.com/warranty
Event triggers	Analytics, Edge storage events	Environmental responsibility: www.axis.com/environmental-responsibility	
Event actions	File upload: FTP, HTTP, network share and email Notification: email, HTTP and TCP Video recording to edge storage Pre- and post-alarm video buffering		
Data streaming	Event data		

a. This product includes software developed by the OpenSSL Project for use in the OpenSSL Toolkit (<http://www.openssl.org/>), and cryptographic software written by Eric Young (ey@cryptsoft.com).

APPENDIX C

CAMERA POWER SOURCE FACT SHEET



PDCPOE1248DR ***DC-DC Converter with PoE Injector***



The AIR802 PDCPOE1248DR DIN rail mount DC to DC converter with PoE Injector output satisfies applications with voltage input from 10 to 26 Vdc where the equipment being supplied requires power-over-Ethernet (PoE) at 48 Vdc.

Applications include powering wireless access points for motor vehicles and marine vessels; 12 or 24 Vdc solar systems; oil and gas industry; and WISPs (wireless Internet service providers).

Features

- Power output to 36 W (0.8 A at 48Vdc) at 75 to 84% efficiency (typical)
- Wide 10 to 26 Vdc input via Ethernet port or plug-in screw terminal
- Input power detection LED
- DIN rail mounting
- One-year limited warranty

PDCPOE1248DR Specifications

Power Input

Input DC Voltage Range: 10 to 26 Vdc
Efficiency: 75 to 84% (typical)
Minimum Current: 3 A @ 10 Vdc
Input Options: PoE or direct screw terminal

Power Output

Output DC Voltage: 48 Vdc
Maximum Current: 0.8 A (0.6 A typical)
Maximum Power: 36 W
Voltage Tolerance: +/- 5%
Short Circuit Protection: Yes
Over Current Protection: Yes
Over Voltage Protection: Yes

Environmental

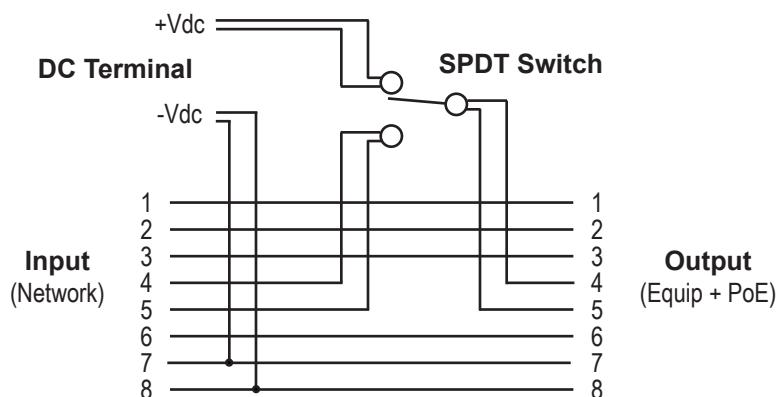
Operating Temperature: -30°C ~ +60°C (-22°F ~ 140°F)
Storage Temperature: -30°C ~ +70°C (-22°F ~ 158°F)
Humidity: 5 to 90% RH

Mechanical

DC Connector Wire Size (AWG): 12, 14, 16, 18, 20, 22, 24, 26
DC Connector Wire Size (mm²): 0.13 to 3.3
Mounting: DIN Rail
Dimensions (H x W x D): 10 x 4 x 9 cm (3.9 x 1.5 x 3.5")
Weight: 224 g (7.9 oz)
Enclosure material: PC UL 94 V-0

Standards-Agency Approvals

UL 60950-1 (in approval process)



Input (Network)			Output (Equip + PoE)	
Pin	Symbol	Description	Symbol	Description
1	RX+	Data Receive (+)	RX+	Data Receive (+)
2	RX-	Data Receive (-)	RX-	Data Receive (-)
3	TX+	Data Transmit (+)	TX+	Data Transmit (+)
4	NC or +Vdc	No connection*	+Vdc	DC power (+)
5	NC or +Vdc	No connection*	+Vdc	DC power (+)
6	TX-	Data Transmit (-)	TX-	Data Transmit (-)
7	-Vdc	DC power (-)	-Vdc	DC power (-)
8	-Vdc	DC power (-)	-Vdc	DC power (-)

* Default is No Connection (input applied to DC terminal), internal switch selectable to +Vdc Input (Network).

AIR802

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APPENDIX D

SNOWPLOW DRIVER SURVEY AND RESULTS

MnDOT is assessing a recent project to collect road condition images on snowplows and integrate them into Minnesota's 511 traveler information system.

As part of this assessment, MnDOT is reaching out to selected snowplow drivers regarding the ease of use of the dash camera in the AVL [automated vehicle location].

We ask for your candid thoughts—your name will not be published in the published survey results, and your honest feedback will be important in making future decisions about this technology.

1. *(Required) Please provide your contact information. (This information will be kept confidential.)

2. How easy or difficult to use was the AVL dash camera feature?

Easy to use	37	79%
Average difficulty	10	21%
Hard to use	0	0%
If you answered "hard to use," please explain. • Never used it. • Have not used. • I never really used it. • Only been in one truck one time with a camera. My truck doesn't have one. Seems silly. The MDSS [maintenance decision support system] gets turned off. I'll ignore a camera too if I ever get one. • Haven't had to use it. • Did not work properly most of the winter, locked up 11/08/16. • I have never been trained to use it. • I don't know how it is used. • Did not use.		

3. Was the AVL dash camera feature a nuisance or distraction? Did it interfere with your regular duties operating the snowplow?

Yes	4	7%
No	50	93%
If you answered "yes," please briefly explain. • Felt like I was being watched like "Big Brother" watching me to do something wrong. Felt a little nervous and anxiety like I had to do everything perfect. • The camera that I first had in my truck was a safety hazard. It blocked the view of my front mirror that I use all the time when I'm plowing. The new one that is mounted on the head liner is much better for that reason. • The screen randomly comes on and is bright. The camera is another blind spot on the dash. It seems like it is an infringement of privacy. • I never used it.		

4. How much attention did the AVL dash camera feature require for regular image collection (automatically taking a still image every five minutes)?

Little or no attention	52	95%
Some attention	2	4%
Significant attention	1	2%

5. Did you use the AVL dash camera feature to take manual snapshots?

Yes	3	5%
No	54	95%
If you answered "yes," under what circumstances? • Damage to property, current drifting conditions. • To see how easy it was to do it. • Just to practice with it.		

6. If you used the manual snapshot feature, how much attention did it require?

Little or no attention	5	9%
Some attention	2	4%
Significant attention	0	0%
Did not use the manual snapshot feature	48	87%

7. Did you use the AVL video feature to create a video (accident, general interest, work zone)?

Yes	2	4%
No	55	96%
If you answered "yes," under what circumstances? • Plow driver sanding operations. • General driving conditions in a snow and ice event.		

8. If you used the AVL video feature, how much attention did it require?

Little or no attention	3	6%
Some attention	3	6%
Significant attention	0	0%
Did not use the video feature	48	89%

9. We welcome any additional comments you have about using the AVL dash camera feature.

Note: The categorization of free responses as positive, negative, neutral or suggestions was completed after the fact by the author of this report. Comments have also been lightly edited for clarity.

Positive

- Have not got into it. I'm sure it will help public.
- I believe this is a great feature. I haven't used it for any general purpose, but I like the capability of the camera. Glad to have it in my truck.

- I have heard from several of my neighbors who accessed the camera online to see what the roads looked like before traveling. I believe the public likes this.
- I think it is a good idea. I wish I had more of a chance to use it and see the images that I would have taken during an event.
- I think it's a good tool.
- I think the AVL still image and video feature are a good idea for the customers and for liability purposes to protect the MnDOT and the employee.
- I think the dash cams are a very useful tool.

Negative

- I feel it's a very strong distraction and that we don't need the public seeing everything we do because they're not going to understand it anyway.
- I have not seen any benefit of the AVL dash camera.
- I think our trucks are too cluttered with wires and screens. I hope they don't cause an electrical malfunction that leaves us stranded in a blizzard.
- Not a fan of the public or manager's watching over my shoulder, while I perform my job duties.
- This is a waste of taxpayers' money.
- Waste of money.

Neutral

- I did not notice any problems with it and it was not a distraction.
- Just never use it or think about it. It's on when I start the truck and I never pay attention to it. Sorry.
- Not much to think about. You turn the AVL on and it is automatic. There were a couple of instances where the AVL wouldn't link up and nothing worked but that's not a camera issue. The camera that was in my truck was mounted on the headliner so really not in the way.
- Sometimes I forget the dash camera is there.
- The camera was broken and not working for most of the winter. With this winter being below average for snowfall I can't say I had enough time using it to give helpful feedback.
- You really don't know it's there, but you need to keep up to date so you know how to run it when needed.

Suggestions

- Did not have any training on how to use the camera features. If you are plowing snow you don't have the time to be playing with a camera. If it had a button on the wheel to take a picture that would be great but when you have to switch screens it takes your attention off what is important out there.
- Have it mounted higher or from the headliner for better pictures of road conditions when snow, ice and road spray build up on the bottom part of the windshield.

- I would have to say not to mount them on the dash of the truck. If you do, I would at least talk to the operator and make sure it doesn't affect his view of operating the truck.
- The camera on our 207556 is mounted on the dash, and when it snows the snow piles up right in front of the camera and all you get is a pic of snow. Maybe think about a new placement for that truck?

APPENDIX E

SUPERVISOR SURVEY AND RESULTS

MnDOT is assessing a recent project to collect road condition images on snowplows and integrate them into Minnesota’s 511 traveler information system.

As part of this assessment, MnDOT is reaching out to selected snowplow supervisors regarding the ease of use of the dash camera in the AVL.

We ask for your candid thoughts—your name will not be published in the published survey results, and your honest feedback will be important in making future decisions about this technology.

1. *(Required) Please provide your contact information. (This information will be kept confidential.)

2. How easy or difficult was the AVL dash camera feature to learn and teach to snowplow drivers?

Easy to learn and teach	20	57%
Average difficulty	15	43%
Hard to learn and teach	0	0%
If you answered “hard to learn and teach,” please explain.		
- I do not have AVL in my truck and have not used this system. - We didn’t really teach to doing anything extra with the camera.		

3. Did any snowplow drivers who you supervise express any concerns or complaints (formally or informally) about using the AVL dash camera feature?

Yes	8	22%
No	29	78%
If you answered “yes,” please briefly explain.		
- Operator was worried about his privacy. - A little complaining at first, but now it is fine. - The screen flashes too many times and it needs to be a dimmer screen. “Big Brother” is now in the cab with you. Told them it’s more for the public to see real-time road conditions. - Just about “Big Brother” watching them. - Nothing legitimate, though (just grumbling and not listening). “Big Brother.” “Big Brother” is watching. They soon got past that.		

4. Do you believe that operating the AVL dash camera feature distracted snowplow drivers from their primary duties?

Yes	5	14%
No	32	86%
If you answered "yes," please briefly explain. - Anytime you have to reach forward to change a screen or something, that can be distracting. - The light on the screen is too bright at nighttime plowing. - The drivers' hands are full and they need to stop to use the equipment. Everything added to the drivers' operations is adding to their distractions. - It's very busy in the cab already. - Find themselves looking at the camera when they should be paying attention to other things.		

5. Did maintaining the AVL dash camera feature or external camera hardware add an undue burden to your regular duties of supervising snowplow operations?

Yes	3	8%
No	34	92%
If you answered "yes," please briefly explain. - I am having a hard time keeping up on this. I have to get help from my guys most of the time. - The shorter operators said it was restricting their sightline. They would like them mounted from the ceiling not on the dash. - If it was not working, it added more time in shop.		

6. We welcome any additional comments you have about using the AVL dash camera feature.

Note: The categorization of free responses as positive, negative or suggestion was completed after the fact by the author of this report. Comments have also been lightly edited for clarity.

Positive

- Amen! Long time coming ;)
- I do like them on 511.
- I think it is a great tool to be able to see what is going on in the sub-area and other sub-areas throughout the state.
- I think that everybody is on board that this is a good thing to have.
- I used the 511 app on my phone to view images fast and easy. I liked it! Good job!
- I would like to see these cameras installed in all new plow trucks.
- Like the feature, look forward to having in all units eventually!
- Plow operators seem to be adapting well. The normal pushback of "they will be watching us" doesn't seem to have any effects anymore.
- The cameras are a good tool for me to see different road conditions in all parts of the service area.

Negative

- I personally think it is not money well spent. We have a hard time to be funded in a lot of areas. We can do our work effectively without these cameras. Too much stuff in the trucks the way it is already.
- It's an unnecessary distraction for the drivers and not worth the benefits to MnDOT just so the public can view the pictures online.

Suggestions

- Would be a good idea to have a laminated cheat sheet on different operations of camera/video/storage information to refresh the drivers from year to year.

APPENDIX F

MANAGER INTERVIEWS

The following MnDOT managers were interviewed for this report.

- Joe Huneke, MDSS/AVL/RWIS section manager.
- Jon Bjorkquist, RWIS coordinator.
- Kelly Braunig, transportation program specialist 3, Freeway System Operations.
- Chase Fester, transportation operations supervisor.

Interview responses are paraphrased and grouped for thematic clarity. Further analysis of these interviews may be found in Chapter 6, Analysis and Recommendations.

MDSS/AVL/RWIS SECTION MANAGER

Project Role

I oversaw the entire project described in this report, though I will note that I joined the project midway through.

“Scope Creep”

There were parties involved in this project, such as our management team and area maintenance engineers, who wanted things that went beyond the original scope of the project.

One of the issues was the clarity of the image captured. Management wanted us to do significant work on image capture and finding the best shutter speed so that cameras would be able to capture blowing and falling snow. This ultimately was not possible because we had accomplished our original goal, which was focused on road conditions and 511.

Some of the scope creep came from the management team saying they were not comfortable with photos that did not fully capture environmental conditions. Toward the end of the project this was one of the major sticking points. In the end, we did not have the resources for this feature, and we put a disclaimer on 511 saying some images may show conditions that appear better than they really are.

Technology Integration

The largest barrier to implementation involved the development of the software package for integrating snowplow cameras into the current AVL system. MnDOT’s AVL provider AmeriTrak was tasked with accomplishing this, and it required a great deal of back-and-forth to get things right.

This led to more scope creep, which included making the package more configurable so that users could remotely set different threshold parameters for speed and image collection.

Moreover, some districts wished to change the default speed setting of 10 mph because in certain situations in which vehicles are going under this speed—such as whiteout conditions—they wanted to be able to document conditions without relying on the driver manually adjusting the camera from within the vehicle. Creating the ability to change thresholds remotely represented the largest change in scope.

Scope of Work Development Efforts

The initial scope itself was only loosely put together. A critical lesson learned from this project was to have a solid scope of work. It is important to define what you want from the software early on, including what data will be used only internally and what will be sent externally to a 511 system. It is also important to create a way for others to access images through some sort of file transfer system.

An important lesson is to get all feedback during the development of the scope, tying in all stakeholders sooner rather than later.

Perspective

There were no large technical problems with the project. Overall, the results of the project have been very popular both internally and with the public.

RWIS COORDINATOR

Project Role

I have been part of MnDOT's RWIS program since 2011. When I started, I was involved in the deployment of AVLs, acting as a regional coordinator. Approximately three years ago I became more exclusively focused on weather stations.

I selected the cameras for the project described in this report. I researched and then tested the various cameras that were available, and made a recommendation for which ones we would be using. I was not involved in the process to integrate images with 511.

Considerations for Camera Selection

We tried to find a camera that was of high enough quality and something that an AVL vendor could use. We ended up choosing two types of cameras from AXIS Communications: one using a dash mount so that it would work with older trucks, and one mounted on the ceiling in new trucks—a dome camera that is high up and out of the way.

We conducted research to make sure that there were not any issues with cameras blocking a driver's view, taking state and federal regulations about this into consideration. We then tested them to make sure they were capturing images at the right resolution and using parameters that worked with AVL.

This process was very straightforward. The AVL vendor had specific requirements that, once defined, made it easy to choose cameras that met the requirements while being as affordable as possible.

Camera Adjustment

It took some effort to get the right camera angle and centrally position the camera so it would see what the driver was seeing, without showing too much of the windshield headliner or the hood.

Perspective

The entire process went very well, and there were no real roadblocks. And the public seems to be very happy with the results. We can tell that people are relying on these images.

TRANSPORTATION PROGRAM SPECIALIST 3, FREEWAY SYSTEM OPERATIONS

Project Role

I was project manager for the 511 site and served as a liaison between Joe Huneke and Castle Rock, the company that integrated snowplow images into the website.

Image Integration into 511

Everything went really smoothly, and Castle Rock had no problem taking the image feed from snowplows. There was some back-and-forth about—and changes to—software functionality, including speed thresholds and the frequency with which images were taken.

District Engineer Resistance

The most significant roadblock involved the resistance of district area maintenance engineers. They, along with snowplow operators, were hesitant about this technology. We reassured them by pointing them to positive results from Iowa's projects, and by assuring them that they would get a chance to look at a staging site before anything went live.

In particular, they were concerned about images not being able to show snowfall and so being deceptive to the public. However, the way the 511 site works, there are other indicators showing road conditions. Moreover, the pictures turned out not to be misleading. Once they saw this, they were reassured.

One lesson learned here is to get buy-in early on. We made sure we got every district on board with the project, and dispersed the cameras evenly between them.

Perspective

Now everyone loves the system. District superintendents use it, and so does the National Weather Service. I am very happy with how the project went, and we have gotten very positive feedback from the public as well.

TRANSPORTATION OPERATIONS SUPERVISOR

Project Role

I oversaw, along with shop supervisors, installations of cameras on trucks, and served as the liaison between Joe Huneke and shop personnel.

Installation Process

The installations took a few months, were not labor-intensive (each installation took two hours at most) and went fairly smoothly. There was an issue with dash mounting near defrost duct systems, so that cameras had to be relocated. Other than that, the process was easy and straightforward.

Driver Resistance

There was some hesitation initially from snowplow operators, but they got over this quickly once they were reassured that the point of the cameras was not to monitor their work. The cameras are automatic and do not require any action on the part of operators.

Perspective

Some districts had been worried about images showing conditions that seemed better than they really were, but they were ultimately reassured by the results of the project. The public's perception was very positive as well.

When communicating with districts and operators, it helps to be able to point to positive results in another state—in this case, Iowa.

APPENDIX G

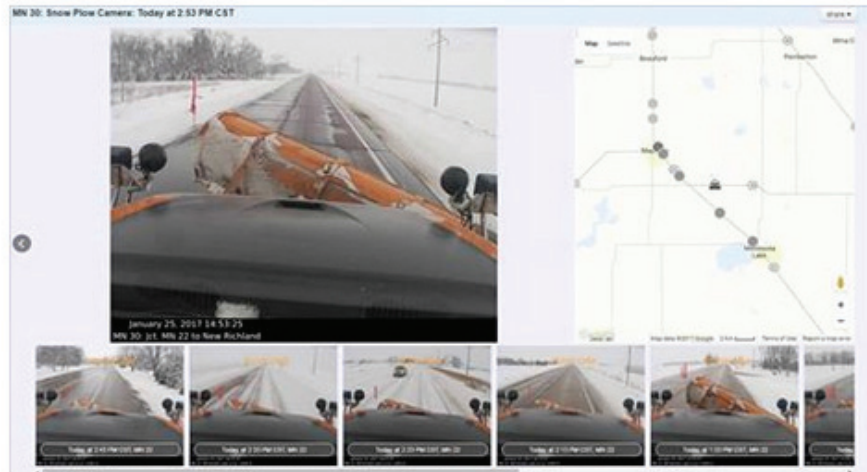
MnDOT'S FACEBOOK POST AND USER COMMENTS



January 25 · 🌐

You can now view winter road conditions from our new "plow cams." Roughly 200 of MnDOT's 838 plows are equipped with these new cameras. Plow cams are available to the public through www.511mn.org. Select "Plow Cameras" from the menu to see icons of active plows. Click an icon to see that plow's snapshots from the past two hours.

For more info on the cams: www.mndot.gov/newsrels/17/01/25snowplowcameras.html



319 Reactions 21 Comments 259 Shares



Like



Comment



Share



319

Most Recent ▾

259 shares

21 Comments



Write a comment...

**James**

How's any one sopost to sleep with that on ?

Like · Reply · January 26 at 7:22pm · Edited

**Deb**

Love the updates to the app!! Use it every day when I commute to Minneapolis for work from Owatonna!!!!!! Must say MNDOT does a MUCH a better job of keeping our roads safe than The city of Owatonna!! They could learn from MNDOT

Like · Reply · January 26 at 6:54pm

**Vinnie**

That's an awesome idea

Like · Reply · January 26 at 1:58pm

**Marilyn**

Thank you Julie for you long hours and dangerous work. Maybe this will also help to see what cars are causing possible accident. Stay safe, I know you love this job 😊

Like · Reply · 3 · January 25 at 9:53pm

**Minnesota Department of Transportation** Meet Tracy:[https://www.facebook.com/mndot/photos](https://www.facebook.com/mndot/photos/a.220030637248.132451.153795482248/10155090550327249/?type=3&theater)
[/a.220030637248.132451.153795482248/10155090550327249/?type=3&theater](https://www.facebook.com/mndot/photos/a.220030637248.132451.153795482248/10155090550327249/?type=3&theater)

Sallie:

[https://www.facebook.com/mndot/photos](https://www.facebook.com/mndot/photos/a.220030637248.132451.153795482248/10155071261042249/?type=3&theater)
[/a.220030637248.132451.153795482248/10155071261042249/?type=3&theater](https://www.facebook.com/mndot/photos/a.220030637248.132451.153795482248/10155071261042249/?type=3&theater)

Jennifer:

<https://www.facebook.com/mndot/photos>

/a.220030637248.132451.153795482248/10155048808622249/?type=3&theater

And Becky:

<https://www.facebook.com/mndot/photos>

/a.220030637248.132451.153795482248/10154896717467249/?type=3&theater



Minnesota Department of Transportation

Like Page

January 25 · 🌐

Crews have been diligently working to clear the roads in southern MN throughout the night and this morning. Before you travel, be sure to check www.511mn.org for current road conditions.

Meet one of our fantastic plow drivers from the southeast/Rochester area:

Like · Reply · 🇺🇸 2 · January 26 at 8:59am



Marilyn

Julie

, she plows for Hennepin Cty out of Elk River

Like · Reply · January 26 at 12:36pm



Write a reply...



Venus

It would be soooooo nice if MNDOT would stop wasting money on Camaras in the trucks the camera need to go on the police, and salt and plowing needs to be completed! I'm looking outside right now and the roads looks as though every one at MNDOT is on winter break! Try spending our money on what we actually NEED!

Like · Reply · January 25 at 5:22pm · Edited



Charles

Being able to actually SEE how the roads are will be better than the current system. Not everyone has the same set of winter driving skills or the same vehicles

Like · Reply · 🇺🇸 7 · January 25 at 7:36pm



Minnesota Department of Transportation Just a reminder that MnDOT maintains state highways and interstates, not city streets or county roads. The city/county is responsible for snow and ice removal on their roads. And Charles is correct, MnDOT has invested in the cameras so that the public can make informed decisions of if traveling in the current conditions is the right choice for them or their loved ones.

Like · Reply · 🇺🇸 10 · January 26 at 8:25am

 **Venus** The public needs to be able to see the roads!!!! Not money wasted on camera's should be put in to materials and manpower to clean the roads that's what the public needs access to. The public needs to see that their tax dollars as used wisely. I guarantee if you put the money into materials, manpower and better forecasting (budget/and materials) the public wouldn't need to cameras in MNDOT truck to make better informed decisions for their families... which but the way is a load of crap!

[Like](#) · [Reply](#) · January 26 at 9:25am · Edited

 **Venus** I also guarantee you better spent dollars on our roads will save more lives and money then those camera's will!

[Like](#) · [Reply](#) · January 26 at 9:27am

 **Charles** Venus, I'm not sure what part of the state you live in but I'm in a mostly rural area of southern MN. I've driven home many nights after the plows have been pulled so being able to see those last images and knowing when they were taken will help. I do have a well setup 4wd suv which allows me to handle conditions that cars can't.

[Like](#) · [Reply](#) ·  1 · January 26 at 9:29am

 **Venus** Charles respectfully, I understand your point. The fact that the roads need better attention and efforts is my point . Better access to and on the roads would be the safest options! MNDOT budgets as if this is a warm climate. The camera's and the maintaining the cameras are a complete waste of money. I promise you if the money was invested in the efforts of the roads... Im pretty sure your/our travel would be a lot safer the looking at the last images of those camera's!

[Like](#) · [Reply](#) · January 26 at 9:52am · Edited

 **Charles** The few dollars it cost to add cameras to an existing system won't go far overall towards road repair.

Now I'm not saying that MN doesn't have many roads which need significant work, just that a much larger budget would be required. I've never worked road construction so I don't know what hurdles they have to deal with.

Running snow plows literally all night for the few people still on the roads (not including the metro area here) would be a greater budget failure than these cameras. THAT is what it would take to help in the situations I was talking about earlier.

[Like](#) · [Reply](#) · January 26 at 11:16am



Write a reply...



 **Greg** I think this is a great feature, and I very much appreciate it being accessible from the website..and hopefully from the smartphone app. I know I'm not alone in supporting this type of addition to the services MNDOT provides. This information helps ME make BETTER decisions about venturing out on state, county, and interstate highways on my daily commute about 45 miles each way.

[Like](#) · [Reply](#) · January 26 at 9:48am

 **Liz** I don't see the plow cam option in my app. Do I need to reinstall it?

 **Minnesota Department of Transportation** We are looking into it to make sure there is not a glitch.

[Like](#) · [Reply](#) ·  3 · January 25 at 4:31pm

 **Charles** I don't see it on mine either

[Like](#) · [Reply](#) · January 25 at 9:22pm

 **Claire** Not on mine either.

[Like](#) · [Reply](#) · January 26 at 9:21am



Write a reply...

G-3



 **Jason** How about not wasting money on crap like this and paying the boys some overtime and having plows out between 10pm and 4am when they are needed !

Like · Reply ·  1 · January 26 at 5:25am

 **Jason** Anders
Like · Reply · January 25 at 3:28pm

 **Anders** Yup works on my truck.
Like · Reply · January 25 at 10:38pm

 Write a reply...  

 **Vanessa** Unfortunately not showing up on my app.
Like · Reply · January 25 at 10:06pm

 **Kim** Dan , Tom did you know they started this?
Like · Reply · January 25 at 7:54pm

 **Thomas** Nope
Like · Reply · January 25 at 7:54pm

 **Kim** Thomas I looked. The ones down south are working.
Like · Reply · January 25 at 8:27pm

 **Dan** I heard they were working on it. They didn't want to start it in D4 because the pics make the road look pretty normal when they are crap. Scared people would look at the pics and think the roads were fine.
Like · Reply ·  2 · January 25 at 8:29pm

 **Kim** Dan pics I saw looked very good on some
Like · Reply · January 25 at 8:30pm

 **Thomas** They said they were having problems with the road and conditions looking way better than they actually were
Like · Reply ·  1 · January 25 at 8:31pm

 **Dan** Ya. That was just what I was told from some of the people out of DL. hope they review these pics before they upload them.
Like · Reply ·  1 · January 25 at 8:32pm

 Write a reply...  

 **Leslie** Cool!!
Like · Reply ·  1 · January 25 at 7:57pm

 **Eileen** Cool! And thanks for your hard work.
Like · Reply ·  1 · January 25 at 7:24pm

 **Monica** Useful today as I decided whether to venture out this evening in SW MN.
Like · Reply ·  1 · January 25 at 6:30pm

 **Beth** Thank you to the men and women of the MnDot fleet for keeping us safe! And to your families who would much rather have you safe at home when roads are terrible. Hopefully these cams will help people understand why we need to give you plenty of room!
Like · Reply ·  9 · January 25 at 5:13pm

 **Michael** Garrett
Like · Reply · January 25 at 4:49pm

 **Judy** Awesome.
Like · Reply ·  1 · January 25 at 4:09pm

 **Jason** Pretty slick !
Like · Reply ·  1 · January 25 at 4:00pm



Dani Brian

Like · Reply · January 25 at 3:51pm



Adam Alden, Sarah, Larry

Like · Reply · January 25 at 3:42pm



Kyle Kevin

Like · Reply ·  1 · January 25 at 3:40pm

Write a comment...

APPENDIX H

PUBLIC COMMENTS

Note: The categorization of public responses as positive, negative or technical issue was completed after the fact by the author of this report. Comments have also been lightly edited for clarity.

Positive

- Awesome.
- Being able to actually SEE how the roads are will be better than the current system. Not everyone has the same set of winter driving skills or the same vehicles.
- Cool! And thanks for your hard work.
- Cool!!
- I think this is a great feature, and I very much appreciate it being accessible from the website and hopefully from the smartphone app. I know I'm not alone in supporting this type of addition to the services MnDOT provides. This information helps ME make BETTER decisions about venturing out on state, county and Interstate highways on my daily commute of about 45 miles each way.
- Love the new snowplow cams. Any chance you might add further plow information like speed, if actively plowing or treating with salt, etc.? Love the site and app. Thanks.
- Love the plow cams.
- Pretty slick!
- Thank you, Julie, for your long hours and dangerous work. Maybe this will also help to see what cars are causing possible accident. Stay safe. I know you love this job.
- Thank you to the men and women of the MnDOT fleet for keeping us safe! And to your families who would much rather have you safe at home when roads are terrible. Hopefully these cams will help people understand why we need to give you plenty of room!
- Thanks for plow cams.
- That's an awesome idea.
- Useful today as I decided whether to venture out this evening in southwest Minnesota.
- Love the updates to the app!! Use it every day when I commute to Minneapolis for work from Owatonna!!!!!!!!!! Must say MnDOT does a MUCH a better job of keeping our roads safe than the city of Owatonna!! They could learn from MnDOT.

Negative

- It would be soooooooo nice if MnDOT would stop wasting money on cameras in the trucks. The cameras need to go on the police, and salt and plowing needs to be completed! I'm looking outside right now and the roads look as though everyone at MnDOT is on winter break! Try spending our money on what we actually NEED!
- How about not wasting money on **** like this and paying the boys some overtime and having plows out between 10 p.m. and 4 a.m. when they are needed!

Technical issue

- How do I see the plow cameras?
- Plow camera error message.
- I don't see the plow cam option in my app. Do I need to reinstall it?
- Unfortunately not showing up on my app.