An Innovative Approach to Smarter Mowing, Utilizing Automated Vehicle Location to Enhance Mowing Operations

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SRF Consulting Group, Inc

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Research Project
Final Report 2017-11
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In 2015 and 2016, MnDOT equipped thirty mowers in the Metro District with Automated Vehicle Location (AVL) systems. The pilot project relied heavily on the work MnDOT has done with AVLs in snow plows and utilized some of the same hardware and software. The project included five tasks of developing software interface, developing data exchange, purchasing and installing the AVL systems, developing a reporting system from collected data, and providing training. This pilot project is a start to gaining a sense of the benefits of AVL in mowing operations and what it takes to plan, budget, and implement these systems. With additional quantitative data, the project will generate a return on investment, highlight safety improvements, and enhance future mowing operations.

The following report documents the process of completing the five tasks, what end user products came out of the implementation, lessons learned and challenges, and what future developments are expected as MnDOT continues to move forward with the AVL in Mowers program.

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FINAL REPORT

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EXECUTIVE SUMMARY

Automated Vehicle Location (AVL) has become a powerful tool in the transportation industry. AVL provides a means for determining and transmitting the geographic location of a vehicle, and when combined with vehicle sensors and/or operator input, the data helps generate efficiencies, improves safety, and potentially saves money. AVL units have commonly been used by state and local agencies in their snow plows and other fleet vehicles, but a limited number of agencies have used AVL in mowing operations.

In 2015 and 2016, MnDOT equipped thirty mowers in the Metro District with AVL systems. The pilot project relied heavily on the work MnDOT has done with AVLs in snow plows and utilized some of the same hardware and software. The goal of the project was to enhance mowing operations by utilizing AVL. Specific project outcomes included, but were not limited to:

1. Generating a protocol for AVL installs, training, and troubleshooting
2. Eliminating paperwork by generating electronic and automated accomplishment reports
3. Ease of supervision: mower location, daily/weekly accomplishments, etc.
4. Improvement on tracking mowing needs and level of service
5. Reducing the spread of noxious weeds and herbicide use on MnDOT roadways
6. Optimizing mower routes

Challenges were met and lessons were learned during the project. It was challenging working through the IT complexities of the project, such as the software development. An important lesson learned was how beneficial it was to do a pilot project to adequately test and develop the application specific software and reports. Another lesson learned was how long it took to implement the project due to resource limitations and after implementation, how long it will take (multiple mowing seasons) to quantify the weed/herbicide reductions.

The pilot project cost $110,000 and will have on-going costs of roughly $11,000 per year.

The information contained in this report was gathered from the knowledge and experiences of MnDOT project managers, mechanics, superintendents, supervisors, and mower operators. This final report includes:

- Description of the project goals and tasks
- Costs of the project
- AVL equipment
- Implementation of the AVL system
- Results of the project
- Next steps

Across the country, only a few agencies have equipped their mowers with AVL. This project could become a well-documented case study for the use of AVL to enhance financial effectiveness for mowing operations.
CHAPTER 1: BACKGROUND AND INTRODUCTION

AVL has shown to be a powerful tool that can benefit the performance, quality, and safety of agency vehicles and services. For example, MnDOT has and continues to install AVL systems in snow plows to help with winter maintenance operations. The AVL systems provide real-time data, including but not limited to: vehicle location, road surface conditions, plow position, material application rates, and temperature readings. The snow plow AVL systems include AVL units, sensors, communication equipment, and complex data management which includes data analysis using business intelligence and publishing data to mn511.org. Data is collected through an in-vehicle controller unit that enables the automatic production of operational reports and alerts. Expounding on the knowledge and expertise of the snow plow AVL systems and understanding that mowing operations would benefit from a similar solution, this pilot project was planned.

There are many different vendors of AVL systems. Each has a unique data storage and transfer method. For this project MnDOT used the vendor they used previously for the snow plow systems, Ameritrak. Along with utilizing some of the hardware and software from the snow plow AVL systems, the project also utilized several years of GPS located noxious weed data. This data was a key element of the project.

Prior to implementation, noxious weeds patches were displayed on paper map books. Mower operators would try to read and flip pages of the maps to avoid weeds while also operating mower decks, maintaining vehicle speed, and watching for traffic. Essentially, mower operators ended up mowing the weeds. Mower operators would also carry a form with them and would have to stop mowing to track locations by reference points and try to accurately capture acres mowed. This methodology had room for improvement.

Like its use in snow plows, the AVL system that was developed needed to track the mower locations. But instead of tracking controller data, the system was designed for the mower operator to input the mower deck status and other needed information. This approach simplified the pilot project from a software design standpoint. The software needed to allow operators to see existing noxious weeds patches on the on-screen map and mark newly discovered noxious weed locations. From the acquired data, maps and reports should be generated for supervisor use.

The pilot project should directly benefit mowing operations with potential benefits as follows:

- Reduced spread of noxious weeds on MnDOT roadways
- Reduced herbicide use
- Lower operational costs
- Reduced risk of exposing field crews (Adopt-A-Highway, STS programs, and Construction) to noxious weeds
- Eliminating paperwork by generating electronic and automated accomplishment reports
- Ease of supervision: mower location, daily/weekly accomplishments, etc.
- Improvement on tracking mowing needs and level of service
- Optimizing mower routes
• Allows operators to mark areas of concern such as weed patches, potholes, etc.
• Display live weather radar and forecasts in the cab so operators can avoid severe and dangerous weather systems.
Prior to starting, goals and a project work plan were established to lay the groundwork for a successful project and to obtain funding.

The project goals included:

- Work with the current vendor to develop the software
- Develop an exchange of data from the vendor server to MnDOT servers
- Create viable reports for reporting of accomplishments
- Create usable maps for supervisors
- Develop a training manual and conduct training for MnDOT Metro District mower operators
- Perform data analysis to quantify noxious weed and herbicide changes over time
- Compute a return on investment

With the project goals in mind, tasks were created for the project. The following diagram represents the sequence of tasks:

The results section describes what was done during each task and the associated results with screenshots.
CHAPTER 3: PROJECT RESULTS

TASK 1 – Develop Software Interface

Initially, several iterations of working with Ameritrak to refine the user interface limited the amount of data that could be collected during the first year. However, these iterations with Ameritrak were critical to develop the necessary user interface for operators and to refine the data outputs.

The mower software application was developed with usability in mind, the mower operator needed to quickly see their current location on a map and avoid noxious weeds ahead of the mower. Shown in Figure 1 below, the live map shows what the operator views in the cab, the noxious weeds are in red. The operator also needed to adjust the mower deck status, the buttons on the bottom of the screen have words and colors that describe the deck status. The software has additional information, such as set mark buttons and shift information the operators enter as appropriate. Further information on the operation of the AVL system can be found in the MnDOT Mower AVL System Operators Manual in Appendix B.

Figure 1: Live Map
TASK 2 – Data Exchange

The means of data communication from the AVL system is a Verizon AirCard. The AirCard plugs into the USB port of the AVL unit to provide internet access. The AirCard draws power from the AVL unit and can remain installed during winter storage of the mowers. The data flows to the vendor on a secure network and then back to MnDOT servers for use and analysis. Figure 2 shown below depicts the exchange of data.

![Figure 2: AVL System](image)

TASK 3 – AVL Hardware Purchase and Install

Ameritrak’s AT-500 hardware was purchased and installed in the 30 mowers. Two mechanics developed a process for the installation of the AVL units. The mechanics constructed a metal rack to protect the AVL unit and the necessary components. In Figure 3, the AVL unit is shown mounted on the tray fabricated from sheet metal for protection. For the operator interface, a screen mounting unit was attached to the metal rack as seen in Figure 4.

![Figure 3: AVL Unit](image)
Figure 4: Screen Mounting Unit Attached to Mounting Tray

Figure 5 shows a typical AVL unit installed in a mower cab. Additional information on installation can be found in the Mower AVL Troubleshooting Guide in Appendix A.

Figure 5: AVL Unit Installed in Cab

TASK 4 - Reporting

Several reports can be created from the mower data, but the completion report was this project’s first priority. At the completion of the operator’s day, an accomplishment report can be generated by the operator, supervisors or managers. Figures 6 and 7 show an example of an accomplishment report produced using data collected by the AVL units.
Each report summarizes the amount of time the mower was active, the number of acres mowed, the number of miles travels, and the GPS coordinates. Additionally, the GPS coordinates can be viewed in Google Earth as shown in Figure 8.
TASK 5 – Training

With the incorporation of AVL in mowers, initial training was provided for MnDOT Metro District supervisors and operators to fully understand the operations of the AVL system. Going forward, training sessions will be offered prior to each mowing season or as needed for new employees.

3.1 END USER PRODUCTS

Reviewing the implementation of AVL units in mowers showed positive results. The end user products developed included:

- MnDOT Mower AVL System Operators Manual
- Mower AVL Troubleshooting Guide
- Accomplishments Reports
- Bread Crumb GPS locations (displayed via Google maps)
- Software Application
- Training Curriculum
- Final report
3.2 LESSONS LEARNED AND CHALLENGES

Over the course of the pilot project, several challenges were encountered and lessons were learned. Working through the challenges and establishing best practices will help improve future development and implementations. Some of the lessons learned and challenges are described below:

3.2.1 Overall

- It was beneficial to do a pilot project to see how the AVL devices would operate and that the data could successfully be transferred from external servers to internal MnDOT servers.
- Due to the IT components of the project (i.e. data exchange, software coding, etc.), implementation was more complex than originally thought.
- The overall public advancement and publicity of AVL has brought more attention to this project than expected.
- Supervisors and superintendents have been very supportive and see the benefits of the project.
- MnDOT employees are becoming more technologically savvy.
- This project is helping to keep MnDOT innovative and forward thinking.
- It will take more than one season’s worth of data to really understand how utilizing AVL will help reduce the number of weeds and pesticide use on MnDOT roadways.

3.2.2 Hardware/Software

- It is difficult to apply software updates to the AVL units because not all updates can be pushed remotely.
- Software updates could temporarily remove a mower from active duty.
- Software changes were slow to be incorporated because of the vendor’s schedule.
- The hardware was purchased near the end of a technology cycle and new upgraded hardware has since come out that is smaller and faster.
- Rental mowers can be equipped with a magnetic GPS antenna to avoid permanent modifications due to typical installation procedures.
- Issues with Verizon GPS dropping the cellular signal.

3.2.3 Training and Installation

- It will take time for the mower operators to learn and utilize a new system/method.
- Installation procedures can vary amongst different tractor manufacturers.
- Some early training sessions were sparsely attended due to responsibility conflicts.

The project had a one-time cost of $110,000, which doesn’t include staff time, and will have on-going costs of roughly $11,000 per year (assuming 30 AVL systems).
3.3 FUTURE DEVELOPMENT

Based on the lessons learned and challenges, further development of the AVL system can be expected.

- As more mower data is collected in the future, supervisors will be able to draw better conclusions and can coordinate with the operators and mechanics to improve performance and reduce costs.
- A project return on investment will be measured through the reduction weeds and herbicide use.
- Additionally, the data could be interpreted to understand the amount of resources typically used or the efficiency of the mowers to better manage the budget and production rates. Therefore, performance targets and measures could be established to meet an acceptable level of service.
- Time spent by the operators and mechanics working with the AVL equipment could lead to ideas to improve operations of the AVL interface and processes of installation.
- Another way the data could be used is for route optimization. Allowing the mowers to maximize their time in the field could potentially reduce costs. Developing the routes would take additional analysis of the data.
- After a full season of use with all 30 mowers, MnDOT operators will be interviewed and responses will provide the framework for potential improvements.
- The data could automatically populate TAMS (Transportation Asset Management System) enterprise database work management system which feeds employee timesheets.
- Finally, an AVL unit was installed on a sweeper but the data has not been utilized. Potential benefits from AVL in mowers and snow plows could be applied to sweepers and patching vehicles.
CHAPTER 4: CONCLUSION

Only a few agencies have equipped mowers with AVL systems across the country and available information is limited. This 30-unit pilot project is a great start to gaining a sense of all the benefits of AVL in mowing operations and what it takes to plan, budget, and implement these systems. With additional quantitative data, the project will generate a return on investment, highlight safety improvements, and enhance mowing operations with efficiencies such as route optimization.
Appendix A: Mower AVL Troubleshooting Guide
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Automatic vehicle location (AVL) is a computer-based system that collects and transmits information on a vehicle’s actual location and other operating characteristics. The Automated Vehicle Locator - Maintenance Decision Support System technology allows our highway maintenance units to be more efficient by providing information and system recommendations on timing and chemical applications. Each AVL unit has a monitor that the operator can review for recommendations based on past history and current weather conditions. In addition to displaying the current conditions, the monitor has color weather radar and gives a forecast. The system stores the data which can be accessed at any time. The touch monitor also allows the operator to enter road and weather conditions.

**AVL System Components**

![AVL System Components Image](image_url)
Mower AVL Mounted in John Deere Tractor
AT 500 - AVL Computer

AT 500 Ports

USB Port # 1 – Located Right Side of AT500 – Keyboard plugin.

USB Port # 2 – Located left side of AT 500 - Monitor plugin.

USB Port # 3 – Located Right side of AT 500 - Air Card plugin.

Com 3 - CAN BUS cable connection.

COM 2 – SAE 10 Event Box cable connection

COM 1 - Sander cable connection

DC IN 6-36V Port- Power board connection. (battery power, ignition power, and ground.)
Air Card - Connects AT 500 to servers to acquire and send data

ATE SA-10 Event Box - interface between sensors (road and air temp, wipers, lights, etc.) and AT 500 computer.
ATE-SA10 Pin Assignments, Wire Color, Indicator Lights and Fusing

<table>
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<tr>
<th>Pin</th>
<th>Signal Description</th>
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<tr>
<td>A</td>
<td>+12 VDC</td>
<td>Red</td>
</tr>
<tr>
<td>B</td>
<td>Ground</td>
<td>Black</td>
</tr>
<tr>
<td>C</td>
<td>Power P1, +5 VDC (supplied by the ATE-SA10)</td>
<td>Red conductor (4-conductor cable)</td>
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<tr>
<td>D</td>
<td>Power P2, Ground (supplied by the ATE-SA10)</td>
<td>Black conductor (4-conductor cable)</td>
</tr>
<tr>
<td>E</td>
<td>Rain sensor relay, common</td>
<td>To be determined, depending on cable chosen</td>
</tr>
<tr>
<td>F</td>
<td>Rain sensor relay, normally open</td>
<td>To be determined, depending on cable chosen</td>
</tr>
<tr>
<td>G</td>
<td>Ignition sense (+3.4 to 24 VDC)</td>
<td>Pink</td>
</tr>
<tr>
<td>H</td>
<td>Active 1 – Assigned to “Lights” (+3.4 to 24 VDC)</td>
<td>Yellow</td>
</tr>
<tr>
<td>I</td>
<td>Active 2 – Assigned to “Wipers” (+3.4 to 24 VDC)</td>
<td>Blue</td>
</tr>
<tr>
<td>J</td>
<td>Active 3 – Unassigned (+3.4 to 24 VDC)</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>Active 4 – Unassigned (+3.4 to 24 VDC)</td>
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**Indicator lamp details:**

- Ignition
- Lights
- Wipers
- Not Assigned
- Not Assigned

**Fuse details:**

- Size: 5 x 20 mm
- Current rating: 1 amp
- Manufacturer: Littlefuse or equivalent
- Manufacturer part number: 0218001.HXP
- Digikei part number: F2419-ND
Power Board- circuit board supplies power form mower to AVL system. Fuses for monitor and AT 500 computer are mounted on power board also.

Charge Guard - protects System from over and under voltage. Charge Guard is set to turn off ignition power to system 15 minutes after vehicle ignition switch is shut off.

Touch Screen Monitor – operator views road, weather and radar information. Operator also enters road and weather information. Mechanic uses touch screen to enter required data into AT 500 when setting up and repairing AVL system.
TESTING MOWER AVL UNIT

• With ignition switch on, all four LED’s should be lit.
• Air card LED should be flashing, this could take up to five minutes.
• You may have to take mower out of building to get a good signal.
• Make sure the wireless connection on the screen is green (green/red circle in upper left) and the GPS connection is green (current time shown).
• Make sure info in Radar and Forecast and Current Winds is up-to-date.
• Make sure the Live Map shows current mower position and make sure the Running/Stopped and Left/Right Deck Lowered/Raised buttons work.
• Make sure information selected in the Set Mark menu displays on the Live Map when selected.
• Make sure the end of shift shows data. You may have to drive the mower around the yard a bit and make sure that in the Live Map Running is selected and Left/Right Deck buttons display Lowered. Data doesn’t get recorded to the end of shift unless these buttons are used to let the AVL know when mowing operations are occurring.
Mower AVL Touch Screen Calibration Instructions

- Re-calibration is needed if AVL Touch screen is not responding to touch, or if screen is responding to touch, but is selecting an area other than where you are pressing.

- Power up the AVL if it isn’t already. Wait until the AVL gets to the Main Screen. Plug a USB keyboard into the USB port on the front of the AVL computer (silver box) on the side with the power button. Press Control-Alt-Enter while on the Main Screen. This will generate a “graphics” console from the AVL’s user interface.

- Run the screen calibration program. To get there, type the first two letters of the command which are eG (case sensitive) and then press the ‘tab’ key. The AVL will finish typing the command for you. Then press the ‘enter’ key.

- While on the “General” tab at the top of the window, use the ‘tab’ key to select the sub-window (frame) that contains icons describing the type of touch controller.
  - Use the ‘right arrow’ key to select the icon labeled “USB.” Then use the ‘tab’ key to navigate back to the top of the window.
    - If there is no USB icon, check to make sure the touch screen’s USB wire is connected firmly into the back of the AVL computer (silver box).

- Use the ‘right arrow’ key to go to ‘tools’. Use the ‘tab’ key to go to ‘4 point calibration’. Press the ‘enter’ key.
- Go through calibration by holding finger at each of the 4 corners as circles appear.
- Touch ‘ok’ on screen when 4 point calibration box appears. Touch ‘linieration’.
- Touch on 9 point calibration. Go through calibration by holding finger at 9 points as circles appear. Touch ‘ok’ when the 9 point calibration box appears.
- Touch on ‘misc’ tab. Touch ‘change button’ once and ‘click on touch’ should be displayed. Touch ‘apply’ then Touch ‘ok’ when finished.
- When complete, use the “Ok” button to exit the screen calibration program.
- On the graphics console, type ‘exit’. This will exit you from the console, dropping you back to the AVL’s Main Screen.
Mower AVL DISTRICT SETUP PROCEDURE

This procedure is intended for the District Repair Shop responsible for setting up a new AVL install in a mower. The process is:

- Configure, activate and install the USB760 air card
  - Should be with AVL. If not contact info is at end of guide.
- Configure AT500 (AVL) local settings for Truck Station assignment
- Test AVL system operations and connectivity
USB760 AIR CARD

About a week before you want to install the USB760 air card, contact your District’s cell phone coordinator and request an unlimited data plan from Verizon using the ESN of the USB760 air card.

- Once the phone number and static IP address are received, send the information to your district’s AVL coordinator. (see contact info)
- **Make sure your computer:**
  - Is disconnected from any internet connection
  - Wireless is disabled, if applicable
- Launch VZ access manager
- Plug the USB760 air card into an open USB port
- Wait until VZ access manager finds air card
- Go to options and then preferences
- Click on WWAN device
- Under device options uncheck the three boxes
  - Nova Speed
  - Removable Disk
  - CD-Rom Disk
- Click OK
- Once the device is configured go to options
- Click on activation
- Wait until air card activates successfully
- Click OK
- Click on connect to make sure air card connects successfully
- When done, disconnect and close VZ access manager
- Remove the USB760 air card from the USB port
- Reconnect your computer to the network and reboot
• Install the USB760 air card in the mower as shown above
  o Connect the USB760 to the USB extension cable and the antenna to the USB760
  o Use tie wraps to secure the USB extension cable and the USB760/antenna to the mounting bracket next to the AT500
CONFIGURE AT500

To complete this task you will need a USB keyboard and the AT500 configuration password.

- Plug the USB keyboard into the USB port on the AT500 front
- Turn the mower key on and wait for the AVL system to start up
- Locate the cherry ball in the upper left corner of the display
- Tap on the cherry ball until the password screen appears
  - If the arrow does not show where you are tapping, complete the Calibrate Screen procedure before continuing
- Use the touch screen to key in the password and touch Enter
  - Contact your AVL coordinator if you need password
- Touch Vehicle Info and then Vehicle Tracking Info
- Verify the following
  - Name: mower unit number
  - Station: assigned truck station (for example, Maple_Grove not Maple Grove or MAPLE GROVE)
  - District (for example, 2a not 2A, 8a not 8A, Metro, etc.)
- To make any changes, touch inside the box you need to change and use the keyboard to enter in the new value
- Touch Update to save any changes and then touch Done
- Touch Done to exit the AT500 System Configuration
- Verify air card and system connectivity
  - Touch Radar & Forecast
    - Enter conditions when requested
  - Check the Current Radar date and time
- Turn the mower key off and unplug the USB keyboard
- Send a message to your District’s AVL coordinator to let them know the mower’s AVL system is now active
Questions/Feedback

Doug Maki: AVL Mower Project Manager  (Metro)

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Appendix B: MnDOT Mower AVL System Operators Manual
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Version Date: 1-18-17
SECTION 1 - STEP-BY-STEP OPERATIONS

AUTOMATIC TURN ON/OFF

a) The AVL unit should turn on automatically, if screen doesn’t come on push screen power button, lower right of screen, make sure blue light is on. If screen still doesn’t come on, check clip connection behind screen.

The screen will turn off automatically about 10-15 seconds after mower is turned off.
ADJUST THE BRIGHTNESS/CONTRAST

a) Press the ‘Menu’ button, middle button in lower right side of the touch screen (to the left of the ‘sun’ button).

b) Press the ‘Menu’ button again to toggle down to Brightness.

c) Press the ‘Left’ or ‘Right’ buttons to adjust the Brightness of the screen. These buttons are located along the bottom right side of the touch screen, just left of the ‘Menu’ button.

d) Press the ‘Menu’ button again to toggle down to Contrast. Adjust Contrast just as Brightness above. If the information on the screen is not fitting correctly you can select the ‘Auto Adjust’ option in the menu.
UTILIZE THE MAIN MENU/HOMESCREEN

*This is the Main Menu/Home Screen. It is a touch Input Interface where the mower operators will access the live map, end of shift report, set marks, and look at road and weather conditions.*

a) Check the **Ball in top left** to make sure it has an internet connection: **green = yes** or red = no. Time in top left shows latest GPS lock. If clock doesn’t match current time and/or ‘GPS Time’ is in red (while mower is outside), there will not be an End-of-Shift report and supervisor should be notified.

b) Use the ‘**Bright**’ or ‘**Dark**’ button in lower left to change to a brighter screen for daytime. These buttons can also be used as a way to get out of a menu entered by mistake.

c) Select the ‘**End Shift**’ button before starting mowing operations to ensure the previous shift’s data has been cleared (discussed further in Step 4). The end shift button brings a mower operator to a report of mowing operations during a selected time period. Time, miles and acres mowed are displayed.

d) The ‘**Set Mark**’ button allows operators to mark locations of noxious weeds, broken or missing signs, pot holes, guard rail hits, and debris.

END PREVIOUS SHIFT

a) Select the ‘**End Shift**’ button before starting the mowing operations shift to ensure the previous shift’s data has been cleared. Select the ‘**Done**’ button along bottom of report
to get pop-up box to clear the shift (shown below). Once the previous shifts data has been cleared, the AVL will produce correct results for the current shift.

![Live Map Start](image)

**START LIVE MAP**

a) Go to main menu and select the ‘Live Map’ button.
b) The map cross-hairs should always be centered over the mowers current location.

c) The ‘Stopped’ and ‘Running’ button is used is used to let AVL system know when the center deck is lowered/engaged in active mowing, or raised during times of transport or any time active mowing is not occurring. When the Center Deck is down, click the ‘Stopped’ button, it should turn GREEN and say ‘Running.’ When the Center Deck is up click the ‘Running’ button, it should turn RED and say ‘Stopped.’ This will contribute to the end of shift report and help collect accurate data.

d) The ‘Left Deck Raised’ and ‘Right Deck Raised’ buttons let the AVL system know when the decks are engaged in active mowing or raised during times of transport or any time when active mowing is not occurring. When physically mowing, click on ‘Left Deck Raised’ or ‘Right Deck Raised’ (or both) buttons to start tracking acres mowed, the buttons should turn GREEN and say ‘Left Deck Lowered’ and/or ‘Right Deck Lowered.’

e) See screen shot below. This example shows the mower is running and the Center Deck and Right Deck are actively engaged in mowing.
f) The live map shows locations of known noxious weeds using pink and red polygons (see screen shot below). The pink polygons specify Thistle and red polygons are for all other noxious weeds, which include the following: Leafy Spurge, Purple Loosestrife, Garlic Mustard, Common Tansy, and others. Mower operators should NOT mow the red and pink mapped areas unless otherwise directed by their supervisor.

g) Infiltration Basins are shown as green dots, drop inlets as blue dots, and aprons as yellow dots. The operator will use these dots to be aware of drainage structures in the area, and to avoid damaging them.

**SET MARK FEATURE**

a) The ‘Set Mark’ Button can be used for a number of different reasons during the mowing shift. It can be used to mark ‘Debris’, ‘Guard Rail’ hits, ‘Pot Hole’s’, broken or missing ‘Sign’s’ in the field, and unmapped areas of noxious ‘Weed’s’ during mowing.
operations. This button can be accessed from the AVL Home Screen as well as from the Live Map used during mowing operations. The ‘Bright’ and ‘Dark’ buttons in lower left of AVL screen can be used as an exit button to return to the main screen without making a selection.

If ‘Sign’ is selected, the operator can then choose between ‘Broken Post’, ‘Broken’, or ‘Missing’, as shown below.
If previously unmapped areas of noxious weeds are discovered, operator can mark them using the ‘**Weed**’ button. When selected, the operator can choose from a group of noxious weeds, which have accompanying names and pictures to aid in identification. The choices with photos include the following: Musk/Nodding Thistle, Spotted Knapweed, Leafy Spurge, Wild Parsnip and Common Tansy. These newly located weed areas will then be investigated and mapped.

**END SHIFT/SUBMIT REPORT**

From the Home Screen or the Live Map, the ‘**End Shift**’ button will send the operator to the screen shown below.
From the drop down, select the time period the operator was in the mower. End of Shift report shows data back the selected amount of time. **Please make sure it doesn’t overlap with previous shift.** An example end of shift summarizing what mower did in past 8 hours could be the following: mower was actively mowing for 1.4 hours, mowed for 0.4 miles and 1.1 acres were mowed. Operator then selects ‘Done’ along bottom to submit their data and clear their shift.

**SECTION 2 - WEATHER INFORMATION**

**CURRENT/FUTURE RADAR**

From the Home Screen, the ‘Radar and Forecast’ button for ‘Radar & Forecast’ takes the operator to the following screen, which shows the ‘Current’ weather radar.
• The radar data refreshes automatically to ensure the operator always has latest info available (operator will see please wait while loading... while data refreshes).

• Operator has color coded radar to show precipitation type: green/yellow/orange for rain, blue for snow, and pink for a rain/snow mix or freezing rain (see below). Radar shows last 2 hours of storm movement.


• The ‘Future’ button shows the same view as ‘Current’ Radar, but adds on about 1 to 2 hours of projected movement of storm. It also displays the Weather Reports larger when zoomed in for easier viewing.

CURRENT/FUTURE RADAR ZOOM

• Operator touches radar to zoom in on an area for a closer look at color coded ‘Current’ or ‘Future’ Radar and to get a better look at latest Weather Report at Airport Weather Stations. First touch zooms in, second touch zooms out.

• These radars are meant for big picture of storm. The operator can use ‘Truck Radar’ for a more local view (shown further below).
• Operator can always see if there is an internet connection (green/red circle), and latest GPS lock (time), located in upper left of screen.

**TRUCK RADAR**

![Truck Radar Screen]

• Select ‘Truck Radar’ to see a radar image of area. Radar is always centered over the mower as long as it has a good GPS signal. Operator also sees other AVL equipped vehicles (mowers, plow trucks, etc.) on map to help coordinate maintenance.

• Zoom in closer by touching the ‘In’ button on top part of screen. For a wider view, touch the ‘Out’ button. The ‘Reset’ button will bring operator back to the default zoom level.

• The radar automatically updates at least once every 10 min. The radar is color coded to show precipitation type: green/yellow/orange for rain, blue for snow, and pink for a rain/snow mix or freezing rain.

• The ‘Truck Radar’ uses the same precipitation abbreviations that were used in the current/future radar screens (e.g. TS: thunderstorm, RA: rain, DZ: drizzle, etc.).

• If no weather is being reported, the wind direction speed and gust will be reported if the speed or gust is 10mph or greater. If operator zooms out far enough only the radar and AVL equipped vehicle locations will display so things aren’t as cluttered.
Radar will keep selected zoom level even if operator changes to other screens and then back to the ‘Truck Radar.’

FORECAST

The ‘Forecast’ button displays a 12 hour Weather forecast displaying Road Temp/Air Temp/Precipitation Type/Probability/Hourly Snow Rate/Wind Speed/Direction and Gusts.

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At first, it displays the forecast for the nearest route(s) to the mowers home truck station, but will use the mower GPS location to change routes once the mower is out and about.

The operator can change to a different route by using the drop down menu along top of the ‘Forecast’ page (described below). Forecast will update at least once per hour.

Always look at ‘Forecast for...’ above the Forecast for correct route, not drop down menu.

There is a Route Selection box that the operator can touch to select a different route from the list. It has the 15-18 routes nearest the mowers current location. Touch a route in the list to select it, then touch the ‘Set’ button to change the forecast to the selected route.
Forecast changes to selected forecast. The forecast will change back to the route the mower is currently on after about 1-2 minutes.

CURRENT WINDS

The ‘Cur Winds’ Button is located on the Home Screen. This page allows the operator to monitor current wind speeds and direction around the area to help in their maintenance decision process.

Wind speed is color coded with lower wind speeds in blue/green and higher winds in yellow/orange/red. Speed values are shown on map as well to help determine wind speed.

Wind direction is shown by arrows (arrow pointed down is a north wind). Wind data is updated once per hour and only shows sustained winds, not gusts. There is also a link to NWS weather radar (currently not used) as well as the ‘Radar and Forecast’ button that brings operator to the other radars and weather forecast that were described in detail above.
ROAD/WEATHER CONDITION RESET

Every 2 hours, or if not entered before going to ‘Radar and Forecast’ pages, the operator is prompted to input ‘Road Conditions’ and ‘Weather Conditions.’ The operator updates these through touch inputs whenever it is safe. The operator can also update these inputs sooner by touching ‘Road Conditions’ and ‘Weather Conditions’ buttons on the Home Screen. Press ‘Close’ button on lower left side of screen to return to Home Screen. Please see the screenshots below for examples of the messages regarding expiration of ‘Road Conditions’ and ‘Weather Conditions.’

Any ‘Road Conditions’ and ‘Weather Conditions’ that are entered are valid for 1 hour, and then are ignored to keep from sending incorrect conditions all day if the operator forgets to update conditions. Also, conditions entered will be applied to any route mower travels on during that 1 hour period.
SECTION 3 – DESKTOP REPORTING

Once the mowing data has been submitted, it can be accessed using the desktop dashboard. The dashboard can be found at the following location:

http://avl.dot.state.mn.us/login.php

The user logs into the dashboard to encounter the screen shown below:
VEHICLE HISTORY REPORT

From the home screen, a user can choose from a number of options to find information on a single tractor or multiple tractors. One popular report is the vehicle history report. As shown in the screenshot below, the user can choose a date range, vehicle name/number, and which events to display. Clicking on “Generate History Report” will display the data in a tabular format shown at the bottom of the screenshot.
OUTPUT FOR GOOGLE EARTH

Another option from the vehicle history report is to display a trail of breadcrumbs showing where the specified vehicle traveled during the specified time frame. Clicking “Generate Output for Google Earth” will export the data points recorded during the mowing operations, resulting in a map similar to the screenshot below:
MOWER REPORT

The mower report is another useful option from the dashboard home screen. The mower report allows the user to track the time spent mowing, the distance traveled, and the total acres mowed. Much like the vehicle history report, the user specifies the time frame to be investigated and the vehicle name/number. Clicking “Generate Mower History Report” will display the data in a tabular format shown at the bottom of the following screenshot. In addition to the data mentioned earlier, this report
can also show when mowing decks were raised/lowered, and if the GPS signal was lost at any time. If further analysis is desired, the data table can be exported to Microsoft Excel as an.xls file.

VEHICLE MANAGEMENT *(EDITING BY ADMIN. ONLY)*

Vehicle Management information can be accessed from the dashboard home screen by clicking on the truck icon in the lower right. The vehicle management subscreen is shown below:
From this subscreen, two tabs are particularly useful. First, the Vehicle Name and Base tab allows the user to edit information about mower units, including the vehicle name, driver name, home base, etc. The information for the aircard assigned to the vehicle is also displayed here, but that information cannot be changed. The following screenshot shows the Vehicle Name and Base “home.” The “Edit” button opens a window to input the new vehicle data.

From the vehicle management subscreen, the other tab of interest is the AT500/AT400 Tracking tab. Clicking on the tab opens the screen shown below:
This screen shows the vehicle’s name/number, homebase, aircard information, and last contact. Clicking on “Last Contact” twice will sort the units by time, so users can know which units have been active most recently. Clicking on a station name will display all of the units assigned to that station, while clicking on the unit name/number will display a record of all the data points recorded by that unit.
Questions/Feedback

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