Use of Dashboards for Winter Operations Case Study: Virginia Department of Transportation

Clear Roads Project 22-05: Use of Dashboards for Winter

Operations

December 2024

Technical Report Documentation Page

1. Report No. CR 22-05	2. Government Accession No.	3. Recipient's Catalog No.		
4. Title and Subtitle Use of Dashboards Winter Operations Case Study: Virginia Department of Transportation		5. Report Date December 2024		
		6. Performing Organization Code:		
7. Author(s) Mallory Crow, PhD, PE; Ming-Shiun Lee, PhD, PE		8. Performing Organization Report No.		
9. Performing Organization Name and Address AECOM 800 LaSalle Avenue, Suite 1100 Minneapolis, MN 55402		10. Work Unit No.		
		11. Contract or Grant No.		
12. Sponsoring Agency Name and Address Clear Roads Pooled Fund Study Lead State: Minnesota Department of Transportation Research Services Section 395 John Ireland Boulevard, MS 330 St. Paul, MN 55155		13. Type of Report and Period		
		14. Sponsoring Agency Code		
15. Supplementary Notes Project completed for Clear Roads Pooled Fund program, TPF-5(218). See www.clearroads.org.				
16. Abstract Public works agencies at state and municipal levels have invested a large amount of personnel and funding resources in dashboards to improve winter maintenance operations. This document is one of the five case studies conducted for the Clear Roads project entitled *Use of Dashboards for Winter Operations*. This case study report summarizes the Virginia Department of Transportation's experiences and lessons learned in using dashboards to support winter maintenance. The case study identifies the purpose of each Virginia DOT dashboard, the performance measures tracked, the data sources, how the dashboards are maintained, difficulties encountered, and key lessons learned.				
17. Key Words Dashboards, Winter Operations, Maintenance, Technology		18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161. http://www.ntis.gov		
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified		21. No. of Pages 44	22. Price

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1.   Overview of Virginia Department of Transportation Dashboards for Winter Operations

This section provides an overview of this Case Study report detailing how the Virginia Department of Transportation (VDOT) has used dashboards for winter operations.

1.1   Case Study Background

This research project is being funded through the Clear Roads pooled fund program to develop Case Study Reports documenting how multiple State departments of transportation (DOTs) and public works agencies use dashboards for winter operations.

1.2   Agency Characteristics

VDOT has nine districts as shown in Figure 1. Each district contains a maintenance superintendent and a maintenance supervisor.
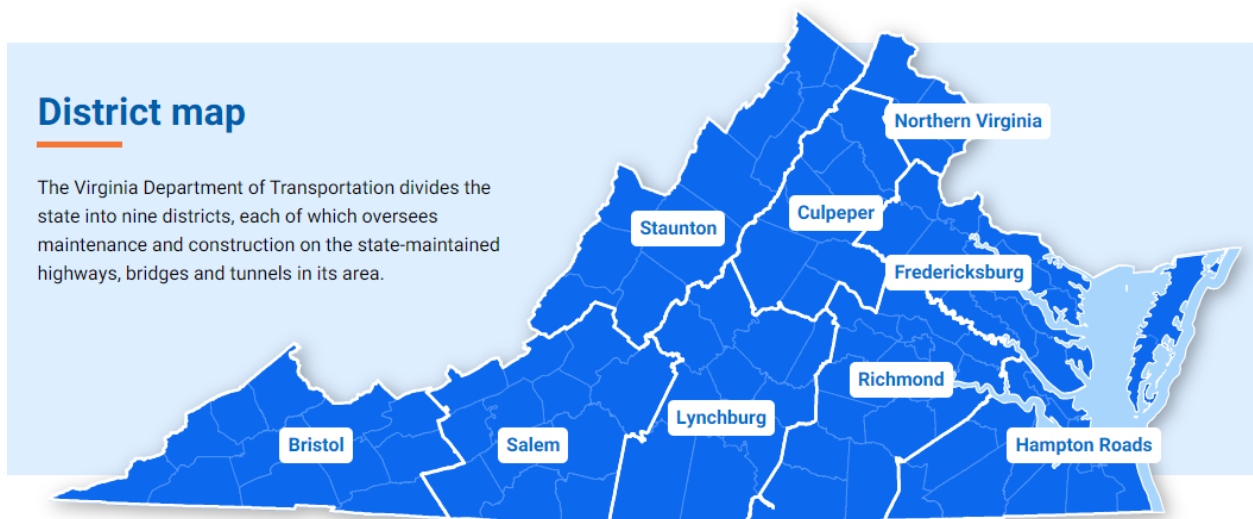

Figure 1 Virginia DOT Districts

VDOT manages 125,000 total lane miles with 2,500 state-owned plow trucks and 6,500 private or local owned plow trucks. VDOT maintains 10% of the state-owned roadways and 90% is maintained by private contractors. In the 2022-2023 winter season, VDOT spent $108 Million on snow and ice operations. The

average accumulated winter season index was 76[1]. These data were reported to the Clear Roads Winter Data Survey.

1.3   Agency Interviews

An interview was conducted virtually with VDOT staff on Tuesday, January 23rd, 2024, at 11 AM EST on the use of dashboards for winter operations. Table 1 contains a listing of the staff interviewed and the subjects discussed in those meetings. Appendix B to this report contains meeting minutes from the interview.

Table 1 Staff Interview Details

Staff Interviewed	Date / Time	Subjects Discussed
Bryan Wade, Emergency Recovery Program Manager, Virginia DOT **AJ Younes**, Emergency Operations Coordinator- Severe Weather Team, Virginia DOT	Jan. 23rd, 2024 / 11:00 AM	Dashboard objectives Description of each dashboard Limitations of each dashboard Process for developing a new dashboard Data accuracy Data storage and management Dashboard maintenance Costs Benefits of dashboards Recommendations and lessons learned Future enhancements

2.   General Overview of Winter Dashboards

As presented in Section 1.2, VDOT contracts out much of its operations. VDOT started dashboarding with the goal of streamlining the process of analyzing hired equipment data for statewide snow and ice control contractors. The data provided to their dashboards originates from multiple sources and refreshes in a range of real-time to daily. PowerBI is the main dashboarding software utilized since it is interoperable with everything else VDOT internally uses, including Power Automate with reporting tools as well as emails. These dashboards allow all resources to be fused for a comprehensive situational awareness review. VDOT has:

- Winter Preparedness Dashboard,

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[1] https://mrcc.purdue.edu/research/awssi/indexAwssi.jsp

- Winter Weather Event Dashboard,

- Full Inventory Dashboard,

- Material Inventory Dashboard,

- M7B Registration Dashboard,

- Minimum Guaranteed Payment (MGP) Look-up Dashboard,

- Equipment Verification Dashboard,

- Equipment Look-up Dashboard,

- Emergency Management Center Dashboard, and

- Damage Assessment Dashboard.

The following sections will provide details on each of the winter maintenance dashboards VDOT utilizes for insights into their winter operations.

2.1   Winter Preparedness Dashboard

The Winter Preparedness Dashboard is used to visualize statewide data which includes equipment and vendor details broken down by district, equipment type, and salt availability. VDOT utilizes the winter preparedness dashboard to visualize key data related to snow removal across the state. This dashboard serves as a central hub for both internal leadership and the public, offering insights into VDOT's equipment, vendor network, and salt availability. At its core, the dashboard displays equipment and vendor details, including multi-year and yearly agreements. Additionally, the dashboard tracks material and equipment usage, location, and status, offering performance measures during critical winter events. Figure 2 shows an example of the Winter Preparedness Dashboard displaying the amount of equipment by district. Table 2 provides details of the Winter Preparedness Dashboard, showing the purpose of the dashboard, performance measures, data sources, refresh rate, users/access, and platform/software.

Figure 2 Winter Preparedness Dashboard

Table 2 Winter Preparedness Dashboard Overview

Purpose	Visualize statewide data clearly which includes equipment and vendor details broken down by district, type, and salt available.
Performance Measures	Material and equipment usage, location, and status
Data Sources	Districts self-report, salt is updated by garage personnel, Severe Weather Application Systems (SWAS)
Refresh Rate	30 minutes
Users/Access	Anyone in the commonwealth but primarily leadership at VDOT
Platform/Software	PowerBI

While offering valuable insights, the dashboard also acknowledges limitations. The current system relies on manual entry for salt availability data, which introduces potential discrepancies. Additionally, not all data sources are fully integrated into a single, unified system of record. Despite these limitations, the winter preparedness dashboard remains a valuable tool for VDOT to assess its readiness, efficiently allocate resources, and make informed decisions throughout the winter season.

2.2   Winter Weather Event Dashboard

The Winter Weather Event Dashboard provides weather event information as soon as someone begins to mobilize within their Severe Weather Application Systems (SWAS). In response to winter weather events, VDOT employs this as a dedicated dashboard to monitor critical data in real time. This platform automatically activates as soon as personnel begin mobilizing in the SWAS, offering valuable insights throughout the event's duration. Once the event concludes and SWAS activity ceases, the dashboard returns to a blank state. Figure 3 shows the example of the Winter Weather Event Dashboard. Table 3 provides details of the Winter Weather Event Dashboard.
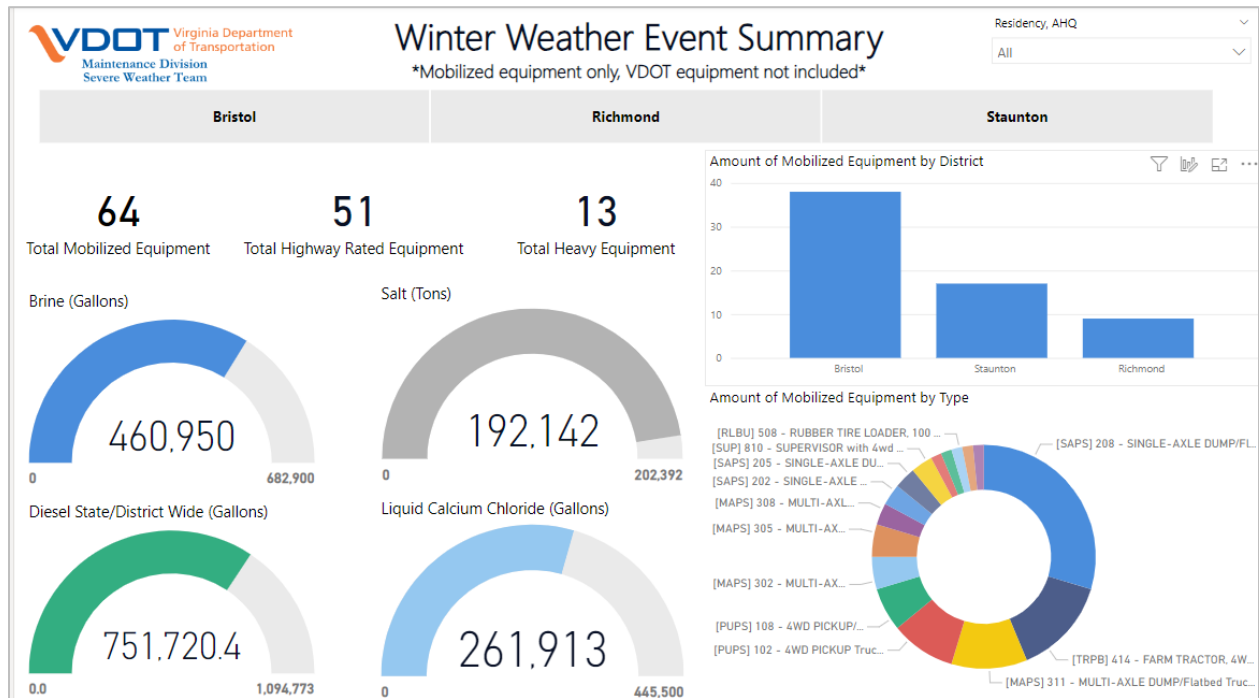

Figure 3 Winter Weather Event Dashboard

Table 3 Winter Weather Event Dashboard Overview

Purpose	Provides weather event information as soon as someone accesses SWAS
Performance Measures	Equipment and material amount only for locations that are in an active event
Data Sources	Fuel system, SWAS
Refresh Rate	30 minutes
Users/Access	Anyone in the commonwealth but primarily leadership at VDOT
Platform/Software	PowerBI

Data for the dashboard originates from multiple sources. Information on hired equipment vendors is collected through SWAS. VDOT equipment details are self-reported by individual districts. Area headquarters' personnel currently manually enter salt availability data, though it is linked to other materials and equipment at any selected location. Other crucial information, such as operational hours, is gathered through SWAS and integrated into a central data warehouse.

The dashboard updates automatically every 30 minutes, providing near real-time insights for authorized users. While it is a public-facing dashboard, primary usage falls on VDOT leadership during winter operations. PowerBI serves as the underlying platform for visualization and data presentation.

As shown in Table 3 the purpose of the Winter Weather Event Dashboard is to provide weather event information as soon as someone accesses SWAS. Focusing on key performance measures, the dashboard provides an overview of resources deployed during an event. This includes tracking the number of mobilized pieces of equipment, categorized by specific areas within the state. Additionally, it monitors crucial supplies like salt, brine, and fuel, assisting in informed decision-making during critical response phases.

Data for the dashboard are gathered from various sources. Fuel level information is automatically updated daily from the designated fuel system. Similarly, real-time activity within SWAS feeds directly into the platform. Notably, the dashboard only populates with data once trucks are documented as mobilized within SWAS, ensuring a direct correlation between displayed information and ongoing operations.

Like the Winter Preparedness Dashboard, this platform refreshes every 30 minutes, maintaining near real-time insights for authorized users. Public access is available to anyone within the commonwealth, while VDOT leadership remains the primary user base during active events. PowerBI serves as the platform for data visualization and presentation.

By providing a centralized hub for monitoring VINs, resources, and supplies, the winter weather event dashboard empowers VDOT leadership to make informed decisions throughout response efforts. While limited to active events triggered in SWAS, this platform remains a valuable tool for ensuring efficient resource allocation and effective management during critical winter weather situations.

2.3   Full Inventory Dashboard

The Full Inventory Dashboard is utilized to break down and summarize fuel data. Fuel management plays a crucial role in VDOT's operations. This dashboard allows VDOT for gaining insights into fuel usage and optimizing resource allocation. This platform offers a comprehensive breakdown of fuel data, providing valuable information for both leadership and the public. Figure 4 shows the fuel inventory dashboard displaying the amount of gasoline and diesel. Table 4 shows the purpose, performance metrics, data sources, refresh rate, users, and software information of the full inventory dashboard data.
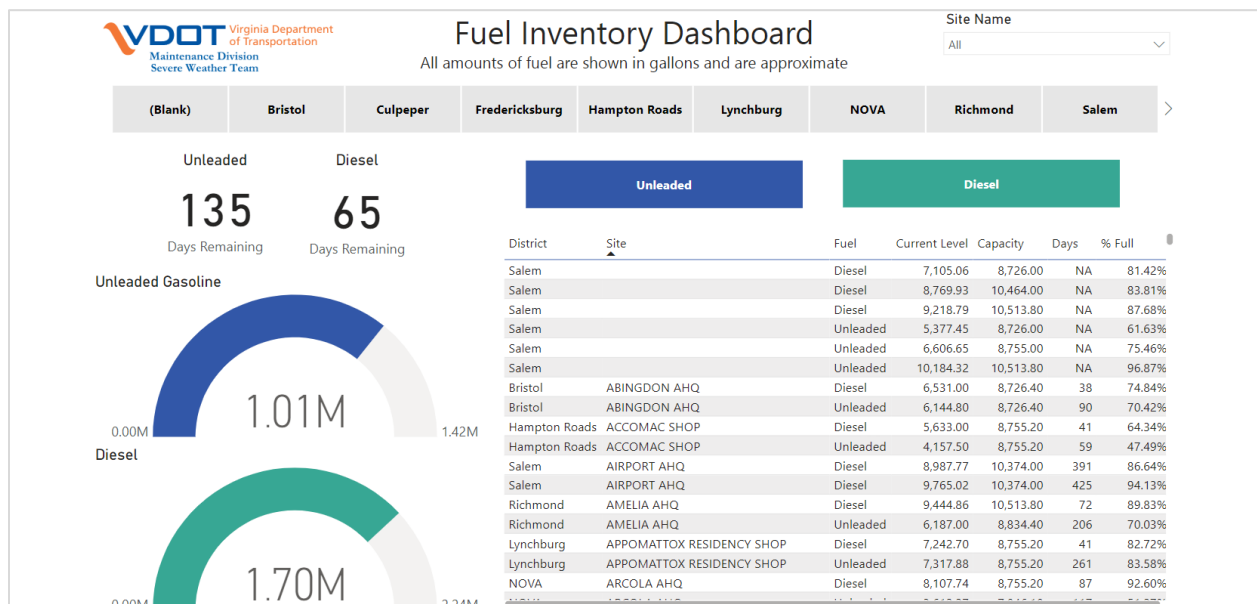

Figure 4 Full Inventory Dashboard

Table 4 Full Inventory Dashboard Overview

Purpose	To breakdown and summarize fuel data
Performance Measures	Calculate an average burn rate using past data and organize it based on fuel type, districts, and amount of fuel.
Data Sources	Fuel System
Refresh Rate	Daily
Users/Access	Anyone in the commonwealth but primarily leadership at VDOT
Platform/Software	PowerBI

The dashboard allows users to filter data down to specific sites, enabling a granular view of fuel consumption across VDOT's facilities. Its core functionality lies in calculating burn rates. Leveraging historical data, the dashboard calculates estimated fuel consumption based on fuel type, individual districts, and the state's total fuel inventory. This information helps identify potential inefficiencies and opportunities for improvement.

Data for the dashboard originates directly from VDOT's fuel system. However, it is important to note that the refresh rate is daily, meaning the displayed information reflects the previous day's data. While not real-time, this daily update offers a valuable snapshot of fuel usage trends.

Like the other dashboards discussed, public access is granted to anyone within the commonwealth, fostering transparency. However, primary usage falls on VDOT leadership, who leverage the insights to make informed decisions regarding fuel procurement, logistics, and resource allocation. PowerBI serves as the platform for data visualization and presentation.

2.4   Material Inventory Dashboard

The Material Inventory Dashboard was created for ensuring the efficient management of materials which is crucial for VDOT operations. To achieve this, VDOT utilizes a dedicated material inventory dashboard, offering insights into material usage and inventory levels across the state. Figure 5 shows the material inventory dashboard and Table 5 shows the purpose, performance measures, data sources, refresh rate, users, and software for the dashboard.
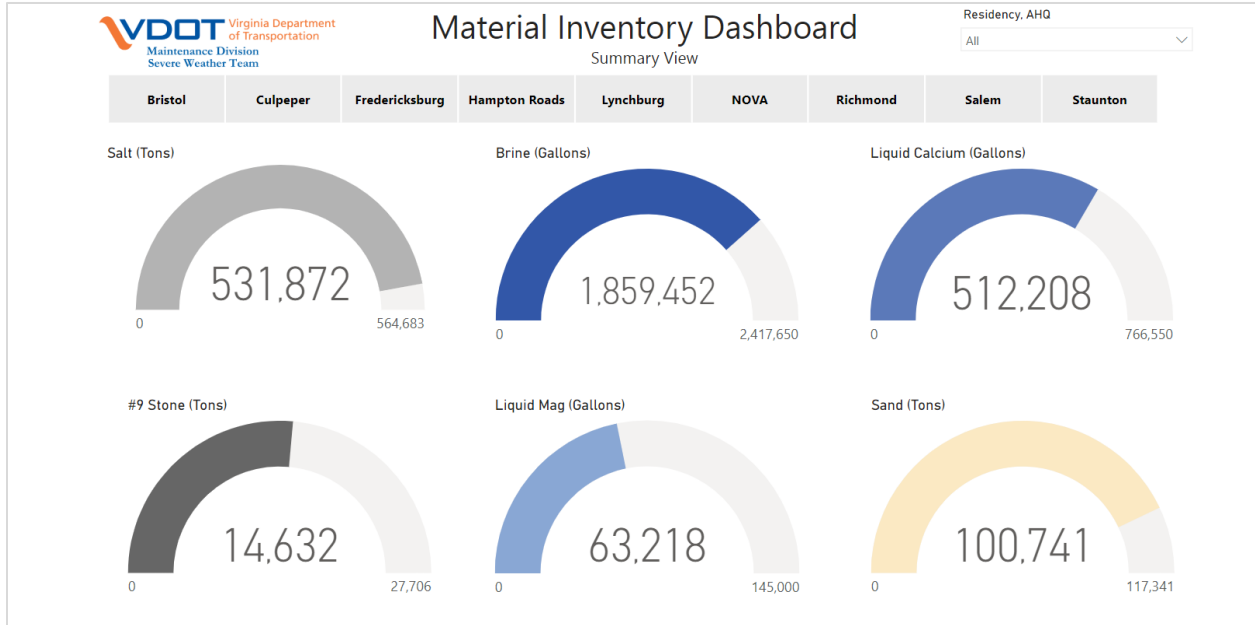
Figure 5 Material Inventory Dashboard

Table 5 Material Inventory Dashboard Overview

Purpose	Material inventory data
Performance Measures	Material usage, availability, locations, and types
Data Sources	Field staff
Refresh Rate	Daily
Users/Access	Anyone in the commonwealth but primarily leadership at VDOT
Platform/Software	PowerBI

As shown in Table 5, the purpose of the Material Inventory Dashboard is to display the material inventory of VDOT. The dashboard primarily caters to two goals: firstly, providing a breakdown of materials used, and secondly, comparing those figures with what is currently ordered and on hand. This comparison allows for proactive identification of potential shortages or surpluses, enabling informed decision-making regarding material procurement and allocation. The data for the dashboard is manually entered by field staff, ensuring timely updates. While the primary refresh rate is daily, more frequent updates can occur depending on individual garage practices. This approach offers a balance between timeliness and data accuracy.

Public access is available to anyone within the commonwealth, fostering transparency in VDOT's material management practices. However, primary usage falls on VDOT leadership, particularly local leaders and upper management. Garages directly input data, eliminating the need for them to rely on the dashboard itself. Notably, users can customize their view to tailor the information to their specific needs. Additionally, frequently used filters may be incorporated as default settings for all users, enhancing the overall user experience.

2.5   M7B Registration Dashboard

The M7B registration dashboard offers two core functionalities. It acts as a searchable vendor information hub, drawing data directly from VDOT's SWAS. This centralized platform also empowers users to streamline vendor management and troubleshoot any SWAS-related issues faced by vendors. Table 6 shows the purpose, performance measures, data sources, refresh rate, users, and software for the dashboard which is discussed later in the general dashboard overview section.

As shown in Table 6 the M7B registration dashboard is to switch off from manual reporting for vendor information and to have a vendor item search that would be based on vendor agreements. The dashboard tracks key performance measures associated with M7B contractor vehicle registration. It displays the number of active contracts and tracks the progress of contractor vehicles going through the equipment registration process. This information helps VDOT identify potential bottlenecks and inefficiencies, aiming to achieve optimal self-reporting of equipment by contractors.

Data for the dashboard is automatically refreshed every 30 minutes, providing near-real-time insights. While public access is available to anyone within the commonwealth, primary usage falls on VDOT leadership. PowerBI serves as the platform for data visualization and presentation.

Table 6 M7B Registration Dashboard

Purpose	To visualize and provide insight into the amount of M7B vendor and truck agreements by status and location.
Performance Measures	Number of vendors, amount of equipment, status of agreements
Data Sources	SWAS
Refresh Rate	30 minutes
Users/Access	Anyone in the commonwealth but primarily leadership at VDOT
Platform/Software	PowerBI

2.6   Minimum Guaranteed Payment (MGP) Look-Up Dashboard

MGP Look-Up Dashboard is used to obtain a database to look at vendors' MGP to help decide who to call in for work. For some winter weather events, VDOT utilizes MGP agreements with contractors. These agreements ensure contractors receive a baseline payment even in low-snow seasons, while VDOT retains the flexibility to call upon their services when needed. To manage these agreements effectively, VDOT employs the MGP Look-Up Dashboard.

This dashboard serves two primary purposes. Firstly, it provides a detailed table summarizing data pulled from SWAS. This table offers VDOT insights into contractor activity, enabling informed decisions about who to call upon during specific events. For instance, if a contractor with a minimum payment has not yet fulfilled their work quota, VDOT may prioritize them over other vendors without such agreements.

Secondly, the dashboard acts as a tool for ensuring fair distribution of work and timely payments. With access to individual MGP details, financial personnel within each district can monitor progress towards minimum payments. This allows them to strategically distribute workload throughout the season and ensure all contractors receive their guaranteed payments promptly. Additionally, the dashboard provides end-of-season insights into outstanding payments, facilitating efficient financial management.

It is important to note that the data displayed on the MGP Look-Up Dashboard requires some manual interpretation and manipulation by VDOT staff. Additionally, the refresh rate is not automated, meaning updates occur as needed. Despite these limitations, the dashboard remains a valuable tool for VDOT to manage MGP agreements effectively, ensuring fair treatment of contractors and optimal resource allocation during winter weather events.

The dashboard is primarily used by VDOT's area headquarters and residencies, which leverage the information for decision-making throughout the winter season. PowerBI serves as the platform for data visualization and presentation.

Figure 6 MGP Look-Up Dashboard

Table 7 MGP Look-Up Dashboard Overview

Purpose	Provide VDOT Insight into a vendor minimum guaranteed payment for financial planning purposes.
Performance Measures	Table of details from SWAS
Data Sources	SWAS and manual data
Refresh Rate	As needed
Users/Access	District/ Residency/ Area headquarters
Platform/Software	PowerBI

2.7   Equipment Verification Dashboard

The Equipment Verification Dashboard provides a database of equipment/vendor inspection details that was used to check the readiness of snow and ice removal equipment. This dashboard offers two core functionalities. Firstly, it acts as a searchable equipment verification hub, drawing data directly from VDOT's SWAS and equipment verification system. This centralized platform empowers users to streamline vendor management and troubleshoot any SWAS-related issues faced by vendors.

Secondly, the dashboard tracks key performance measures associated with M7B contractor vehicle registration. It displays the number of active contracts and tracks the progress of contractor vehicles

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going through the equipment verification process. This information helps VDOT identify potential bottlenecks and inefficiencies, aiming to achieve optimal self-reporting of equipment by contractors. As shown in Table 8 the equipment verification dashboard provides a database of equipment/vendor inspection details that was used to check the readiness of snow and ice removal equipment.

Data for the dashboard is automatically refreshed every 30 minutes, ensuring near-real-time insights. While public access is available to anyone within the commonwealth, primary usage falls on VDOT leadership. PowerBI serves as the platform for data visualization and presentation.
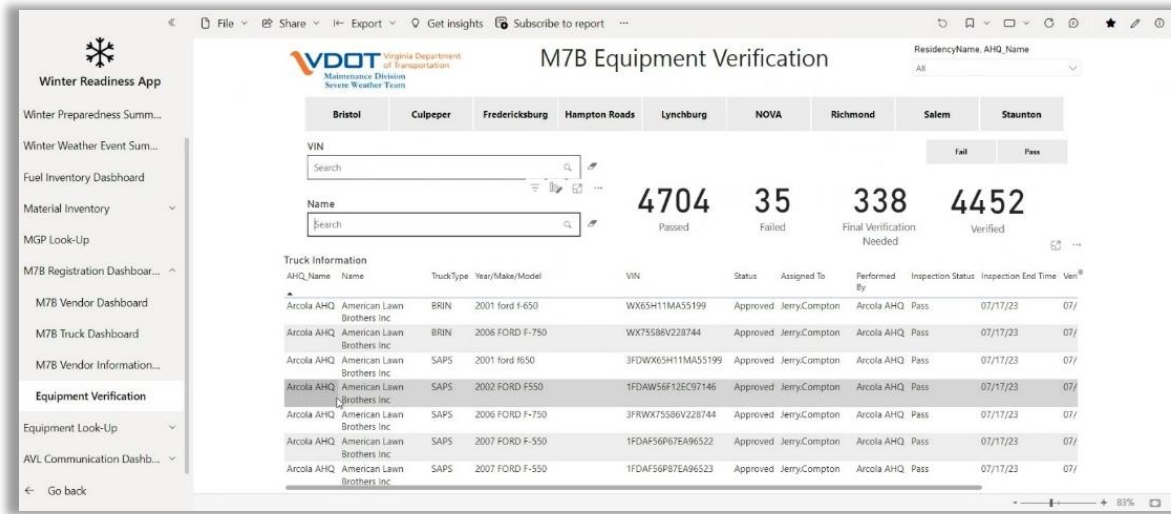
Figure 7 M7B Equipment Verification Dashboard

Table 8 Equipment Verification Dashboard Overview

Purpose	Provides a database of equipment/vendor inspection details that was used to check the readiness of snow and ice removal equipment
Performance Measures	Pass/fail verification of inspection.
Data Sources	Inspection System – CAL AMP K-12 (SYNOVIA)
Refresh Rate	Once a day
Users/Access	Anyone in the commonwealth but primarily leadership at VDOT
Platform/Software	PowerBI

2.8   Equipment Look-Up Dashboard

VDOT relies on a diverse network of vendors and equipment to tackle winter weather events. To ensure efficient management and coordination, VDOT utilizes the Equipment Look-Up Dashboard. This platform offers a comprehensive searchable database, empowering users to locate specific vendors and equipment with ease. Unlike other dashboards limited to M7B program vendors, the Equipment Look-Up Dashboard extends its reach to encompass all VDOT-contracted vendors. This comprehensive approach makes it a valuable tool for verifying equipment details and streamlining communication across the entire winter operations network.

As shown in Table 9 the equipment look-up dashboard offers a comprehensive searchable database, empowering users to locate specific vendors and equipment with ease. The dashboard goes beyond listing vendors and equipment. It provides key performance measures related to each entry. This includes details regarding active agreements, Automatic Vehicle Location (AVL) orders, equipment installations, and the most recent communication ping from AVL systems. This information allows users to assess equipment readiness and identify potential issues promptly.

Data for the Equipment Look-Up Dashboard is gathered from multiple sources. SWAS provides vendor and agreement information, while the AVL order date system and AVL system itself contribute installation and communication data. With a refresh rate of 30 minutes, the dashboard offers near-real-time insights. While public access is granted to anyone within the commonwealth, primary users come from VDOT's district and residency levels, directly interacting with vendors on the ground. This ensures that those closest to operations have the information they need to make informed decisions and collaborate effectively. PowerBI serves as the underlying platform for data visualization and user interaction.

Figure 8 Equipment Look-Up Dashboard

Table 9 Equipment Look-Up Dashboard Overview

Purpose	To allow users to search all vendors and equipment in the database.
Performance Measures	Agreement, Automatic Vehicle Location (AVL) orders, installation, AVL communications last ping
Data Sources	SWAS and AVL
Refresh Rate	Thirty minutes
Users/Access	Anyone in the commonwealth but primarily leadership at VDOT
Platform/Software	PowerBI

2.9 Emergency Management Center Dashboard

The Emergency Management Center Dashboard is a specialized tool that focuses on emergency management, as shown in Figure 9. Table 10 provides a general overview of the dashboard. The dashboard's primary purpose is to provide comprehensive weather information. This includes data on various weather conditions, with a particular emphasis on snow and radar data. The dashboard's performance is evaluated based on the accuracy and timeliness of these data.

Data used by the dashboard are collected from a variety of sources. These include Data Transmission Network and Dataline (DTN), local storm reports, radar, the National Weather Service (NWS), AVL

systems, Waze, and other spatial details such as park and ride locations. This diverse range of data sources allows the center to make informed decisions during emergencies.

One of the key features of the center is its real-time data refresh rate. This ensures that the most current information is always available, which is crucial during emergency situations. The platform is designed to be shared with state partners and districts. It has a flexible permission system that allows for various views on the hub, depending on the access level granted. The center operates on the ArcGIS Online (AGOL) software platform.
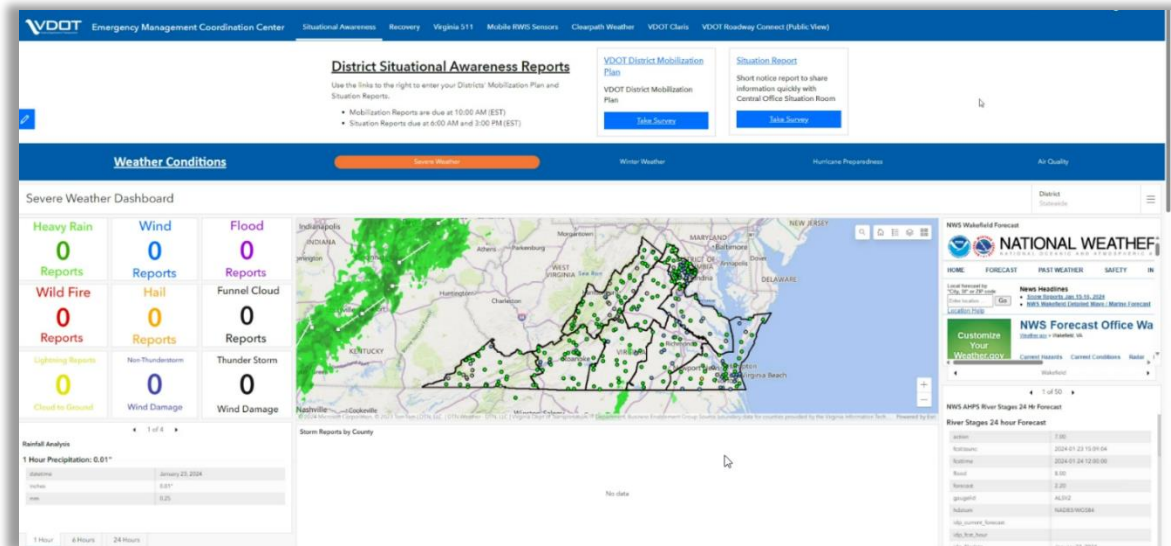
Figure 9 Emergency Management Center Dashboard

Table 10 Emergency Management Center Dashboard Overview

Purpose	Provides all weather information
Performance Measures	Snow and radar
Data Sources	Data Transmission Network (DTN) data, local storm reports, radar, National Weather Service (NWS), AVL, Waze, and other spatial details
Refresh Rate	Real-time
Users/Access	State partners and districts
Platform/Software	ArcGIS Online (AGOL)

2.10   Damage Assessments Dashboard

The Damage Assessments Dashboard tracks, manages, and adds value to damages in order to determine if the Federal Emergency Management Agency (FEMA) or Federal Highway Administration (FHWA) are needed. This dashboard tracks the review/status of the damage reports. VDOT faces the crucial task of assessing damage and initiating repairs efficiently. VDOT utilizes this dedicated Damage Assessments Dashboard powered by AGOL to streamline this process and ensure timely recovery. This dashboard serves several key purposes. Firstly, it provides a centralized platform for tracking and managing all reported damages, offering a comprehensive overview of the situation. This allows VDOT to prioritize repairs based on severity and resource availability. Secondly, the dashboard facilitates the process of adding value to damage assessments. By integrating with relevant systems and procedures, the dashboard can help determine eligibility for federal assistance from FEMA or FHWA, streamlining financial recovery efforts. Thirdly, the dashboard allows VDOT to track the review and approval status of individual damage reports. Figure 10 presents an image of the dashboard, and Table 11 provides additional details.

Performance measures displayed on the dashboard include the status of each damage report, associated images for visual verification, and estimated repair costs. This information empowers VDOT leadership to make informed decisions regarding resource allocation and prioritize critical repairs. Data for the dashboard originates from Survey123, a mobile data collection app utilized by VDOT field crews. This app streamlines the data collection process, capturing information directly at the damage site and feeding it into the dashboard in real-time. This eliminates manual data entry and significantly reduces processing time. Prior to implementing Survey123 and the AGOL dashboard, damage assessments were a manual and time-consuming process, often taking weeks to complete. The digitalized approach has updated VDOT's response, saving weeks of time and enabling a more efficient and data-driven recovery process.

Figure 10 Damage Assessments Dashboard

Table 11 Damage Assessments Dashboard Overview

Purpose	Track, manage, and add value to damages and determine if the Federal Emergency Management Agency (FEMA) or Federal Highway Administration (FHWA) are needed. This dashboard will also track the review/status of the damage reports.
Performance Measures	Status of reports, images of damage, cost of damage
Data Sources	Survey 123 from field crews
Refresh Rate	Real-time
Users/Access	State districts
Platform/Software	AGOL

3.   Development of Dashboards

The decision for the development of winter operations related dashboards for VDOT is based on whether there is a manual process that can be automated to save time. By having dashboards that automate work, resource sharing has become easier. With the data platforms VDOT has available, they can make as many dashboards as they need. The more people utilizing the dashboards will lead to more enhancements.

A team of Emergency Operations and Management Specialists mostly developed these dashboards. The extract, transform, and load process for the dashboard involved using Power Automate tools, and all data was stored in the cloud and exported and shared from ESRI. The accuracy of the data is usually verified by the provider. When data have errors, it is easily catchable as the team is very familiar with what "normal data" looks like. Most of the data is stored in an IT data warehouse; however, a large-scale data system for PowerBI is in the works. Some of the team uses ESRI cloud storage. Data can be queried as far back as 2019 from ESRI's cloud storage; however, PowerBI cannot go back and view older data since there are so many changes made to historical data.

Some issues that were encountered in the development of these dashboards include issues with internal connections to PowerBI and collaborating with vendors. Since VDOT manages so many contractors that all have difference processes for managing data. No specific issues with ESRI occurred since there were plenty of online resources.

4.   System Operations and Maintenance

The hosting of the dashboards and data update responsibility varies depending on the dashboard. The same team that developed the dashboards, which is the team of Emergency Operations and Management Specialists, is also responsible for their maintenance if there are any issues or enhancements that need to be made. The databases for these dashboards are maintained by ESRI and an Emergency Operations Specialist, and IT maintains the data warehouse for PowerBI. The costs to maintain these dashboards and resources are associated with the personnel who use and maintain them. VDOT has 700 ESRI licenses with cloud services and weather vendors.

5.   Benefits and Lessons Learned

Some of the benefits gained from having these dashboards include having a faster response time thus shorter recovery time, automating workflow, dealing with fewer emails, standardizing processes, resource allocation, and managing vendors. Lessons learned from creating these dashboards were that going to ESRI conferences helped gain a deeper understanding because the team was able to meet other users and gain in-person assistance. VDOT also noted that ideals for new dashboards can be inspired by speaking to other DOTs. Also, while VDOT has a lot of people skilled in software, better and more effective communication among them can further improve the efficiency and reduce the risk of duplicating efforts.

6.   Plans for the Future and Potential Enhancements

Some future enhancements include: adding 511 data involving road closures during the winter into the emergency response dashboards; and using ArcGIS Velocity for early weather warnings as well as big data analytics with damage assessments and insight for analytics. For dashboards on PowerBI platform,

the team would like to explore the possibility of using historical data. A new data miner is also in the works to potentially be implemented for situational awareness around security.

7.   Key Point

- VDOT started dashboarding to streamline the process of exporting data for vendor and truck agreements for statewide snow removal, since 90% of their roadways are managed by private contractors.

- VDOT has ten different dashboards set up for this purpose. Some of the benefits gained from having these dashboards include having a faster response time, automating workflow, dealing with fewer emails, standardizing processes, resource allocation, and managing vendors.

- The data provided to their dashboards originates from multiple sources. Depending on the dashboards, data refresh frequencies range from real-time, thirty minutes, to daily.

- The majority of the dashboards are created using PowerBI. They are interoperable with many tools and systems that VDOT uses internally, such as power automate with reporting tools and emails. This provides VDOT with the ability to streamline the data sharing and integration for one giant situational awareness problem.

- VDOT has many contracted services and data schema that can be a hindrance sometimes for winter maintenance operations and management. Having dashboards interoperable across an agency helps reduce some of the issues. VDOT recommends other DOTs to consider interoperability for their dashboard development.

- The databases for these dashboards are maintained by ESRI and an Emergency Operations Specialist, and IT maintains the data warehouse for PowerBI.

- Some future enhancements include adding 511 data involving road closures during the winter into the emergency response dashboards.

Appendix A Survey Response

Contact Information

Name	Bryan Wade	A.J. Younes
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Survey Information

1. Do you have any dashboards (with interactive performance measures) using data of winter maintenance operations?	Yes	Yes
If yes, how many?	2	approx. 12
1A. If you answered yes to the previous question (you do have dashboards) please briefly describe how each on is used.	We have out winter weather dashboard using ArcGIS and a maintenance dashboard using powerbi. The winter weather dashboard looks at impactful winter weather affecting the commonwealth of Virginia. The maintenance dashboard reflects equipment readiness and supply information for winter weather treatments. There are also ArcGIS dashboards that capture recovery information form damage assessments.	They are used to visualize mobilization, weather, financial, materials, and contracting data/progress
2. Do you find these dashboards useful during an event in real-time?	Yes	Yes
3. Do you find these dashboards useful after an event, such as after-action reports?	Yes	Yes
4. Do you use the dashboards to inform beneficial / best practices?	Yes	Yes
5. What data are you using in your dashboard(s)? (Select all that apply)	7	6
Automatic Vehicle Location/Global Positioning System (AVL/GPS)	X	X
Material Usage total	X	X
Material Usage Rates		
Weather Data (For example: Road Weather Information System (RWIS))	X	X
Cycle Time		

Plow Position	X	
Traffic Data (Speed and/or Volumes)	X	X
Connected Vehicle (CV) data		
Incident Data	X	X
Finance data	X	X
Other (please specify)		
6. What are the sources of the data in the dashboards? (Select all that apply)	6	7
Automatic Vehicle Location/Global Positioning System (AVL/GPS)	X	X
Spreader/Sprayer Controller		
Plow Position Sensor		
Mobile Weather Sensors, etc.	X	X
Maintenance Decision Support Systems (MDSS)	X	X
RWIS Stations	X	X
Advance Traffic Management System (ATMS)		X
Maintenance Management System	X	X
Probe Traffic Data		
Connected Vehicles (CVs)		
Crowd Sourced data (e.g. Waze)	X	X
Other (please specify)		
7. How are the data ingested into the dashboard? (Select all that apply)		
Application Programming Interface (API) from data source	X	X
SQL database updated		X
Excel spreadsheets	X	X
CSV/Text File	X	X
Access Database		
Other (please specify)	ArcGIS	CSV files to Sharepoint Online, automated with Blue Prism or Power Automate
8. What is the frequency of the data refresh? (Select all that apply)	5	5
Minutes / Close to real-time (5)	X	X
Hourly (4)	X	X
Daily (3)	X	X
Weekly (2)		

Monthly (1)		
Other (please specify)		
9. How are data stored? (Select all that apply)		
Cloud-based	X	X
Client-Owned Server		
Third-Party Server		
Enterprise Content Management System (For example: SharePoint)	X	X
Other (please specify)		
10. What dashboarding platforms are used? (Select all that apply)		
PowerBi	X	X
Tableau		
ArcGIS	X	X
Internally custom created or other platform (please describe)		
11. What metrics/performance measures presented on the dashboard(s) do you find most helpful for operations? And describe why they are the most helpful.		Virginia contracts a significant portion of snow removal services. Dashboards that visualize the contracting process offer a lot of insight into the amount of contractors we have vs the amount we need, the types of equipment we are signing up, the progress of the applications and more.
12. Are you able to generate static reports / outputs from the dashboard?	Yes	Yes
13. Who has access to view the dashboards? (Select all that apply)	2	2
Internal agency	X	X
Partner Agencies	X	X
Contractors		
Public		
Other (please specify)		
14. Who developed the dashboard(s)? (Select all that apply)		
Internal agency	X	X
Consultant		
AVL / GPS Vendor	X	
Other Third-Party vendor		

University		
Other (please specify)		
15. If an external entity developed any of your dashboards, were you a part of the design process?	Yes	
15A. Is your dashboard customizable to fit your needs?	Yes	Yes
16. Who maintains the dashboard and data used?	Office of Safety, Security, and Emergency Management, VDOT Maintenance Division, AVL Provider	My team does. Other working groups maintain dashboards as well. Data ownership maybe shared depending on type of data.
17. How are the data checked for accuracy and who is responsible for checking?	Recovery data is verified and reviewed by district and central office staff; Maintenance division reviews district inputted data	Each dashboard owner is responsible for accuracy.
18. What data do you wish you had within a dashboard? And why?	Data from our 511 system. To be able to show road closure information, traffic incidents, and other traffic related dated	Real time inventory management data (for salt, etc.). Our current IMS system isn't real time, resulting in manual entry to keep material data updated during weather events.
19. What are the limitations of your current dashboard(s)?	the potential for human error during the data collection process. Fear of putting in data that reflects poorly on a district or user	Data availability
20. Do you have any enhancements to current dashboards, or new dashboards, you want to develop or are in the process of developing?	Yes	Yes
If yes, please describe:	New situational awareness site and integration of new capabilities within the DOT	
21. Has your agency deployed or planned to deploy connected vehicle technology that may assist with winter operations?	No	No
22. Has your agency used or planned to use connected vehicle data for winter maintenance dashboards?	Yes, we have used connected vehicle data	We plan to use connected vehicle data
23. What issues has your agency experienced with developing the dashboard(s)?	Cost and technical abilities of staff	Automating data that wasn't previously maintained in a fashion that easily allows for automation.
24. What issues has your agency experienced with using the dashboard(s)?	licenses for some products expire because of use limits set by the State IT Agency	Adjusting to the different functionality of the dashboard platform (exporting, manipulating, filtering, etc.)

25. What practical advice and/or lessons learned can be offered to others interested in developing and implementing dashboards to support winter maintenance operations?	worth the time and effort	Develop dashboards that replace existing manual processes to build confidence and familiarity with dashboards. Most of our dashboards have been created with a needs-based design approach
26. May we contact you with follow-up questions?	Yes	Yes

Appendix B Virtual Interview Meeting Minutes

PROJECT 22-05: USE OF DASHBOARDS FOR WINTER OPERATIONS

SUMMARY OF VIRGINIA DOT VIRTUAL INTERVIEW

Overview

Virtual interviews were conducted by Ming-Shiun Lee, Allison Balogh, and Mallory Crow of AECOM and coordinated with the assistance of Bryan Wade and AJ Younes with the Virginia Department of Transportation (VDOT) on Tuesday January 23rd, 2024, at 11 AM EST.

VDOT Staff Interviews

Meeting attendees on Tuesday, January 23rd included the following individuals:

- Bryan Wade

- AJ Younes

Introduction

The VDOT started dashboarding with a goal to streamline the process of analyzing hired equipment data for statewide and ice contractors.

Winter Preparedness Dashboard

Winter Preparedness Dashboard Overview

Purpose	Visualize statewide data clearly which includes equipment and vendor details broken down by district, type, and salt available
Performance Measures	Material and equipment usage, location, and status
Data Sources	Districts self-report, salt is updated by garage personnel, Severe Weather Application Systems (SWAS)
Refresh Rate	30 minutes
Users/Access	Anyone in commonwealth but primarily leadership at VDOT
Platform/Software	PowerBI

VDOT utilizes a winter preparedness dashboard to visualize key data related to snow removal across the state. This dashboard serves as a central hub for both internal leadership and the public, offering insights into VDOT's equipment, vendor network, and salt availability.

At its core, the dashboard displays equipment and vendor details, including multi-year and yearly agreements. This information is broken down by district and equipment type, providing a picture of VDOT's resources across the state. Additionally, the dashboard tracks material and equipment usage, location, and status, offering performance measures during critical winter events.

Data for the dashboard originates from multiple sources. Information on hired equipment vendors is collected through SWAS. VDOT equipment details are self-reported by individual districts. Importantly, salt availability data is currently entered manually by area headquarters' personnel, though it is linked to other materials and equipment at any selected location. Other crucial information, such as operational hours, is gathered through SWAS and integrated into a central data warehouse.

The dashboard updates automatically every 30 minutes, ensuring near real-time insights for authorized users. Public access is granted to anyone within the state, while primary usage falls on VDOT leadership during winter operations. PowerBI serves as the underlying platform for visualization and data presentation.

While offering valuable insights, the dashboard also acknowledges limitations. The current system relies on manual entry for salt availability data, which introduces potential discrepancies. Additionally, not all data sources are fully integrated into a single, unified system of record. Despite these limitations, the winter preparedness dashboard remains a valuable tool for VDOT to assess its readiness, efficiently allocate resources, and make informed decisions throughout the winter season.

Winter Weather Event Dashboard Overview

Purpose	Provides weather event information as soon as someone accesses SWAS
Performance Measures	Equipment and material amount only for locations that are in an active event
Data Sources	Fuel system, SWAS
Refresh Rate	30 minutes
Users/Access	Anyone in commonwealth but primarily leadership at VDOT
Platform/Software	PowerBI

In response to winter weather events, VDOT employs a dedicated dashboard to monitor critical data in real-time. This platform automatically activates as soon as personnel begin mobilizing in the SWAS, offering valuable insights throughout the event's duration. Once the event concludes and SWAS activity ceases, the dashboard returns to a blank state.
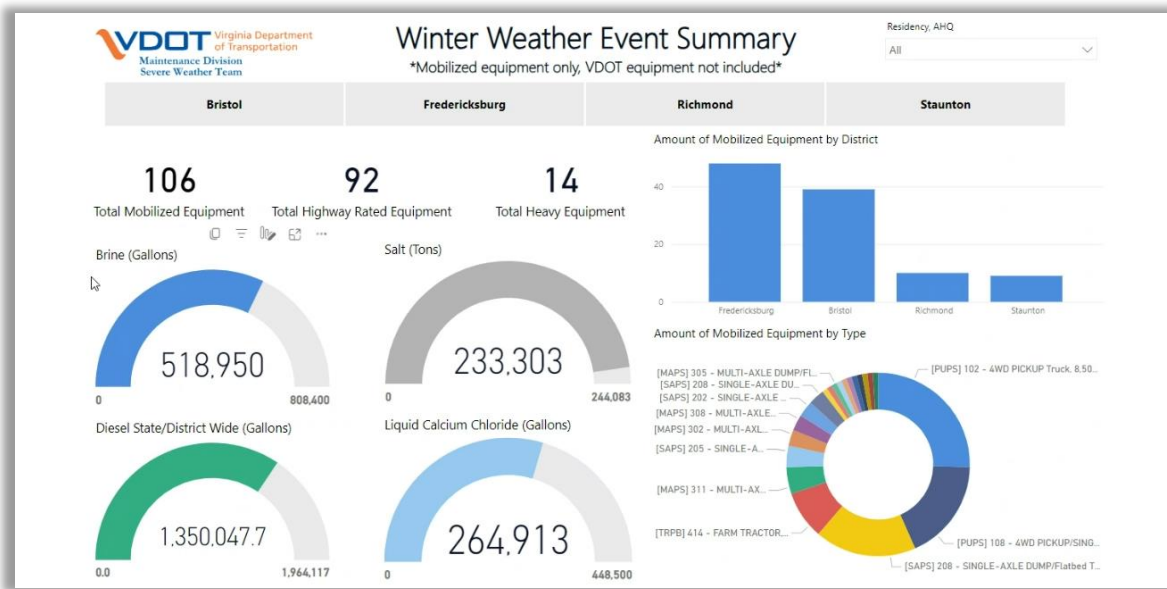
Focusing on key performance measures, the dashboard provides an overview of resources deployed during an event. This includes tracking the number of mobilized pieces of equipment, categorized by specific areas within the state. Additionally, it monitors crucial supplies like salt, brine, and fuel, ensuring informed decision-making during critical response phases.

Data for the dashboard is gathered from various sources. Fuel level information is automatically updated daily from the designated fuel system. Similarly, real-time activity within SWAS feeds directly into the platform. Notably, the dashboard only populates with data once trucks are documented as mobilized within SWAS, ensuring a direct correlation between displayed information and ongoing operations.

Like the Winter Preparedness Dashboard, this platform refreshes every 30 minutes, maintaining near real-time insights for authorized users. Public access is available to anyone within the commonwealth, while VDOT leadership remains the primary user base during active events. PowerBI serves as the platform for data visualization and presentation.

By providing a centralized hub for monitoring VINs, resources, and supplies, the winter weather event dashboard empowers VDOT leadership to make informed decisions throughout response efforts. While

limited to active events triggered in SWAS, this platform remains a valuable tool for ensuring efficient resource allocation and effective management during critical winter weather situations.

Full Inventory Dashboard

Full Inventory Dashboard Overview

Purpose	To breakdown and summarize fuel data
Performance Measures	Calculate an average burn rate using past data and organize it based on fuel type, districts, and amount of fuel
Data Sources	Fuel System
Refresh Rate	Daily
Users/Access	Anyone in commonwealth but primarily leadership at VDOT
Platform/Software	PowerBI

Fuel management plays a crucial role in VDOT's operations. To gain deeper insights into fuel usage and optimize resource allocation, VDOT utilizes a dedicated Fuel Inventory Dashboard. This platform offers a comprehensive breakdown of fuel data, providing valuable information for both leadership and the public.

The dashboard allows users to filter data down to specific sites, enabling a granular view of fuel consumption across VDOT's facilities. Its core functionality lies in calculating burn rates. Leveraging historical data, the dashboard calculates estimated fuel consumption based on fuel type, individual districts, and the state's total fuel inventory. This information helps identify potential inefficiencies and opportunities for improvement.

Data for the dashboard originates directly from VDOT's fuel system, ensuring consistency and accuracy. However, it is important to note that the refresh rate is daily, meaning the displayed information reflects the previous day's data. While not real-time, this daily update offers a valuable snapshot of fuel usage trends.

Like the other dashboards discussed, public access is granted to anyone within the commonwealth, fostering transparency. However, primary usage falls on VDOT leadership, who leverage the insights to make informed decisions regarding fuel procurement, logistics, and resource allocation. PowerBI serves as the platform for data visualization and presentation.

Material Inventory Dashboard

Material Inventory Dashboard Overview

Purpose	Material inventory data
Performance Measures	Material usage, availability, locations, and types
Data Sources	Field staff

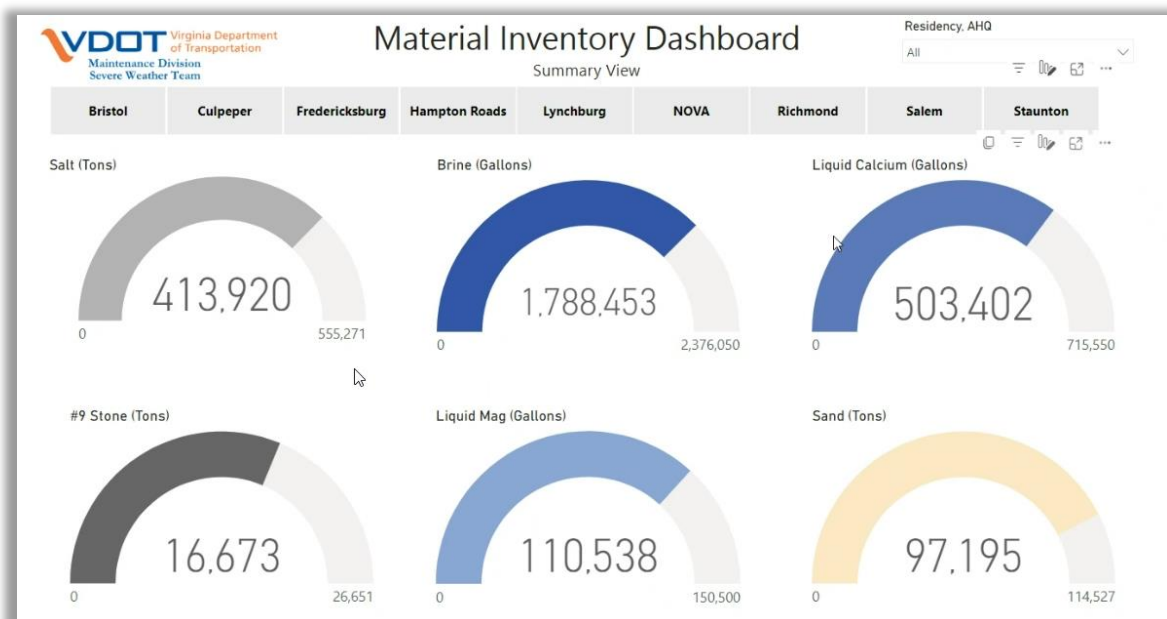| Refresh Rate	Daily
Users/Access	Anyone in commonwealth but primarily leadership at VDOT
Platform/Software	PowerBI

Ensuring the efficient management of materials is crucial for VDOT operations. To achieve this, VDOT utilizes dedicated material inventory dashboards, offering insights into material usage and inventory levels across the state.

These dashboards primarily cater to two goals: firstly, providing a breakdown of materials used, and secondly, comparing those figures with what is currently ordered and on-hand. This comparison allows for proactive identification of potential shortages or surpluses, enabling informed decision-making regarding material procurement and allocation. The data for the dashboards is manually entered by field staff, ensuring timely updates. While the primary refresh rate is daily, more frequent updates can occur depending on individual garage practices. This approach offers a balance between timeliness and data accuracy.

Public access is available to anyone within the commonwealth, fostering transparency in VDOT's material management practices. However, primary usage falls on VDOT leadership, particularly local leaders and upper management. Garages directly input data, eliminating the need for them to rely on the dashboard itself. Notably, users can customize their view to tailor the information to their specific needs. Additionally, frequently used filters may be incorporated as default settings for all users, enhancing overall user experience.

M7B Registration Dashboard

Purpose	To visualize and provide insight into the amount of M7B vendor and truck agreements by status and location
Performance Measures	Number of vendors, amount of equipment, status of agreements
Data Sources	SWAS
Refresh Rate	30 minutes
Users/Access	Anyone in commonwealth but primarily leadership at VDOT
Platform/Software	PowerBI

This dashboard helps to visualize and provide insight into the amount of M7B vendor and truck agreements by status and location. This centralized platform empowers users to streamline vendor management and troubleshoot any SWAS-related issues faced by vendors.

Secondly, the dashboard tracks key performance measures associated with M7B contractor vehicle registration. It displays the number of vendors, amount of equipment, status of agreements. This information helps VDOT identify potential bottlenecks and inefficiencies, aiming to achieve optimal self-reporting of equipment by contractors.

Data for the dashboard is automatically refreshed every 30 minutes, ensuring near real-time insights. While public access is available to anyone within the commonwealth, primary usage falls on VDOT leadership. PowerBI serves as the platform for data visualization and presentation.

MGP Look-Up Dashboard

MGP Look-Up Dashboard Overview

Purpose	Provide VDOT Insight into a vendors minimum guaranteed payment for financial planning purposes
Performance Measures	Table of details from SWAS
Data Sources	SWAS and manual data

Refresh Rate	As needed
Users/Access	District/ Residency/ Area headquarters
Platform/Software	PowerBI

For some winter weather events, VDOT utilizes minimum guaranteed payment (MGP) agreements with contractors. These agreements ensure contractors receive a baseline payment even in low-snow seasons, while VDOT retains flexibility to call upon their services when needed. To manage these agreements effectively, VDOT employs the MGP Look-Up Dashboard.

This dashboard serves two primary purposes. Firstly, it provides a detailed table summarizing data pulled from SWAS. This table offers VDOT insights into contractor activity, enabling informed decisions about who to call upon during specific events. For instance, if a contractor with a minimum payment has not yet fulfilled their work quota, VDOT may prioritize them over other vendors without such agreements.

Secondly, the dashboard acts as a tool for ensuring fair distribution of work and timely payments. With access to individual MGP details, financial personnel within each district can monitor progress towards minimum payments. This allows them to strategically distribute workload throughout the season and ensure all contractors receive their guaranteed payments promptly. Additionally, the dashboard provides end-of-season insights into outstanding payments, facilitating efficient financial management.

It is important to note that the data displayed on the MGP Look-Up Dashboard requires some manual interpretation and manipulation by VDOT staff. Additionally, the refresh rate is not automated, meaning updates occur as needed. Despite these limitations, the dashboard remains a valuable tool for VDOT to manage MGP agreements effectively, ensuring fair treatment of contractors and optimal resource allocation during winter weather events.

The dashboard is primarily used by VDOT's area headquarters, districts and residencies, who leverage the information for decision-making throughout the winter season. PowerBI serves as the platform for data visualization and presentation.

Remaining Minimum Guaranteed Payment
Last Update: 1/17/24

Bristol	Culpeper	Fredericksburg	Hampton Roads	Salem	Staunton

Residency	Area HQ	Vendor	Truck Name	Plate Number	Min Payment Amount	Total Paid
Bristol Interstate Maintenance	BIM Atkins Stock Location	KAR Construction	2323		$60,000	$0
Bristol Interstate Maintenance	BIM Ft. Chiswell Stock Location	Interstate Construction LLC	SB1		$60,000	$0
Bristol Interstate Maintenance	BIM Glade Springs Stock Location	Fox Valley LLC	SB1		$60,000	$0
Bristol Interstate Maintenance	BIM Glade Springs Stock Location	Fox Valley LLC	B-10	UA91911	$52,000	$0
Bristol Interstate Maintenance	BIM Glade Springs Stock Location	Fox Valley LLC	C-24		$52,000	$0
Bristol Interstate Maintenance	BIM Atkins Stock Location	Complete Truck Service Inc.	Bill		$32,000	$0
Bristol Interstate Maintenance	BIM Atkins Stock Location	Carol Anne Hash	2002 Dodge 3500		$30,000	$0
Bristol Interstate Maintenance	BIM Atkins Stock Location	Carol Anne Hash	2007 GMC 3500HD		$30,000	$0
Martinsville Residency	Fairystone AHQ	Cut-Rite Harvesting Inc	2022 Fendit 930	N/A	$7,050	$0
Bristol Interstate Maintenance	BIM Atkins Stock Location	Aaron W Lundy	1		$20,000	$0
Bristol Interstate Maintenance	BIM Atkins Stock Location	Aaron W Lundy	6		$20,000	$0
Bristol Interstate Maintenance	BIM Atkins Stock Location	Complete Truck Service Inc.	2012 Chevrolet 1500 4x4		$12,000	$0
Bristol Interstate Maintenance	BIM Atkins Stock Location	Complete Truck Service Inc.	2012 Chevrolet 2500		$12,000	$0
Bristol Interstate Maintenance	BIM Bristol District Stock Location	C L Fencing	W-1		$12,000	$0
Bristol Interstate Maintenance	BIM Bristol District Stock Location	C L Fencing	W-2		$12,000	$0
Bristol Interstate Maintenance	BIM Bristol District Stock Location	C L Fencing	W-3		$12,000	$0
Martinsville Residency	Fairystone AHQ	Garland R West	1998 Mack Tandem	UB51482	$12,000	$0
Wytheville Residency	Volney AHQ	Poplar Grove Farm II LLC	2012 JOHN DEERE 6430	NA	$6,000	$0
Martinsville Residency	Fancy Gap AHQ	JOSEPH HOUK	1996 FORD 750	231-247	$10,600	$0
Christiansburg Residency	Christiansburg AHQ	William Ryan	2006 John Deere 6420	N/A	$5,250	$0
Total						

Equipment Verification Dashboard

Equipment Verification Dashboard Overview

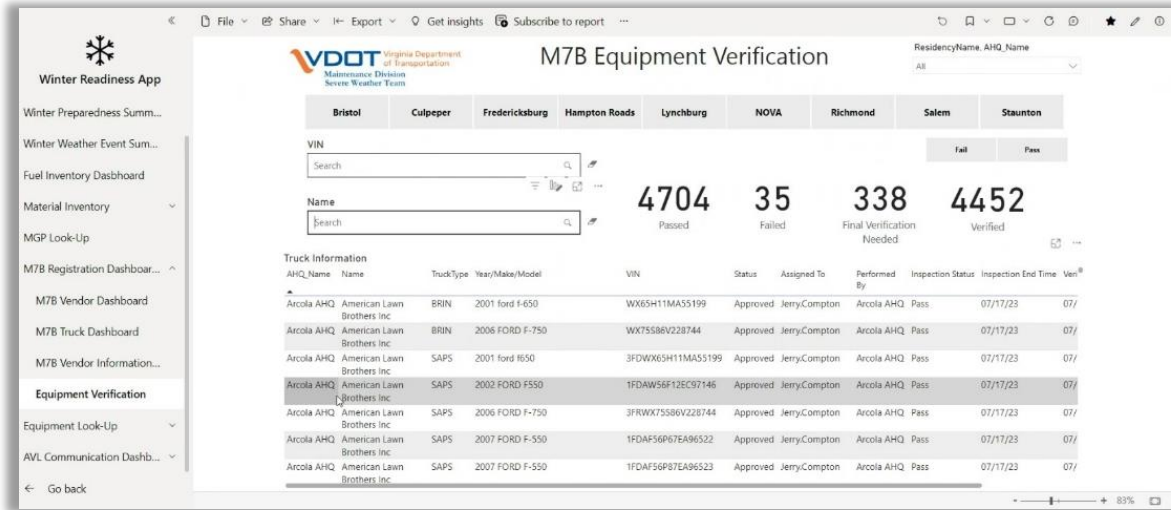|	
Purpose	Provides a database of equipment/vendor inspection details that was used to check the readiness of snow and ice removal equipment
Performance Measures	Pass/fail verification of inspection
Data Sources	Inspection System – CAL AMP K-12 (SYNOVIA)
Refresh Rate	Once a day
Users/Access	Anyone in commonwealth but primarily leadership at VDOT
Platform/Software	PowerBI

This dashboard offers two core functionalities. Firstly, it acts as a searchable equipment verification hub, drawing data directly from VDOT's SWAS and equipment verification system. This centralized platform empowers users to streamline vendor management and troubleshoot any SWAS-related issues faced by vendors.

Secondly, the dashboard tracks key performance measures associated with M7B contractor vehicle registration. It displays the number of active contracts and tracks the progress of contractor vehicles going through the equipment verification process. This information helps VDOT identify potential bottlenecks and inefficiencies, aiming to achieve optimal self-reporting of equipment by contractors.

Data for the dashboard is automatically refreshed every 30 minutes, ensuring near real-time insights. While public access is available to anyone within the commonwealth, primary usage falls on VDOT leadership. PowerBI serves as the platform for data visualization and presentation.
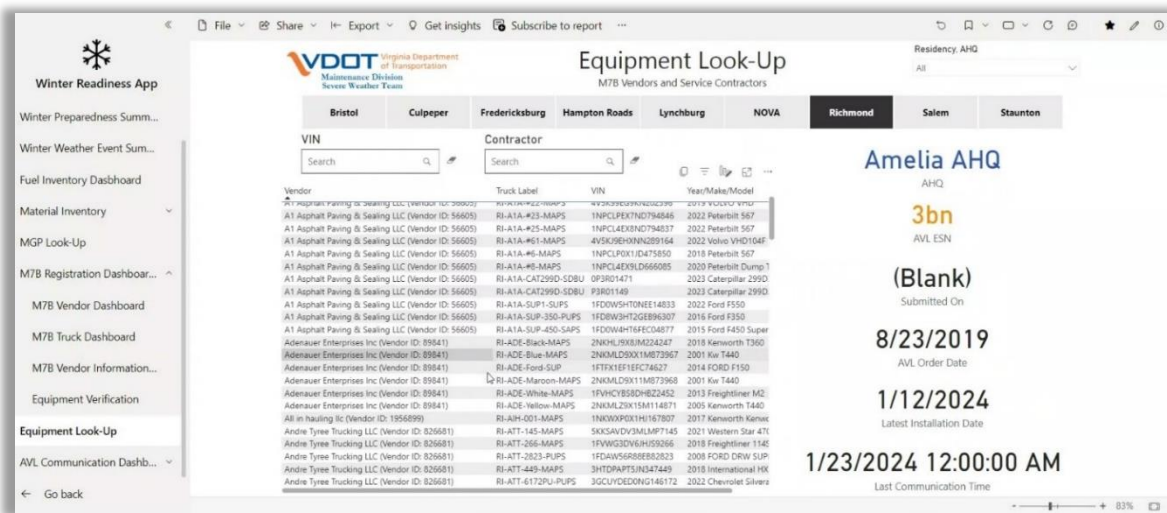

Equipment Look-Up Dashboard

Equipment Look-Up Dashboard Overview

Purpose	To allow users to search all vendors and equipment in the database
Performance Measures	Agreement, Automatic Vehicle Location (AVL) orders, installation, AVL communications last ping
Data Sources	SWAS and AVL
Refresh Rate	Thirty minutes
Users/Access	Anyone in commonwealth but primarily leadership at VDOT
Platform/Software	PowerBI

VDOT relies on a diverse network of vendors and equipment to tackle winter weather events. To ensure efficient management and coordination, VDOT utilizes the Equipment Look-Up Dashboard. This platform offers a comprehensive searchable database, empowering users to locate specific vendors and equipment with ease. Unlike other dashboards limited to M7B program vendors, the Equipment Look-Up Dashboard extends its reach to encompass all VDOT-contracted vendors. This comprehensive approach makes it a valuable tool for verifying equipment details and streamlining communication across the entire winter operations network.

The dashboard goes beyond listing vendors and equipment. It provides key performance measures related to each entry. This includes details regarding active agreements, AVL orders, equipment installations, and the most recent communication ping from AVL systems. This information allows users to assess equipment readiness and identify potential issues promptly.

Data for the Equipment Look-Up Dashboard is gathered from multiple sources. SWAS provides vendor and agreement information, while the AVL order date system and AVL system itself contribute installation and communication data. With a refresh rate of 30 minutes, the dashboard offers near real-time insights. While public access is granted to anyone within the commonwealth, primary users come from VDOT's district and residency levels, directly interacting with vendors on the ground. This ensures that those closest to operations have the information they need to make informed decisions and collaborate effectively. Power BI serves as the underlying platform for data visualization and user interaction.

Emergency Management Center Dashboard

Emergency Management Center Dashboard Overview

Purpose   Provides all weather information

|	
Performance Measures	Snow and radar
Data Sources	Data Transmission Network (DTN) data, local storm reports, radar, National Weather Service (NWS), AVL, Waze, other spatial details
Refresh Rate	Real time
Users/Access	State partners and districts
Platform/Software	ArcGIS Online (AGOL)

The Emergency Management Center Dashboard is a specialized tool that focuses on emergency management. Its primary purpose is to provide comprehensive weather information. This includes data on various weather conditions, with a particular emphasis on snow and radar data. The dashboard's performance is evaluated based on the accuracy and timeliness of this data.

The data used by the dashboard is collected from a variety of sources. These include DTN, local storm reports, radar, the NWS, AVL systems, Waze, and other spatial details such as park and ride locations. This diverse range of data sources allows the center to make informed decisions during emergencies.

One of the key features of the center is its real-time data refresh rate. This ensures that the most current information is always available, which is crucial during emergency situations. The platform is designed to be shared with state partners and districts. It has a flexible permission system that allows for various views on the hub, depending on the access level granted. The center operates on the AGOL software platform.
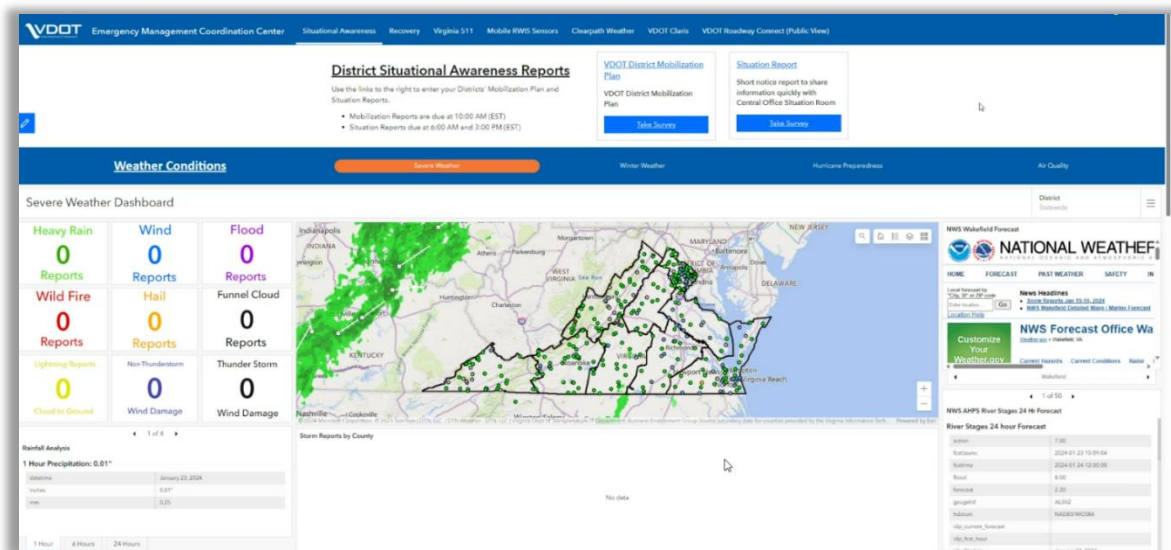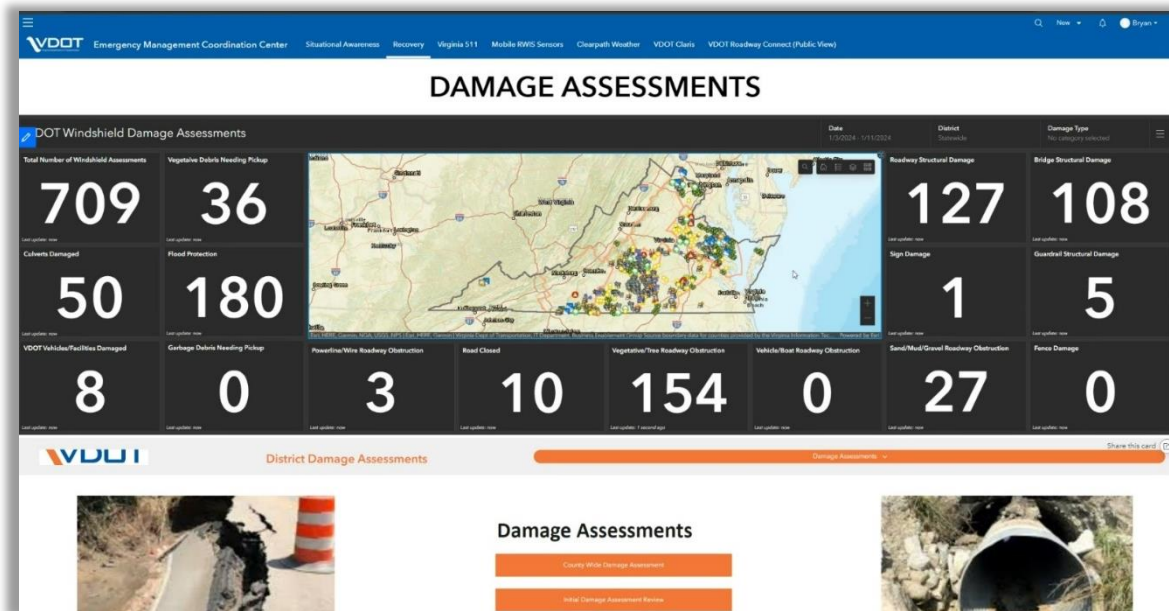
Damage Assessments Dashboard

Damage Assessments Dashboard Overview

Purpose	Track, manage, and add value to damages and determine if the Federal Emergency Management Agency (FEMA) or Federal Highway Administration (FHWA) are needed. This dashboard will also track the review/status for the damage reports.
Performance Measures	Status of reports, images of damage, cost of damage
Data Sources	Survey 123 from field crews
Refresh Rate	Real time
Users/Access	State districts
Platform/Software	AGOL

VDOT faces the crucial task of assessing damage and initiating repairs efficiently. To streamline this process and ensure timely recovery, VDOT utilizes a dedicated Damage Assessments Dashboard powered by AGOL. This dashboard serves several key purposes. Firstly, it provides a centralized platform for tracking and managing all reported damages, offering a comprehensive overview of the situation. This allows VDOT to prioritize repairs based on severity and resource availability. Secondly, the dashboard facilitates the process of adding value to damage assessments. By integrating with relevant systems and procedures, the dashboard can help determine eligibility for federal assistance from FEMA or FHWA, streamlining financial recovery efforts. Thirdly, the dashboard allows VDOT to track the review and approval status of individual damage reports.

Performance measures displayed on the dashboard include the status of each damage report, associated images for visual verification, and estimated repair costs. This information empowers VDOT leadership to make informed decisions regarding resource allocation and prioritize critical repairs. Data for the dashboard originates from Survey123, a mobile data collection app utilized by VDOT field crews. This app streamlines the data collection process, capturing information directly at the damage site and feeding it into the dashboard in real-time. This eliminates manual data entry and significantly reduces processing time. Prior to implementing Survey123 and the AGOL dashboard, damage assessments were a manual and time-consuming process, often taking weeks to complete. The digitalized approach has updated VDOT's response, saving weeks of time and enabling a more efficient and data-driven recovery process.

Development of Dashboards

The process for deciding the development of dashboards for VDOT is based on if there is a manual process that can be automated to save time. By having dashboards that automate work, resource sharing has become easier. With the data platforms VDOT has available, they can make as many dashboards as they need. The more productions and users there are the more enhancements that take place.

A team of Emergency Operations and Management Specialists mostly developed these dashboards. The extract, transform, and load process for the dashboard involved using Power Automate tools and all data was stored in the cloud and exported and shares from ESRI. The accuracy of the data is usually verified by the provider, but when data does have errors from moving it is easily catchable as the team is very familiar in what "normal data" looks like. Most of the data is stored in an IT data warehouse; however, a large-scale data system for PowerBI is in the works. Some of the team use ESRI cloud storage. Data can be queried as far back as 2019 from ESRI's cloud storage, however PowerBI cannot go back and view older data since there are so many changes made to historical data.

Some issues that were encountered in development of these dashboards include issues with internal connections to PowerBI and collaborating with vendors. No specific issues with ESRI occurred since there were plenty of online resources.

System Operations and Maintenance

The hosting of the dashboards and who is responsible for updating the data varies depending on the dashboard. The same team that developed the dashboards, which is the team of Emergency Operations and Management Specialists, is also responsible for their maintenance if there are any issues or enhancement that needs to be made. The databases for these dashboards are maintained by ESRI and

an Emergency Operations Specialist, and IT maintains the data warehouse for PowerBI. The costs to maintain these dashboards and resources are associated with the personnel who use and maintain them. VDOT has 700 ESRI licenses with cloud services and weather vendors.

Benefits / Lessons Learned

Some of the benefits gained from having these dashboards include having a faster response time, automating workflow, dealing with less emails, standardizing processes, resource allocation, and managing vendors. Some lessons learned from creating these dashboards were that going to ESRI conferences helped gained a deeper understanding because the team was able to meet other users and gain in-person assistance. By speaking to other DOT's, new dashboards can be inspired. Also, VDOT has a lot of people skilled in software, but they need to communicate more efficiently so that work is not duplicated.

Future / Enhancements

Some future enhancements include adding 511 data involving road closures during the winter into the emergency response dashboards. Also using ArcGIS Velocity for early weather warnings as well as big data analytics with damage assessments and insight for analytics. For PowerBI, the team would like to explore the possibility of using historical data. A new data miner is also in the works to potentially be implemented for situational awareness security.