

Road Weather Management

The intent of System Layers is to define in further detail recommendations that would serve toward the goals of how ADOT should be operating and managing their network. This System Layer Plan is focused on:

- **Road Weather Management** – Road weather management includes the operation and management of the transportation network through flooding, fires, snow, ice, dust, and rain conditions.

Context of Existing Capabilities

ADOT experiences a variety of weather-related events including snow/ice, dust (visibility), flooding, and fires. Data related to these events is primarily gathered through road weather information systems (RWIS), National Weather Service, and first-hand observation. The conditions then trigger responses ranging from traveler information (posting to DMS in the area) to dispatching services (snowplows or other). Many of these systems have been developed ad-hoc and are not integrated to the larger ADOT TOC system.

The existing road weather management functions within ADOT cover basic elements that pose operational challenges but there are challenges and gaps in the coverage, execution, and integration of Road Weather Management capabilities that drive the recommendations outlined in this System Layer Plan.

All RWIS feeds back to a centralized data management system to support TOC operations, safety, and winter operations staff.

Challenges and Gaps

Through a variety of meetings, workshops, and review of existing conditions and applications utilized by the state, current issues were uncovered that provide insight into the direction that ADOT should focus on addressing. The following are some of the current issues identified as related to Road Weather Management:

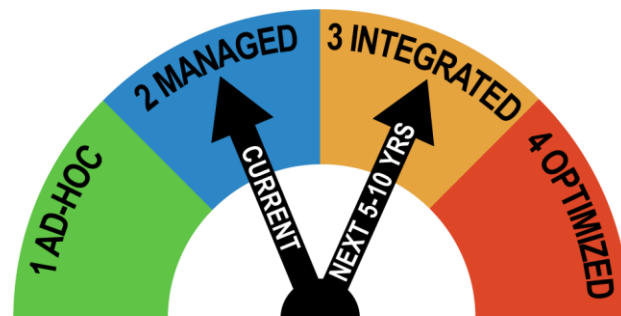
- Need to address weather data gaps in coverage throughout the state via RWIS or other sensors where weather conditions are likely to cause issues for drivers.
- Installing RWIS in rural areas requires a significant amount of resources.
- Need process and resources to apply CV technology or crowdsourced data to augment physical infrastructure or where physical infrastructure is not feasible.

Future Direction

The project team conducted a series of individual workshops with ADOT for each System Layer Plan to identify the perceived existing readiness and future direction within the functional areas. The workshop included an interactive, online (JamBoard) activity in which ADOT staff provided specific feedback following a similar structure to the TSMO Capability Maturity Model (CMM) Framework. For Road Weather Management, the workshop was held on April 1, 2022.

CMM levels for consideration of ADOT staff for their current capabilities, where they see progress in the next 5 years, and where there is desire to move toward in the next 10 years.

- **Level 1 – Ad-Hoc** – Activities are ad-hoc, informal, champion-driven
- **Level 2 – Managed** – Basic strategy application is understood with limited internal accountability or coordination
- **Level 3 – Integrated** – Standardized strategy applications that are managed for performance and aligned
- **Level 4 – Optimized** – Full and sustainable program based on prioritized data-driven process of continuous improvement



A summary of the feedback for the state is that the current capabilities are at the managed Level 2 state and in the future can be moved toward the Level 3 integrated state.

Knowing weather conditions around the state and knowing how that weather is going to impact travel on the roads is an ongoing challenge. ADOT has 21 RWIS locations providing robust real-time weather conditions data around the state. There are areas of the state without RWIS coverage and in some cases existing RWIS technologies have communications challenges with transmitting data centrally accessible to be utilized for better operations and management of the roadways. ADOT should move toward a future where weather information is integrated into ADOT processes at the TOC and weather data collection is consistent, reliable, and is used to support decision making and traveler information throughout the state.

Future efforts should include management of a centralized data management system, forecasting being used to inform maintenance activities, and enhanced information dissemination for travelers in terms of rerouting during inclement weather.

Recommendations

This section provides a summary of important steps that be used as building blocks for achieving the ultimate vision that extends to the five- to 10-year horizon. Because ADOT is looking at the three- to five-year horizon for implementation, these recommendations will focus on investments that are foundational technologies needed to support ADOT's future. The remaining gaps between what ADOT has today and where ADOT needs to be in the future becomes the recommended changes/additions that are needed.

ADOT desires to look at potential recommendations in the following areas:

- Dust Detection/ Visibility
- Winter Storm
- Crosswind
- Flood Warning
- Rockfall Warning
- Animal Crossings
- Fire Scar management

Table 1 provides a summary of recommendations that ADOT should undertake to move toward Level 3 capabilities for Safety Applications on a statewide basis. While many of the recommendations are independent and can be accomplished in a short timeframe, ADOT should focus on a few key recommended activities (denoted in bold) to ensure adequate resources are available and generate the greatest benefits in progressing their readiness level.

Table – Road Weather Management System Layer Plan Recommendation Summary (STIP level information)

PROCESS Recommendation Title	Description	Steps and Outcomes	Context for Recommendation	Recommended Champion	Recommended Stakeholder Involvement in Implementation	Total Funding Required	Annual Funding Required	Contracting Mechanism
DATA MANAGEMENT								
Develop Statewide RWIS Management Plan	Develop a RWIS Management Plan including an operational framework to provide automated weather conditions/weather responsive traffic management for ADOT that addresses how weather information is collected, stored, forecasted, disseminated, and used (internal, external).	<p>Steps: The deployment of a weather responsive traffic management strategy entails an operational plan for responding to various weather events including snow and ice, floods, fire, low visibility (dust, rain, snow, etc.). It is recommended that ADOT develops an operational framework to “automate” weather alerts. ADOT should consider which types of events will be automated, who is required to validate the response, which sources will be used to trigger an operational review, and when to clear the event. The leading information may be driven from crowd sourced data, national weather service, automated alerts from road weather assets, amongst many options. Work with each TSMO group and ADOT District on defining weather needs based on location and type of events. Identify data needs, data sources, and response efforts. Establish a long-term vision and goals specific to road weather management. Identify general cost requirements and potential funding sources within ADOT. Determine if any new business processes are required to support road weather management.</p> <p>Outcomes: A formal guiding document that addresses ADOT’s road weather practices.</p>	The current ADOT RWIS approach has been developed over the years based on field experience and operations. Formal documentation does not exist that outlines current or future direction of the program elements. ADOT has implemented numerous RWIS and ITS devices across the state to address safety and operations concerns. However, there remains a critical need to better automate weather alerts to the motorists and across state lines using existing infrastructure. During critical weather events, ADOT can utilize their 511 system, their existing dynamic warning systems, as well as their network of Dynamic Message Signs (DMS) to notify motorists about weather conditions and safety alerts. However, ADOT aims to enhance operations responsiveness to weather events and provide near real-time alerts when a condition warrants a more robust and timely response. The goal of the operational enhancement is to provide more accurate weather information using the available resources that are already deployed.	ADOT Road Weather Manager	ADOT Districts	\$150K	\$0	Out-source through TSMO On-Call assignment

PROCESS Recommendation Title	Description	Steps and Outcomes	Context for Recommendation	Recommended Champion	Recommended Stakeholder Involvement in Implementation	Total Funding Required	Annual Funding Required	Contracting Mechanism
DATA MANAGEMENT								
Evaluate RWIS Inventory for Modernization	Develop a statewide evaluation approach/plan for RWIS modernization – replacement of old, unsupported, or failed devices statewide. Identify criteria for replacement, cost, and forecast, conduct technology obsolescence.	<p>Steps: Research best practices utilized by other DOT's for upgrading and maintaining RWIS & ITS infrastructure. Conduct RWIS inventory related to age, condition, and functionality. Evaluate devices and systems for modernization needs and prepare a risk assessment. Define appropriate funding to repair/replace/upgrade over time. Update annually.</p> <p>Outcomes: Proactive plan to modernize and upgrade equipment.</p>	ADOT maintains and operates a number of RWIS devices statewide, including a suite of environmental sensors and CCTV to support monitoring of the roadway network during inclement weather. These RWIS systems have been installed over numerous years and are at different stages of lifecycle, maintenance, and functionality.	ADOT Road Weather Manager	TSMO Group Managers, ADOT Districts	\$250K	-	Out-source through TSMO On-Call assignment
Create RWIS Dashboard and Reporting	Established Performance Management Dashboard and Reporting for key weather activities.	<p>Steps: Work with the TSMO group to identify level of service (LOS), key performance metrics for road weather activities. This would include LOS characterization, return time to normal conditions, and storm severity index tracking. Develop a plan for measuring results and frequency and owner of the data to drive the dashboard. Develop user requirements for the dashboard to provide to the development team. Determine pathway for creating the dashboard (internal vs external).</p> <p>Outcomes: Dashboard/Power BI Tool for better tracking of weather response and overall planning.</p>	ADOT incorporates a number of tools to help plan for winter storms and perform after action reviews within the districts. A performance dashboard would allow for better visibility of winter weather storm planning and overall performance.	ADOT Road Weather Manager	ADOT Winter Maintenance Team and District	\$75K	\$25K	In-house development or out-source through TSMO On-Call assignment
Integrate Vehicle Sensor Data Into ADOT RWIS	Obtain mobile road weather sensor data from vehicles and integrate into ADOT's road weather applications.	<p>Steps: Identify available mobile sensor data providers. Establish data exchange protocol and data agreements. Integrate mobile data into existing ADOT platforms (Cameleon and Navigator) to enable real-time monitoring.</p> <p>Outcomes: Expanded geographic coverage of road weather data.</p>	Advanced sensors are increasingly being installed on vehicles and generating available road weather data. Integrating this data into ADOT's system can expand geographic coverage beyond stationary RWIS locations.	ADOT Road Weather Manager	TSMO Systems Technology Group Manager	\$100K	\$25K	Out-source – Procurement

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DATA MANAGEMENT								
Disseminate RWIS Data to 3 rd Party Providers	Export road weather data to external partners that provide 3 rd party applications to increase traveler access to the information.	<p>Steps: Research industry standard approaches for data type, format, and delivery. Coordinate with ADOT ITG to establish protocol and data repository. Communicate with 3rd party vendors on access and agreements/conditions as necessary.</p> <p>Outcomes: Expanded public consumption of available road weather data.</p>	RWIS data is valuable to traveling public and communication can be expanded through use of 3 rd party applications (Google/Apple/etc). ADOT should push road weather information to private services to give travelers a better awareness before they come across a DMS.	ADOT Road Weather Manager	ADOT ITG	\$100K	-	In-house or out-source through TSMO On-Call assignment
PERFORMANCE MEASURES								
Generate Quarterly RWIS Metrics	Develop weather statistics related to RWIS detection, activations, agency response, and other activity. Along with simple frequency data, coordinate available data from TOC to develop relationship for identifying hot spots.	<i>Steps and Outcomes have been incorporated in the Develop and Utilize TSMO Performance Measure Platform action item in the Data and Performance Management System Layer Plan</i>	ADOT operates a network of RWIS devices and other systems that provide public information and agency response to events. Standardized reporting of RWIS activity and weather events would improve transparency and understanding of the benefits and needs.	ADOT TSMO Director and TSMO Operational Traffic & Safety Group Manager	ADOT ITG, TSMO Group Managers	\$75K	\$50K	In-house
Monitor and Evaluate VSL Operations	Monitor I-10 dust and I-40 winter VSL systems and develop a concept for VSL operations statewide.	<p>Steps: Define performance measures for determination of VSL effectiveness. Conduct before and after study to determine impact on safety and speed reductions. Conduct safety analysis statewide to determine possible corridors for future deployment consideration. Draft a report highlighting future location and operation decisions.</p> <p>Outcomes: Performance data for VSL operations and basis of design and deployment for other corridors.</p>	VSL technology has not been widely adopted in Arizona. An assessment of the effectiveness of the initial systems will provide ADOT additional information for future use cases for VSL.	ADOT Road Weather Manager	TSMO Operational Traffic & Safety Group Manager	\$100K	-	In-house and/or out-source through TSMO On-Call assignment
STAFFING STRUCTURE								
Expand Real-Time Weather Monitoring	Expand RWIS monitoring in the TOC by adding contract staff.	<p>Steps: Determine TOC need in terms of staff and duration (operator or meteorologist, full-time or seasonal). Work with HR and procurement to advertise position. Select and train staff in TOC processes.</p> <p>Outcomes: Enhanced real-time weather monitoring to support decision-making.</p>	ADOT TOC operators are typically fully utilized on incident response with limited capability to monitor and manage weather conditions/concerns. Supplementing TOC operators with external resources can increase RWIS coordination.	TSMO Traffic Management Group Manager	None	\$250K	\$250K	Out-source

PROCESS Recommendation Title	Description	Steps and Outcomes	Context for Recommendation	Recommended Champion	Recommended Stakeholder Involvement in Implementation	Total Funding Required	Annual Funding Required	Contracting Mechanism
STAFFING STRUCTURE								
Create Maintenance Program	Development of a more robust maintenance program that includes routine replacement and re-calibration of sensors to allow for better system performance and accurate weather reporting.	<p>Steps: Determine which maintenance efforts are needed to address RWIS components statewide. Define RWIS sensor replacement and routine maintenance schedules ahead of the seasonal events, including how often sensors should be calibrated, best practices of RWIS maintenance in general. Define overall preventative maintenance for the entire RWIS network. Establish procurement strategy to bring on RWIS maintenance through existing contract or through standalone approach.</p> <p>Outcomes: Contract mechanism to keep the RWIS system in a state of good repair and high performance through the peak season.</p>	ADOT does not have a maintenance contractor for RWIS with SLA requirements for device uptime and availability. Historical challenges with sensor failures and less than optimal turn-around time for replacing and repairing failed RWIS equipment. This creates gap in data for roadway maintenance staff and unreliable data.	ADOT Road Weather Manager	TSMO Systems Maintenance Group Manager	Varies – could be \$500K - \$3M	Varies	Out-source
PROCESS STRUCTURE								
Standardize VSL Thresholds	Standardize how VSL is operated statewide based on weather conditions including roadway condition (grip value or other) and/or LOS.	<p>Steps: Identify all existing and proposed VSL systems. Determine the common events that trigger activation of a reduced speed. Develop common thresholds (to the extent possible) for speed management. Document activation rules for TOC operators.</p> <p>Outcomes: Standardized activation and management.</p>	ADOT has installed an initial VSL system on I-10 for dust (visibility) and in progress on a VSL on I-40 for snow/ice. As more systems are developed and installed, a common approach will benefit the TOC operators.	Traffic Management Group Manager	TSMO Group Managers	\$0	\$0	In-house

INFRASTRUCTURE DEPLOYMENT Recommendation Title	Description	Steps and Outcomes	Context for Recommendation	Recommended Champion	Recommended Stakeholder Involvement in Implementation	Quantity	Cost Per Unit	Total Capital Cost	Total O&M Cost	Contracting Mechanism
LIFECYCLE REPLACEMENT										
RWIS Modernization	Utilizing a statewide evaluation approach/plan for RWIS modernization – replace old, unsupported, or failed devices statewide.	<p>Steps: Develop conceptual and final design</p> <p>Outcomes: Proactive plan to modernize and upgrade equipment.</p>	ADOT maintains and operates a number of RWIS devices statewide, including a suite of environmental sensors and CCTV to support monitoring of the roadway network during inclement weather. These RWIS systems have been installed over numerous years and are at different stages of lifecycle, maintenance, and functionality.	ADOT Road Weather Manager	TSMO Leads, District Leads	20	\$100K	\$2.0M	\$100K	Out-source
EXPANSION OF ADOT TECHNOLOGY DEPLOYMENT										
Add Remote Closure Capabilities	Install remote road closure gates in particular areas where there are none.	<p>Steps: Conduct a weather and safety analysis to determine optimal locations where roadway closures are warranted during inclement weather. Seek input from Districts for known hotspots. Identify possible traffic detour strategies including conceptual placement of signage and closure gates for system activation. Procure and install gates and associated infrastructure.</p> <p>Outcomes: Quicker response to roadway closure/management.</p>	During inclement weather conditions, several rural corridors experience unsafe conditions for motorists to traverse, resulting in increased crashes, and longer than usual response time for incident response for operations to support emergency calls.	TBD	Northeast, North Central and Northwest District	10	\$10K Planning \$20K Design \$200K Construction	\$2.35M	\$50K	Out-source
Expand DMS to Support Weather Messaging	Install DMS in the immediate area adjacent to existing RWIS.	<p><i>Steps and Outcomes have been incorporated in the Real-Time Roadway Condition Enhancements – DMS and CCTV action item in the Traffic Management System Layer Plan</i></p>	Weather conditions can be very localized and messaging should match available conditions. Installing DMS at or near RWIS allows for more accurate messaging to the public and messaging when road conditions return back to normal.	TSMO RTEs	District Maintenance Managers, one representative from each TSMO group	TBD	\$150K for mini DMS \$250K for full DMS	TBD	TBD (\$15K per DMS)	Out-source – either RFP or TSMO On-Call assignment

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EXPANSION OF ADOT TECHNOLOGY DEPLOYMENT										
<p>Expand RWIS Locations</p>	<p>Add additional RWIS locations around state to fill in gaps provided in the Prioritization Tool.</p>	<p>Steps: Evaluate available data related to weather events and associated safety and closure data to identify critical hot spots for additional RWIS. Identify, in established TIP funding program for lifecycle and new capital investments, the priority locations and packages that will occur in the upcoming fiscal year. Determine available 3rd party data. In locations or situations where data is not sufficient, procure and install new RWIS infrastructure. Develop SOQ or RFP to solicit design support for development of procurement documents. Manage design process through bidding. Bid construction project. Acquire contractor. Manage construction with assistance from designer. During construction of first phase, initiate design of next phase.</p> <p>Outcomes: Wider and/or increased RWIS coverage and density with replacements or implementation of new equipment.</p>	<p>ADOT has a network of RWIS locations around the state but has many gaps. It is recommended that ADOT consider additional RWIS to address hot spots not covered by existing sites and/or data. Locations should focus on the northern area of the state where winter weather is most prevalent and areas that are critical in terms of dust and flood events.</p>	<p>TSMO RTEs</p>	<p>District Maintenance Managers, one representative from each TSMO group</p>	<p>114</p>	<p>\$2K Planning \$10K Design \$100K Construction</p>	<p>\$12.76M</p>	<p>\$800K</p>	<p>Out-source – either RFP or TSMO On-Call assignment</p>

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DEMONSTRATED TECHNOLOGIES FOR ADOT DEPLOYMENT										
Fleet Vehicle Data Collection	ADOT fleet vehicles statewide could be collecting a variety of road condition information if equipped. Leverage the existing snowplow AVL (automated vehicle location) program to better automate snowplow operations and friction data with mobile sensors.	Steps: 1. Conduct a vehicle data collection best practice review to assist ADOT in determining types of sensors that could be deployed and the information that can be collected and utilized from those sensor suites. Review vehicle deployment plan and implementation strategies and best practices and synthesize back-end hosting data retention and data sharing best practices. 2. Develop a fleet vehicle data deployment plan to define the sensors, systems, and procurement strategy. 3. Prepare specifications for equipment and define installation requirements.	The utilization of fleet vehicles to collect additional road condition insights provides ADOT an advantage in automating snowplow operations and better predicting the conditions before material is put down. Fixed friction data at RWIS station location is useful and can be extrapolated to support this function. However near-real-time data at locations between RWIS stations can be used by operations to better respond to weather challenges.	ADOT Road Weather Manager	District Maintenance Managers TSMO Leads	Varies based on Fleet Count	\$30K Deployment	\$50K Planning \$150K Design TBD Deployment	\$3K per vehicle	Out-source
EMERGING TECHNOLOGY FOR ADOT PILOTING										
None.	ADOT needs to focus on getting the data management structure solidified in order for data ingestion, use, and metric evaluation prior to diving into deploying new types of data investments not already used within ADOT.									

Performance Measures

The ADOT TSMO Plan defines performance measures using three categories, safety, mobility, and infrastructure/system health. The following performance measures were developed to track the progress of the above recommendations associated with the Road Weather Management System Layer Plan.

Performance Measurement Topic	Performance Measure	Measure Applicability
Mobility and improvement of highway performance	Reduction in weather-related maintenance and incident response	Cost of agency activities related to weather response to incidents and infrastructure damage
Infrastructure/system health	Increased coverage of RWIS data in snowplow regions	Number of mobile and fixed RWIS assets located in snowplow regions based on the priority list
Safety	Improved safety and operations during weather events	Number and severity of crashes attributed to adverse weather