Source: USDOT/Getty.

U.S. Department of Transportation
Federal Highway Administration

ROAD WEATHER MANAGEMENT PROGRAM

FACTSHEET

Arizona Department of Transportation Dual Use Safety Technology (DUST) Warning System

In Arizona, one of the biggest challenges for road weather management along Interstate 10 (I–10) is dust storms. In the spring of each year, these often unpredictable events wreak havoc on travel along the interstate. They are a significant safety concern in the region, especially for out-of-state drivers who are unfamiliar with the phenomenon. Dust storms can reduce visibility to extremely low levels, causing multiple-car accidents.

In response, the Arizona Department of Transportation (ADOT) developed the Dual Use Safety Technology (DUST) Warning System. The system is intended to help reduce loss of life, injury, and property damage. It was initially placed along rural I–10 in Cochise County between the communities of Bowie and San Simon. Later on, ADOT added another DUST Warning System along a critical 10-mile segment of I–10 between Tucson and Phoenix. The system has been designed to focus on dual challenges:

1. Visibility hazards caused by blowing dust
2. Unexpected snow and ice in the Texas Canyon area of I–10

The DUST Warning System provides detection and early warning for both icy conditions in the Texas Canyon as well as windborne dust along I–10. The system uses several environmental sensor stations (ESS), precipitation and visibility sensors, and a comprehensive sensor array. Each ESS site is equipped with a snapshot closed circuit television (CCTV) camera to visually confirm any potential low-visibility conditions.

Figure 1. Visibility sensor in Arizona Department of Transportation Dual Use Safety Technology Warning System. (Source: Arizona Department of Transportation)

System Components

The following enabling technologies are integrated to form the DUST Warning System:

- **Wireless Ethernet Networks.** Based on the Worldwide Interoperability for Microwave Access IEEE 802.16 standard, the wireless network solution is integrated to serve as a cost-effective and reliable long-range communications backbone for the DUST Warning System.
- **Photovoltaic Cells.** Power for the remote telemetry sites is derived from renewable solar energy generated using photovoltaic cells. Initially developed to power satellites, the technology has gained widespread acceptance for solar-powered remote telemetry and warning applications.

- **Anemometers.** These devices measure wind speed to predict the potential for the onset of high wind conditions, which may lead to reduced visibility.
- **Forward Scatter Visibility Sensors Technology.** These sensors use the forward scatter principle of light in the presence of atmospheric particles to measure the extinction coefficient and visibility. A high-intensity infrared light-emitting diode (LED) transmitter is used to illuminate the sensor's scatter volume. This process results in a high signal-to-noise ratio and reduces the effects of background light variations. Visibility measurements are possible over a standard range up to more than 10 miles.
- **Light-Emitting Diodes.** LEDs have been in use as indicators for decades. As the reliability, heat tolerance, brightness, and efficiency have increased, LED technology has gained widespread acceptance for use in traffic signal or warning beacon indications.
- **CCTV Camera.** Each ESS site is equipped with a snapshot CCTV camera to visually confirm any potential low-visibility conditions.
- **Precipitation and Visibility Sensor.** On the newer 10-mile I–10 system between Tucson and Phoenix, there are 13 sensors placed in strategic locations. The instruments measure the number of particles in the air and then derive visibility in feet. The sensors are installed 8 feet off the ground to record visibility that is the same as what drivers are experiencing.
- **Weather Radar.** The newer system also utilizes a weather radar with a 60-mile radius. The purpose of the radar is to provide advance notice and warning of approaching storms to complement the real-time ground observations the visibility sensors provide when the event is occurring.

Figure 2. Dynamic message sign with warning message. (Source: Arizona Department of Transportation)

System Operations

The overall concept of operations for the DUST Warning System is simple. Radar is used to gather advance warnings, and sensors are used to detect high winds and low-visibility conditions. CCTV cameras provide snapshots for visual confirmation of low-visibility conditions. This information allows ADOT and the Department of Public Safety to make informed decisions regarding roadway closures and detours as needed.

The DUST Warning System uses programmable logic controllers to trigger various warning devices when wind speed thresholds are exceeded or when sensors detect that minimum visibility thresholds are not met at any of the monitored sites. Methods of providing warnings include:

- Hardware connected to nearby ADOT dynamic message signs (DMS) that enable the system to post from a set of stored DMS messages based on sensor inputs, as seen in figure 2.
- Highway Advisory Radio Services (HARS) that are played from a set of eight locally stored messages, based on sensor inputs.

- Sensor alerts sent to a group of programmable email addresses to alert highway operations and law enforcement staff of high wind conditions, low-visibility conditions, or both.
- Programmable speed limit signs (part of a variable speed limit system) on the newer section of the DUST Warning System that can change the legal speed limit from 75 mph to as low as 35 mph.

Transportation Outcomes

ADOT implemented the DUST Warning System in an effort to reduce the number of crashes on I–10 caused by the limited visibility experienced during certain weather conditions. Instrumentation detects adverse weather conditions and triggers alerts to travelers of high winds and limited visibility. Additionally, the system notifies ADOT operations personnel of these conditions and records certain parameters for future review. ADOT personnel use video equipment to quickly assess field conditions remotely. Although there are additional DUST Warning System components located at the Texas Canyon Mountain pass, further west between Benson and Wilcox, that part of the system monitors for snow and ice conditions but does not trigger any public alerts.

Under certain conditions, a variety of field components automatically deliver alert and informational messages to the public. Messages are prescripted and vary with instrumentation input. The combination of static and dynamic signing plus the HARS broadcasts present drivers with timely, important, and usable information when needed to help prevent driver distraction and information overload.

Operational personnel can access data and live video feeds plus receive email notifications. This ability allows the quick assessment, confirmation, and subsequent sharing of information with law enforcement and New Mexico DOT counterparts. Decisions regarding highway closures and remote traveler notification are expedited and more reliable.

Implementation Issues

ADOT's DUST Warning System is not a new technology, but rather a second-generation prototype that expands the capabilities of an older, smaller system. There are issues that should be addressed as the technology evolves, with consideration given to deploying similar systems elsewhere. Although not mutually exclusive, these issues can be segregated into administrative and technical areas in nature.

The administrative issues highlighted here could be considered typical in any weather-warning project:

- ADOT must commit operating and maintenance funds to sustain the system, not just the initial cost for installation. Training on how to operate and maintain the system must be reflected in the funding allocated.
- The integration of other measures and stakeholders, and the degree of integration, must be considered. For example, allowing New Mexico DOT to view Arizona weather data is fairly simple via the Internet. However, ensuring than an appropriate and coordinated multiagency, multistate response is provided for a large-scale, sustained weather event takes a substantial amount of effort.

Technical issues discovered to date include the following:

- Specifying, procuring, and installing the system requires a team with specialized experience. Using a qualified consultant greatly helps. A warranty period should be included in any agreement as well as training and field shadowing to facilitate knowledge transfer from the vendor to public-sector Department personnel. Vendor technical support should include both hardware and software.
- Determining what data to collect, and how to store and review them as well as how long to keep them is quite a significant effort. There has been some discussion around liability concerns regarding data recording that has not been fully resolved within ADOT.
- Integrating multiple devices from multiple vendors was a challenge ADOT was able to overcome with consistent communication using a collaborative approach.
- Discerning the initial calibration and set points for parameters takes time. Variability in wind speed, soil type, dryness, and so forth can make each site unique. There is a growing body of knowledge, but in the end the operator will need to adjust the system sensitivity until false alarms are minimized and the alerts delivered to the public are accurate (e.g., so dust storm messages are not displayed during a calm day but are displayed only when appropriate).
- Designing and building the algorithms that determine what speeds the variable speed limit should be changed to relative to what observation analytics are available was a challenge. However, the system design includes flexibility and scalability so that as it grows and evolves, these algorithms and analytics can be modified and become more effective.
- The HARS have serious limitations due to Federal Communications Commission transmission power and frequency assignment restrictions. Although the immediate vicinity may be covered, the signal becomes imperceptible in less than a mile's distance. HARS is not an effective long-distance warning device; it is good for delivering instructions to travelers in the immediate area. Many question its cost effectiveness.
- Email overload is one of the first observations users make, especially before the system set points are dialed in to minimize false alarms. Several users first excited about participating in the new system chose to later unsubscribe from the email warning distribution list because of the high volume of repetitive warnings. Operations personnel in the field typically do not have access to email, especially after hours. Typically, law enforcement has no interest in receiving automated email messages but rather relies on ADOT notifications or personal field observations.
- Sensory instrumentation and subsequent alerts are just snapshots of conditions in the immediate vicinity within a long corridor that, in reality, may be experiencing a wide variety of conditions. Placing a continuous array of sensors and warning devices along any corridor would be cost prohibitive, so any proposed effort should focus on segments of highway where weather-related problems have already been demonstrated. Because this segment of I–10 in southeastern Arizona had a history of crashes and a larger-than-normal number of fatalities due to weather-related visibility problems, it

was deemed an appropriate location for deployment of this technology.

- ADOT has struggled with whether to periodically review weather, crash, and system performance data with the goal of validating if the system is worth the cost. Both weather events and crashes are highly random in nature, and it can be expected to take several years to collect enough data for a meaningful assessment. However, ADOT knows that a single fatality has both a very high emotional as well as financial cost to society. If the Department can reduce the number of crashes, then the system cost could be justified in a traditional business sense. Analytically demonstrating that this warning system has reduced crashes may be difficult. Nevertheless, system reliability will always be an issue, and maintenance programs have real costs that need to be justified, so this particular question remains open.
- All involved would do well to remember that a certain portion of the traveling public will either be confused by the warning messages or choose to ignore them and attempt to pass through an area experiencing bad weather while hoping for the best. Current technology will not resolve that challenge.

References

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