California DOT Fog Detection and Warning System

California's Great Central Valley suffers from Tule fog. It is a thick ground fog which reduces visibility to one hundred feet or less that settles in the San Joaquin Valley and Sacramento Valley areas of California's Great Central Valley. Tule fog forms during the late autumn and winter (California's rainy season) after the first significant rainfall. This phenomenon is named after the tule grass wetlands (*Tulare's*) of the Central Valley. Accidents caused by the tule fog are the leading cause of weather-related traffic accidents in California.

In response the California Department of Transportation (Caltrans) contracted ICx Transportation to build and integrate a fog detection and warning system along a 13-mile section of the California Highway 99 corridor in the central part of the state. The system was completed in 2009.

California's Central Valley—extending from Bakersfield in the south to Redding in the north—is one of the country's largest agricultural regions. It is also a major transportation corridor, with Interstate 5 and California Highway 99 (CA-99) running through the valley. CA-99 in Fresno in the project area carries more than 100,000 vehicles per day. The region is subject to a particularly dense kind of fog, known as Tule fog, during the winter. In fog season, which runs roughly from November 1 to March 31, Tule fog can form overnight and reduce visibility to less than an eighth of a mile, and in some cases to nearly zero. Drivers along the corridor routinely would continue to drive at unsafe speeds despite the low visibility, which has led to large, multiple-car crashes. In November 2007, Tule fog caused a 108-car pile-up. There were two deaths and nearly forty injuries. The pile-up, which included 18 semi-trailer trucks, extended for nearly a mile and closed CA-99 for over twelve hours. The last vehicle collided ten minutes after the initial crash.

In addition to the threat to life and property, these major pile-ups have an enormous effect on the economy of the Central Valley. In order to reduce the likelihood of future multi-vehicle crashes, District 6 of the Caltrans is implementing a pilot project to automatically detect fog and warn motorists of hazardous conditions. Construction on the Fog Detection and Warning System (FDWS) began in October 2008.

Phase 1 was completed in February 2009 and Phase 2 was completed before the beginning of the 2009–2010 fog season on November 1, 2009. The project covers a thirteen-mile stretch of CA-99 south of Fresno, California.

System Components: The FDWS system consists of visibility sensors, speed detectors and cameras to detect congestion and visibility problems that could affect driver and passenger safety.

The installation is forty percent solar powered and uses both point-to-point and point-to-multipoint wireless radios to provide network connectivity. Local field controllers allow the field equipment to work autonomously if there is a break in communications to the central system.

System Operations: Through intelligence built into the ICx Cameleon™ ITS product, the system alerts motorists automatically of dangerous weather conditions and slow speeds by using changeable message signs (CMS) and highway

Figure CA-1. Sensor array.

advisory radio (HAR). The system will soon be incorporated into a 511 traffic web page and telephone system.

Speed detectors have been deployed every quarter of a mile, and fog sensors and CMSs deployed every half mile. Using the data collected from the sensors, the CMSs warn drivers of the presence of fog downstream and instruct them to slow down when they are in dense fog. When slower speeds are detected downstream, the CMSs warn drivers of the slower traffic ahead. HARs, roadside weather stations, cameras and multi-color changeable message signs are included.

The FDWS will use sensors to detect both visibility and speed on CA-99 in the project area. To measure visibility, the team selected the PWD10 forward scatter sensor developed by Vaisala. The sensors have been installed every half-mile covering both directions of the freeway. They are installed at driver eye level to ensure the system is reporting the current conditions as seen by the driver. In addition, the project team has installed SmartSensor HD radar spot speed sensors from Wavetronix every quarter-mile through the project area. These radars are capable of measuring traffic volume, classification, speed, lane occupancy and presence in both directions of travel. Figure 1 shows the sensors on the roadside. These two sensing technologies combine to provide a more complete picture of traffic and visibility conditions than has ever been attempted on a large scale.

The data from the sensors will be used to assess both visibility conditions and, equally importantly from the perspective of both travelers and traffic managers, speed differential at downstream locations on the freeway.

Due to the relatively rural nature of the project area, dedicated wire line communications are not available. Moreover, even if they were, the cost of trenching to connect into such systems would be prohibitive. As a result, all system communications are wireless. The communications system uses Proxim wireless devices to communicate between devices in the corridor. Backhaul communications to Caltrans' Transportation Management Center (TMC) is done using Verizon Wireless EVDO modems. Also due to the scarcity of fixed infrastructure, forty percent of the field equipment runs on solar power.

Data processing ensures that the data collected in the field is available in a useful format to travelers and to traffic managers. The system was developed with two levels of data processing.

Under normal system operations, all data are collected in the field and transmitted wirelessly to the TMC. There it is processed using the Cameleon™ ITS platform developed by ICx 360 Surveillance. If there are significant speed differentials on the freeway or if there is fog, Cameleon automatically generates messages for the data dissemination systems. If an incident has occurred, the CMS's will warn drivers of slower traffic ahead in order to prevent chain-reaction collisions.

Planned enhancements include providing the speed and visibility data from the system to the new 511 traveler information system for the southern Central Valley. The 511 system will inform travelers of problems in the project area via the telephone and the Internet before they reach it, possibly before they even leave their home or office. This will help reduce the impact of severe fog by minimizing the number of vehicles on the roadway.

As the system is further refined and enhanced, Caltrans envisions that it will have some or all of the following features:

- Full Matrix Color CMS to provide better information

- Road Weather Information Systems (RWIS) at various locations to monitor the full range of weather conditions, including rain, wind, humidity and temperature. The data from these sensors could potentially be used to predict fog.
- HAR reports, with alerts to travelers using extinguishable message signs
- Closed Circuit Television Cameras to provide more detailed information to the TMC and to the public over the Internet
- Pulsing in-pavement lighting to be used to slow traffic down under certain conditions (such as when there is an incident ahead) The lights would not be used during low visibility until an incident has occurred for fear the lights would guide drivers to move at unsafe speeds.
- Thermal Cameras
- Incident detection using advanced radar detection

Transportation Outcome(s): The system alerts motorists automatically of dangerous weather conditions and slow speeds by using CMS's and HAR. When slower speeds are detected downstream, the CMS's warn drivers of the slower traffic ahead. If an incident has occurred, the CMS's will warn drivers of slower traffic ahead in order to prevent chain-reaction collisions.

Presently, the system only employs CMS's and HAR to communicate road conditions t0 travelers. Both of these methods are very effective. The addition of the 511 system addresses the shift to mobile data devices and the increased reliance by the motorist on receiving this information while traveling. Once the fog detection data is integrated with the 511 system, it will help reduce the impact of severe fog by minimizing the number of vehicles on the roadway.

Implementation Issues: The FDWS installation involved a very short design-build cycle and innovative uses of existing technology. A number of issues were encountered in the implementation of the FDWS:

- Internal controls needed to be reconciled with the aggressive schedule and cost constraints of the FDWS.
- Existing infrastructure had to be reconfigured in order to merge the old and new components into a unified system, under the control of the Cameleon software.
- Evaluations of new technologies, such as Color CMS's, took time and resources to complete.
- User interfaces to the TMC needed to be developed around existing procedures, policies and systems.
- Caltrans policies regarding information technology security issues needed to be addressed due to the nature of the communication systems deployed by the FDWS.

Additionally, the density of detectors was limited by funding. In general, more detection capability equates with a more robust coverage of fog events. However, the nature of the funding for this project, did not allow for even small deviations from the allotted and agreed upon budget. Finally, there were concerns regarding the aesthetics of the project, due to the perceived clutter that the number of proposed field elements would present to the motorist.

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