WHITE PAPER

Caltrans Fog Detection and Warning System

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ABSTRACT

The California Department of Transportation (Caltrans) has implemented a fog detection and warning system on Highway 99 near Fresno. The entire central valley region is susceptible to Tule fog, which can reduce visibility tremendously, sometimes to near zero. This area has experience numerous multiple vehicle crashes because of the fog, most recently in 2007, when a 108 car pile-up caused two deaths and nearly 40 injuries, and closed the highway for more than twelve hours. The fog detection system, which was installed last winter, uses speed and visibility detectors to assess road conditions, traffic management software to process data and control the field devices, and changeable message signs to provide information to the traveling public.

KEY WORDS

Fog, Weather, ATMS, Cameleon™, Detection, Speed, Visibility, Wireless, Solar Power

INTRODUCTION

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 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 continue to drive at unsafe speeds for the 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 40 injuries. The pile-up, which included 18 big rigs, extended for nearly a mile and closed highway 99 for over twelve hours. The last vehicle collided 10 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 California Department of Transportation ("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 will be 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.

In an effort to deploy a system before there were additional major fog-related collisions, Caltrans used Emergency Funds to construct and implement this system. Caltrans chose a team led by ICx Transportation, a California-based systems integrator, to design and deploy the FDWS.

A fully functioning fog detection and warning system requires the ability to monitor current conditions on the roadway; a system to evaluate the data received from the roadway and determine what it means; the ability to communicate information about current conditions to transportation management staff in a timely enough and accurate enough manner that they can take action based on the information; and the ability to communicate current information directly to the traveling public. The Caltrans FDWS performs all of these functions.

SYSTEM ARCHITECTURE

A high-level view of the system's data flow is shown in Figure 1. Each element of the system is described below.

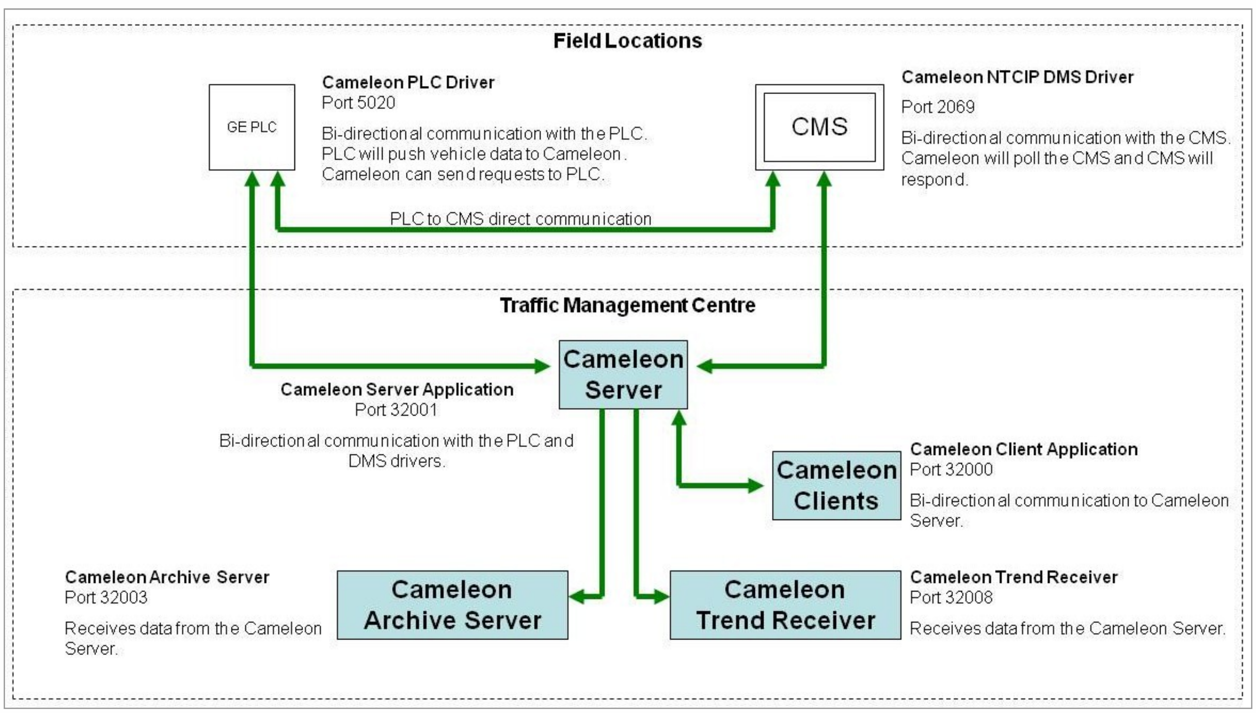

Figure 1 - FDWS Data Flows

DETECTION AND COMMUNICATIONS

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 2 shows the sensors on the roadside.

Figure 2 - Sensor Array

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 wireline 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 the corridor. Backhaul communications to the TMC is done using Verizon Wireless EVDO modems. Also due to the scarcity of fixed infrastructure, 35% of the field equipment runs on solar power.

DATA PROCESSING

Data processing ensures that the data collected in the field is available in a useful format to travelers and to traffic managers. We developed the system with two levels of data processing. Under normal system operations, all data is collected in the field and transmitted wirelessly to the Caltrans Traffic Management Center (TMC). At the TMC, 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 (discussed below).

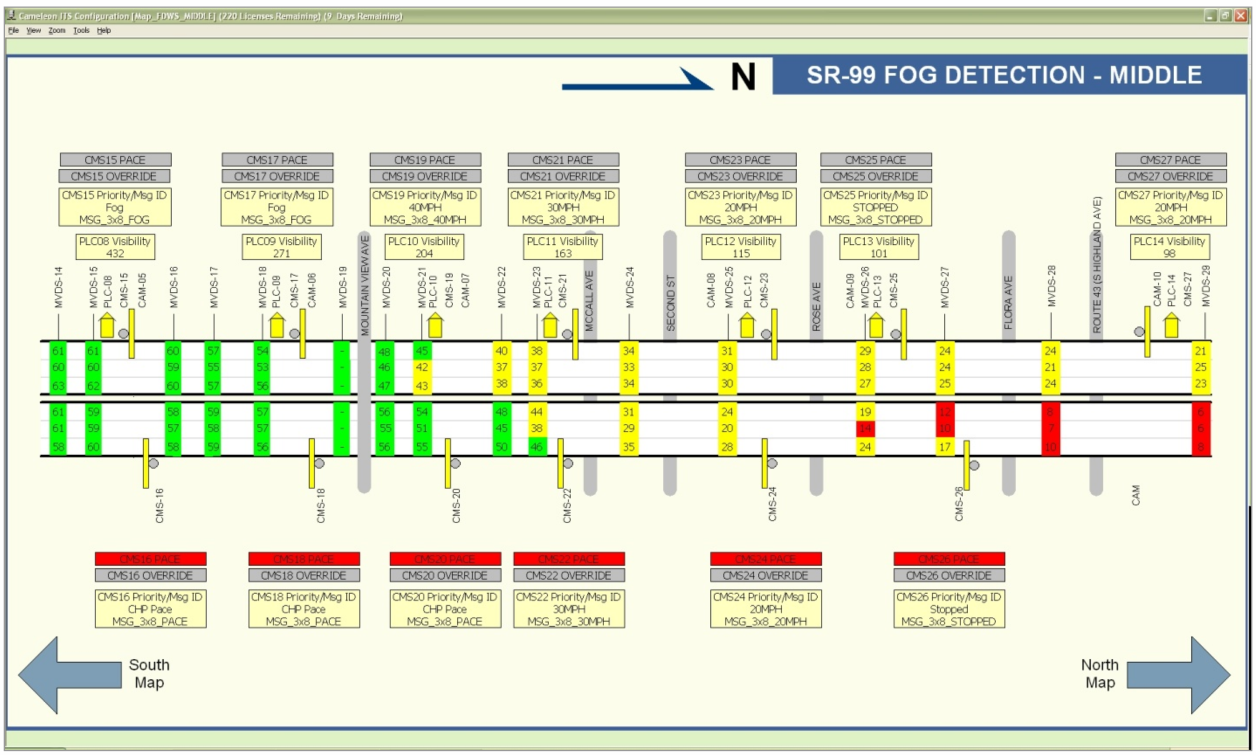

Figure 3 – Cameleon Screen Shot

Figure 3 is a screen shot of the Cameleon interface. In addition, staff in the TMC have access to the data and can use it to ask the California Highway Patrol (CHP) to implement its traffic-slowing procedures in the fog zone known as PACE.

If communications to the TMC are disrupted for any reason, the system will use the intelligence built into the field equipment to generate the appropriate messages on the Changeable Message Signs (CMS). This ensures that the system will continue to function even should the wireless communications be disabled during periods of heavy demand.

DATA DISSEMINATION

The system uses both roadside and wide-area dissemination methods to make sure that information about current road conditions reaches as wide an audience as possible. On the roadside, we deployed CMS signs every half-mile on both sides of the freeway. The signs—Addco Brick signs—are configurable, and can be built to whatever size is most appropriate for each specific location. A screen showing a test message—there were no significant fog events after the project was completed—is shown in Figure 4.

Figure 4 - Installed CMS

The CMSs have messages indicating when traffic is slower ahead and when there is fog, based on the rules in Table 1.

Priority	Conditions	Warning Message
0	(NOT FOG_REQUEST AND NOT DENSE_FOG_REQUEST OR COMMLOSS AND VISIBILITY≥ 800’) AND NOT CHP_PACE_REQUEST	Sign is blanked. Local control is de-asserted.
1	(FOG_REQUEST OR COMMLOSS AND 200’≤VISIBILITY<800’) AND SPEED≥45 AND NOT MSG_OVERRIDE	**FOG AHEAD**
2	(DENSE_FOG_REQUEST OR COMMLOSS AND 0≤VISIBILITY<200’) AND SPEED≥45 AND NOT MSG_OVERRIDE	**DENSE FOG AHEAD**
3	CHP_PACE_REQUEST AND SPEED≥45 AND NOT MSG_OVERRIDE	**DENSE FOG CHP PACE DO NOT PASS**
4	COMMLOSS AND VISIBILITY<800’ AND 35≤SPEED<45 AND NOT MSG_OVERRIDE	**FOG AHEAD TRAFFIC SLOWS TO 40 MPH**
5	COMMLOSS AND VISIBILITY<800’ AND 25≤SPEED<35 AND NOT MSG_OVERRIDE	**FOG AHEAD TRAFFIC SLOWS TO 30 MPH**
6	COMMLOSS AND VISIBILITY<800’ AND 15≤SPEED<25 AND NOT MSG_OVERRIDE	**FOG AHEAD TRAFFIC SLOWS TO 20 MPH**
7	COMMLOSS AND VISIBILITY<800’ AND 5≤SPEED<15 AND NOT MSG_OVERRIDE	**FOG AHEAD TRAFFIC SLOWS TO 10 MPH**
8	VISIBILITY<800’ AND 0≤SPEED<5 AND NOT MSG_OVERRIDE	**STOPPED TRAFFIC AHEAD**
9	MSG_OVERRIDE	Local control is de-asserted.

Where, for a given CMS:

VISIBILITY is the visibility detected in the same zone.
SPEED is the minimum speed of downstream traffic in the same zone.
FOG_REQUEST is a request flag from the Cameleon Head End.
DENSE_FOG_REQUEST is a request flag from the Cameleon Head End.
CHP_PACE_REQUEST is a request flag from the Cameleon Head End.
COMMLOSS is an internal PLC flag indicating loss of communication with the Cameleon Head End.
MSG_OVERRIDE is a request flag from the Cameleon Head End.

Note: Messaging shown for Permanent CMS (max. 3 rows of 13 characters)

Table 1 – CMS Messages

If an incident has occurred, the CMSs will warn drivers of slower traffic ahead in order to prevent chain-reaction collisions. It is difficult to anticipate how drivers will react to the messages. If the system is successfully, drivers will read the CMSs and slow to an appropriate speed.

Speed and visibility data from the system will also be provided to a new 511 traveler information system being developed as part of this project. This system, which will also include general traffic information for the southern Central Valley, will be able to 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.

PHASE 2

Upon the successful completion and operation of Phase 1, the project team embarked on Phase 2. While this phase is still in the planning stages, we envision that it will feature some or all of the following features:

- Full Matrix Color CMS to provide better information
- Full RWIS (Road Weather Information System) 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.
- Highway Advisory Radio (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.

EXPECTED OUTCOMES

Caltrans and rest of the project team believe that this demonstration project will both reduce the impact of fog in the project area and also provide valuable lessons for deploying fog detection projects elsewhere. Key questions that we expect to answer over the project period are:

- Is the detection density appropriate? Is more detection needed, or would it be possible to reduce costs by using less?
- What is the best way to communicate road conditions to travelers?
- How do drivers react to the information provided?

For more information on this project, please contact:

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