Tennessee DOT Low Visibility Warning System

In December of 1973, the segment of Interstate 75 near Calhoun, Tennessee, was opened to traffic. Following this date, multiple vehicle accidents occurred due to visibility problems experienced in foggy conditions. The culmination of these events occurred on December 11, 1990 when dense fog contributed to a series of chain-reaction collisions involving 99 vehicles with 42 injuries and 12 fatalities. In 1993, a fog detection and warning system was implemented along the Interstate section. This system includes a three-mile (five-kilometer) fog detection area spanning north and south of the Hiwassee River and an eight-mile (13-kilometer) warning zone on each approach to the fog prone area. In 2006, a project was initiated to upgrade the original system to current technology. Driver safety issues due to visibility problems have improved significantly since the system has been in place, with only one fog-contributed accident being recorded in 2001.

System Components: The fog detection component of the system is comprised of nine (9) forward-scatter visibility sensors (Figure TN-1), fourteen microwave radar vehicle detectors, and 21 Closed Caption Television (CCTV) cameras (Figure TN-2). Data from these devices is transmitted by buried fiber optic cable to an on-site control center. Information from the on-site control center is relayed to a central computer located in the Highway Patrol office in Tiftonia, Tennessee, with the use of a leased point-to-point, T1 communication link. In addition to the electronic instrumentation, reflective roadside delineators are placed in the detection zone at 80-foot increments for visibility estimation in the field.

Figure TN-1. Fog detector.

Figure TN-2. CCTV camera.

Figure TN-3. CSLS.

The fog warning component of the system is made up of six (6) static warning signs with flashing beacons, ten Changeable Speed Limit Signs (CSLS) (Figure TN-3), ten overhead Dynamic Message Signs (DMS), and two Highway Advisory Radio (HAR) transmitters. These warning systems are connected to the on-site control center by buried fiber optic cable, and to the central computer on the leased T1 communication link. In addition to the warning systems, six remotely operated swing gates are located at interchange on-ramps to control access to the interstate in the most severe conditions (Figure TN-4).

Figure TN-4. Swing gate.

System Operations: Operators monitor workstations connected to the system's central computer from the Tennessee Highway Patrol Office in Tiftonia, Tennessee. This computer system processes information from the detectors and alerts operators when pre-defined visibility or traffic speed thresholds have been reached. When these conditions are met, operators trigger pre-programmed messages to be displayed on the DMS boards, and notify the Highway Patrol troopers in the field. Troopers are stationed in the fog zone area daily during the fog prone hours (from 5 AM to 10 AM). After receiving word from the operators, troopers move to verify the roadway conditions by counting the number of reflective roadside delineators visible.

Table TN-1. Advisory and Control Strategies for Various Road Conditions.

Roadway Conditions	Advisory & Control Strategies		
	OMS	CSLS	HAR
Case 1- Vehicle Speeds Below 45 mph	"CAUTION" alternating with "SLOW TRAFFIC AHEAD"	N/A	N/A
Case 2 - Fog Detected With Visibility Greater Than 1,320 feet (402.3 meters)	"CAUTION" alternating with "FOG AHEAD TURN ON LOW BEAMS"	"FOG" Displayed, & Flashing Warning Lights Activated	N/A
Case 3 - Fog Detected With Visibility Between 480 feet (146.3 meters) & 1,340 feet (402.3 meters)	"FOG AHEAD" alternating with "ADVISORY RADIO TUNE TO XXXX AM"	"FOG" Displayed, Speed Limit Reduced To *50 mph, & Flashing Warning Lights Activated	Activated
	"FOG AHEAD" alternating with "REDUCE SPEED TURN ON LOW BEAMS"		
	"FOG" alternating with "SPEED LIMIT 50 MPH"		
Case 4 - Fog Detected With Visibility Between 240 feet (73.2 meters) & 480 feet (146.3 meters)	"FOG AHEAD" alternating with "ADVISORY RADIO TUNE TO XXXX AM"	"FOG" Displayed, Speed Limit Reduced To *35 mph, & Flashing Warning Lights Activated	Activated
	"FOG AHEAD" alternating with "REDUCE SPEED TURN ON LOW BEAMS"		
	"FOG" alternating with "SPEED LIMIT 35 MPH"		
Case 5 - Fog Detected With Visibility Less than 240 feet (73.2 meters)	"DETOUR AHEAD" alternating with "REDUCE SPEED MERGE RIGHT"	"FOG" Displayed & Flashing Warning Lights Activated	Activated
	"1-75 CLOSED" alternating with "DETOUR"		
	"FOG AHEAD" alternating with "ADVISORY RADIO TUNE TO XXXX AM"		

***The initial posted interstate speed limit on the roadway section Is 70 mph.**

Currently, there are five separate cases in which fog warning and safety strategies are implemented. A decision is made as to what case is initiated based on the information provided by the system's control software and field observations. Table TN-1 details the five cases and the corresponding advisory and control strategies. In Cases 3 through 5, there are three

separate messages for the DMS boards which appear relative to the sign's location from the incident. The messages displayed in these three cases are dependent on the relative location and scale of the fog event. The DMS board located on the peripheral of the system will display the first alternating message. When closure of the interstate section is warranted (Case 5), the ramp gates are closed and a detailed route detour scheme is coordinated by the Tennessee Highway Patrol. The local media is contacted for all levels of activation. A pre-recorded message is broadcasted from the HAR (Highway Advisory Radio) when activated by the operators. The control software allows for customized message to be displayed and broadcasted.

Transportation Outcome(s): From October 1st of 2011 to March 31th of 2012, the system detected fog in the target area a total of 45 times. This time frame represents the most active for fog production. Of the 45 times fog was detected by the sensors, advisory strategies were activated by the operators during 31 fog events. Of these events, 12 were elevated beyond the basic preliminary warning to a speed reduction. Since the system became operational, visibility conditions have warranted closure of the interstate section on two occasions: once for fog, and once for the presence of toxic smoke from a chemical plant fire.

Driver safety issues due to visibility problems have improved significantly since the system has been in place, with only one fog-contributed accident being recorded, in 2001. There were no fatalities from this accident. The fog warning and detection system has the additional benefit of providing an effective tool for general incident management. In the October 2011 to March 2012 time period, the system was manually activated to alert motorists of non-fog related incidents 34 times.

Implementation Issues: In the years leading up to the 1990 multi-vehicle incident, the Tennessee DOT and THP had implemented methodologies to help prevent fog-related accidents. In 1980, the DOT completed improvements that included enhanced striping, adding raised pavement markers, adding flashing beacon warning signs, and providing portable detour signs for the THP. The 1990 accident spurred increased research, and the development of an interdepartmental plan of action. The existence of waste treatment facilities from a nearby paper plant necessitated studies into both the natural and man-made causes of fog production. After a review of available technology, it was decided that a fog detection and warning system should be implemented to augment safety practices carried out by the Tennessee Highway Patrol.

The planning and design process of the system was aided by a review of a low visibility warning system located in Charleston, South Carolina. With defined requirements for the system functionality, the overall project area (based on fog incident information), and field component locations were selected. System redundancy was built-in to provide backup communication and power capabilities. The fog detection and warning system became operational in December of 1993.

In 2005, a determination was made that a renovation of the fog system was required. The various components that made up the system had aged to a point where it was difficult to continue operations and maintenance. A systems-engineering approach was used to ensure compatibility with future technologies and additions. Included in this upgrade was the integration of a CCTV video component. These cameras, mounted on 50-foot poles throughout the fog zone, are used to verify system operation and monitor weather and traffic conditions.

The incorporation of the CCTV video required an improvement in the system's communication abilities. The original system transmitted data with the use of a wireless radio microwave link. The required bandwidth for full-motion, real-time video and responsive remote camera operation

made the wireless system a less desirable design. The updated fog system operates with a leased, point-to-point, T1 communication link. In the future this T1 link will be replaced by a department-owned fiber optic link from the on-site control center to the Traffic Management Center (TMC) in Chattanooga, Tennessee.

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Keywords: fog, visibility, low visibility warning system, freeway management, traffic management, emergency management, law enforcement, advisory strategy, motorist warning system, traveler information, control strategy, speed management, access control, decision support, vehicle detection, environmental sensor station (ESS), variable speed limit (VSL), closed-circuit television (CCTV) cameras, dynamic message signs (DMS), highway advisory radio (HAR), gates, crashes, safety, Traffic Management Center (TMC)