## Tennessee Low Visibility Warning System

On December 11, 1990 the visibility distance on a segment of Interstate 75 in southeastern Tennessee was less than 10 feet (3.1 meters). In both northbound and southbound lanes extremely low visibility contributed to chain-reaction collisions involving 99 vehicles, 42 injuries, and 12 fatalities. This crash prompted the design and implementation of a low visibility warning system on the interstate freeway. The system covers 19 miles (30.6 kilometers) including a three-mile (five-kilometer), fog-prone section above the Hiwassee River and eight-mile (13-kilometer) road sections on each side of the river.

*System Components*: Managers with the Tennessee Department of Transportation (DOT) and the Tennessee Department of Safety access a central computer system that collects field data from two Environmental Sensor Stations, eight forward-scatter visibility sensors, and 44 vehicle detectors. Underground fiber optic cables transmit sensor data from the roadway to an on-site computer for processing. Data from the on-site computer is relayed via a microwave communication system to the central computer in the Highway Patrol office in Tiftonia.

**Tennessee VSL Sign**

Traffic and emergency managers employ both advisory and control strategies. Motorists are notified of prevailing conditions via flashing beacons atop six static signs, two Highway Advisory Radio (HAR) transmitters, and ten Dynamic Message Signs (DMS). Roadside delineator posts with highly reflective stripping are spaced roughly 80 feet (24.4 meters) apart throughout the project area for visual observation of visibility conditions. Speed management is accomplished by controlling ten Variable Speed Limit (VSL) signs, shown in the figure. When necessary, access to the affected highway section is restricted with eight gates located on interchange ramps.

*System Operations*: By continually monitoring sensor data, the on-site computer predicts and detects conditions conducive to fog formation and detects significant reductions in traffic speed. The central computer sounds an audible alarm in the Highway Patrol office when established threshold criteria are met. When alerted dispatchers post a reduced speed message on DMS and notify Highway Patrol troopers. Troopers are stationed in the project area from 5:00 AM to 10:00 AM when most fog events occur. Within five minutes of an alarm troopers verify conditions by counting the number of visible delineator posts.

Control software provides decision support by correlating field sensor data with pre-determined response scenarios. When troopers confirm low visibility conditions, managers select pre-programmed DMS messages, pre-recorded HAR messages, and appropriate speed limits based upon scenarios proposed by the central computer. The system also allows the display or broadcasting of customized messages.

Managers are notified if visibility distance is less than 1,320 feet (402.3 meters) or if average speed falls below 45 mph (74 kph). The speed limit is reduced from 65 to 50 mph (105.4 to 80.4 kph) when visibility is between 480 feet (146.3 kph) and 1,320 feet. The limit is lowered to 35 mph (56.3 kph) for visibility distances between 240 and 480 feet. Managers also notify local media when the warning system is activated.

Under the worst-case scenario—visibility less than 240 feet or 73.2 meters—Highway Patrol troopers activate automatic ramp gates to close the interstate and detour traffic to US Highway 11. Low visibility has caused freeway closures twice since the warning system was deployed; once due to fog and once due to smoke from a nearby fire. Advisory and control strategies are summarized in the following table.

**Tennessee Ramp Gate**

**Tennessee Low Visibility Warning System Strategies**

| Conditions | Advisories on DMS | Other Strategies |
|---|---|---|
| Speed Reduced | "CAUTION" alternating with "SLOW TRAFFIC AHEAD" | N/A |
| Fog Detected | "CAUTION" alternating with "FOG AHEAD TURN ON LOW BEAMS" | • "FOG" displayed on VSL signs |
| Speed Limit Reduced | "FOG AHEAD" alternating with "ADVISORY RADIO TUNE TO XXXX AM" | • "FOG" & Reduced Speed Limits displayed on VSL signs<br>• HAR messages broadcasted |
| | "FOG AHEAD" alternating with "REDUCE SPEED TURN ON LOW BEAMS" | |
| | "FOG" alternating with "SPEED LIMIT XX MPH" | |
| Roadway Closed | "DETOUR AHEAD" alternating with "REDUCE SPEED MERGE RIGHT" | • "FOG" displayed on VSL signs<br>• HAR messages broadcasted<br>• Ramp Gates closed |
| | "I-75 CLOSED" alternating with "DETOUR" | |
| | "FOG AHEAD" alternating with "ADVISORY RADIO TUNE TO XXXX AM" | |

*Transportation Outcome*: From October to March, the low visibility warning system is typically activated about once a week. Ninety-five percent of system activations result in a speed limit reduction to 50 mph. Approximately 13 percent of activations required further reduction to 35 mph. There have been over 200 crashes, 130 injuries and 18 fatalities on this highway section since the interstate opened in 1973. Safety improved significantly after deployment of the warning system in 1994, as only one crash has occurred in fog.

*Implementation Issues*: After the multi-vehicle crash in 1990, a DOT and Department of Safety task force investigated fog-related crashes on the affected freeway segment, which was near settling ponds owned by a local paper mill, and recommended deployment of a fog warning system. When planning the Interstate 75 system, managers assessed another low visibility warning system in Charleston, South Carolina.

Field device technologies, system components, and operational procedures were evaluated to assist Tennessee managers with system design. After developing requirements for equipment, communications, and power supply DOT managers determined system scope (i.e., coverage of the most fog-prone area), field equipment locations, and warning messages. To ensure system reliability, backup radio and telephone communication systems, as well as an emergency power system were designed. Construction was completed in 1992 and the system began operating in 1993.

Some system integration problems were experienced during implementation. There were minor complications associated with hardware failures due to the harsh outdoor environment. Lightning protection systems were installed to prevent hardware damage. Communication failures were minimized by mounting stabilization devices on microwave antennas to prevent misalignment in high winds. Traffic managers have been unable to observe system status or receive alerts due to trouble with data transmission from the project site to the regional DOT office.

System designers addressed system maintenance and expandability. Both routine and emergency maintenance are performed regularly on all system components. The system was planned to accommodate future integration of new technologies or components, including an upgrade to the microwave communications system and a new digital Closed Circuit Television surveillance system.

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