TECHBRIEF

Highway Fog Warning System

The national Intelligent Transportation Systems (ITS) program includes the development and application of advanced systems upon all parts of the transportation network, including rural areas. The U.S. DOT has developed the Advanced Rural Transportation Systems (ARTS) program to meet the needs of travelers in and through rural areas, as well as the agencies responsible for the operation and maintenance of the rural transportation system. The ARTS program complements the ITS efforts in metropolitan areas and commerical vehicle operations (CVO) by studying ways to best implement technologies that address transportation problems in rural areas.

U.S. Department of Transportation
Federal Highway Administration

Research, Development, and Technology
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA 22101-2296

The need for a highway fog warning system has long been internationally recognized. With such a system, motorists can avoid tragic pile-up accidents caused by dense or patchy fog, which are often fatal. Some examples of devasting crashes under reduced visibility include:

Date	Place	Deaths	Injuries	Vehicles
12/90	Calhoun, TN	12	44	99
1/91	N. Salt Lake City, UT	4	25	69
12/94	Tejon Pass, CA	2	27	40
1/95	Menifee, AR	5	—	>9
3/95	Mobile, AL	1	74	100
11/95	Monroe, MI	—	9	54

The development of a cost-effective highway visibility sensor that measures the density of roadway fog and is linked to traveler information systems could substantially reduce fog accidents. With this in mind, FHWA conducted a study to develop a low-cost, reliable fog sensor.

Project Description

The approach to the problem was to measure the light scattered in a forward direction by fog particles. Such a device is called a nephelometer. While nephelometers have been around for some time and are the basis for sensors that are now widely used in automated weather stations, including airport locations, these particular sensors are designed with roadside highway use in mind. They are smaller and lighter than their existing counterparts, and have their light emitters and detectors recessed deeply within their housing, eliminating the need for external lenses and windows. These differences make for an easier, and thus less expensive, installation and lower maintenance costs.

Sensor units were placed in several locations for this study. Spacing between sensor units was between 61 and 213 m (200 and 700 ft), covering the study area. With this configuration, patchy fog, as well as dense fog, over a large area could be monitored along the highway.

The host computer requests fog density data from each sensor and determines the level of warning based on a pre-established conversion equation. The warning signal is then transferred to motorists through roadside displays or audio communication.

System Capabilities

The sensor unit consists of an optical system, electronics, and software for communication to a host computer. The data obtained by the detector are digitized and transferred to the host computer. The sensor unit is designed to provide: (1) accurate fog density measurement, (2) low maintenance requirements, and (3) selectable output format (visibility in distance units or voltage proportional to fog density).

Four optional communication links between the sensors and a host computer are available: cable, fiber optics, telephone (wired or cellular), and radio frequency (RF). The necessary software and hardware to operate under any of these communication methods have been developed.

A personal computer or laptop computer can be used to operate the sensor units and may be located near the sensors or remotely, depending on the communication method. The software provides a menu for selecting manual or automatic data acquisition modes, warning indication method, and data display options. Also available is software that can predict the time of a fog occurrence using temperature and humidity information from a location near the fog sensors. It will automatically adjust the visibility acquisition interval so that fog data is obtained more frequently when fog is most likely to occur.

Evaluation Approach

A number of sensors were designed and fabricated, laboratory tested, and then used in field tests. Laboratory tests determined their sensitivity to various fog densities and demonstrated their ability to withstand extreme environmental conditions. Subsequent field tests determined their usefulness in measuring the level of naturally occurring fog at actual roadside locations. Airport field tests enabled comparisons to be made with existing visibility sensors approved by the Federal Aviation Administration.

Results

The project has demonstrated the ability of the fog sensor to accurately determine fog density in a highway environment. Both laboratory and field tests have shown that this device can withstand the rigors of extreme temperature ranges, heavy rainfall, and blizzard conditions. It is also able to detect blowing snow that causes "white out" conditions on winter roads. The field tests enabled comparisons to be made with existing visibility sensors, followed by further testing.

Positive findings learned during the field tests included:

- Basic idea worked.
- Software worked.
- Communication system worked.
- Telephone lines were the most reliable for remote locations.
- Sensor was insensitive to orientation and shadowing.
- Rain did not adversely affect the measurement of fog.

Lessons learned during the field tests included (many of which have been addressed through design modifications):

- VHF communication entailed a cumbersome Federal Communications Commission permit process.
- Cellular communications were expensive and not reliable enough.
- Power consumption was too high for cellular communications with solar power.
- Fog chamber testing was time-consuming.
- Raindrops and frost formation may have caused false readings.

Refinements based on field-testing experiences have been incorporated into the latest design of this device. Specific improvements in the production and testing of future sensors have been proposed.

For more information

This project was conducted by Sentec Corporation, 2000 Oakley Park Road, Suite 205, Walled Lake, MI 48390-1502, (248) 960-1020. Work was conducted under the Small Business Innovative Research (SBIR) program. For more information contact Tim Penney, Office of Safety Research and Development, (703) 285-2174.