Summary Report

Traffic Safety Research Program

The FHWA Traffic Safety Research Program addresses the visibility of the roadway and its environment, and traffic control methods and devices to promote the safe and efficient movement of vehicles and pedestrians. The current emphasis areas are: the ITS program on advanced traveler information systems (ATIS), condition-responsive traffic control devices, and improved driver visibility through fluorescent materials and ultraviolet headlighting. Recent research includes recommending guidelines for the retroreflective requirements for traffic signs and pavement markings. The research is to support the programs of the FHWA's Office of Highway Safety and the Manual on Uniform Traffic Control Devices.

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Environmental Sensors for Safe Traffic Operations

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The meteorological parameters that have the greatest impact on drivers and their safety are rainfall, snow, ice, fog, and wind. To minimize the impact of these conditions, information can be provided to travelers en route or prior to departing, as well as to highway maintenance crews. The rapid response of appropriate measures can potentially save lives, as well as retain mobility. This demand has led to the development of sensor systems to collect data on pavement temperatures and chemical composition, air temperature and humidity, wind velocity and direction, visibility, and precipitation. This research was initiated to review the state of the art of environmental sensors and to determine where improvements might be made.

Research Approach

The research involved a review of environmental monitoring based on the literature, State activities, and site visits. Basic meteorological principles were reviewed to determine the frequency and severity of adverse weather. Functional requirements for pavement, visibility, and wind sensor systems were developed in terms of performance criteria, parameters to be measured, location of sensors, data output, and operation and control.

The commercial sensors were reviewed and compared with the functional requirements. An emphasis was placed on visibility sensors. Five visibility sensors were obtained and tested in a laboratory setting. Four of these sensors were installed at a fog-prone location on Thomson Hill, along I-35, near Duluth, MN. A video system was also used to record weather conditions.

Results

- Most pavement sensors are point sensors installed in the pavement. These sensors determine whether the surface is wet or dry, the temperature of the pavement, and the conductivity of any surface water to estimate salt concentration. They only indicate conditions at one specific point on the roadway. As a result, strategic placement of the sensors is critical for monitoring and predicting entire roadway conditions. The Strategic Highway Research Program (SHRP) developed guidelines for citing roadway weather information sensors. Pavement sensors are considered to be developed to a point that additional evaluation is not needed.

- A number of types of wind sensors are available. A differential pressure tube measures static and total pressure, and relates these parameters to wind speed. Sonic anemometers give very accurate wind speed measurements. The rotational speed of a propeller anemometer is the most commonly used method for measuring wind speed. Hot wire and hot film anemometers are also used to measure wind speed. Like the other sensors, the measurements are limited to a point location. The wind sensors do not need further evaluation.

- Visibility sensors operate on one of three main principles. These principles are atmospheric transparency, light scattering by airborne particles, and luminance contrast. The transmissometer involves a laser source carefully aimed at a receiver some distance away. The light-scattering sensor uses a light transmitter with the receiver placed from 33 to 70° off the light-source axis, or a backscatter would have the transmitter and receiver aligned on the same axis. Video cameras may be used to measure visibility from video images. Few of the available sensors were specifically designed for highway applications. Those contacted in this study desire additional information on visibility sensors.

Evaluation of Visibility Sensors

In the functional requirements, it was indicated a visibility sensor should measure visibility of at least 10 to 400 m, with an accuracy better than ± 20 percent of human visibility. This is the range that affects driver speed based on comfort and stopping sight distance. Four sensors were obtained from interested manufacturers. These were:

- HSS Incorporated VR-3-1B Digital Visibility Sensor.
- Belfort Instrument Model 6210 Visibility Sensor.
- Vaisala Visibility Meter FD-12.
- Sten Löfving Optical Sensor *OVPD* Visibility Sensor.

The sensors were installed at the side of I-35, south of Duluth, MN, to evaluate their accuracy and operational features. The sensors were connected to a processing computer housed in a shed to record measurements. Also, a video camera was installed at the site to record weather conditions. The camera was connected to a frame-grabber card in the computer to enable capture of visual images for comparison with sensor data. A series of targets was placed at fixed distances from the video camera to provide visibility reference points. See figure 1 for the installation layout.

When a chance of low visibility was predicted, the project team began remote monitoring for site conditions. If a low-visibility condition was noted, an observer was sent to the test site to begin manual observations.

During the 7-month test period, 13 low-visibility conditions were encountered (12 fog and 1 blowing snow). The initial test was to determine which of the sensors most accurately reflected the visibility as recorded by the manual observer. The HHS sensor, with a 55-percent rating, was the most accurate. All sensors responded similarly to the conditions at the test site, so they were recalibrated in an attempt to maximize the number of reported visibilities that corresponded to the observed visibilities. See table 1. Three of the sensors were within the 20-percent accuracy range.

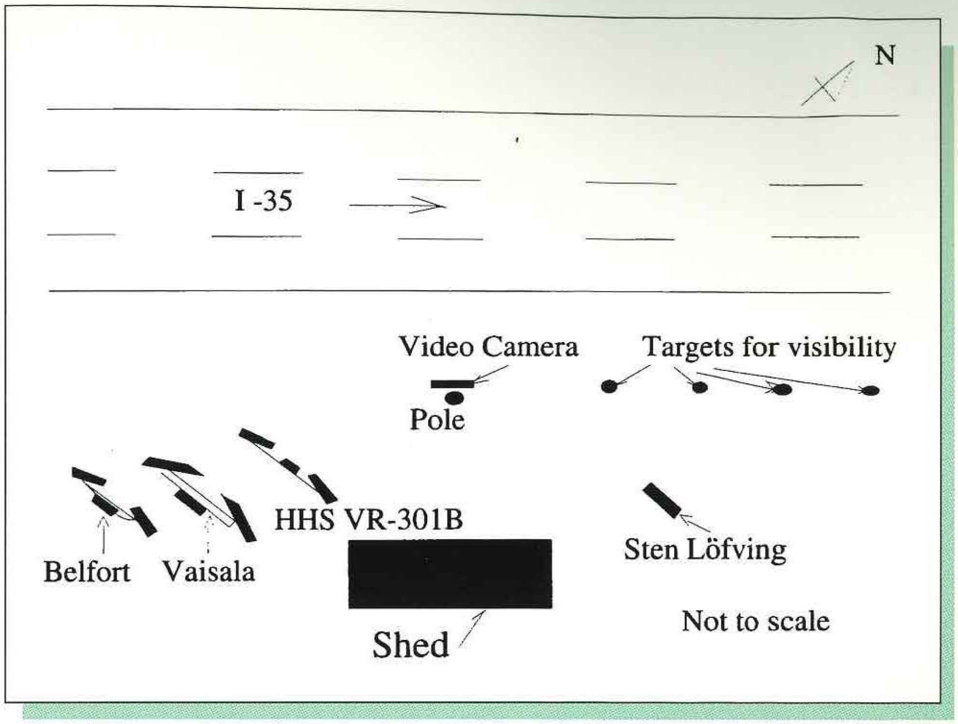

Figure 1. Installation layout.

Table 1. Accuracy of sensors after calibration.

	Belfort	HHS	Sten Löfving	Vaisala
No. of Visibility Points	233	235	134	212
Ave. Exact Match to Manual Data	57%	57%	46%	45%
Ave. Percent Error from Manual Data	12%	13%	45%	18%

The use of the video image related to low visibility was investigated. The contrast ratio of the targets has a definite potential for developing visibility thresholds.

Also, a visibility sensor was mounted on a MnDOT vehicle for evaluation as a possible probe. Except for the need to regularly clean the sensor lenses, it proved to be an adequate mobile source.

A need exists to develop compatibility among manufacturer's systems and to develop lower cost sensors to allow greater coverage of the road network.

For More Information

A full report on this study is available from the FHWA R&D Report Center, phone no. 703 285-2144.
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This research was conducted by Castle Rock Consultants. For more information, contact Howard Bissell of FHWA, HSR-30, 703 285-2428.