Fog Detection and Warning Systems throughout the World: a Summary
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Fog-Detection and Warning Project, Netherlands


- Variable message signs every 0.4 to 0.5 miles, and 20 visibility sensors.

- Flexible speed limits and warning displays that can be varied to match traffic and environmental conditions, including fog.

- Variable speed limits dependent upon visibility:

<table>
<thead>
<tr>
<th>Visibility Range</th>
<th>Posted Speed Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>456 feet (140 meters) or more</td>
<td>100 km/h (62 mph)</td>
</tr>
<tr>
<td>228 to 456 feet (70 to 140 meters)</td>
<td>80 km/h (49 mph)</td>
</tr>
<tr>
<td>Below 228 feet (70 meters)</td>
<td>60 km/h (37 mph)</td>
</tr>
<tr>
<td>If an incident is detected</td>
<td>50 km/h (31 mph) on the first sign upstream, and 70 km/h (43 mph) on the second sign upstream</td>
</tr>
</tbody>
</table>
Fog-Detection and Warning Project, Netherlands (continued)

- Evaluation of the system examined changes in individual vehicle speeds and headways during fog conditions.

- Results: Mean speeds at all of the monitoring stations were reduced by 8 to 10 km/h during fog conditions. Mean speeds still above displayed speeds.

- A small reduction in the standard deviation of speeds. Small, but significant, decrease in the percentage of vehicles with headways less than one second.

- Researchers concluded that the system has positive effects on driver behavior during fog.

- 50% reduction in secondary accidents reported.
Variable Speed Limits on Autobahn, Germany

- In use since 1960 on sections of the autobahn in urban areas, to improve traffic flow and adapt traffic to adverse environmental conditions. Germany has 130 traffic management facilities covering 800 km.

- Due to high costs, systems are installed on a priority basis on hazardous sections, especially in areas of adverse environmental conditions.

- Vehicle speed and count monitored through inductive loops. Fog, ice, wind, and other detectors monitor environmental conditions.

- Computer algorithms actuate variable message signs for the conditions detected. Displays can also be operated manually. In addition to the speed limit, the reason for the restriction is also displayed.

- Results: Systems reduce the accident rate by 20 to 30 percent, with an average reduction of 25 percent.

- German citizens and officials, including traffic safety researchers, appear to support the practice of not posting speed limits on autobahns outside of urban areas.
Fog Warning and Advisory Speed Limit System, Australia

• Installed 1993 along an 11-km section of the F6 Tollway south of Sydney.

• 12 fiber-optic sign locations, with signs in both directions, ~1 km apart. Each location equipped with inductive loops and a visibility detector.

• Fully automated: Speed of each vehicle is measured over a distance of 200 m, and this speed is used to present an advisory speed to the next vehicle passing the station. The advisory speed is based on visibility distance and the speed of the preceding vehicle.

• Results: Reduction of 60 percent of the vehicles traveling in excess of the speed limit. Effect is temporary: 300 m downstream, no reduction in speeds.

• Currently data are being collected to conduct an accident evaluation of the system. Extensive data on accidents by type, fog condition, and time of day, are being collected.

- Six visibility detection sites.
- Remotely activated fixed warning signals are automatically activated when visibility drops below minimum threshold.
- Transportation Research Laboratory observed an overall reduction in mean speeds of about 1.8 mph when signals were activated.
The Weather-Controlled Road System, Finland

• Implemented in 1994.
• Located along a 15.5 mile section of E18 between Pyhtaa and Hamina.
• Consists of 5 automatic road weather monitoring stations, 66 VSL signs, and 13 CMS.
• Sensors at each station measure wind speed and direction, air temperature, roadway surface temperature, humidity, intensity and state of precipitation, visibility, and road surface state (wet, dry, icy).
• Results: System succeeded in reducing mean speeds and variance in adverse conditions.
• 95% of drivers interviewed said that varying speed limits were useful and enhanced traffic safety. No accident data reported.
Storm Warning System, Idaho

- Implemented in 1993 in response to 18 major visibility-related crashes between 1988 and 1993, involving a total of 91 vehicles.
- Located along the I-84 in southeast Idaho.
- Consists of sensors to measure traffic, visibility, roadway, and weather data, video cameras to verify visibility readings, and 4 CMS.
- Idaho Transportation Department receives alerts from the central computer and decides which message to display on the CMS.
- Results of system evaluation conducted between 1993 and 2000:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Average Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Without Advisory</td>
</tr>
<tr>
<td>High Winds</td>
<td>54.8 mph</td>
</tr>
<tr>
<td>High Winds and Precipitation</td>
<td>47.0 mph</td>
</tr>
<tr>
<td>High Winds and Accumulated Snow</td>
<td>54.7 mph</td>
</tr>
<tr>
<td>All Conditions</td>
<td>61.5 mph</td>
</tr>
</tbody>
</table>
The Fog-Detection and Warning System, Tennessee

- Located along 19 miles of the I-75, near the Hiwassee River.
- Central computer receives data from 8 fog and 44 speed detectors.
- Motorists are advised of fog conditions using 6 static signs, 2 HAR transmitters, 10 CMS, 10 VSL signs, and automatic ramp gates.
- Center managers with Tennessee DOT and Tennessee Highway Patrol select pre-programmed CMS messages, pre-recorded HAR messages, and appropriate speed limits (35 or 50 mph) based upon the data.
- Under worst-case scenario (visibility < 240 feet), the Highway Patrol activates the ramp gates and detours traffic to US Route 11.
- Results: There were over 200 crashes, 130 injuries, and 18 fatalities on the section from 1973 to 1994. Since activation, no fog-related accidents reported.
TravelAid, Washington State

- Implemented in the winter of 1997/98.
- Located along the I-90, across Snoqualmie Pass.
- 13 CMS that display enforceable speed limits and/or messages.
- Decision to reduce speeds is based upon vehicle speeds, volume, and classification, atmospheric conditions, and observations from Washington State DOT maintenance personnel and the State Patrol.
- Existing control is manual. Goal is for the system to automatically post safe speeds based upon real-time data.
- Results: Currently under evaluation by the Washington State Transportation Center at the University of Washington.
Adverse Visibility Information System (ADVISE), Utah

- Implemented in the winter of 1999/00.
- Consists of 4 visibility sensors, 2 CMS, and 6 traffic counters.
- Central computer identifies threats using visibility, vehicle speed, and vehicle classification, and prompts display of an adaptive speed limit and warning message:

<table>
<thead>
<tr>
<th>Visibility Range</th>
<th>Speed Limit Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>820 feet (250 meters) or more</td>
<td>None</td>
</tr>
<tr>
<td>656 to 820 feet (200 to 250 meters)</td>
<td>&quot;FOG AHEAD&quot; / &quot;POOR VISIBILITY&quot;</td>
</tr>
<tr>
<td>492 to 656 feet (150 to 200 meters)</td>
<td>&quot;MAX SPEED 50&quot; / &quot;POOR VISIBILITY&quot;</td>
</tr>
<tr>
<td>328 to 492 feet (100 to 150 meters)</td>
<td>&quot;MAX SPEED 40&quot; / &quot;POOR VISIBILITY&quot;</td>
</tr>
<tr>
<td>197 to 328 feet (60 to 100 meters)</td>
<td>&quot;MAX SPEED 30&quot; / &quot;POOR VISIBILITY&quot;</td>
</tr>
<tr>
<td>Less than 197 feet (60 meters)</td>
<td>&quot;MAX SPEED 25&quot; / &quot;POOR VISIBILITY&quot;</td>
</tr>
</tbody>
</table>

- Results: Speed variation reduced 22%. Average speed increase 5%. Insufficient accident data to report.
Fog Detection and Warning System, Georgia

- Located along 12-mile stretch of I-75, near Adel.
- $2.4 million system installed by Georgia Tech Research Institute in collaboration with Georgia DOT.
- Consists of 19 fog sensors, 10 sets of traffic monitoring loops, weather instruments, 5 closed-circuit televisions, and 4 CMS on the north- and southbound outskirts of the fog zone.
- In fog conditions, the central computer automatically notifies officials at the Transportation Management Center in Atlanta, sends cautionary messages to the CMS, and turns on streetlights on the roadway.
- Results: The project is currently in its study phase, in which they are attempting to provide information about how often fog occurs, how severe visibility conditions can become, and traffic speeds during various fog conditions.
The Variable Speed Limit Project, Arizona

• Currently under development.

• Test area will be located along I-40.

• Northern Arizona University is developing a variable speed limit system that uses a fuzzy logic algorithm to compute and display appropriate road speed limits for different environmental conditions.

• Maximum prudent speeds are to be determined using weighted averages of road surface conditions, average wind speed, wind gust speed, angle of cross wind, visibility and precipitation intensity.

• The project is currently in Phase III, involving the collection of weather and traffic data, and resolving legal issues regarding the enforcement of variable speed limits.

• Planned end of Phase III is Sep. 2002.
New Jersey Turnpike - Variable Speed Limits

First components installed in the late 1960s on urban and rural sections of New Jersey Turnpike.

120 variable speed limit signs over 148 miles

Inductive loop detectors collect speed and volume data. Weather sensing equipment is currently being installed.

Speed limits are based on average travel speed and are displayed automatically (manual override used for lane closures and construction zones).

Speed limit can be reduced for six reasons: crashes; congestion; construction; ice; snow; and fog.

The speed warning signs display, “Reduce Speed Ahead” and the reason for the speed reduction. When appropriate, the distance between the warning sign and the beginning of the congestion is also displayed.

The New Jersey Turnpike Authority feels that the signs are effective.
Variable Speed Limit Project - Nevada

- 22 weather stations, installed throughout the state. The sensors monitor air temperature, wind speed and direction, humidity, precipitation, dew point, visibility, road condition (wet, dry, icy), pavement surface and subsurface temperature, and the amount of chemical on the roadway.

- Variable speed limit and warning signs are currently being installed to warn drivers of diminished road and visibility conditions.

- Vehicle speeds will also be monitored along I-80, 15 miles east of Reno. Data will be used to calculate the appropriate speed for current weather conditions. This speed will be shown on the variable speed limit signs.

- If speed limits are reduced, signs will be activated that read “Reduce Speed When Flashing.”

- Remote access to forecasts available by computer.
Florida Evaluation of Motorist Warning Systems for Fog-Related Incidents in the Tampa Bay Area

- A 1997 study prior to implementation of a proposed driver warning system.

- Investigation began after a 54-vehicle fog-related incident on Dec. 27, 1996.

- The Center for Urban Transportation Research (CUTR) was retained by the Florida Department of Transportation to conduct a four-month investigation to determine the extent of patterns of fog-related incidents in the Tampa Bay area, and suitable countermeasures to warn motorists of fog conditions.

Conclusions:

- Introducing a warning system ahead of the fog conditions increases the time available for reaction, but there is no comprehensive evidence that it consistently leads to speed reductions.

- Major investments in detection and warning technology in fog-crash-prone areas was not warranted at the time.

- Instead, they recommended a focused driver awareness campaign prior to and during the fog season.
Demographics for Countries in Which Warning Systems have been Installed

<table>
<thead>
<tr>
<th></th>
<th>Netherlands</th>
<th>Germany</th>
<th>Sweden</th>
<th>Australia</th>
<th>USA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Motor Vehicles x 1,000</td>
<td>6,700</td>
<td>45,400</td>
<td>4,300</td>
<td>10,200</td>
<td>194,400</td>
</tr>
<tr>
<td>Fatalities (1993 data)</td>
<td>1,252</td>
<td>9,949</td>
<td>632</td>
<td>1,946</td>
<td>40,115</td>
</tr>
<tr>
<td>Accident Rate (Accidents per vehicle km x 106)</td>
<td>0.38</td>
<td>0.67</td>
<td>N/A</td>
<td>0.15</td>
<td>0.63</td>
</tr>
</tbody>
</table>

General Speed Limits (km/ h)

<p>| | | | | | |</p>
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<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Freeway</td>
<td>120</td>
<td>No limit</td>
<td>110</td>
<td>110</td>
<td>105</td>
</tr>
<tr>
<td>Rural Road</td>
<td>80</td>
<td>100</td>
<td>80</td>
<td>100-110</td>
<td>89</td>
</tr>
<tr>
<td>Urban Area</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>60</td>
<td>40-56</td>
</tr>
</tbody>
</table>

Source: BASt, based on International Road Traffic and Accident Database, January 1995.