Do Speed Advisories Work in Fog – Utah Experience

National Highway Visibility Conference
Madison Wisconsin, May 19, ’04
Sam Sherman, UDOT ITS & CVO Engineer
Utah Dept. of Transportation
University of Utah Traffic Lab
Fog – A National Problem?

- Between ‘81 & ‘89, 6000 deaths nationwide due to fog
- 4 major fog related accidents in 1990-91 involved 240 vehicles, 21 fatalities
  
  Source: NCHRP Synthesis 228

- 670+ fatalities (2001)
Fog – A Local Problem?

- In Utah, multiple vehicle accidents occurrences in Fog:
  - 1988: 66 vehicles involved,
  - 1991: 10 accidents in 1 day at same location 62 vehicles - 3 fatalities
  - 2002: 11 vehicles, 3 fatalities
  - 2003: 59 Vehicles

- Fog can be highly localized across I-215, winter inversions, 29 fog days between 1995 & 98 with visibility's below SSD.

- Visibility can change dramatically from moment to moment.

11 year period:

3,100 Accid. – Fog Related

18 of those accidents involved fatalities

17% involved severe injuries
System Requirements

From National Transportation Safety Board to Tennessee DOT (1992):

“The plans should provide for the immediate detection of traffic flow disruption and fog, uniform driver response to reduce and maintain traffic speed in advance of and through the hazardous area, enforcement of countermeasures, and a public information and education program to ensure that motorists receive specific behavioral guidance for the fog-prone area.”
System Requirements

- Countermeasures are needed that ensure drivers proceed through limited visibility conditions at uniform reduced speeds.
- Credible (real-time) information and behavioral guidance signs are essential to reducing speed variation.
- Comprehensive countermeasure systems should include both traffic flow detectors and visibility sensors that automatically alerts drivers of hazardous conditions or slow traffic.

Source: National Transportation Safety Board Highway Accident Report, ‘92
ADVISE Project History
(Adverse Visibility Info. System Evaluation)

- FHWA accepted ADVISE proposal Aug. ‘93
- ADVISE RFP Prepared May ‘94
- Rockwell awarded contract Oct. ‘94
- Phase 1 Data collection Winter 95/96
- VMS installed June ‘96
- Phase I Evaluation Completed Oct. ‘96
- VMS refurbished Summer ‘98
- Phase III Evaluation Winter 99/00
ADVISE Project Objectives

1) Select one or more sites with poor visibility conditions
2) Design and operate a system to involve fixed and/or mobile technology such as VMS and visibility monitoring systems
3) Provide data collection through induction loops or video
4) Provide a comprehensive evaluation involving measurements of speed flow characteristics, accidents and driver behavior.
5) Determine sensitivity, calibration, reliability and maintenance requirements of the system.
ADVISE SYSTEM
Fog System Layout

Project Location Map

- Fog Sensor (Visibility)
- Loop Detectors
- VMS

Locations:
- E1
- E2
- E3
- W1
- W2
- W3

Roads:
- Jordan Road
- 1300 West
- Riverside Drive
- I-15

Surroundings:
- Mountain range
- Snow-covered land
ADVISE Evaluation

Data Collected in Three Phases

- Phase I - Pre-VMS Signs (95/96)
- Phase II - with VMS Signs (96/97, 97/98)
- Phase III - with VMS Signs (99/00)
Phase I Summary of Findings
Prepared by: CH2M HILL / BSU - 1996

- During Periods of Low Visibility, No Predictable Driver Behavior Exists
- Speed Reductions Identified Due to Low Visibility Conditions On Average Are Not Sufficient for Safe Stopping Sight Distances
- No Consistent Relationships Between Average Speed and Precipitation Types
- Headway Between Vehicles Is a Function of Traffic Volume; Not Weather Conditions Or Speed
- In General, At Low Levels of Visibility, Variability Of Individual Vehicles Speeds Increases-- Recipe for Accidents
Modifying Behavior

- **Speed Advisories**

**Highway Visibility Range & VMS Message**

- > 250 meters: No message
- 200 – 250 meters: “Fog Ahead”
- 150 – 200 meters: “Dense Fog” alternating with “Advise 50 mph”
- 100 – 150 meters: “Dense Fog” alternating with “Advise 40 mph”
- 60 – 100 meters: “Dense Fog” alternating with “Advise 30 mph”
- < 60 meters: “Dense Fog” alternating with “Advise 25 mph”
Phase 2/3 Evaluation Objectives

By informing drivers of appropriate speed for conditions, does it:

- Reduce mean speeds?
- Reduce deviations between speeds?
Phase 2/3 Research Plan

- Statistically Evaluate the effectiveness of the ADVISE system.

- The ADVISE system utilizes VMS in real-time (1-minute intervals) to inform drivers of recommended safe speeds:
  - Is there a change in mean speeds and standard deviations?
  - By direction, lane, classification, time of day based on available visibility
<table>
<thead>
<tr>
<th>Overall</th>
<th>Visibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle Class</td>
<td>Peak Period</td>
</tr>
<tr>
<td>Day/Night</td>
<td>Corridor Locations</td>
</tr>
<tr>
<td>Directional Lane</td>
<td>Time of day</td>
</tr>
</tbody>
</table>
Data Collection

- Phase I – 32 Events - 19 with useable data (N = 43,917)
- Phase II – 11 Events - 5 with useable data (N = 14,001)
- Phase III – 4 Events – 3 with useable data (N = 6,803)
  - N = number of vehicles in Sample size
- Unusable events means that either Speed, Sign or Visibility information was not available
Standard Deviations for Three Phases

P2 = \( R^2 = 0.0555 \)

P1 = \( R^2 = 0.0065 \)

P3 = \( R^2 = 0.2003 \)
Speed for Three Phases

- Phase I: $P1 = R^2 = 0.1048$
- Phase II: $P2 = R^2 = 0.171$
- Phase III: $P3 = R^2 = 0.5235$

Visibility vs. Mean Speed graph showing the correlation between visibility and mean speed for different phases.
Data Scatter

Better Correlation

More Scatter

$r^2$

Phase

I

II

III

Poor

Worse

Fair
Standard Deviation of Speeds
For recorded values during Phases 1 and 3
Mean Speeds
For recorded values occurring in Phase 1 and 3

Sign On ← → Sign Off (Phase 3)

Second Order Polynomial

Poly. (phase 3)
Poly. (phase 1)
Comparison of Speed Distribution
For Phases 1 and 3

Change in Mean Speeds

Reduced Deviations
Change in Mean Speed

- Speed Limit changed in December 1995
- Phase I data is in 95/96
- May be a fundamental change in mean speeds from 95/96 to 99/00 due to:
  - Acclimated to new Speed Limit
  - Construction Frustration
  - Increased Aggressive Driving
Compared Non-Fog Info

- Night-time change in speed of +5.6 mph from 1996 to 1999
- Daytime change in speed from 65 mph in 1996 to 69.2 mph in 1999
- Average standard deviation has increased by 1.3 mph.

- Comparison from two Fridays, one in February 1996 the other in December 1999
## Clear Day Speed Information

<table>
<thead>
<tr>
<th></th>
<th>1996</th>
<th>1999</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>65</td>
<td>69.2</td>
<td>+4.2</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>6.2</td>
<td>7.5</td>
<td>+1.3</td>
</tr>
</tbody>
</table>
Results

- St. Dev. of Speed on Foggy Days are 2 to 3 times higher than clear days (with no signs)
- ADVISE Decreases Standard Deviation of Speed by 22% (9.5 to 7.4 MPH)
- Mean Speeds Increases by 15% (+8 MPH) but 6 MPH attributed to general increase in average speeds
- Extreme slow drivers seen in Phase I not present in Phase III
Mean Speeds
For recorded values occurring in Phase 1 and 3

Low Speed Drivers Not Present with Advise
Visibility Range

- For a given Visibility Range the speed distributions are much more uniform in Phase III.
Comparison of Speed Distributions of Visibility Increments

For Phase 1

Comparison of Speed Distributions of Visibility Increments

For Phase 3
Summary of Results

ADVISE:

- Reduces the Standard Deviation of speeds by 22% → improved safety.
- Observed Increase in Mean Speeds Mostly attributed to the general increase in speeds in the area
- ADVISE SE does not reduce driver speeds to the recommended speeds
Recommendations

- ADVISE System has a positive effect on traffic provided the system can be maintained such that accurate and reliable information is conveyed to drivers.

- Additional information should continue to be collected to provide for an ongoing evaluation to answer some of the issues above.
Needed System Improvements

- Update Sign Controllers to NTCIP & incorporate into TOC Operations (multi-use)
- Replace wireless communications with Fiber
- Incorporate Downstream Vehicle Speed Loop information into system logic
- Incorporate Pavement Condition (RWIS)
- Notify/alarm Traffic Operation Center
- Verify Message Display
ADVISE SE Lessons Learned

- Utilize Regional ITS Architecture/
- Automate Vehicle speed collection and storage using dept. standard equipment
- Utilize PTP hardwire communications
- Use mainstream Technology & Standards
- Obtain buy-in from groups early and nurture acceptance (Traffic Engrs, highway patrol, incident management, traffic operations)
- If possible, avoid isolated systems....build into Traffic Operations
- Consider Obsolescence and have a Plan
What’s Next
We can Do It!!!!

THANK-You

More Info – Contact
Sam Sherman, UDOT
(801)887-3744
ssherman@utah.gov