IDENTIFICATION AND DOCUMENTATION OF WEATHER AND ROAD CONDITION DISSEMINATION DEVICES AND DATA FORMATS

Mn/DOT Agreement No. 79575

Prepared for the

AURORA PROGRAM

Submitted by

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INTRODUCTION

In 1994 Minnesota Guidestar of the Minnesota Department of Transportation (Mn/DOT) conducted a scoping study to identify the needs and concerns of rural travelers. The study revealed that road and weather conditions were found to be the most desired type of information.

In response to this study and others throughout the U.S., various agencies and private companies have initiated numerous efforts to disseminate traveler information to the general public. This includes the Advanced Transportation Weather Information System (ATWIS™) implemented in North and South Dakota. It also includes a partnership of Upper Midwest states, which is implementing a road and weather information service entitled FORETELL™. Almost all states have some form of weather and/or road condition information dissemination capability.

The goal of this project was to identify means for improving the consistency and usability of road and weather information presentation. This involved the identification of current and planned implementation of road and weather information dissemination systems. Furthermore, it involved a review of these implementations in order to create a synthesis of the various means of presenting information to end users and defining a possible set of best practices for use in promulgating and promoting preliminary standards among the Intelligent Transportation Systems (ITS) Standards Development Organizations.

The original intent was for the project to produce two reports. The first report would be a summary report of state-of-the-practice for weather and road conditions information dissemination. The second would be a report on the analysis of the current practice and recommendations for standardized presentations. These reports have been combined into this one report.

THE PROBLEM

Methods of providing real-time road and weather information to the traveler are becoming increasingly varied. Information dissemination devices include in-vehicle units, kiosks, the Internet, the media (which includes, e.g., the Weather Channel), and the telephone, both wire and cellular. As the number of information devices increases, so does the number of formats in which information is communicated. Typically these programs are initiated independently within an agency. To date there has been little coordination between agencies. This lack of coordination has resulted in differing methods for receiving road and weather information as well as for disseminating it to travelers.

It is also important to understand the nature of the term “road conditions” in order to categorize the information dissemination methods. Road conditions generically include traffic, congestion, construction, and closures. They include basically anything that affects the road user. For the purpose of this project, “road conditions” refers to weather-related road conditions. However, this report will also briefly describe the forms of other types of information being disseminated to road users.

Some prior work has investigated weather and road condition information dissemination. The need for information was well documented in the Mn/DOT study. The FORETELL project conducted an extensive needs assessment in order to define the weather and road conditions information requirements of road users. In another effort, Minnesota Guidestar also worked with Volvo to define some icons for use in disseminating weather information to road users. The Federal Highway Administration (FHWA) has also undertaken a study to define user weather-related requirements for surface transportation. However, the formats for presentation of weather information typically have not been investigated.

The premise of this project is that no standardized form or format exists for presenting road and weather information to the public. Therefore, it is important for this project to summarize the various forms and formats for weather and road condition information dissemination. This report will describe those forms and formats uncovered during the investigation to support this premise. A second effort of this report will involve the assessments of the forms and formats in a synthesis analysis to suggest best practices for use by highway agencies.

INVESTIGATION METHODOLOGY

Literature Searches

It was believed that a considerable body of knowledge could be found describing road and weather condition dissemination. In order to survey literature, a review of publications was conducted at the Missouri Department of Transportation (MoDOT) Research Library. A preliminary set of publications for review was obtained after queries submitted to the Transportation Research Board (TRB) On-Line Publications web site. Nearly all those identified through the TRB web site were available at MoDOT. Literature reviewed other than periodicals and newsletters is identified in the Bibliography.

We also reviewed current Weather Solutions Group holdings as well as new publications related to the ITS. This involved monitoring closely those publications describing Advanced Traveler Information System (ATIS) implementations.

Internet Searches

The FHWA National Traffic and Road Closure Information web site facilitated the initial searches for weather and road conditions sites on the Internet. The Internet address for this site is http://www.fhwa.dot.gov/trafficinfo/index.htm. This site provides links to every state agency site that provides roadway condition and traffic information. Each state agency site was visited to determine the availability and types of weather and road condition reporting.

Information on weather and road condition information was also checked through the Newsletter of the ITS Cooperative Deployment Network (ICDN) posted at National Associations Working Group for ITS web site, http://www.nawgits.com.

Local agencies' information dissemination sites were documented through information retrieved from the FHWA web site mentioned above, and papers from the ICDN for the MMDI ATIS

Symposium & ATIS Data Collection Guidelines Workshop held in Arizona in February. One paper documented surveys that were conducted with customers of all known local agency ATIS sites. Information on local agencies was also gathered from the ITS American Traveler Information site where a listing of real-time traffic information sites is available. A selected set of these sites was visited.

ATIS programs were surveyed through the Internet via the reports provided at the ICDN web site for the MMDI ATIS Symposium & ATIS Data Collection Guidelines Workshop. In addition to the ICDN, ATIS information was obtained from the ITSA ATIS Committee site that documented traveler information sites in the real-time traffic information sites page and the ATIS News Archives.

Internet List-Server Contacts

A request for assistance was sent to the Iowa Snow-Ice List managed by the University of Iowa. In addition, a transportation discussion group through the Transportation Communications Newsletter produced by Bernie Wagenblast of TransCore was also contacted.

Agency Contacts

Agency contacts for information gathering were developed from replies to the list server contacts, accessing the ITS America list of members, and through state agency directories available on the agencies' web site. Collections of ITS America papers were also reviewed for ATIS or other traveler information. Project contact information is provided in Appendix B.

Other Contacts

FORETELL™

The FORETELL™ project is a publicly funded private development of road weather information gathering, forecasting, and dissemination capabilities. The FORETELL project is an FHWA Rural ITS operational test. The test area for FORETELL products includes the states of Iowa, Missouri, and Wisconsin. The departments of transportation in these states are helping fund the project. Products are currently available to authorized users on the FORETELL web site. Products include forecasts and observations or meteorological and pavement-specific conditions, as well as actual road condition reports.

ATWIS™

The Advanced Transportation Weather Information System (ATWIS) is a decision support package that was designed at the University of North Dakota's (UND) Regional Weather Information Center to assist transportation personnel in planning and managing summer maintenance, construction, and winter maintenance operations. The ATWIS is now operated by Meridian Technologies, Inc., which transferred the technology developed at UND to a private venture. The ATWIS now provides weather forecast information to South and North Dakota Departments of Transportation, which post the information to their web sites. The forecasts are

presented as textual information by maintenance districts. Road users as well can obtain information via cell-phone by entering their Interstate highway number and milepost location from the telephone keypad. Forecasts for road segments are provided by voice messages.

rWEATHER

rWeather is a project involving the Washington State Department of Transportation (WSDOT), the University of Washington, and a consortium of agencies in the Puget Sound area interested in weather. This site, currently under development, provides forecasts of weather and current weather conditions. The site can be found at http://www.wsdot.wa.gov/Rweather/. The University of Washington is developing fine-scale modeling capability that will eventually provide forecasts of weather and road conditions at 4 km resolution.

SERVICE PROVIDERS

Surface Systems, Inc. of St. Louis has developed a web site for providing road-specific weather and road condition information to commercial vehicle operators. The site provides radar imagery, precipitation forecasts, a summary discussion that is tailored to weather problems on roadways, color-coded maps of forecast road conditions and text-based summaries of current and forecast road conditions, by state. The site can be found at http://www.truckerweather.com. A sample of the forecast road conditions is shown in Figure 1. This map is the SSI TravelCast map that is also used in kiosks and rest areas.

Data Transmission Network/Kavouras Weather Services (DTN) provides traveler information to a number of agencies for presentation to the traveling public. DTN uses any distribution technique available for the dissemination of weather information. This includes satellite-PC based, Internet, pagers, and in-vehicle systems (e.g., ONSTAR). Most of the products are DTN standardized preset package. Agencies can customize and redisplay information. DTN also integrates other vendors' products into their data stream. This product integration includes the SSI TravelCast and EarthSat products.

TROPIC

A European consortium project entitled Traffic Optimisation [sic] by the Integration of information and Control (TROPIC) has investigated the use of Variable Message Signs (VMS) in Europe. In Europe, VMS are one of the principal means of communicating with drivers. Contact was made with the project coordinator, Matthew Clarke of WS Atkins Consultants in the United Kingdom. TROPIC evaluated existing and proposed pictogram presentations of road, weather, and travel conditions. The evaluation included surveys of motorists for pictogram recognition and preference. The TROPIC report provides recommendations for implementation.

Additional contacts were made through the Mid West RWIS (road weather information system) Team and the AASHTO Lead States Team for Anti-icing/RWIS. Electronic mail messages were sent to team members inquiring about contacts for participation. Names provided were contacted for further information.

SUMMARY OF INFORMATION GATHERED

Weather and road condition information is presented to the traveling public via a number of mediums. The type of information presented and the methods for delivery vary considerably because of the lack of standardization. In addition, no public presentations of forecasts of road condition information were found. It should also be pointed out that the investigation encountered a very dynamic situation with the evolution of technology changing the face of information dissemination on nearly a daily basis.

Information Dissemination

INTERNET

The Internet is by far the most widely used mechanism for the dissemination of weather and road conditions. Information is available from the FHWA National Traffic and Road Closure Information web site at http://www.fhwa.dot.gov/trafficinfo/index.htm. Although the majority of the links are to the relatively new commercial traffic reporting services, nearly every state that has to deal with winter road conditions has some reporting for both weather and road conditions. Appendix A-1 provides an array of the state agency web site dissemination practices. There is a large variety of displays and no standard process for displaying either weather or road conditions. Figure 1 is an example of an SSI-prepared product showing forecasts of road conditions. Figure 2 shows an example taken from the WSDOT rWeather site that shows the locations of available weather observations.

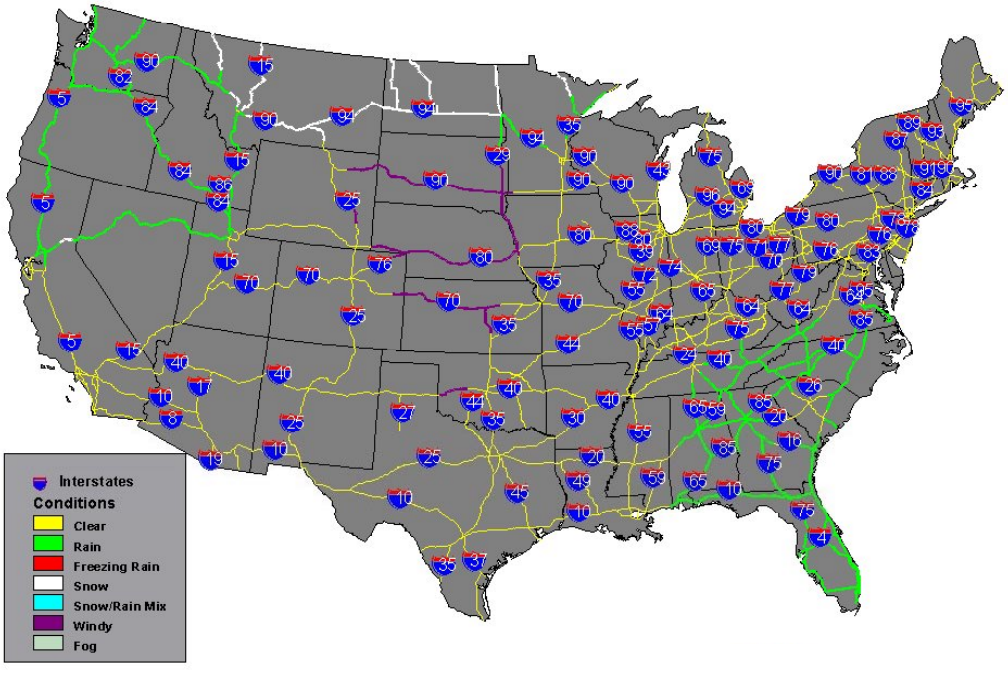


Figure 1. SSI TravelCAST® Map of Forecast Road Conditions.

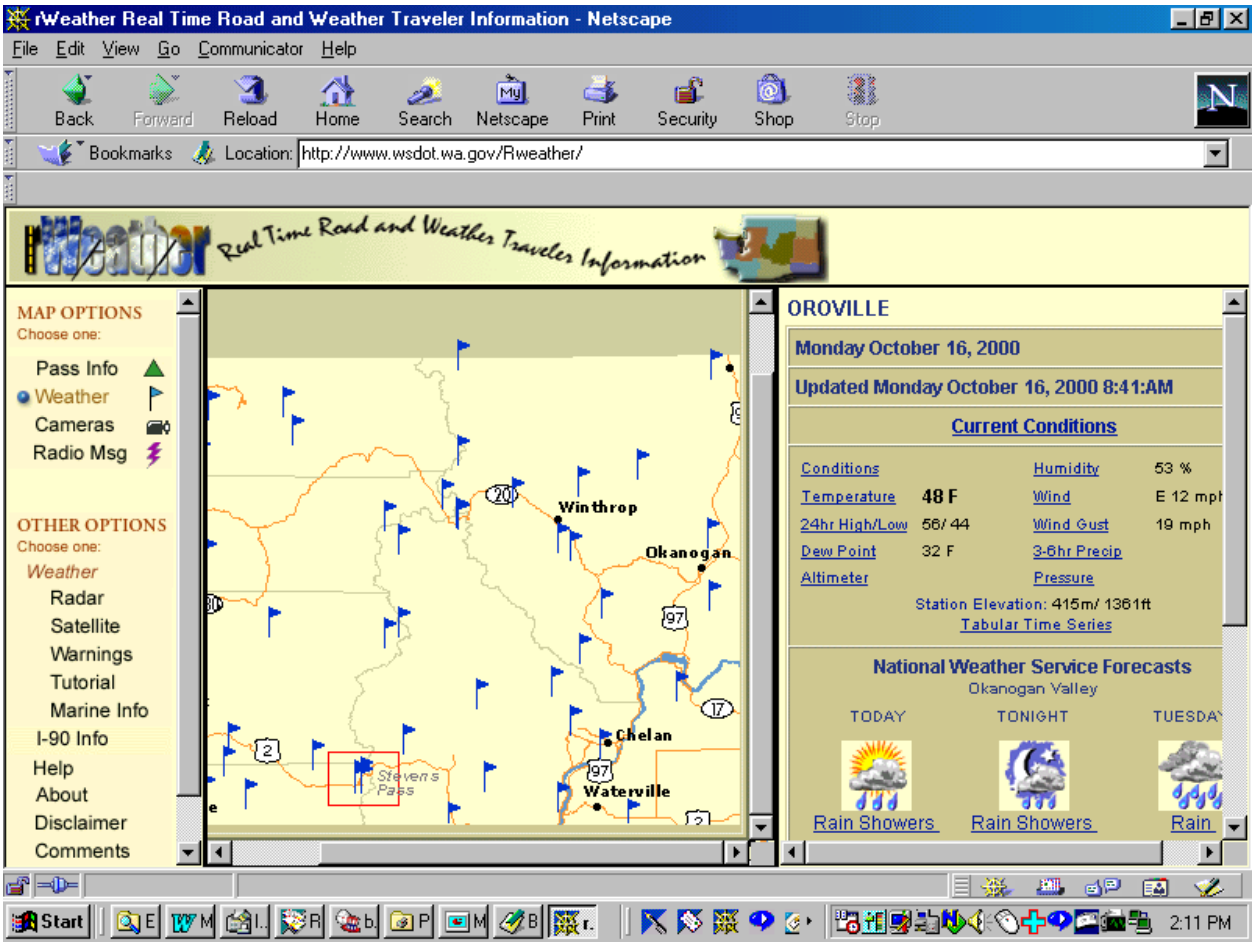


Figure 2. WSDOT rWeather Web Page with Weather Observation Locations in North Central Washington State.

Figure 3 is a travel forecast map prepared by Accu Weather and available via the Internet. Note that the forecasts are general in nature and are for weather conditions not road conditions. However, forecasts are available from the Accu Weather web site along interstate routes. One can enter an interstate highway number and get forecasts for cities along an entire interstate route.

Figure 4 is a sample of a forecast product from the WSI, Inc. Intellicast web site. One can click on either an interstate icon or on a list of highways that is provided below the map and obtain forecasts for cities along the route. As with the Accu Weather site, only weather forecasts, and not road condition forecasts, are provided.

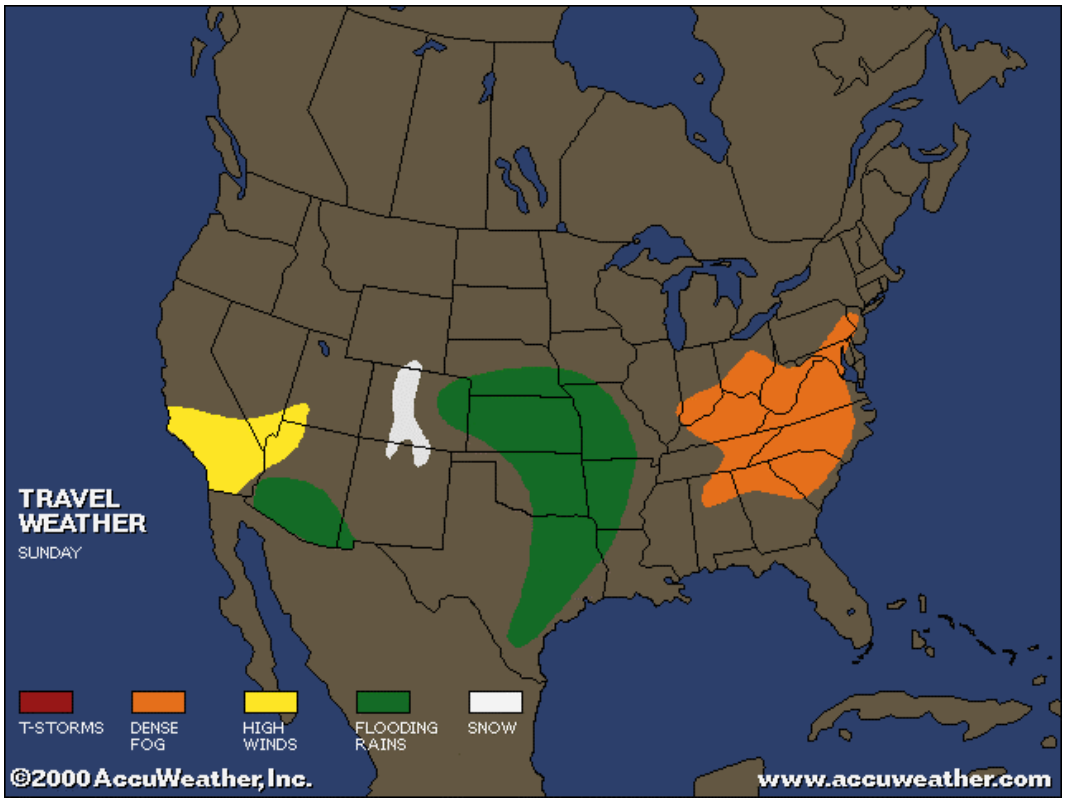


Figure 3. Accu Weather Travel Weather Map (Courtesy of Accu Weather, Inc., State College, PA).

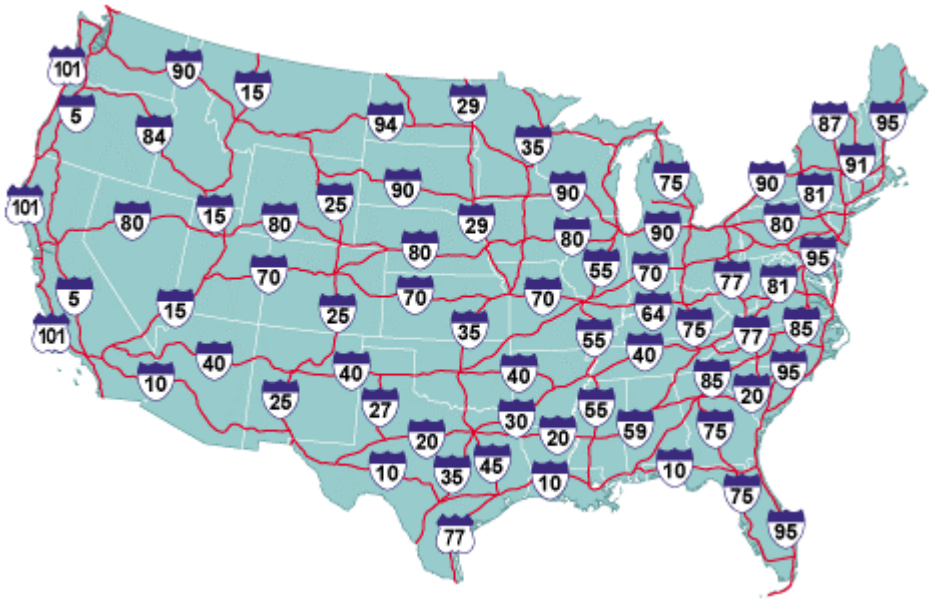


Figure 4. WSI Intellicast Interstate Map for Obtaining Weather Forecasts (Courtesy of WSI, Inc. and Litton).

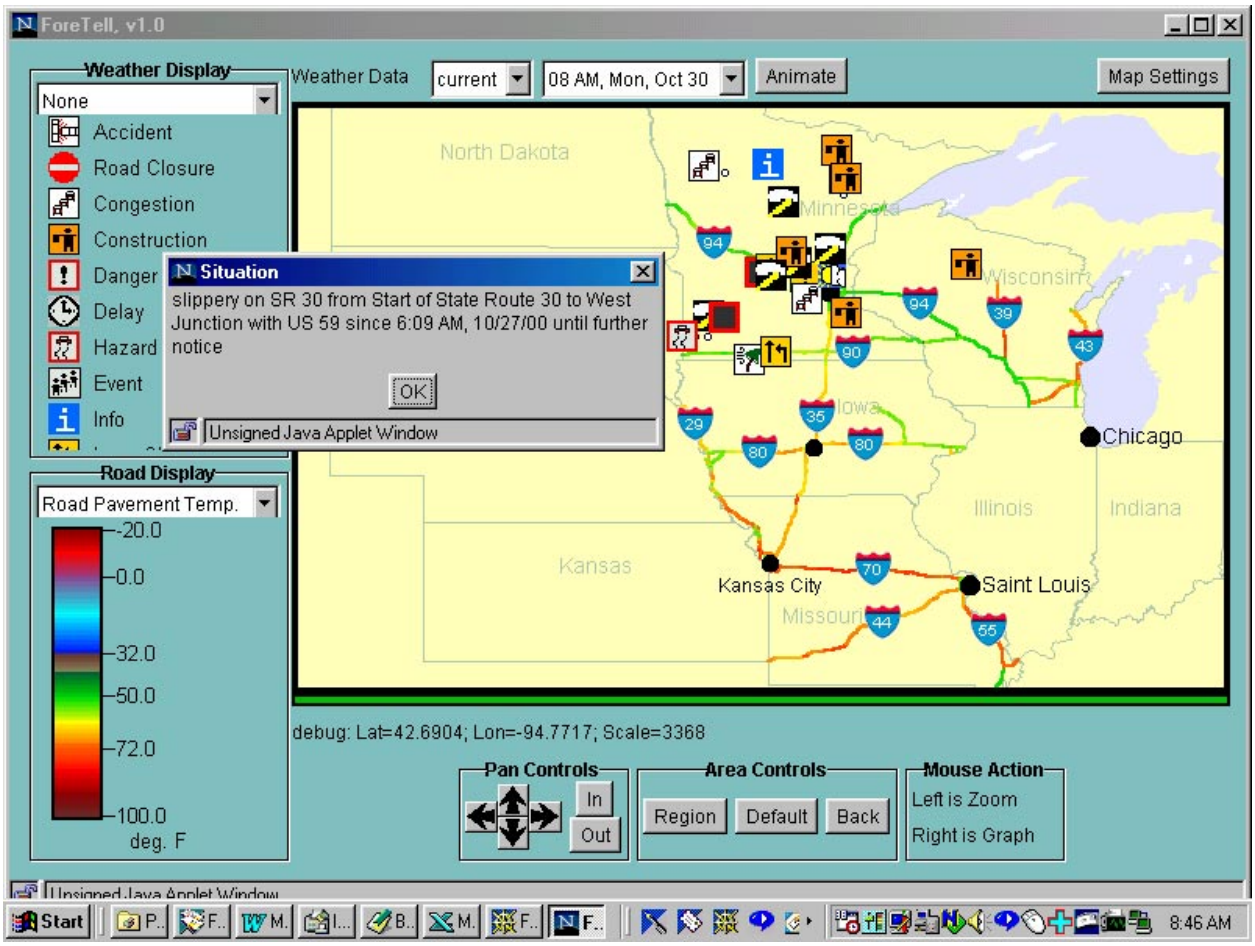


Figure 5. Example of a FORETELL™ Map Showing Pavement Temperatures (Approval for use provided by the FHWA Weather Team).

Figure 5 shows an example of a FORETELL web site display with color-coded road temperatures and icons representing various road conditions. The map displays can provide forecasts as well as observations of meteorological and road-specific parameters, such as temperature, dewpoint temperature, precipitation, etc.

VARIABLE MESSAGE SIGNS

Variable or dynamic message signs (VMS) are not commonly used in the United States to provide weather or road condition information. When the information is weather related, the signs usually only provide regulatory information. Examples include changeable speed limits and traction device requirements. Road closures for weather-related conditions are provided in Wyoming and Idaho. Nearly all signs display manually inserted information. Examples of automated input include changeable speed limits in Nevada (and similar work is ongoing in Arizona) using fuzzy logic algorithms based on sensor input, and icy road or bridge conditions in Minnesota at the entrance/exit to a tunnel and in Oregon on a bridge. The latter uses only a small fixed-message sign. Arizona has been deploying variable message signs (VMS) along its I-40 corridor for roadway- and weather-related information.

VMS are also a key component in active systems monitoring reduced-visibility situations and provide various warnings of fog or other visibility problems. A number of states have installed or are developing systems as a result of serious visibility-related crashes, which have frequently included numerous fatalities. Figure 6 shows a reconstruction of a set of signs used in the Netherlands for warning motorists of reduced visibility. The term, "MIST" is the European English term for fog.

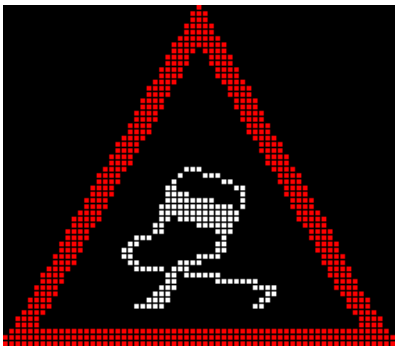
VMS are commonly used in Europe to provide road and weather condition information. The TROPIC project identified a need for standardizing icons (pictograms is the term used in Europe). Figure 7 shows currently used weather-related warning and control pictograms from Great Britain and France. The pictograms in the red triangles are warnings; the pictogram in the red circle (maximum speed limit, e.g., for reduced visibility or other reason) is a control message requiring compliance. These pictograms are for a high-resolution, 63x63 matrix VMS.

Figure 6. Representation of Matrix Signs of a Fog Warning System in the Netherlands.

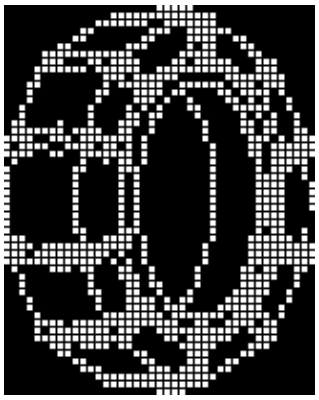
Following surveys of motorists, and based on pictogram recognition and preference ratings, additional pictograms for reduced visibility have been developed. Figure 8 shows a TROPIC-recommended set of fog icons developed in France and Great Britain.

RADIO

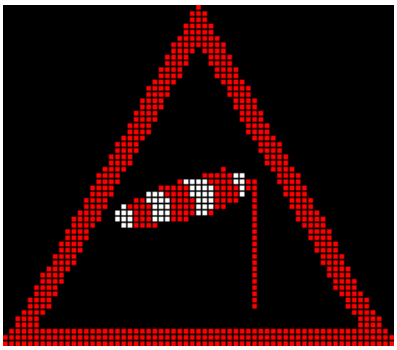
Highway Advisory Radio is also occasionally used for weather or road conditions. It is used in Washington State for providing information on mountain pass weather and road conditions, and in Connecticut (as Traveler Advisory Radio) for road conditions. Both of these states also provide the radio broadcast over the Internet. Tennessee uses HAR as part of its reduced-visibility warning system. The HAR are located after a VMS that alerts motorists to tune to the HAR.



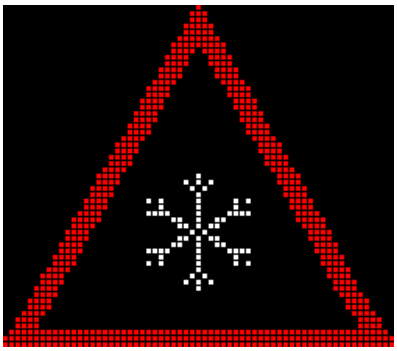
Slippery Road



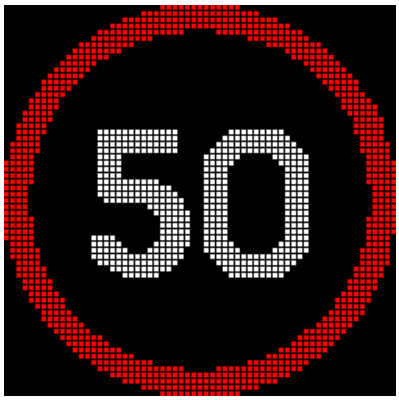
Chains Required



Cross Wind

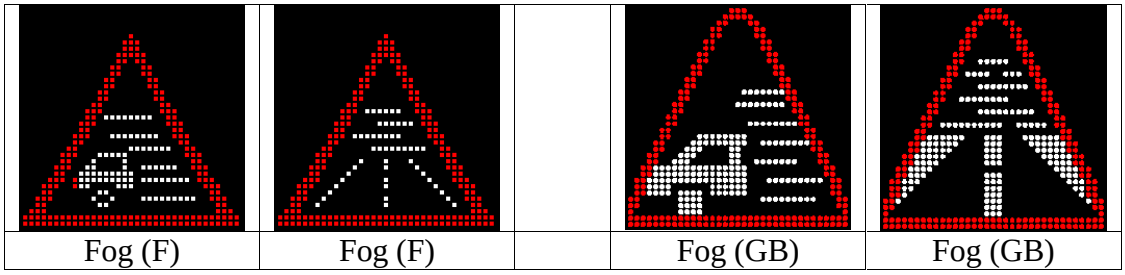


Danger of Ice



Maximum Speed Limit

Figure 7. Existing Pictograms in Europe (Courtesy of the TROPIC Project).



Fog (F)	Fog (F)		Fog (GB)	Fog (GB)

Figure 8. TROPIC-Recommended Newly Developed Pictograms for Fog from France (F) and Great Britain (GB) (Courtesy of the TROPIC Project).

IN-VEHICLE INFORMATION SYSTEMS

In-vehicle information delivery systems are evolving at a rapid pace. The concept is called "telematics." Most telematics information involves traffic and other-than-weather-related road conditions, although DTN is currently providing weather information to ON-STAR. Some providers indicate they will provide weather information. However, a conversation with the

Director of the TANN project in California indicated that the issue is not whether or not to provide weather information; the issue is where to get the data.

INFORMATION DISPLAYS

Kiosks are being used in a few states for providing weather and road condition information at ports of entry or rest areas. Arizona DOT uses kiosks to provide information from their Highway Condition Reporting System (HCRS). HCRS incorporates a link to the NWS in Arizona for providing weather information, as well as weather-related road closures.

Iowa has an extensive system of weather centers at rest areas that provide both observed and forecast weather and road condition information. The weather centers receive information from DTN. Nebraska, Wisconsin, Illinois, Tennessee, and Kentucky also provide weather information in state rest areas.

TELEPHONE

In addition to the information disseminated as described above, weather and road condition information are also disseminated by cellular telephone and facsimile. The ATWIS program provides information to travelers via cellular telephone. FORETELL includes the potential for cellular, facsimile, and electronic mail dissemination. Oregon Department of Transportation has also implemented a system called QuickFax for commercial truckers. The truckers can get up-to-the-minute information on closures and traffic delays on Oregon state highways through the free QuickFax service. The system includes weather-related closures and restrictions.

The target audience varies from agency to agency and within the various dissemination systems. Most of the Internet sites target pre-trip travelers who need to make decisions related to delays and re-routing. ATWIS provides information to road users via the cellular phone system, as well as the Internet. FORETELL's initial target audience is highway operations personnel, but the eventual targets include all road users, including the special segments, e.g., commercial vehicle operations, transit, and school bus systems. Much of the weather-related information is targeted to rural travelers while urban travelers are more interested (except in bad weather) in traffic related information.

Events Described

Except for standard National Weather Service or Federal Aviation Administration observations, the typical weather conditions for the road environment are RWIS-based. The conditions described are a relatively standard set of minimum weather information: air temperature, dew-point and/or relative humidity, and wind speed and direction. Sky conditions are rarely reported, but precipitation is more frequently described. Visibility is also reported at RWIS sites that have visibility instruments.

Road conditions reported vary greatly from agency to agency. The conditions reported appear to depend on the types of weather-related road conditions in an agency's area of responsibility. The conditions also vary based on whether or not the input is from highway maintenance personnel,

police, or other agency. Some agencies also offer RWIS information to the public. This additional information may include pavement temperature and the surface sensor-determined pavement condition.

The next section gives some insight into the variability of road condition reporting.

Information Representations

ICONS

The terms icons and pictograms seem to be used relatively interchangeably for graphical representation or pictorial representation. In any case, they are symbols that provide information pictorially. To ease the burden of discussion, the term icon will be used throughout this document, recognizing that the term represents a broad definition of pictorial representation of information.

The use of icons to represent weather and road condition information in electronic forms, such as variable or dynamic message signs, has evolved of necessity in Europe. "Because of the many languages of Europe, symbolization is a very high priority. However, this is increasingly important in the United States as well, with increasing immigration of non-English speaking people and increasing tourism from many foreign countries." [Tignor, et al]

The rWeather site from WSDOT and the University of Washington presents forecasts and observations using both icons and text. Figure 9 shows the icons used at this site for representing weather. The site will eventually provide forecasts of road conditions down to 4 km detail. The road condition forecasts will most likely be shown as color-coded road segments.

Figure 9. Washington DOT rWeather Icons on the Internet.

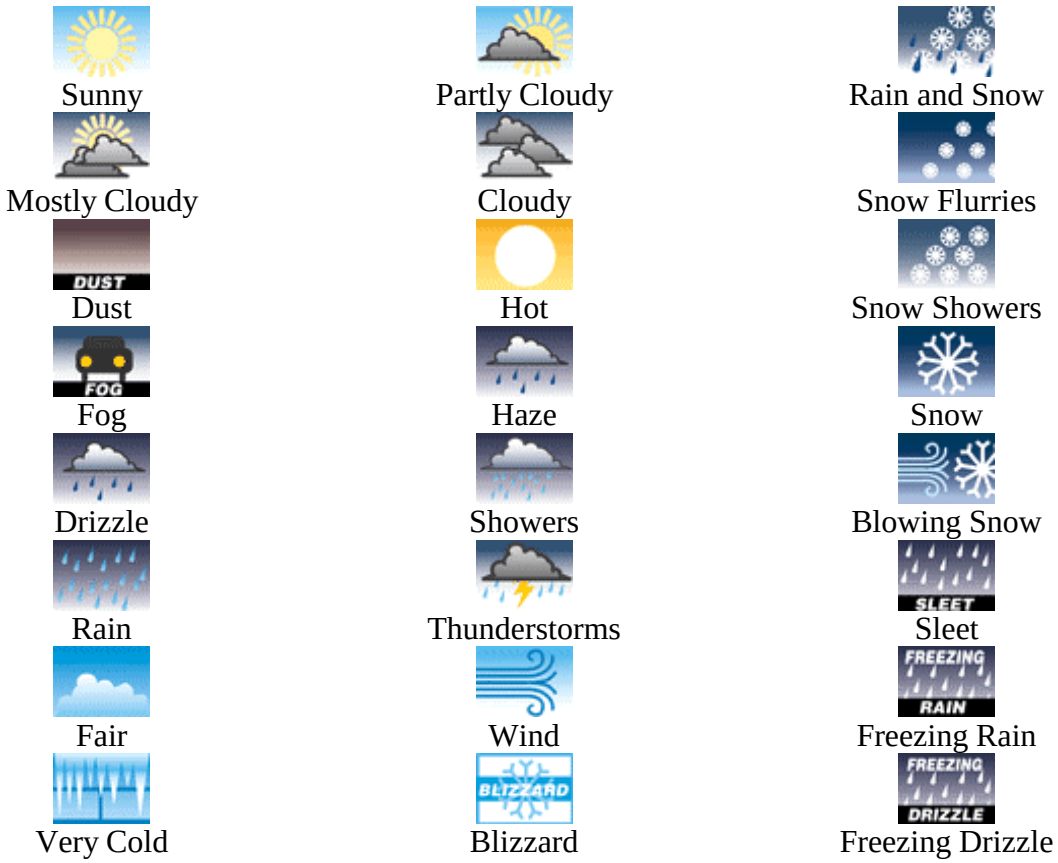


Figure 10. Yahoo Web Site Weather Icons.

Figure 10 present icons of weather currently being used on a Yahoo Weather Internet web site.

There are also icons used to describe road conditions. Figure 11 shows an example of the Arizona Department of Transportation Highway Condition Reporting System (HCRS). Figure 12 shows the icons that can be used with the Arizona available on the Internet. These icons typically represent incidents, construction zones, or closures. The HCRS set of icons does include four or five icons that represent weather or weather-related road conditions.

COLOR SCHEMES

Weather-related road conditions on web sites can be represented by color codes. Figure 13 presents some examples of those color schemes.

Those states that report road conditions tend to use a color code for road segments. These are usually for Interstate highways. There is an obvious lack of standardization in the variety of color schemes used.

Montana has added special notation for site-specific phenomena. This added notation allows for providing additional important information to motorists.

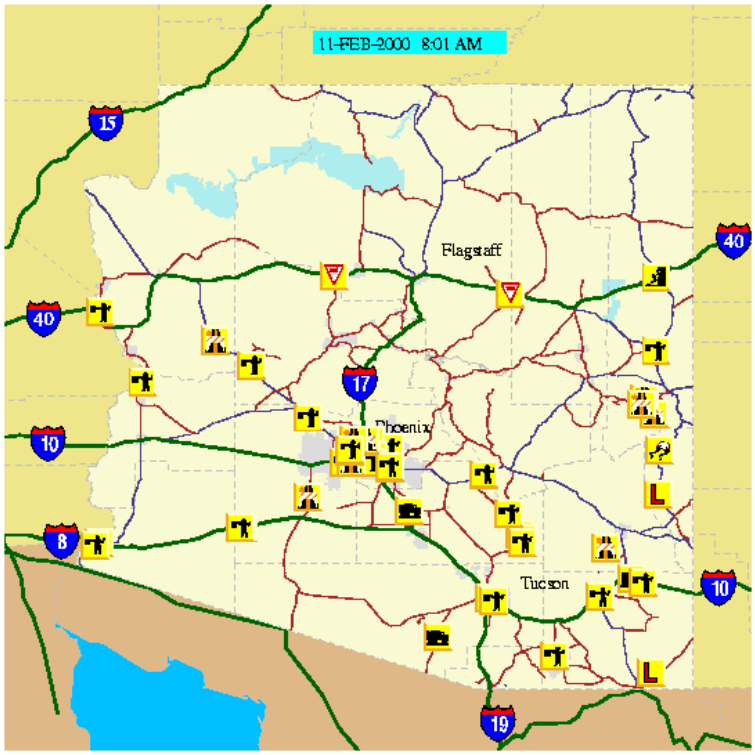


Figure 11. Arizona DOT Highway Condition Reporting System (HCRS) Map.

Figure 12. Arizona HCRS Icons.

Figures 14-18 show examples of state web sites showing road conditions. These examples point out the variations in the methods of providing weather and road condition information. Note that some of the examples show color-coded road segments while others, notably Oklahoma and Ohio (Figures 17 and 18) show color-coded counties. Information in some of the examples is difficult to read because the images have been downloaded from the Internet.

Figure 19 presents the proposed road condition reporting scheme to be used in the WSDOT weather and road condition reporting Internet site. Much of the road condition information will be computer-generated from a road surface model developed at the University of Washington and run in conjunction with high-resolution atmospheric models, providing information at approximately 4 km resolution.

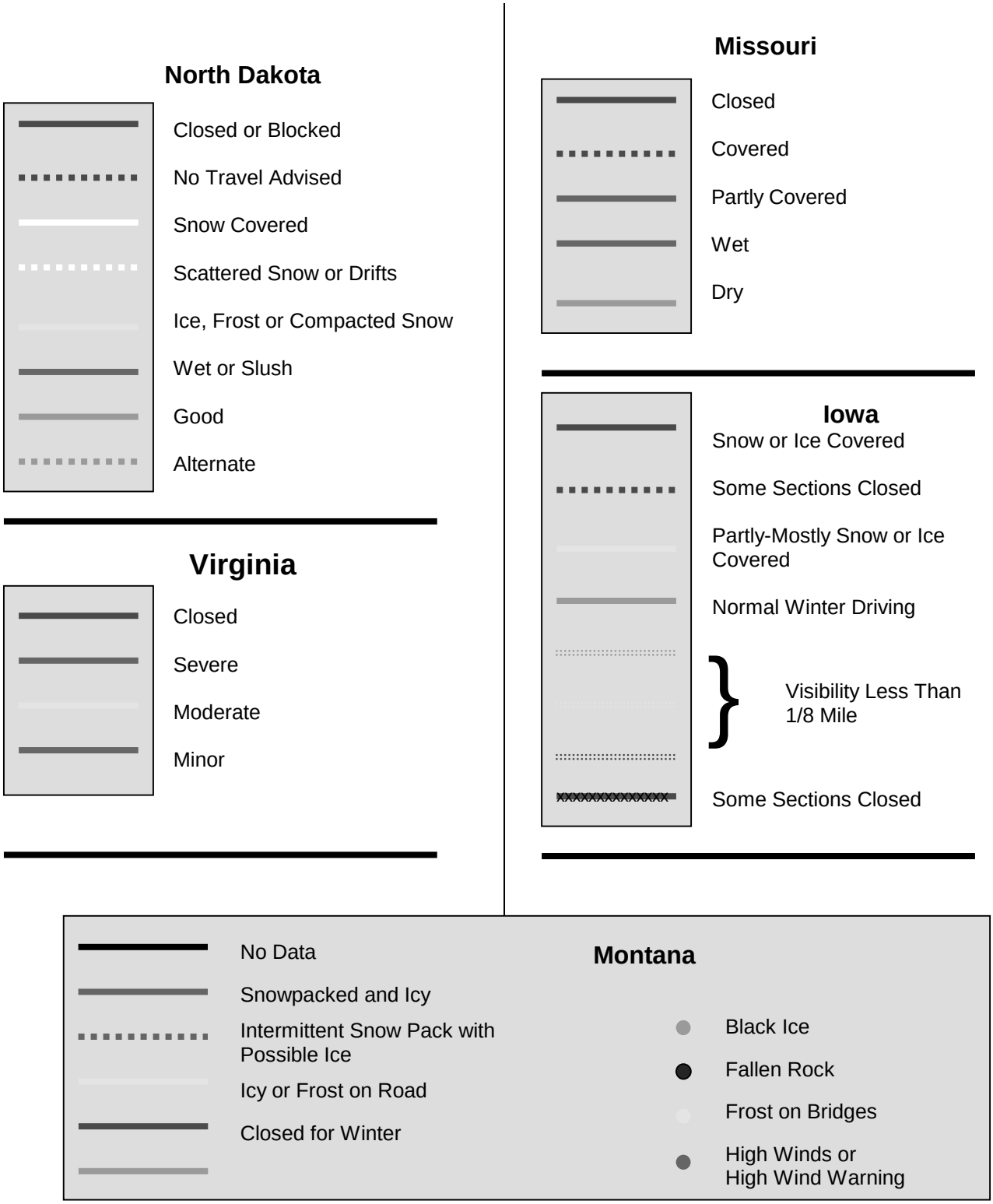


Figure 13. Road Condition Color Schemes from Highway Agency Web Sites.

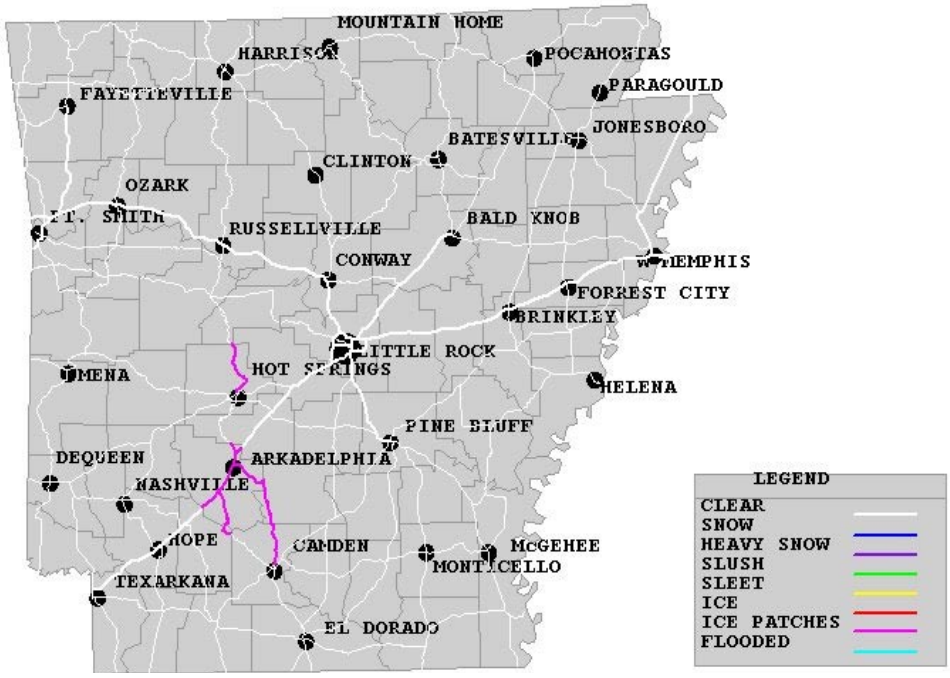


Figure 14. Arkansas Internet Road Condition Map with Legend.

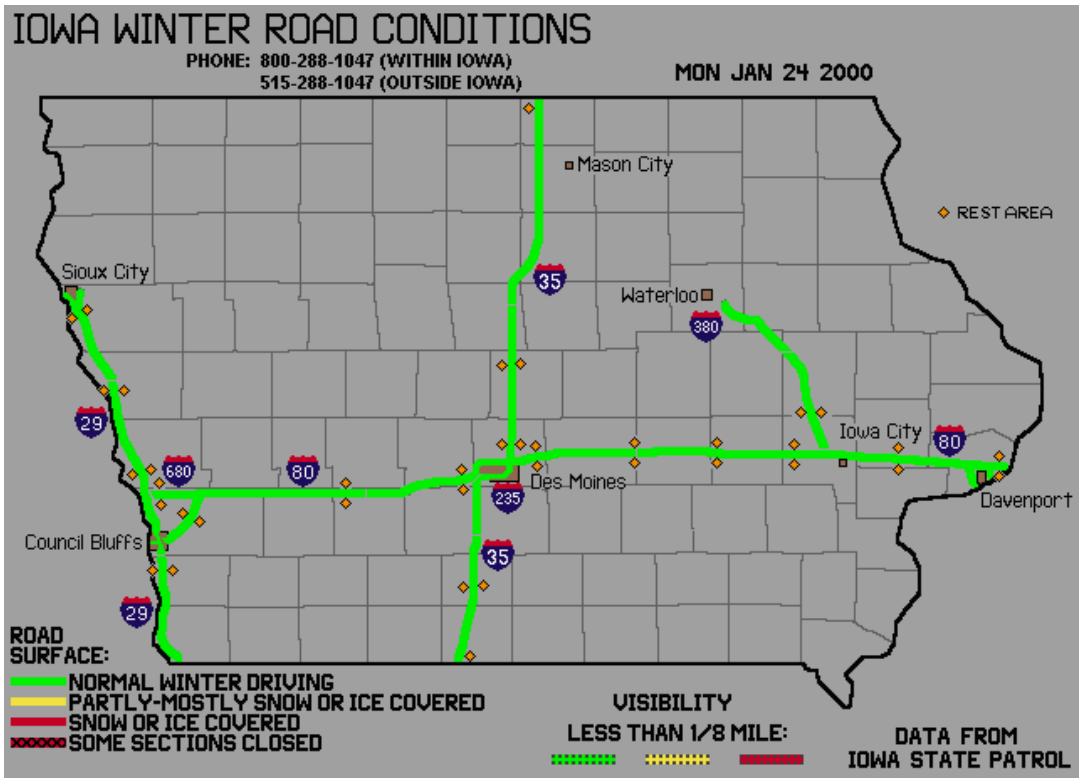


Figure 15. Iowa Internet Winter Road Conditions Map.

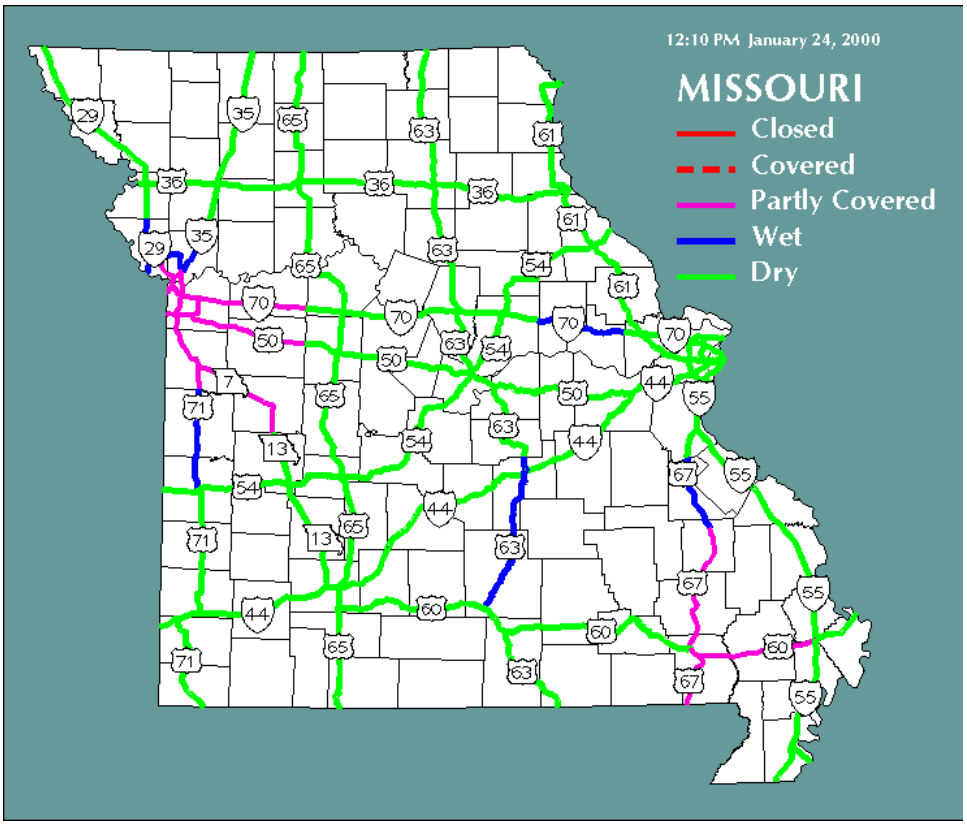


Figure 16. Missouri Internet Road Condition Map.

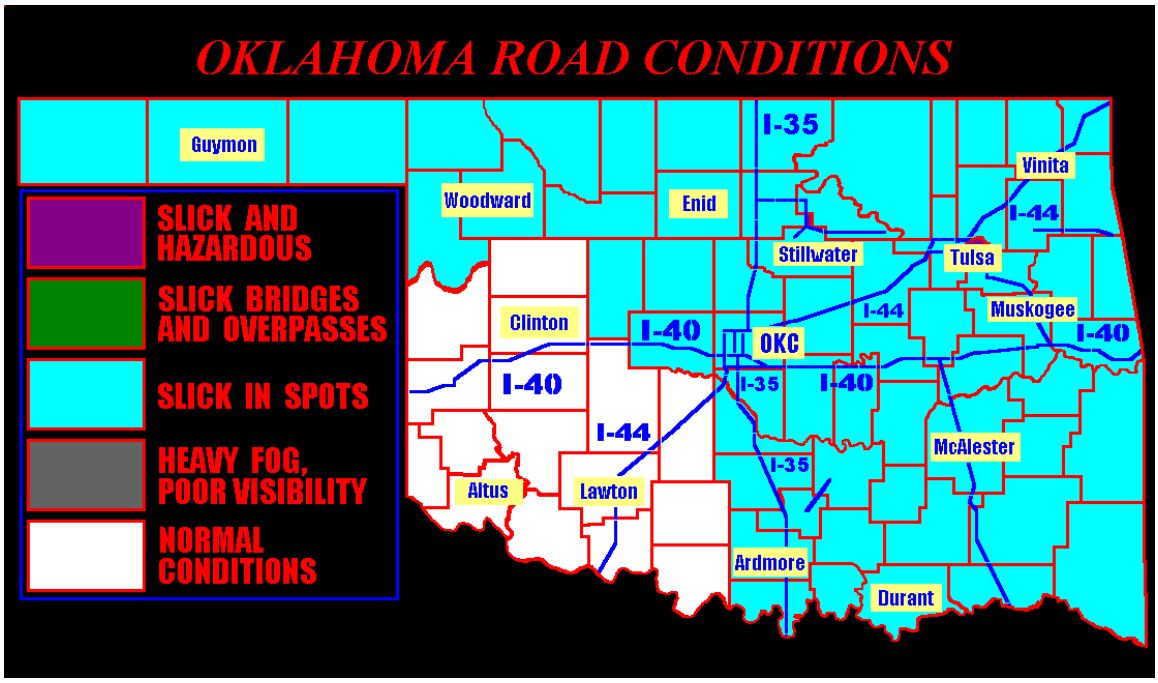
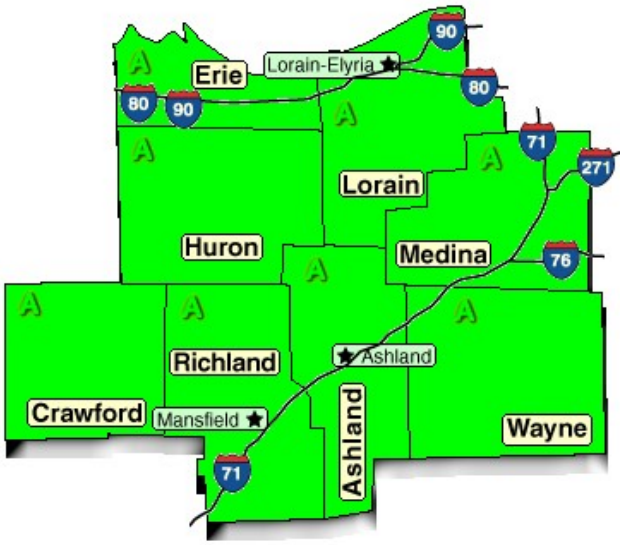


Figure 17. Oklahoma Internet Road Condition Map.



A	DRY CONDITIONS– Normal winter driving conditions.
B	WET CONDITIONS– Roads wet. May be slippery in spots.
C	SNOW/ICE CONDITIONS– Partly snow covered to snow covered. Icing conditions may be present on bridges, ramps, and spot locations. Some
D	SEVERE SNOW/ICE/ DRIFTING CONDITIONS– Some roads may be impassable. Extremely hazardous conditions. ODOT vehicles working as weather conditions allow.
	NO DATA– No information under 24 hours old available.

Figure 18. Ohio Department of Transportation District Map with Color-coded Weather by Counties.

Figure 19. Proposed Washington State DOT Road Condition Presentation.

RWIS Data

As is shown in Appendix A, a few states provide RWIS information publicly through web sites. Data are typically presented in text format after either accessing a map and clicking on a site or going to a web-based tabular listing of sites.

Figure 20 shows an Ohio DOT map with RWIS sites indicated by the blue balls.

Data provided can include both atmospheric and pavement data. There is some concern among agencies for providing pavement data, especially pavement status and pavement temperature because of liability issues. In addition, there is concern that viewers of these data may second-guess the maintenance personnel while not fully understanding the meaning of the RWIS data.

Figure 20. Central Ohio Map with RWIS Sites.

Figure 21 provides a map from Montana showing the statewide RWIS network. The RWIS sites are indicated by the green triangles. There are also icons representing web-accessible TV cameras along the Montana highways.

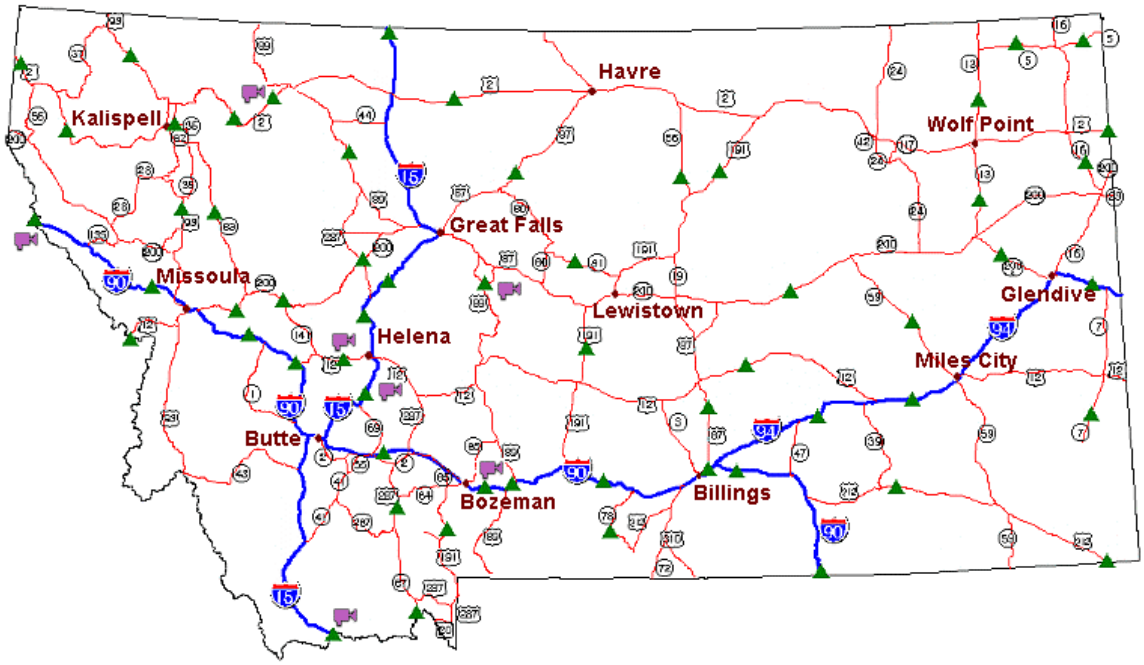


Figure 21. Montana RWIS Locations.

Most DTN products delivered are in graphical form. Occasionally products are text-based. Examples:

- The Kentucky DOT provides road condition reports to DTN which creates overlays of road conditions.
- In Tennessee the I-75 project has kiosks that provide some weather data and some text information.

The DTN devices use graphics with some text data on graphics. Once a state pays for the initial communications to get data into the DTN pipeline, DTN can facilitate the exchange of the data. This is done only with the permission of the originating state. The Nebraska DOR allows other agencies to have access to their DTN products. This includes some in agencies in Nebraska. Wyoming DOT maintenance personnel get Nebraska data, too, while some Nebraska data are available in Western Iowa. Tennessee and Kentucky also display each other's data.

Message Standards

Standards for data formats are becoming increasingly important as technology expands and with it, the ability to provide information via weather and road condition information to both fixed and mobile users. However, finding standards in use has proven to be very difficult.

In the European transportation community, the International Standards Organization (ISO) has worked on developing standards through the ISO/TC204 Transport Information and Control

Systems Working Group 10, Traveller [sic] Information Systems. The Society of Automotive Engineers (SAE) maintains the International Secretariat of the ISO/TC204 Transport Information and Control. Contact through the SAE and ISO/TC204 web site proved fruitless. E-mail addresses for six Working Group 10 members were listed. Attempts to contact members resulted in finding that two e-mail names were unknown and one location refused to accept e-mail. Information was obtained from two of the remaining members.

Also in Europe, a set of data messages for environmental information has been developed under the auspices of the International Traveler Information Interchange Standard (ITIIS) program. The Message Exchange for Travel Situations (METS), through efforts of the Foretell project working with National Standards Development Organizations (SDO), has evolved to the Event Report Message (ERM) and is currently moving through the SDO approval process.

SAE also provides the host web site for the Intelligent Transportation Society of America (ITSA) Advanced Traveler Information System (ATIS) committee. Through ITSA, it was learned that there are two important standards for ATIS: SAE J2353, ATIS Data Dictionary, and SAE J2354, ATIS Core Message List and Data Dictionary. Attempts to find these standards through the SAE web site proved fruitless. Finally, through e-mail contact it was learned that the standards are not yet published. However, SAE did provide preprint copies for review.

ITSA has also worked to develop standards for interfacing equipment in the highway environment. The National Transportation Communications for ITS Protocol (NTCIP) effort has established standards for environmental sensor stations (ESS) in the highway environment. The NTCIP ESS protocol, developed under the direction of the SDOs (the American Association of State Highway and Transportation Officials (AASHTO) with assistance from the Institute of Transportation Engineers (ITE) and National Electrical Manufacturers Association (NEMA)), is not yet published. However, it is available from the NTCIP web site for downloading.

AASHTO, ITE, and NEMA have also released a standard for the control of roadside dynamic message signs (DMS). NTCIP-DMS has been published and provides standards for data between traffic centers and DMS.

Another standard including weather and road condition information is the Traffic Management Data Dictionary (TMDD) and associated Message Sets for External Traffic Management Center Communications (MS/ETMCC) published within the Advanced Traffic Management System (ATMS) group of ITS. The Institute of Transportation Engineers (ITE), working cooperatively with the Federal Highway Administration (FHWA) and the American Association of State Highway and Transportation Officials (AASHTO), is leading a national effort to develop a standardized TMDD. A companion effort in this cooperative program is developing Message Sets for External Traffic Management Center Communications (MS/ETMCC) which occur between (TMC's) and other external Intelligent Transportation Systems (ITS) centers. These message sets are based on the data elements as defined in the TMDD.

There is an obvious interest in developing and implementing standards through ITS, in particular the ATIS and ATMS communities. However, within the framework of the SHAs and their promulgation of web sites and other services for the dissemination of weather information, there

appears to be no concerted effort to develop standard data formats. In the vernacular, each agency does its own thing based on its own technology and the tools within the agency.

In 1997 a group of Midwest states developed an initial set of recommended color coding and road condition reporting categories for web-based maps. Ideally the map displays of neighboring or adjacent states would provide similar displays of the same information.

However, in general there are no standard weather information presentations, no standard method of providing information, no standard color coding methodology for weather or road conditions, and no standard sets of icons or pictograms for presenting information. As the ability to gather and present data and information to the traveling public increases, the importance of establishing standards is being recognized in many agencies.

Evaluation Documentation

Iowa DOT surveyed people who had visited rest areas and used the Iowa Weather Center information. Over 90% of the users indicated that the Weather Center is a valuable service, that it is a useful expenditure of public funds, and that the Weather Center capability should be added to other locations where it currently doesn't exist. Of all the possible other information that might be provided, the highest percentage of travelers indicated winter road conditions reports were most desired. [IADOT, 1996]

Minnesota DOT surveyed its customers who identified weather and road condition information as the most important information for travelers. [Mn/DOT, 1994]

USDOT reported at a recent ATIS symposium that "Nearly all drivers want appropriate, relevant weather conditions included with their traffic information … Weather is another form of incident, and drivers want to know about it when it's there, but do not value the information if there is nothing of significance to report." [Lappin, 2000]

USDOT also reported at the same ATIS symposium that the two largest groups of ATIS customers they surveyed rely heavily on the Internet for ATIS information. Although this was mostly for travel time, as indicated above, weather becomes another incident affecting travel time.

An InfoMove company news release in January, 2000 provided results of a market survey. Those results showed that 94 percent of survey respondents want to receive real-time, location specific traffic information in their vehicle. Of those, 72 percent indicated a desire to receive live traffic alerts while driving. Although weather and weather-related road and traffic conditions are not specifically mentioned, as pointed out above, they become important traffic information.

It is apparent that weather and road conditions are important to travelers. It should also be apparent that providing information to travelers in a consistent format from any means of dissemination is important.

SYNTHESIS ANALYSIS

From the information presented in the previous section, it is clear that there are many ways of presenting weather or road condition information. In addition, with the many mediums for presenting information, it is possible that different information could be provided to users. The lack of standardization has been lamented in national forums (see, e.g., Sweeney and Ravier). There was no literature that identified research that would identify a suggested set of standards.

One problem for the motorist is that there is no consistency in information provided when crossing state lines. Each state has its own method for providing the information. This is true for Internet sites, traveler rest areas, kiosks, or message signs. A number of agencies have recognized the need to standardize. A number of states in the Midwest met to try to define a common appearance for road conditions reports. DTN has also attended regional and multi-state meetings to address standardization of presentations of weather and road conditions.

Weather Conditions

As can be seen with the Yahoo weather icons shown in Figure 3, there are many possible weather conditions that could be reported. There are many more weather observation types that are presented in National Weather Service standard observations. The average motorist probably needs only to be apprised of general conditions, e.g., clear, cloudy, windy, reduced visibility, type of precipitation (liquid, freezing, or frozen), and severe weather. It is suggested that additional qualifiers on the conditions, such as light, moderate or heavy precipitation, may only serve to confuse motorists.

Road Conditions

In a similar manner as weather conditions, there are hundreds of possible road conditions that could be presented to motorists. One proposed set of road conditions to be used in the ITS ATIS standardization efforts and derived from European ITS work contains 13 pages of condition definitions. Approximately two of those pages, or close to 100 of the conditions relate to weather, some of which would be included in the weather conditions, some of which are weather-related road conditions. It is again suggested that a subset of these road conditions are all that are necessary for informing, alerting, or warning motorists.

Figure 13 shows various representations of a small set of road conditions. There is also some obvious need for identification of local phenomena, with items such as visibility restrictions not being indicated in the spot reports, or with areal coverage for visibility restrictions. A combination of icons and reports similar to Montana's example could fill the gap.

Currently, at least in the United States, road condition reports are not standardized. DTN indicated that the road conditions reported to them for display by DTN for use in satellite-delivered products in traveler information systems are not currently in a standardized format. Therefore, products are agency dependent.

FHWA research from the Center for Applied Research identified over 800 possible messages for 30 situations. Following field tests, the FHWA developed a set of recommended messages for the 30 situations, 8 of which are weather related. These messages and their variants are listed in Table 1 [FHWA, 1996]. Separate research for the FHWA suggested that examples of conditions that should be displayed are Ice, Flooded, Snow, or Fog [Dudek, 1992].

Table 1. Weather Related Recommended Standard Messages for (Portable) Changeable Message Signs.

SITUATION	VARIANT 1	VARIANT 2
FOG	CAUTION FOG	CAUTION FOG AHEAD
ICY ROAD	CAUTION ROAD	ICY AHEAD
SNOW	BLOWING SNOW	
CHAINS REQUIRED		CHAINS REQUIRED AHEAD
SLIPPERY ROAD		CAUTION SLIPPERY ROAD
ROAD FLOODED		CAUTION ROAD FLOODED
DUST STORM		
HIGH WINDS		CAUTION HIGH WINDS

It is evident that motorists could easily be overwhelmed with information. The purpose of such information should be to cause a driver to change behavior. Confusion or misunderstanding due to information overload may not allow for that behavior change.

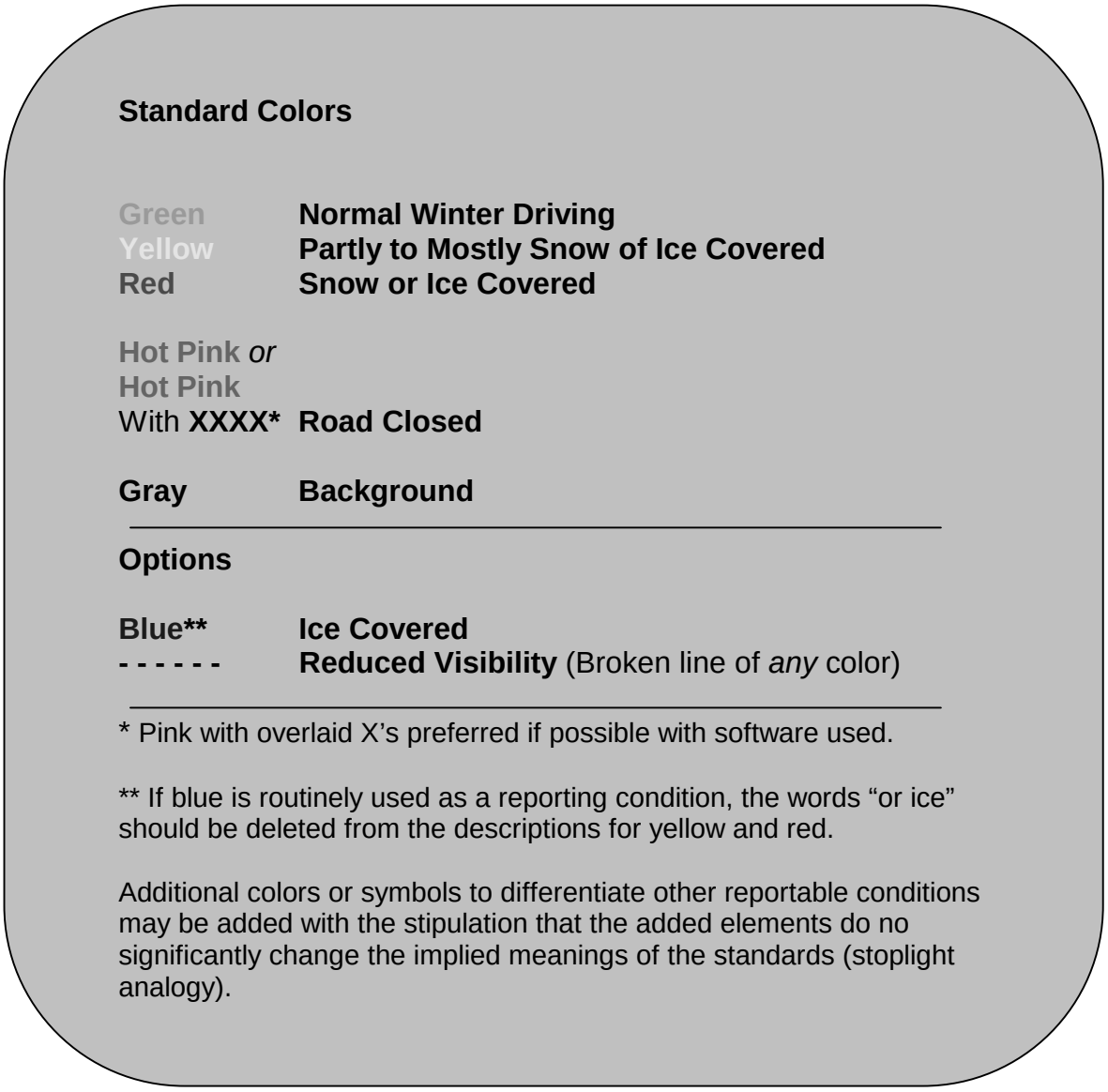


Figure 22. Iowa DOT Proposed Set of Road Condition Reporting Standards

Color Coding

As is shown in Figures 13-18, there are numerous color-coding schemes for graphical displays of weather and road conditions information. One pattern does emerge, and that is the traffic signal format: a green color tends to represent bare (or bare and wet) pavement and red tends to signify a road closure. The rest of the weather-related road conditions have various different representations and definitions.

The Midwest multi-state meetings in 1997 resulted in the Iowa Department of Transportation developing a proposed set of road condition statements and a map color scheme. The proposed set of standard colors and road conditions are recreated in figure 22. There has been no effort to implement these. [IADOT, 1997]

The Iowa-proposed set of reporting standards tends to follow the traffic signal theme as pointed out in their graphic (recreated for this report). However the recommendation departs from that theme since red typically indicates road closed. In addition, the reports appear to be a limited set of what could be reported and could lead to uncertainty. Also, the road condition shown in green, "Normal Winter Driving," could have many different meanings depending on one's location and the snow and ice control level of service.

The "hot pink" color is one that gets obvious attention and would be useful in identifying trouble spots, such as icy stretches. The gray background suggested is also useful because it allows the various colors to be readily seen.

The assortment of colors used by various states as shown in Figure 13 present additional options for reporting. Combinations of those presentations may be the best solution. For instance, the white color shown for snow cover in North Dakota is intuitive and one that most people could probably understand. Blue for wet (water) may also be intuitive.

According to DTN, who has attended some multi-state meetings, the states can't agree on colors for road conditions. As a result, DTN has decided to go with presentations based on individual state desires. Hence even the DTN products are not standardized.

Icons

The primary examples of the use of icons are found on the Washington DOT rWeather, FORETELL, and the Arizona DOT HCRS web sites. These are shown in figures 2, 5, and 12, respectively. The HCRS site provides icons for general conditions, e.g., road condition, weather, high wind, and temperature.

Figures 9 and 10 provide examples of weather icons used on web sites. The number of icons probably exceeds the limits of practicality for anything other than web sites. Road users, whether obtaining information from a kiosk at a rest area or truck stop, may need only a subset of these representations. It may be important to a motorist to distinguish between rain and snow, but more detail than that may be superfluous.

Other than variable speed limit postings, no use of icons was identified in this country for weather-related road conditions on VMS. Table 1 presents a recommended set of VMS messages for weather-related road conditions. This set of recommendations may represent a sufficient number of messages for icon development for use on other-that web sites or traveler displays.

The TROPIC project recommended a suite of icons for weather related road conditions messages on VMS. These icons are based on standard approved icons for fixed message signs used in

Europe (See Figures 7 and 8) [Hubert, 1998]. These icons may also represent a point of departure for icon development in the United States.

CONCLUSIONS

In order to help users to understand road and weather condition information more quickly and easily, the information presented and its format require some form of standardization. The development of specifications for common messages and formats will help ensure that the format for presenting information will be consistent, as far as possible, across the variety of presentation devices and jurisdictional boundaries.

No standard method of presenting weather and road condition information via the Internet exists. This includes a lack or standard color coding of road segments and a lack of a standard set of icons. This is important not only for the desktop acquisition of information, but for in-vehicle displays and "palm top" devices that are becoming increasingly used.

No standards exist for the display of weather or road condition information via VMS or DMS. The use of these dissemination devices will increase over the next few years and it is important that the display of traveler information be considered.

The ATIS standards for weather and road condition information lack sufficient detail for the dissemination of weather information. For example, there is no data element for precipitation, much less the type of precipitation.

RECOMMENDATIONS

Following is a set of recommendations developed after reviewing the material and information acquired and described above.

1. Highway agencies should develop and implement a standard map format for weather and weather-related road condition information dissemination. A gray map background is recommended so that color-coded road segments are readily discernible. In addition to the color-coded maps, the same information base used to generate the road conditions should be available as text for use by individuals who are visually color impaired. It is also suggested that except for the very small states, the information should be provided on district-level or county maps in order to provide more detail. Primary highways, as well as interstate highways, should also be included.

2. Highway agencies should adopt a standard set of road condition descriptors and implement those with a standard color coding. Figure 23 provides a suggested standard set of colors for road conditions along with a suggested set of spot or areal road condition indicators.

3. Highway agencies should adopt a standard minimum set of icons for use in depicting weather and weather-related road conditions on web sites or traveler information displays. Figure 24

provides a suggested minimum set of weather and road condition icons that could also be used with color-coded road maps. The icons can be used as spot weather indicators on a map or as representations of forecasts of conditions.

4. Highway agencies should consider the development of a minimum set of icons for depicting weather or road conditions on VMS or DMS. These icons should be developed in cooperation with an expansion of the MUTCD and should be consistent with the icons used on web sites or traveler information displays.

5. Aurora members should work closely with the ATIS SDOs to upgrade the weather and road condition data sets for ATIS so that they, at a minimum, are compatible with the weather and road condition information dissemination recommendations listed above.

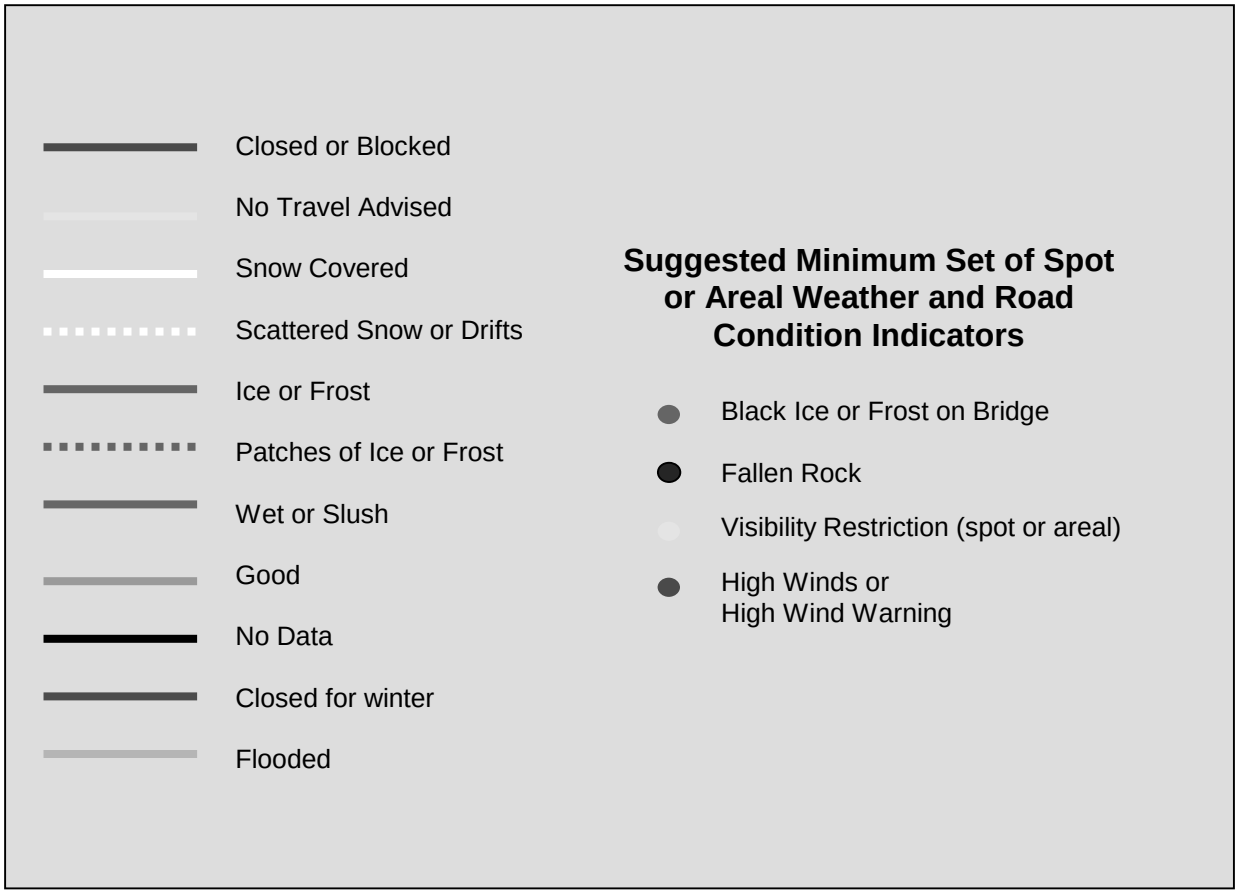


Figure 23. Suggested Color-coding Scheme for Weather and Road Condition Map Displays on Highway Agency Web Sites.

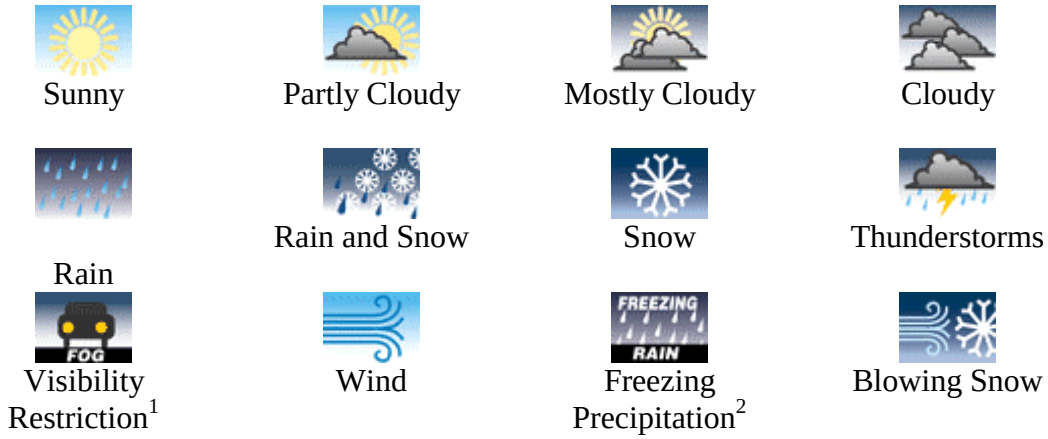


Figure 24. Suggested Minimum Set of Weather and Road Condition Icons.

6. All weather and road condition information provided to the traveling public should be consistent no matter the platform or the medium. The standard set of weather and road conditions, the color schemes, and the icons used should be the same for VMS, IVIS, web sites, personal data devices, and traveler information displays.

[1] The specific visibility restriction, e.g., fog, haze, dust, or smoke should be identified.
[2] The specific type of freezing precipitation, e.g., sleet, freezing rain, or freezing drizzle should be identified

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APPENDIX A. Summary of State Agency Weather and Road Condition Reporting via Web Sites

State	Wx Obs	Wx Fcst	Maps	Icons	Rd Cond.	Cond. Fcst	WX Links	State Links
Alabama					?		Y	
Alaska					Y-T			
Arizona	Y	Y	Y	Y	Y		Y	
Arkansas			Y-CC		Y			
California		NWS			Y-T			
Colorado					Y-T		Y	
Connecticut					N		Y	
Delaware					?+TARS?			
DC					N		Wash, POST	
Florida					N			
Georgia					Y-T			
Hawaii					N			
Idaho					Y-T			
Illinois					Y-T			
Indiana					Y-T		Y	Y
Iowa	Y (AWOS/RWIS)		Y-CC	Y	Y		Y	
Kansas					Y		Y	
Kentucky			Y-CC	?	Y		Y	
Louisiana			Y?					
Maine					Y-T			
Maryland	RWIS				Y--T			
Massachusetts					N			
Michigan					AAA site		Y	
Minnesota					Y-T		Y	Y
Mississippi			Y?				Y	

Legend Y = Yes N = No NWS = National Weather Service
CC = Color coded T = Text Reports Only ? = Unknown (due to no significant weather)
TARS = Traveler Advisory Radio Service* HAR = Highway Advisory Radio*
ASOS = Automated Surface Observing System AWOS = Automated Weather Observing System

* Audio is available on the Internet

Summary of State Agency Weather and Road Condition Reporting (continued)

State	Wx Obs	Wx Fcst	Maps	Icons	Rd Cond.	Cond. Fcst	WX Links	State Links
Missouri			Y-CC		Y			
Montana	SCAN Web-CC	Y	Y-CC		Y		Y	Y
Nebraska			Y-CC				Y	
Nevada	RWIS				Y-T			
New Hampshire					N			
New Jersey					N		Y	Trnpike/Pkway
New Mexico					N		Y	
New York					Capital Area		NY Turnpike	Turnpike
North Carolina					Y-T		Y	Y
North Dakota	SCAN Web-CC	Y (ATWIS)	Y-CC		Y		Y	Y
Ohio	RWIS		Y-CC				Y	
Oklahoma			Y-CC					
Oregon					Y-T			
Pennsylvania			Y-CC					
Rhode Island		Y			?			
South Carolina					?			
South Dakota		Y (ATWIS)	Y		Y-T		Y	Y
Tennessee			Y-CC				Y	
Texas			Y	Y	Y-T		Y	
Utah					Y-T			
Vermont					N			
Virginia			Y-CC		Y			
Washington	AWOS/ASOS	Y	Y	Y	Y+HAR		Y	Y
West Virginia					Y-T			
Wisconsin					Y-T			
Wyoming					Y-T			

APPENDIX B. Project Agency Contact Information

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Colorado DOT	Roderick Mead
Connecticut DOT	Jim Mona
DTN	Don Wilmes
FHWA	Paul Pisano
FORETELL	Peter Davies
Illinois DOT	Harold Dameron
IN (Indianapolis)	Gary Vandegriff
Iowa DOT	Dennis Burkheimer
Kansas DOT	Jaci Vogel
Kentucky DOH	Glenn Anderson
Maine DOT	Steve Hunnewell
Maryland SHA	David Rossbach
Minnesota DOT	Lorraine Kramer
Minnesota DOT	Jan Ekern
Missouri DOT	Bill Stone
Montana DOT	Mike Bousliman
Nevada DOT	Rick Nelson
New York State DOT	Joe Doherty
NYS Thruway Authority	Art O'Donnell
Oregon DOT	David Davis
SD (Sioux Falls)	Kevin Smith
South Dakota DOT	Dave Huft
SSI	Bob Hart
Washington State DOT	Don Hewitt
Wisconsin DOT	Mike Adams
Finland	Yrjö Pilli-Sihvola
Japan	Yasuhiko Kajiya
New Brunswick	Dave Macfarlane
Sweden	Lennart Axelson
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