SHARING OF OBSERVATIONS COLLECTED WITH ROAD WEATHER INFORMATION SYSTEM ENVIRONMENTAL SENSOR STATIONS

Current Nationwide Status and Practices of Successfully Sharing States

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1. Executive Summary

Observational data are among the key sources of information utilized by scientists at the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) to provide weather, water and climate forecasts and warnings for the U.S., its territories, coastal waters and oceans. NOAA's operational systems for collection and processing of observational data are extensive and comprehensive, but do not yet provide coverage at a high enough spatial and temporal resolution to assess all aspects of surface weather conditions in the meso and micro scales.

NOAA does take advantage of non-NOAA sources of observational data by partnering and leveraging opportunities for data sharing. Observations collected by Road Weather Information Systems (RWIS) Environmental Sensor Stations (ESSs) installed by state Departments of Transportation (DOTs) are now shared with NOAA on a very limited basis.

The focus of the work for this results project was to enhance the sharing of RWIS observations between the states and NOAA, by conducting an assessment of present sharing of RWIS observations, documenting best practices, and formulating recommendations for future enhancements to policies and practices and existing activities in this area.

We were able to leverage an Intelligent Transportation Systems (ITS) survey already in planning by the Federal Highway Administration (FHWA), and added questions to obtain an assessment of the present sharing of the RWIS observations.

Results from the survey of the state DOTs indicate the potential for great benefits to the NWS, the sharing states, and the nation if sharing of RWIS observations can be systematically and completely shared with NOAA. Several states already routinely share observations which are collected centrally at the Meteorological Data Information System (MADIS) run by NOAA's Forecast System Laboratory (FSL). There is a potential for many more states to share their observations with NOAA.

Several recommendations for NOAA and FHWA result from an analysis of the survey results and follow up interviews with points of contact at the state DOTs. Some of these recommendations would enhance present practices and policy and could be implemented at relatively low cost in the short term, such as: working with state DOTs to establish a standard data reporting format; working with the FHWA to establish siting standards for RWIS ESS equipment; establishing an archive for RWIS observations, and continuing to leverage FHWA surveys.

Recommendations which could be implemented in the longer term include: fully transitioning MADIS to operations; following a flexible design for the communication systems to enable broader state participation in sharing; NWS and FHWA partnerships to fund hardware needed to facilitate local collection and processing of state RWIS ESS observations via Law Enforcement Telecommunications System (LETS).

2. Introduction

2.1. Background

Observational data obtained from surface-based atmospheric sensors are one of the primary sources of weather information utilized by meteorologists for monitoring of atmospheric conditions in the near surface boundary layer. The NWS has deployed standard *in situ* observational sensors such as the Automated Surface Observing System (ASOS) at more than 1200 sites nationwide from which automated observations are reported at high temporal frequency, and processed and collected centrally.

These observations are critical to the success of the NWS mission to provide forecasts and warnings to our nation. These observations are used in various manners, nationally, regionally and locally.

The observations collected nationally are quality controlled, and ingest into the numerical model analyses from which forecast guidance is prepared on global and national scales. The historical records of these observations are used to compute climate normals at points and as gridded datasets.

Surface observations and weather information from various sources are used by local forecasters to assess and monitor local conditions. The use of these observations is an integral part of the routine activities conducted in the forecast process at all NWS forecast offices. Some offices also use these observations in locally run mesoscale models. These observations are included in routine forecast products, and are used for the verification of local forecasts and warnings.

Two major shortcomings to existing sensor networks are that there is an insufficient number of sensors nationwide, and they are not distributed uniformly across the nation. These limitations impact the real-time assessment of surface weather conditions, and the subsequent forecasting of weather conditions.

Traditionally the NWS has relied upon routine observations collected by volunteers to supplement those collected by the NOAA commissioned automated observational systems. One group of these cooperative volunteers manually report observations that are transmitted for national collection as a part of the NWS Cooperative Observer Program (COOP) Program.

Another supplemental source of information comes from RWIS deployed by state highway authorities. These systems use Environmental Sensor Stations (ESSs) with both atmospheric and pavement sensors from which automated observations are collected locally and statewide. A small subset of all of these observations collected nationwide are routinely shared with NOAA centrally and locally at NWS local offices.

2.1.1. Genesis of Results Project

Our results team was comprised of members from the FHWA, the NWS, the U.S. Air Force, and Food and Drug Administration. These individuals initially formed a team with an interest in exploring ways in which the NWS could provide more highway weather information to the public via the NOAA Weather Radio, now known as the NOAA All Hazards Radio.

As we began to investigate this topic within the FHWA and NWS, we found that there is no comprehensive and systematic mechanism in place to share highway weather information collected by highway authorities with the NWS. At present only a small subset of the observational data collected by RWIS are shared with NOAA.

If additional information about highway weather conditions is to be disseminated with the NOAA All Hazards Radio and other NWS dissemination means, the extent of sharing of the observational data between the highway authorities, FHWA and NWS must be more complete and systematic. Based upon recommendations from NOAA management, this results project was chosen to focus on assessing the existing practices and methodologies for sharing of RWIS ESS observations, documenting best practices for the sharing, and making recommendations for enhancing activities related to this topic.

2.1.2. Potential Benefits of Sharing of Road Weather Information Observations with NOAA

2.1.2.1. Benefits to the National Weather Service

- Allows scientists to better understand the environment and ecosystems
- Provides regularly scheduled weather information from non-NOAA sites
- Provides information from geographically remote locations
- Allows NWS to provide more detailed analyses and forecasts at higher spatial and temporal resolution
- Provides additional observations for assimilation into meso-scale models
- Allows incorporation of information that did not get integrated into NWS forecast process
- Demonstrates trends in the weather due to natural climate variability or man made effects such as urbanization
- Allows scientists to better monitor rapidly evolving weather conditions with more sources of data
- Augments existing synoptic scale and cooperative mesonet observations
- Provides additional sources for verification of forecasts and warnings
- Allows for the generation of high resolution gridded analyses and forecasts
- Allows scientists to better understand the climate variability found in the meso, macro and micro scales
- Allows scientists to better understand impact of land use changes
- Provides more information for decision-making

2.1.2.2. Benefits to Highway Authorities in States that Share RWIS Data with NOAA

- Resultant availability of more detailed forecasts from NOAA will improve the ability of decision makers to anticipate weather events and enable better planning and efficiency in transportation operations activities including snow and ice control, traffic management, and routine construction and maintenance
- Quality monitoring of data and feedback from NOAA
- Ability to provide improved traveler information

2.1.2.3. Benefits to the Nation

- Improved information on climate variability and trends
- Improved information on health of ecosystems and links to disease and vulnerability
- Improved information about weather hazards
- Improved understanding of weather in remote areas
- Potential for private sector vendors the ability to prepare improved tailored forecasts to support decision making
- Improved NWS forecasts and warnings
- Reduced weather related highway crashes
- Improved information for trip planning
- Reduced public expenditures

2.2. Results Project Objectives

We hoped to promote increased sharing of surface weather observations obtained by Road Weather Information Systems (RWIS) used by state DOTs. This project aims to use information gathered through surveys and interviews conducted with state DOT personnel, and FHWA and NOAA managers, to provide a summary of current practices and serve as the basis for recommendations for improvement. The intent is to provide an easy to read summary of the responses to each of the survey questions. We have summarized interviews with key individuals.

We achieved our objectives by:

- Documenting the current status of ESS use by state DOTs
- Documenting the practices of states that are already sharing their RWIS observations
- Documenting perceived barriers to sharing

2.3. Data Collection and Methods

One of the first activities of the results team was to develop assessment questions relating to sharing of RWIS ESS observations. We developed a web-based assessment instrument with questions regarding a wide range of RWIS topics. These questions were incorporated into a ITS survey administered by the FHWA. State DOT personnel were requested to complete the survey over a month period in the spring of 2004. We had a very high response rate (88% complete response and 94% partial response), compared to the typical 5-10% response rate for web-based questionnaires.

A total of 46 state transportation personnel completed the surveys for their state. After review of the survey responses, follow-up interviews were conducted with ITS points of contact (POCs) from states who presently share their RWIS observations with the NWS locally or with NOAA nationally.

Additional calls were made to individuals from states that have RWIS ESS but do not share the data with the NWS or NOAA, to assess their use of the LETS for the local transmission and statewide collection of the ESS observations.

We used information from these interviews and from interviews with NOAA officials who are involved in facilitation of this type of sharing, to develop the conclusions and recommendations in this document. The extensive information received in the assessment itself provides a wealth of insight into the current status of state DOT ESS systems, and summary tables are included in this document.

3. Status of Sharing of Road Weather Information by State Departments of Transportation

3.1. Summary Information for all Responding States

3.1.1. Demographic Information and Points of Contact

This survey was sent as part of a larger federal survey to state DOT Intelligent Transportation Systems points of contact. The respondents were not necessarily experts in road weather information systems, but provided their best knowledge regarding the state of road weather information gathering and sharing in their states. Their contact information is provided in the following table:

Table 3.1.1: State DOT Intelligent Transportation Systems Points of Contact

State	POC Name	Agency	Email	Phone
AL	Nick Amberger	AL DOT	ambergern@dot.state.al.us	251-470-8230
AK	Jack Stickel	AK DOT	jack_stickel@dot.state.ak.us	907-465-6998
AR	Dorothy Rhodes	AR Highway and Transportation Dept	dorothy.rhodes@ahtd.state.ar.us	501-569-2072
AZ	Tim Wolfe	AZ DOT	twolfe@dot.state.az.us	602-712-6622
CA	Tom West	CA DOT	tom.west@dot.ca.gov	916-654-7143
CO	Rod Mead	CO DOT	rod.mead@dot.state.co.us	303-512-5822
CT	John P. Carey	CT DOT	john.p.carey@po.state.ct.us	860-594-2609
DE	Gene Donaldson	DE DOT	gdonaldson@mail.dot.state.de.us	302-659-2401
FL	Nick Adams	FL DOT	nick.adams@dot.state.fl.us	850-410-5608
GA	Hugh Colton	GA DOT	hugh.colton@dot.state.ga.us	404-635-8006
HI	Kyle Oyasoto	HI DOT	Kyle_Oyasoto@hawaii.gov	808-485-6208
ID	David Jones	ID DOT	djones@itd.state.id.us	208-332-7893
IL	David Zavattero	IL DOT	zavetteroda@nt.dot.state.il.us	847-705-4800
IN	Dennis Belter	IN DOT	dbelter@indot.state.in.us	317-232-5424
IA	John Whited	IA DOT	john.whited@dot.state.ia.us	515-239-1411
KS	Michael Floberg	KS DOT	Floberg@ksdot.org	785-296-5652
KY	Nancy Albright	KY Transportation Cabinet	nancy.albright@ky.gov	502-564-3020
LA	Stephen Glascock	LA DOT	StephenGlascock@dotd.state.la.us	225-935-0131
ME	Russ Charet	ME DOT	russ.charette@maine.gov	207-624-3238
MD	Dave Rossbach	MD State Highway Administration	drossbach@sha.state.md.us	410-582-5545
MA	Michelle Maffeo	MA Highway	Michelle.Maffeo@state.ma.us	617-973-7315

Table 3.1.1: State DOT Intelligent Transportation Systems Points of Contact				
State	**POC Name**	**Agency**	**Email**	**Phone**
MI	Jim Schultz	MI DOT	shultzj3@michigan.gov	248-483-5131, Ext301
MS	John Rainwater	MS DOT	rainwater@mdot.state.ms.us	601-359-1454
MN	Curt Pape	MN DOT	curt.pape@dot.state.mn.us	651-297-1798
MO	Lisa Vieth	MO DOT	Lisa.Vieth@modot.mo.gov	573-751-1323
MT	Mike Bousliman	MT DOT	mbousliman@state.mt.us	406-444-6159
NE	Jim McGee	NE Department of Roads	jmcgee2@dor.state.ne.us	402-471-1811
NV	Tom Moore	NV DOT	tmoore@dot.state.nv.us	775-888-7566
NH	Ken Kyle	NH DOT	KKyle@DOT.STATE.NH.US	603-271-7419
NJ	Richard Shaw	NJ DOT	richardm.shaw@dot.state.nj.us	609-530-2589
NM	Tom Blaine	NM State Highway and Transportation Dept	tom.blaine@nmshtd.state.nm.us	505-841-9174
NY	Jeff Thorn	NY St DOT	jthorn@dot.state.ny.us	518-457-1951
NC	Tom Parker	NC DOT	tparker@dot.state.nc.us	919-733-1506
ND	Jerry Horner	ND DOT	jhorner@state.nd.us	701-328-4443
OH	Howard Wood	OH DOT	Howard.Wood@dot.state.oh.us	614-466-2255
OK	Alan Stevenson	OK DOT	astevenson@odot.org	405-521-2861
OR	Douglas Tindall	OR DOT	douglas.j.tindall@state.or.us	503-986-3005
PA	Alfred Uzokwe	PA DOT	auzokwe@state.pa.us	717-787-6263
RI	John Nickolson	RI DOT	jnick@dot.state.ri.us	401-222-2378
SC	Mark Hannah	SC DOT	hannahm@dot.state.sc.us	803-737-1290
SD	Dave Huft	SD DOT	dave.huft@state.sd.us	605-773-3358
TN	Gerald Gregory	TN DOT	gerald.gregory@state.tn.us	615-741-2027
TX	Mel Partee	TX DOT	mpartee@dot.state.tx.us	512-506-5116
UT	Dave Kinnecom	UT DOT	dkinnecom@utah.gov	801-887-3707
VT	Dan Grahovac	VT DOT	dan.grahovac@state.vt.us	802-828-5751
VA	Mike Hall	VA DOT	Mike.Hall@virginiadot.org	804-786-7919
WA	Larry Senn	WA DOT	larsenn@u.washington.edu	206-543-6741
WV	Barry Warhoftig	WV DOT	bwarhoftig@dot.state.wv.us	304-558-3722
WI	Michael Adams	WI DOT	michael.adams@dot.state.wi.us	608-266-5004
WY	Ken Shultz	WY DOT	ken.shultz@dot.state.wy.us	307-777-4051

3.1.2. Types of Weather Events Impacting Road Operation and Maintenance

State Transportation officials were asked to identify (from a checklist) weather events that significantly affect the operation and maintenance of roads in their jurisdictions. The results are summarized in the following table; only positive responses are recorded. The absence of a "y" in a column does not necessarily mean that a given states does not have that particular weather problem affecting its roads; in some cases, it may be that the reporter did not check off relevant

events. States which did not respond to the survey are not listed, to avoid the impression that they are unaffected by particular events.

Table 3.1.2: Weather Events Reported by DOTs as Impacting Road Operation and Management

State	Rain	Frozen Precip[1]	Low Vis Fog[2]	Low Vis Snow[3]	Low Vis Dust[4]	Low Vis Smoke[5]	Flooding	High Winds
Alabama	y		y				Y	y
Alaska	y	y	y	y	y	Y	Y	y
Arkansas	y	y	y				Y	y
California	y	y	y	y	y	Y	Y	y
Colorado	y	y	y	y	y	Y	Y	y
Connecticut		y						
Florida	y		y			Y	Y	y
Georgia	y	y	y					y
Hawaii	y							y
Idaho	y	y	y	y	y	Y	Y	y
Indiana	y	y	y	y				
Iowa		y	y	y			Y	y
Kansas		y	y	y			Y	y
Kentucky	y	y	y			Y	Y	
Louisiana	y		y					y
Maine	y	y	y	y			Y	
Maryland	y	y	y	y			Y	y
Massachusetts	y	y		y			Y	
Michigan	y	y	y	y				y
Minnesota	y	y	y	y	y		Y	y
Missouri	y	y	y				Y	
Montana	y	y	y	y			Y	
Nebraska	y	y	y	y	y	Y	Y	y
Nevada	y	y	y	y	y		Y	y
New Hampshire	y	y	y				Y	y
New Jersey		y					Y	
New Mexico					y			y
New York								
North Carolina	y	y	y	y		Y	Y	y
North Dakota	y	y					Y	y
Ohio	y	y		y			Y	y
Oklahoma		y	y	y	y		Y	
Oregon	y	y	y		y	Y	Y	y

Table 3.1.2: Weather Events Reported by DOTs as Impacting Road Operation and Management								
State	**Rain**	**Frozen Precip[1]**	**Low Vis Fog[2]**	**Low Vis Snow[3]**	**Low Vis Dust[4]**	**Low Vis Smoke[5]**	**Flooding**	**High Winds**
Pennsylvania		y	y				Y	
Rhode Island		y						
South Carolina		y	y					
South Dakota	y	y	y	y	y	Y	Y	y
Tennessee	y	y					Y	
Texas								
Utah	y	y	y	y	y	Y		y
Vermont		y	y				Y	
Virginia	y	y	y				Y	y
Washington State	y	y	y	y	y	Y	Y	y
West Virginia		y	y				Y	
Wisconsin	y	y	y					
Wyoming		y		y				y
Total	**32**	**39**	**34**	**22**	**13**	**12**	**16**	**28**
% of Responding States With Specified Weather Event	**70%**	**85%**	**74%**	**48%**	**28%**	**26%**	**38%**	**61%**

[1]Frozen Precipitation (snow, sleet, freezing rain)
[2]Low visibility due to fog
[3]Low visibility due to wind-blown snow
[4]Low visibility due to wind-blown dust
[5]Low visibility due to smoke

Table 3.1.2 (cont) Weather Events Reported by State DOTs as Impacting Road Operation and Management							
State	**Hurricane[6]**	**Tornado**	**Slick Pvmt[7]**	**Sand or Dust**	**Land-slide[8]**	**Snow-slide[9]**	**Other**
Alabama	y	y	y		y		
Alaska			y	Y		y	
Arkansas		y	y				
California			y	Y	y	y	Coastal erosion[10]
Colorado		y	y	Y	y	y	
Connecticut			y				
Florida	y		y				
Georgia	y	y	y		y		
Hawaii	y		y		y		Clouds
Idaho			y	Y	y	y	

Table 3.1.2 (cont) Weather Events Reported by State DOTs as Impacting Road Operation and Management							
State	**Hurricane[6]**	**Tornado**	**Slick Pvmt[7]**	**Sand or Dust**	**Land-slide[8]**	**Snow-slide[9]**	**Other**
Indiana		y	y				
Iowa		y	y				
Kansas			y				
Kentucky		y	y				
Louisiana	y						
Maine			y				
Maryland	y	y	y				
Massachusetts			y				
Michigan		y	y	Y			
Minnesota		y	y	Y			
Missouri			y				
Montana			y	Y	y	y	
Nebraska		y	y				
Nevada			y	Y	y	y	
New Hampshire	y		y				
New Jersey			y				
New Mexico			y	Y			
New York							
North Carolina	y	y	y	Y	y		
North Dakota	y		y				
Ohio		y	y		y		
Oklahoma		y	y				
Oregon			y		y	y	
Pennsylvania			y				
Rhode Island			y				
South Carolina							
South Dakota		y	y	Y	y		
Tennessee		y	y		y		
Texas							
Utah			y	Y	y	y	
Vermont			y				
Virginia	y		y				Sinkholes
Washington State			y		y	y	
West Virginia			y		y		
Wisconsin			y				
Wyoming					y	y	
Total	**10**	**16**	**41**	**12**	**17**	**10**	n/a

Table 3.1.2 (cont) Weather Events Reported by State DOTs as Impacting Road Operation and Management							
State	**Hurricane[6]**	**Tornado**	**Slick Pvmt[7]**	**Sand or Dust**	**Land-slide[8]**	**Snow-slide[9]**	**Other**
% of Responding States with Specified Weather Event	**22%**	**35%**	**89%**	**26%**	**37%**	**22%**	n/a

[6]Hurricanes and tropical storms
[7]Slick pavement due to water, snow, ice or black ice
[8]Landslides, mudslides or rockslides
[9]Snowslides or avalanches
[10]High surf (bluff erosion) along coastal highways

The types of road weather events which were most frequently identified by State DOT officials as impacting road operations and maintenance were slick pavement, frozen precipitation and fog. Those weather events identified least frequently included snowslides/avalanches and hurricanes/tropical storms.

3.1.3. Types of Road Weather Information Used by State DOTs to Make Operational Decisions

State DOT representatives were asked what environmental data are collected by their agencies to support operational decisions. The following table summarizes the states' responses. Each column header represents a "check-off" option that the reporter had. Lack of a "y" in for a particular type of information does not necessarily mean that the states do not use that type of data; some states may simply not have checked off a particular box. States that did not respond to the survey are not included in the table.

Table 3.1.3.1: Types of Road Weather Information Used by State DOTs to Support Operational Decisions			
State	**Atmosph Data[1]**	**Pvmt Condition Data[2]**	**Water Level Data[3]**
Alabama	y	Y	Y
Alaska	y	Y	Y
Arkansas	y	Y	Y
California	y		Y
Colorado	y	Y	
Connecticut	y	Y	Y
Florida	y	Y	
Georgia	y	Y	
Hawaii	y	Y	Y
Idaho	y	Y	
Indiana	y	Y	
Iowa	y	Y	
Kansas	y	Y	

Table 3.1.3.1: Types of Road Weather Information Used by State DOTs to Support Operational Decisions			
State	**Atmosph Data[1]**	**Pvmt Condition Data[2]**	**Water Level Data[3]**
Kentucky	y	Y	Y
Louisiana	y		
Maine	y	Y	
Maryland	y	Y	Y
Massachusetts	y	Y	
Michigan	y	Y	
Minnesota	y	Y	
Missouri	y	Y	
Montana	y	Y	
Nebraska	y	Y	Y
Nevada	y	Y	
New Hampshire	y	Y	Y
New Jersey	y	Y	
New Mexico	y	Y	
New York			
North Carolina	y		Y
North Dakota	y	Y	
Ohio	y	Y	
Oklahoma	y	Y	
Oregon	y	Y	Y
Pennsylvania	y	Y	
Rhode Island	y	Y	
South Carolina	y	Y	
South Dakota	y	Y	Y
Tennessee	y	Y	
Texas			
Utah	y	Y	Y
Vermont			
Virginia	y	Y	
Washington State	y	Y	Y
West Virginia	y	Y	Y
Wisconsin	y	Y	
Wyoming	y	Y	
Total	**43**	**40**	**16**
% of States Using this Type of RWI[4]	**93%**	**87%**	**35%**

Table 3.1.3.1: Types of Road Weather Information Used by State DOTs to Support Operational Decisions			
State	**Atmosph Data[1]**	**Pvmt Condition Data[2]**	**Water Level Data[3]**

[1]Atmospheric data, e.g. precipitation, air temperature, visibility
[2]Pavement condition data, e.g. wetness, freeze point temperature, chemical concentration
[3]Water level data, e.g. stream levels, river forecasts, tide levels
[4]Road Weather Information

A great majority of reporting states use atmospheric data and pavement condition data, while a minority use water level data.

State DOTs were asked what sources of weather information they use to gather road weather information. Information from responding states is summarized in the following table:

Table 3.1.3.2: Sources of Road Weather Information Used by State DOTs									
State	**NWS[1]**	**FAA[2]**	**USGS[3]**	**NHC[4]**	**DOD[5]**	**Field Personnel Reports**	**PWIS[6]**	**Do Not Gather RWIS Data**	**Other**
AL	Y			y	y	y			
AK	Y	y	y		y				
AR								y	
CA	Y					y	Meteorologix, SSI		
CO	Y	y					DTN Weather		
CT		y					Accuweather		
FL	Y			y		y			
GA	Y			y		y			Fog and smoke detection at problem locations
HI								y	
ID	Y	y	y			y	SSI		
IN	Y						Meridian		
IA	Y	y				y	Y		
KS	Y						Accuweather, Intellicast, Underground Weather, Weather Channel		
KY	Y					y			
ME	Y					y	local		

Table 3.1.3.2: Sources of Road Weather Information Used by State DOTs									
State	**NWS[1]**	**FAA[2]**	**USGS[3]**	**NHC[4]**	**DOD[5]**	**Field Personnel Reports**	**PWIS[6]**	**Do Not Gather RWIS Data**	**Other**
							meteorologists		
MD	Y	y	y	y		y	SSI		
MA	Y					y			
MI	Y					y	AM radio WWJ 950		
MN	Y	y				y	Meridian		
MO	Y					y	SSI, DTN		
MT						y			
NE	Y	y	y	y	y	y	Meridian		
NV	Y					y	Northwest Weather Net		
NH	Y					y	Northwinds Weather, Sandwich NH		Northwinds Weather provides daily forecast by mnt district during winter
NJ						y	Accuweather		
NM						y			
NC	Y		y	y		y	Accuweather		
ND							Meridian		
OH	Y					y	Meteorologix		
OK	Y		y			y			
OR	Y					y	"various"		
PA							"paid vendors"		
RI	Y					y	Ocean State Weather		
SC	Y			y			Meteorologix		
SD	Y	y				y	Grand Forks, ND		
TN	Y					y	SSI		
UT							Northwest Weathernet		
VT	Y	y	y			y	DTN, WSI, FORETELL		
VA	Y					y	SSI		
WA	Y					y	Northwest		

Table 3.1.3.2: Sources of Road Weather Information Used by State DOTs									
State	**NWS[1]**	**FAA[2]**	**USGS[3]**	**NHC[4]**	**DOD[5]**	**Field Personnel Reports**	**PWIS[6]**	**Do Not Gather RWIS Data**	**Other**
							Weathernet		
WV	Y					y			
WI	Y					y	SSI		
WY	Y					y	Y		
Total (n = 43)	34	10	7	7	3	32	31	2	n/a
% of States Using this RWIS Data Source	79%	23%	16%	16%	7%	74%	72%	n/a	n/a

[1]National Weather Service, e.g. general weather forecasts
[2]Federal Aviation Administration, e.g. ASOS/AWOS data
[3]US Geological Survey, e.g. stream gauge data
[4]National Hurricane Center, e.g. storm track and landfall forecasts
[5]Department of Defense
[6]Private Weather Information Services

A significant majority of responding states use the National Weather Service, reports from field personnel, or data from private weather information services as sources of road weather information. Few use the FAA, USGS, NHC or DOD. Only two states responded that they did not gather road weather information.

3.1.4. Types of State DOT Personnel who Use Road Weather Information

State DOTs were asked which personnel in their agency use road weather information to make operational decisions. Answers from responding states are summarized in the following table.

Table 3.1.4: Types of State DOT Personnel who use Road Weather Information to Make Operational Decisions							
Responding State	**Traffic Mgmt**	**Trav Info[1]**	**Winter Mnt[2]**	**Summer Mnt[3]**	**Construction[4]**	**Do Not Use RWIS for Ops Decisions**	**Other**
AL	y			Y	y		
AK		y	y	Y			
AR							y
CA	y		y	Y	y		
CO		y	y	Y			

Table 3.1.4: Types of State DOT Personnel who use Road Weather Information to Make Operational Decisions							
Responding State	**Traffic Mgmt**	**Trav Info[1]**	**Winter Mnt[2]**	**Summer Mnt[3]**	**Construction[4]**	**Do Not Use RWIS for Ops Decisions**	**Other**
CT	y	y	y	Y	y		
FL	y	y			y		
GA	y	y					
HI	y			Y	y		
ID		y	y				
IN	y		y				
IA			y	Y			
KS			y	Y			
KY	y	y	y				
LA		y					
ME			y				
MD	y	y	y	Y	y	Bridge, Landscape, Survey, Utility	
MA	y	y	y	Y	y		
MI		y	y				
MN	y	y	y	Y	y		
MO	y	y	y	Y	y		
MT		y	y				
NE	y	y	y	Y	y		
NV			y	Y	y		
NH			y	Y	y		
NJ			y				
NM			y		y		
NC	y		y	Y			
ND		y	y	Y	y		
OH	y	y	y	Y	y		
OK			y	Y	y		
OR			y				
PA			y				
RI			y				
SC			y				
SD		y	y	Y	y		
TN	y	y	y		y		

Table 3.1.4: Types of State DOT Personnel who use Road Weather Information to Make Operational Decisions							
Responding State	**Traffic Mgmt**	**Trav Info[1]**	**Winter Mnt[2]**	**Summer Mnt[3]**	**Construction[4]**	**Do Not Use RWIS for Ops Decisions**	**Other**
UT	y	y	y	Y	y		
VT		y	y		y		
VA	y	y	y				
WA			y	Y	y		
WV		y	y		y		
WI			y	Y			
WY		y	y				
Total (n = 44)	18	24	38	23	22	n/a	1
% of States with this Type of Personnel Using RWIS for Ops Decisions	41%	55%	86%	52%	50%	n/a	2%

[1]Traveler information dissemination personnel
[2]Winter maintenance personnel (for snow and ice control activities)
[3]Summer maintenance personnel (for weed control, patching, etc)
[4]Construction personnel (for paving operations, concrete pouring, etc)

A significant majority of state DOTs reported that their winter maintenance personnel use RWIS information for making operational decisions about such activities as snow and ice control. A majority of states also reported use of RWIS data for operational decisions by their traveler information dissemination personnel and summer maintenance personnel. Several states also reported use of RWIS data for operational decisions by traffic management personnel and construction personnel.

3.1.5. Types of ESS Data Collected by States, and Responsibility for ESS Systems

3.1.5.1. Environmental Data Collected by State DOTs

The following table summarizes the environmental data that state DOTs reported that they collect to support operational decisions.

Table 3.1.5.1: Environmental Data Collected by State DOTs										
State	**Air Temp**	**Air Qual[1]**	**Dew Pt and Rel Hum[2]**	**Bar Pres[3]**	**Pptn Type[4]**	**Pptn Rate[5]**	**Wind Spd[6]**	**Wind Dir[7]**	**Vis Dist[8]**	**Cloud Cover, Solar Rad[9]**
Alabama	y		y	y	Y	y	y	Y	y	
Alaska	y		y	y	Y	y	y	Y		

Table 3.1.5.1: Environmental Data Collected by State DOTs										
State	**Air Temp**	**Air Qual[1]**	**Dew Pt and Rel Hum[2]**	**Bar Pres[3]**	**Pptn Type[4]**	**Pptn Rate[5]**	**Wind Spd[6]**	**Wind Dir[7]**	**Vis Dist[8]**	**Cloud Cover, Solar Rad[9]**
Arkansas										
California	y				Y	y	y	Y	y	
Colorado	y		y	y	Y		y	Y	y	
Connecticut	y		y		Y	y	y			
Florida	y		y	y	Y	y	y	Y	y	
Georgia	y	y	y	y	Y	y	y	Y	y	
Hawaii	y	y	y		Y		y	Y		
Idaho	y		y	y	Y	y	y	Y	y	
Indiana	y		y				y	Y		
Iowa	y		y		Y	y	y	Y	y	
Kansas	y		y				y	Y		
Kentucky	y		y			y	y	Y		y
Louisiana	y		y				y	Y	y	
Maine	y		y	y	Y	y	y	Y	y	
Maryland	y		y		Y	y	y	Y	y	
Massachusetts	y		y		Y	y	y	Y	y	
Michigan	y			y		y	y			
Minnesota	y		y	y	Y	y	y	Y	y	y
Missouri	y		y		Y	y	y	Y		
Montana	y		y		Y	y	y	Y	y	
Nebraska	y	y	y	y	Y	y	y	Y	y	y
Nevada	y		y			y	y	Y	y	
New Hampshire	y		y		Y	y				
New Jersey	y		y	y	Y	y	y	Y	y	
New Mexico										
New York										
North Carolina										
North Dakota	y		y		Y		y	Y	y	
Ohio	y		y		Y	y	y	Y	y	
Oklahoma	y		y				y	Y	y	
Oregon	y		y				y	Y	y	
Pennsylvania	y		y		Y	y	y	Y	y	
Rhode Island	y		y		Y	y	y			y
South Carolina	y		y		Y		y	Y		
South Dakota	y		y	y	Y	y	y	Y	y	y
Tennessee	y		y		Y	y	y	Y	y	

Table 3.1.5.1: Environmental Data Collected by State DOTs										
State	**Air Temp**	**Air Qual[1]**	**Dew Pt and Rel Hum[2]**	**Bar Pres[3]**	**Pptn Type[4]**	**Pptn Rate[5]**	**Wind Spd[6]**	**Wind Dir[7]**	**Vis Dist[8]**	**Cloud Cover, Solar Rad[9]**
Texas										
Utah	y	y	y		Y	y	y	Y	y	
Vermont	y		y		Y	y	y	Y	y	
Virginia	y	y			Y	y	y		y	
Washington State	y	y	y	y	Y	y	y	Y	y	y
West Virginia					Y	y			y	
Wisconsin	y		y		Y	y	y	Y	y	
Wyoming	y		y	y	Y		y	Y		
Total	**40**	**6**	**36**	**14**	**32**	**31**	**39**	**35**	**29**	**6**
% of States Collecting this Type of Data	**87%**	**13%**	**78%**	**30%**	**70%**	**67%**	**85%**	**76%**	**63%**	**13%**

[1]Air quality
[2]Dew point and relative humidity
[3]Barometric pressure
[4]Precipitation type
[5]Precipitation rate
[6]Wind speed and gusts
[7]Wind direction
[8]Visibility distance
[9]Cloud cover/solar radiation

Table 3.1.5.1 (cont): Environmental Data Collected by State DOTs								
State	**Pvmt Temp[10]**	**Pvmt Frz Pt[11]**	**Pvmt Cond[12]**	**Pvmt Snow Depth[13]**	**Pvmt Friction Coeff[14]**	**Pvmt Chem Conc[15]**	**Subsurf Cond[16]**	**Water Level[17]**
Alabama			y		y			y
Alaska	y	y	y				Y	y
Arkansas								
California	y		y					
Colorado	y	y	y			y	Y	
Connecticut	y	y	y			y	Y	
Florida	y		y		y			y
Georgia	y	y	y			y	Y	
Hawaii								
Idaho	y	y	y			y	Y	
Indiana	y	y	y			y	Y	
Iowa	y	y	y			y	Y	

Table 3.1.5.1 (cont): Environmental Data Collected by State DOTs								
State	**Pvmt Temp[10]**	**Pvmt Frz Pt[11]**	**Pvmt Cond[12]**	**Pvmt Snow Depth[13]**	**Pvmt Friction Coeff[14]**	**Pvmt Chem Conc[15]**	**Subsurf Cond[16]**	**Water Level[17]**
Kansas	y	y	y			y		
Kentucky	y						Y	
Louisiana								
Maine	y	y	y	Y				
Maryland	y	y	y	Y		y	Y	
Massachusetts	y	y	y	Y				
Michigan			y	Y				
Minnesota	y	y	y	Y		y	Y	
Missouri	y	y	y	Y		y		
Montana	y		y				Y	
Nebraska	y	y	y	Y			Y	
Nevada	y	y	y			y	Y	
New Hampshire	y	y	y	Y		y		
New Jersey	y	y	y			y	Y	
New Mexico								
New York								
North Carolina		y						
North Dakota	y		y			y	Y	
Ohio	y		y	Y	y	y	Y	
Oklahoma		y	y	Y	y	y	Y	y
Oregon	y	y	y			y	Y	y
Pennsylvania	y	y	y					
Rhode Island	y	y	y			y	Y	
South Carolina	y	y	y			y	Y	
South Dakota	y		y	Y		y	Y	y
Tennessee	y	y	y				Y	
Texas								
Utah	y	y	y	Y		y	Y	
Vermont	y	y	y	Y		Y	Y	
Virginia	y	y	y	Y		Y	Y	
Washington State	y	y	y			Y	Y	y
West Virginia			y					
Wisconsin	y	y	y			Y	Y	
Wyoming	y		y				Y	
Total	**35**	**29**	**38**	**14**	**4**	**25**	**28**	**7**
% of States Collecting this	**76%**	**63%**	**83%**	**30%**	**9%**	**54%**	**61%**	**15%**

Table 3.1.5.1 (cont): Environmental Data Collected by State DOTs								
State	**Pvmt Temp[10]**	**Pvmt Frz Pt[11]**	**Pvmt Cond[12]**	**Pvmt Snow Depth[13]**	**Pvmt Friction Coeff[14]**	**Pvmt Chem Conc[15]**	**Subsurf Cond[16]**	**Water Level[17]**
Type of Data								

[10]Pavement temperature
[11]Pavement freezing point
[12]Pavement condition (e.g. wet, dry, icy, snow-covered, flooded)
[13]Pavement snow depth
[14]Pavement friction coefficient
[15]Pavement chemical concentration
[16]Subsurface conditions (e.g. soil temperature, depth of frost level)
[17]Water level (in streams, rivers, and lakes near roads)

A significant majority of state DOTs collect environmental data for parameters such as: air temperature, wind speed and gusts, and weather-related pavement conditions. Very few state DOTs collect data for the following parameters: air quality; cloud cover/solar radiation; pavement friction coefficient; or water level of streams, rivers or lakes near roads.

State DOTs collect varying kinds of environmental data. Some states report collection of almost every type of specified data, while others did not report collection of any of the specified types of data. This table presents a rich array of potential sources of road weather information. The table also identifies those states that might have a paucity of road weather data gathering capability. However, lack of reporting may also reflect that the state DOT contact did not have access to this information or chose not to answer this particular survey question.

3.1.5.2. Numbers of ESSs in State DOT Road Weather Information Systems

State DOT contacts were asked if they used environmental sensor stations that are field components of a state DOT Road Weather Information System to gather road weather information. 34/46 (74%) responded yes.

For these positive responders, the following table documents the number of environmental sensor stations in each state's RWIS.

Table 3.1.5.2: Number of RWIS ESS Sites in each Responding State			
State	**# of ESSs in State's RWIS**	**State**	**# of ESSs in State's RWIS**
Alaska	24	**Montana**	60
California	81	**Nebraska**	45
Colorado	120	**Nevada**	54
Connecticut	6	**New Hampshire**	4
Florida	30	**North Dakota**	19
Georgia	47	**Ohio**	158
Idaho	30	**Oregon**	55
Indiana	31	**Pennsylvania**	4

Table 3.1.5.2: Number of RWIS ESS Sites in each Responding State			
State	**# of ESSs in State's RWIS**	**State**	**# of ESSs in State's RWIS**
Iowa	53	**Rhode Island**	8
Kansas	43	**South Carolina**	19
Kentucky	7	**South Dakota**	40
Louisiana	3	**Tennessee**	37
Maine	5	**Utah**	41
Maryland	60	**Virginia**	66
Minnesota	93	**Wisconsin**	60
Missouri	15	**Wyoming**	28

3.1.5.3. Location information for State RWIS ESSs

States that had reported that they used ESSs as field components of a state RWIS were then asked if a map of their state's RWIS ESS locations was available; the following table gives information on how to obtain those maps for states which made this information available. The table was also augmented with additional links researched by a results group member. A limited national map is also available, with some usage restrictions, at http://www.roadweather.com/.

Table 3.1.5.3: Sources for Maps (or Other Location Information) for State RWIS ESS Locations	
State	**Source for RWIS ESS Location Map or Other Location Information**
AK	http://www.dot.state.ak.us/iways/roadweather/index.html
CA	District 2: http://www.dot.ca.gov/dist2/rwis/rwissites.php
CO	http://www.cotrip.org/atis/web.ZoomboxMarshal?device=Weather&Zoombox=0
GA	www.georgianavigator.com/weather
ID	http://164.165.237.41/apps/RWIDS_Public/default.asp
IL	http://gis.dot.il.gov/idotgis/rwis/presentation/basic/map.asp?Cmd=INIT&ExtentLeft=1920280.2643213982%20&ExtentRight=3058450.927141207%20&ExtentBottom=125491.10558196157%20&ExtentTop=2131015.066336367
IN	Contact Dennis Belter at dbelter@indot.state.in.us
IA	http://mesonet.agron.iastate.edu/RWIS/current.php http://www.weatherview.dot.state.ia.us/
KS	http://www.ksdot.org/burcompser/generatedreports/weather.htm or http://mesonet.agron.iastate.edu/RWIS/currentSF.phtml?network=KS_RWIS
KY	www.kytc.state.ky.us/RWIS/index.htm
ME	Contact Russell Charette at 207-624-3238 or russ.charette@maine.gov
MD	http://www.chart.state.md.us/mapping/CHARTMap.asp?tab=Emergency&Time=101615
MN	http://mesonet.agron.iastate.edu/RWIS/currentSF.phtml?network=MN_RWIS or curt.pape@dot.state.mn.us
MT	http://www.mdt.state.mt.us/travinfo/weather/rwis.html
NV	http://www.nevadadot.com/traveler/rwis/rwis.asp?id=up

ND	http://nddot.meridian-enviro.com/public/
OH	www.buckeyetraffic.org/rwis/nosvg/
PA	http://www.dot.state.pa.us/ Click "Traveler Information", then click "Road Weather Information System"
RI	Contact John Nickelson at 401-222-2378 or jnick@dot.state.ri.us
SD	http://meridian-enviro.com/sddot/scan.html or contact Dave Huff at 605-773-3358
WA	http://www.wsdot.wa.gov/traffic/weather/default.aspx
WI	michael.adams@dot.state.wi.us
WY	http://www.wyoroad.info/highway/roadbuddies.html http://www.wrds.uwyo.edu.wydot/wydot.html (historical info only) or contact Ben Saunders at 307-777-3892

3.1.5.4. Seasonality of Data Collection

State DOTs were asked to indicate the seasons during which their ESSs are operational. Results from responding states are included in the following table.

Table 3.1.5.4: Reported Seasons of Operation of State DOT ESSs

State	Year-round	Winter	Spring	Summer	Fall
Alaska	y	y	y	Y	y
California	y	y	y	Y	y
Colorado	y	y	y	Y	y
Connecticut	y	y	y	Y	y
Florida	y	y	y	Y	y
Georgia	y	y	y	Y	y
Idaho	y	y	y	Y	y
Indiana	y	y	y	Y	y
Iowa	y	y	y	Y	y
Kansas	y	y	y	Y	y
Kentucky	y	y	y	Y	y
Louisiana	y	y	y	Y	y
Maine	y	y	y	Y	y
Maryland	y	y	y	Y	y
Massachusetts	y	y	y	Y	y
Minnesota	y	y	y	Y	y
Missouri	y	y	y	Y	y
Montana	y	y	y	Y	y
Nebraska	y	y	y	Y	y
Nevada	y	y	y	Y	y

Table 3.1.5.4: Reported Seasons of Operation of State DOT ESSs					
State	**Year-round**	**Winter**	**Spring**	**Summer**	**Fall**
New Hampshire	y	y	y	Y	y
North Dakota	y	y	y	Y	y
Ohio	y	y	y	Y	y
Oregon	y	y	y	Y	y
Pennsylvania	y	y	y	Y	y
Rhode Island	y	y	y	Y	y
South Carolina		y			
South Dakota	y	y	y	Y	y
Tennessee	y	y	y	Y	y
Utah	y	y	y	Y	y
Virginia	y	y	y	Y	y
Washington State	y	y	y	Y	y
Wisconsin	y	y	y	Y	y
Wyoming	y	y	y	Y	y
Total					
% of Responding States With ESS Operational in Specified Season (total responding n = 33)	97%	100%	97%	97%	97%
% of Responding States with ESSs Operational in this Season, but not Year-Round	n/a	3%	0	0	0

For the vast majority of responding states, their ESSs are operational year round. South Carolina's ESSs are operational only during winter.

3.1.5.5. Parameters Measured by State DOT ESSs, and Siting and Performance Standards

State DOTs were asked to indicate which parameters their ESSs measure, and the source of any siting or performance standards that have been specified for each type of sensor. Their responses are summarized in the following tables. If siting or performance standards were given, they are listed in the footnotes below the tables.

Respondents of the survey provided very few indications that siting standards or guidelines are used by their state. Three states out of the total responding states, MD, AK, and WA did report that siting standards are used, or a meteorologist reviews the siting of the instruments.

Table 3.1.5.5: State DOT ESS Parameters and Siting/Performance Standards						
State	**Air Qual[1]**	**Atmosph Press[2]**	**Pvmt Cond[4]**	**Pvmt Frxn[6]**	**Pvmt Chem[7]**	**Pptn Occurrence[9]**
AK		y[3]	y[3]		y[3]	y[3]
CA		y	y			Y
CO		y	y		y	

CT			y		y	Y
FL		y				Y
GA		y	y		y	Y
IN			y		y	Y
IA			y		y	Y
KS			y		y	Y
KY						Y
MD			y		y	Y
MA			y			Y
MN		y	y		y	Y
NE			y		y	Y
NV			y[8]		y	Y
NH			y		y	Y
ND			y		y	Y
OH			y		y	Y
OR			y		y	Y
PA			y		y	Y
RI			y		y	Y
SC			y		y	Y
SD		y	y			Y
TN			y		y	
UT			y	y	y	Y
VA		y	y		y	Y
WA	y	y[5]	y[5]		y[5]	y[5]
WI		y	y		y	Y

[1]Air quality
[2]Atmospheric pressure
[3]Siting and performance standards: RFP 253002 specifications, 3 Jul 02
[4]Pavment condition (wet, dry, icy, snow-covered, flooded)
[5]Performance standards: http://www.ga.wa.gov/pca/contract/01501c.doc
[6]Pavement friction coefficient
[7]Pavement chemical concentration
[8]Siting standards: Thermal Mapping Design Criteria
[9]Precipitation occurrence

Table 3.1.5.5 (cont): State DOT ESS Parameters and Siting/Performance Standards

State	Discrim Rain[1]	Discrim Frz[2]	Discrim Sleet[4]	Discrim Snow[6]	Pptn Rate[7]	Pptn Accum[8]
AK	y[3]	y[3]		y[3]	y[3]	y[3]
CA	y			y		y
CO	y					
CT	y	y			y	
FL					y	y

Table 3.1.5.5 (cont): State DOT ESS Parameters and Siting/Performance Standards						
State	**Discrim Rain[1]**	**Discrim Frz[2]**	**Discrim Sleet[4]**	**Discrim Snow[6]**	**Pptn Rate[7]**	**Pptn Accum[8]**
GA	y	y			y	y
IN						
IA	y	y		y	y	y
KY						y
LA					y	
MD	y	y	y	y	y	y
MN	y	y	y	y	y	y
NE		y				
NV	y				y	y
NH	y	y		y	y	
OH	y	y				
PA	y					y
SC	y					
SD						y
TN	y	y	y	y	y	
UT	y	y		y	y	y
VA					y	y
WA	y[5]	y[5]		y[5]	y[5]	
WI	y	y		y	y	y

[1]Precipitation type discrimination (rain)
[2]Precipitation type discrimination (freezing vs nonfreezing)
[3]Siting and performance standards: RFP 253002 specifications, 3 Jul 02
[4]Precipitation type discrimination (sleet-specific)
[5]Performance standards: http://www.ga.wa.gov/pca/contract/01501c.doc
[6]Precipitation type discrimination (snow-specific)
[7]Precipitation rate
[8]Precipitation, amount of accumulation

Table 3.1.5.5 (cont) State DOT ESS Parameters and Siting/Performance Standards					
State	**Rel Hum[1]**	**Snowfall**	**Snow Depth**	**Amb Temp[2]**	**Dew Pt[4]**
AK	y[3]	y[3]	y[3]	y[3]	y[3]
CA				y	
CO	y			y	y
CT				y	y
FL	y			y	y
GA	y	y		y	
IN	y			y	y
IA	y			y	y
KS	y			y	y

Table 3.1.5.5 (cont) State DOT ESS Parameters and Siting/Performance Standards					
State	**Rel Hum[1]**	**Snowfall**	**Snow Depth**	**Amb Temp[2]**	**Dew Pt[4]**
KY	y			y	y
LA	y			y	
MD	y	y	Y	y	y
MA				y	y
MN	y			y	y
NE	y			y	y
NV	y			y	y
NH	y			y	y
ND	y			y	
OH		y			
OR	y			y	y
PA	y	y		y	
RI				y	
SC	y			y	y
SD	y			y	y
TN	y			y	y
UT	y	y		y	y
VA	y			y	y
WA	y[5]			y[5]	y[5]
WI	y			y	y
WY	y				

[1]Relative humidity
[2]Ambient air temperature
[3]Siting and performance standards: RFP 253002 specifications, 3 Jul 02
[4]Dew point temperature
[5]Performance standards: http://www.ga.wa.gov/pca/contract/01501c.doc

Table 3.1.5.5 (cont): State DOT ESS Parameters and Siting/Performance Standards						
State	**Pvmt Frz Pt[1]**	**Pvmt Surf Temp[2]**	**Subsurf Temp[7]**	**Vis[4]**	**Wind Dir[6]**	**Wind Spd[8]**
AK	y[3]	y[3]	Y[3]		y[3]	y[3]
CA		y		y	y	y
CO					y	y
CT	y	y	Y		y	y
FL					y	y
GA	y	y	Y	y	y	y
IN		y	Y		y	y
IA	y	y	Y		y	y
KS	y	y	Y		y	y

Table 3.1.5.5 (cont): State DOT ESS Parameters and Siting/Performance Standards						
State	**Pvmt Frz Pt[1]**	**Pvmt Surf Temp[2]**	**Subsurf Temp[7]**	**Vis[4]**	**Wind Dir[6]**	**Wind Spd[8]**
KY		y	Y		y	y
LA				y	y	y
MD	y	y	Y	y	y	y
MA	y	y				
MN	y	y	Y	y	y	y
NE	y	y	Y	y	y	y
NV		y	Y	y	y	y
NH	y	y	Y		y	y
ND		y	Y	y	y	y
OH		y	Y			
OR	y	y	Y	y	y	y
PA		y	Y	y	y	y
RI	y	y	Y		y	y
SC	y	y	Y		y	y
SD		y	Y		y	y
TN	y	y	Y	y	y	y
UT	y	y	Y	y	y	y
VA	y	y	Y	y	y	y
WA	y[5]	y	Y[5]	y[5]	y[5]	y[5]
WI	y	y~~5~~	Y	y	y	y

[1]Pavement freeze point temperature
[2]Pavement surface temperature
[3]Siting and performance standards: RFP 253002 specifications, 3 Jul 02
[4]Visibility
[5]Performance standards: http://www.ga.wa.gov/pca/contract/01501c.doc
[6]Wind Direction
[7]Subsurface temperature
[8]Wind speed

ESS parameters that were given as choices in the survey, but which no states indicated they measure, included cloud height, lightning and sky condition.

3.1.5.6. Comparison of Reported Siting Standards to existing NWS Standards

In addition to the survey responses, We also contacted the states that indicated they used siting guidelines or standards for the ESS. Two states provided detailed information about their practices and policy for siting of the sensors.

NWS siting standards for atmospheric sensor instruments are described in policy documents such as the NWS I –10-1302 available from http://weather.gov/directives/ and also in the COOP Modernization Program Development Plan, March 2004.

Considerations for siting in AK is primary based upon availability of power sources to operate, communications infrastructure to transmit the locally collected data, right of way to access the site, and the ease of construction at the site. Their main area of interest in deploying ESS is to obtain local weather information.

The NWS generally prefers to obtain information from data-sparse areas and the RWIS are usually located in areas that are hard to access, known trouble spots and far from maintenance stations, and often at higher terrain.

The AK DOT typically has included atmospheric sensors with the pavement sensors to optimize the information from a specific site. Atmospheric sensors are placed close to the roadway, but far enough away to ensure there is no influence from the road environment such as splashing, vehicle induced winds, and heat from traffic. Pavement sensors are placed between 8 and 12 inches from the wheel track center.

Alaska ESS siting standards:

- Site must meet the Fatal Flaw Test. The site must be free of obstructions to the flow of air and be typical of the ambient atmospheric conditions [obstructions include trees, embankments, buildings, and cuts]
- Site must meet the Meteorological Criterion: Provides meteorologically important information such as the type, intensity, and progress of a storm to allow the development of accurate and timely forecasts of weather conditions, pavement temperature and the associated road conditions.
- Site must meet the Decision-Maker Criterion: Provides operationally important information to decision makers by detecting the road conditions in conjunction with the forecast weather conditions, and observations of parameters such as wind speed and direction to make decisions about the appropriate maintenance, deicing materials and anti-icing strategies
- The users of data from the site must be able to monitor, detect and forecast weather conditions (ARWI).

Siting of instruments in Washington State is done by a review of proposed sites by a staff Meteorologist, using their professional judgment and state guidelines. There are other major considerations such as availability of power, communications availability, and staying out of the "clear zone".

Siting guidelines for Washington State include the following recommendations:

- Locate the tower at or above the level of the roadway
- If the tower is to be located within 100 ft of the roadway, a 30 foot tower must be used to minimize false precipitation accumulation, and wind sensor interference caused by high speed truck spray/blast
- Avoid locating the tower in the clear area adjacent to the roadway
- Avoid locating the tower near obstructions such as buildings or trees that would influence the wind
- Avoid locating the tower where snow blast from a plow or blower will strike it

- Avoid locating the tower where standing water collects
- Avoid locating the tower under or within 100 ft of an elevated roadway structure
- Ensure the site will not be compromised by future roadway work
- Install fences around the site to prevent vandalism

All of these state guidelines are relatively general in nature and focus on ensuring the site is environmentally representative for weather in that area. While use of these guidelines such as those used in WA and AK are a first step in ensuring that the observations from the RWIS ESS are of a sufficiently high enough quality to be used by NOAA, they may not be specific enough for unqualified use of the data such as for issuance of warning products.

In contrast, the NWS siting standards are quite specific for climate, aviation, synoptic, and cooperative observations. These guidelines detail aspects such as the location of the sensor with respect to nearby pavement, the height above ground, and a minimum distance from obstructions.

3.1.5.7. Ownership of ESSs

State DOT contacts were asked who owns, operates, and maintains ESSs to which their state DOTs have access. The results of responding states are summarized in the following tables.

Table 3.1.5.7: Ownership of ESSs used by State DOTs

State	State DOT Only	State DOT + Other Entity	Other Entity Only
Alaska	y (but Univ of Alaska Fairbanks and NWS have donated supplemental equipment for specific ESSs)		
California	y		
Colorado		y (CDOT owns 80; cities and counties own 40; all data come into CDOT servers)	
Connecticut	y		
Florida	y		
Georgia	y		
Idaho		y ("too numerous to list")	
Indiana		y (City of Indianapolis)	
Iowa	y		
Kansas		y (42 KDOT-owned, 1 county-owned)	
Kentucky	y		
Louisiana	y		
Maine	y		
Maryland		y (other state and county agencies)	

Table 3.1.5.7: Ownership of ESSs used by State DOTs			
State	**State DOT Only**	**State DOT + Other Entity**	**Other Entity Only**
Massachusetts	y		
Minnesota		y (DOTs for Iowa, N Dakota, S Dakota and Wisconsin)	
Missouri		y (Boone County)	
Montana	y		
Nebraska		y (airports, NWIS, RWIS vendor, DOR)	
Nevada	y		
New Hampshire	y		
North Dakota	y		
Ohio	y		
Oregon	y		
Pennsylvania	y		
Rhode Island	y		
South Carolina	y		
South Dakota	y		
Tennessee	y		
Utah	y		
Virginia		y (2 counties own a total of 3 ESSs; VDOT owns 63)	
Washington State		y (WSDOT 66, City of Spokane 2, Spokane Internat Airport 3, Yakima County 5)	
Wisconsin	y		
Wyoming	y		
Total (N responding = 34)	24	10	0
% of Responding States With Specified Ownership Status	71%	29%	0

Most state DOTs own all the ESSs they use. No state DOTs rely entirely upon ESSs owned by other entities. Among those states who own some of their ESSs and use some ESSs owned by others, the other entities are most commonly counties and cities.

3.1.5.8. Operation of ESSs

Table 3.1.5.8: Entities that Operate ESSs used by State DOTs			
State	**State DOT Only**	**State DOT + Other Entity**	**Other Entity Only**
Alaska	y		
California	y		
Colorado		y (State DOT operates the ESSs they own; cities/counties operate the ESSs they own; all RWIS data come thru 6 regional servers provided by a proprietary vendor)	
Connecticut	y		
Florida		Y	
Georgia	y		
Idaho		y ("too numerous to list")	
Indiana		y (City of Indianapolis)	
Iowa	y		
Kansas	y (KDOT system polls 42 KDOT-owned ESSs and 1 county-owned ESS)		
Kentucky	y		
Louisiana	y		
Maine	y		
Maryland	y		
Massachusetts	y		
Minnesota		y (MnDOT maintains all ESSs they own; out-of state DOTs from which MnDOT obtains data maintain their own ESSs)	
Missouri	y		
Montana	y		
Nebraska	y		
Nevada	y		
New Hampshire	y		
North Dakota	y		
Ohio	y		
Oregon	y		
Pennsylvania	y		
Rhode Island	y		
South Carolina	y		
South Dakota		y (City of Sioux Falls)	
Tennessee	y		

Table 3.1.5.8: Entities that Operate ESSs used by State DOTs			
State	**State DOT Only**	**State DOT + Other Entity**	**Other Entity Only**
Utah	y		
Virginia	y		
Washington State		y (Owning Agencies operate; all data go thru WSDOT's server system)	
Wisconsin	y		
Wyoming	y		
Total (n responding = 34)	27	7	0
% of Responding States With Specified ESS Operation Status	79%	21%	0

A significant majority of state DOTs that have access to ESS data operate the ESSs themselves. Three state DOTs are responsible for operation of ESSs owned by other entities. No states have all the ESSs they use operated by another entity. Of those states which operate some ESSs and get data from some ESSs operated the others, the other operators are usually the owners of the ESSs.

3.1.5.9. Maintenance of ESSs

Table 3.1.5.9: Entities that Maintain ESSs used by State DOTs			
State	**State DOT Only**	**State DOT + Other Entity**	**Other Entity Only**
Alaska		y (Surface Systems Inc maintains two RWIS servers and the ESS polling sequences; and maintains the ESS system under extended warranty)	
California	y		
Colorado		y (CDOT maintains servers and ESSs they own, with help from private contractors; cities/counties maintain ESSs they own)	
Connecticut	y		
Florida		Y	
Georgia	y		
Idaho		y ("too numerous to list")	
Indiana		y (City of Indianapolis)	
Iowa	y		
Kansas		y (KDOT maintains those it owns; county maintains 1)	

Table 3.1.5.9: Entities that Maintain ESSs used by State DOTs			
State	**State DOT Only**	**State DOT + Other Entity**	**Other Entity Only**
Kentucky	y		
Louisiana	y		
Maine	y		
Maryland		y (Local agency, manufacturer)	
Massachusetts	y		
Minnesota		y (MnDOT maintains those they own; out-of state DOTs from which MnDOT obtains data maintain their own ESSs)	
Missouri	y		
Montana	y		
Nebraska		y	
Nevada	y		
New Hampshire		y (Vaisala = contractor for installation and service)	
North Dakota	y		
Ohio	y		
Oregon	y		
Pennsylvania	y		
Rhode Island	y		
South Carolina	y		
South Dakota		y (City of Sioux Falls)	
Tennessee	y		
Utah	y		
Virginia	y		
Washington State		y (Each owning agency maintains its own ESS)	
Wisconsin	y		
Total (n responding = 33)	21	12	0
% of Responding States With Specified ESS Operation Status	64%	36%	0

Most state DOTs maintain their own ESSs. No state DOTs reported relying completely on another entity for ESS maintenance. Of those states that share maintenance with another entity, those other entities are most commonly the owners of the ESSs; some state DOTs share ESS maintenance with a private contractor.

3.1.5.10. Vendors Used by State DOTs for ESS Data Collection, Operations or Maintenance

Those states that use a private vendor (for ESS data collection, RWI network operation, or RWIS network maintenance) were asked to provide the names of their vendors. Almost all these state DOTs perform part of these functions themselves, and use the private vendor for only a portion of the work. This information is summarized in the following table.

Table 3.1.5.10: Vendors used by State DOTs for some ESS Data Collection, RWIS Network Operation, or RWIS Network Maintenance

State	Vendor for ESS Data Collection	Vendor for RWIS Operation	Vendor for RWIS Mnt	Other
AK	SSI[1] ESS polling sequence	SSI	SSI extended warranty	
CA				RWIS/ESS purchases by field offices; not standardized for the state. Vendors include SSI, Vaisala and DTN/Meteorologix
CO	SSI	SSI, ETSI[2]	SSI, ETSI	SSI is vendor; ETSI provides some mnt of RPUs[3] and network servers
FL	Univ of North Fl	Univ of North Fl	Univ of North Fl	
IN	SSI	SSI	SSI	
KS	SSI designed and configured	SSI designed	SSI designed	
MD	SSI	SSI		
MN		Occasionally SSI for problems with proprietary software or processes		
MT	SSI	SSI		
NE	SSI	SSI	SSI	
NH	Vaisala	Vaisala	Vaisala	
NV			Vaisala	
OH	Quixote			Nextel (responsibility not specified)
PA	Intellimark	SSI, Numterics, Boschung	SSI, Numterics, Boschung	
RI	SSI		SSI	
SC	SSI			
SD	Meridian Env Technol			
TN			SSI, Vaisala	
VA	SSI	SSI	SSI	

Table 3.1.5.10: Vendors used by State DOTs for some ESS Data Collection, RWIS Network Operation, or RWIS Network Maintenance				
State	**Vendor for ESS Data Collection**	**Vendor for RWIS Operation**	**Vendor for RWIS Mnt**	**Other**
WA			SSI maintains server system	
WI	SSI	SSI	SSI	

[1]Surface Systems Inc
[2]Enroute Traffic Systems Inc
[3]Remote processing units

Sixteen states use some type of private vendor for at least part of their ESS data collection; 13 use a private vendor for at least part of their RWIS operation, and 14 use a private vendor for at least part of their RWIS maintenance.

3.1.5.11. Frequency of Use of Particular Vendors

From the above table, the frequency of use of particular vendors is summarized in the following table. The percentage of states using a particular vendor is derived using only those states that use any vendor; states that did not report use a vendor for a particular type of service are not included in the denominator. Some states use more than one vendor for a particular function; therefore, the sum of percentages in a column might not add up to 100%.

Table 3.1.5.11: Frequency of Use of Particular Private Vendors for ESS Data Collection, RWIS Operations, or RWIS Maintenance			
Vendor	**# (%) of Vendor-User State DOTs (total n = 16) Using Vendor for ESS Data Collection**	**# (%) of Vendor-User State DOTs (total n = 13) Using Vendor for RWIS Operations**	**# (%) of Vendor-User State DOTs (total n = 14) Using Vendor for RWIS Mnt**
Boschung		1 (8%)	1 (7%)
ETSI		1 (8%)	1 (7%)
Intellimark	1 (6%)		
Meridian Environ Technol	1 (6%)		
Numterics		1 (8%)	1 (7%)
Quixote	1 (6%)		
SSI	11 (69%)	11 (85%)	11 (79%)
Univ of No Fl	1 (6%)	1 (8%)	1 (7%)
Vaisala	1 (6%)	1 (8%)	3 (21%)

SSI is by far the most commonly cited vendor, with Vaisala the only other private vendor mentioned more than once for a given function.

3.1.6. Systems other than ESSs used by State DOTs to Gather Road Weather Information

3.1.6.1. Types of other Systems Used

State DOTs were asked what other systems (besides ESSs) are used by their agency to gather road weather information. Answers from responding states are summarized in the following table:

Table 3.1.6.1: Systems other than ESSs used by State DOTs to Gather Road Weather Information

State	Ag[1]	Air Qual[2]	Airport[3]	CCTV[4]	MES[5]	State Mesonet[6]	Other Mesonet	Other	No RWIS[7]
AL				y				y (fog detection system at the tunnel complex)	
AK			y	y				y (private CCTV sites)	
AR									
CA				y					
CO			y	y					
CT				y					
FL									
GA				y					
HI									y
ID	y	y	y	y			y (Utah)		
IN					y				
IA	y		y				y		
KS			y	y	y				
KY				y	y				
LA				y					
ME								y	
MD				y	y				
MA				y					
MI				y					
MN			y		y				
MO			y		y			y (working toward incorp ASOS, AWOS)	
MT					y				
NE	y	y	y	y					
NV			y	y					
NH				y				y (observations by field personnel)	
NJ					y			y ("31 SSI RWIS weather stations statewide")	

Table 3.1.6.1: Systems other than ESSs used by State DOTs to Gather Road Weather Information									
State	**Ag[1]**	**Air Qual[2]**	**Airport[3]**	**CCTV[4]**	**MES[5]**	**State Mesonet[6]**	**Other Mesonet**	**Other**	**No RWIS[7]**
NM									
NY									
NC									y
ND	y		y						
OH					y				
OK							y		
OR			y	y					
PA				y	y				
RI					y				
SC				y	y				
SD	y		y						
TN				y				y	
TX									
UT				y	y		y		
VT			y			y	y ("NWS, COE, Airports")	y [has FORETELL system which gathers NWS info and presents it graphically by road segment location. Mostly atmospheric (not ground specific) data]	
VA				y	y			y (DTN, satellite, Cable Weather Channel)	
WA	y		y	y			y (Univ of Wash)		
WV									
WI			y	y	y				
WY				y					
Total	6	2	15	25	15	1	6	9	2
% of Responding States (n = 40)	15%	5%	38%	63%	38%	3%	15%	23%	5%

1 Agricultural monitoring networks
2 Air quality sensing stations
3 Airport monitoring systems (e.g. ASOS, AWOS)
4 Closed circuit television cameras
5 Mobile environmental sensors
6 State-owned mesoscale environmental monitoring network
7 State does not gather road weather information

State DOTs use a variety of systems other than ESSs to gather road weather information. Of those reporting an alternate system, closed circuit television cameras were mentioned more frequently than any other system. Use of airport and mobile environmental sensor systems was

also frequently reported. Few states use air quality sensing stations for road weather information.

3.1.6.2. Types of Vehicles with Mobile Environmental Sensors

Those states that reported using mobile environmental sensors to gather road weather information were asked to specify the type of vehicle carrying those sensors. Answers from responding states are included in the following table:

Table 3.1.6.2: Types of Vehicles on Which States have Mobile Environmental Sensors for Road Weather Information Gathering

State	Mnt Vehicles with AVL[1]	Other Vehicles
Indiana		"various mnt vehicles"
Kansas		infrared sensors, truck-mounted; KDOT also testing one camera
Kentucky		mnt vehicles without AVL
Maryland	y	
Minnesota	y	snowplows and supervisors' pickup trucks
Missouri	y	
Montana		temp sensors on plow trucks; no AVL
New Jersey	y	
Ohio	y	freeway service patrol (future)
Pennsylvania		infrared temp sensors mounted on snow plow trucks
Rhode Island		mnt; no AVL
South Dakota		mnt supervisors' vehicles
Utah		Y
Virginia	y	AVL piloted for evaluation only
Washington State		"All non-WSDOT data are collected by the Univ of Washington Dept of Atmospheric Sciences in conjunction with the local NWS office and the Northwest Modeling Consortium, and sent to WSDOT. All info is available via WSDOT web pages."
Wisconsin		mnt vehicles; no AVL
Wyoming		"CCTV will be used for the first time. Webcams have been used extensively for visual reasons."

[1]Automated vehicle location technology

A few states have mobile environmental sensors on vehicles with AVL; several have such sensors on vehicles without AVL, especially on snow plows and supervisors' vehicles.

3.1.6.3. Data Collected by Mobile Environmental Sensors

Those state DOTs that reported use of mobile environmental sensors were asked what types of data those sensors collect. Information from responding states is summarized in the following table:

Table 3.1.6.3: Types of Data Collected by State DOT Mobile Environmental Sensors

State	Air Temp	Pvmt Surf Temp	Pvmt Freeze Pt	Pvmt Condition[1]	Pvmt Friction Coeff[2]	Other
Connecticut	y	y				
Indiana	y	y				
Kansas	y	y				
Kentucky	y	y				
Maryland				y		
Minnesota	y	y				
Missouri	y	y		y		
New Jersey	y	y				
Ohio	y	y			Y	
Pennsylvania		y				
Rhode Island		y				
South Dakota	y	y				
Utah		y				
Virginia						GPS[3], application rate of chemical for deicing
Wisconsin	y	y				

[1]Pavement condition (wet, dry, icy, snow-covered, flooded)
[2]Pavement friction coefficient
[3]Global Positioning Satellite location

Most State DOTs which responded regarding use of mobile environmental sensors reported measurement of air temperature and pavement surface temperature. Few other types of measurements were reported.

3.1.7. Entities with Whom States Share Road Weather Information

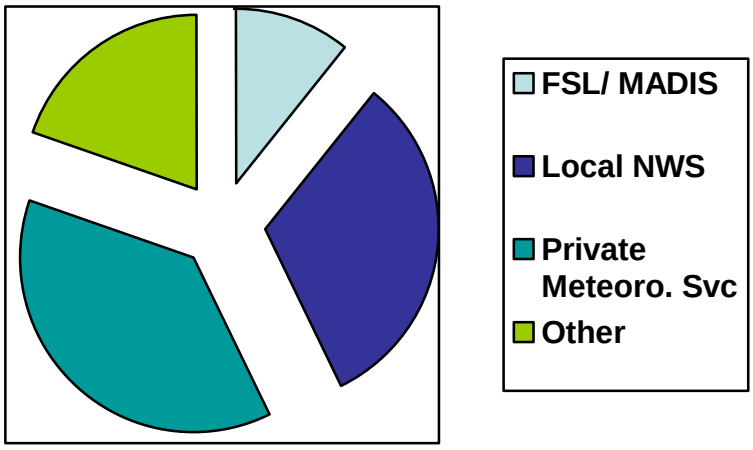
Specific meteorological organizations with whom participating states share some Road Weather Information are outlined in the following table:

Table 3.1.7.1: Weather Organizations with whom State DOTs Share Road Weather Information					
State	**FSL/ MADIS[1]**	**Local NWS[2]**	**Private Meteoro. Svc[3]**	**Do Not Share**	**Other**
Alaska		y			
California		y	y		
Colorado					"Colorado-based cities and counties, entire traveling public via www.cotrip.org "
Connecticut				y	
Florida		y	y		
Georgia			y		"Data is (sic) freely available from the www.georginavigator.com website"
Idaho	y	y			Utah mesonet
Indiana			y		City of Indianapolis
Iowa	y	y	y		
Kansas	y	y	y		"Weather station outputs on Internet"
Kentucky	y	y	y		
Louisiana				y	
Maine					"Will have a more mature system in coming years"
Maryland			y		Available via www.chart.state.md.us
Massachusetts					"May share in future, when ESS integrated into their TOC system software"
Minnesota	y	y	y		
Missouri					"Working towards sharing with partners"
Montana		y	y		
Nebraska					Meridian Environmental
Nevada		y	y		MesoWest, Nevada University System, National Climate Center
New Hampshire			y		
North Dakota		y	y		
Ohio	y	y	y		
Oregon		y	y		
Pennsylvania		y			
Rhode Island				y	
South Carolina			y		
South Dakota			y		
Tennessee		y	y		
Utah			y		Univ. of Utah, MesoWest
Virginia				y	

Table 3.1.7.1: Weather Organizations with whom State DOTs Share Road Weather Information					
State	**FSL/ MADIS[1]**	**Local NWS[2]**	**Private Meteoro. Svc[3]**	**Do Not Share**	**Other**
Washington State		y	y		Washington Dept of Atmospheric Sciences
Wisconsin		y			
Wyoming		y	y		
TOTAL	6	18	21	4	11

[1]NOAA's Forecast System Laboratory to the Meteorological Assimilation Data Ingest System
[2]National Weather Service through local forecast offices
[3]Private meteorological services

The following pie chart illustrates the percentage of responding states that reported each type of sharing:



State DOTs were asked about other agencies with whom they share road weather information. Answers from responding states are summarized in the following table.

Table 3.1.7.2: Other Agencies and Entities with whom State DOTs Share Road Weather Information									
Responding State	**Emerg Mgmt[1]**	**Public Safety[2]**	**Transit[3]**	**Info Svcs[4]**	**Comm Vehicle Ops[5]**	**Schools[6]**	**Traffic Mgmt Ctrs**	**Mnt Crews**	**Other**
AL	y	y							major weather conditions posted on website
AK	y	y						y	
CA		y					y	y	"very spotty and location-specific, due to networking challenges"
CO	y	y	y	y	y	y	y	y	statewide media, military,

Table 3.1.7.2: Other Agencies and Entities with whom State DOTs Share Road Weather Information									
Responding State	**Emerg Mgmt[1]**	**Public Safety[2]**	**Transit[3]**	**Info Svcs[4]**	**Comm Vehicle Ops[5]**	**Schools[6]**	**Traffic Mgmt Ctrs**	**Mnt Crews**	**Other**
									USPS
CT	y		y					y	
FL	y	y		y					
GA									data.georgianavigator.com and www.georgianavigator.com
HI								y	
ID	y	y						y	Utah MesoNet directly through FTP
IN							y	y	
IA	y	y	y	y	y	y	y	y	"publish page on internet"
KS		y							
KY	y	y	y				y	y	TV stations
LA	y	y					y		
MD	y	y	y	y			y	y	
MA									
MI		y					y		"Our control rm is also the State Dispatch Police center. Sharing is automatic from the CCTV cameras."
MN	y	y					y	y	
MO									"Working toward sharing with any interested agencies/entities"
MT									data freely available on web
NE									511 ATIS
NV								y	University system in Nevada, Univ of Utah, National Climate Ctr
NC							y	y	
ND	y	y			y			y	
OH	y	y							
OR		y		y			y	y	
PA								y	motorists on PA roads
RI									
SC	y								
SD		y			y			y	any public agency via internet
VT		y		y					
VA	y	y		y	y	y	y	y	
WA	y	y	y		y		y	y	Univ of Washington

Table 3.1.7.2: Other Agencies and Entities with whom State DOTs Share Road Weather Information									
Responding State	**Emerg Mgmt[1]**	**Public Safety[2]**	**Transit[3]**	**Info Svcs[4]**	**Comm Vehicle Ops[5]**	**Schools[6]**	**Traffic Mgmt Ctrs**	**Mnt Crews**	**Other**
WV	y	y						y	
WI							y	y	
Total (n = 35)	17	21	6	7	6	3	14	21	15
% of Responding States Sharing with this Type of Entity	49%	60%	17%	20%	17%	9%	40%	60%	43%
1 Emergency Management 2 Public Safety (eg law enforcement, highway patrol) 3 Transit operators 4 Information service providers 5 Commercial vehicle operators 6 School districts									

Among states who share RWIS data with entities other than weather organizations, a majority share with Public Safety agencies and maintenance crews. A substantial percentage of these states also share with Emergency Management agencies or traffic management centers. Few reported sharing with school districts. A few make their data widely available on the Internet.

3.1.8. Road Weather Information Disseminated by State DOTs to the Traveling Public

State DOTs were asked if they provided road weather information to the traveling public; 35/40 responding states answered yes (88%), while 5/40 (12%) responded no. Ten states did not respond initially. However, upon further questioning, a total of 39 states provided information on at least one means of dissemination of road weather information to the traveling public.

State DOTs that stated that they do provide road weather information to the traveling public were asked what types of road weather information they disseminate. The answers from responding states are included in the following table.

Table 3.1.8: Types of Road Weather Information Disseminated by State DOTs to the Traveling Public							
Responding State	**Atmosph[1]**	**Route-Specific Pvmt Data[2]**	**Route Video[3]**	**Weather-related Travel Restrictions[4]**	**Gen Forecast Data[5]**	**Route-Specific Forecast Data**	**Other**
AL	y			y	y		
AK	y	y	y	y	y		
CA							In extreme conditions, will

Table 3.1.8: Types of Road Weather Information Disseminated by State DOTs to the Traveling Public							
Responding State	**Atmosph[1]**	**Route-Specific Pvmt Data[2]**	**Route Video[3]**	**Weather-related Travel Restrictions[4]**	**Gen Forecast Data[5]**	**Route-Specific Forecast Data**	**Other**
							use HAR/CMS signs to forewarn of unusually poor conditions (dense fog, snow and ice/chain controls, flooding, etc.
CO	y	y	y	y	y		
CT		y	y	y			
FL		y	y	y			
GA				y			
HI		y		y			
ID		y	y	y			
IA	y			y	y		"Towing services prohibited"
KS	y	y		y	y	y	
KY	y			y	y		
LA			y	y			
ME		y	y		y		
MD	y		y	y	y	y	Pvmt temp
MA						y	
MI		y	y				
MN		y		y	y	y	
MO		y					"Implementation plan will incorporate all listed"
MT	y	y	y	y		y	
NE		y		y	y		
NV	y			y			High wind warnings
NH		y			y		
NM	y	y	y	y			
ND		y		y		y	
OH	y	y		y			
OR	y	y	y	y	y		
PA	y		y				

Table 3.1.8: Types of Road Weather Information Disseminated by State DOTs to the Traveling Public							
Responding State	**Atmosph[1]**	**Route-Specific Pvmt Data[2]**	**Route Video[3]**	**Weather-related Travel Restrictions[4]**	**Gen Forecast Data[5]**	**Route-Specific Forecast Data**	**Other**
RI	y				y		
SC		y	y		y	y	
SD	y	y		y		y	
TN		y					Severe weather warnings
UT			y	y			In process of putting RWIS data on the commuterlink website
VT	y	y		y	y	y	Hazardous driving conditions
VA	y	y	y	y			
WA	y	y	y	y	y	y	
WV		y					
Total (n = 37)	18	25	17	25	16	10	n/a
% of Responding States Disseminating this Type of Info	49%	68%	46%	68%	43%	27%	n/a

1Atmospheric observations (e.g. precipitation and air temp from ESS)
2Route-specific pavement condition data (e.g. dry, wet, plowed, flooded)
3Video images of selected routes
4Weather-related travel restrictions (e.g. tire chain requirements, closed routes)
5General weather forecast data (e.g. NWS warnings)

A majority of responding states disseminate route-specific pavement condition data and weather-related travel restrictions to the traveling public. A significant percentage of these states also disseminate atmospheric observations, selected route video, and general weather forecast data. A few states disseminate route-specific weather forecast data.

3.1.9. Systems for Dissemination of State DOT Road Weather Information

3.1.9.1. Types of Dissemination Systems Used for State DOT Road Weather Information

State DOTs that do share road weather information with the traveling public were asked to specify the types of dissemination systems they use. The following table summarizes answers provided by responding states.

Table 3.1.9.1: Types of Dissemination Systems Used by State DOTs to Provide Road Weather Information to the Traveling Public												
State	**Rdside Warning Dev[1]**	**In-vehicle Dev[2]**	**Inter-active Kiosks**	**Pers Comm Dev[3]**	**Dedic TV[4]**	**Fax**	**Email**	**Web**	**511[5]**	**Non-511 Tel[6]**	**IVRT?[7]**	**Other**
AL	Y							y				
AK	Y							y	y		y	
AR								y				
CA	Y											
CO	Y		y	y	y	y	y	y	y	y	y	www.cotrip.org
CT	Y									y		
FL	Y								y		y	
GA								y		y		
HI	Y											
ID								y		y		
IN								y				
IA	Y		y					y	y		y	
KS								y	y		y	
KY	Y							y	y		y	
LA	Y							y	y			
ME								y	y		y	
MD	Y							y				
MA										y		
MI	Y											
MN		y						y	y		y	
MO								y	y	y		
MT								y	y		y	
NE	Y							y	y		y	
NV	Y							y				
NH								y	y		y	
NM	Y							y	y	y	y	
ND			y			y		y	y		y	
OH								y				
OR					y			y	y			
PA								y		y		
RI	Y				y			y				
SC								y		y		
SD			y				y	y	y			
TN								y				satellite-fed kiosks at rest areas and welcome centers
UT	Y						y	y	y		y	
VT								y	y		y	one

Table 3.1.9.1: Types of Dissemination Systems Used by State DOTs to Provide Road Weather Information to the Traveling Public												
State	**Rdside Warning Dev[1]**	**In-vehicle Dev[2]**	**Inter-active Kiosks**	**Pers Comm Dev[3]**	**Dedic TV[4]**	**Fax**	**Email**	**Web**	**511[5]**	**Non-511 Tel[6]**	**IVRT?[7]**	**Other**
												LPFM radio station
VA	Y			y		y	y	y	y	y	y	
WA	Y		y					y	y	y	y	
WV								y		y		
Total (n = 39)	19	1	5	2	3	3	4	33	21	12		n/a
% of States Using this System	49%	3%	13%	5%	8%	8%	10%	85%	54%	31%		n/a

1 Roadside warning devices, eg DMS, HAR
2 In-vehicle devices
3 Personal communication devices, e.g. pagers, and PDAs
4 Dedicated television channel
5 511 Telephone system
6 Telephone system other than 511
7 Does the telephone system use interactive voice response technology?

By far, the most commonly used method of dissemination of road weather information from state DOTs to the traveling public is web-based. A significant percentage of responding states use roadside warning signs or a 511 telephone system, and several use a non-511 telephone system.

3.1.9.2. Websites and Telephone Numbers for Road Weather Information for the Traveling Public

Those DOTs that provide road weather information to the traveling public via the web or a non-511 telephone number were asked to provide those websites or phone numbers. Responses are detailed in the following table.

Table 3.1.9.2: Websites and Non-511 Telephone Numbers for Road Weather Information for the Traveling Public		
Responding State	**Web Info**	**Non-511 Tel #**
AL	www.AlabamaDOT.com	
AK	http://511.alaska.gov/	
AR	www.ahtd.org	
CO	images provided on web for rebroadcast by local cable networks	303-639-1111
CT		860-594-2650 1-800-443-6817
GA	www.georgianavigator.com	*dot 888-635-8287

Table 3.1.9.2: Websites and Non-511 Telephone Numbers for Road Weather Information for the Traveling Public		
Responding State	**Web Info**	**Non-511 Tel #**
		404-635-6800
ID		1-888-ida-road
IN	http://www.in.gov.dot/ (to start Fall 2004)	
IA	dotweatherview.com	
KY	www.511.ky.gov	
LA	http://www.dotd.louisiana.gov/	
ME	http://www.511Maine.gov	
MD	www.chart.state.md.us	
MA		*1 cell 617-374-1234 land
MN	http://www.511mn.org/	
MO	www.modot.org/road_conditions/index.htm	1-800-222-6400
MT	http://www.mdt.state.mt.us/trvinfo/weather/rwis.html	
NE	www.nebraskatransportation.org	
NV	http://www.nevadadot.com/traveler/rwis/	
NH	www.nh.gov/dot/511/	
NM	CARS software	
ND	http://www.state.nd.us/dot/roadreport/roadreport/roadreportinfo.asp	
OH	www.buckeyetraffic.org	
OR	www.tripcheck.com	
PA		1-888-783-6783
SC	www.scdot.org	1-888-877-9151
SD	www.sddot.com	
TN	www.tdot.state.tn.us	
VT	www.511vt.com www.511vt.org www.511Vermont.com	800-429-7623
VA	www.511Virginia.com	1-800-367-7623
WA	wsdot.wa.gov/traffic	1-800-695-road
WV	http://www.wvdot.com	1-877-wva-road

3.1.9.3. Feasibility of Integration of State DOT RWIS Data with Existing GIS

States that share RWIS data in some fashion were asked if their weather information was provided in a format that can be integrated with an existing Geographic Information System

(GIS) and overlaid on a road network. Responses are summarized in the following table. States that provided no answer are not included in the table.

Table 3.1.9.3: Responses from State DOTs to: "Is weather information provided in a format that can be integrated with existing GIS and overlaid on a road network?"		
Responding State	**Yes**	**No**
AL		√
AK	√	
AR		√
CA		√
CO	√	
CT	√	
FL		√
GA	√	
HI		√
ID		√
IN	√	
IA		√
KS	√	
KY		√
LA	√	
ME	√	
MD	√	
MA		√
MI		√
MN		√
MO	√	
MT	√	
NE	√	
NV		√
NH	√	
NJ	√	
NM	√	
NC		√
ND	√	
OH	√	
OK		√
OR		√
PA	√	
RI		√

Table 3.1.9.3: Responses from State DOTs to: "Is weather information provided in a format that can be integrated with existing GIS and overlaid on a road network?"		
Responding State	**Yes**	**No**
SC	√	
SD	√	
TN		√
UT		√
VT	√	
VA	√	
WA	√	
WV		√
WI	√	
Total (n = 43)	24	19
% of Responding States	56%	44%

A majority of responding states do have weather information that is provided in a format that can be integrated with existing GIS and overlaid on a road network.

3.1.9.4. Archiving of State DOT Road Weather Information

State DOTs were asked if their weather information is archived in a way that would permit their re-use in forensics or validation studies. The following table summarizes responses; non-responding states are not included in the table.

Table 3.1.9.4: Weather Data Archiving[1] by State DOTs			
Responding State	**Data Archived-Yes**	**If Archived, How Used**	**Data Not Archived**
AL			√
AK	Y	Oracle; access through a data warehouse for internal DOT users	
AR			√
CA			√
CO			√
CT			√
FL			√
GA			√
HI			√
ID			√
IN			√
IA	Y	Training	

Table 3.1.9.4: Weather Data Archiving[1] by State DOTs			
Responding State	**Data Archived-Yes**	**If Archived, How Used**	**Data Not Archived**
KS	Y	Climatological studies, Wind Power Inquiries, Road Painting Damage claims	
KY	Y	Comma separated files	
LA			√
ME			√
MD	Y	Available via public website for download in .csv files. has also been provided in dataset format to NOAA and Private Wind Turbine companies	
MA			√
MI			√
MN	Y	All ESS data archived	
MO	Y	"Working towards this"	
MT	Y		
NE			√
NV	Y	Construction claims	
NH			√
NJ	Y		
NM	Y		
NC			√
ND	Y		
OH	Y	Comparison of reading between sites; evaluation of response to snow events	
OK			√
OR	Y	Research, public requests	
PA			√
RI	Y		
SC			√
SD	Y	Retrospectively assess road/weather condition system performance	
TN			√
UT	Y		
VT			√
VA	Y		
WA	Y	Identify weather trends in mountain passes	
WV			√
WI	Y	A few requests for crash investigations	
Total (n = 43)	20	n/a	23

Table 3.1.9.4: Weather Data Archiving[1] by State DOTs			
Responding State	**Data Archived-Yes**	**If Archived, How Used**	**Data Not Archived**
% of Responding States	47%	n/a	53%

By a small majority, most responding state DOTs do not archive their road weather data. Those who do archive have used their data for a variety of processes, including data validation, claims investigations, private wind turbine company requests, et al.

3.1.10. Non-weather Entities from whom State DOTs Receive Road Weather Information

Table 3.1.10: Non-weather Entities from whom State DOTs Receive Road Weather Information									
Responding State	**Emerg Mgmt**	**Public Safety**	**Transit**	**Info Svcs**	**Comm Vehicle Ops**	**Schools**	**Traffic Mgmt**	**Mnt Crews**	**Other**
CO		y	y					y	
HI								y	
IA		y							
KS									Sedgwick County
LA		y							
MD	y	y					y		
MN								y	
NE								y	
NH	y	y				y		y	
NJ	y						y	y	
NC	y								
RI	y	y							
UT							y		"We staff the Traffic Operations Center with consulting meteorologists to support all of our weather needs."
VT		y							Safety Department
VA	y	y					y	y	
WV	y	y						y	
Total (n = 16)	8	9	1	0	0	1	4	8	n/a
% of Responding	50%	56%	6%	0	0	6%	25%	50%	n/a

Table 3.1.10: Non-weather Entities from whom State DOTs Receive Road Weather Information									
Responding State	**Emerg Mgmt**	**Public Safety**	**Transit**	**Info Svcs**	**Comm Vehicle Ops**	**Schools**	**Traffic Mgmt**	**Mnt Crews**	**Other**
States Receiving RWIS info from this Type of Entity									

Among those state DOTs which receive road weather information from non-weather entities, just over half receive them from Public Safety entities. Half also receive information from Emergency Management entities or maintenance crews. Almost no state DOTs receive road weather information from transit operators, information service providers, commercial vehicle operators or schools.

3.1.11. Barriers to State DOT Sharing of Road Weather Information

3.1.11.1. Barriers to Obtaining or Implementing ESSs

State DOTs were asked to identify barriers to obtaining or implementing ESSs. Answers from responding states are summarized in the following table.

Table 3.1.11.1: Barriers to Obtaining or Implementing ESSs					
Responding State (total n = 44)	**No Perceived Need**	**Cost**	**Use Other Source(s)**	**No Barriers**	**Other**
Alabama		y			
Alaska		y			
Arkansas	Y				
California		y			Perceived as much lower priority than other highway infrastructure projects such as safety improvements, pavement rehabilitation, mobility enhancements, etc.
Colorado					"Vendor support has been suspect at times"
Connecticut				y	
Florida		y			
Georgia					
Hawaii	Y			y	
Idaho		y			Proprietary nature of ESS and software
Indiana		y			
Iowa				y	

Table 3.1.11.1: Barriers to Obtaining or Implementing ESSs					
Responding State (total n = 44)	**No Perceived Need**	**Cost**	**Use Other Source(s)**	**No Barriers**	**Other**
Kansas		y			
Kentucky		y			
Louisiana				y	
Maine				y	
Maryland	Y				
Massachusetts		y			
Michigan	Y	y	y		
Minnesota					Communication costs
Missouri		y	y		
Montana				y	
Nebraska					Proprietary business models, data ownership
Nevada				y	
New Hampshire		y			Technical resolution of processing, storing and disseminating data within NHDOT
New Jersey					70 other ESS throughout NJ. Rutgers Univ will be creating a web page to display the information.
New Mexico	Y	y			
North Carolina	Y	y	y		
North Dakota		y			
Ohio	Y	y			
Oklahoma	Y	y	y		
Oregon				y	
Pennsylvania		y			Field operators have not started using them actively for snow removal operational decision-making
Rhode Island		y			Other time commitments
South Carolina		y			
South Dakota		y			Burden of maintenance to ensure reliable operation
Tennessee				y	
Utah		y			Maintenance costs are very high, especially road puck replacements due to surface work
Vermont				y	
Virginia	Y	y			
Washington State		y			

Table 3.1.11.1: Barriers to Obtaining or Implementing ESSs					
Responding State (total n = 44)	**No Perceived Need**	**Cost**	**Use Other Source(s)**	**No Barriers**	**Other**
West Virginia	y		y	y	Tried one RWIS station in the early 1990s; did not perform adequately. Recently installed a fog sensor, which activates flashing lights on warning signs; evaluating this fog sensor's reliability and performance.
Wisconsin		y			
Wyoming				y	
Total	10	25	5	12	12
% of Responding States With Specified Response	23%	57%	11%	27%	27%

Among responding states, the most commonly cited barrier to obtaining or implementing ESSs was cost (57% of responders). The second most frequently cited barrier was "no perceived need" (27%). Several states answered that they had no barriers (27%). Several other reasons were given, including low priority and proprietary problems.

3.1.11.2. Barriers to Sharing ESS Data

Those states that have RWIS ESSs, but do not share information, were asked to state the reasons for not sharing at this time. The following table summarizes those responses:

Table 3.1.11.2: Barriers for Sharing Data for States with RWIS ESS but with Limited Sharing				
State		**Cost**	**Proprietary Restraints from Private Meteorological Service Providers**	**Other**
California		Y	Y	"Hardware is not 'open source' NCTIP compliant"
Colorado			Y	
Connecticut				Accuracy of data
Louisiana				System not yet fully integrated
Maine				Minimal data
Massachusetts		Y		In plan for future
Nebraska				"Will address as need arises"
New Hampshire				"Still experimenting with our one site"
Rhode Island				Liability; reliability of data
Wisconsin		Y		

Table 3.1.11.2: Barriers for Sharing Data for States with RWIS ESS but with Limited Sharing				
State		**Cost**	**Proprietary Restraints from Private Meteorological Service Providers**	**Other**
Virginia			y	Currently under development

States who had stated that they had RWIS ESSs were also given the option of answering that they never considered sharing data, but none checked this answer.

3.1.11.3. Feasibility of Use of NLETS for Communications

Communications systems are a significant issue for many states. One proposal for a widely available and potentially cost-effective communications solution is the use of the National Law Enforcement Telecommunications System (NLETS). This system takes advantage of specific radio frequencies reserved for law enforcement agencies. Road weather observations would be transmitted via radio from ESSs to local law enforcement drop sites, and from there via landline to the NLETS system.

The possibility of use of this system came to light after our survey was complete. One of our members made phone calls to those states which were not yet sharing ESS data, or were not sharing widely, to inquire about their familiarity with the NLETS communications possibility. The results from responding states are summarized in the following table:

Table 3.1.11.3: State DOT Responses Regarding NLETS Communications Feasibility					
State	**Current RWIS Communications System**	**Considered NLETS?**	**Willing to Consider NLETS?**	**Perceived NLETS Positives**	**Perceived NLETS Negatives**
Alaska	Recent plan includes wide area network, internet, wireless radios and telephone	No	Possibly		
Georgia	Uses dial-up modem exclusively, but expensive. Considering use of radio in 900 mHz-1.2 gHz range	No	If viable and practical		
Kentucky	Dial-up modem	No	If practical		
Maine	Dial-up	No	Probably not		State Police wanted $15 million for communications system upgrade
Massachusetts	Cell, state-owned microwave	No	Probably not		In the past, law enforcement agencies have wanted to charge for use of their system
Minnesota	Dial-up, DSL, cell, 960	No			

Table 3.1.11.3: State DOT Responses Regarding NLETS Communications Feasibility					
State	**Current RWIS Communications System**	**Considered NLETS?**	**Willing to Consider NLETS?**	**Perceived NLETS Positives**	**Perceived NLETS Negatives**
	mHz radio				
Missouri	Dial-up, microwave, direct-link landline	No	Probably not		Limited band width, hilly terrain in Missouri
Tennessee	Radio transmitters to dial-up server	No	Possibly		Concerned about hardware upgrade costs
Utah		Yes	If practical		Concerned about unproven technology
Wisconsin		Yes	No		Cost of radios at each site

3.1.12. State DOT Sections other than ITS with Responsibility for RWIS

This survey contacted state POCs for ITS; POCs were asked what other sections within their agency were involved in or had responsibility for RWIS. The following table summarizes this information for states that identified other responsible sections.

Table 3.1.12: State DOT Sections (Other than ITS) Involved in or Responsible for RWIS						
Responding State	**Traffic Mgmt**	**Trav Info[1]**	**Mnt[2]**	**Construction**	**None[3]**	**Other**
Alaska		y				
California	Y		y			
Colorado		y	y			
Connecticut	Y	y	y	Y		
Florida		y				
Georgia	Y		y			
Idaho					y	
Indiana					y	
Iowa			y			
Kansas		y				"All Agency access, Mnt responsible, ATIS automatically accesses"
Kentucky	Y		y			
Louisiana		y				
Maine			y			"Mnt and Ops[4] have full responsibility for RWIS"
Maryland			y			
Massachusetts			y			District Mnt Office
Minnesota			y			"Office of Electronic Communications-Mnt of ESS Sites"
Missouri	Y	y	y			
Montana	Y	y				

Table 3.1.12: State DOT Sections (Other than ITS) Involved in or Responsible for RWIS						
Responding State	**Traffic Mgmt**	**Trav Info[1]**	**Mnt[2]**	**Construction**	**None[3]**	**Other**
Nebraska		y	y			Ops
Nevada			y			Districts, Information Systems
New Hampshire						"Our Materials and Research Bureau- our one site is Research- funded"
North Dakota		y	y			
Ohio	Y	y	y	y		
Oregon	Y	y	y			
Pennsylvania			y			
Rhode Island					y	
South Carolina					y	
South Dakota			y			
Tennessee			y			
Utah	Y	y	y			
Virginia	Y	y	y			
Washington State	Y	y	y	y		
Wisconsin			y			

[1]Traveler information dissemination
[2]Maintenance
[3]State POCs could check a box for "none"
[4]Operations

3.1.13. Coordination of RWIS Data Gathering Between States

State DOTs were asked if they coordinate data-gathering with other states. Of the responding states, eight responded "yes". Those states, and the states with whom they coordinate data-gathering, are summarized in the following table:

Table 3.1.13: Coordination of RWIS Data-gathering Between States	
Responding State Which Reported Coordination of RWIS Data-gathering with other States	**States with Which Responding State Coordinates RWIS Data-gathering**
California	Nevada, Oregon
Colorado	
Idaho	Utah, Montana
Maine	New Hampshire, Vermont
Montana	Idaho, North Dakota
Nebraska	Missouri, Colorado, Wyoming, Iowa
South Dakota	North Dakota, Montana, Nebraska, Kansas
Washington State	Idaho current; Oregon soon

3.2. Breakdown of Survey Information by Level of Information Sharing

3.2.1. States Currently Sharing with a Mesonet or NOAA, and NWS

Seven state DOTs reported this level of sharing, and included Idaho, Iowa, Kansas, Kentucky, Minnesota, Ohio and Utah. Some characteristics of these states included:

- They tended to collect more types of environmental data than states in other sharing categories (average of 12 vs 9 types of data).
- They do not tend to be particularly wealthy states; average annual per capita income for these states falls below the national average in census data (US average $27,857; these states $25,188, source: http://www.census.gov/statab/ranks/rank29.html)
- They tend to be in the Midwest or Northern Interior states, but are not necessarily those states with the harshest winter weather.
- They all have established systems in place for sharing of road weather information with the traveling public; all have web-based systems, and most have multiple means of dissemination.
- Their weather information is not consistently provided in a format that can be integrated with GIS.
- They do not consistently archive their road weather information.
- Even though these states are sharing the road weather information they have at this time, most perceive a cost barrier to obtaining or implementing further ESSs.

3.2.2. States Currently Reporting Sharing only with NWS

These states include Alaska, California, Florida, Montana, Nevada, North Dakota, Oregon, Pennsylvania, Tennessee, Washington State and Wisconsin. Characteristics of these states include:

- They tend to collect about the same number of different kinds of ESS data as states that are fully sharing (average of 11 types of data).
- They also are not on average particularly wealthy states, with an average Per Capita Income (PCI) ($26,818) slightly less than the national average.
- They are diverse in geography and climate for the US spectrum.
- They do not all have systems in place for dissemination of road weather information to the traveling public.
- The majority does not have their weather information in a format that can be integrated into existing GIS.
- They do not consistently archive their road weather data.
- A majority of the POCs perceive cost as a barrier to expanding their ESS systems, and some have other barriers.
- Only California gave information regarding barriers to wider sharing, and cited cost, proprietary restraints, and lack of 'open-source' compliance for software.

3.2.3. States that Reported that they Make Weather Information Available on a Website, but are Not Yet Actively Sharing

These states included Colorado, Georgia and Maryland. The small size of this group precludes meaningful characterization, and no patterns emerged.

3.2.4. States Sharing with Private Weather Organizations

These states include Indiana, Nebraska, New Hampshire, South Carolina and South Dakota. Their characteristics include:

- They also collect about the same number of types of environmental data as fully sharing states (average = 12 types).
- They also have an average PCI slightly below the national average ($26,045).
- They are not geographically clustered.
- All have established systems for sharing of road weather information with the traveling public; all have web-based systems, and most have multiple means of dissemination.
- All report that their road weather information is provided in a format that can be integrated with existing GIS.
- Only South Dakota archives their road weather information.
- Most have at least two barriers (usually cost and proprietary restraints) to expansion of ESS systems or further sharing of their data.

3.2.5. States that Have ESSs, but do Not Share Observations

These states include Connecticut, Louisiana, Maine, Massachusetts, Missouri, Rhode Island and Virginia. Their characteristics include:

- They collect only slightly fewer types of environmental data than fully sharing states (10 types vs 12 for full sharers).
- They tend to be somewhat wealthier states than the national average (average PCI $29,366 for these states vs $27,857 for the nation).
- They are not geographically clustered.
- Although all have some system for sharing of road weather information with the traveling public, not all have web-based systems.
- Their weather information is not consistently provided in a format that can be integrated with GIS.
- Only Rhode Island and Virginia archive their road weather information at this time.

3.2.6. States that do Not Have ESSs

These states include Alabama, Arkansas, Hawaii, Michigan, New Jersey, New Mexico, North Carolina, Oklahoma, Vermont and West Virginia. Their characteristics include:

- Although these states reported having no ESSs, 7/10 do collect road weather information by some means. These 7 states collect an average of 9 types of environmental data.

- Per capita income for these states is significantly below the national average ($23,108 for these states vs $27,857 for the nation) and is even lower when one excludes the one wealthy state, New Jersey (average PCI of remaining nine states = $21,729).
- They are not geographically clustered.
- Some do not report any means of dissemination of road weather information to the traveling public.
- For most, the type of road weather information they collect is not provided in a format that can be integrated with GIS.
- Only New Jersey and New Mexico archive their road weather data.
- Most of these states cite "no perceived need" and cost as barriers to obtaining ESSs.

3.2.7. Conclusions Regarding Characteristics of Sharing vs Non-sharing States

- States that are fully sharing now, and states that share only with private weather services, tend to collect the most types of environmental data.
- Fully sharing states are not necessarily wealthy states. However, states with no ESSs do tend to be poorer states. The latter does not hold entirely true, however; New Jersey, the state with the second highest PCI, reports that it has no ESSs. Connecticut, the wealthiest state in the country in terms of PCI, reports that it has ESSs, but does not share.
- Fully sharing states tend to cluster geographically in the Midwest and Northern Interior. States in other sharing categories do not tend to cluster geographically.
- States that are fully sharing now, and states that share only with private weather services, all have established systems for sharing of road weather information with the traveling public. All have web-based systems, and most have multiple means of dissemination.
- Only those states that share only with private weather services consistently have a GIS-compatible format.
- Archiving of road weather data is variable in all groups.
- Cost is the most frequently cited barrier to expanding ESS systems and to expanding sharing. Proprietary barriers to sharing are also commonly mentioned.

4. Practice Information from Selected RWIS Sharers

Our group gathered information, through our survey and by other means, on states and organizations that are successfully sharing road weather information, or are interested in expanding their sharing. Several individuals granted us interviews to give us insight into their practices. A few key points from some of these interviews follow.

4.1. A State Sharing RWIS Observations with an Active Interest in Expanded Sharing: Alaska

Mr. Jack Stickel of the Alaska Department of Transportation provided extensive information on the history of implementation of road weather information sharing in Alaska. A brief summary of information that he provided that might be of particular interest to states interested in sharing road weather information, or to agencies interested in facilitating sharing, follows.

Alaska included the National Weather Service in the very early stages of the state's RWIS deployment. Alaska included the NWS in several areas of planning:

- identification of user needs
- identification of existing data sources
- vendor reconnaissance
- planning of site selection
- planning of instrument location at each site
- ITS integration

A Memorandum of Understanding (MOU) between Alaska DOT and the NWS included the following elements:

- NWS will maintain the integrity of the data.
- NWS will acknowledge the source of the data if shared with another party.
- Alaska DOT will provide NWS access to the DOT's ftp site.
- Alaska DOT will provide NWS access to future ftp and website changes.

Method for sharing of data:

- NWS accesses the ADOT read-only ftp site and grabs the data.
- This process is fully automated on the ADOT side.
- Data are loaded to Oracle hourly and maintained for up to 48 hours.

Problems/challenges encountered by ADOT:

- Takes time to identify the right agency contact
- Takes time to identify the right person to champion data sharing
- Lack of a state climatologist for Alaska
- Lack of an effective way to notify NWS of site or communication outages
- Lack of a way to backfill missing observations in the NWS database
- Lack of feedback from NWS when there are problems

Funding issues:

- No special equipment needed to provide environmental data on the ftp site
- The NWS River Forecast Center provided tilting bucket precipitation gauges to supplement the observational network.
- ADOT provided funding for installation, commissioning and maintenance for the NWS-supplied tipping buckets
- Communication and power are additional costs
- Some cost for SSI data exporter changes for precipitation

Benefits:

- Additional environmental information (from tipping buckets)
- Increased NWS high wind warning capability
- Significant public use of website data, especially of weather images

- Long-term partnership with the NWS Alaska region HQ, the three regional forecast offices (Anchorage, Juneau and Fairbanks), and the River Forecast Center
- Goodwill

Things the NWS or FHWA could do to help state or local road authorities with the process of RWIS data sharing:

- Additional funding
- Assistance with communication tie-in. Some federal agencies have the communication systems ADOT needs to effectively and cheaply retrieve data, but these agencies have been unwilling to deal with ADOT due to heightened security concerns.
- Allow NWS to provide support other than equipment, e.g. maintenance sharing, communications networks

4.2. A State Sharing RWIS Observations with a Multi-state Mesonet: Utah

Mr. Ralph Patterson of the Utah DOT spoke with our team regarding Utah's experience in developing a multi-state road weather information sharing system. Points of possible use to states wishing to share, and agencies wishing to facilitate sharing, include the following.

How Sharing Occurs:

- UDOT's philosophy is to make RWIS ESS data available to anyone who wants it
- UDOT shares RWIS data with MesoWest, which is managed by the University of Utah
- NWS accessed the RWIS data through MesoWest
- Avalanche data are passed directly to NWS by UDOT
- RWIS ESS data uploaded by UDOT to an ftp site at 10-15 minute intervals
- Thinks NWS could just as easily get this information directly from the ftp site, rather than via MesoWest

Cost Considerations

- Negligible cost for support of ftp site; T-1 lines already there to support other functions, and made room on existing server
- Arrangement with MesoWest was prompted by Salt Lake City Olympics; University of Utah now absorbs much of the cost
- University of Utah archives atmospheric data, but not road condition data. There is a fee associated with accessing the archived data; seems unfair since UDOT provided the data to begin with

Problems/challenges Encountered

- Different data standards used by different vendors; at this time, University of Utah is having trouble reading SSI data due to recent changes by SSI. System reconfiguration will be necessary.
- UDOT has no capacity to archive data

- Concerned that users must be educated. If systems are deployed without the users fully understanding what the systems can and cannot do, users may just turn away from the technology
- Siting guidelines, if available at all, are too subjective
- Lack of power and communications systems, especially in rural areas

Things NWS or FHWA Could Do to Facilitate Sharing

- Archiving of data, and provision of access to data at no charge to sharing states
- Develop objective siting standards

4.3. A State Sharing RWIS Observations with a NWS Forecast Office: Wisconsin

Mr. Mike Adams of the Wisconsin DOT gave our team some insight into Wisconsin's process that led to sharing of RWIS data.

What Led to Sharing

- WDOT had previously made their data available to NWS via a dial-in account
- NWS Forecast Office in Sullivan, WI requested that the data be made available to NWS by a system other than dial-in, due in part to the cost of dialing in
- In a Request for Proposal (RFP), WDOT requested that a File Transfer Protocol (FTP) site be established with NWS and other users in mind
- FTP server set up and maintained by vendor
- NWS has password and can access hourly RWIS observational data.

Cost Considerations

- Cost of server lumped into total costs for data gathering and web capabilities, therefore minimal additional expense
- DSL for Internet access to St. Louis (where data are replicated) is $70/mo.

Problems/Challenges

- No feedback from NWS regarding whether WDOT's data have been beneficial to the forecast process

Future Plans

- WDOT wants to provide data to MADIS
- As new ESS sites are added, WDOT plans to make observations available to NWS

What NWS or FHWA Can Do to Help Facilitate Sharing

- FHWA continue to keep NWS and American Meteorological Society (AMS) involved
- Emphasize the significance of RWIS observations to those parties who could advocate with a high level of influence
- Make the data available to all interested users, and not just NWS

4.4. Sharing of RWIS Data: Role of NOAA's Forecast Systems Laboratory

Ms. Patty Miller of FSL shared information regarding how FSL has successfully obtained RWIS data from multiple states.

The Process

- FSL is one of the development organizations that have helped the NWS implement the Advanced Weather Interactive Processing System (AWIPS). FSL has developed capabilities that allow ingest and quality control of local observations made available in AWIPS.
- Over time, FSL realized that significant amounts of weather data were being collected as surface observations from RWISs of several state DOTs; FSL wanted to find a way to share this data
- Initially, Ms. Miller contacted organizations and people that she knew had access to these surface observations to ask them if they would be agreeable to sharing
- More states became aware, and have been contacting FSL regarding possibility of sharing
- Data come directly from some state DOTs, and sometimes through MesoWest or a Forecast Office. In general, better for FSL to get data directly from state DOT servers, as this decreases time delay. FSL does not access from individual ESSs.
- Almost all data obtained via internet with scripts, using the ftp or http protocols
- Mostly, FSL "pulls" data, but some mesonets "push" to FSL
- FSL generally gathering data at a 10 or 15 minute update frequency; hopes to upgrade hardware and software to enhance data processing and allow acquisition of more frequent data updates
- FSL performs quality control on the observations and makes the data available real-time

Preferred Format

- FSL flexible in accepting various formats, in order to encourage sharing
- FSL reformats incoming data as necessary
- When a state discusses planned format changes with FSL, FSL recommends a very simple comma-delimited text, because most providers already have their data in text format

Levels of Distribution:

When a state brings in data, FSL asks the state what category of data distribution the state desires. Examples include:

- NWS only
- Government
- Research
- Educational organizations
- Full public distribution

Needed Metadata about ESSs

- Longitude

- Latitude
- Elevation (needed, but often not provided; FSL then interpolates from high-resolution terrain map)
- Unique station identifier

States that have ESSs, and Plan to Share when FSL has Capacity:

- Alaska
- Georgia
- Kentucky
- Missouri
- Nebraska
- North Dakota
- Ohio
- Pennsylvania
- South Dakota
- Vermont
- Virginia
- Wisconsin

Problems/Challenges

- Need more personnel at FSL for this purpose
- Need funding for these personnel
- Proprietary restraints
- Some states not comfortable with making their data public

5. An Emerging National Effort at Capture of RWIS ESS Data: NOAA's COOP Modernization Plan

Dr. Ken Crawford, who has recently been appointed NOAA Program Director for COOP Modernization, shared ideas regarding facilitation of capture of RWIS ESS data. The COOP Modernization effort seeks to enhance and modernize a national volunteer cooperative mesonet for sharing of weather observations. Addition of RWIS data to this network could provide a substantial amount of potentially useful information. A specific area of discussion included the possibility of use of LETS as a communication system for transmission of RWIS data.

- LETS is a two-way communication system used for transmission of data that impacts safety.
- Successfully used in Oklahoma to transmit approximately 1,000,000 observations per day.
- A specific frequency radio transmits ESS data to a local drop point, from which the data are transmitted via landline to a central server.
- Repeaters used in areas where terrain affects transmission.
- Relatively little equipment cost, since a dial-up system with phones is not used
- Requires radio and antenna for ESS; and modem, antenna and plug into backbone network at receiving end. Estimated cost of hardware at each site <$1000.
- High capacity in the possible frequencies of use

- Sharing of state-to-state data occurs through NLETS

6. Summary

Observations obtained from non-NOAA sources are currently utilized to augment those obtained from commissioned NOAA observational systems. Opportunities exist to improve the access and integration of observations collected from RWIS ESS sensors into NOAA operations.

There are numerous benefits for enhancing the availability of RWIS surface observations at local, regional and national levels, ranging from improving the understanding of mesoscale real time weather conditions by the NWS and federal, academic, and private partners to improved products and services for all sectors of our nation, including customers and the general public.

The results obtained from the survey of State DOTs provide a wealth of information on the present status of sharing of the RWIS observations with NOAA. Several states are partnering with NOAA to routinely provide this data at the MADIS run by OAR's FSL. Other states have expressed an interest in partnering with the NOAA to do so, but lack resources at the state level to do so. The primary barriers for enhancing the availability of RWIS surface observations to NOAA are the initial and maintenance costs to the state for necessary communications and supporting hardware and software development, and for human resources within NOAA.

A few key findings include:

- Many millions of road weather observations are collected every day.
- Much of these data are already in a web-based format that could easily be shared at the regional and federal level.
- Few state DOTs reported established siting and performance standards for their ESSs.
- States that are consistently widely sharing tend to have well-established web-based methods for dissemination of road weather information to the traveling public.
- Almost all state DOTs have cost barriers to sharing, but the states that are sharing most widely did not tend to be among the wealthier states.
- State DOTs that do not possess RWIS ESSs tend to have no perceived need for them.
- Other than cost, current barriers to sharing include proprietary restraints from private vendors, lack of identified "RWIS data sharing champions" for each state, lack of a unified affordable communications system, lack of uniform siting and performance standards for ESSs, and lack of feedback from NWS.

During our project, both NOAA and FHWA continued and expanded their efforts to increase sharing of RWIS ESS observations. NOAA's COOP Modernization effort is actively working toward capture of RWIS observations in its national cooperative weather data gathering model. Siting and performance standards guidelines are under development. DOTs from additional states have begun to share their RWIS ESS data at a multistate or national level.

POCs from states responding to the survey of RWIS described practices and policy that should be considered by the NWS as they plan for integrating these observations into the modernized COOP program. Existing state practices and policy for siting guidelines and standards will help the NWS begin to categorize levels of use for these observations.

7. Recommendations for NWS and FHWA:

7.1. Short-term

- Ensure NWS participates with the FWHA sponsored project to establish RWIS ESS siting guidelines
- Decide upon a nationwide standard for RWIS observations and recommend it be adopted at all states
- Coordinate all promotion of RWIS ESS data sharing through a single ultimate NOAA point of contact. A logical choice would be to appoint someone within the COOP Modernization team. It has been difficult for state DOTs to identify the appropriate officials to help them with their sharing efforts.
- Based upon siting standards, establish levels of NWS data use for these categories:
  - Verification
  - Analyses
  - Climate analyses of record and normals
  - Incorporation into NWS numerical model guidance forecasts
  - Incorporation into NWS forecasts and warnings
- Ensure local NWS Weather Forecast Offices work closely with state DOTs to partner to better understand how the NWS can incorporate decision making thresholds into routine and warning products. For example, 2" of snow coverage on pavements is used by operators to begin the snow removal process, and the NWS warning for 6' total over 24 hour is not helpful
- Ensure local NWS offices periodically provide feedback to state DOTs about benefits of RWIS observations for specific weather case studies
- Ensure state DOTs consult with the local NWS forecast office and the national NWS Headquarters when they consider augmenting their existing RWIS network with more ESS to maximize benefit to public
- Provide FHWA and State DOTs examples of objective evaluations of impact of the use of RWIS observations in NWS to demonstrate benefit of these additional observations
- Ensure managers at NWS, DOT and FHWA are aware of the significance of the benefits of the RWIS observations
- Ensure state DOTs begin to document the metadata for the ESS sensors
- Provide elevation data for all ESS to Patty Miller at FSL

7.2. Intermediate-term:

- Ensure a flexible architectural design is followed so states using other communication systems such as Land Mobile Radio can participate in the COOP Modernization
- Reduce proprietary constraints to RWIS ESS data sharing. Consider developing model contract language that would allow state DOTs to share RWIS ESS data obtained via state contracts with private weather service vendors.
- Continue to leverage FHWA surveys on RWIS to obtain feedback and information desired by the NWS

- Fully transition MADIS to operations
- Need to investigate how to transmit and utilize video from cameras mounted on RWIS ESS platforms to assist in the quality control of RWIS observations
- As FHWA becomes aware of plans for augmentation to existing RWIS networks, work with local Weather Forecast Offices (WFOs) to consult on location and siting of ESS
- Establish archive of RWIS observations with free and open access to the data at the NCDC
- Partner with vendors to establish a consistent and standard format for ESS observations

7.3. Long-term:

- NWS and FHWA partner to fund antennae, radios and hardware needed to locally and centrally collect and process state mesonet RWIS ESS observations via LETS and NLETS
- DOT operators need to work with NWS to better understand the relationship between the near surface air temperature and pavement temperature
- Continue to fund FSL's research on quality control
- Invest in snow depth measurement RWIS sensors (Alaska)

8. References:

U.S. Department of Commerce. (March 2004) COOP Modernization: Building the National Cooperative Mesonet Program Development Plan. (COOP).

Matrix Management Group. (December 2003) Alaska Roadway Weather Information (ARWI)

9. Acronyms

AMS	American Meteorological Society
ARWI	Alaska Roadway Weather Information
ASOS	Automated Surface Observing System
AWIPS	Advanced Weather Interactive Processing System
AWOS	Automated Weather Observing System
AVL	Automated Vehicle Location
COOP	Cooperative Observer Program
DOT	Department of Transportation
ESS	Environmental Sensor Station
FHWA	Federal Highway Administration
FSL	Forecast Systems Laboratory
FTP	File Transfer Protocol
GIS	Geographic Information System
ITS	Intelligent Transportation Systems
LETS	Law Enforcement Telecommunications System
NLETS	National Law Enforcement Telecommunications System
NCDC	National Climatic Data Center
NOAA	National Oceanographic and Atmospheric Administration
NWS	National Weather Service
MADIS	Meteorological Data Information System
MOU	Memorandum of Understanding
OAR	Office of Atmospheric Research
PCI	Per Capita Income
POC	Points of Contact
RFP	Request for Proposal
RWI	Road Weather Information
RWIS	Road Weather Information Systems
WFO	Weather Forecast Office