Assessment of Montana Road Weather Information System

Weather Data and Software Analysis

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1) INTRODUCTION

This interim report details the weather data and software analysis task as part of the overall project to assess the Montana Department of Transportation (MDT) Road Weather Information System (RWIS). This task builds upon the findings from the previously completed tasks (*State of Art* and *Practice* and *Needs Assessment*) by establishing an overview of the current system, identifying any gaps in the current system compared to the needs of the agency, and identifying and analyzing potential alternatives that may best meet the needs of the agency. From these possible alternatives, select sensor, hardware, and software possibilities may then be included in the future *Benefit Cost Analysis* project task to determine economic feasibility and help establish recommendations for future MDT RWIS improvements.

This interim report requires investigation into commercially available products, and efforts were made for the investigation to be inclusive of all potential alternatives available in North America. The reader should be aware that information regarding the capabilities of RWIS hardware, sensors, and software is often only available from the manufacturers and vendors themselves and is not necessarily verifiable by any unbiased sources.

2) CURRENT SYSTEM CONFIGURATION

MDT currently operates 73 individual RWIS sites that consist of environmental sensor stations (ESS), hardware and software that are used to process, display or disseminate road weather information in a format that can easily be interpreted by various users. Figure 1 shows the location of the 73 RWIS sites.

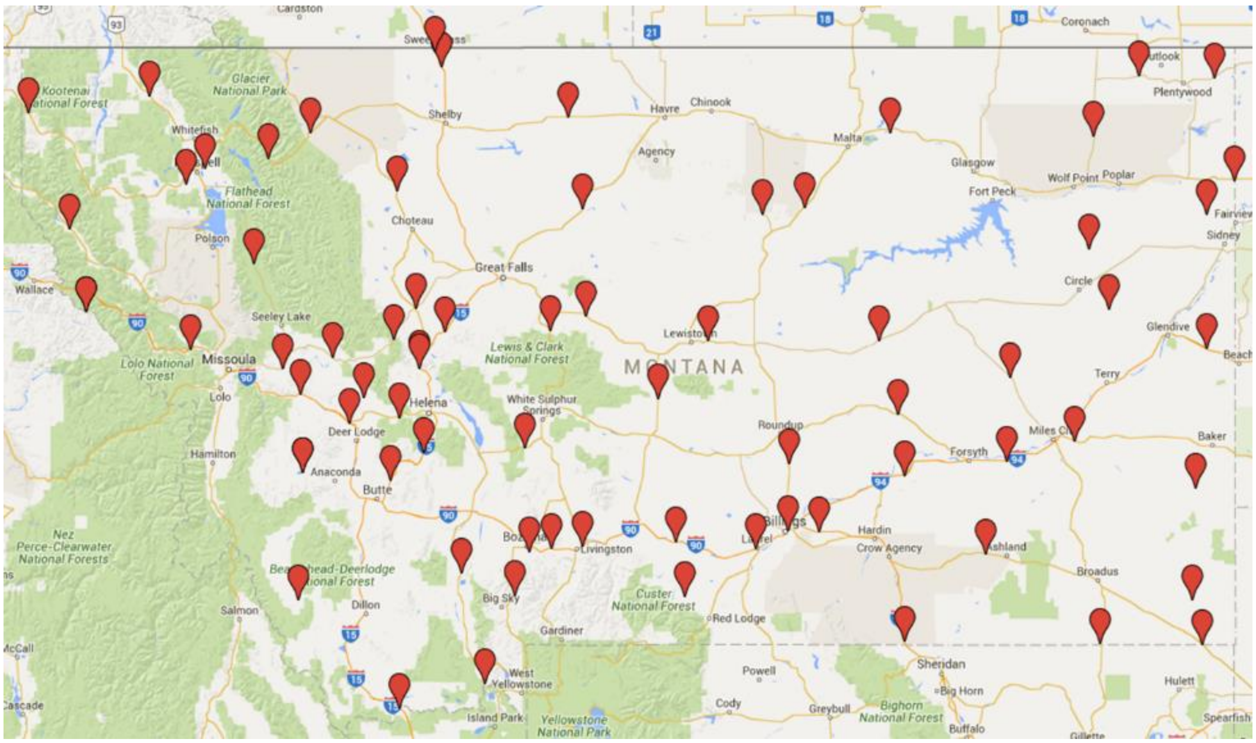


Figure 1: MDT RWIS Sites (Map Source: Google Maps)

These RWIS stations provide the data that are ultimately utilized by MDT Maintenance personnel tasked with winter maintenance activities around the state. The RWIS data are also provided to the travelling public by MDT via agency traveler information websites and mobile applications. A third party vendor (Iteris) also uses the RWIS data as part of systems related to the 511 telephone service. The National Oceanic and Atmospheric Administration (NOAA) also makes use of the RWIS data for the National Weather Service (NWS) and the Meteorological Assimilation Data Ingest System (MADIS). The Western Transportation Institute (WTI) at Montana State University (MSU) also uses MDT RWIS data as part of two larger multi-state corridor travel information and operations management systems. This section outlines the high-level RWIS system architecture, more detailed configurations of the individual ESS, and the current software used as part of the overall MDT RWIS.

2.1. System Architecture

A high-level system architecture showing the MDT RWIS program and associated uses is shown in Figure 2.

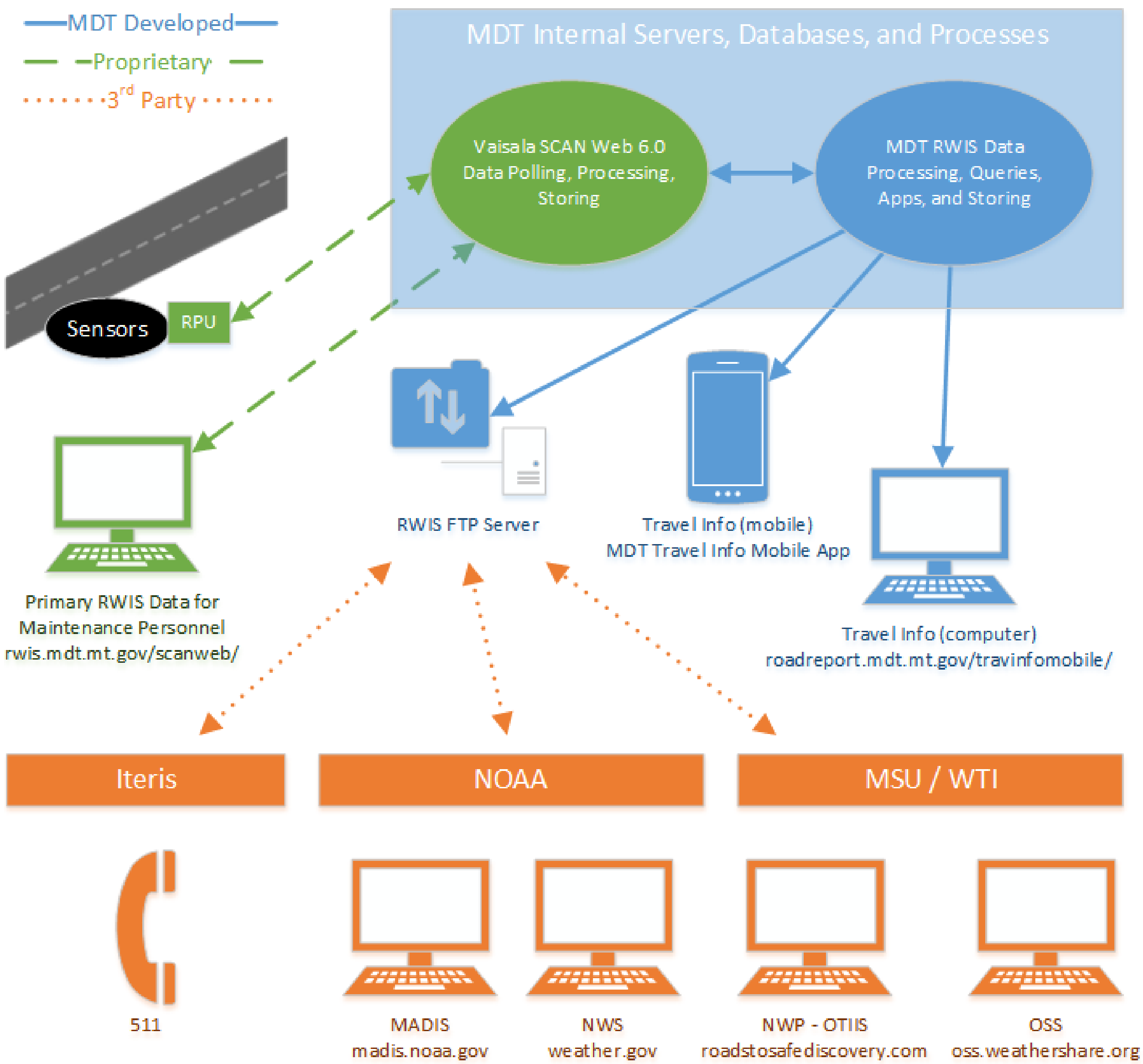


Figure 2: System Architecture

The sensors, cameras, and remote processing units (RPU) in the field at the 73 RWIS stations are owned by MDT. The sensor and camera data are stored locally at each of the RPUs which are then polled by proprietary software (part of Vaisala SCAN Web 6.0) housed at MDT which also processes and displays the data for the primary user group, MDT Maintenance personnel. MDT also has many internal processes, queries, applications, and storage functions that allow for publishing the RWIS data to the travelling public via MDT traveler information websites and mobile apps and to third party users via a RWIS file transfer protocol (FTP) site.

2.2. ESS Configurations

All 73 ESS at RWIS locations essentially have the same core sensor array with a small number of ESS having additional or more advanced sensors than the typical setup. All ESS are grid powered except for five solar powered sites. All ESS use cellular communications except for seven sites that use landline communications due to cellular coverage issues. The core sensor setup that exists at virtually all ESS includes the following hardware, sensors, and associated weather information:

- Air Temperature & Humidity Sensor (Thies or Vaisala) for
    - air temperature,
    - relative humidity, and
    - dew point temperature.
- Wind Speed and Direction Sensor (RM Young) for
    - wind speed and
    - wind direction.
- In-Pavement Sensor (Vaisala) for
    - pavement temperature and
    - surface condition (dry, wet, snow, ice, chemical, etc.).
- Subsurface Temperature Sensor (Vaisala) for
    - subsurface temperature.
- Precipitation Sensor (Vaisala) for
    - precipitation occurrence (yes / no).
- Camera (Axis, Cohu, or Mobotix) for
    - static camera images.
- Remote Processing Unit, RPU, (Vaisala) for
    - sensor reading, processing, and local storage.
- Cellular Modem (AT&T or Verizon) for
    - communication

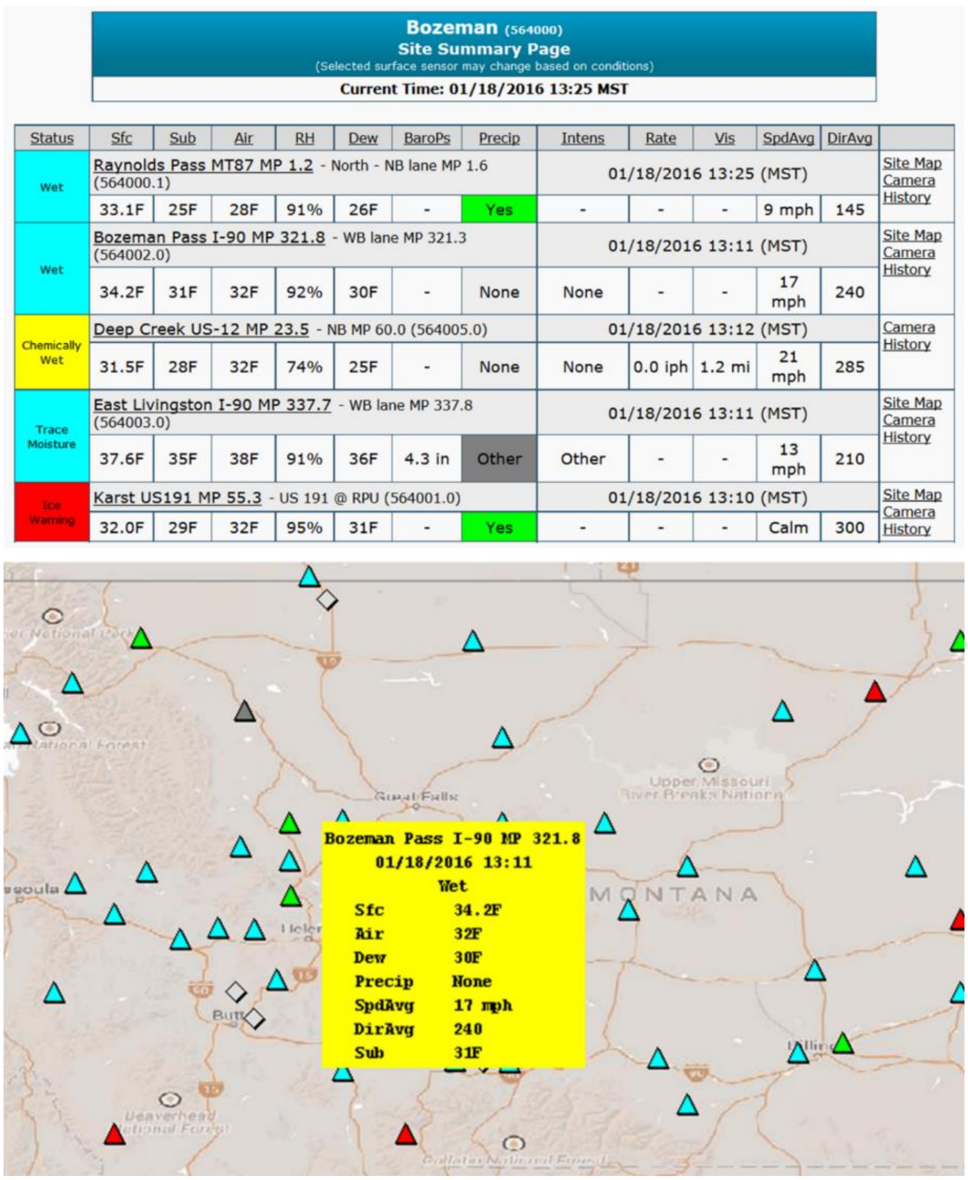
The non-core sensors that exist at limited locations to improve the capabilities of the ESS include:

- Advanced Precipitation Sensor (Optical Scientific Inc. or Vaisala) for
    - precipitation type with intensity or rate (at 6 sites).
- Visibility Sensors (Optical Scientific Inc. or Vaisala) for
    - visibility (at 4 sites).
- Infrared Illuminator for
    - nighttime camera images (at 6 sites).

2.3. Software

MDT maintenance personnel primarily use the Vaisala SCAN Web 6.0 software to view RWIS data and camera images on an internet browser (rwis.mdt.mt.gov). This software, while viewable on mobile devices, seems developed primarily for use on a larger computer screen. As such, some maintenance users monitor RWIS conditions and cameras via the MDT Travel Info mobile application.

SCAN Web allows maintenance personnel to view the most current sensor readings and camera images organized into tables by geographical region or on a map based layout of the state with selectable individual stations (see Figure 3).

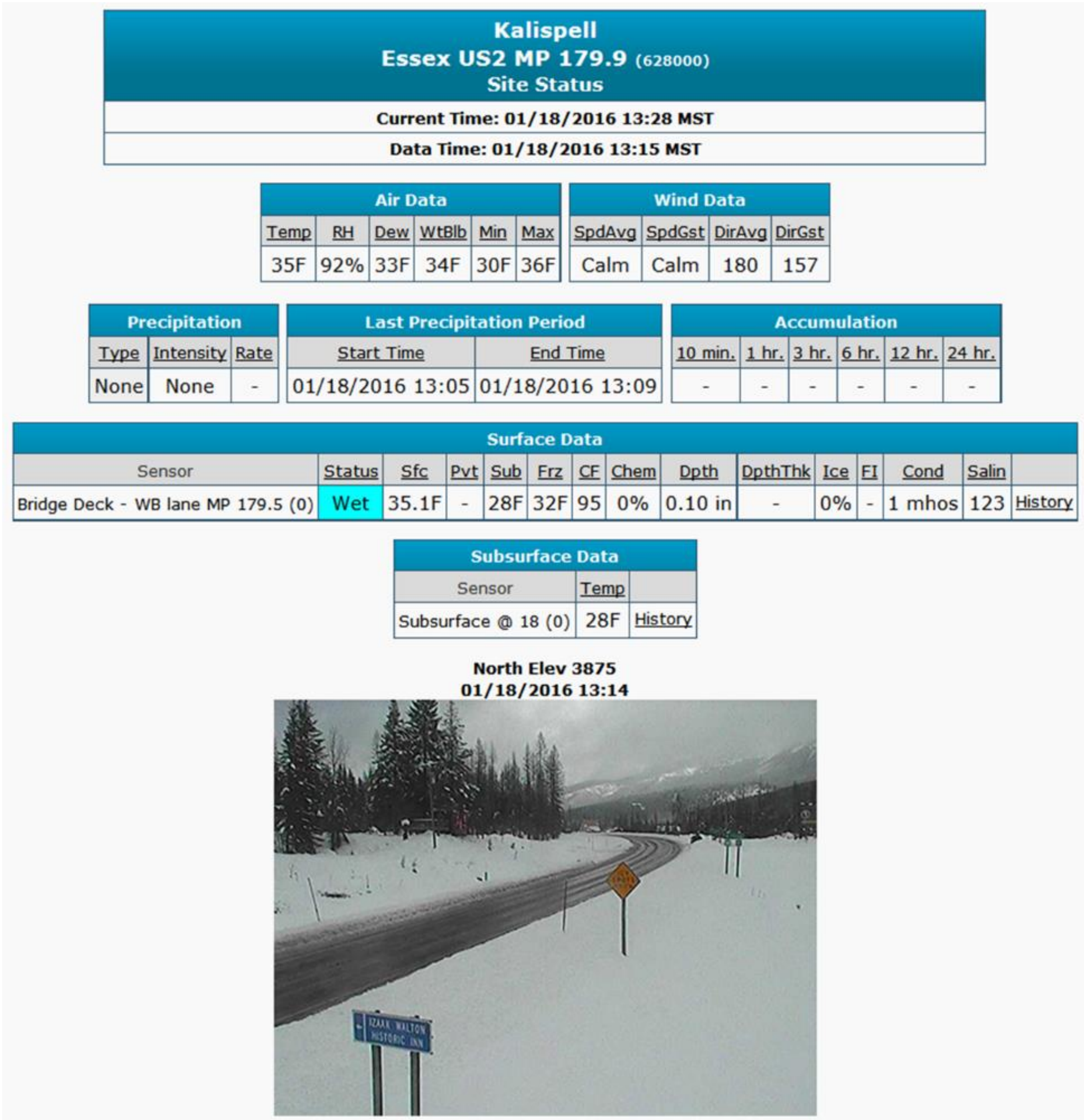


Bozeman (564000)
Site Summary Page
(Selected surface sensor may change based on conditions)
Current Time: 01/18/2016 13:25 MST

Status	Sfc	Sub	Air	RH	Dew	BaroPs	Precip	Intens	Rate	Vis	SpdAvg	DirAvg	
Wet	Raynolds Pass MT87 MP 1.2 - North - NB lane MP 1.6 (564000.1)							01/18/2016 13:25 (MST)					Site Map Camera History
	33.1F	25F	28F	91%	26F	-	Yes	-	-	-	9 mph	145	
Wet	Bozeman Pass I-90 MP 321.8 - WB lane MP 321.3 (564002.0)							01/18/2016 13:11 (MST)					Site Map Camera History
	34.2F	31F	32F	92%	30F	-	None	None	-	-	17 mph	240	
Chemically Wet	Deep Creek US-12 MP 23.5 - NB MP 60.0 (564005.0)							01/18/2016 13:12 (MST)					Camera History
	31.5F	28F	32F	74%	25F	-	None	None	0.0 iph	1.2 mi	21 mph	285	
Trace Moisture	East Livingston I-90 MP 337.7 - WB lane MP 337.8 (564003.0)							01/18/2016 13:11 (MST)					Site Map Camera History
	37.6F	35F	38F	91%	36F	4.3 in	Other	Other	-	-	13 mph	210	
Ice Warning	Karst US191 MP 55.3 - US 191 @ RPU (564001.0)							01/18/2016 13:10 (MST)					Site Map Camera History
	32.0F	29F	32F	95%	31F	-	Yes	-	-	-	Calm	300	

Figure 3: SCAN Web RWIS Data by Geographic Region (top) and Map Based (bottom)

A detailed site status is also available showing the most recent RWIS data with the most recent camera image(s) and information about the last precipitation period observed (see Figure 4).



Kalispell
Essex US2 MP 179.9 (628000)
Site Status

Current Time: 01/18/2016 13:28 MST

Data Time: 01/18/2016 13:15 MST

Air Data						Wind Data			
Temp	RH	Dew	WtBlb	Min	Max	SpdAvg	SpdGst	DirAvg	DirGst
35F	92%	33F	34F	30F	36F	Calm	Calm	180	157

Precipitation			Last Precipitation Period		Accumulation					
Type	Intensity	Rate	Start Time	End Time	10 min.	1 hr.	3 hr.	6 hr.	12 hr.	24 hr.
None	None	-	01/18/2016 13:05	01/18/2016 13:09	-	-	-	-	-	-

Surface Data														
Sensor	Status	Sfc	Pvt	Sub	Frz	CF	Chem	Dpth	DpthThk	Ice	FI	Cond	Salin	
Bridge Deck - WB lane MP 179.5 (0)	Wet	35.1F	-	28F	32F	95	0%	0.10 in	-	0%	-	1 mhos	123	History

Subsurface Data		
Sensor	Temp	
Subsurface @ 18 (0)	28F	History

North Elev 3875
01/18/2016 13:14

Figure 4: SCAN Web RWIS Site Status

Histories of data from the sensors are also viewable in table or graphical form for periods up to 48 hours in duration (see Figure 5).

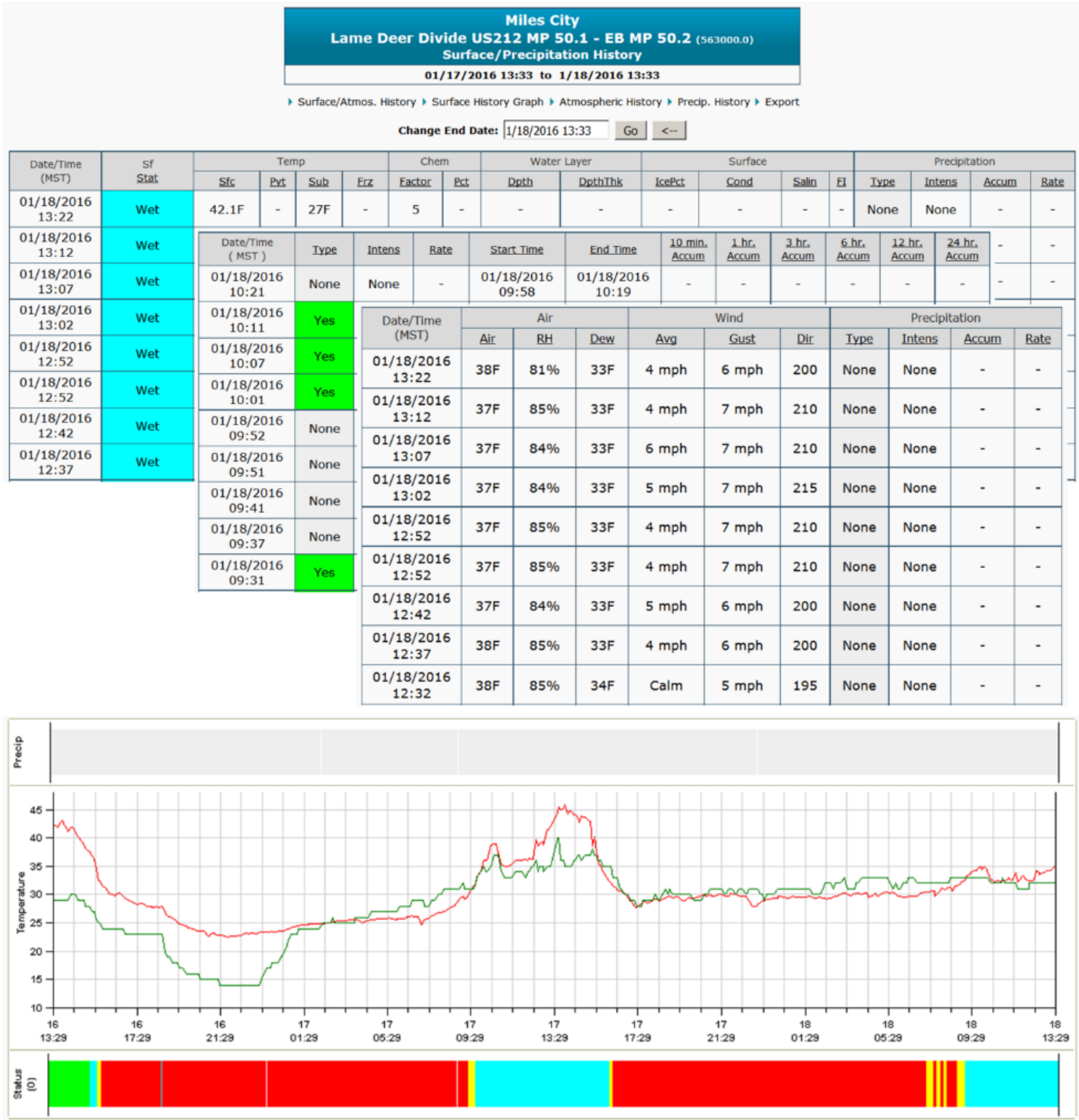


Figure 5: SCAN Web RWIS Site History Tables (top) and Graph (bottom)

A detailed site map graphic is also available for each location to show details of the sensor locations relative to the roadway with their current measurements (see Figure 6).

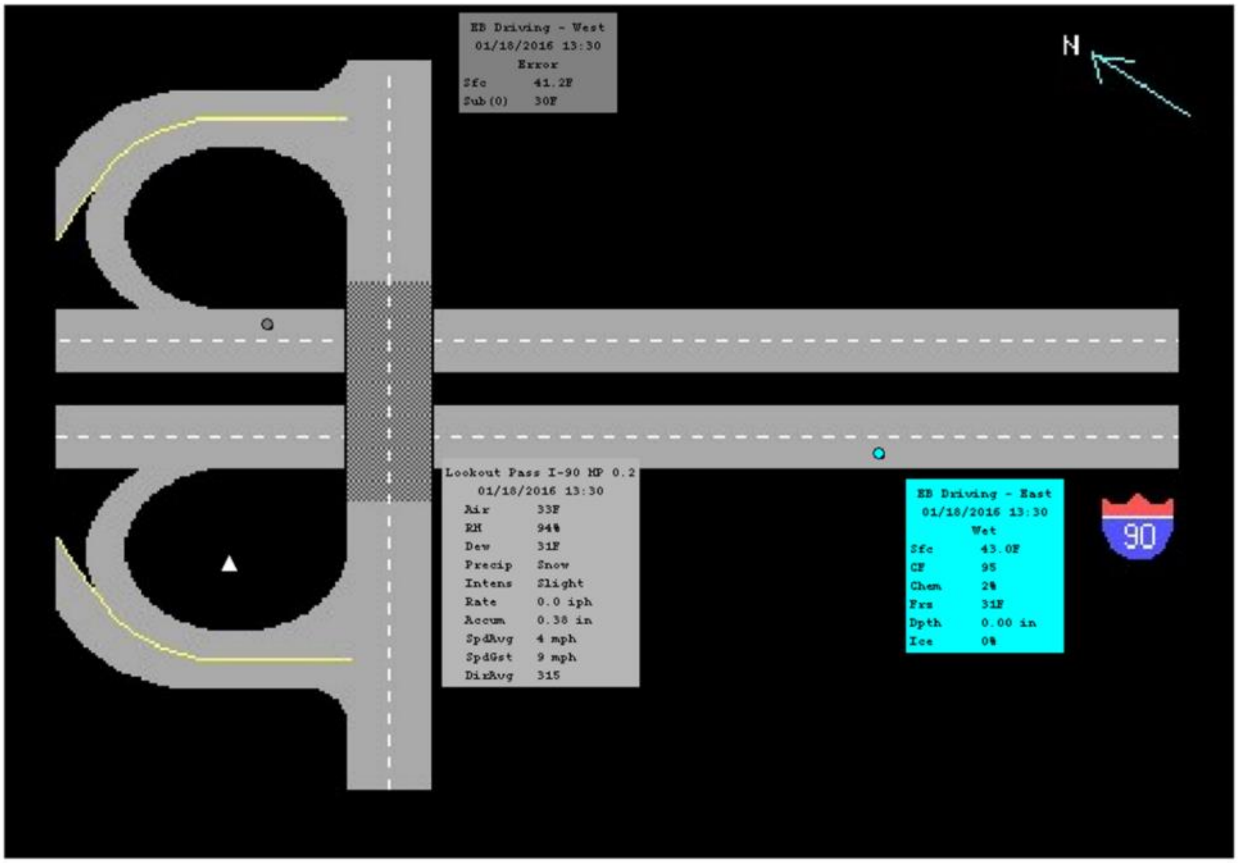


Figure 6: SCAN Web RWIS Site Map

The MDT Travel Info mobile application provides RWIS data and camera images along with other traveler information and is targeted for the traveling public. Some maintenance personnel use this mobile application to view current camera images and RWIS data which are presented on the mobile device primarily using a map display (centered on user GPS location) with selectable RWIS stations. Figure 7 shows the MDT Travel Info mobile app.

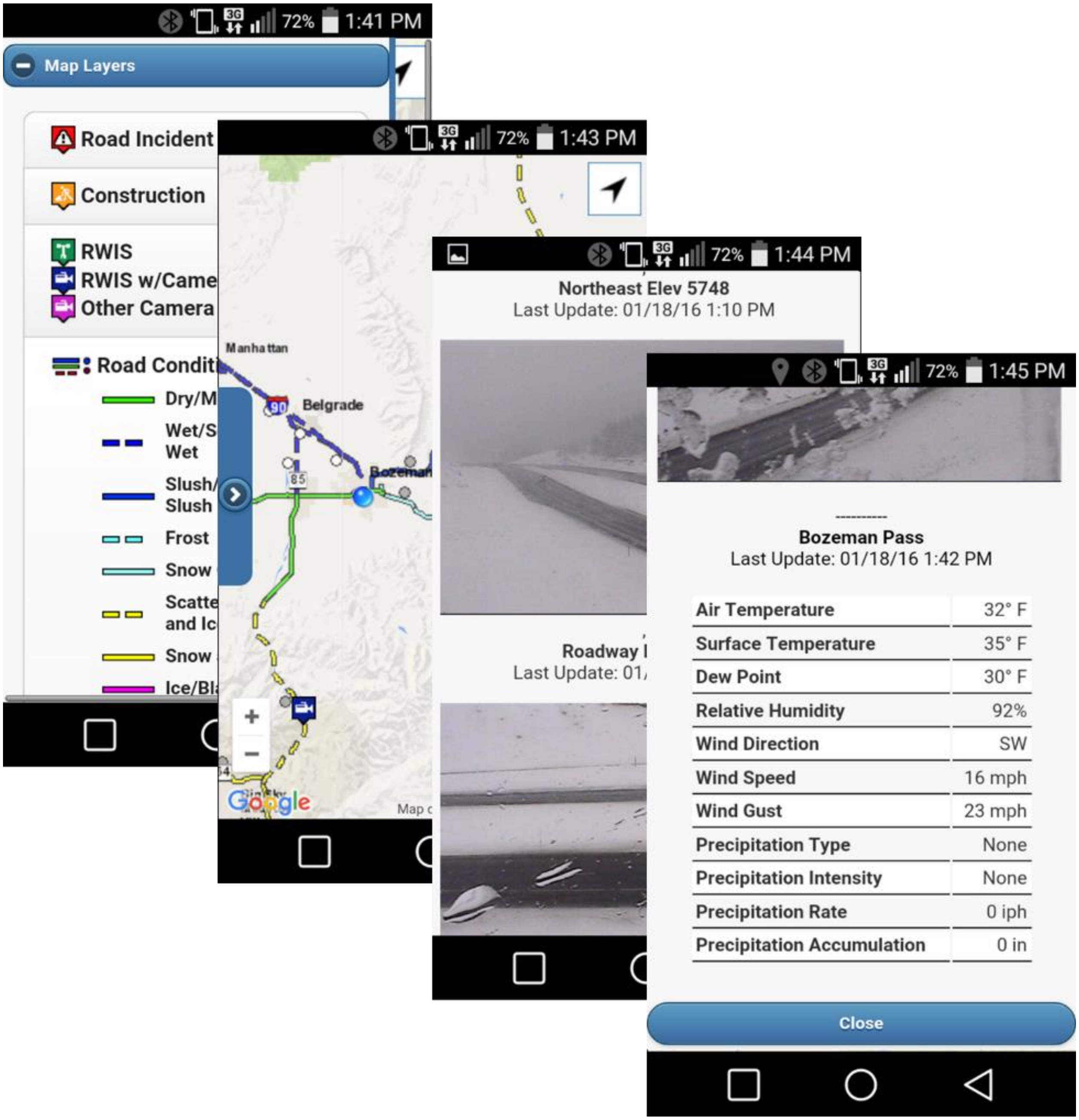


Figure 7: MDT Travel Info Mobile App

3) POTENTIAL GAPS: STATED NEEDS VERSUS THE CURRENT SYSTEM

MDT agency needs related to the RWIS program are documented in the previous *Needs Assessment* project task. Interviews and surveys of various agency stakeholders were performed and the findings documented how RWIS data are used by the agency and the needs associated with using RWIS information. Comparing the current RWIS configuration to the previously documented agency needs reveals some areas that may have opportunities for improvement.

3.1. Sensor / Hardware Capabilities

The current basic sensor array that exists at virtually all ESS meets most of the needs of the agency but a few sensors and weather attributes not currently available in the core ESS configuration were desired by large portions of agency users including:

- sensors that provide precipitation type and intensity or rate (currently available at 8% of sites),
- sensors that provide visibility (currently available at 5% of sites), and
- infrared lights to make camera images visible at night (currently available at 8% of sites).

3.2. Software Functionality

The current software does meet basic needs of the agency but lacks certain functionalities that were desired by RWIS data users including:

- customizable alarms to alert users when certain weather conditions exist (not currently available),
- a self-diagnosis type function to discover unresponsive or malfunctioning sensors or sites (not currently available),
- mobile-device based information (currently available via travel information app only), and
- forecast information (currently available from outside sources on separate software -- NOAA or other 3rd parties).

3.3. Practices

Certain needs related to specific RWIS practices were also raised during the agency needs assessment including:

- polling data and images every 15 minutes (currently every 30 minutes), and
- including a horizon view for aviation users (only feasible where pan-tilt-zoom, PTZ, cameras exist, so as to not compromise the road views, PTZ cameras currently available at 45% of sites).

4) ALTERNATIVES

Various hardware, sensor, and software alternatives for providing RWIS data and images have been identified and those most relevant to MDT's needs are included in the following sections.

4.1. Sensors and Hardware

A number of alternative sensor types have been identified that may provide the additional capabilities raised from the agency needs assessment. Precipitation sensors are available with capabilities beyond yes/no occurrence readings including precipitation type, intensity, rate, and depth. These more detailed precipitation capabilities are available from a number of sensor types including atmospheric combination sensors, advanced precipitation sensors, and non-invasive pavement sensors. Figure 8 shows examples of these alternative sensor types.

Figure 8: Alternative Sensors Examples (atmospheric combination: left, advanced precipitation: center, non-invasive: right)

Visibility monitoring can be obtained from certain advanced precipitation sensors or standalone visibility sensors. Nighttime camera images may be best obtained using infrared light emitters to illuminate the camera's view of the roadway. Table 1 shows the functionality of the alternative sensor types compared to each other and the existing base ESS configuration.

Table 1: Sensors and Associated Weather Attributes

	Sensor	Air Temp., Hmd., Dew Pt.	Wind Speed & Direction	Pavement Temp.	Pavement Condition	Subsurface Temp.	Camera Image	Precip. Occurrence	Night Camera Image	Precipitation Type	Precip. Intensity or Rate	Precipitation Depth	Visibility	Road Friction
Current Base ESS Config.	Air Temp. / Humidity Sensor	X												
	Wind Speed & Direction Sensor		X											
	In-Pavement Sensor			X	X									
	Subsurface Sensor					X								
	Static Camera						X							
	Precipitation Sensor (yes/no)							X						
Alternative Sensors	Atmospheric Comb. Sensor	X	X					X		X	X	X		
	Infrared Light for Camera								X					
	Visibility Sensor												X	
	Advanced Precipitation Sensor							X		X	X		X	
	Non-Invasive Sensor	X		X	X			X		X	X	X		X

Certain older RPUs may not comply with the National Transportation Communications for ITS Protocol (NTCIP) 1204 - ESS Interface Standard. This standard is the non-proprietary communications protocol developed by a joint effort of the National Electronics Manufacturers Association (NEMA), the American Association of State Highway and Transportation Officials (AASHTO), and the Institute of Transportation Engineers (ITE) with funding from the US Department of Transportation (USDOT) Intelligent Transportation Systems Joint Program Office (ITS-JPO). NTCIP 1204 version 3 is the most recent published edition with version 4 revision underway.

All commercially available RPUs discovered for use with RWIS in this analysis are now NTCIP complaint which allows for non-proprietary polling of the data from the ESS. All RPUs currently in use at MDT RWIS sites are NTCIP compliant.

Often times RPUs can communicate successfully with sensors regardless of manufacturer, but certain sensors, especially more advanced or specialized sensors, may only communicate with same provider RPUs using proprietary communication protocols. Examples of this may include:

- RPU from provider X able to determine all in-pavement sensor readings from provider Y in full detail except precipitation depth or chemical concentration which are reduced to tiered (low, medium, high) output.
- Non-invasive sensor from provider X only able to communicate with RPUs from provider X, while non-invasive sensor from provider Y uses an open-architecture communication protocol available to any RPU provider.
- Mobile RWIS sensor from provider X only able to communicate with RPUs from provider X.

Combinations of the existing base type sensors, alternative sensors, RPUs, and the software options presented in the following section will likely be included in the economic feasibility task. Consultation with the project Technical Panel will help to establish which sensor, hardware, and software alternatives to include in the economic feasibility analysis. Confirmation of the specific sensor-RPU communication capabilities may be necessary in the following economic analysis task depending on the overall functionalities and alternatives chosen by the Technical Panel for inclusion in that investigation.

4.2. Software

A number of RWIS software products may be considered as potential alternatives to the current system that would be capable of meeting MDT’s current needs and possibly allowing greater functionality and flexibility for the future of RWIS in Montana. There are different levels of sophistication in terms of the functionality of the RWIS software options identified from more basic observational-only type software to options that can incorporate alerts, forecasting, maintenance decision support, automated performance metrics, advanced traffic management system (ATMS) functionality, or mobile RWIS and automatic vehicle location (AVL) components.

The capabilities of the software in this section are derived from vendor created data sheets and direct communication with vendor representatives. Most of the providers aim to be flexible and provide software to meet a clients stated needs. The information in the following sections is meant to provide the typical functionalities of the software products as described by the vendor without accounting for the additional customization that may be available. Many of the more sophisticated software products are also modular allowing for the use of certain levels of functionality without having to obtain an entire all-inclusive package of all possible options.

4.2.1. Observational Software

The most straightforward RWIS software options are those that simply allow for the observation of the conditions and camera images at the ESS locations. They may also allow for some limited sensor history displays and map displays. The currently used SCAN Web 6.0 software fits into this category.

4.2.2. Alerting Functionality

The ability to add weather condition alerts or sensor/site malfunction alerts are other common functionalities of many RWIS software products. These alerts can be delivered to personnel via email, short message service (SMS), multimedia messaging service (MMS), automated voice message phone calls, or audible tones and visual alerts at a computer station. These alerts can help maintenance personnel by reducing their need to check RWIS conditions manually and rely instead on alerts to be provided when certain customizable weather conditions are met. Similarly, alerts can be created that would trigger when certain data checking routines identify malfunctioning or unresponsive sensors.

RTMC Pro software from Campbell Scientific is a highly customizable software option that has been used for certain city and county type RWIS installations. The product is designed such that users can create their own customizable displays and alarms, with or without additional assistance from Campbell Scientific. An RWIS type base project file (Road Aware) is available, but in general RTMC Pro is seemingly less of an off-the-shelf type RWIS solution for a large network like MDT's and more of a "Consumer in Control Technology" option that would allow an agency to build displays and alarms of their choosing. An example of an RWIS station display using RTMC Pro is shown in Figure 9.

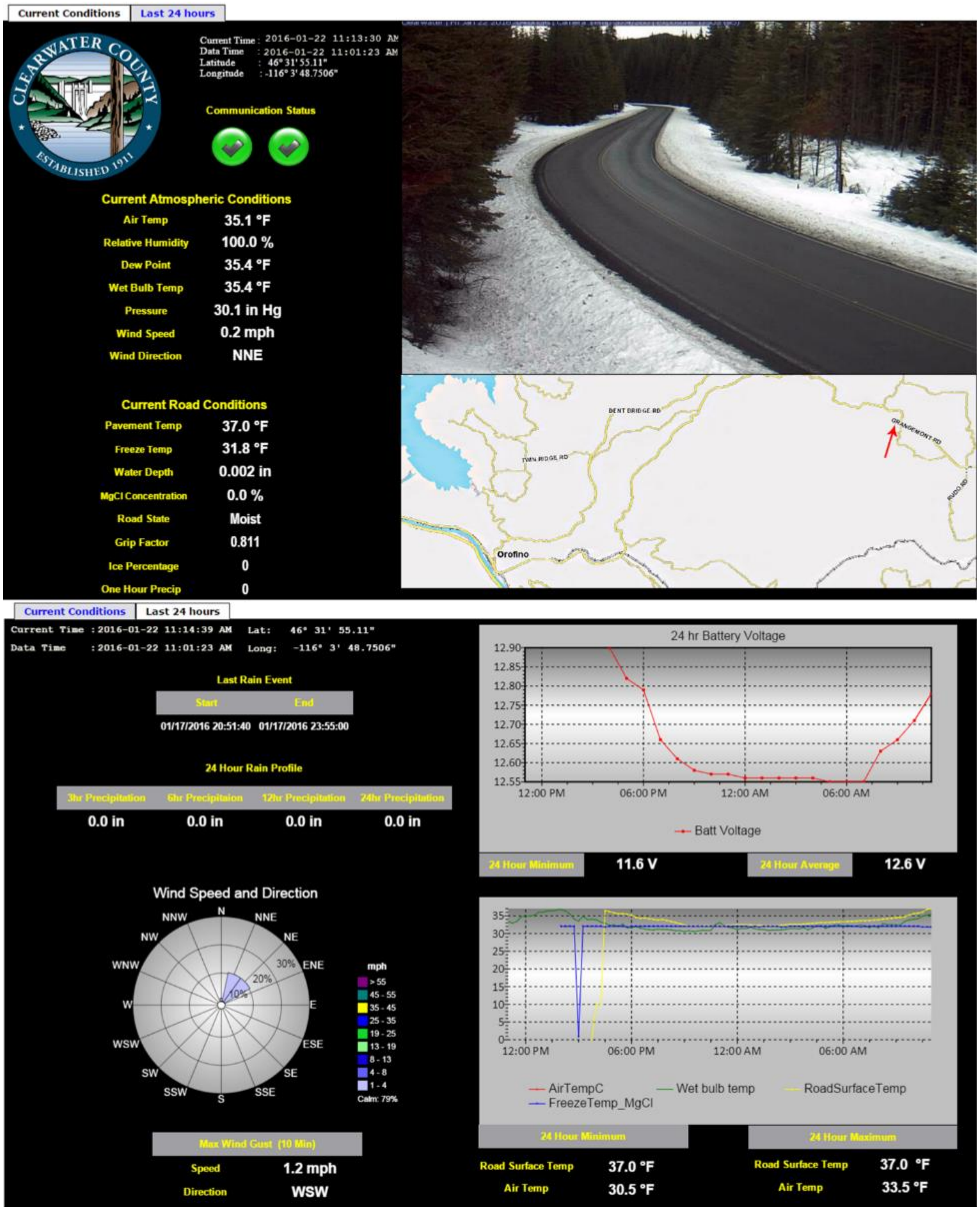


Figure 9: RTMC Pro Software Example (gc.clearwatercounty.org)

Another observational RWIS software with alerting functionality is the Geonica Suite 4K software products. No US examples of this software being used were discovered with most Geonica products being used internationally, but they are available through at least one domestic vendor (Advanced Monitoring Methods). Figure 10 shows an example of the Geonica Suite 4K software.

Figure 10: Geonica Suite 4K Software Example (english.geonica.com)

RWIS vendor High Sierra Electronics provides a couple of software products that include observational and alerting functionalities. One is known as Contrail (from OneRain Inc.) and the other is DataWise (from DataWise Environmental Monitoring, Inc.). Both of these products can provide typical map and tabular displays of current RWIS conditions and camera images along with customizable alarms. Contrail has traditionally been more focused on rainfall, flood warning, and hydrologic data monitoring, but is capable and has included RWIS sensors and cameras in a couple of locations. Contrail and DataWise are both currently used for RWIS applications at the city/county level and are not believed to be primary RWIS software for any entire state transportation agency. Figure 11 shows an example of the Contrail software being used for RWIS stations in Kansas with a map display of pavement conditions (top) and dashboard of RWIS information and cameras (bottom).

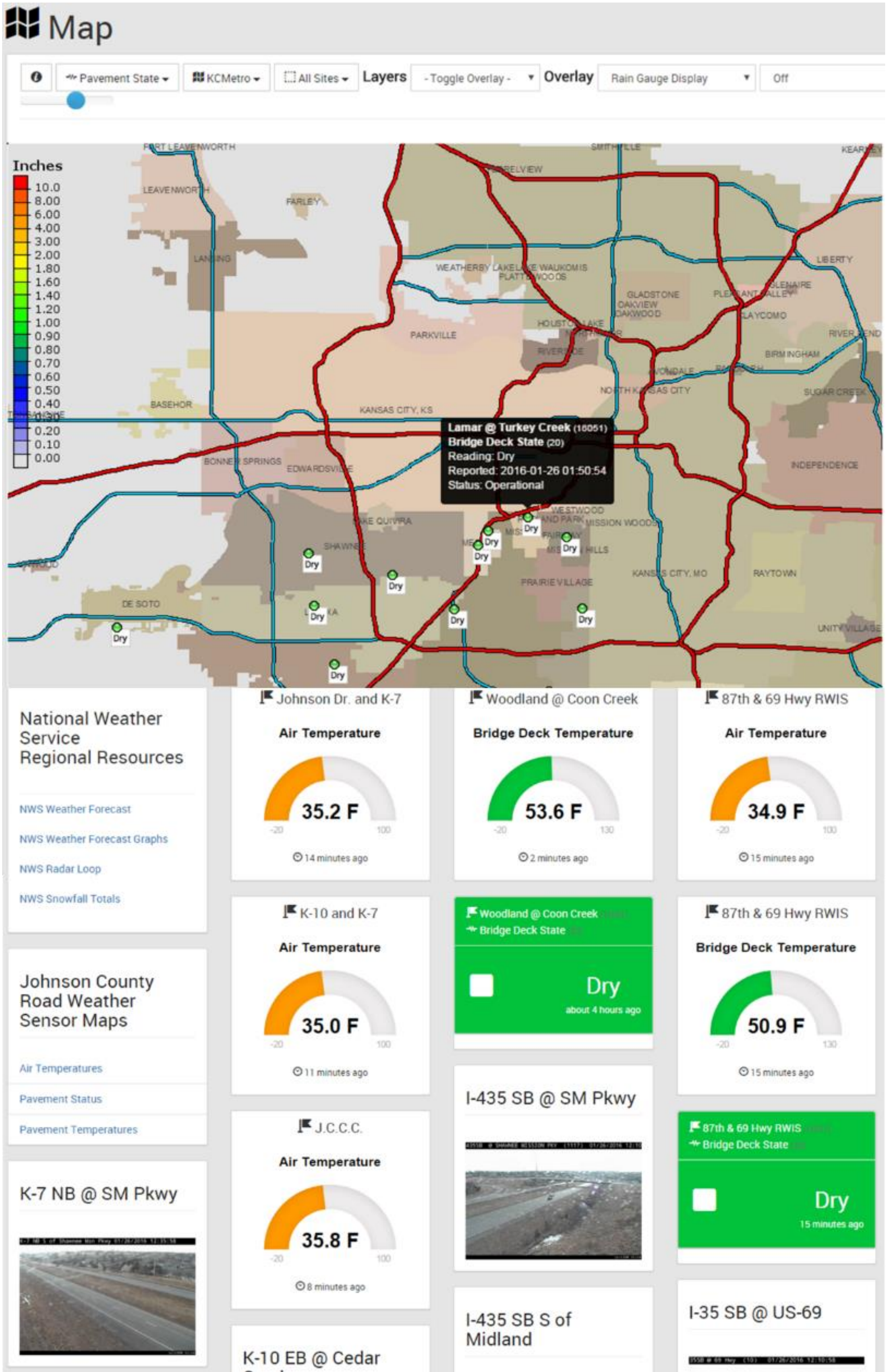


Figure 11: Contrail Software Example (contrail.opkansas.org)

Figure 12 shows an example of the DataWise software.

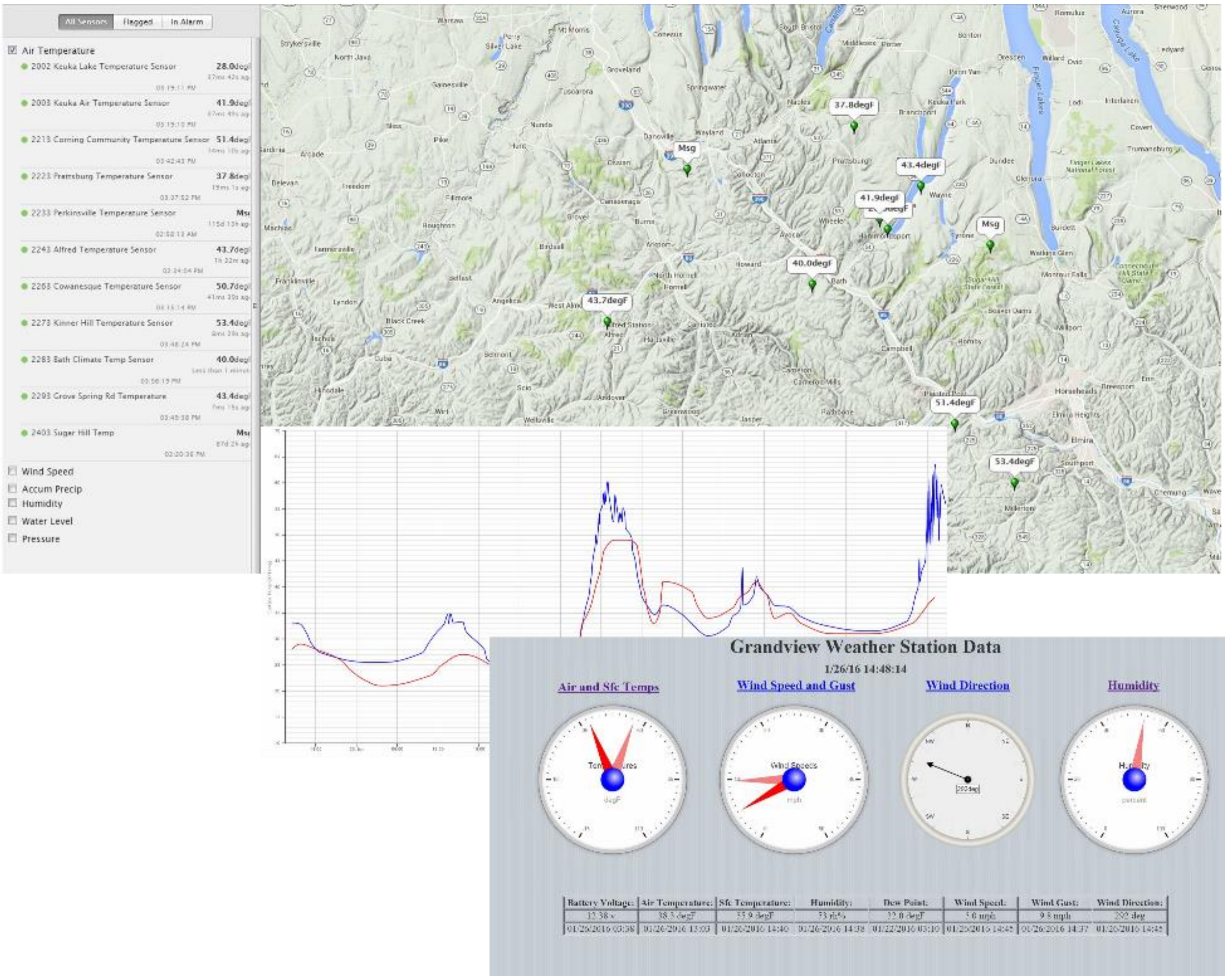


Figure 12: DataWise Software Example (courtesy of High Sierra Electronics)

RWIS provider Lufft offers a couple of software products, one of which is known as SmartView3. This software provides similar observational and alerting functionality as the others in this section. SmartView3 is used as the primary RWIS software by state transportation agencies according to the vendor. Figure 13 shows an example of the SmartView3 software.

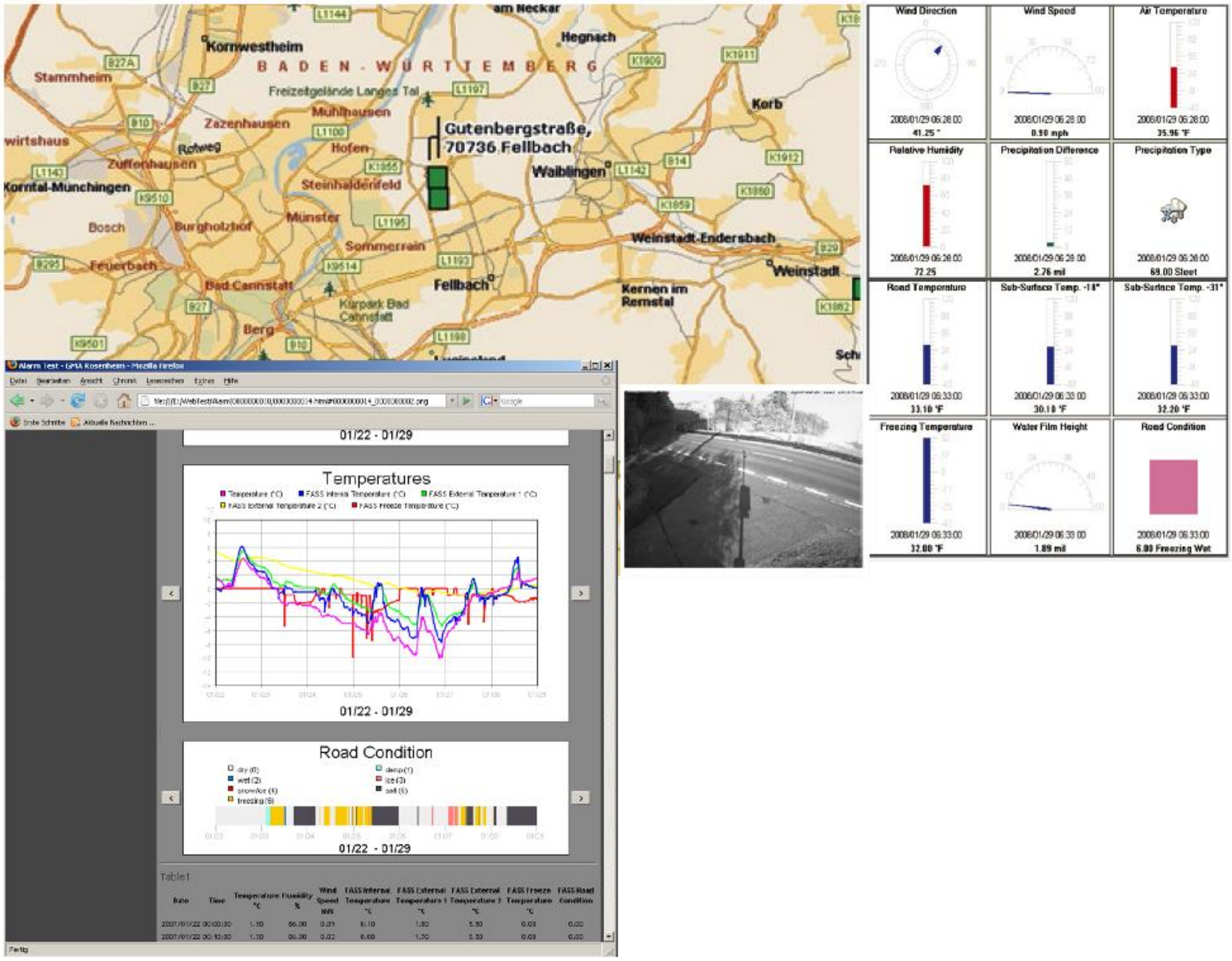


Figure 13: SmartView3 Software Example (courtesy of Lufft)

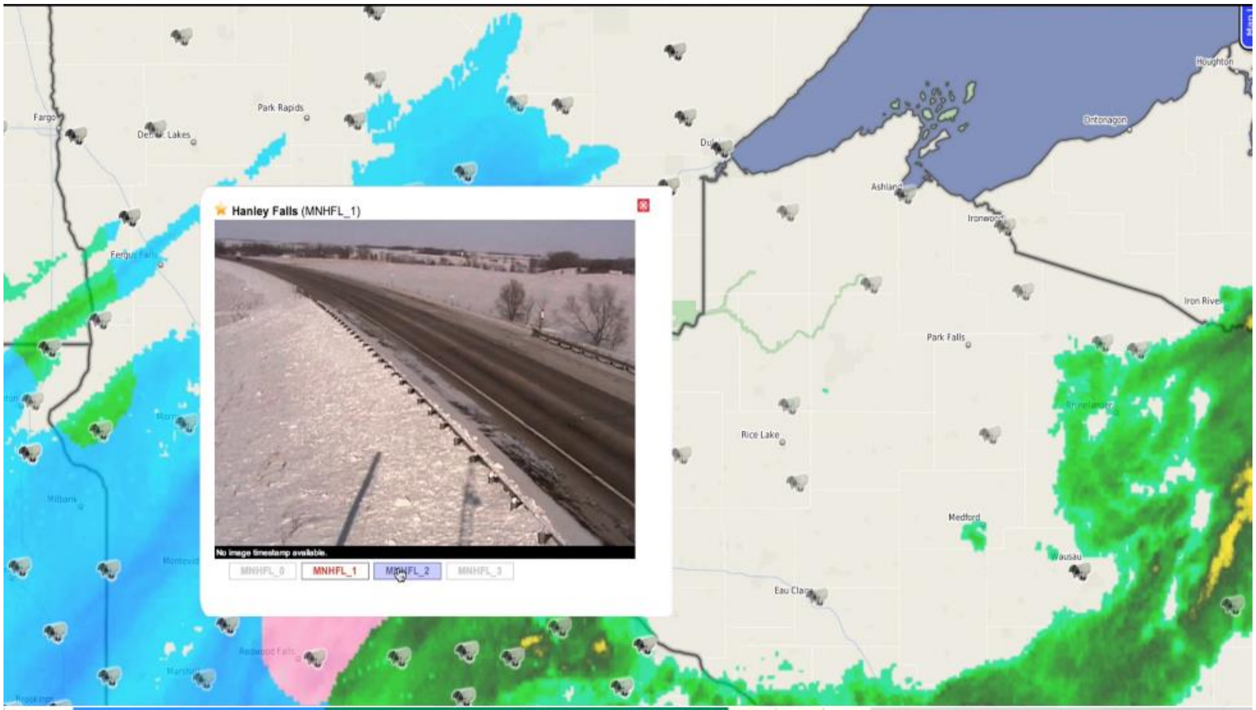
Vaisala also has a couple of software products that would be capable of supporting a state transportation agency's RWIS network. The lighter version, known as RoadDSS Observer, also fits into this observational and alerting category. Figure 14 shows an example of the RoadDSS Observer software which is also reported as being used by multiple state transportation agencies.

Figure 14: RoadDSS Observer Software Example (vaisala.com)

4.2.3. Forecasting and MDSS

Atmospheric weather and pavement condition forecasting can be integrated into RWIS software and provided by the primary software producer or third party sources. Often these forecasts can help determine winter maintenance actions via maintenance decision support system (MDSS) type suggestions that can be automated by the software. Multiple software products seem to focus on providing sophisticated atmospheric and pavement condition forecasts along with automated MDSS information. Software from Boschung, Iteris, Schneider Electric, and Vaisala all seem to provide these forecasting and decision support type information.

ClearPath Weather from Iteris is a product that seems focused on providing detailed forecasts and maintenance suggestions, but can also provide the more typical observational RWIS functionality and weather alerting. The detailed forecast information can be done independent of RWIS data inputs (which are used if available to adjust the forecasts). ClearPath Weather software is used by multiple state transportation agencies according to the vendor. Figure 15 shows a sample of some of the functionality of the ClearPath Weather software with a map and camera view (top) and a table of forecast weather and pavement conditions and MDSS actions (bottom).



	Roadway: Treatment: None					Roadway: Treatment: MDSS								Wind				
Time (CDT)	Temp (Â° F)	Pvmt Cond	Frost Prob (%)	Maintenance	Rate	Temp (Â° F)	Pvmt Cond	Frost Prob (%)	Maintenance	Rate	Air Temp (Â° F)	Dew Pt (Â° F)	Humidity (%)	Direction	Speed (mph)	Gust (mph)	Wind Chill	Type	Prob (%)
Mon 3pm	40	Damp	0	---	---	40	Damp	0	---	---	35	23	61	N	9	17	---	---	---
Mon 4pm	36	Damp	0	---	---	36	Damp	0	---	---	34	24	65	N	9	15	---	SN	80
Mon 5pm	34	Wet	0	---	---	34	Wet	0	---	---	35	24	64	N	10	16	---	SN	80
Mon 6pm	32	Wet	0	---	---	32	Wet	0	NaCl	300	34	24	66	N	11	18	---	SN	70
Mon 7pm	32	Slush	0	---	---	31	CWet	5	---	---	34	24	67	N	10	19	---	SN	70
Mon 8pm	32	SN	5	---	---	31	CWet	5	---	---	33	25	71	NNW	10	18	---	SN	70
Mon 9pm	31	SN	10	---	---	30	Slush	10	---	---	32	25	75	N	11	18	---	SN	70
Mon 10pm	30	CmpSn	10	---	---	30	Slush	10	---	---	31	24	74	N	11	18	---	SN	70
Mon 11pm	29	CmpSn	10	---	---	29	Slush	10	---	---	30	23	75	N	11	20	---	SN	60
Tue 12am	28	CmpSn	10	---	---	28	Slush	10		---	30	22	72	N	12	20	---	SN	60
Tue 1am	28	CmpSn	10	---	---	28	Slush	10	---	---	29	22	73	NNW	13	22	---	SN	20
Tue 2am	28	CmpSn	15	---	---	28	Slush	15	---	---	29	22	75	NNW	12	21	---	FR	20

Figure 15: ClearPath Weather Software Example (clearpathweather.com)

Another robust RWIS software that can provide forecasting and maintenance decision support functions is WeatherSentry (and associated products) from Schneider Electric. This software is able to provide all the observational and alerting functions in addition to forecasting and MDSS type information. A mobile application is also available for viewing the information and forecasts on mobile devices. WeatherSentry is currently used as the primary RWIS software by multiple state transportation agencies and by the Department of Transportation in Alberta, Canada. Figure 16 shows samples of some of the functionality of the WeatherSentry software with RWIS information, pavement forecasts and MDSS treatment recommendations (top), and the mobile application (bottom).

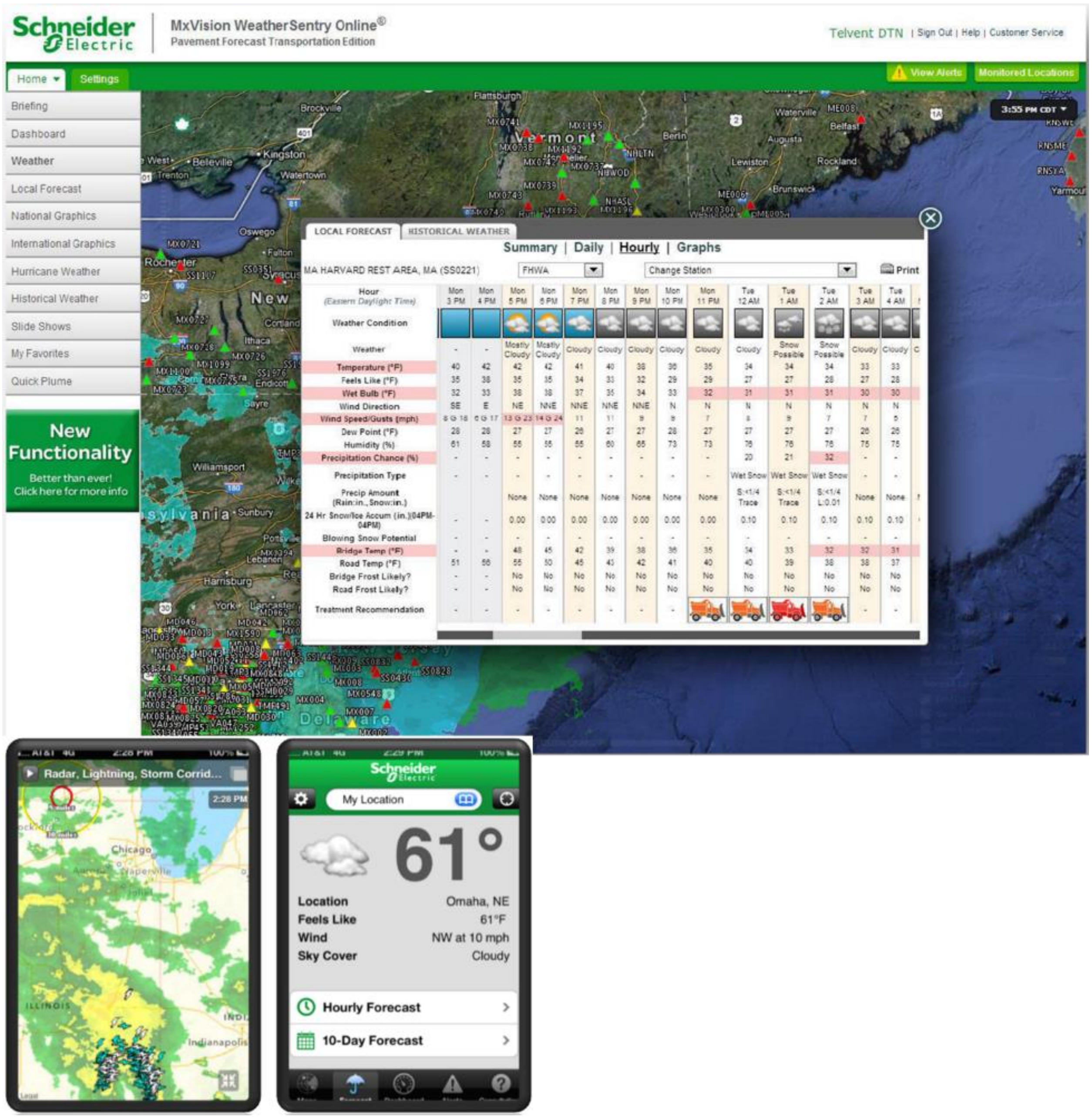


Figure 16: WeatherSentry Software Example (courtesy of Schneider Electric)

4.2.4. AVL and Mobile RWIS

Certain software products also integrate automatic vehicle location (AVL) data into RWIS software including winter maintenance type data on snowplow position and material spreader controller data in order to track maintenance vehicle locations and treatments. Mobile RWIS sensors for monitoring conditions like air temperature, pavement temperature, and surface conditions can also be integrated into certain software products. AVL and related maintenance treatment data is available with Boschung (BORRMA-web) and Iteris (ClearPath Weather) products. Mobile RWIS sensor integration is available with Lufft (ViewMondo) and Vaisala (RoadDSS Navigator) software.

BORRMA-web from Boschung is a software option that provides AVL information in addition to forecasting and the basic observational and alarm functionality. This software is modular allowing for selection of certain functions. Boschung also offers a mobile app for observing RWIS information on mobile devices. BORRMA-web software also allows for integration with fixed automated spray technology (FAST) systems like those used to spray deicer on bridges based on ESS observations. Montana DOT may soon have part of the BORRMA-web software for a FAST system being installed in Helena. The BORRMA-web software is used throughout the US on systems with a moderate number of stations, but is not believed to currently be the primary RWIS software for any entire state transportation agency. BORRMA-web is however used for larger systems internationally like for the transportation agency in Austria with hundreds of ESS locations and hundreds more AVL sensors. Figure 17 shows examples of the Boschung software with a map view and AVL data (top), forecasts (bottom, left) and the mobile app (bottom, right).

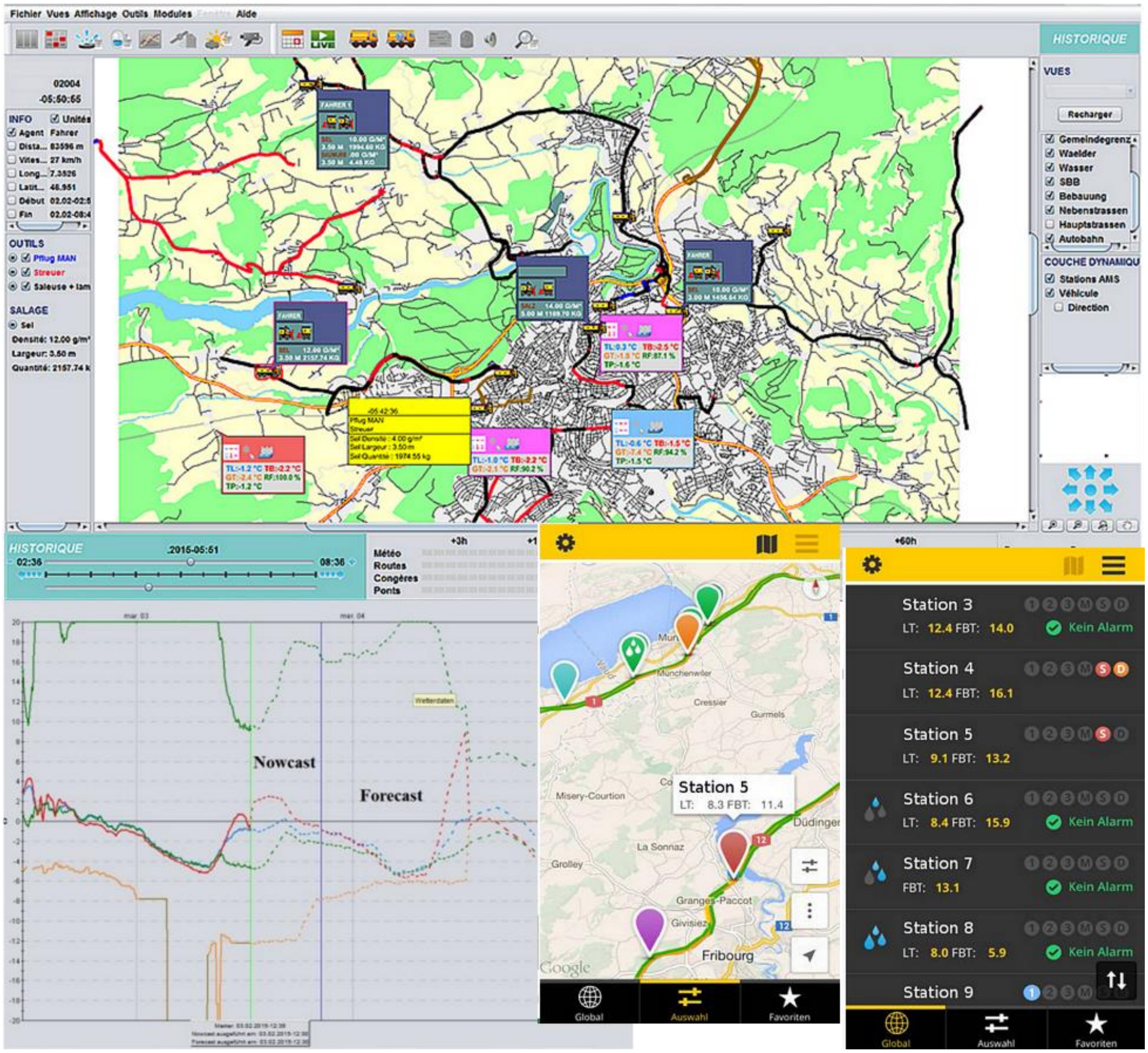


Figure 17: Boschung Software Example (boschungamerica.com & boschung.com)

Mobile RWIS sensor integration into RWIS software is available from a recently developed product known as ViewMondo (by Informatik Werkstatt in Germany). This software was developed in cooperation with RWIS provider Lufft. ViewMondo is capable of observational and alerting functions similar to Lufft's original RWIS software (SmartView3) but can also integrate with Lufft's mobile RWIS sensors. ViewMondo is not believed to be the primary RWIS software of any US state transportation agency at this time. Figure 18 shows an example of mobile sensor monitoring on ViewMondo.

Figure 18: ViewMondo Example (blog.lufft.com)

4.2.5. Automated Performance Measures

Vaisala's RoadDSS Navigator provides observational, alerting, forecasting, MDSS, and mobile RWIS integration functionalities along with some automated winter performance measures data which seems to be a unique functionality. RoadDSS Navigator also has a mobile app (Apple only). The winter performance measures rely on data collected from Vaisala non-invasive road weather sensors that are capable of producing a road surface friction estimate among other readings. These automated winter performance measures were recently developed in cooperation with Idaho Transportation Department (ITD) (Koeberlein, 2013). RoadDSS Navigator can quickly produce storm severity index values and winter performance measure index values which give ITD personnel some indication of the effectiveness of their winter maintenance treatments. Figure 19 shows some of the winter performance measures type information generated by the ITD RoadDSS Navigator software.

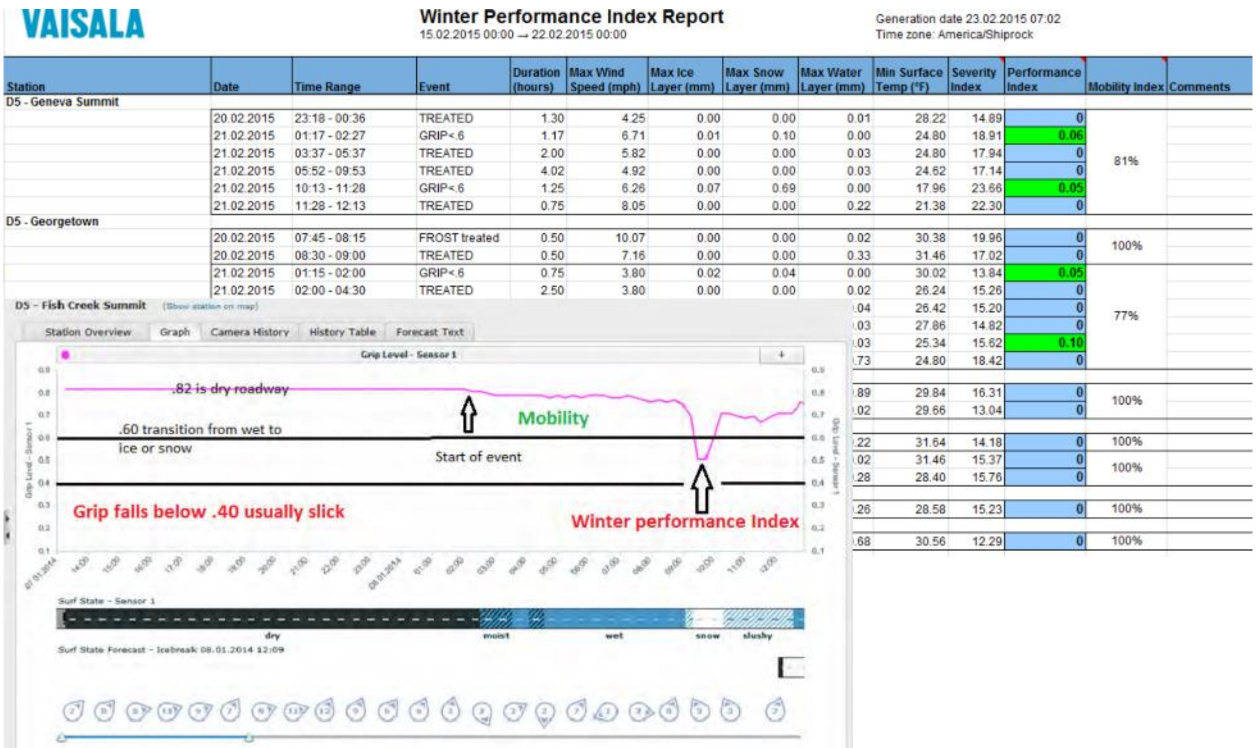


Figure 19: RoadDSS Navigator Winter Performance Measures Example (2)

4.2.6. ATMS

Another software option for monitoring RWIS conditions is to utilize an advanced transportation management system (ATMS) software that would be capable of monitoring and controlling not just RWIS and cameras but other agency ITS applications like dynamic message signs (DMS), highway advisory radios (HAR), traffic signals, weigh-in-motion sensors, and traveler information systems.

One example of an ATMS software that has been used as the primary RWIS software for state transportation agencies is the Intelligent NETworks ATMS software from Delcan (Parsons). This software is modular allowing agencies to choose which modules they need without having to use all 26 modules. Like the recently released MDT snow plow camera pilot project, this ATMS software can also be used to review snow plow camera images using a slider bar to quickly scroll through the images moving temporally. North Dakota is one example of a state transportation agency that has recently started utilizing Delcan ATMS software with certain modules for its RWIS needs. Figure 20 shows an example of the Intelligent NETworks ATMS software.

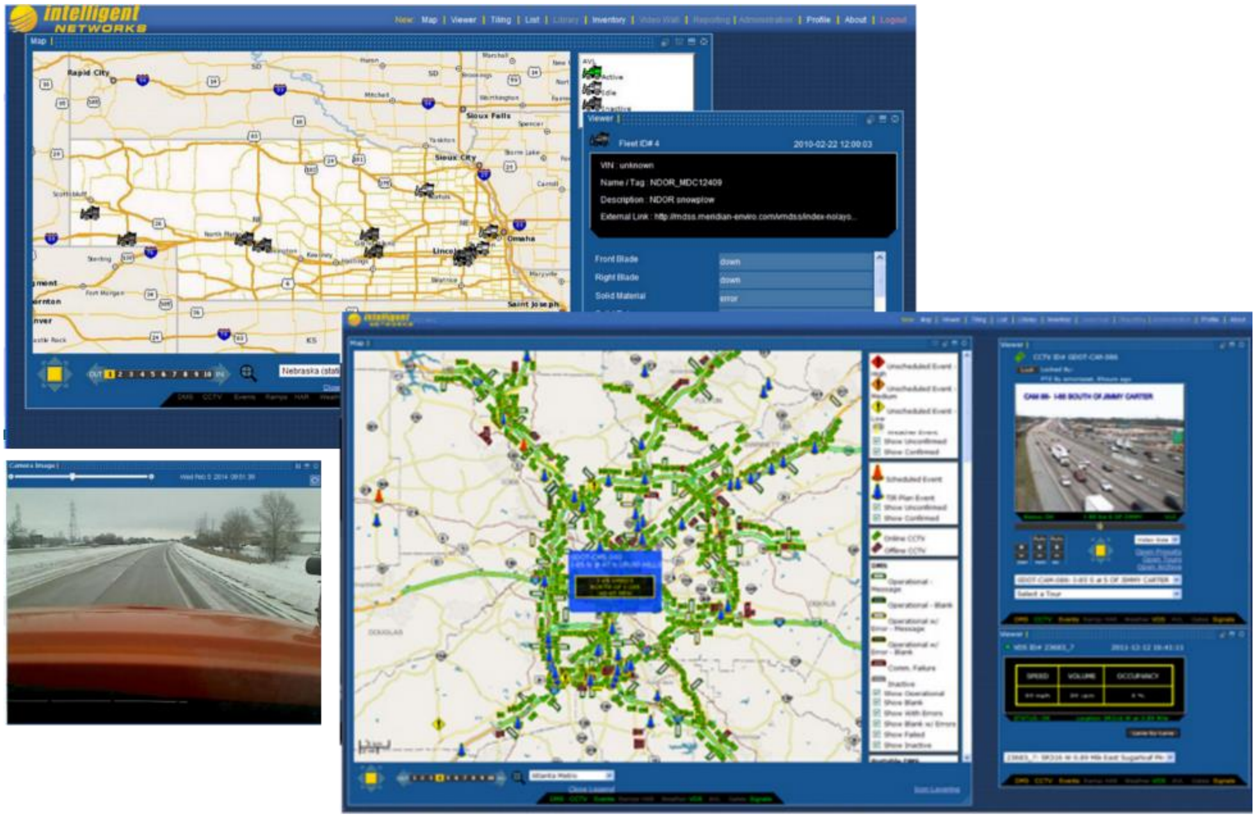


Figure 20: Intelligent NETworks ATMS Example (delcantechnologies.com)

4.2.7. Hosting

Many of the more sophisticated RWIS software products (and associated services) discovered in this analysis are only offered as hosted services. These hosted products do not require any physical DOT server space and the services are accessed by the agency using an internet browser. Some of the RWIS software options found during this analysis are software that is purchased and run entirely on DOT servers, and some can be either hosted or operated in-house by the DOT. Table 2 presents an overview of functionality of all of the capable RWIS software options found during this analysis including their hosting options.

Readers should note that software from Aanderaa (Xylem), All Weather Inc., and Narwhal Group may also exist, but not enough information could be found to include any of those options that may or may not be classified as alternatives suitable for MDT needs.

Table 2: Software Products and Functionality

	Observational					Alerts		Forecast			Other Functions				Hosting
	Current Data	Current Images	Data History	Map Display	Mobile App	Condition Alerts	Site Failure	Atmospheric	Pavement	MDSS	AVL	Mobile RWIS	Perf. Measures	ATMS	DOT or Hosted
SCAN Web 6.0 (Current)	●	●	●	●											DOT
MDT Travel Info Mobile App	●	●		●	●										DOT
Contrail	●	●	●	●		●	●								Either
DataWise	●	●	●	●		●	●								Either
Geonica Suite 4K	●	●	●	●		●	●								DOT
RoadDSS Observer	●	●	●	●		●	●								Hosted
RTMC Pro	●	●	●	●		●	●								DOT
SmartView3	●	●	●	●		●	●								DOT
ViewMondo	●	●	●	●		●	●					●			Hosted
WeatherSentry	●	●	●	●	●	●	●	●	●	●					Hosted
BORRMA-web	●	●	●	●	●	●	●	●	●	●	●				Either
ClearPath Weather	●	●	●	●		●		●	●	●	●				Hosted
RoadDSS Navigator	●	●	●	●	●	●	●	●	●	●		●	●		Hosted
Intelligent NETworks	●	●	●	●							●			●	DOT

Note: while a mobile app may be more robust, most options have data and images that are also viewable on mobile devices using internet browsers

5) SUMMARY AND RECOMMENDATIONS

The current RWIS program has been compared to the stated needs of the agency and the possible alternative sensor, hardware, and software options have been established. While the current system proves to be a great tool for many end users, there may be certain areas with room for improvement. Many sensor, hardware, and software alternatives have been analyzed to understand the functional opportunities they may provide. There are certain quantifiable and intangible benefits associated with some of these alternative sensor capabilities and RWIS software functionalities like forecasting, MDSS, and winter performance measures (Yi, et al. 2009; Koeberlein, et. al. 2014; Koeberlein, 2015).

Since there are many alternatives, a technical panel meeting with the research team will likely be needed to establish which specific alternatives MDT may value the most. Those alternatives may then be able to be investigated during the benefit-cost analysis. Table 3 provides a framework to visualize many of the alternatives that may be possible using different sensors and software and possible ESS expansion scenarios.

Table 3: Possible Alternatives for Benefit Cost Analysis

		Software Functionalities						
	Sensors	Obs.	Obs. + Alert	Obs. + Fcast/ MDSS	Obs. + AVL	Obs. + Mobile RWIS	Obs. + Perf. Meas.	Obs. + ATMS
Current ESS	Base	Current		A				
	Base + IR							
	Base + Prec. ± IR		B					
	Base + NI ± IR						C	
ESS Expansion	Cam ± Pv. Temp	D						
	Mobile RWIS					E		
	Base							
	Base + IR							
	Base + Prec. ± IR							
	Base + NI ± IR							

Note: Obs. = observational, Base = current typical base sensor configuration, IR = infrared light, Prec. = more than yes/no precipitation sensor, NI = non-invasive sensor, Cam = camera

The current scenario is shown along with some possible alternatives (A through E) that may be particularly attractive based on the needs assessment findings and prior benefit-cost literature. The benefit cost task will likely include the current scenario regardless of other options selected in order to quantify a baseline. The other identified possible scenarios can be described as:

- A: Use the current RWIS configuration and sites in conjunction with a software product with forecasting and MDSS type functions that may be capable of providing targeted suggestions that could save agency labor and materials.
- B: Equip the current sites with sensors to allow for more advanced precipitation monitoring (with or without night-time camera images) to meet a stated desire(s) of many maintenance users.
- C: Equip existing sites with non-invasive pavement sensors that would be required to realize the benefits of software that can produce automated winter performance measures which may in turn result in improved operations, mobility, and safety.
- D: Expand the current RWIS network using the “limited ESS” type model which may include only a camera (with or without pavement temperature sensors) to meet the stated desires from multiple user groups.
- E: Expand the current network using mobile RWIS sensors and a capable software.

These scenarios (A through E) are suggestions from the research team, but ultimately the desires and preferences of the Technical Panel will be required to help determine exactly which scenarios to include in the following project tasks.

6) REFERENCES

1. Koeberlein, B. Winter Performance Measures. Presented at National Rural ITS Conference, St. Cloud Minnesota, August, 2013.

2. Koeberlein, B. Idaho Transportation Department Winter Performance Measures, Western States Rural Transportation Technology Implementers Forum, June 2015.

3. Ye, Z., Strong, C., Shi, X., and Conger, S. Analysis of Maintenance Decision Support System (MDSS) Benefits & Costs. Report SD2006-10-F for the South Dakota Department of Transportation. May, 2009.

4. Koeberlein, R., Jensen, D., and Forcier, M. Relationship of Winter Road Weather Monitoring to Winter Driving Crash Statistics. Paper prepared for the 2015 Transportation Research board Annual Meeting. October, 2014.