

MDOT RWIS Existing System Evaluation Memorandum

Prepared by:

Parsons Brinckerhoff Michigan & Iteris

August 2013

PARSONS BRINCKERHOFF

ITERIS

MDOT Michigan Department of Transportation

Table of Contents

List of Figures

List of Tables

1.0 INTRODUCTION AND PURPOSE

In 2013, the Michigan Department of Transportation (MDOT) will have a Road Weather Information System (RWIS) which includes 53 full and 14 partial stationary Environmental Sensor Stations (ESS) primarily in the Superior and North Regions. The ESS collects a variety of data including: pavement temperature (in-pavement and non-invasive), atmospheric, frost depth, snow depth, traffic, cameras, and/or visibility. Transportation authorities use data from these sensors, additional weather information, and forecasts from a statewide contract to make decisions on deploying maintenance crews and determining appropriate pavement treatments. These actions, based on accurate pavement forecasts, are critically important to public safety, the State's economy, and the environment.

The ITS Program Office has embarked on this project aimed at evaluating the statewide road weather program. In this specific task, our team consisting of Parsons Brinkerhoff and Iteris, was tasked to evaluate the system currently in place in Michigan and derive user needs for continued use and collection of weather information. The existing evaluation will not replace existing Concept of Operations documents previously completed in several of MDOT's regions, but rather to augment the documents with a fresh look at how MDOT uses weather data in their activities and if any of the new emerging technologies or existing systems could be leveraged to support the program. This memo will address several defined outcomes, including:

- Comprehensive statewide review of existing and planned deployments of ESS sites,
- Identification of user needs for the use weather data
- Identification of the coverage of existing and planned systems, and
- Identification of potential gaps in coverage, system or operations
- Identification of institutional gaps for use of weather data

2.0 EXISTING RWIS OVERVIEW

In 2007, the Michigan Department of Transportation (MDOT) began widespread deployment of a Road Weather Information System (RWIS), beginning in the Upper Peninsula. Through a series of strategically placed Environmental Sensor Stations (ESSs), the RWIS was intended to help better identify inclement weather and adverse road conditions at critical locations in order to more efficiently deploy and prioritize maintenance needs and provide improved information to motorists. Since 2007, both the Superior and North Regions have made significant investments in the road weather program. With the rapid availability of funding in 2008/2009, the state was able to expedite the deployment of additional ESS's to serve the needs of the region. These deployments represent a strategic development of a large system of ESSs throughout Northern Michigan and the Upper Peninsula, as envisioned in the RWIS Concepts of Operations (ConOps) developed for each region.

Other MDOT regions have also planned and deployed ESS sites with a limited array of sensors to meet specific needs to support the collection of weather data. For example, in Metro Region, MDOT has deployed an array of sensors to be used for a Curve Warning System at key interchanges and exit ramps across the region.

2.1 MDOT'S Environmental Sensor Stations

An ESS site can consist of all or some the following devices depending on whether it is a full or partial site:

- Visibility Sensor - measures atmospheric visibility by determining the amount of light scattered within an optical sample volume by particles (e.g., smoke, dust, haze, fog, rain, and snow) in the air,
- Air Temperature/Relative Humidity Sensor – provides air temperature and relative humidity from which the dew point temperature is derived by the processing unit

- Barometric Pressure Sensor – provides the atmospheric pressure at the site; called the altimeter or station pressure,
- Wind Sensor – measures horizontal wind speed, wind direction, and gusts,
- Precipitation Sensor – measures the precipitation type (rain, snow, sleet, freezing rain, hail), quantity, and intensity,
- Surface Sensor – provides an accurate reading of pavement temperature, salinity and surface conditions, including water, ice, and snow,
- Subsurface Sensor – measures temperatures below the pavement; may measure temperature at one or multiple depths,
- Processing unit – routinely polls RWIS sensors, converts sensor output to digital values, and communicates the data to a central server,
- IP Surveillance System (CCTV) – used to visually monitor the site, road condition, and traffic,
- Traffic Sensor (MVDS) – provides and accurate reading of traffic speed, vehicle type (cars or trucks), and traffic volumes per configured lane.

2.2 Existing/Planned RWIS Assets (Statewide View)

MDOT had a total of 33 existing fixed ESS sites at the end of 2012 (24 full and 9 limited sensor stations) as shown in Table 1. In addition to these existing sites, MDOT is in the process of installing 34 additional stationary ESS sites (25 full and 9 limited sensor stations), in the North, Superior, and University Regions as shown in Table 2. All of the planned locations are slated to be online by the end of 2013. MDOT existing/planned assets are shown in Figure 1. The following section is a summary of MDOT's deployment of RWIS in each of the MDOT regions.

- Superior Region – This region started its initial deployment in 2007. Since then, MDOT has expanded the system to a total of 14 full ESS as of the end of 2012. In 2013, an additional 19 locations will come online, bringing the total to 33 ESS locations in the Superior Region. In addition, MDOT has deployed an ESS near the Cut River Bridge for monitoring road and bridge deck conditions. The information gathered from each site will be integrated in WeatherSentry, MDOT's hosted web-application. See Section 2.3
- North Region – This region started its first deployment in 2010 with 12 full ESS locations. The second phase of 11 new full ESS is scheduled to be online by the end of 2013. The third phase which is currently in construction is scheduled to be online in 2014 which will include two (2) bridge de-icing warning systems (BDWS) with associated non-invasive pavement sensors, and invasive pavement sensors co-located with two (2) Dynamic Message Signs near Gaylord. The total ESS locations in North Region by the end of the 2014 will be 27. The information gathered from each site will be integrated in WeatherSentry.
- University Region – This region has 4 limited sensor (partial) ESS locations that are being constructed in conjunction with an ITS expansion in the greater Lansing area. These devices will be co-located with existing traffic camera and vehicle detection devices to provide motorists with additional weather information on icy bridges and areas that experience dense fog.
- Metro Region – This region has several partial ESS locations throughout the region. These systems are all currently online and were deployed between 2007 to 2013. The systems include:
    - Two Curve Warning Systems are deployed in the region that use a limited array of ESS sensors to provide advanced warning about weather and traffic conditions to motorists along key curves/interchanges.
    - RWIS network with three ESS, operated by the Road Commission for Oakland County (RCOC), located at each of their truck garages, and a Fixed Anti-icing Spray Technology (FAST) system installed on the Grand River Avenue bridge.

  - One non-invasive sensor located on I-275/Nine Mile to detect bridge conditions
  - FAST system installed on M-97 to mitigate hazardous road conditions
- Southwest Region – This region does not currently have any fixed ESS. However, the region is currently underway with an Integrated Mobile Observation (IMO) deployment project in conjunction with University of Michigan Transportation Research Institute (UMTRI) that will outfit 10 MDOT fleet trucks and 10 vehicles with surface patrol sensors to obtain road temperature and condition. In addition, 40 vehicles will be outfitted with an on-board diagnostic units to obtain various characteristics such ABS, trac control, and RPM. Lastly, 20 MDOT fleet trucks will be outfitted with android phones to provide accelerometer, GPS data and imagery.
- Grand Region – This region does not have any fixed or mobile ESS.
- Bay Region – This region does not have any fixed or mobile ESS

Figure 1: MDOT Existing ESS Assets

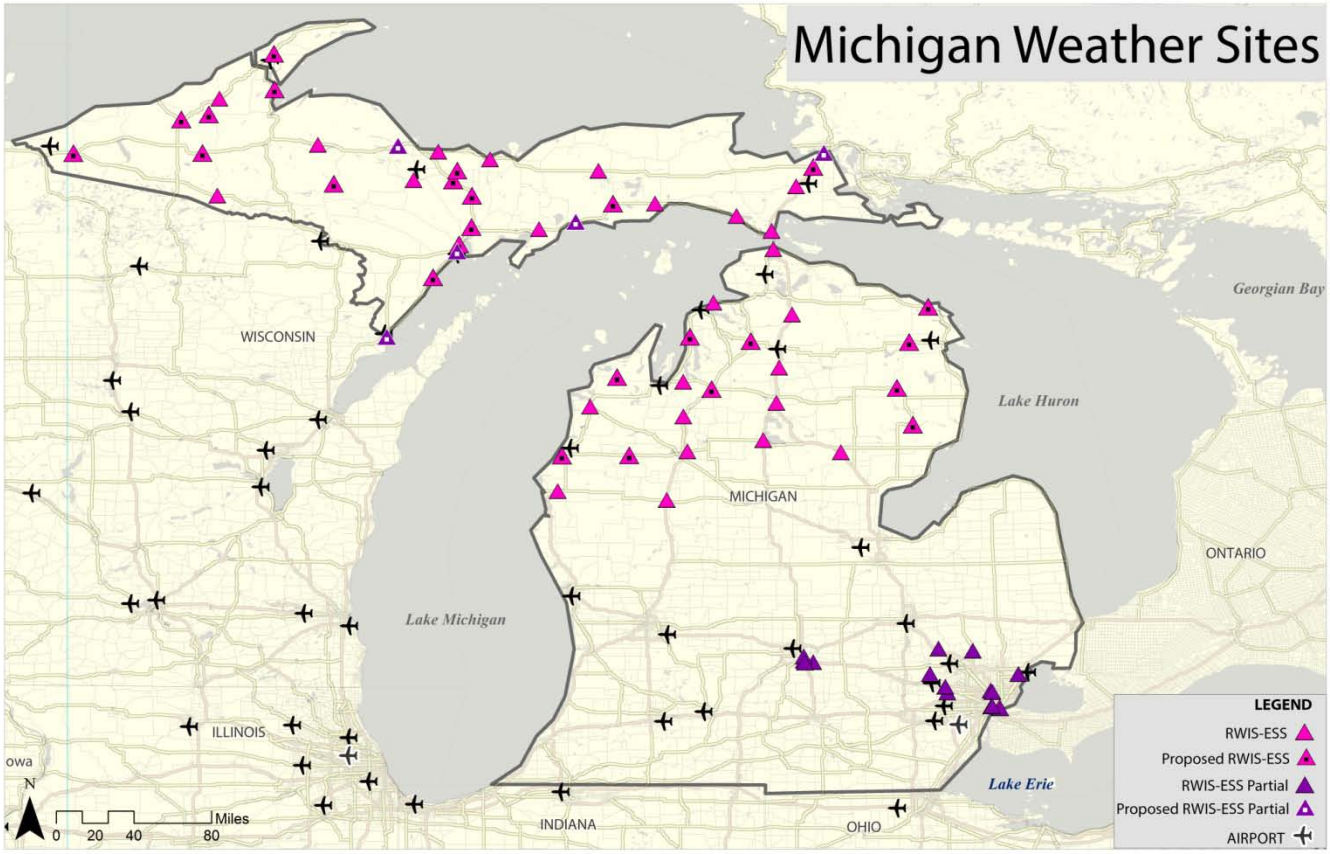


Table 1: MDOT Existing ESS Assets

Region	Site Name	Air Sensor	Wind Sensor	Invasive Pavement Sensor	Subsurface Sensor	Snow Depth Sensor	Precipitation Sensor	Visibility Sensor	IP Surveillance System	Barometric Pressure Sensor	Traffic Sensor	IR Illuminator	Non-Invasive Pavement Sensor	Invasive Pavement Temp Sensor	Position, Speed, Direction, Altitude, Distance, Vehicle Dynamics, Roughness, Imaging	Vehicle Data - VIN, RPM, Throttle, ABS, Trac Control
Superior	Harvey ESS	x	x	x	x	x	x	x	x	x						
	Autrain ESS	x	x	x	x	x	x	x	x	x						
	Seney RA ESS	x	x	x	x	x	x	x	x	x	x					
	Engadine ESS	x	x	x	x	x	x	x	x	x						
	Brevort ESS	x	x	x	x	x	x	x	x	x						
	Rudyard ESS	x	x	x	x	x	x	x	x	x	x					
	St. Ignace ESS	x	x	x	x	x	x	x	x	x	x					
	Cooks ESS	x	x	x	x	x	x	x	x	x	x					
	Gwinn ESS	x	x	x	x	x	x	x	x	x	x					
	Michigamme ESS	x	x	x	x	x	x	x	x	x	x					
	Twin Lakes ESS	x	x	x	x	x	x	x	x	x	x					
	Golden Lakes ESS	x	x	x	x	x	x	x	x	x	x					
	Escanaba ESS	x	x	x	x	x	x	x	x	x	x					
	Cut River Bridge ESS	x	x	x	x	x	x	x	x	x	x					
North	Benzonia ESS	x	x	x	x		x	x	x	x						
	Ludington ESS	x	x	x	x		x	x	x	x						
	Reed City ESS	x	x	x	x		x	x	x	x						
	Williamsburg ESS	x	x	x	x		x	x	x	x						
	Charlevoix ESS	x	x	x	x		x	x	x	x						
	Waters ESS	x	x	x	x		x	x	x	x						
	Grayling ESS	x	x	x	x		x	x	x	x						
	Houghton Lake ESS	x	x	x	x		x	x	x	x						
	West Branch ESS	x	x	x	x		x	x	x	x						
	Mackinac City ESS	x	x	x	x		x	x	x	x						
	Wolverine ESS	x	x	x	x		x	x	x	x						
Metro	I-375 ESS	x		x			x	x								
	I-75/I-375 ESS	x		x			x	x								
	I-94 EB ESS	x		x			x	x								
	I-94 WB ESS	x		x			x	x								
	I-75 NB ESS	x		x			x	x								
	I-75 SB ESS	x		x			x	x								
	M-5 ESS	x		x			x	x								
	9 Mile ESS	x		x			x	x								
	I-275 ESS												x			
Southwest	60 Mobile Phones in Vehicles														x	
	20 Surfce Patrol Units in Trucks/Vehicles	x											x			
	40 OBD Units in Trucks/Vehicles	x								x						x

Table 2: MDOT Proposed ESS Assets

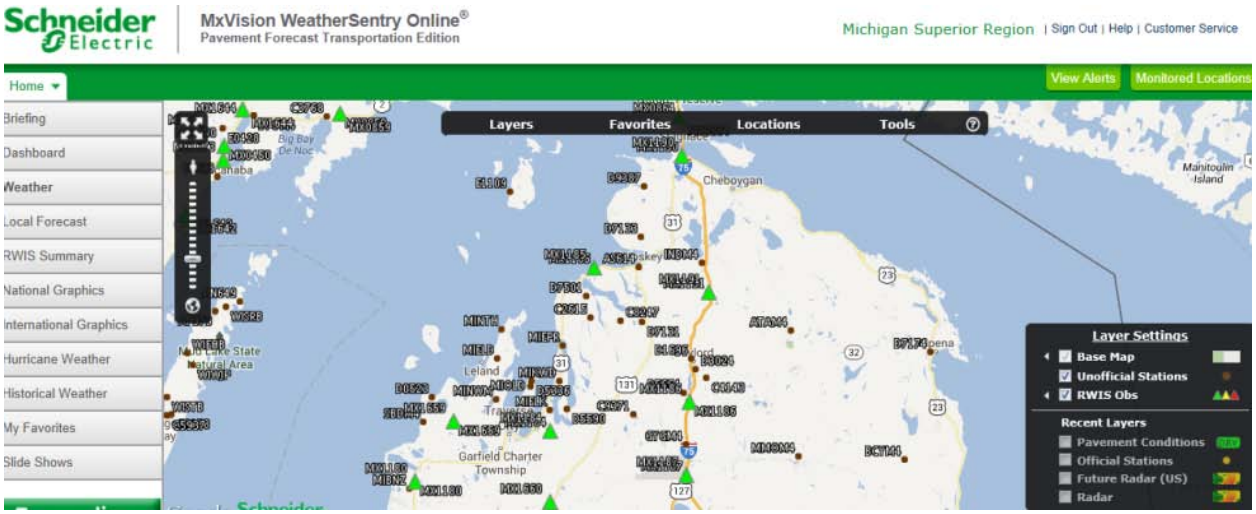
Region	Site Name	Air Sensor	Wind Sensor	Invasive Pavement Sensor	Subsurface Sensor	Precipitation Sensor	Visibility Sensor	IP Surveillance System	Barometric Pressure Sensor	Traffic Sensor	IR Illuminator	Non-Invasive Pavement Sensor	Invasive Pavement Temp Sensor
Superior	Wakefield ESS	X	X	X	X	X	X	X	X	X	X		
	Rockland ESS	X	X	X	X	X	X	X	X	X	X		
	Trout Creek ESS	X	X		X	X	X	X	X	X	X		
	Nisula ESS	X	X	X	X	X	X	X	X	X	X		
	Calumet ESS	X	X	X	X	X	X	X	X	X	X		
	Arnheim ESS	X	X	X	X	X	X	X	X	X	X		
	Republic ESS	X	X	X	X	X	X	X	X	X	X		
	Negaunee ESS									X		X	
	Cedar River ESS	X	X	X	X	X	X	X	X	X	X		
	Rapid River ESS	X	X	X	X	X	X	X	X	X	X		
	Trenary ESS	X	X	X	X	X	X	X	X	X	X		
	Kiva ESS	X	X	X	X	X	X	X	X	X	X		
	Sundell ESS	X	X	X	X	X	X	X	X	X	X		
	Manistique ESS				X			X		X	X	X	X
	Blaney Park ESS	X	X	X	X	X	X	X	X	X	X		
	Dafter ESS	X	X	X	X	X	X	X	X	X	X		
	Escanaba Signal ESS			X				X		X			
	Menomenee Signal ESS							X		X			
	Sault St. Marie Signal ESS							X		X			
North	Leelanau ESS	X	X	X	X	X	X	X	X		X		
	Fife Lake ESS	X	X	X	X	X	X	X	X	X	X		
	Wellston ESS	X	X	X	X	X	X	X	X		X		
	Manistee ESS	X	X	X	X	X	X	X	X	X	X		
	Eastport ESS	X	X	X	X	X	X	X	X	X	X		
	Elmire ESS	X	X	X	X	X	X	X	X	X	X		
	Kalkaska ESS	X	X	X	X	X	X	X	X	X	X		
	Lachine ESS	X	X	X	X	X	X	X	X	X	X		
	Grand Lake ESS	X	X	X	X	X	X	X	X		X		
	Curran ESS	X	X	X	X	X	X	X	X		X		
	Five Channels ESS	X	X	X	X	X	X	X	X		X		
	Charles Brink BDWS											X	
	Trowbridge BDWS											X	
	SB Gaylord			X									
	NB Gaylord			X									
University	Site #5 - Okemos Rd			X			X						
	Site #6 -			X			X						
	Site 7 - Dunkell			X			X						
	Site #8 - Trowbridge			X			X						

2.3 WeatherSentry – Hosted Server & Forecasting Tool

At the end of 2012, MDOT initiated a new agreement with Schneider Electric to provide a hosted application for MDOT's central repository of weather data and forecasting. The data collected from each ESS is transferred to WeatherSentry where real-time data from each station is populated on the website. The WeatherSentry application (see Figure 2) receives data directly from the ESS sites and shares the data with the National Oceanic and Atmospheric Administration (NOAA) Meteorological Assimilation Data Ingest System (MADIS). MADIS leverages partnerships with international agencies; federal, state, and local agencies (e.g. state Departments of Transportation); universities; volunteer networks; and the private sector (e.g. airlines, railroads) to integrate observations from their stations with those of the NOAA to provide a finer density, higher frequency observational database for use by the greater meteorological community.

WeatherSentry uses all of these data sources in Michigan and surrounding states to generate several types of forecasts for the users. Schneider Electric uses a combination of in house meteorologists and forecasting algorithms to issue a forecast. For example, a pavement forecast (where pavement data is available) is generated by the system based on various parameters of atmospheric and pavement condition/temperature data. Similarly, general forecasts are developed that represents the weather conditions for the entire state of Michigan. Users can click on a city and get local and 10-day forecast similar to visiting a National Weather Service site or private sector source such as "weather.com". WeatherSentry is a versatile, web-based tool which provides various layers of data that can easily be shown or hidden on the website. For example, users can select various weather features such as radar, pavement temperature or air temperature.

Figure 2: WeatherSentry Online



3.0 STAKEHOLDER WORKSHOPS

This chapter will discuss a series of statewide workshops that were conducted with MDOT and several weather partners to understand how weather can be used to support their activities and the justification and need for additional RWIS along other roadways in the State.

3.1 Workshop Plan and Schedule

A series of stakeholder workshops and meetings were conducted over a 3-day period during the week of July 8-12, 2013 throughout the state of Michigan to gain input about the existing MDOT RWIS system. The primary focus of the workshops was to determine how the existing system performs compared to the performance measures that MDOT identifies for the system. A secondary focus was to explore what new sources of weather information exist and whether the owners of that information would be interested in sharing weather information with MDOT in order to supplement MDOT's and their existing data. Three meetings were hosted in each geographic location. Each day, various stakeholders from each of the following groups provided valuable input during the workshops:

- Road Maintenance and Operations – this category represents the MDOT, County, and hired road maintenance community that uses weather information to service the roadways. In addition, this community includes operations personnel for arterials and freeways, such as traffic management centers (TMC).

- Weather Sharing Partners – this category represents potential partners that may already have their own source of weather data that MDOT may be able to leverage for their system, and similarly, data or information MDOT may be able to use for their proposes. This includes, National Weather Service, agricultural communities, Michigan Department of Natural Resources, Bridge Authorities, and Research Institutions.

- MDOT Planning Staff and Management – this category represents the management and planning groups at MDOT that rely on weather data to assist with various design, construction projects, performance monitoring, maintenance fleet planning, and bridge monitoring.

Because Michigan is such a large state with various needs, three separate workshop days were scheduled to focus the needs discussion with the users from the areas listed below. Meetings were supplemented by conference calls when scheduling demands required it.

- Rural – The rural stakeholder meeting was held in Saint Ignace on July 9, 2013, and focused on issues relating to the North/Superior Regions of the Michigan. With the abundance of existing MDOT weather assets, numerous county stakeholders, and the potential weather partners the meetings focused on use of data in this area.

- Rural/Urban – This stakeholder meeting was held in Lansing on July 10, 2013, and focused on issues relating to freeway and arterial operations along key corridors in Grand Rapids, Flint, Saginaw, Kalamazoo, Jackson, Battle Creek, Lansing and Ann Arbor. The discussion was framed around operations and maintenance for these areas, potential weather sharing opportunities, and other initiatives that depend on the use of weather data for performance measures/metrics, such as the Regional Integrated Transportation Information System (RITIS).

- Urban – The final stakeholder meeting was held in Detroit on July 11, 2013, and also via conference call August 1, 2013, and focused on key issues for maintenance and operations in large city centers such as Detroit that has limited state owned assets and a large reliance on county road systems, or weather partners. The discussion was framed around challenges and benefits with obtaining and using data.

Information about the meetings that took place can be found below in Table 3.

Table 3: MDOT Proposed ESS Assets

Day 1 – July 9, 2013: Saint Ignace, MI
▪ 8:30a – 11:00a – Maintenance & Operations Workshop for Rural Deployments
▪ 11:00a – 12:00p – MDOT Management & Planning for Rural Deployments
▪ 1:00p – 2:30p – MDOT Weather Sharing
Day 2 – July 10, 2013: Lansing, MI
▪ 9:00a – 12:00p – Maintenance & Operations Workshop for Urban/Rural Deployments
▪ 1:00p – 2:30p – MDOT Management & Planning for Urban/Rural Deployments
▪ 2:30p – 4:00p – MDOT Weather Sharing
Day 3 – July 11, 2013: Detroit, MI
▪ 9:00a – 12:00p – Maintenance & Operations Workshop for Urban Deployments
▪ 1:00p – 2:30p – MDOT Management & Planning for Urban Deployments
Day 4 – August 1, 2013: Conference Call
▪ 1:00p – 2:30p – Maintenance & Operations Workshop for Urban Deployments
▪ 2:30 – 3:30p – MDOT Weather Sharing

3.2 Meeting Participants

The following companies, agencies and departments were represented at the stakeholder meetings conducted in July and August.

- MDOT – ITS Program Office
- MDOT – Superior Region
- MDOT – North Region
- MDOT – Grand Region
- MDOT – Bay Region
- MDOT – Southwest Region
- MDOT – Metro Region
- MDOT – University Region
- MDOT – Aeronautics
- MDOT – Jackson TSC
- MDOT – Grand Rapids TSC
- MDOT – Oakland TSC
- MDOT – Ishpeming TSC
- MDOT – Newberry TSC
- MDOT – Engadine TSC
- MDOT – STOC
- MDOT – SEMTOC
- MDOT – WMTOC
- MDOT – Muskegon TSC
- MDOT – System Operations
- MDOT Maintenance Garages (various regions)
- Mackinac Bridge Authority (MBA)
- International Bridge Authority (IBA)
- Michigan Department of Natural Resources
- Oceana County Road Commission
- Road Commission for Oakland County
- Center for Automotive Research (CAR)
- NWS – Marquette
- NWS – Grand Rapids
- NWS – Gaylord
- Michigan State University
- City of Grand Rapids
- Schneider Electric
- Parsons Brinckerhoff
- Iteris

3.3 Questions

The section below includes questions that were asked of the participants at the workshop. The questions were developed to aid in the discussion.

3.3.1 Maintenance & Operations Questions

- What is the current method of obtaining road weather data?
  - What benefit is realized as a result of this data?
  - Are there any deficiencies with the data or system?
- What data allows the Department/Road Agencies to make decisions for Road Maintenance?
- Would having truck mounted sensors enhance the maintenance ability? If so, how?
- What is the current decision making process followed by maintenance staff?

- Do you utilize pavement forecasts in your decision-making? Is Schneider Electric the source of the forecasts or do you receive other pavement forecasts?
- Are camera images helpful in decision making for treatment?
- What areas do you feel are not covered well by the existing source of data?
- How does the maintenance fleet get their data (forecast or real-time)?
- Has data accuracy or reliability been a concern?
- Is weather data disseminated to the traveling motorists? If so, how?
- Is there a need to provide motorist additional information about road conditions?
- Does your agency/department have vehicles with Mobile Data Collection (MDC)/Automated Vehicle Locator (AVL) equipment installed and in use?
    - What parameters are being collected and transferred to a data processing center? Are the parameters collected automatically or are they entered in-vehicle via touch-screen computer monitors?
- Does MDOT currently obtain camera images from outside parties for decision making? County roadways?
- What works well in the current RWIS system?
- How would you improve the current RWIS program?

3.3.2 Management & Planning Questions

- Do you use road weather data in your day to day duties?
- What is the current method of obtaining road weather data?
    - What benefit is realized as a result of this data?
    - Are there any deficiencies with the data or system?
- What data allows the Department/Road Agencies to make decisions for Road Maintenance?
- Does MiDRIVE currently use weather data in conjunction to traffic data?
- Is there any weather data that would assist the various planning groups in design/operations?
    - How accurate does the data need to be?
- Does MDOT currently obtain camera images from outside parties for decision making? County roadways?

3.3.3 Weather Sharing Partners Questions

- What is the current method of obtaining road weather data?
- What type of data is being collected?
- Are camera images helpful to weather partners? Are you currently using MDOT camera images?
- Has data accuracy or reliability been a concern with the current source of data from MDOT?
- How does weather data help/aid in your business area?
- How is your data hosted? Do you currently share that data with external parties such as MDOT?
- Does your agency/department have vehicles with MDC/AVL equipment installed and in use?
    - What parameters are being collected and transferred to a data processing center? Are the parameters collected automatically or are they entered in-vehicle via touch-screen computer monitors?

4.0 USER NEEDS

Based on the interactions our team had with stakeholders during the month of July and August, a detailed summary of user needs was developed for each of the various focus areas. These user needs are categorized by which Region indicated the need, how the needs rank overall, and how well the existing system or program addresses these needs. Some of the user needs may be addressed with the existing system in certain parts of the state, while others may find some deficiencies in those same areas. Because of this, we've provided comments to emphasize where this result may not be indicative of the entire state and further review may be needed to best address this need. These needs and priorities were derived from general discussion with individuals in each workshop. Our team will perform an assessment of how well the system performs and identify where there may be deficiencies with the system or institutional challenges that need to be addressed. The following sections are a summary of user needs based on feedback during the stakeholder meetings.

4.1 User Needs for Maintenance & Operations

Table 4-1: Maintenance and Operations User Needs

USER NEEDS	Region*	Overall Priority (High, Medium, Low)	How Existing System Performs (Very Good, Average, Poor)	Comments
Maintenance personnel need improved visibility on conditions near the edge of their area of responsibility to help in allocating resources efficiently.	Superior, North, Southwest, Metro	High	Average	This is done well in Metro region and other areas down state, but is not done so well in some areas of North and Superior that do not currently have ESS.
General need for real-time RWIS reporting from the hosted web application.	All	High	Very Good	Real-time reporting available statewide.
General need clear camera images for decision making. Images include clear night images with the use of infrared technology.	All	High	Very Good	Camera images are generally covered pretty well in the state. More is always better, increased need for night time illumination at camera locations where there is low ambient light.
MDOT personnel need to receive forecasts to determine when and where a storm will take place.	All	High	Average	System does this well, but users in Southern portions of the state are not using the data yet and the forecasts often do not pick up localized storm cells, like lake effect snow..
General need information to determine if maintenance should treat the roadway, how they should treat, and if the treatment was accurate.	Metro, North, Superior	High	Average	This is done well in North and Superior since the system is being used for this purpose. Limited RWIS assets in other areas prevent users from obtaining this detail from the system.
Maintenance personnel need better forecast and/or detection of lake effect snow bands, and squall of snow. Expanded, enhanced, or improved RWIS data made available to weather forecasters will lead to improved forecasts.	All	High	Poor	
MDOT need for traveler information to be disseminated to motorists regarding recommendations about safe travel during inclement conditions. (e.g. don't use cruise control).	Superior, North	Medium	Average	This is done well down state in urban environments and moderately well in the North and Superior Regions. The biggest challenge in rural areas is the scarcity of dynamic message signs.

MDOT maintenance personnel need to have access to RWIS data on a smart phone or mobile application for in-field reporting to maintenance crews.	Superior, North	Medium	Average	This is done moderately well for the North/Superior crews.
MDOT maintenance personnel need frost depth data for non-freeway corridors to better manage road restrictions at the end of the winter season.	Grand, Bay, Southwest, University	Medium	Poor	Frost tubes are currently used, reading of which requires a trip to the field and accessing the tube from the traveled roadway.
MDOT maintenance personnel need specialized road weather information at locations that may not require a full ESS site. They need to have site specific data such as surface conditions (or "grip" values) on bridges that tend to ice up and create problems for motorists or flood gauges in areas prone to flooding.	All	Medium	Average	This is done moderately well in pockets across the state. Each region is actively looking to address site specific concerns, but need for additional site specific conditions still exists.

* Only the regions listed expressed concern for any of the given user needs.

4.2 User Needs for Management & Planning

Table 4-2: Management and Planning User Needs

User Needs	*Region**	*Overall Priority (High, Medium, Low)*	*How Existing System Performs (Well, Good, Poor)*	*Comments*
MDOT personnel need historical weather data included in MDOT"s RITIS program for performance monitoring.	Grand, Bay, University, Southwest, Metro	High	Poor	
MDOT personnel need start/end time of a storm for performance measurement activities such as monitoring for regain time related to MDOT's goals.	Grand, Bay, University, Southwest, Metro	High	Poor	
MDOT personnel need to be able to provide the public information about weather conditions on the roadway and where snow plows are working	Metro, North	High	Poor	

MDOT personnel need to have RWIS data integrated with the statewide Advanced Traveler Management System (ATMS) to enhance ability for providing real-time weather conditions.	All	Medium	Average	

* Only the regions listed expressed concern for any of the given user needs.

4.3 User Needs for Weather Sharing

Table 4-3: Weather Sharing User Needs

User Needs	*Region**	*Overall Priority (High, Medium, Low)*	*How Existing System Performs (Very Good, Average, Poor)*	*Comments*
MDOT personnel need to make RWIS data available to NOAA through WeatherSentry or other industry standard means such as MADIS.	All	High	Very Good	
MDOT personnel need to make RWIS data available to emergency, fire and first responders.	Metro	Medium	Average	
MDOT personnel need to make RWIS data available to bridge crossings such as Mackinac Bridge Authority, International Bridge Authority, and Blue Water Bridge.	Superior, North, Metro	Medium	Average	RWIS data is available from public sources if the users have an interest in looking for the data.
MDOT personnel need to have an RWIS that can accept data feeds from mobile and connected vehicle platforms.	Southwest and Metro	Medium	Poor	
MDOT personnel need to make RWIS data available to private sector industries and research institutions that are interested in weather data.	Metro	Low	Poor	
MDOT personnel need to make RWIS data available to State of Michigan departments such as Michigan Department of Natural Resources, and Michigan State Police.	All	Low	Average	The data are available; When a request is made, MDOT can make the RWIS data available to private sector, research institutions, and State departments through the Data Sharing Contract. The forecasting is not available to parties outside of MDOT

* Only the regions listed expressed concern for any of the given user needs.

5.0 ANALYSIS

Using the needs defined by stakeholders at the various meetings, several conclusions can be drawn about the existing gaps that are apparent within MDOT's road weather program. This chapter will analyze all of the user needs described in 4.0 and define gaps in all respects of MDOT's RWIS. A solution for these gaps is not presented in this memo. Upon completion of other key tasks within the entire evaluation project, a further review of these gaps will be completed.

5.1 Gap Analysis

Based on feedback from the users at the various workshops, several gaps with the RWIS program became apparent. Some of the high-level conclusions can be drawn from the gaps. These include:

- Define Region MDOT Champions: MDOT RWIS Program is missing a champion in several of the MDOT regions. Without an advocate for the weather program, investment in obtaining new weather data will be difficult from an institutional standpoint.
- Better Lake Effect Snow Reporting: There appears to be a widespread need for lake effect snow forecasting and reporting. There aren't enough data points on the lakeshore, specifically off of Lake Michigan to assist in providing an accurate forecast for these localized, rapidly changing events. This is prevalent in all regions that border lakes Michigan, Huron or Superior.
- Integrate with ATMS: There appears to be lack of weather integration in to MDOT's traveler management system. Users have expressed interest to provide motorist with some indication of road conditions, however the ability to disseminate weather conditions automatically or using forecasted data is not currently available within the existing system configuration.
- Determine Frost Depth Measurement Sensor Locations: There is need across the state to safely and efficiently determine frost depth measurement on non-freeway trunklines with lower AADT and weak pavement profiles. The North and Superior areas have sensors for frost depth measurement, but certain regions such as University, Southwest and Grand are lacking in sensor coverage.
- Define Performance Measurements: There is a gap between what MDOT needs to measure performance against their Wildly Importation Goals (WIGs) and the data that is available. An example is measuring the start and end of storms. There is a lack of understanding across the department regarding how to measure the start and end to a storm. While this should be defined at the management level, this value can be derived from WeatherSentry to aid in their performance measuring/monitoring against WIG's.
- Provide Training and Awareness: There is a gap related to the training and awareness of the Maintenance Decision Support System (MDSS). It was found through the stakeholder meeting that some users don't have it or maybe have it but don't use it are not certain that MDSS will be helpful.
- Defined High Priority Areas: There weren't major areas that stood out as having deficient weather coverage. However, it was noted that there is a gap in site specific trouble areas across all regions. An adequate ESS density is dependent upon the stakeholder. Different user needs determine whether a user senses the ESS distribution is adequate or not. This becomes a consideration as we go forward because the user community is changing from just the maintenance community to a broad spectrum of users with widely varied needs.
- Determine Grip Value Calculations: There is an apparent need for grip value calculations in across the state that will aid maintenance in their day-to-day operations to treat segments of roadway that see recurring icy conditions during the winter months.

- Better Storm Forecasting: There is an apparent need for better forecasting of storms in Metro Region, specifically in Oakland County. A limited array of ESS in the region is impacting the ability for the maintenance engineers to better plan road treatment on specific routes around the region.
- Improve Mobile Observations: A significant gap in MDOT's system today is the ability to capture mobile observations in real-time across the state and for these observations to be a usable benefit for all regions of the state. What we need to further understand is the intent or purpose of the mobile data collection program to fulfill the needs of the RWIS requirement for mobile data.
- Mobile Access to ESS Data: There appears a need to get ESS data to the field staff in the form of a mobile application platform (iPhone or droid) so there is real time access to data such as forecasts. While there is an application developed for the existing hosted server, not all features are available, limiting the decision making from the mobile phone.

5.2 Next Steps

The stakeholder workshops highlighted a broad spectrum of user needs and differing perspectives regarding the RWIS program from different Regions within the state and across agencies tasked with different transportation support responsibilities. The workshop discussions touched on topics that were previously considered external to the RWIS program but are rapidly becoming an integral part of road weather (traffic monitoring, camera imagery, data from mobile platforms, and traveler information services). The integration of these new areas into the RWIS program has occurred over the past decade or more and has been accelerated recently by communications technologies and mobile devices such as smart phones and tablets. The ability to share information has tended to aggregate these diverse areas into a closer integrated support system. This evolution in RWIS presents significant challenges in evaluating the RWIS of the future because the needs of the stakeholder community are evolving rapidly and are far more extensive than the original needs set the maintenance community. As traffic volumes increase the level of service expectations increase, the needs of the maintenance community itself are changing. These new needs and expectations create functional gaps in MDOT's RWIS program induced by the changing operational and social environment.

The statewide RWIS asset review also brought out physical gaps in the MDOT RWIS network when the network is viewed as a maintenance resource. Most of the operational gaps in the Superior and North Region accentuated locations that were known problem areas that needed closer scrutiny. However, the most obvious gap in the current program is the dearth of ESS sites outside of the Superior and North Regions. This distribution disparity was part of a phased plan, but the intriguing factor that faces MDOT is that the criteria that determined the RWIS distribution and ESS placement in the Superior and North Regions may not be indicative of the specific requirements of the remainder of the regions in the state. Thus, a mere translation of the RWIS network criteria used in the Superior and North regions may not establish a network of road weather information that satisfies the needs of the main end user communities in the remaining regions of the state.

The issues that MDOT faces are not unique to Michigan alone. Other states and provinces that deal with road weather issues similar to those in Michigan are addressing the same issues as RWIS and related technologies change the road weather environment. The Parsons Brinckerhoff team is collecting input from roughly 20 other states and provinces on the technical aspects of their RWIS programs and their best practices in dealing with the same issues Michigan is currently facing. The team will use this best practices information to address the user need gaps defined by the workshop, especially the functional gaps associated with the technological and social issues that

are impacting RWIS. This process will ensure that the user needs are addressed using proven methods. The recommendations will be identified in the Deployment Strategy memorandum along with a phased approach ranking the priorities from high to low.