Assessment of Montana Road Weather Information System

Task 4 Report

Needs Assessment

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1) INTRODUCTION AND METHODOLOGY

This interim report details the methodology and findings of the Montana Department of Transportation (MDT) Agency Needs Assessment Task as part of the overall project to assess the state's Road Weather Information System (RWIS). This task captures the needs of different agency stakeholders that use RWIS information. Identifying these needs is essential to subsequent project tasks including the *Weather Data and Software Analysis*, *Benefit Cost Analysis*, and the *Implementation Plan* to ensure the most important aspects of these tasks are considered in recognition of the agency stakeholder's duties.

In consultation with the project Technical Panel, the agency RWIS stakeholders were identified. The Maintenance Division is the primary RWIS user and the original developer of the system. Maintenance personnel, especially those responsible for winter maintenance activities, are the primary RWIS data user and as such much of the needs assessment efforts were targeted toward understanding and documenting their needs. Other agency personnel involved with traveler information services and the Aeronautics Division were identified as secondary RWIS data users and were also included in this needs assessment task.

1.1. Primary Agency Users: Maintenance Division

Multiple methods were used to gather the needs of the primary RWIS users within the Maintenance Division. The first method was a brief workshop type session held during the 2015 Spring Maintenance Chiefs Meeting. This time was used to introduce the project to the Division and begin gathering information on the RWIS needs as expressed by the meeting attendees: Maintenance Chiefs and Supervisors from each of the 10 area offices as well as key Maintenance Equipment, Communications, and Facilities personnel. The next method used was a questionnaire that was sent to each of the Maintenance Chiefs and then forwarded to any Section Supervisors or Maintenance Superintendents that the Chiefs wanted to include. This questionnaire included sections on the responsibilities, practices and decision making of the maintenance personnel, RWIS equipment, software and maintenance and geographic coverage and placement of RWIS stations. A copy of the questionnaire is included in Appendix A. The last method used to understand the RWIS system and needs from the perspective of the Maintenance Division was telephone interviews with key personnel involved with RWIS hardware, communications, and information services/technology.

1.2. Secondary Agency Users: Traveler Information and Aeronautics

The secondary RWIS data users were interviewed in order to understand their uses of RWIS and document their needs. A representative of MDT responsible for the traveler information activities of the agency was interviewed as well as a representative of the Aeronautics Division.

These telephone interviews were semi-structured with lists of questions helping to guide discussions and follow-up emails used as needed.

2) RWIS USES AND NEEDS

The following sections detail the agency uses of RWIS data and the needs of each of the stakeholder groups.

2.1. Maintenance Division

The documented RWIS uses and needs in this section are generated from the workshop-type session, the personnel interviews and especially from the questionnaire which was answered by 33 maintenance personnel including 6 Maintenance Chiefs (MC), 19 Section Supervisors (SS), and 8 Maintenance Superintendents (MS).

2.1.1. Responsibilities, Practices and Decision Making

For the most part RWIS data helps the maintenance personnel with winter maintenance related activities like snow and ice pre-treatment and removal. However, RWIS data is also used occasionally for practices outside of winter maintenance including: road work projects that may be weather sensitive, issuing high wind and visibility warnings, monitoring and potentially issuing load restrictions during the spring thaw period, and monitoring conditions for weed spraying and road sweeping concerns.

A number of winter maintenance goals and objectives were cited by the questionnaire respondents. Providing safety for the travelling public is the primary mission. Other reported goals included providing a certain level of service and mobility in an economically sensible way without overusing materials that may be costly and impact the environment.

There were no formally documented winter maintenance performance metrics used to monitor and track performance, but a couple of maintenance personnel did say that they do consider the amount of time it takes to return to bare or wet pavement as a sort of informal measure they use to gauge performance.

Winter maintenance decisions are made based on RWIS data as well as other sources of weather information like National Weather Service information and other weather provider forecasts. Figure 1 shows the summary of responses when the maintenance personnel were asked about the percent of winter maintenance decisions that are based on RWIS data compared to other weather data sources. On average, the MCs weighed their winter maintenance decision making as approximately 24% RWIS data driven while the SSs and MSs reported approximately 45% of their decisions being RWIS data driven. These values represent the averages for the response groups with individual responses from MCs varying in the range of 5% to 45% and individual responses from SSs and MSs varying within a 0% to 100% range.

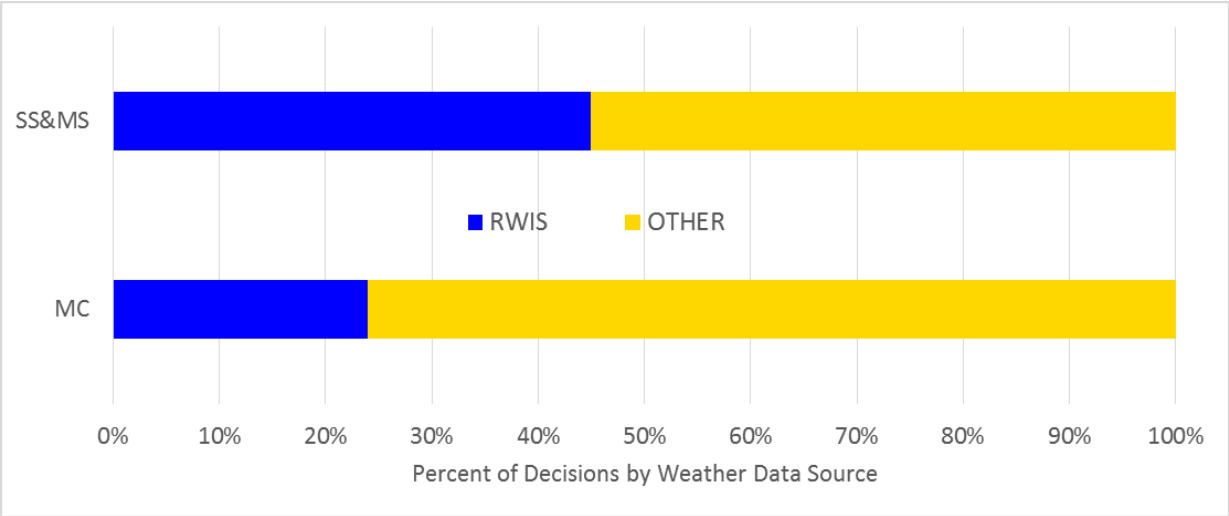

Figure 1: Weather Information for Winter Maintenance Decisions

The main comments related to the use of RWIS data in relation to other sources focused on forecasts. Since RWIS does not currently provide weather forecasts, many maintenance personnel use the other weather information sources that do provide forecasts for planning prior to a storm, then switch and rely on RWIS and/or personnel observations to make decisions during a storm.

2.1.2. Equipment and Software

Various types of weather information are available from many different RWIS sensors and equipment types that are made by different manufacturers. The maintenance personnel were asked to rank the weather information by importance as either “must have”, “helpful”, or “not necessary”. Figure 2 shows the importance of the different weather attributes as reported by the MCs.

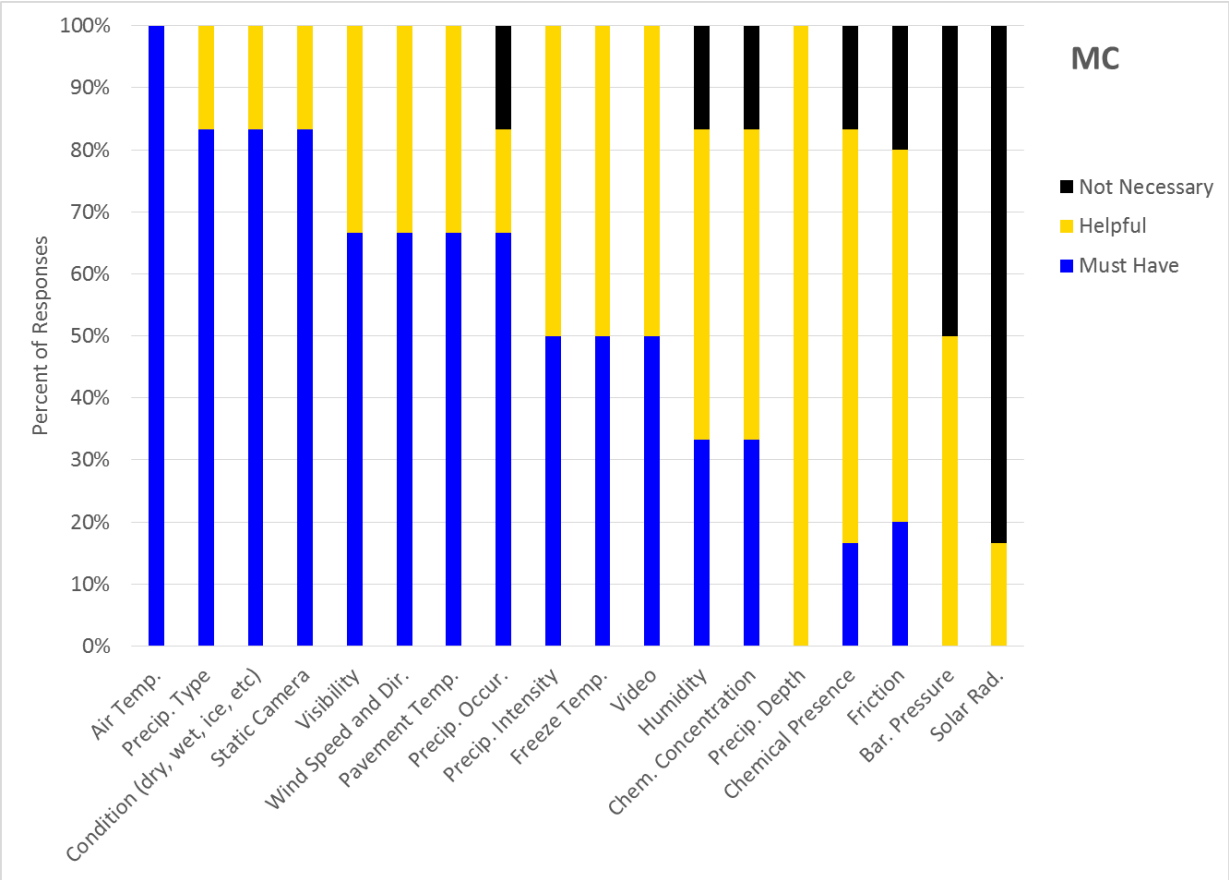

Figure 2: Weather Attribute Importance (Maintenance Chiefs)

The weather attribute importance responses for the SSs and MSs are shown in Figure 3.

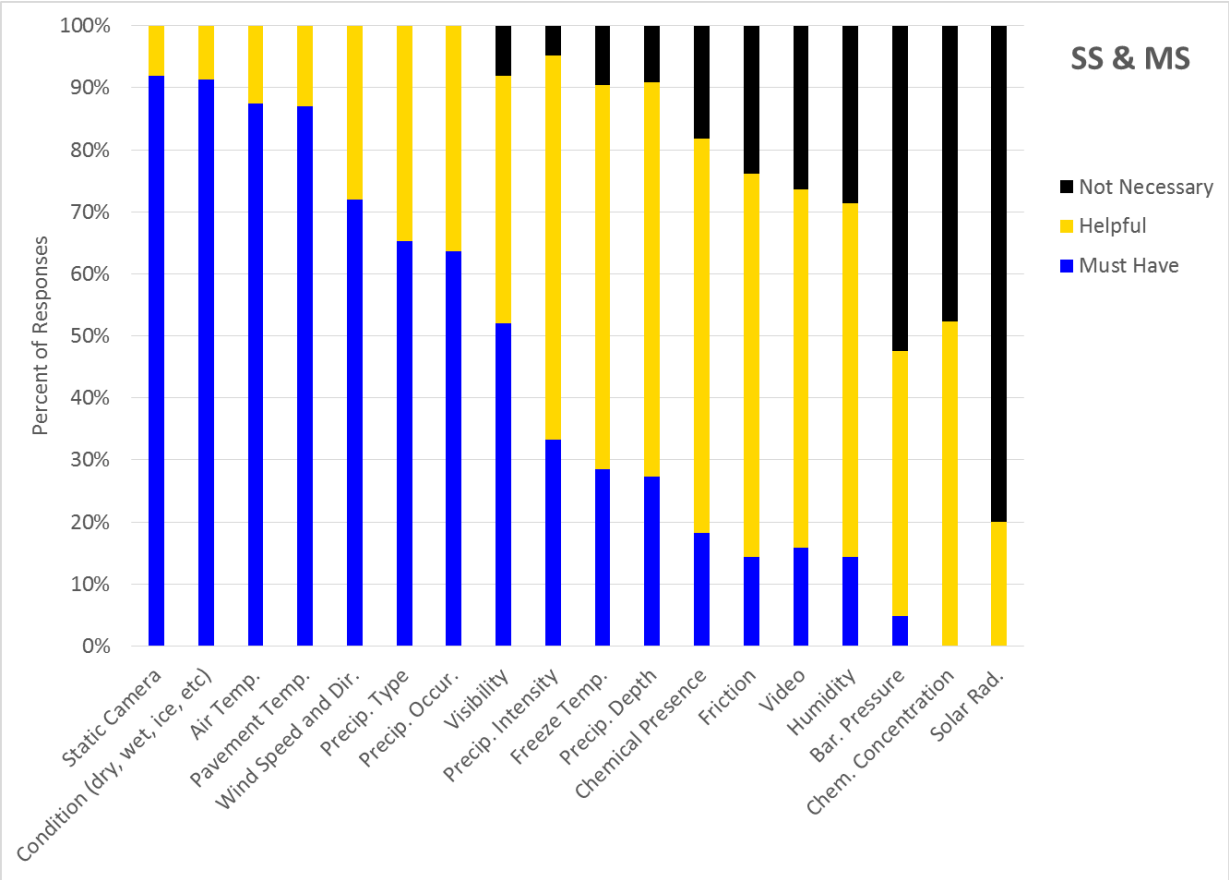

Figure 3: Weather Attribute Importance (Section Supervisors and Maint. Superintendents)

The ranked importance ratings do vary between the two groups (MCs versus SSs and MSs), but for both groups the same 8 attributes that received over 50% of responses as "must have" included: static camera images, pavement conditions, air temperature, pavement temperature, wind speed and direction, precipitation type and occurrence, and visibility.

The maintenance personnel were also asked how often their critical weather attributes should be reported. Figure 4 shows the responses from both groups.

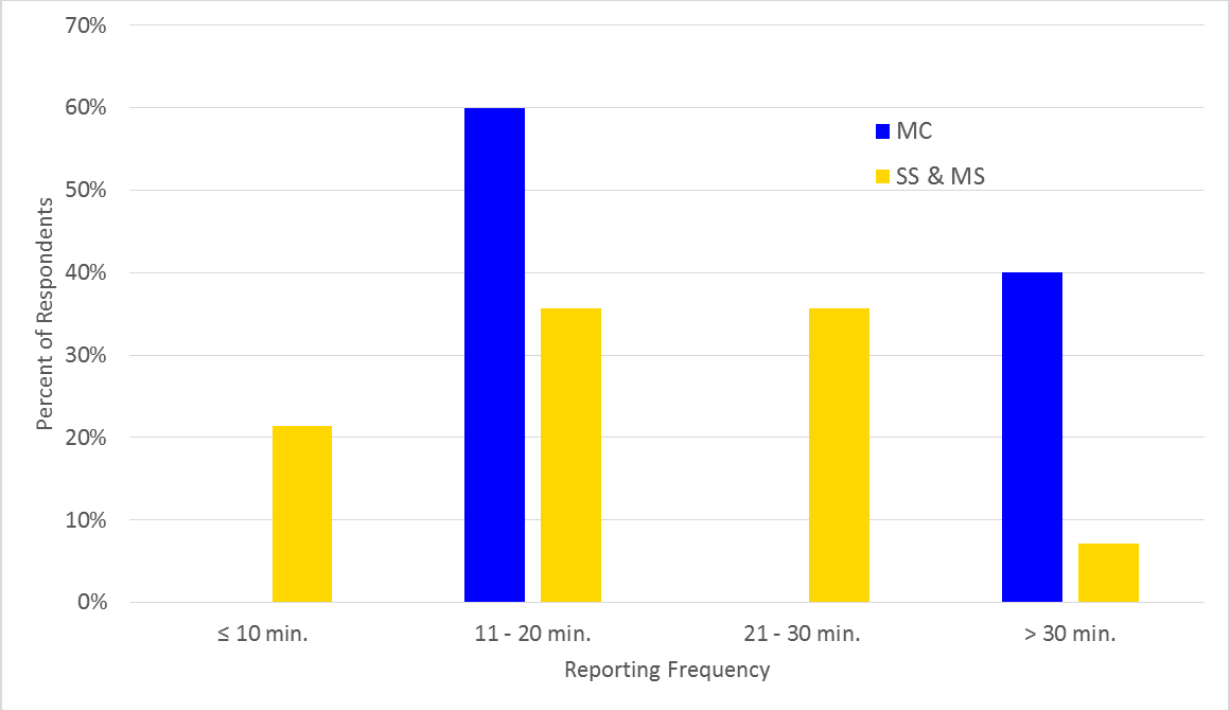

Figure 4: Reporting Frequency

Most respondents indicated they need new data every 15 to 30 minutes, with 15 minutes being the most common response.

For the most part the maintenance personnel find the current RWIS sensors to be accurate and reliable (17 out of 22 responses). It was also found (during the interview with a key RWIS hardware and communications equipment contact) that when data is unavailable it is usually due to a cellular communications or power issue and not due to individual sensor failures. While maintaining the entire RWIS program, "two to three times a week" a single RWIS site will become unavailable and often require remote diagnostics and repair. MDT technicians spread throughout the 10 area offices are called upon when remote repairs can't remedy the problems.

The maintenance personnel responses indicated that RWIS data communication reliability and timeliness was at times problematic (11 yes reliable and timely, 7 not reliable and timely, 6 sometimes or certain places are problematic). Again the most common issue is with the cellular network. Over 90% of the RWIS sites rely solely on cellular communications and the cellular network provider often has to shut down a cellular tower or block of towers for maintenance or upgrades. These outages are typically without warning and therefore cause RWIS sites to be unavailable for undetermined and unannounced periods due to situations beyond the control of MDT personnel. These outages often last "a few days to a week".

The maintenance personnel felt that currently the RWIS data is updated frequently enough for their needs (16 out of 25 responses). The reporting frequency for the vast majority of the sites is currently 30 minutes.

Approximately half of the maintenance personnel (13 of 25) indicated that they need the sub-surface temperature probes for their duties. These sub-surface temperature probes are often used during the spring thaw season.

The maintenance personnel generally indicated that certain other sensor capabilities are desired:

- 72% of respondents desired non-invasive pavement sensors,
- 82% of respondents desired better precipitation sensors with type, intensity, and depth,
- 87% of respondents desired visibility sensors, and
- 93% of respondents desired improved camera imaging with more pan-tilt-zoom (PTZ) functions and more frequent static images or live video.

Other equipment and software related responses from the maintenance personnel include:

- Static camera images are currently updated enough (19 out of 27 responses).
- Live video is beneficial (17 out of 22 responses).
- Vandalism is typically not a problem (29 out of 31 responses).
- Mobile RWIS sensors are not desired by most SSs & MSs (9 out of 13 responses), but are more desired by MCs (3 out of 5 responses).
- The display of RWIS data on mobile devices is needed (17 out of 22 responses).

2.1.3. Geographic Coverage and Placement

Similar to what was found during the state of the art and practice reviews, previous RWIS placements have been primarily based on MDT personnel experience. Generally the primary users (maintenance personnel) have placed RWIS where they see needs in relation to benefiting winter maintenance activities or addressing known problem areas such as a high wind location or a specific visibility situation near an “alkaline lakebed”. It was also noted that in more recent years, as traveler information has become more popular, the public often voices desires for cameras in certain locations, and those desires are taken into consideration when placing new RWIS sites.

The idea of installing more RWIS sites with limited sensors made possible by the cost savings of fewer sensors per site compared to traditional configurations was uncovered during the state of art and practice reviews. This notion was generally supported by the maintenance personnel (16 out of 20 responses including all 6 MCs supporting) with the understanding that it may be more beneficial to have more coverage with sites having only a camera and temperature probe than fewer traditional sites with more instrumentation. One main caveat was noted however for having

wind sensors in addition to the cameras and pavement temperature sensors at high-wind prone locations.

2.1.4. Maintenance of RWIS Software and Equipment

The overall maintenance of the RWIS equipment, communications, and software is performed by a handful of key personnel stationed at MDT headquarters and a number of technicians spread across the state in the 10 area offices.

Currently around half of the RWIS sites in the state have PTZ cameras. These PTZ cameras tend to give a better view of the overall weather conditions than a single fixed view as they take 3 to 4 images at different positions every minute. However, the cameras are the one piece of equipment most prone to failure, and the PTZ cameras tend to fail more often than fixed cameras.

From a maintenance perspective the approach to utilize more RWIS sites with just a camera and pavement temperature sensor could be somewhat more challenging than the traditional RWIS sites approach. This may be the case because the cameras in particular tend to be the most common equipment prone to failure and presumably the more sites, the more frequent would be the typical cellular-related communication failures. A more detailed investigation into the economic impact of these concerns will be included in the *Benefit Cost Analysis* Task should that scenario be one of the possible scenarios to be included in the task as determined in consultation with the project Technical Panel.

A service-based RWIS provider contract was another approach uncovered in the state of the art and practice reviews. Under such an approach, an RWIS provider would be under contract to provide certain RWIS data at certain levels of reliability. This approach was unpopular among the maintenance personnel and the key personnel interviewees, mainly due to poor past experience relying on RWIS providers (for RWIS equipment maintenance, not data delivery). In the early 2000s, when many of the RWIS sites were new a performance based maintenance contract was tried that relied on an RWIS provider. The RWIS provider was largely unable to provide adequate and timely maintenance, especially considering the travel required for a company based in another state to the many possible and often remote RWIS locations across Montana. The agency has since taken over maintaining their entire RWIS program, which is not a trivial task and requires the agency resources that are geographically spread across the state in the 10 area offices.

The software architecture involved in gathering and disseminating the RWIS data from across the state also requires a considerable amount of effort to maintain and that maintenance was also problematic under the previous provider contract. Somewhat recent required software and server upgrades have had impacts on the RWIS program including the loss of certain alerting functions based on changing weather conditions and the loss of the ability to scan the RWIS system for unresponsive sensors at RWIS sites. The alerting and scanning functionality was built on the older

software versions and would require new software to be programmed to re-gain that functionality for the new software versions. Unresponsive or malfunctioning equipment are often reported by maintenance personnel or the public who notice the errors on the traveler information websites or mobile apps.

2.1.5. Other Comments, Needs, and Ideas for Improvement

The maintenance personnel were also asked some open-ended questions about including anything not addressed in other questions and any other ideas for improvements they may have. The most common comments from these questions include:

- Real-time and more frequently updated data and camera images would be ideal.
- More RWIS sites are desired, especially at maintenance section boundaries.
- Cameras that provide images in the dark and live video would be beneficial.

Note that under the current cellular communications service plan there is a fixed data amount that is shared by the RWIS sites, so the ability to gather more frequent or live data (or video) may be limited or more costly at the present time. This will also need to be investigated more thoroughly if included in any of the scenarios as part of the *Benefit Cost Analysis* Task.

2.2. Traveler Information Personnel

The RWIS data and camera images are provided to the public via the traveler information website and mobile app from MDT. The RWIS data is also used by the 511 provider to help create route specific forecasts for the public that call the 511 telephone number for traveler information. The traveler information website and mobile app are used "very frequently" by the public. Some maintenance personnel also utilize the traveler information mobile app since it provides much of the RWIS data they use that is not otherwise readily available in a mobile friendly format.

The public tends to provide a lot of feedback on the traveler information made available by MDT. When sensors, cameras, and sites are unavailable the public typically informs MDT fairly quickly. Also the travelling public often voice their desires for more cameras in specific locations. They have also begun to ask for cameras that can provide images in the dark.

The traveler information services and the travelling public (based on traditional feedback) would tend to favor the potential approach of having more RWIS sites with just a camera and temperature sensor compared to fewer fully instrumented sites. Their only concern with such an approach would be that of being able to keep up with the maintenance of more sites, as they are aware of the maintenance challenges from the frequent public feedback.

2.3. Aeronautics Division

The Aeronautics Division of MDT often makes flights around the state especially to the 15 state-owned and 125 public-use airports for various inspections, meetings, and improvement grant related activities. The Division's pilots (and pilots from the general public) use the RWIS data and especially certain cameras when planning a flight. Cameras images are valuable to pilots if they include a view of the horizon. Similar to surface transportation, aviation decisions often hinge upon the conditions at key mountain pass locations. For example if a camera with a mountain pass horizon view shows poor visibility or low clouds then a flight may be postponed for safety concerns.

The most important types of data for aviation were said to be the camera images, wind speed and direction, visibility and air temperature. RWIS data is not the primary source of data for aviation decisions, but does add valuable information (especially camera images) in certain locations.

3) SUMMARY AND KEY FINDINGS

The agency needs established through this assessment are essential to ensure that the most relevant information is included in the subsequent tasks especially the *Weather Data and Software Analysis* and the *Benefit Cost Analysis* tasks which will investigate how the current RWIS system meets the needs and desires of the agency stakeholders, potential alternative approaches including data and software options, and the economic feasibility of the current and alternative approaches.

A number of key RWIS uses and needs have been communicated by MDT stakeholders throughout this process including:

- Maintenance personnel need camera images, pavement conditions, air temperature, pavement temperature, wind speed and direction, precipitation type and occurrence, and visibility.
- All Stakeholder groups generally favor the idea of having more sites with only a camera and pavement temperature sensor compared to fewer sites with more sensors per site.
    - Maintenance personnel may also need wind sensors or visibility sensors only at certain locations.
- It may be beneficial to update camera images and RWIS data every 15 minutes.
- The most problematic pieces of equipment (PTZ cameras) are also the most valuable.
- Cellular communications are the main source of outages and those outages are largely out of MDT's control.
- There are certain sensor and camera technologies that may be desired including non-invasive sensors, more robust precipitation sensors, visibility sensors, live video, and cameras with the ability to produce images in the dark.
- The ability to display RWIS data for maintenance personnel on mobile devices is desired, but may be partially available currently via the traveler information mobile app.
- More RWIS sites are desired overall and especially near maintenance section boundaries.
- Mobile RWIS are not generally desired at the SS and MS level, but more interest is shown at the MC level.
- Required RWIS software and server upgrades have recently resulted in some specific functionality losses.
- RWIS data is widely used by the public via the traveler information systems from MDT.
- The public (via traveler information) may be the most common method for the agency to learn of unavailable or malfunctioning sensors or RWIS sites.
- Cameras are the most popular type of information for the public who would presumably prefer more camera-only sites compared to fewer fully-instrumented sites.
- RWIS is a secondary data source for the Aviation Division and general aviation uses in Montana.

- Camera images with horizon views and especially those near mountain passes may be the most valuable RWIS information for aviation.

These RWIS uses and needs raise questions and suggest certain potential alternate approaches. The options and economic feasibility related to the following issues will likely need to be explored in the next project tasks:

- Improving communications reliability.
- Improving camera imaging.
    - PTZ failures, freezing lenses, night-time imaging, more frequent image updates, live video, horizon views for aviation
- Feasibility and outcomes of more sites with fewer sensors per site.
- Sensor technologies and manufacturers that may best meet weather data needs.
- Software and functionality that may benefit agency stakeholders.
- Feasibility and outcomes from a larger mobile RWIS installation.
- Utilizing other existing data sources and systems that may not be part of current methods.

4) APPENDIX A

Maintenance Personnel Needs Assessment Questionnaire

Responsibilities / Practices / Decision Making

- Are your primary concerns snow and ice pretreatment and removal?

- Do you have responsibilities outside of winter maintenance that utilize road weather information system (RWIS) data (i.e. spring thaw load restrictions, others)?

- Do you have winter maintenance mission statement, goals, objectives?

- Do you use any winter maintenance performance metrics to evaluate performance (ie. time to bare pavement, time to wet pavement, return to near-normal traffic, friction, travel speeds, etc)?

- What % of your winter maintenance decisions are driven by RWIS data (either directly or via forecasts using RWIS data) vs outside sources like TV weather forecasts, National Oceanic and Atmospheric Administration (NOAA) Weather Alerts, etc.?

- Are maintenance decision support systems (MDSS) commonly used, how much human involvement is necessary in MDSS guided decisions?

Equipment and Software

- Rank weather attributes for your uses as must have (1) OR helpful (2) OR not necessary (3)

air temp.	humidity	barometric pressure
solar radiation	visibility	wind speed and direction
precip. occurrence	precip. type	precip. intensity
precip. depth	pavement temp	pavement condition (dry, wet, ice, ...)
chemical presence	chemical concentration	freeze temp. (using chemical sensing)
friction	static camera image	live video

Others:

- What reporting frequency do you need for critical attributes?

- Are current sensors accurate and reliable?

- Past studies performed for other transportation agencies have found instances of different RWIS sensor types reporting inaccurate data that does not match personnel observations. Do these errors also occur in Montana?

- Do sensors fail often?

- Are RWIS communications reliable and timely?

- Do communications failures often hinder data transmission?

- Are sensor readings communicated frequently enough?

- Is the most common failure of: sensors OR communications OR power OR software?

- Past studies vary: some agencies want temperature sensors at depths underground some agencies don't need that – what about Montana?

- Past studies have shown desires for certain sensor capabilities – are the following also wanted in Montana:
    - better precipitation sensors (with type, intensity, depth)
    - visibility sensors
    - cameras (with PTZ and more frequent static images or live video)
    - non-invasive pavement sensors

- Currently are static images from RWIS cameras updated frequently enough?

- Is live video beneficial?

- Is vandalism of RWIS equipment a problem?

- Are mobile sensors desired? Do you see benefits to having a mobile sensor fleet?

- What does the ideal RWIS software display?

- Is the display of RWIS data on mobile devices and smartphones needed?

Maintenance of RWIS Equipment and Software

- Who installs your environmental sensor station (ESS) equipment?

- Who performs maintenance on your ESS equipment?

- Who performs maintenance on your RWIS software?

- Would a performance based service contract be beneficial (ie. pay a vendor to maintain and deliver specified quality of accurate and reliable RWIS data)?

Geographic Coverage and Placement

- Some past studies have indicated that winter maintenance needs could potentially be met by very limited ESS deployments using only a camera and pavement temp sensor? Is that possible for your needs in Montana?

- Please discuss your desired balance between: more numerous but limited sensor ESS sites vs. fewer but more comprehensive ESS sites?

- Are any ESS placements currently the result of other uses besides winter maintenance?

- Are any additional sensors at existing ESS specifically for uses other than winter maintenance?

Other / Overall / I wish…

- If cost were no issue, what would be best for you?

- I think we need: more ESS locations OR more sensors at existing ESS locations OR better sensors/communications/power at existing locations?

- Suggested other groups or people to interview?

- Any last thoughts on what to improve and/or how to improve it?