

# **Greater Yellowstone Rural ITS Project**

## **Work Order II-2C Dynamic Warning VMS Evaluation of Montana Signs**

Prepared for

MONTANA DEPARTMENT OF TRANSPORTATION

And

U.S. DEPARTMENT OF TRANSPORTATION,  
FEDERAL HIGHWAY ADMINISTRATION

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## **IMPLEMENTATION STATEMENT**

This study is sponsored by the U.S. Department of Transportation, Federal Highway Administration in cooperation with, the Montana Department of Transportation, the Wyoming Department of Transportation, the Idaho Transportation Department, and the Yellowstone National Park. The major objective of this document is to summarize GYRITS Work Order II-2C, Evaluation of Dynamic Warning Signs in Montana.

## **DISCLAIMER**

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## 1. INTRODUCTION

This report summarizes the Montana component of the evaluation of Work Order II-2C, Dynamic Warning Variable Message Signs. The overall purpose of the work order was to deploy and evaluate Dynamic Warning Variable Message Signs (DVMS) in Montana, Wyoming and Idaho.

This report summarizes the evaluation of the effectiveness of the Montana signs (evaluation of the deployments in Idaho and Wyoming will be summarized in separate reports). This report includes a description of the GYRITS Project, a system description of the dynamic warning variable message signs, an overview of the challenges and issues.

### 1.1. Description of the GYRITS Corridor

The Greater Yellowstone Rural ITS Project (GYRITS Project) was initiated to move rural intelligent transportation systems (ITS) forward by demonstrating and evaluating ITS in a rural environment. GYRITS began in January 1997 with a Congressional Earmark to fund (1) the development of a Regional ITS Strategic Deployment Plan, (2) the implementation of “early winner” projects, and (3) the development of supporting documentation. In February 2000 a strategic plan was completed that included stakeholder input, GYRITS organizational structure, regional architecture, legacy systems, and candidate projects. The Dynamic Warning VMS is one of the candidate projects selected for implementation.

The Greater Yellowstone Rural Intelligent Transportation System Priority Corridor is a 200-mile long, 100-mile wide, heavily utilized rural transportation corridor between Bozeman, Montana and Idaho Falls, Idaho (Figure 1). This corridor includes:

- three states: Montana, Idaho and Wyoming;
- two national parks: Yellowstone (YNP) and Grand Teton (GTNP); and
- a variety of transportation facilities ranging from Interstate freeway to low-volume, two-lane rural highways.

Primary transportation facilities include:

- Interstate 90/15 from Bozeman, Montana to Idaho Falls, Idaho through Butte, Montana;
- U.S. Highway 191/20 from Bozeman, Montana to Idaho Falls, Idaho; and
- U.S. Highway 89/26 from Livingston, Montana through Jackson, Wyoming to Idaho Falls, Idaho.

Additional highways added to the corridor at the March 1998 Steering Committee meeting include:

- Highway 212 from Red Lodge, Montana, through Cooke City, Montana and into Yellowstone National Park;
- Highway 14 from Cody, Wyoming, through the east entrance of Yellowstone National Park and into the Park interior; and Highway 31 from Swan Valley Idaho, over Teton Pass to Jackson, Wyoming.

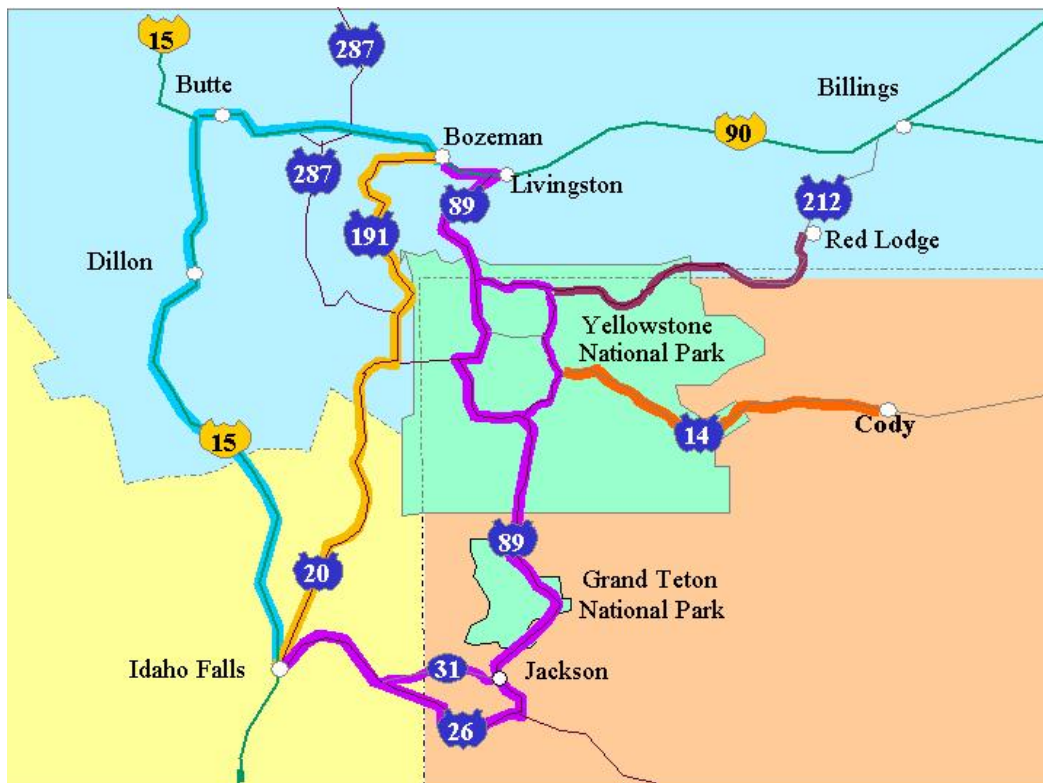


Figure 1: GYRITS Study Area

These routes represent vital transportation links for the economy and well being of the three-state area of Montana, Wyoming and Idaho. They also serve the recreational and resource needs of a growing number of individuals seeking to utilize the Greater Yellowstone ecosystem and Grand Teton National Park. The national importance of the corridor is further emphasized by its function as the connector for the trucking industry between the upper Midwest markets along Interstate 90 and the Intermountain and Southwest markets accessible by Interstate 15.

Because this report addresses DVMS deployed only in Montana, this report will focus on the Montana portion of the GYRITS Study Area, in particular Interstates 15 and 90. Because of their portable nature, the signs were used throughout Montana, beyond the GYRITS corridor in

order to gain maximum benefit. The exact locations of the DVMS will be detailed later in this report.

## **1.2. Report Components**

This evaluation of the Montana DVMS will be presented in the following sections:

- a description of the system components, locations, costs and challenges (Section 2);
- user surveys methodology and analysis (Section 3);
- portable DMS Needs (Section 4); and
- summary and next steps (Section 5).

## 2. SYSTEM DESCRIPTION

This section describes the components, locations and cost of the Montana Dynamic Warning Variable Message Signs (DVMS). The system consists of eight (8) portable variable message signs (Figure 2) that perform multiple functions throughout the year. The signs provide warnings about construction, road conditions, and potential delays. During the winter months, the signs were utilized as semi-permanent installations where winter weather frequently creates challenges. Concrete pads were placed in some winter semi-permanent locations for ease of installation and stability. Concrete pads are located at:

- Location 1: Interstate 90 southbound, milepost 191.1
- Location 2: Interstate 90 northbound, milepost 186.4
- Location 3: US Highway 12 northbound, milepost 178.1
- Location 4: US Highway 12 southbound, approximate milepost 178

Aside from the concrete pads, the system is purely portable. The signs were assigned to maintenance divisions as shown in Table 1.



Figure 2: Sign at Semi-Permanent Winter Location



The signs use a light emitting diode (LED) light source with adjustable brightness for increased lamp life and decreased power requirements. The sign displays are approximately 11 feet wide by 7 feet high and allow for the display of three lines of text up to 8 characters long. Each character is 5 by 7 pixels, with 4 LEDs per pixel. Messages are clearly visible from a minimum of 1,000 feet. Letter height is 18 inches with a 17-degree cone of visibility. They allow for multiple panels of information to be displayed in a repeating flash mode display. The signs allow for the use of any user specified message. For this project 184 messages were pre-programmed by the vendor (Appendix A) and cannot be modified. Additional messages can be pre-programmed by the user. Batteries, a solar panel, and a cellular connection allow the signs to operate self sufficiently in any conditions provided the messages are updated on a regular basis.

The sign is attached to a hydraulic mount that can raise the bottom of the sign 7 feet above the ground and rotate 360 degrees in order to increase visibility to motorists. The Montana Department of Transportation is able to program and monitor each sign from their office computer by using the cellular connection, or through the use of a laptop computer on-site.

The signs were purchased in the Spring of 2002 and have been in use since that time.

## **2.1. Deployment Costs**

The eight signs were purchased from Ver-Mac Inc. out of Quebec, Canada for a total cost of \$135,960, with a warranty period of three years. The GYRITS project paid for \$120,000 from FHWA funds with MDT paying the remaining \$15,960. Additional MDT and WTI staff time was not accurately tracked for activities including developing specifications, contracting for signs, training on signs, placing signs, and operating and maintaining signs. There are no monthly power costs as the signs are powered with solar. The only power cost would be battery replacement as needed. Cellular service is required for each sign.

### 3. USER SURVEYS

This section of the report will detail the methodology employed in gathering evaluation data for the Montana portable dynamic message signs. Data collection for this evaluation includes user surveys and additional locations for portable DMS.

#### 3.1. Data Collection Methodology

Prior to the purchase of the eight portable DMS, the only DMS that existed in Montana were four permanent signs located in the Bozeman Maintenance Division. Due to the fact that the use of DMS (permanent or portable) is relatively new in Montana to both motorists and maintenance staff, it was felt that surveying the maintenance staff would provide useful information for the Montana Department of Transportation. Surveys were sent to the divisions that have possession of the portable signs including Billings, Butte, Miles City, and Missoula.

Although four surveys do not make this study statistically significant, the information gained from these surveys is valuable.

#### 3.2. Analysis and Results

An example of the survey used can be found in Appendix A. The survey questions can be grouped by theme including: DMS location and situation for use; perception of signs; hardware challenges/improvements; additional training; and DMS messages.

##### 3.2.1. DMS Location and Situation for Use

Eight portable DMS were purchased for Montana. They are located in the Billings, Butte, Glendive, and Missoula Maintenance Districts. The number of DMS in each area is shown in Table 1.

Table 1: Portable Unit Locations

District	Division	Number of Portable DMS	Location
Billings	Billings	1	Billings Area
Butte	Butte	2	Homestake Pass
Butte	Butte	2	McDonald Pass
Glendive	Miles City	1	Miles City Area
Missoula	Kalispell	1	East Glacier
Missoula	Kalispell	1	Browning

Frequency of DMS use was the next question. According to the survey, Butte was the only division to use their portable DMS during the winter. During this time, the DMS were permanently stationed on concrete pads on MacDonald Pass (US 12 Milepost 178) and on Homestake Pass (I-90 Mileposts 191 and 186). The signs were used on the mountain passes to provide motorists with wintertime traveler information such as CHAINS REQUIRED, EMERGENCY TRAVEL ONLY, and I-90 CLOSED. During the summer, Billings, Butte, and

Missoula used the portable DMS at least "once per week," while Miles City used theirs "once per month."

The average duration or average number of hours a message was being displayed when the portable DMS was in use also varied by maintenance divisions as shown in Table 2.

Table 2: Average Duration of Use

Location	Average Duration
Billings	4-8 hours each day for 3 days
Butte	1 day to a couple weeks
Miles City	4 days
Missoula	1 to 2 weeks

The next question on the survey addressed the type of messages displayed when the portable DMS was in use. The types of messages that can be used include: construction, weather, fire season, road hazards, detours, and other. The results are shown in Figure 3.

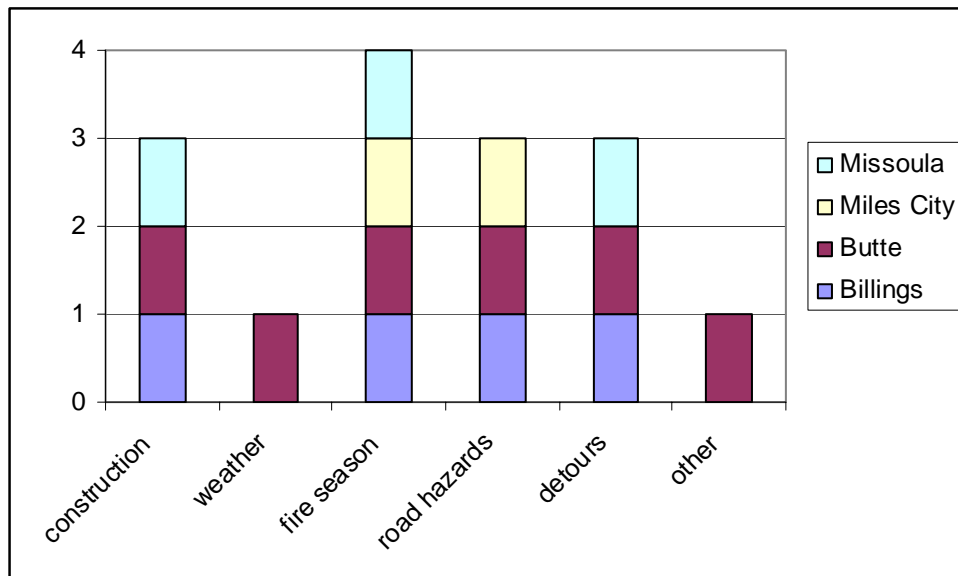


Figure 3: Sign Usage

As can be seen from this graph, Butte is the only division that used the sign for weather-related events. This makes sense as most weather related events in Montana happen over the winter and as mentioned previously, Butte is the only division that utilized the signs during this period. It is interesting to note that the Missoula division also has mountain passes where these signs may have been of use, but rather than use portable DMS in this area, three permanent DMS are being installed in this division.

The fact that Miles City only used their signs "once a month" as opposed to "once a week" like other divisions may explain why they are the only division that did not use the signs for construction and detours. Butte was the only division that used their signs for something other than the message type listed in the question. The "other" type of message they displayed on the

portable DMS was “USE YOUR SEATBELT, IT’S THE LAW” during seatbelt awareness month.

Lastly, the fact that all divisions used their signs for fire season is of no surprise as the summer of 2003 had a significant amount of fires in Montana. All four of these areas along with other areas of Montana were devastated by fires. When these signs were not being used in the areas they were purchased for, they were used by other areas affected by the fires. The usefulness of these signs for this particular event is one of the major reasons that MDT would like to purchase more portable signs.

As these signs are portable and therefore can be positioned next to any road within the maintenance division that has adequate space to contain the device, the divisions were asked if there were locations that they repeatedly used the signs. Butte mentioned that they repeatedly used the signs at their semi-permanent locations while Billings repeatedly used the signs in locations for closures due to accidents, construction, and various maintenance projects.

### 3.2.2. Perceptions of Signs

Next the researchers hoped to obtain the users perceptions of the signs. Questions asked included how easy the signs are to use, their usefulness, how satisfied users are with the signs, and how worthwhile users find the signs to be.

When asked how easy the signs were to use, the users mean answer was 3.625 corresponding to a rating between fair (3) and easy (4). None of the divisions said that the signs were “very easy” to use, which means that there is room for improvement. All of the divisions felt that the signs were “very useful.” Three out of four divisions said they were “very satisfied” (mean of 4.75 corresponding to a rating between satisfied (4) and very satisfied (5)). The division that said “satisfied” did not have any suggestions for improvement and is the division that used the signs the least amount.

All four divisions felt the signs were “very worthwhile.” Butte felt that “this type of mobile message system is proving to be a very valuable tool for the Highway Department” and “this approach has already served as a great asset to the traveling public.”

### 3.2.3. Hardware Challenges/Improvements

Only one of the four divisions had maintenance problems with the portable DMS. Billings mentioned that they had problems with the keyboards, but that it was “a result of not keeping it inside when not in use.”

Improvements to the sign hardware that were suggested including improving the keyboard, improving the reliability of the remote connectivity (at some times it took up to 30 minutes to access and change the sign), adding independently directional solar mounts, and expanding the size of the sign to allow for ten characters per line rather than eight. This would allow them to use “EMERGENCY” and “VISIBILITY” rather than “VISION.” All of these recommended improvements are viable except changing the character space to ten as the MUTCD states that “Portable Changeable Message signs shall be temporary traffic control devices with the

flexibility to display a variety of messages. Each message shall consist of **either one or two phases**. Typically, a phase shall consist of **up to three lines of eight characters per line (1)**.” Several of the user message sets in Figure 8 have more than two phases and should be reduced.

### 3.2.4. Additional Training

When asked if they felt that training was needed, three of the four divisions said yes. Butte, the division with the most portable DMS and the most usage, feels that they do not need additional training on the signs. As shown in Figure 4, two of the four divisions would like additional training on the manual aspect of using the units (e.g. how to set them up and configure them) along with the policies and procedures of using the signs (e.g. how long a message should be on a sign, what the message priority is, etc). Three of the four divisions want more training on how to create an actual message for display on the sign. It should be noted that the only training provided to these divisions upon receipt of the signs was the manual aspect of using them. It should also be noted that Miles City would like all three types of training plus an “other” training; perhaps this is why they were not “very satisfied” with the signs.

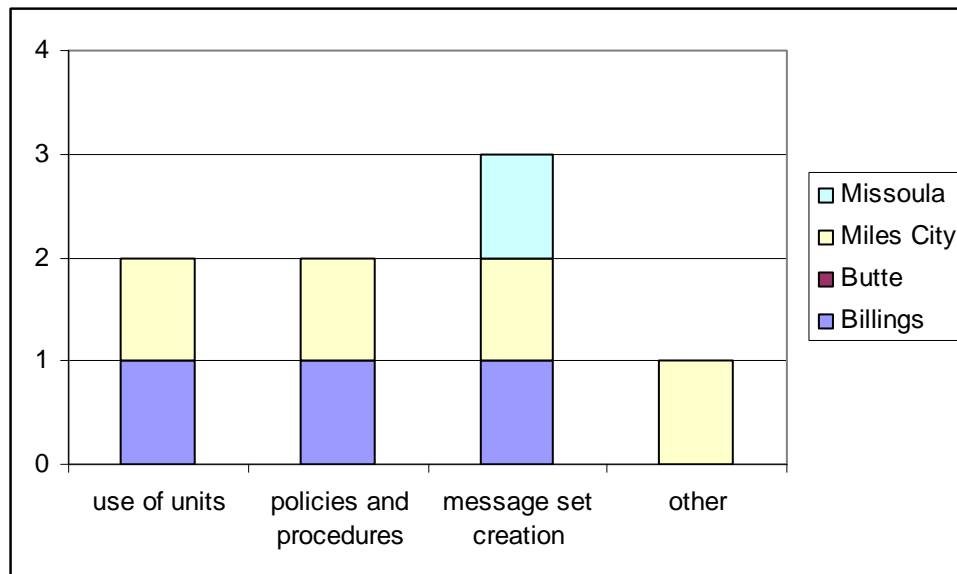


Figure 4: Type of Training Needed

### 3.2.5. DMS Messages

The portable DMS were set-up by the vendor to have 184 pre-programmed messages (#201-384). These messages are created and saved in the sign for quick and easy use by the divisions. These pre-programmed messages can be found in Appendix B.

One of the survey respondents noted that due to the signs being manufactured in Canada, some of the pre-programmed messages were not typical “American” messages such as the pre-programmed message “FORM ONE LINE LEFT.” This would be “RIGHT LANE CLOSED AHEAD” in the states. A list of Butte’s most commonly used pre-programmed messages can be seen in Figure 5.

Message Number	Line #1	Line #2	Line #3
#210	BE	PREPARED	TO STOP
#214	CAUTION	ACCIDENT	AHEAD
#216	CAUTION	DETOUR	AHEAD
#218	CAUTION	FLAGGER	AHEAD
#231	CAUTION	WRECK	AHEAD
#275	MERGE	LEFT	
#278	MERGE	RIGHT	
#288	MOWERS	NEXT	5 MILES
#289	MOWERS	NEXT	10 MILES
#290	MOWERS	AHEAD	
#306	PAINT	CREW	AHEAD
#307	PASS	LEFT	
#308	PASS	RIGHT	
#312	PREPARE	TO	STOP
#326	ROAD	CLOSED	AHEAD
#335	ROAD	WORK	AHEAD

Figure 5: Butte's Most Commonly Use Pre-programmed Messages

The divisions were asked whether or not the pre-programmed messages contained all of the messages that they needed. One of the divisions felt that the pre-programmed messages did include all of the messages that were needed, although they did some message programming themselves. Two of the other divisions felt that although the pre-programmed messages were useful, they needed to be used in conjunction with more area specific information such as:

- “LOLO PASS HIGHWAY 12 CLOSED DUE TO FIRE DANGER;”
- “I-15 NORTH BOUND CLOSED AT BOULDER;”
- “FIRE CREWS MAY BE PRESENT;” and
- “EMERGENCY TRAVEL ONLY.”

The divisions were then asked to list examples of the types of messages that were displayed along with the number of hours they were displayed and the number of times they were displayed. This information is shown in Figure 6.

Along with the messages shown in Figure 6, Bozeman, Butte, and Missoula also used these signs for fire related messages from June through August and Missoula used them for construction related messages from September through October.

Location	Message	Average Number of Hours	Number of Times
			Displayed
Butte	CHAINS REQUIRED	33 hours	7
Butte	EMER GENCY TRAVEL ONLY	6 hours	3
Butte	I-90 CLOSED	12 hours	1
Butte	SLOW MOVING VEHICLE SWEEPER AHEAD	70 hours	14
Butte	ROAD WORK AHEAD	16 hours	2
Butte	WATER ON ROAD	12 hours	1
Butte	CHIP SEAL IN PROGRESS	12 hours	2
Butte	BUCKLE UP IT'S THE LAW	month of June	
Miles City	POOR VISIBILITY POSSIBLE DELAYS	24 hours	every 5 to 10 seconds
Miles City	RIGHT LANE CLOSED AHEAD	4 hours	every 5 to 10 seconds
Missoula	HIGHWAY 12 CLOSED DUE TO FIRE DANGER	12 hours	2
Missoula	NO PARKING NEXT 7 MILES	12 hours	2
Missoula	LEFT LANE CLOSED AHEAD	8 hours	3

Figure 6: Example Messages Used

The pre-programmed messages have #1-200 open for the divisions to program messages into. The messages that Butte has chosen to add into these spaces are shown in Figure 7. After filling in a number of these open message slots, Butte then developed a plan for using sequences as the primary programming option for their signs. The survey respondent said this was done “due to the nature of the use of temporary employees and the need for consistency in message content” and because “once set-up it is the easiest way for occasional users to quickly change a message.”

To complete this programming option, Butte staff formulated probable message scenarios and created a profile with these. The profile is kept in the ten computers used to access the sign, a laminated version kept with the sign trailer for programming locally and in a notebook at the division office that also has a listing of pre-programmed messages, frequently used pre-programmed messages, user defined messages, and instructions sheets on how to program. This profile can be seen in Figure 8.

Butte also mentioned that they have a policy of “not using these message boards simply for weather conditions, but to use them in hazardous conditions.” For example, they would not use them for “ROADS MAY BE SNOW PACKED.” They also stay away from messages such as “HAVE A NICE DAY.”

Message Number	Line #1	Line #2	Line #3
001	BLANK	BLANK	BLANK
002		CAUTION	
003	SNOW	REMOVAL	AHEAD
004	REDUCE	SPEED	AHEAD
005	ACCIDENT		AHEAD
006	USE	CAUTION	AHEAD
007	CHAINS		REQUIRED
008	TOWING		UNITS
009	ALL		VEHICLES
010	EMER	GENCY	
011	TRAVEL		ONLY
012	I-15		
013	I-15	NORTH	BOUND
014	I-15	SOUTH	BOUND
015	I-90		
016	I-90	EAST	BOUND
017	I-90	WEST	BOUND
018	ROAD		CLOSED
019	CLOSED		AT
020	ROAD	CLOSED	AT
021		LIMA	
022		BOULDER	
023		GARRISON	
024		WHITEHALL	
025		TOWNSEND	
026		CLANCY	
027		SIEBEN	
028	LINCOLN		ROAD
029	INTER-	CHANGE	
030		AHEAD	
031	SINGLE	LANE	TRAFFIC
032	TRAFFIC	CONTROL	AHEAD
033	LIMITED		VISION
034	DO	NOT	PASS
035	SNOW		PLOWS
036			
037			
038			
039			
040	BUCKLE	UP	
041	IT'S	THE	LAW
042	HIGHWAY	CLOSED	WISDOM
043	TO JCT	HIGHWAY	93
044	FIRE		CREWS
045	MAY BE		PRESENT
046	HIGHWAY	93	CLOSED
047	78 MILES		AHEAD
048	TO	SALMON	IDAHO
049	HIGH		WINDS
050	IDAHO		BORDER
051	9PM	TO	6AM
052			
053			
054	CLOSED	37 MILES	AHEAD
059	WALKERS		AHEAD
098	TEST	TEST	TEST

Figure 7: User Defined Messages



Sequence	Message Number	Line #1	Line #2	Line #3
A	Leave this line blank			
B				
C	007	CHAINS		REQUIRED
	008	TOWING		UNITS
D	007	CHAINS		REQUIRED
	009	ALL		VEHICLES
E	010	EMER	GENCY	
	011	TRAVEL		ONLY
F	013	I-15	NORTH	BOUND
	019	CLOSED		AT
	022		BOULDER	
G	013	I-15	NORTH	BOUND
	019	CLOSED		AT
	026		CLANCY	
H	017	I-90	WEST	BOUND
	019	CLOSED		AT
	024		WHITEHALL	
I	014	I-15	SOUTH	BOUND
	019	CLOSED		AT
	021		LIMA	
J	016	I-90	EAST	BOUND
	018	ROAD		CLOSED
K	210	BE	PREPARED	TO STOP
	214	CAUTION	ACCIDENT	AHEAD
L	013	I-15	NORTH	BOUND
	019	CLOSED		AT
	028	LINCOLN		ROAD
	029	INTER-	CHANGE	

Figure 8: Butte's Sequenced Messages

Sequence	Message Number	Line #1	Line #2	Line #3
M				
N				
O				
P	034	DO	NOT	PASS
	035	SNOW		PLOWS
Q	040	BUCKLE	UP	
	041	IT'S	THE	LAW
R				
S	002		CAUTION	
	003	SNOW	REMOVAL	AHEAD
T	098	TEST	TEST	TEST
U				
V	006	USE	CAUTION	AHEAD
	033	LIMITED		VISION
W	210	BE	PREPARED	TO STOP
	231	CAUTION	WRECK	AHEAD
X	042	HIGHWAY	CLOSED	WISDOM
	043	TO JCT	HIGHWAY	93
Y	044	FIRE		CREWS
	045	MAY BE		PRESENT
	006	USE	CAUTION	AHEAD
Z	046	HIGHWAY	93	CLOSED
	047	78 MILES		AHEAD
	048	TO	SALMON	IDAHO
*	049	HIGH		WINDS
	050	IDAHO		BORDER
	051	9PM	TO	6AM

Figure 8: Butte's Sequenced Messages Continued

#### 4. PORTABLE DMS NEEDS

Between December 2002 and February 2003, WTI met with MDT divisions to identify and prioritize their traveler information needs and devices that can fulfill these needs. Portable dynamic message signs were included in this discussion. Figure 9 shows the outcome from the divisions needs.

In total, the divisions “wish lists” included an additional 34 portable DMS. This number may also have changed since some of the divisions that said none in December, January, and February (Bozeman, Kalispell, and Missoula) used them extensively this summer for wildfires and therefore may feel differently than they did previously.

Division	Existing Portable DMS	Portable DMS Needs	Location for Needs
Billings	1	10	<ul style="list-style-type: none"> <li>• At least 1 or 2</li> <li>• Red Lodge Southbound</li> </ul>
Bozeman	0	0	
Butte	4	4	<ul style="list-style-type: none"> <li>• Garrison Junction Westbound</li> <li>• N. Helena Northbound</li> <li>• N. Lima Southbound</li> <li>• Flint Creek Hill Westbound</li> </ul>
Great Falls	0	0	
Havre	0	1	<ul style="list-style-type: none"> <li>• Havre</li> </ul>
Kalispell	2	0	
Lewistown	0	3	<ul style="list-style-type: none"> <li>• Lewistown</li> <li>• Grass Range</li> <li>• Big Timber</li> </ul>
Miles City	1	3	<ul style="list-style-type: none"> <li>• Miles City</li> <li>• 1-2 additional portables</li> </ul>
Missoula	0	0	
Wolf Point	0	13	<ul style="list-style-type: none"> <li>• Malta</li> <li>• Glasgow</li> <li>• Culbertson</li> <li>• Plentywood</li> <li>• Wolf Point</li> <li>• Opheim</li> <li>• Scobey</li> <li>• Flowing Wells</li> <li>• Westby</li> <li>• Sidney</li> <li>• Circle</li> <li>• 2 floaters</li> </ul>

Figure 9: Portable DMS Needs by Division

## 5. SUMMARY AND NEXT STEPS

### 5.1. Summary of Survey Results

A summary of the survey results indicates the following:

- Billings and Miles City each have one portable DMS, Missoula has two, and Butte has four;
- Butte uses their portables during the winter and summer while the other divisions only use theirs in summer;
- The portable DMS were mostly used for fire related messages closely followed by construction, detour, and road hazard related messages;
- The overall perceptions of the portable DMS were that they were between fair and easy to use, very useful, very worthwhile, and the respondents were between satisfied and very satisfied with them;
- There was only one maintenance problem reported with the portable DMS relating to the keyboards;
- Suggestions for improvement included new keyboards, better connectivity, bi-directional solar panels, and increasing the number of characters per line displayed on the sign;
- Additional training was highly suggested; and
- Respondents felt that the messages needed to be more area specific than the pre-programmed messages.

### 5.2. Recommendations

#### 5.2.1. Operations Recommendations

Based on this analysis, it is recommended that MDT create a written “Policies and Procedures Manual for Portable DMS Use” along with a written “Message Set Guide for Portable DMS Use.” Butte’s documents should be used as a starting point, however, messages should be condensed to two frames based on the MUTCD requirements.

It is also recommended that MDT consider creating a training program for portable and permanent DMS users. This training would include manual use of the signs, explanation and verification of the policies and procedures, and how to create messages for the signs. This training would cover MDT policies and guidelines in addition to United States Department of Transportation (USDOT) and Federal Highway Administration (FHWA) policies and guidelines. This training would help the users better understand how the signs should be used and the potential liabilities from incorrect use. Minnesota Department of Transportation (Mn/DOT) is starting a training course on message set creation that shows operators videos containing

potential situations, then has them create a message for that situation, and lastly goes over what the correct message would be and why. It is suggested that a training course like this be created (Mn/DOT is willing to share video clips).

It is also recommended that MDT challenge their operators to use the signs for situations that would be helpful, but that are not currently being used for, such as incidents and winter weather.

### 5.2.2. Hardware Recommendations

It is recommended that MDT consider testing both the permanent and portable signs to ensure that they are NTCIP compliant. A lot of states are realizing that this is a need due to the fact that the specifications only stated that the signs “must be NTCIP compliant” without describing how this would be tested. In order to ensure that the signs are working to the best of their ability, this should be tested and fixed.

It is also recommended that MDT examine different options for portable DMS keyboards, explore the possibility for purchasing mounts that will brace the portable DMS against the strong Montana winds, consider different options for communicating with the signs, and consider purchasing bi-directional solar panels.

### 5.2.3. Additional Units

Since maintenance staff generally like the signs and want more, it is also recommended that MDT consider purchasing more of these devices for their divisions using **Figure 9** as a guideline.

## 5.3. Future Research

Future research that could be done for the Montana portable DMS include:

- Motorist surveys;
- Human factors research on which message sets make sense for Montana portable DMS; and
- Training programs for DMS.

## 6. REFERENCES

1. Manual on Uniform Traffic Control Devices, Millennium Edition: Parts 6. U.S. Department of Transportation, Washington D.C. 2001.

**APPENDIX A: MOTORIST SURVEY**

**MONTANA PORTABLE DYNAMIC MESSAGE SIGN (DMS) SURVEY**

The purpose of this survey is to get your opinion on the accuracy and usefulness of the new portable DMS in Montana and to identify any thing that can be improved with the units.

Contact Name: \_\_\_\_\_  
Phone Number: \_\_\_\_\_  
Division: \_\_\_\_\_

**1** HOW many portable DMS units did your division use?  
\_\_\_\_\_ DMS units

**2** How frequently did you deploy/move the portable DMS units (Check only one response for each item)?  
Daily   Once per Week   Once per Month  
a) Winter           
b) Summer        

**3** What was the average time duration of the portable DMS unit deployments (e.g. two days or 2 hours)?  
\_\_\_\_\_

**4** What types of locations did you use the portable DMS units for (Check all that apply)?  
 Construction  
 Weather  
 Fire season  
 Road hazards (please specify: \_\_\_\_\_)  
 Detours  
 Other (please specify: \_\_\_\_\_)

**5** Were there any locations where the portable DMS were repeatedly used? If so, please specify.  
\_\_\_\_\_  
\_\_\_\_\_

**6** How easy were the portable DMS units to use?  
Very Easy   Easy   Fair   Difficult   Very Difficult  
           

**7** How useful do you think that the portable DMS units were to motorists?  
Very Useful   Useful   Neutral   Not Useful   Very Useless  
           

**8** How satisfied were you with the mobility of the portable DMS units?  
Very Satisfied   Satisfied   Neutral   Not Satisfied   Very Unsatisfied  
           

**9** If you were not 'VERY SATISFIED' with the mobility of the portable DMS units, what improvements would you recommend?  
\_\_\_\_\_  
\_\_\_\_\_

**10** Were there any maintenance problems with the portable DMS units? If so, what were they?  
\_\_\_\_\_  
\_\_\_\_\_

**11** What improvements would you recommend for the portable DMS units?  
\_\_\_\_\_  
\_\_\_\_\_

**12** Do you feel that additional training is needed on the following:  

	<u>Yes</u>	<u>No</u>
a) Use of the units?	<input type="checkbox"/>	<input type="checkbox"/>
b) Policies and procedures for use of the units?	<input type="checkbox"/>	<input type="checkbox"/>
c) Message set creation and usage?	<input type="checkbox"/>	<input type="checkbox"/>
d) Other (please specify _____)?	<input type="checkbox"/>	<input type="checkbox"/>

**13** Overall, how worthwhile do you thin the portable DMS units were?  
Very Worthwhile   Worthwhile   Neutral   Barely Worthwhile   Worthless  
           

**14** Did the message sets provided to you include all of the messages that you needed? If, not what was missing?  
\_\_\_\_\_  
\_\_\_\_\_





**APPENDIX B: VMS MESSAGES**

#201	ACCIDENT	AHEAD	
#202	ACCIDENT	CENTER	LANE
#203	ACCIDENT	ON	LEFT
#204	ACCIDENT	ON	RIGHT
#205	ALL	RAMPS	OPEN
#206	ALL	TRAFFIC	EXIT
#207	TRAFFIC	EXIT	LEFT
#208	TRAFFIC	MUST	STOP
#209	TRAFFIC	EXIT	RIGHT
#210	BE	PREPARED	TO STOP
#211	BRIDGE	CLOSED	AHEAD
#212	BRIDGE	WORK	AHEAD
#213	BRIDGE	WT LIMIT	AHEAD
#214	CAUTION	ACCIDENT	AHEAD
#215	CAUTION	BUMP	AHEAD
#216	CAUTION	DETOUR	AHEAD
#217	CAUTION	DIP	AHEAD
#218	CAUTION	FLAGGER	AHEAD
#219	CAUTION	FLOODED	ROAD
#220	CAUTION	ICE ON	BRIDGE
#221	CAUTION	ICE ON	ROAD
#222	CAUTION	LOOSE	GRAVEL
#223	CAUTION	MERGE	AHEAD
#224	CAUTION	ROUGH	ROAD
#225	CAUTION	SHOULDER	DROP OFF
#226	CAUTION	SLOW	TRAFFIC
#227	CAUTION	SOFT	SHOULDER
#228	CAUTION	TRUCKS	CROSSING
#229	CAUTION	TWO WAY	TRAFFIC
#230	CAUTION	VEHICLES	CROSSING
#231	CAUTION	WRECK	AHEAD
#232	CENTER	LANE	CLOSED
#233	CURVE	AHEAD	
#234	DENSE	FOG	AHEAD
#235	DO	NOT	PASS
#236	EXIT	CLOSED	AHEAD
#237	EXIT	HERE	-->
#238	EXIT	HERE	<--
#239	EXPECT	DELAY	
#240	FORM ONE	LINE	LEFT
#241	FORM ONE	LINE	RIGHT
#242	FORM TWO	LINES	LEFT
#243	FORM TWO	LINES	RIGHT
#244	FRESH	TAR	
#245	FRESH	OIL ON	ROAD
#246	HEAVY	TRAFFIC	AHEAD
#247	ICE	ON	ROAD
#248	KEEP	LEFT	
#249	KEEP	LEFT	<--
#250	KEEP	<--	LEFT

#251	KEEP	RIGHT	
#252	KEEP	RIGHT	-->
#253	KEEP	->	RIGHT
#254	LANE	CONTROL	AHEAD
#255	LANE	ENDS	
#256	LANE	NARROWS	AHEAD
#257	LANES	SHIFT	AHEAD
#258	LEFT	LANE	CLOSED
#259	LEFT	LANE	NARROWS
#260	LEFT	2 LANES	CLOSED
#261	LIMITED	SIGHT	DISTANCE
#262	LOOSE	GRAVEL	AHEAD
#263	LOW	BRIDGE	AHEAD
#264	MAX	SPEED	25 MPH
#265	MAX	SPEED	30 MPH
#266	MAX	SPEED	35 MPH
#267	MAX	SPEED	40 MPH
#268	MAX	SPEED	45 MPH
#269	MAX	SPEED	50 MPH
#270	MAX	SPEED	55 MPH
#271	MEDIAN	WORK	AHEAD
#272	METAL	PLATES	AHEAD
#273	MEN	WORKING	AHEAD
#274	MERGE	AHEAD	
#275	MERGE	LEFT	
#276	MERGE	LEFT	<--
#277	MERGE	<--	LEFT
#278	MERGE	RIGHT	
#279	MERGE	RIGHT	-->
#280	MERGE	-->	RIGHT
#281	MERGING	TRAFFIC	AHEAD
#282	MINIMUM	SPEED	20 MPH
#283	MINIMUM	SPEED	25 MPH
#284	MINIMUM	SPEED	30 MPH
#285	MINIMUM	SPEED	35 MPH
#286	MINIMUM	SPEED	40 MPH
#287	M'CYCLES	USE	CAUTION
#288	MOWERS	NEXT	5 MILES
#289	MOWERS	NEXT	10 MILES
#290	MOWERS	AHEAD	
#291	NEXT	MILE	
#292	NEXT	2 MILES	
#293	NEXT	3 MILES	
#294	NEXT	4 MILES	
#295	NEXT	5 MILES	
#296	NEXT	6 MILES	
#297	NEXT	7 MILES	
#298	NEXT	8 MILES	
#299	NEXT	9 MILES	
#300	NEXT	10 MILES	

#301	NIGHT	WORK	AHEAD
#302	NO	PASSING	
#303	NO	SHOULDER	
#304	ONE LANE	BRIDGE	AHEAD
#305	ONE	LANE	TRAFFIC
#306	PAINT	CREW	AHEAD
#307	PASS	LEFT	
#308	PASS	RIGHT	
#309	PAVEMENT	ENDS	
#310	PILOT	CAR	AHEAD
#311	PREPARE	TO	MERGE
#312	PREPARE	TO	STOP
#313	RAMP	CLOSED	
#314	RAMP	CLOSED	AHEAD
#315	REDUCE	SPEED	
#316	REDUCE	SPEED	15 MPH
#317	REDUCE	SPEED	20 MPH
#318	REDUCE	SPEED	25 MPH
#319	REDUCE	SPEED	30 MPH
#320	REDUCE	SPEED	35 MPH
#321	REDUCE	SPEED	40 MPH
#322	REDUCE	SPEED	45 MPH
#323	REDUCE	SPEED	50 MPH
#324	RIGHT	LANE	CLOSED
#325	ROAD	CLOSED	
#326	ROAD	CLOSED	AHEAD
#327	ROAD	CLOSED	1/4 MILE
#328	ROAD	CLOSED	1/2 MILE
#329	ROAD	CLOSED	3/4 MILE
#330	ROAD	CLOSED	1 MILE
#331	ROAD	MACHINES	AHEAD
#332	ROAD	NARROWS	AHEAD
#333	ROAD	PAVING	AHEAD
#334	ROAD	WORK	
#335	ROAD	WORK	AHEAD
#336	ROAD	WORK	500 FT
#337	ROAD	WORK	1000 FT
#338	ROAD	WORK	1500 FT
#339	ROAD	WORK	1/2 MILE
#340	ROAD	WORK	1 MILE
#341	ROAD	WORK	2 MILES
#342	ROCKS	ON	ROAD
#343	ROUGH	ROAD	AHEAD
#344	RUNAWAY	TRUCK	RAMP
#345	SHARP	CURVE	AHEAD
#346	SHOULDER	DROP	OFF
#347	SHOULDER	WORK	AHEAD
#348	SIGNAL	AHEAD	
#349	SIGNAL	NOT	WORKING
#350	SINGLE	LANE	AHEAD

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#351	SLOW	ACCIDENT	AHEAD
#352	SLOW	DETOUR	AHEAD
#353	SLOW	FLAGGER	AHEAD
#354	SLOW	MOVING	VEHICLE
#355	SLOW	ROAD	FLOODED
#356	SNOW	BLOWERS	AHEAD
#357	SLOW	STOP	AHEAD
#358	SLOW	TRAFFIC	AHEAD
#359	SLOW	YIELD	AHEAD
#360	SPEED	LIMIT	ENFORCED
#361	STAY	IN	LANE
#362	STEEP	GRADE	
#363	STOP	AHEAD	
#364	SURVEY	CREW	AHEAD
#365	SWEEPER	AHEAD	
#366	TRACTION	DEVICES	REQUIRED
#367	TRUCK	CROSSING	
#368	TRUCKS	USE LEFT	LANE
#369	TRUCKS	USE LOW	GEAR
#370	TUNNEL	CLOSED	AHEAD
#371	TWO LANE	TRAFFIC	AHEAD
#372	TWO WAY	TRAFFIC	AHEAD
#373	UNEVEN	PAVEMENT	AHEAD
#374	UNMARKED	LANES	AHEAD
#375	USE	CAUTION	
#376	USE	DETOUR	ROUTE
#377	USE	LEFT	LANE
#378	USE	RIGHT	LANE
#379	USE	NEXT	EXIT
#380	WATCH	FOR	TRUCKS
#381	WATER	ON	ROAD
#382	WET	PAINT	
#383	WORKERS	IN	TUNNEL
#384	YIELD	AHEAD	