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Applications of ITS in Work Zones

Study SD2003-16-F
Final Report

Prepared by
South Dakota Department of Transportation
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DISCLAIMER

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16. Abstract

Work zones, traffic incidents and high traffic areas during major events are often places where drivers can become confused or drive aggressively. Such an environment can cause congestion and endanger workers. During the summer months, SDDOT operates many work zones where drivers need to reduce speed, merge, and take extra precautions. These same characteristics are true for arrival and departure traffic at major special events.

Intelligent Transportation Systems (ITS) solutions are available to provide drivers with advance warning of work zones and traffic congestion. These systems can also provide project and traffic engineers real-time information necessary for timely traffic control. The Indiana Lane Merge system gives motorists instructions such as when to merge to prevent congestion at "bottle neck" areas. Products are also available for warning workers when errant vehicles breach the work zone.

A review of available literature regarding the use of ITS devices in work zones revealed that states who have had experience with ITS in work zones have benefited from increased efficiency and speed for motorists, and decreased frustrations and delays.

It was also found that several of SDDOTs policies that relate to work zones, incidents, and emergencies don't address the SDDOTs Strategic Plan that states "Provide timely, system-wide information to travelers on conditions related to inclement weather, construction and maintenance activities, and traffic incidents."

Recommendations: 1. Upgrade those portable DMSs in each region that are mechanically in good shape and new enough that new controllers and communication equipment can be interfaced. 2. Purchase IDI control software for the monitoring and control of DMSs statewide. 3. Require the use of the attached specifications when requisitioning new portable DMSs. 4. When purchasing new DMSs, specify NTCIP testing and on-site communications survey for acceptance. 5. Provide Incident Management training for field traffic management personnel. 6. Revise SDDOT policies regarding work zones and emergency and disaster traffic control to align them with SDDOT's strategic plan regarding traveler information.

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Executive Summary

Work zones, traffic incidents and high traffic areas during major events are often places where drivers can become confused or drive aggressively. Such an environment can cause congestion and endanger workers. During the summer months, SDDOT operates many work zones where drivers need to reduce speed, merge, and take extra precautions. These same characteristics are true for arrival and departure traffic at major special events.

Intelligent Transportation Systems (ITS) solutions are available to provide drivers with advance warning of work zones and traffic congestion. These systems can also provide project and traffic engineers real-time information necessary for timely traffic control. The Indiana Lane Merge system gives motorists instructions such as when to merge to prevent congestion at "bottle neck" areas. Products are also available for warning workers when errant vehicles breach the work zone.

While ITS technology has been researched and evaluated by many agencies, research is needed to inventory SDDOT and other state agencies to determine what traffic control needs exist for work zones and special events, and whether existing equipment can be utilized as a part of an ITS solution such as an early lane merge system or a traffic management system.

ITS technology in work zones has matured to the point where it is likely to improve travel time and safety in work zones and event traffic areas. SDDOT operates large work zones such as those near Sioux Falls and Rapid City where ITS technology can likely improve the Department's traffic control.

A review of available literature regarding the use of ITS devices in work zones revealed that states who have had experience with ITS in work zones have benefited from increased efficiency and speed for motorists, and decreased frustrations and delays.

It was also found that several of SDDOT's policies that relate to work zones, incidents, and emergencies don't address the SDDOT's Strategic Plan that states "Provide timely, system-wide information to travelers on conditions related to inclement weather, construction and maintenance activities, and traffic incidents." This study recommends that the following policies regarding work zones and emergencies be updated:

- S-2002-02, "Operational Procedures for Emergency and Disaster Assistance",
- OC-2002-04, "Work Zones for Interstate and 4-Lane Divided Highways",
- OT-1985-02, "Policy for Traffic Safety in Highway & Street Work zones".

Traffic Control Needs Survey

A survey was sent out at the end of April 2004 to Area engineers and Region Operations and Traffic Engineers. Surveys were also sent to the Office of Emergency Management and the Highway Patrol. Questions addressed topics of Traffic Control, Traffic sensors, Traveler Information, Worker Safety and Work Zone Enforcement. The majority of the SDDOT Area offices felt that some communication with portable DMSs (PDMS) would be useful. In most cases, the PDMSs are old enough that they will not support an upgrade to allow remote communications. Other issues include mechanical problems and flip-disk technology that does not properly function. In all of these cases, the survey respondents cautioned against spending money to upgrade such signs.

For the most part, the survey results indicated that more than half of the Area offices supported remote communication with DMSs.

Task Description

Task 1: **Perform a literature search regarding ITS technology in work zones.**

DOT personnel from Minnesota, Kansas, North Carolina and Maryland were contacted regarding their experiences with ITS devices in work zones and at incidents. Their responses are summarized later in the report. Also summarized are FHWA and AASHTO documents discussing ITS devices in work zones.

Task 2: **Perform an equipment inventory of SDDOT, BIT, HP, and Emergency Management to determine the location, model, and condition of traffic control/information equipment.**

Personnel from SDDOT, BIT, and the Department of Public Safety and Emergency Management were interviewed to locate equipment that might be used in work zones or as a part of a traffic control system. The only equipment located were Highway Advisory Radio trailers owned by the Department of Public Safety. This equipment has been made available to SDDOT for traffic control at events and incidents.

Personnel in SDDOT Region and Area offices were asked about the condition of portable DMSs in their jurisdiction. Signs are of various ages and conditions. Details regarding the signs are given in the body of the report.

Task 3: **Perform a survey of SDDOT regions and areas to determine requirements for traffic control at special events, traffic incidents and in work zones.**

The purpose of task 3 was to determine what SDDOT's needs are with respect to special events, traffic incidents, and work zones. A survey was prepared and emailed to personnel in the SDDOT Region and Area offices. Survey results are shown in the Needs section. The survey itself is shown in Appendix A.

Task 4: **Based on the needs expressed by the panel, map appropriate ITS systems to the identified needs, and make recommendation to the panel.**

Various ITS systems and solutions are discussed that meet the identified needs. Existing equipment and the possibility of sharing equipment among regions was taken into account.

Task 5: **Determine whether equipment owned by the state might be used in traffic control or lane merge systems.**

Results of the survey and interviews revealed that of the 32 DMSs owned by the Department, 9 to 12 of them need to be upgraded or replaced. None of the DMSs owned by the Department are capable of remote communications, making them incapable of being used in any dynamic traffic control or lane merge system.

Task 6: **Meet with the technical panel to summarize literature and findings of ITS technology used in work zones.**

The findings from the study were presented to the panel in May 2004.

Task 7: **Provide a final report including methodology, findings, conclusions, recommendations, and architecture deliverables.**

This report includes the methodology used in the project, findings from the literature and interviews, conclusions drawn from the findings and recommendations for the implementation of ITS technologies in work zones. The results from the equipment inventory and Department needs surveys are included. The recommended system conforms to the South Dakota Statewide ITS Architecture and National ITS Standards.

Task 8: **Make an executive presentation to the Research Review Board.**

The findings, conclusions and recommendations from the report were summarized and presented to the Research Review Board on June 10, 2004. This presentation exists as a Microsoft Powerpoint™ file in the Office of Research.

Conclusion

The survey revealed that SDDOT's greatest need is communicating with our portable signs, specifically in Mitchell, Winner, Yankton, Rapid City and Sioux Falls. A few respondents felt that Automated Speed Enforcement and transmitters to inform drivers of an approaching work zone might be worth investigating. Some surveys stated that the problem in work zones is not that the workers are unaware of drivers, but the drivers are unaware of the workers. To address that concern, we should be focused on putting timely and relevant messages on our DMSs. There was little support for such things as sensors for measuring queue length and promoting early lane merges.

A number of special events were listed on the surveys. By using central control software, and planning for each of these special events, traffic engineers will be able to program messages for each DMS located near a special event for several traffic scenarios. If, for example, traffic is backed up at one entrance to a park, DMSs may be configured in real time to give messages on all pertinent routes that another entrance should be used. If an incident occurs, drivers can be informed as to which route they should use as an alternative.

Several software options were evaluated, and IDI central software appears to be the most suitable and feasible software for controlling field devices. It is capable of controlling any device that is National Transportation Communications for ITS Protocol (NTCIP) compliant.

Recommendations

1. **Work with Region Engineers in each region to upgrade those portable DMSs that are mechanically serviceable and new enough that new controllers and communication equipment can be interfaced.**

About two portable DMSs in each region should have an IDI controller installed to make it NTCIP compliant, allowing remote communications with central software. The upgrade should include a GPS transceiver, necessary for portable devices that will be relocated frequently. In a couple of areas, no DMSs are usable. In those cases, new signs should be purchased.

2. **Purchase IDI control software for the monitoring and control of DMSs statewide.**

IDI software is capable of controlling not only permanent and portable DMSs, but other NTCIP devices such as cameras, weather sensors, road closure gates and traffic signals. The software is capable of scheduling messages on signs and intelligent control such as monitoring information from sensors and displaying an appropriate message on a DMS. IDI software is more capable and easily configurable than other ITS control software.

3. **Require the use of the attached specifications when requisitioning new portable DMSs.**

The specifications in Appendix A ensure that DMSs purchased by SDDOT meet minimum requirements for performance, maintenance, and NTCIP conformance and communication.

4. **When purchasing new DMSs, specify NTCIP testing and an on-site communications survey for acceptance.**

NTCIP testing ensures that new devices will communicate with central software reliably. IDI has software for performing this testing called Device Tester. Performing on-site communications survey in an area where equipment is likely to be used will ensure that the purchased equipment is within communications range of each other, and not in an area where electrical noise degrades communications.

5. **Provide Incident Management training and ITS awareness training for field traffic management personnel.**

Traffic Incident Management is an important tool to use during an incident or emergency to maintain the safe and efficient flow of traffic. Because secondary accidents can be more severe than the initial accident, SDDOT must do what it can to reduce its liability when such an incident occurs. Incident management training workshops were held in Rapid City and Sioux Falls the week of May 9, 2005.

6. **Revise SDDOT policies regarding work zones and emergency and disaster traffic control to align them with SDDOT's strategic plan regarding traveler information.**

SDDOT Policies OC-2002-04, "Work Zones for Interstate and 4-Lane Divided Highways", S-2002-02, "Operational Procedures for Emergency and Disaster Assistance", and OT-1985-02, "Policy for Traffic Safety in Highway & Street Work Zones", provide guidelines to be used by SDDOT for setting speeds, providing traffic control and equipment, but they make no mention of providing information for traveler information. These policies should be revised to reflect the Department's strategic plan regarding traveler information.

Introduction

Work zones, traffic incidents and high traffic areas during major events are often places where drivers can become confused or drive aggressively. Such an environment can cause congestion and endanger workers. During the summer months, SDDOT operates many work zones where drivers need to reduce speed, merge, and take extra precautions. These same characteristics are true for arrival and departure traffic at major special events.

ITS solutions are available to provide drivers with advance warning of work zones and traffic congestion. These systems can also provide project and traffic engineers real-time information necessary for timely traffic control. The Indiana Lane Merge system gives motorists instructions such as when to merge to prevent congestion at "bottle neck" areas. Products are also available for warning workers when errant vehicles breach the work zone.

While ITS technology has been researched and evaluated by many agencies, research is needed to inventory SDDOT and other state agencies to determine what traffic control needs exist for work zones and special events, and whether existing equipment can be utilized as a part of an ITS solution such as an early lane merge system or a traffic management system.

ITS technology in work zones has matured to the point where it is likely to improve travel time and safety in work zones and event traffic areas. SDDOT operates large work zones such as those near Sioux Falls and Rapid City where ITS technology can help improve the Department's traffic control.

Background

The South Dakota Department of Transportation has 32 portable dynamic message signs in its inventory. These signs are manufactured by ADDCO and are of various ages. Most of them have no communication capabilities and must be programmed on site. Each of the state's four regions has one or two signs that have cellular capabilities, but because of incompatibilities with other signs and software that is difficult to use, these signs also are programmed on site.

As ITS equipment has become more pervasive throughout the country, standards have been, and continue to be developed to facilitate interoperability and interchangeability with equipment provided by other manufacturers. The National Transportation Communication for ITS Protocol (NTCIP) is a family of protocols and standards that attempts to accomplish that goal.

With the increasing capabilities of work zone equipment, it is clear that the traffic management needs of SDDOT can be met by using equipment that is capable of communications that allow traffic engineers to monitor and control it remotely in real-time.

We need to have any ITS system considered for purchase to be demonstrated on site. It must demonstrate reliable communication, easy-to-use software, and the ability to integrate other devices such as HAR, cameras, etc. Prior to delivery, ITS devices must pass NTCIP exerciser device tests.

SDDOT has 32 portable DMS signs in all. Signs manufactured during 1998 and later are capable of using cellular and wireless network communications, but older signs would need to have their controller replaced. The condition of some of the older signs is such that purchasing new signs may be a better investment.

Project Objectives

1. **To determine SDDOT's needs for traffic control at special events, traffic incidents and in work zones;**

It was necessary to collect information from SDDOT region and area offices regarding their perceived needs for traffic control at special events, traffic incidents and in work zones. The survey and responses are shown later in the report.

2. **To investigate existing ITS technologies that will improve traffic flow and worker safety in work zones and special event traffic areas;**

To gain an understanding of the available ITS technologies that apply to this topic, several states were contacted. Their practices regarding the use of DMSs and other ITS devices are given. The literature summary provides insite into how ITS is employed on larger work zones and construction projects.

3. **To determine whether ITS technology should be used by SDDOT for traffic control during special events, and whether existing equipment might be used as a part of ITS traffic control systems.**

After collecting information through literature reviews, surveys of surrounding states and of SDDOT personnel, the researcher concluded that the most significant step that could be taken to improve safety on work zones and at incidents and special events is to make existing DMSs NTCIP compliant and acquire NTCIP central software. Through the survey of SDDOT and other state agencies it was learned that the only equipment that can be readily used by SDDOT owned by another agency is the Highway Advisory Radio (HAR) trailers owned by the Department of Public Safety.

Task Description

Task 1: Perform a literature search regarding ITS technology in work zones.

States including Minnesota, Kansas, North Carolina and Maryland have performed work on this topic. ITS efforts have been summarized in FHWA's Cross Cutting study as well as documents published by AASHTO. These efforts are included in the literature review.

Task 2: Perform an equipment inventory of SDDOT, BIT, HP, and Emergency Management to determine the location, model, and condition of traffic control/information equipment.

Personnel from SDDOT, BIT, and the Department of Public Safety and Emergency Management were interviewed to locate equipment that might be used if necessary as a part of a traffic control system. Equipment located so far includes Highway Advisory Radio trailers owned by BIT. No other equipment was located.

Personnel in SDDOT Region and Area offices were asked about the condition of portable DMSs in their jurisdiction. Signs are of various ages and conditions. Details regarding the signs are given in the body of the report.

Task 3: Perform a survey of SDDOT regions and areas to determine requirements for traffic control at special events, traffic incidents and in work zones.

The purpose of task 3 was to determine what SDDOT's needs are with respect to special events, traffic incidents, and work zones. These needs were used to develop specific user requirements necessary for the acquisition of ITS equipment. A survey was prepared and emailed to personnel in the SDDOT Region and Field offices. Survey results are shown in the Needs section. The survey itself is shown in Appendix C.

Task 4: Based on the needs expressed by the panel, map appropriate ITS systems to the identified needs, and make recommendation to the panel.

Various ITS systems and solutions are discussed that meet the identified needs. Existing equipment and the possibility of sharing equipment among regions is taken into account.

Task 5: Determine whether equipment owned by the state might be used in traffic control or lane merge systems.

After matching ITS solutions to the needs identified in the survey and interviews, I will determine whether any of the resources identified in the inventory might be used along with new equipment or a new system. I will point out such opportunities as upgrading an existing DMS for a low cost to save the cost of a new one. Because the focus of traffic control systems and devices is to alert motorists to roadway conditions, getting information to the Road Condition Reporting System (RCRS) will be considered. Any event that might cause road restrictions, congestion, delays, etc, should be reported on RCRS.

Task 6: **Meet with the technical panel to summarize literature and findings of ITS technology used in work zones.**

The findings from the study were presented to the panel on July 22, 2004. The discussion included the status of DMSs throughout the state, how they could best be used for work zones and incidents, and the cost to upgrade or replace. The draft report was also discussed.

Task 7: **Provide a final report including methodology, findings, conclusions, recommendations, and architecture deliverables.**

This report includes the methodology used in the project, findings from the literature and interviews, conclusions drawn from the findings and recommendations for the implementation of ITS technologies in work zones. The results from the equipment inventory and Department needs surveys are included. The recommended system conforms to the South Dakota Statewide ITS Architecture and National ITS Standards.

Task 8: **Make an executive presentation to the Research Review Board.**

The findings, conclusions and recommendations from the report were summarized and presented to the Research Review Board on June 10, 2004.

North Dakota DOT has replaced the factory installed controllers in their portable dynamic message signs with NTCIP compliant controllers. They use software from Intelligent Devices Inc. to integrate and communicate with all their PDMSs. Similar NTCIP controllers are available for many other devices, allowing them to communicate with central software. Cellular modems are used where service is available.

Wyoming DOT uses cellular modems with ten PDMSs they have deployed statewide, although they have encountered communication problems. Upgrading to newer technology "tri-mode" modems may solve the problem.

Montana DOT deploys 8 PDMSs, primarily in mountain passes. These devices are not NTCIP compliant and do not connect to any central location. Work zones are regulated by MUTCD guidelines, and they do not use intrusion alarms.

North Carolina DOT leases ITS equipment as part of their construction contracts. This includes portable DMSs, cameras, sensors and wireless communications. Communications for all devices relay information to a single point on the project, such as a trailer at the job site or a hotel room. They do not require devices to be NTCIP compliant yet, but will in the future. North Carolina does not use work zone intrusion devices, but like the other states interviewed, relies on their travel information devices to maintain driver awareness of the work zone environment.

Intelligent Transportation Systems in Work Zones, FHWA, November 2002

This report provides real-world experiences of using intelligent transportation systems (ITS) in work zones in four locations across the U.S.:

The ITS applications in work zones were used to provide traffic monitoring and management, and traveler information. The primary purpose of the ITS for the Albuquerque project was incident management. Each of the work zone systems provided real-time information on dynamic message signs (DMSs). Real-time work zone information was also provided on the Internet with the exception of the Arkansas system. The ITS devices were automated with two traffic management centers being staffed during early morning to evening. Most systems were temporary; however, the Albuquerque system was to become part of the permanent freeway management system after the construction project was completed.

Springfield, IL

The Illinois DOT (IDOT) used ITS in a 40-mile work zone on I-55. The Real-Time Traffic Control System (RTTCS) consisted of 17 remotely-controlled portable DMSs connected to a base station server via wireless communication, eight portable traffic sensors connected to the server via wireline, and four portable cameras linked to the base station server via wireless communication. IDOT leased the system for the duration of the reconstruction project. The lease included a provision for contractor personnel to monitor the system. The system operated in an automatic mode; however, one person was assigned to check system performance periodically during week days. After hours and during weekends, contractor personnel were on-call to handle problems.

Specific costs for the RTTCS were not available; however, the cost to lease the system was less than 10% of the total project cost annually for the two-year project.

Lansing, MI

The Michigan DOT (MDOT) used a Temporary Traffic Management System (TTMS) during a construction project in downtown Lansing. The system was deployed from March 2001 to October 2001 and removed at the completion of the construction project. The project involved a complete closure of portions of I-496. The $40 million construction project included the rebuilding of 32 bridges, reconstructing one mile and repairing seven miles of freeway, and adding a third lane/merge weave in each direction for a section of the freeway. The TTMS was used throughout the construction project. The system included 17 cameras, 12 DMSs, six queue detectors (microwave sensors), and a commercial off-the-shelf (COTS) software package which ran on a server located at the Construction Traffic Management Center (CTMC). Based on data from the detectors, appropriate messages from a bank of predefined messages would be displayed on each DMS and on the Internet. Operators had the option of manually updating the messages. MDOT purchased some of the hardware components of the work zone system (e.g., communications tower, antenna, queue detectors, and cameras) and software license, but most of the system was leased. The cost of the lease was $2.4 million which is about 6% of the total project cost.

Albuquerque, NM

The New Mexico State Highway and Transportation Department (NMSHTD) used ITS in a 2-year construction project of "The Big I" interchange where I-40 and I-25 intersect. The primary purpose of employing ITS was to aid in incident management and response. The 2-year project began June 30, 2000 and involved construction of 111 lane-miles, 45 new bridges, and 10 rehabilitated bridges. The ITS included eight fixed CCTV cameras, eight modular (expandable) DMSs, four arrow dynamic signs, four portable DMSs, four portable traffic management systems (a single integrated platform for camera and DMS), and four highway advisory radio (HAR) units. Components were linked to base station computers via wireline and wireless communications. Camera images were monitored at the traffic management center by NMSHTD staff from 5:00 am to 8:00 pm. Information on traffic conditions were provided via the HAR and DMS, and via other outlets to include website, radio, fax and email distribution lists. Although pre-defined messages could be activated automatically, the system was set for manual initiation.

NMSHTD purchased the ITS with the intent of incorporating much of the system into a freeway management system once construction was completed. Other components would be used in future work zone projects. The ITS work zone system cost $1.5 million.

West Memphis, AR

The Arkansas State Highway and Transportation Department (AHTD) employed an ITS for a 3-mile concrete reconstruction project in West Memphis on I-40 near the intersection with I-55. The work zone was near a bridge across the Mississippi River from Memphis, Tennessee and abutted a Tennessee work zone on the bridge. The reconstruction project was expected to last 12 to 18 months and cost $13.8 million. The work zone was expected to be in place for the duration of the construction project.

The Automated Work Zone Information System (AWIS) included 12 queue detectors and five remotely controlled DMS which were linked to a central base station server via wireless communications, three HAR units, five pagers, and an email alert system. The traffic detectors were installed one mile on each side of the work zone. The DMSs were deployed over approximately 9 miles on each side of the work zone. The HARs range was approximately 23 miles. The server processed data from the queue detectors and disseminated messages to the DMS and HAR based on predefined messages for specific traffic

conditions. AHTD and Tennessee DOT staff, contractors for both work zones, traffic reporters and other media were informed of traffic conditions via email and pager alert systems.

The AWIS was leased for the duration of the work zone project. The lease included personnel to monitor the system. Usually one person was required for periodic system maintenance and to be on-call after hours. The terms of the lease called for a daily fee paid to the contractor and a lump sum for the HARs. The fee was assessed each day the system was operational, thereby the state did not pay for any system down time. The total cost of the AWIS was $495,000 which included the daily fee and purchase of three HARs. The AWIS cost was less than 4% of the total reconstruction cost.

Nebraska Smart Work Zone

The Nebraska Department of Roads has installed and activated an automated work-zone system along I-80 in the Omaha area. It is designed to collect real-time data in an I-80 reconstruction project work zone. Electronic detectors are in place to measure the speed of traffic. The information from the detectors is sent to a central computer system and then to changeable message signs (CMS), alerting motorists of delays and advising them to slow down or take alternate routes. There are 21 CMS boards and nine detectors in place along the nine-mile project and west of the project. The website address for the system is www.nebraskaI80construction.com.

Traffic Incident Management Handbook, PB Farradyne, FHWA, November 2000.

This handbook was developed to provide guidance for developing incident management programs and to identify tools and strategies to enhance field operations. The handbook states that "although the problems most often associated with highway incidents is traveler delay, by far the most serious problem is the risk of secondary crashes." It goes on to provide evidence that "the severity of secondary crashes is often greater that that of the original incident. The longer the incident is in place, the greater the exposure to additional crashes."

Steven P. Latoski, Walter M. Dunn, Jr., Bernie Wagenblast, Jeffrey Randall, Matthew D. Walker, Managing Travel for Planned Special Events, Dunn Engineering Specialists, P.C., FHWA, September 2003.

This handbook provides guidance for the advanced planning, management and monitoring of travel for planned special events.

SDDOT Traffic Management Needs Survey

A survey was prepared and sent to SDDOT region operations and traffic engineers, and area engineers to assess the perceived traffic management needs of SDDOT. Surveys were also sent to the Highway Patrol and Emergency Management to assess their perspective on DOT operations in work zones and during incidents. The survey is copied in Appendix C. The survey listed some available ITS technologies and asked recipients whether any of those technologies filled their needs. Those surveyed were asked to report any problem areas they felt needed to be addressed by the Department.

Survey topics included Traffic Control, Traffic sensors, Traveler Information, Worker Safety and Work Zone Enforcement.

Traffic Management

Do you see any benefit in having the capability to communicate remotely with the portable DMS?

Pierre, Huron and Watertown saw little or no benefit to this. Rapid City, Mitchell, Winner, Sioux Falls and Yankton support remote communications. Aberdeen and Watertown felt there may be a slight benefit, but may not warrant the expense. The Highway Patrol and Emergency Management felt this would be a good idea considering the speed of disseminating information and limited personnel.

Do you think we need more DMSs or ones with different capabilities? Should our portable DMSs be full matrix signs or 3 line signs?

Pierre, Huron, Watertown and Winner Areas expressed satisfaction with the equipment they have. Sioux Falls, Yankton and Mitchell Areas, and Rapid City and Aberdeen Regions felt that more DMSs would be beneficial. Nearly all areas reported maintenance problems with signs. The PDMSs that use flip-disk technology or diesel engines seem to be used less because they experience more maintenance down-time. The few signs SDDOT has that use cellular modems are analog, which limits their utility because cell companies have switched to digital. Highway Patrol and Emergency Management felt the number of existing signs is adequate, however they both supported full matrix due to the broader array of messages available.

Given the information on the attached map (Figure 1), are there any other locations where portable DMSs would compliment the permanent DMS locations for use during winter weather?

Figure 1 DMS locatioins in South Dakota

Aberdeen Area recommended a PDMS to be placed on US12 at Webster to warn travelers in the case that I-29 is closed. None of the other survey respondents suggested other locations for deploying DMSs. Several stated only that more are better.

Do you see a need for a traffic management system for incidents, forest fires, special events, lane merges, long work zones, travel information, traffic management?

Watertown felt that road conditions should be shown on signs with driving tips. i.e. ICY ROADS – SLOW DOWN – DON'T USE CRUISE. Pierre had a similar idea, suggesting communications between RWIS and DMSs, so high wind or poor visibility warnings could be displayed ahead of the conditions so travelers could consider options. Emergency Management, Highway Patrol, and Mitchell Area felt that a traffic management system would be useful during forest fires.

Sioux Falls, Yankton, Highway Patrol and Emergency Management indicated some interest in lane merge systems.

Special events to be considered for additional traffic management consideration include the Sturgis Rally, Mt. Rushmore Fireworks display, concerts, Ft. Sisseton Celebration, Dakota Fest at Mitchell, Riverboat Days in Yankton, major events in Sioux City at the New Tyson Events Center, Dakota Dunes golf events, and events at the Dakota Dome at Vermillion.

Do you see a need for camera monitoring?

Winner Area, Rapid City and Aberdeen Regions, Highway Patrol and Emergency Management were interested in cameras for monitoring traffic and detecting incidents. The most immediate need for camera monitoring is during the Sturgis motorcycle rally.

Do you see a need for Highway Advisory Radio (HAR)?

Highway Patrol, Emergency Management, Aberdeen, Winner and Rapid City Region saw some benefit to using HAR in certain circumstances. The Department of Public Safety currently owns two HAR units – one is stationed in Pierre, and one at the Rapid City Region office, which is used most frequently for traffic control in forest fire areas.

Worker Safety

Do you see a need for work zone intrusion alarms?

Most respondents didn't think there was a need for this, or that it would be necessary only on interstate or in high population areas. Highway Patrol indicated that the real problem is that drivers are not aware of the workers, as opposed to workers not being aware of drivers.

Do you see a need for devices that make the beginning of the work zone more visible to motorists?

A few thought this was a good idea, but the majority felt that following MUTCD guidelines as SDDOT does currently is the best practice. Region traffic engineers keep abreast of new technology and deploy them as appropriate to individual projects.

Radar Transmitters in work zones that activate the approaching vehicle's radar detectors indicating that the driver is approaching a work zone?

Some areas thought this might be a good idea, but there were no strong feelings either way. Highway Patrol commented that transmitting information over vehicle radios would have some benefits. This sounds like the Data Radio Channel technology that is being advertised by some car manufacturers.

Changeable message signs giving driver information regarding the work zone?

Most respondents felt that using DMSs in work zones was necessary.

Automated Speed Enforcement that automatically photographs speeding vehicles and generates a citation which is mailed to the offender?

Highway Patrol and Emergency Management thought Automated Speed Enforcement was worth considering. Mitchell, Yankton, Winner, Pierre, Aberdeen, Watertown, Sioux Falls also thought it would be effective. Huron and Mobridge did not express a need for it due to low traffic volumes.

Any other ideas you can think of?

The only comment given was from Yankton Area who suggested stiffer penalties/fines for violators.

Have you used or needed Real Time Monitoring System (RTMS) or video detection to detect traffic volume, queue length or incidents?

No respondents had used RTMS for other than signal control or thought they would be useful for their area. The Office of Transportation Inventory Management uses RTMS in some locations for traffic monitoring. Video detection is used in Rapid City and Sioux Falls to activate traffic signals, but not to detect queue lengths or incidents. Video detection will be used for incident detection and signal control during the Sturgis motorcycle rally.

Are you aware of other agencies that possess equipment useful in traffic management?

No respondents were aware of equipment in other agencies.

SDDOT's Portable Dynamic Message Signs

SDDOT has 32 signs in its four regions. Signs manufactured during 1998 and later are capable of using cellular and wireless network communications, but older signs would need to have their controllers replaced. Even the newer signs would need upgrades to render them NTCIP compliant. The poor condition of some of the older signs is such that purchasing new signs may be a better investment. Problems with the older signs range from the older "flip-disk" style not flipping, to mechanical problems with the trailers themselves. According to the Rapid City Region, even the signs that are capable of remote communication were not used because of communication trouble and software that is difficult to use. Figure 2 below shows two of the currently available DMSs.

Figure 2 Commercially available DMSs.

The main issue with using DMSs remotely is their ability to communicate with central software, allowing traffic management personnel to provide vital information and direction to travelers in work zones and approaching incident scenes. To make this control possible, DMSs having older controllers not conforming to new communications requirements must be upgraded. Also, control software must be acquired, and NTCIP testing is necessary to determine whether DMSs truly meet the national NTCIP standard. This is important because it allows us to purchase signs from anyone with the confidence to know that if it is NTCIP compliant, it will communicate reliably with existing NTCIP compliant software. NTCIP testing specifications are listed in Appendix A.

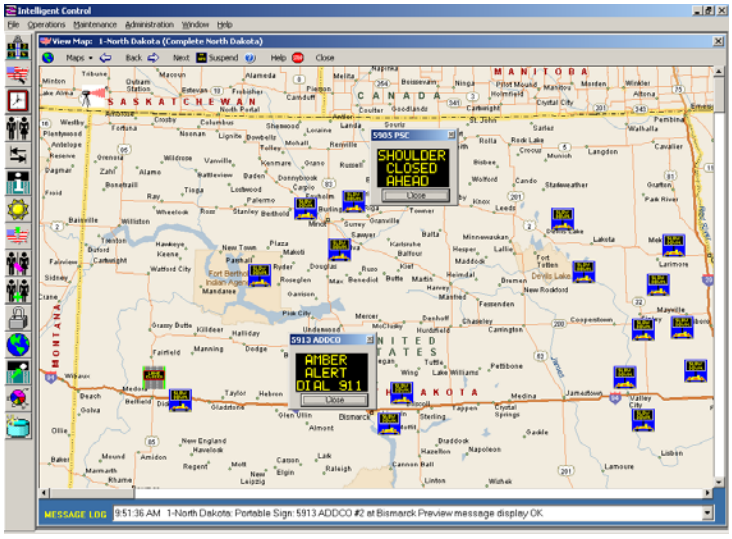

Figure 3 Image of control software configured for North Dakota DOT.

Figure 3 shows an example of software configured for North Dakota available from Intelligent Devices Incorporated (IDI). This software communicates with any transportation device that conforms to NTCIP standards. It is capable of performing the scheduling of messages on DMSs and programming scenarios for use during road closures, special events, or incidents – a helpful feature when planning for alternative routes. Other devices that can be controlled by the software are cameras, traffic signals, Road Weather Information Sensors (RWIS). Its intelligence also allows it to be used for variable speed limit signs and dynamic passing zone systems.

When congestion is a problem at lane merge locations, dynamic lane merge systems can help by informing motorists they need to merge earlier. These systems comprise a sign displaying the "merge now" message, and sensors to detect slow traffic and developing queues. Operation of a dynamic merge system is shown in Figure 4 below (Smart Lane Merge, ©2004, ADDCO, Inc.).

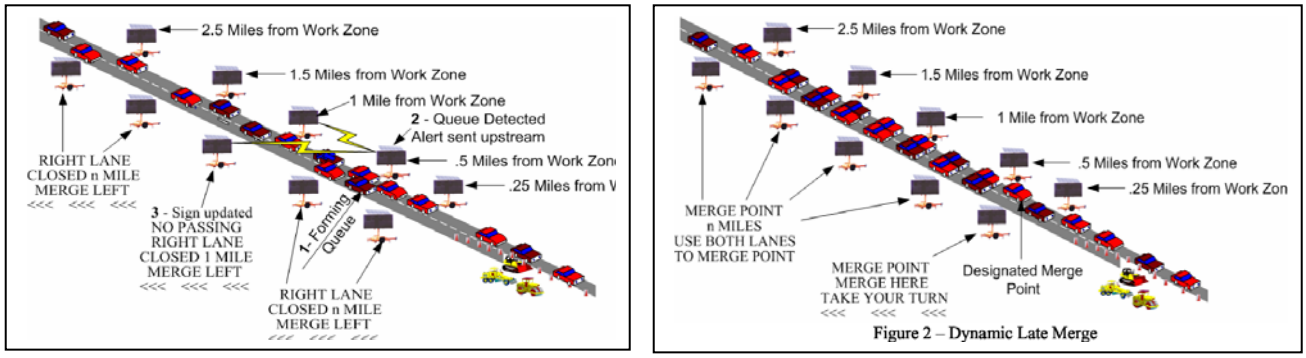

Figure 4 Dynamic Lane Merge Operation

Traffic Control Upgrade Cost

Upgrading SDDOT's fleet of portable DMSs to create a viable traffic management system to improve safety in work zones and at incidents and special events will require one or more of the following things:

New DMS with wireless communications:	$20,000-25,000
Controller and communications upgrade:	$3,000
Central control software:	$50,000
NTCIP test software:	$5,000

Based on the ITS needs survey and subsequent conversations with Region personnel, 6 new DMSs should be purchased, and 4should be upgraded with new controllers. These purchases including software total $212,000.

ITS Architecture

The South Dakota Rural ITS Architecture (Jaffe, R.S., Eisenhart, B., Consensus Systems Technologies Corp, South Dakota DOT Office of Research, February 2003) contains "market packages", or services, that address weather information, work zone management, and travel information. Each of these functions include the use of DMSs to provide traffic information to travelers.

Environmental Information Processing

This equipment package processes current and forecast weather data, road condition information, local environmental data, and uses internal models to develop specialized detailed forecasts of local weather and surface conditions. The processed environmental information products are presented to the user.

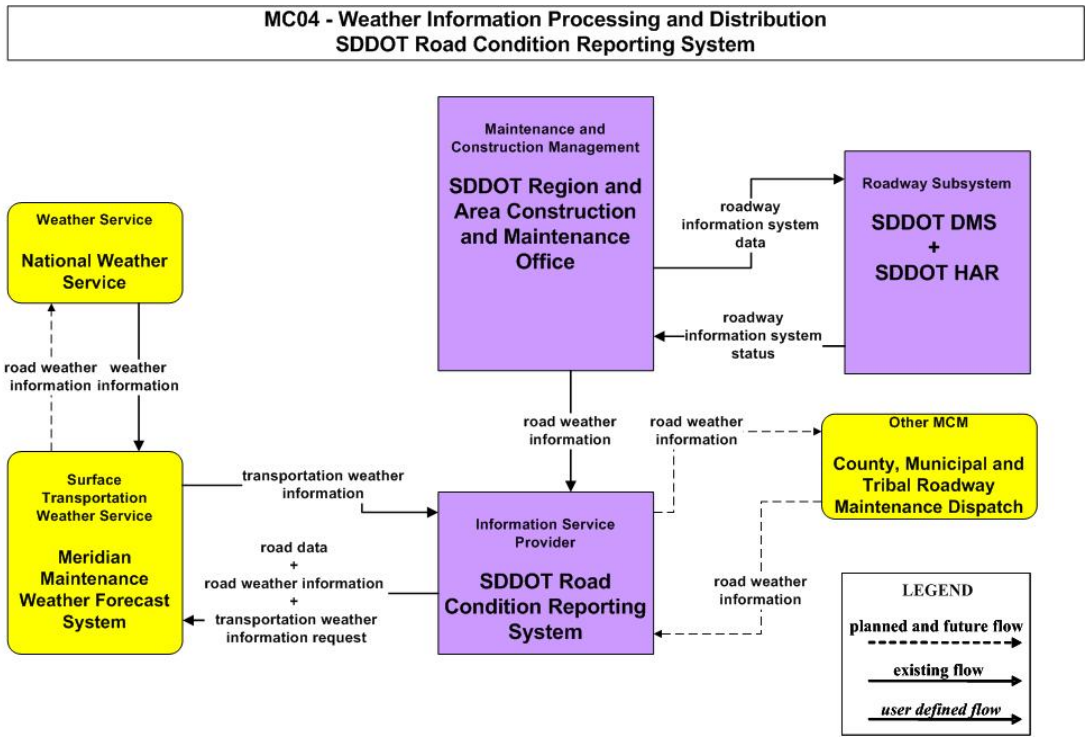

Figure 5 ITS Equipment Package for Weather Information.

In this system, data entered by SDDOT maintenance personnel into the Road Condition Reporting System (RCRS), and data collected from Road Weather Information Systems (RWIS) or the National Weather Service may prompt Operations personnel to display a message on a DMS. The market package above indicates that the Region and Area offices control the DMSs, but the Office of Operations Support also has access to DMS control.

Traffic Information Dissemination Equipment Package

This Equipment package provides the capability to disseminate incident related information to travelers and private information service providers.

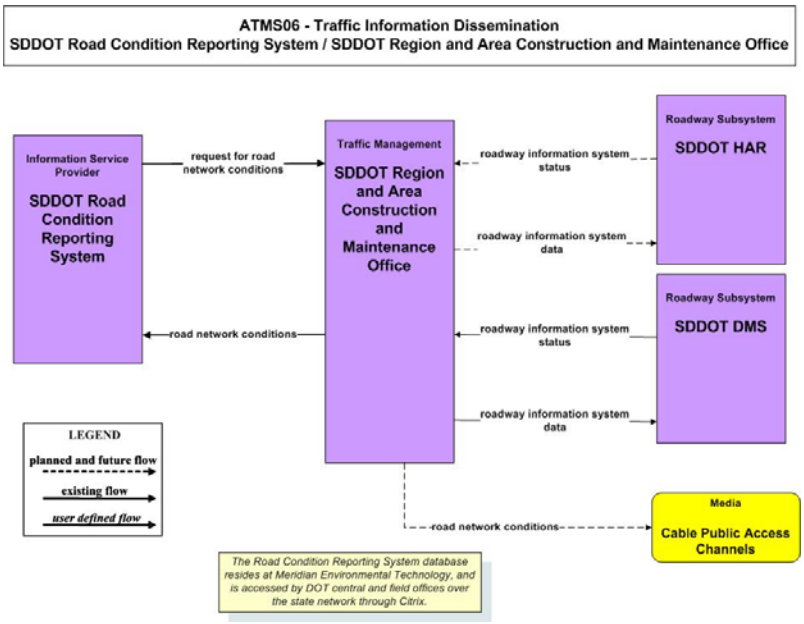

Figure 6 Traffic Information Dissemination with RCRS, DMS and HAR.

Figure 6 may be the most typical use of a DMS in South Dakota. Road condition data placed in the Road Condition Reporting System (RCRS) will inform SDDOT personnel of road and traffic conditions that need to be displayed on a DMS to inform motorists. Figure 7 below illustrates communication between a mobile traffic management center and cameras, traffic signal controllers and DMSs. This is the scenario used for special events such as the Sturgis motorcycle rally.

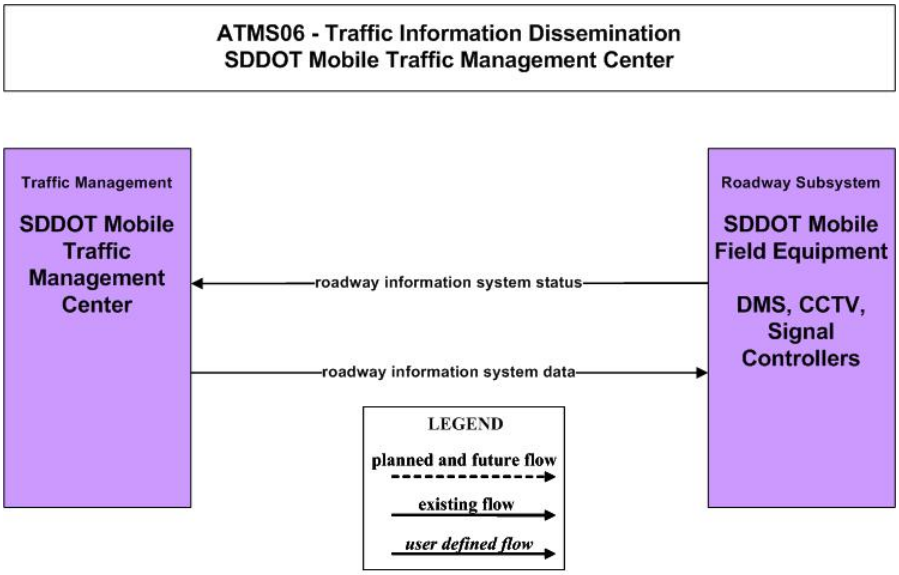

Figure 7 Mobile Traffic Management Center Package.

Conclusion

It appears from the survey and literature that our greatest need is for communicating with our portable signs, specifically in Mitchell, Winner, Yankton, Rapid City and Sioux Falls. A few respondents felt that Automated Speed Enforcement and transmitters to inform drivers of an approaching work zone might be worth investigating. Some surveys stated that the problem in work zones is not that the workers are unaware of drivers, but the drivers are unaware of the workers. To address that concern, we should be focused on putting timely and relevant messages on our DMSs to inform motorists and effectively slow traffic. There was little support for such things as sensors for measuring queue length and promoting early lane merges.

A number of special events were listed on the surveys. By using central control software, and planning for each of these special events, traffic engineers will be able to program messages for each DMS located near a special event for several traffic scenarios. If, for example, traffic is backed up at one entrance to a park, DMSs may be configured in real time to give messages on all pertinent routes that another entrance should be used. If an incident occurs, drivers can be informed as to which route they should use as an alternative.

IDI central software appears to be the most suitable and feasible software for controlling field devices. It is capable of controlling any device that is National Transportation Communications for ITS Protocol (NTCIP) compliant.

Recommendations

1. **Upgrade those portable DMSs in each region that are mechanically in good shape and new enough that new controllers and communication equipment can be interfaced.**

About two portable DMSs in each region should have an IDI controller installed to make it NTCIP compliant, allowing remote communications with central software. The upgrade should include a GPS transceiver, necessary for portable devices that will be relocated frequently. In a couple of areas, no DMSs are usable. In those cases, new signs should be purchased.

2. **Purchase IDI control software for the monitoring and control of DMSs statewide.**

IDI software is capable of controlling not only permanent and portable DMSs, but other NTCIP devices such as cameras, weather sensors, road closure gates and traffic signals. The software is capable of scheduling messages on signs and intelligent control such as monitoring information from sensors and displaying an appropriate message on a DMS. IDI software is more capable and easily configurable than ADDCO's VTOC software.

3. **Require the use of the attached specifications when requisitioning new portable DMSs.**

The specifications in Appendix A ensure that DMSs purchased by SDDOT meet minimum requirements for performance, maintenance, and NTCIP conformance and communication.

4. **When purchasing new DMSs, specify NTCIP testing and on-site communications survey for acceptance.**

NTCIP testing ensures that new devices will communicate with central software reliably. IDI has software for performing this testing called Device Tester. Performing on-site communications survey in

an area where equipment is likely to be used will ensure that the purchased equipment is within communications range of each other, and not in an area where electrical noise degrades communications.

5. **Provide Incident Management training and ITS awareness training for field traffic management personnel.**

Traffic Incident Management is an important tool to use during an incident or emergency to maintain the safe and efficient flow of traffic. Because secondary accidents can be more severe than the initial accident, SDDOT must do what it can to reduce its liability when such an incident occurs. Incident management training workshops were held in Rapid City and Sioux Falls the week of May 9, 2005.

6. **Revise SDDOT policies regarding work zones and emergency and disaster traffic control to align them with SDDOT's strategic plan regarding traveler information.**

SDDOT Policies OC-2002-04, "Work Zones for Interstate and 4-Lane Divided Highways", S-2002-02, "Operational Procedures for Emergency and Disaster Assistance", and OT-1985-02, "Policy for Traffic Safety in Highway & Street Work Zones", provide guidelines to be used by SDDOT for setting speeds, providing traffic control and equipment, but they make no mention of providing information for traveler information. These policies should be revised to reflect the Department's strategic plan regarding traveler information.

References

PB Farradyne, *Traffic Incident Management Handbook*, FHWA, November 2000.

Steven P. Latoski, Walter M. Dunn, Jr., Bernie Wagenblast, Jeffrey Randall, Matthew D. Walker, *Managing Travel for Planned Special Events*, Dunn Engineering Specialists, P.C., FHWA, September 2003.

Intelligent Transportation Systems in Work Zones, FHWA, November 2002

Jaffe, R.S., Eisenhart, B., *South Dakota Rural ITS Architecture*, Consensus Systems Technologies Corp, South Dakota DOT Office of Research, February 2003.

Appendix A – NTCIP Testing and Acceptance

ACCEPTANCE TEST PROCEDURE

Preamble:

Establish communication with the sign from the test computer to verify:
Communication port
Baud rate and other communication parameters
Community name
Device Address

Conduct this acceptance test connected to the sign via a serial cable, and repeat the tests 2, 3, 4 and 11 over the dial-up communication link to verify that the remote communication is reliable.

Test 1 Sign Interrogation

Purpose:

The purpose of this test is to verify that the sign reports the applicable parameters required for the Central System to know the sign size, configuration, manufacturer and version.

Procedure:

Perform a Get on the following objects, and verify that the values returned are correct for the sign being tested.

	Object	Value
1.	*dmsSignType.0*	
2.	*dmsBeaconType.0*	
3.	*dmsSignAccess.0*	
4.	*dmsSignHeight.0*	
5.	*dmsSignWidth.0*	
6.	*dmsHorizontalBorder.0*	
7.	*dmsVerticalBorder.0*	
8.	*dmsLegend.0*	
9.	*dmsSignTechnology.0*	
10.	*globalMaxModules.0*	
11.	*moduleDeviceNode.1*	
12.	*moduleMake.1*	
13.	*moduleModel.1*	
14.	*moduleVersion.1*	
15.	*moduleType.1*	
16.	*moduleDeviceNode.2*	
17.	*moduleMake.2*	
18.	*moduleModel.2*	
19.	*moduleVersion.2*	
20.	*moduleType.2*	

21. *vmsCharacterHeightPixels.0*
22. *vmsCharacterWidthPixels.0*
23. *vmsSignHeightPixels.0*
24. *vmsSignWidthPixels.0*
25. *vmsHorizontalPitch.0*
26. *vmsVerticalPitch.0*

Notes:

Module type 2 is for hardware, and 3 is software.
Dimensions of sign parameters are in millimeters.

DeviceTester script NDDOT Test 1

Test 2 Download and Display a Changeable Message

Purpose:

The purpose of this test is to check that the sign will download and display a changeable message.

Procedure:

1. Download changeable message 1

    a. Set *dmsMessageStatus.3.1* to **6** (modifyReq)
    b. Set *dmsMessageMultiString.3.1* to **TEST[nl]MESSAGE**
    c. Set *dmsMessageOwner.3.1* to **Customer**
    d. Set *dmsMessageBeacon.3.1* to **0**
    e. Set *dmsMessagePixelService.3.1* to **0**
    f. Set *dmsMessageRunTimePriority.3.1* to **255**
    g. Set *dmsMessageStatus.3.1* to **7** (validateReq)

2. Verify that no errors are reported.

3. Check changeable message 1 validation status

    a. Get *dmsMessageStatus.3.1* and verify the value is 4 (valid)
    b. Get *dmsValidateMessageError.0* and verify the value is 2 (none)
    c. Get *dmsMultiSyntaxError.0* and verify the value is *2* (none)

4. Activate changeable message 1

    a. Get *dmsMessageCRC.3.1*, and verify the value is a positive integer of 40959 (9F FF).

    b. Construct a 12 byte MessageActivationCode using the following parameters:

        i. Duration 15
        ii. Priority 255
        iii. Memory Type 3
        iv. Message Number 1
        v. CRC 40959
        vi. IP Address "1.2.3.4"

    c. Set the *dmsActivateMessage.0* object with the MessageActivationCode, and verify that "TEST MESSAGE" is displayed on the sign.

d. Get *dmsMessageMultiString.5.1* (the current message) and verify that "TEST[nl]MESSGE" is reported.

e. Get *dmsActivateMsgError.0*, and verify that the value is 2 (none)

Notes:

DeviceTester script NDDOT Test 2

Test 3 Display All Permanent Messages

Purpose:

The purpose of this test is to verify that the signs correctly display all the permanent messages required.

Procedure:

1. Get *dmsNumPermanentMsg.0*, and verify the value returned is correct.
2. For each permanent message, construct a 12 byte MessageActivationCode with the following parameters:
    a. Duration 15
    b. Priority 255
    c. Memory Type 2
    d. Message Number 1 to value of dmsNumPermanentMsg.0 from step 1
    e. CRC value of dmsMessageCRC.2.MessageNumber
    f. IP Address "1.2.3.4"

3. Set the *dmsActivateMessage.0* object with the MessageActivationCode for each Permanent Message from Step 2, and verify that each Permanent Message is correctly displayed on the sign.

Notes:

DeviceTester script NDDOT Test 3

Test 4 Download and Display All Changeable Messages

Purpose:

The purpose of this test is to verify that the signs correctly download and display changeable messages in the required number of different changeable message slots.

Procedure:

1. Get *dmsMaxChangeableMsg.0*, and verify the value returned is correct.

2. Set *dmsMemoryMgmt.0* to **3** (clearChangeableMessages), to clear all the changeable messages.

3. Get *dmsMemoryMgmt.0*, and verify the value is 2 (normal)

4. Get *dmsNumChangeableMsg.0*, and verify that the value is 0.

5. Get *dmsFreeChangeableMemory.0*, and verify that value is sufficient to store the required number of changeable messages.

6. For each changeable message (Numbered N in the sequence below), up to the value of *dmsMaxChangeableMsg.0*, perform the following steps:
    a. Prepare a Changeable Message of the form "TEST[nl]MESSAGE[nl] & N (the message number)
    b. Download this message to Changeable Message N slot using the following steps
        i. Set *dmsMessageStatus.3.N* to **6** (modifyReq)

ii. Set *dmsMessageMultiString.3.N* to the message prepared in step a.
iii. Set *dmsMessageOwner.3.N* to **Customer**
iv. Set *dmsMessageBeacon.3.N* to **0**
v. Set *dmsMessagePixelService.3.N* to **0**
vi. Set *dmsMessageRunTimePriority.3.N* to **255**
vii. Set *dmsMessageStatus.3.N* to **7** (validateReq)

c. Construct a 12 byte MessageActivationCode with the following parameters:

i.	Duration	15
ii.	Priority	255
iii.	Memory Type	3
iv.	Message Number	N
v.	CRC	value of dmsMessageCRC.3.N
vi.	IP Address	"1.2.3.4"

d. Set the *dmsActivateMessage.0* object with the MessageActivationCode from Step c, and verify that the Changeable Message N is correctly displayed on the sign.

e. Get *dmsNumChangeableMsg.0*, and verify that it increments correctly by 1 each time a new changeable message is downloaded.

f. Get *dmsFreeChangeableMemory.0*, and verify that it decrements correctly each time a new changeable message is downloaded.

7. Set *dmsMemoryMgmt.0* to **3** (clearChangeableMessages), to clear all the changeable messages on completion of the test.

Notes:

DeviceTester script NDDOT Test 4

Test 5 MULTI Tags

Purpose:

The purpose of this test is to very that the sign will correctly display various messages that contain MULTI tags that are required to be supported.

Procedure:

1. Set the default message parameters for normal message display as follows:
   a. Set *defaultBackgroundColor.0* to **0** (black)
   b. Set *defaultForegroundColor.0* to **9** (amber)
   c. Set *defaultFlashOn.0* to **4**
   d. Set *defaultFlashOff.0* t0 **4**
   e. Set *defaultFont.0* to **1**
   f. Set *defaultJustificationLine.0* to **3** (center)
   g. Set *defaultJustificationPage.0* to **3** (middle)
   h. Set *defaultPageOnTime.0* to **20**
   i. Set *defaultPageOffTime.0* to **0**
   j. Set *defaultCharacterSet.0* to **2** (eightBit)

2. Use the procedure from Test 2 to download and display each of the following messages to Changeable Message 1, and verify that the message is correctly displayed.
    a. Message: **TEST[nl]MESSAGE[nl]PAGE ONE[np]PAGE TWO[nl]TEST[nl]MESSAGE**.
        i. Description: Two pages, 2 second duration per page, no flashing, center justified.
    b. Message: **TEST[nl]MESSAGE[nl]PAGE ONE[np]PAGE TWO[nl]TEST[nl]MESSAGE[np]PAGE[nl]THREE[nl]TEST**
        i. Description: Three pages, 2 second duration per page, no flashing, center justified.
    c. Message: **[pt20o10]TEST[nl]MESSAGE[nl]PAGE ONE[np]PAGE TWO[nl]TEST[nl]MESSAGE[np]PAGE[nl]THREE[nl]TEST**
        i. Description: Three pages, 2 second on time, one second off time per page, no flashing, center justified
    d. Message: **[jl2][pt20o10]TEST[nl]MESSAGE[nl]PAGE ONE[np]PAGE TWO[nl]TEST[nl]MESSAGE[np]PAGE [nl]THREE[nl]TEST**
        i. Description: Three pages, 2 second on time, one second off time per page, no flashing, left justified.
    e. Message: **[jl4][pt20o10]TEST[nl]MESSAGE[nl]PAGE ONE[np]PAGE TWO[nl]TEST[nl]MESSAGE[np]PAGE [nl]THREE[nl]TEST**
        i. Description: Three pages, 2 second on time, one second off time per page, no flashing, right justified.

Notes:

DeviceTester script NDDOT Test 2, modifying the MultiString (line 1.5) to reflect the required message above.

Test 6 Message Errors

Purpose:

The purpose of this test is to verify that incorrect messages will not be validated or displayed on the sign.

Procedure:

1. Use the procedure from Test 2 to download and display each of the following messages to Changeable Message 1, and verify that the message is NOT displayed, and the correct error value is reported by the *dmsMessageStatus.3.1*, *dmsValidateMessageError.0*, *dmsMultiSyntaxError.0*, and *dmsMultiSyntaxErrorPosition.0*

    a. Message: **TEST[nl]MESSAGE[nl]BIG MESSAGE**
    Third line too big to fit on the sign.
    b. Message: **TEST[nl]MESSAGE[nl]LINE 3[nl]LINE 4**
    Four line message too big to fit on the sign.
    c. Message: **TEST[nl]MESSAGE[nlLINE 3**
    unsupported tag (missing closing "]").

Notes:

DeviceTester script NDDOT Test 2, modifying the MultiString (line 1.5) to reflect the required message above.

Test 7 Activate Message

Purpose:

The purpose of this test is to verify that the messages are activated using the message priority and CRC attributes correctly.

Procedure:

1. Use the procedure from Test 2 to download and display each of the following messages to Changeable Message 1, and verify that the message is correctly displayed.
    a. Message: **HIGH[nl]PRIORITY[nl]MESSAGE**
    b. Runtime Priority: **100**
    c. Activate Priority: **255**
    d. Beacons **0**
    e. Pixel Service **0**

2. Use the procedure from Test 2 to download and display each of the following messages to Changeable Message 1, and verify that the message is correctly downloaded, but NOT displayed.
    a. Message: **LOW[nl]PRIORITY[nl]MESSAGE**
    b. Runtime Priority: **100**
    c. Activate Priority: **99**
    d. Beacons **0**
    e. Pixel Service **0**

3. Verify that *dmsActivateMsgError.0* reports a value of 3 (priority)

4. Set the *dmsActivateMessage.0* object to hex value

    00 0F 64 03 00 01 24 4F 01 02 03 04

5. Verify that the low priority message is now displayed.

6. Get the *dmsMessageCRC.3.1* object. Verify that the value is 24 4F hex (integer 9295), and the *dmsActivateMsgError.0* reports a value of 2 (noError)

7. Activate any permanent message, and verify that it is correctly displayed on the sign.

8. Set the *dmsActivateMessage.0* object to hex value

    00 0F 64 03 00 01 24 4E 01 02 03 04

9. Verify that the set returns a genErr, and the *dmsActivateMsgError.0* reports a value of 7 (messageCRC), and the Low Priority Message is NOT displayed.

Notes:

DeviceTester script NDDOT Test 7

Test 8 Default MULTI Message Attributes

Purpose:

The purpose of this test is to verify that the sign will respond correctly to the default page time and justification parameters.

Procedure:

1. Record the values of the following objects:
    a. defaultJustificationLine.0
    b. defaultJustificationPage.0
    c. defaultPageOnTime.0
    d. defaultPageOffTime.0

2. Set the following objects
    a. *defaultJustificationLine.0* to **3** (center)
    b. *defaultJustificationPage.0* to **3** (middle)
    c. *defaultPageOnTime.0* to **20** (2 seconds)
    d. *defaultPageOffTime.0* to **0** (0 seconds)

3. Use the procedure from Test 2 to download and display the following to Changeable Message 1
    a. Message: **TEST[np]MESSAGE**
    b. Runtime Priority: **100**
    c. Activate Priority: **255**
    d. Beacons **0**
    e. Pixel Service **0**

4. Verify that the message is displayed centered on the middle line, and that each page is on for 2 seconds with no flashing or blinking.

5. Set the following objects
    a. *defaultJustificationLine.0* to **2** (left)
    b. *defaultJustificationPage.0* to **2** (top)
    c. *defaultPageOnTime.0* to **10** (1 second)
    d. *defaultPageOffTime.0* to **10** (1 second)

6. Get the *dmsActivateMessage.0* object. Set the value received back to the *dmsActivateMessage.0* object to re-activate the message.

7. Verify that the message is displayed on the top line of the sign, left justified. Verify that each page of the message is on for one second, and off for one second.

8. Set the following objects
    a. *defaultJustificationLine.0* to **4** (right)
    b. *defaultJustificationPage.0* to **4** (bottom)
    c. *defaultPageOnTime.0* to **15** (1.5 seconds)
    d. *defaultPageOffTime.0* to **5** (0.5 seconds)

9. Get the *dmsActivateMessage.0* object. Set the value received back to the *dmsActivateMessage.*0 object to re-activate the message.

10. Verify that the message is displayed on the bottom line of the sign, right justified. Verify that each page of the message is on for one and a half seconds, and off for one half second.

Notes:

DeviceTester script NDDOT Test 8

Test 9 Default Messages

Purpose:

The purpose of this test is to verify that the sign will correctly perform the following operations:

1. Display a message for a given duration, and then, after that duration has expired, display the configured End Duration message.
2. Display the configured Short Power Loss message after a brief power failure.
3. Display the configured Long Power Loss message after a long power failure.
4. Display the Comm Loss Message after the Central System has been silent for longer than the Comm Loss Timer.

Procedure:

1. Using the download procedure from Test 2, configure changeable messages as follows:
   Changeable Message 2: **END[nl]DURATION[nl]MESSAGE**
   Changeable Message 3: **SHORT[nl]POWER[nl]LOSS**
   Changeable Message 4: **LONG[nl]POWER[nl]LOSS**
   Changeable Message 5: **COMM[nl]LOSS[nl]MESSAGE**

   Beacon **0** (Changeable Message 2 - 5)
   Pixel Service **0** (Changeable Message 2 - 5)

2. Set *dmsEndDurationMessage.0* to the hex value **03 00 02 60 AD**

3. Using Test 2, download and display the message "**TEST[nl]MESSAGE**" using a duration of 3 (minutes). Verify that the message is correctly displayed.

4. Get the *dmsMessageTimeRemaining.0* object, and verify that the value is 3. Verify that the value decrements as each minute elapses.

5. After 3 minutes (and not more that 4 minutes) verify that the message "END DURATION MESSAGE" is displayed.

6. Get the *dmsMsgSourceMode.0* object, and verify that the value 14 (endDuration) is returned.

7. Set the *dmsShortPowerLossTime.0* object to **30** (seconds).

8. Set the *dmsShortPowerRecoveryMessage.0* to **03 00 03 AF 37**

9. Set the *dmsLongPowerRecoveryMessage.0* to **03 00 04 F6 DE**

10. Using Test 2, download and display the message "**TEST[nl]MESSAGE**" using a duration of 10 (minutes). Verify that the message is correctly displayed.

11. Remove power to the sign for 5 to 10 seconds, and then reapply power.

12. Verify that after power up the message "SHORT POWER LOSS" is displayed.

13. Using Test 2, download and display the message "**TEST[nl]MESSAGE**" using a duration of 10 (minutes). Verify that the message is correctly displayed.

14. Remove power from the sign for 1 to 2 minutes, and then reapply power.

15. Verify that after power up the message "LONG POWER LOSS" is displayed.

16. Set the *dmsCommunicationsLossMessage.0* object to **03 00 05 12 50**

17. Set the *dmsTimeCommLoss.0* to **2** (minutes).

18. Using Test 2, download and display the message "**TEST[nl]MESSAGE**" using a duration of 10 (minutes). Verify that the message is correctly displayed

19. Do not communicate with the sign for 3 minutes. Verify that after 2 minutes and before 3 minutes the message "COMM LOSS MESSAGE" is displayed.

20. Reset objects to a benign state as follows:
    a. *dmsTimeCommLoss.0* to **0**
    b. *dmsShortPowerLossTime.0* to **0**
    c. *dmsMemoryMgmt.0* to **3** (to clear the changeable messages)

Notes:

DeviceTester script NDDOT Test 9

Test 10 Time

Purpose:

The purpose of this test is to verify that the sign will keep the time, and has support for daylight saving time.

Procedure:

1. Get the *globalTime.0* object, and record the value.
2. Wait for twenty seconds.
3. Get the *globalTime.0* object, and verify the value returned is twenty more than the value recorded in step 1.
4. Get the *globalDaylightSaving.0* object.
5. Set the *globalDaylightSaving.0* object value to **2** (disableDST)
6. Get the *globalLocalTimeDifferential.0* object.
7. Set the *globalLocalTimeDifferential.0* object value to **-21600** (for central time zone).
8. Set the *globalTime.0* object to **1065453611**. (this will set the clock in the sign to a time in US daylight time)
9. Set the *globalDaylightSaving.0* object value to **3** (enableUSDST)
10. Get the *globalLocalTimeDifferential.0* object. Verify that the value returned is -18000 to reflect the presence of US daylight savings time.

Notes:

The calculation of time will be checked in Test 11.

DeviceTester script NDDOT Test 10

Test 11 Scheduling

Purpose:

The purpose of this test is to verify that the sign will display messages on a time based schedule, and this schedule will be correctly executed during winter (standard time) and summer (daylight saving time).

Procedure:

1. Get the following objects, and record the values.
    a. *globalTime.0*
    b. *globalDaylightSaving.0*

c. *globalLocalTimeDifferential.0*
d. *maxTimeBaseScheduleEntries.0*
e. *maxDayPlans.0*
f. *maxDayPlanEvents.0*
g. *numActionTableEntries.0*

2. Set up Schedule 1 and Day Plan 1
   a. Set *timeBaseScheduleMonth.1* to **8190** (every month)
   b. Set *timeBaseScheduleDay.1* to **254** (every day)
   c. Set *timeBaseScheduleDate.1* to **214748346** (every date)
   d. Set *timeBaseScheduleDayPlan.1* to **1**
   e. Set *dayPlanHour.1.1* to **17** (5 PM)
   f. Set *dayPlanMinute.1.1* to **30** (5:30 PM)
   g. Set *dayPlanActionNumberOID.1.1* to **1.3.6.1.4.1.1206.4.2.3.8.2.1.1.3** (dmsActionMsgIndex.3)
   h. Set *dayPlanHour.1.2* to **19** (7 PM)
   i. *Set dayPlanMinute.1.2* to **45** (7:45 PM)
   j. Set *dayPlanActionNumberOID.1.2* to **1.3.6.1.4.1.1206.4.2.3.8.2.1.1.1** (dmsActionMsgIndex.1)
   k. Set *dayPlanHour.1.3* to **6** (6 AM)
   l. Set *dayPlanMinute.1.3* to **23** (6:23 AM)
   m. Set *dayPlanActionNumberOID.1.3* to **1.3.6.1.4.1.1206.4.2.3.8.2.1.1.2** (dmsActionMsgIndex.2)

3. Using the download procedure from Test 2, configure changeable messages as follows:
   a. Changeable 1: **CHANGE[nl]MSG 1**
   b. Changeable 3: **TEST[nl]MSG 1**
   c. Changeable 4: **TEST[nl]MSG 2**
   d. Beacon **0** (Changeable Message 1,3,4)
   e. Pixel Service **0** (Changeable Message 1,3,4)
   f. Runtime Priority **100** (Changeable Message 1,3,4)

4. Set Action Message Codes as follows:
   a. Set *dmsActionMsgCode.1* to hex **03 00 03 21 C3**
   b. Set *dmsActionMsgCode.2* to hex **03 00 01 20 90**
   c. Set *dmsActionMsgCode.3* to hex **03 00 04 45 2C**

5. Blank the sign, by setting the *dmsActivateMessage.0* object to hex value **FF FF FF 07 00 01 00 00 01 02 03 04**

6. Activate the schedule by setting the *dmsActivateMessage.0* object to hex value **FF FF FF 06 00 01 00 00 01 02 03 04**

7. Enable daylight savings time, by setting the *globalDaylightSaving.0* object value to **3** (enableUSDST)

8. Modify the time in the sign.
   a. Set *globalTime.0* to **1031765310**
   b. Set *globalLocalTimeDifferential.0* to **0**

9. Wait for up to three minutes for the schedule to activate, and verify that “TEST MSG 2” is displayed.

10. Modify the time in the sign.
    a. Set *globalTime.0* to **1031773410**
    b. Set *globalLocalTimeDifferential.0* to **0**

11. Wait for up to three minutes for the schedule to activate, and verify that “TEST MSG 1” is displayed.

12. Modify the time in the sign.
    a. Set *globalTime.0* to **1031725290**
    b. Set *globalLocalTimeDifferential.0* to **0**

13. Wait for up to three minutes for the schedule to activate, and verify that “CHANGE MSG 1” is displayed.

14. Modify the time in the sign.
    a. Set *globalTime.0* to **1031761710**
    b. Set *globalLocalTimeDifferential.0* to **3600**

15. Wait for up to three minutes for the schedule to activate, and verify that “TEST MSG 2” is displayed.

16. Modify the time in the sign.
    a. Set *globalTime.0* to **1031769810**
    b. Set *globalLocalTimeDifferential.0* to **3600**

17. Wait for up to three minutes for the schedule to activate, and verify that “TEST MSG 1” is displayed.

18. Modify the time in the sign.
    a. Set *globalTime.0* to **1031721690**
    b. Set *globalLocalTimeDifferential.0* to **3600**

19. Wait for up to three minutes for the schedule to activate, and verify that “CHANGE MSG 1” is displayed

Notes:

DeviceTester script NDDOT Test 11

Test 12 Brightness Control

Purpose:

The purpose of this test is to verify that the sign correctly dims the sign at night, and that the sign brightness can be manually controlled.

Procedure:

1. Get the following objects, and record the values:
    a. dmsIllumControl.0
    b. dmsIllumMaxPhotocellLevel.0
    c. dmsIllumPhotocellLevelStatus.0
    d. dmsIllumNumBrightLevels.0
    e. dmsIllumBrightLevelStatus.0
    f. dmsIllumManLevel.0
    g. dmsIllumBrightnessValues.0
    h. dmsIllumBrightnessValuesError.0
    i. dmsIllumLightOutputStatus.0

2. Set the *dmsIllumControl.0* object to **2** (photocell).

3. Change the light value entering the photocell, by covering it if the ambient light is bright, or by shining a light on it if the ambient light is low. Verify that the following objects change to reflect the new value of light entering the photocell:
    a. *dmsIllumPhotocellLevelStatus.0*
    b. *dmsIllumBrightLevelStatus.0*
    c. *dmsIllumLightOutputStatus.0*

4. Verify that the actual brightness of the sign has changed in accordance with the new parameters.

5. Set the *dmsIllumControl.0* object to **4** (manual).

6. Set the *dmsIllumManLevel.0* to 1. Verify that this sign is dim.

7. Get *dmsIllumBrightLevelStatus.0* and *dmsIllumLightOutputStatus.0*

8. Set the *dmsIllumManLevel.0* to the value returned by the *dmsIllumNumBrightLevels.0* object. Verify that the sign is bright.
9. Get *dmsIllumBrightLevelStatus.0* and *dmsIllumLightOutputStatus.0*

10. Restore the *dmsIllumControl.0* and *dmsIllumManLevel.0* objects to the original values

Notes:

DeviceTester script NDDOT Test 12

Test 13 Sign Status

Purpose:

The purpose of this test is to verify that the sign correctly reports the battery voltage of the sign, and other power parameters

Procedure:

1. Get the *signVolts.0, lineVolts.0* and *powerSource.0* objects.

2. Verify that the value returned correctly reflects the battery voltage and the power status of the sign.

Notes:

Battery voltage is in 1/100 of a volt.

DeviceTester script NDDOT Test 13

Notes:
The following optional NTCIP conformance groups and associated functionality were not tested for ND DOT

Security

Reporting

Downloadable fonts

Aux I/O

Multi Fields

Pixel Test and Pixel Errors

Fans

Power Supplies

Appendix B – DMS Specifications

SOUTH DAKOTA DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION FOR
PORTABLE DYNAMIC MESSAGE SIGNS

November 21, 2003

I. DESCRIPTION

This work shall consist of furnishing and installing LED portable dynamic message signs (PDMS), associated control, operation, 120/240VAC power, telephone and monitoring equipment in accordance with these Specifications and as directed by the Engineer.

II. MATERIALS

PVMS provided for this contract shall comply with the most recent revision of the following standards, even if no revision date is given:

A. Aluminum Welding – The PDMS housing shall be fabricated, welded, and inspected in accordance with *ANSI/AWS D1.2-97 Structural Welding Code-Aluminum (1997)/CSA W59.2 welded aluminum construction (1998*

B. Electrical Components – High-voltage components and circuits (120 VAC and greater) shall be wired and color-coded per the National Electric Code.

C. Environmental Resistance – The PVMS housing shall comply with type 3R enclosure criteria, as described in *NEMA Standards Publication 250-1997, Enclosures for Electrical Equipment (1000 Volts Maximum)*.

D. Maintenance Access – The LED display matrix and other internal PDMS components shall be accessible through doorways by opening the face of display and by a pneumatic system.

E. Structural Integrity – The PDMS housing shall be designed and constructed to withstand a minimum sustained wind load of 60 mph with a 30% wind gust factor. The PVMS housing shall support a front face ice load of 4 pounds per square foot. The PVMS housing shall be designed and constructed to comply with all applicable sections of *AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, Third Draft, March 1999*, as well as the fatigue resistance requirements of *NCHRP Report 412, Fatigue-Resistant Design of Cantilevered Signal, Sign, and Light Supports*.

F. Couplers/safety chains – The PMVS shall be designed in accordance with SAE J847/J684.

III. VARIABLE MESSAGE SIGN

A. Displays - The PDMS shall contain a full display matrix measuring a minimum of 72 pixel colums wide by 27 pixel rows high. The matrix shall display messages that are continuous, uniform, and unbroken in appearance to motorists and travelers. PDMS messages shall be legible within a minimum distance range of 150 feet to 1,000 feet from the PDMS display face. The PDMS shall contain 9-pixel high, minimum, by 6-pixel wide, minimum, LED display modules, which are placed side-by-side to form a continuous full LED pixel matrix. Modules shall be mounted to the inside of the PVMS display housing, using hardware that requires either basic hand tools or no tools for removal and replacement. Each 9x6 display module shall be constructed as follows:

- One or more LED pixel circuit board(s) shall be mounted to the back of an aluminum panel to form the 9-pixel high by 6-pixel wide module. Pixel boards shall be mounted to the aluminum panel with durable, non-corrosive hardware, and their removal from the panel shall not require the use of tools
- The aluminum module panel shall have a minimum thickness of 0.063 inches and shall contain a circular or rectangular opening for each LED pixel. The openings shall be sized so they do not block any portion of the LED viewing cone

- The front side of the aluminum module panel, which faces the viewing motorists, shall be primed and coated with automotive-grade flat black acrylic enamel paint

- LED display module electrical and signal connections shall be the quick-disconnect locking connector type. Removal of a display module from the PDMS, or a pixel board or driver circuit board from its display module, shall not require a soldering operation.

- It shall not be possible to mount a display module upside-down or in an otherwise incorrect position within the PVMS display matrix

- All LED display modules, as well as the LED pixel boards and driver circuit boards, shall be identical and interchangeable throughout the PVMS.

B. LED's - All LED's provided for the manufacture of VMS shall conform to the following minimum requirements:

- LEDs shall be obtained from a two-bin luminous intensity sort. A bin is defined such that, when all LEDs from a given bin are driven with an identical forward current, the dimmest LED in the bin emits no less than half the luminous intensity of the brightest LED in the bin. Intensity sorting shall be performed by the LED manufacturer.

- LEDs shall have a minimum 30º vertical and 30º horizontal viewing angles

- LED's shall emit a true amber color at a wavelength of 590 nm.

- Size of the LED shall be T-1¾ (0.2 inches).

- LED's shall be nominally rated for 100,000 hours of operation under field conditions which shall include operating temperatures between -22° and +185°F.

- LED's shall have 30° viewing angle.

- LED's shall have no less than 50% of the normalized intensity at the 30° viewing angle.

- LED's shall be soldered to circuit boards with through-hole type of circuit board mounting. Surface mounting of LED's will not be allowed.

- All exposed metal on both sides of the LED driver circuit board, except power and signal connectors, shall be protected from water and humidity exposure by a thorough application of acrylic conformal coating. Bench level repair of individual pixels, including discrete LED replacement and conformal coating repair, shall be possible

- All LEDs used in all PVMS provided for this contract shall be from the same manufacturer and of the same part number.

C. Pixel's - Each display module shall contain one or more printed circuit boards, which multiple LED pixels are soldered. Each pixel board shall contain a minimum of six (6) and a maximum of fifty-four (54) LED pixels. Each pixel shall contain a circular or square grouping of four (4) or more discrete LEDs.

One (1) electronic driver circuit board shall be provided for each LED display module and shall individually control a maximum of fifty-four (54) pixels on that module.
LED pixel's and pixel boards shall conform to the following requirements:

- Pixel's shall be constructed with two strings of LED's. Each LED string shall be in series.
- LED pixels shall produce the luminous intensity levels required herein at a drive current of 20 mA per string with a forward voltage drop not to exceed 24 VDC. The LED drive current shall be adjustable up to and shall not be allowed to exceed 30 mA per string.
- Each pixel shall produce a luminous intensity of 6 Cd when driven with a LED drive current of 20 mA per string.
- The failure of an LED string shall not cause the failure of any other LED string or pixel in the PVMS, and failure of a pixel shall not cause the failure of any other pixel in the PVMS.
- Each pixel string shall contain an identical quantity of LEDs
- Materials used in the fabrication of LED clusters shall contain UV light inhibitor and shall be designed for direct exposure to sunlight.
- All exposed metal on both sides of the LED pixel board, except power and signal connectors, shall be protected from water and humidity exposure by a thorough application of acrylic conformal coating. Bench level repair of individual pixels, including discrete LED replacement and conformal coating repair, shall be possible.
- Each LED pixel shall be rated for outdoor use over the environmental range expected for the sign locations (including heat absorption due to sunlight).
- LED pixel's shall be attached to the display panel with a secure fastening system.
- LED pixel's shall be mounted perpendicular to the display panel.
- LEDs shall be soldered so that the base of their lenses are flush with and perpendicular to their printed circuit board
- Printed circuit board laminate shall be FR-4 fiberglass and shall have a minimum thickness of 0.062 inches. The printed circuit board shall be plated on both sides with a copper trace thickness of one ounce per square foot of plated area. Printed circuit board through-holes shall be plated with one ounce of copper per square foot of plated area.
- It shall not be possible to mount a display module upside-down or in an otherwise incorrect position within the PVMS display matrix.
- LED display module electrical and signal connections shall be the quick-disconnect locking connector type. Removal of a display module from the PVMS, or a pixel

board or driver circuit board from its display module, shall not require a soldering operation.

- Characters formed by the PDMS displays shall have a minimum of nine (9) pixels in height. The number of pixels making up the character width shall vary by character and shall be in accordance with the characters described herein.

- The pixel pitch, or center to center spacing, shall be such that nine (9) pixels, minimum, in height shall produce a character 18" in height (±0.5%) measured from the top of the top pixel to the bottom of the bottom pixel.

D. Power Supplies - The PDMS shall run on solar-powered battery and shall be have the capability to be connected to standard line voltage for recharging purposes.

Solar-powered batteries system shall conform to the following:

- Solar panels shall provide a minimum of 330 Watt.
- A photovoltaic controller must be provided to monitor batteries and maintain the maximum power level in it without over charging the batteries. This must be done so batteries expected life will not be affected. The photovoltaic controller shall monitor the batteries and provide an automatic shut off display is operating below 11.5VDC. This prevents the batteries from being over drained and preserves their life.
- Solar panels shall be inclinable to reach a minimum of 45º backward and 28º frontward
- Batteries shall be placed in an easy access for maintenance
- Batteries shall be deep-cycle type
- Batteries shall be locked in a cabinet. This cabinet shall have enough ventilation to evacuate the gas generated by the batteries
- PMVS must have 10 batteries (for environmental cause and cost saving)

Line powered system shall conform to the following:

- Operating input voltage range: +90 to +140 VAC
- Operating input frequency range: 50 to 60Hz
- Operating temperature range: -40º to +140° F
- Easy access and environment protected outlet
- UL listed

E. PVMS Housings Structural Certification - A professional engineer registered in North America shall analyze the PVMS structural design and shall certify that the PVMS:

- Will withstand a wind velocity of 80 mph with a 30% gust factor
- Will support a front face ice load of 4 pounds per square foot
- Complies with the applicable requirements of *AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, Third Draft, March 1999*
- Complies with the fatigue resistance requirements of *NCHRP Report 412, Fatigue-Resistant Design of Cantilevered Signal, Sign, and Light Supports*.

The PVMS manufacturer shall include a signed and sealed copy of the P.E. certification from a licensed P.E. registered in the state North Dakota, including all supporting calculations, with the pre-build technical submittal.

Serviceability
The PDMS housing shall provide safe and convenient access for all modular assemblies, components, wiring, and other materials located within the PVMS housing. All internal components shall be removable and replaceable by a single technician.

Locking provisions shall be provided with each enclosure on the trailer.

F. Interior PDMS Environment Control

Housing Exhaust System – Each air intake and exhaust port shall be covered on its top, front, and sides by an aluminum hood that is riveted to the rear PVMS wall. Exhaust air shall pass through an opening on the bottom of each hood, and openings shall be screened to prevent the entrance of insects and small animals. Hoods shall be fabricated from 0.090-inch or thicker aluminium sheeting. All hood-to-housing contact edges shall be thoroughly sealed to prevent water from entering the PDMS.

Ambient Light Measurement System
Sensors that measure outdoor ambient light levels at the PDMS site shall be mounted in-line with the PDMS housing walls. This system shall consist of two (2) commercially available photoelectric sensor.

One of the photo sensors shall be placed to measure the ambient light levels striking the PDMS housing walls. The second photo sensor shall be mounted to the PVMS housing bottom and shall face the ground. A change in the amount of light striking a photo sensor shall cause its output to vary. The DVMS field controller shall continuously monitor sensor outputs and use the information to automatically adjust LED display matrix intensity to a level that creates a legible PDMS message.

Internal Temperature Measurement System
Each display module provides its own temperature reading directly off the PCB itself. Sensors shall be able to measure a temperature range of –40° to +125° F, and sensor output shall be reportable to the PDMS field controller.

Internal Wiring
Wiring for LED display module control, environmental control circuits, and other internal PDMS components shall be installed in the PVMS housing in a neat and professional manner. Wiring shall not impede the removal of display modules, power supplies, environmental control equipment, or other sign components. Wires shall not make contact with or around sharp metals edges. LED display module power and signal wiring shall be cut to a length and installed such that it is not possible to connect a module to the wrong set of wires. All wiring shall conform to the National Electric Code.

G. Trailer construction

The trailer shall conform the following:

- The trailer is made from tubular steel frame or equal
- 3,500 pound axle with torsion suspension and standard tires
- Four heavy duty screw type adjustable leveling jacks located at each corner
- Electric/Hydraulic brakes or equal
- The sign shall be lockable in any position across a 360º range
- Transportation height must not exceed 10 feet
- Easy removable tow bar/tongue so the trailer can be left on site without tow bar/tongue.
- 6000 pound hitch
- Adjustable hitch with interchangeable 2” ball coupler to 3”
- 2,000 pound screw type adjustable swing up tongue jack
- USDOST lighting – Stop, turn, and tail lights
- Seven pole SAE, ATA, and CSA round trailer connector Standard Motor Products, Inc. model TCP77M with spring cable guard
- The trailer shall be supplied with 15 inch radial tires

Display Raise/Rotating system
The PDMS shall have the ability to be elevated and lowered via a hydraulic system. The PDMS shall have the ability to be manually aligned, but the manufacturer shall provide an

optional motorized display alignment.

The hydraulic system shall be conform to the following:

- Switch button hydraulic system so the display can be raised over a range of 13 feet
- The hydraulic system shall be fuse protected
- The pump shall be easy to access for maintenance purposes

The display alignment system shall be conform to the following:

- Manual alignment across a 360º range
- Self locking system, so no strap or human intervention is needed to fix the display in place
- Switch button motorized alignment across a 360º range with all the previous features

Trailer And Display Paint
PVMS front face panels and border pieces shall be coated with semi-gloss black Kynar 500 resin or an equivalent brand of oven-fired fluoropolymer coating, which has an expected outdoor service life of 20 years.

Both the trailer and display shall be painted of the same color.

The paint shall be conform to the following:

- The color shall be manufacturers standard orange
- The thickness of paint shall not be less then 0.006".

H. Field Controller Hardware

General Specifications
A field controller shall be provided with each PVMS. The controller shall:

- Be a stand-alone microprocessor-based computer that runs on an embedded operating system
- Mount in a cabinet fixed to the trailer with an easy access
- Operate throughout a temperature range of -40º to +140° F and a humidity range of 0 to 99% non-condensing, without the assistance of an auxiliary heater
- Require an RS232 communications signal having a baud rate between 2,400 bps and 115,200 bps
- Comply with NTCIP standards specified herein
- Comply with the NTCIP Class B (PMPP) communications profile as specified
- Support all of the control, monitoring, and diagnostic features described in the PVMS specification and the PVMS control software specification
- Be individually addressable, so that it does not respond to commands intended for other field controllers
- Perform most PVMS control and monitoring functions specified herein, without continuous communications with the system central computer.

Field controller hardware and software shall permit communication with the PVMS system central computer in the following mode:

- **Polled Operation** – in which the field controller informs the central computer of its current status, in response to a periodic automatic query from the central computer.

Memory
The field controller shall have both permanent and changeable memory. Permanent memory shall be in the form of flash-PROM integrated circuits that contain the executable field

controller software. If new versions of executable code become available, it shall be possible to upgrade the field controller with the latest version.

Data Transmission Requirements
Each field controller shall contain a minimum of two EIA/TIA-232E communication ports:

- One shall be for direct (PMPP) connection (e.g., fiber optic) with the system control computer
- One shall be for local, direct communication with a laptop computer.

Both ports shall be capable of operation at baud rates of 2,400, 9,600, 14,400, 19,200, 28,800, 56,600, and 115,200 bits per second. The exact baud rate used shall be configurable by the user.

Internal Clock
The PVMS field controller shall contain a computer-readable time-of-year clock that has a lithium battery backup. The battery shall keep the clock operating properly for at least 10 years without external power, and the clock shall automatically adjust for daylight savings time and leap year using hardware or software, or a combination of both.

I. Field Controller Software

Message Presentation on the PVMS Display Matrix
The PVMS field controller shall instruct the LED display driver circuitry in a manner that causes the desired message to appear on the PVMS display matrix. At a minimum, the field controller shall support the following features, as described in the PVMS specification:

- Display of alphanumeric character fonts and graphic pictures
- Message format details, such as centering text on a display line, right justification, left justification, and legible spacing of letters and words
- Selection of a particular character font style
- Display of static messages
- Flashing of all or part of a message
- Message scrolling
- Alternating between pages of a multiple-page message.

Message and Schedule Functions
The PVMS field controller shall support the following message selection functions, which may be initiated by a PVMS control software operator:

- Cause the field controller to implement a message or message schedule stored in its memory
- Cause the field controller to implement a new message or schedule entered via the control software
- Edit or completely replace a message or message schedule stored in the field controller memory
- Cause the field controller to report the contents of any message or message schedule stored in its memory
- Override a scheduled message

The field controller shall be able to implement a message stored in its memory at a particular time and date, as supported by a message schedule feature.

Field controller software shall incorporate a fail-safe procedure to check the content of messages received and shall not change a message stored in memory, the message

displayed on the sign, the schedule stored in memory, or the current controller clock time, unless the new message is correctly received.

A displayed message shall remain on the sign until the controller receives a command to change the message or blank the sign, or a schedule stored in the field controller memory indicates that it is time to implement a different message. It shall possible to confer a "priority" status onto any message, and a command to display a priority message shall cause any non-priority message to be overwritten.

PVMS Intensity Control
The PVMS field controller shall be able to automatically adjust the LED display matrix intensity. A system operator shall be able to override the automatic system in order to manually change the LED intensity.

The intensity control system shall employ photoelectric sensors as described in the PVMS specification. When the system is running in the automatic mode, the field controller shall continuously analyze ambient light levels and shall automatically adjust LED display intensity in order to provide optimum message legibility for the given ambient light condition. Intensity control shall be achieved using pulse width modulation of the LED forward drive current, as described in the PVMS specification.

The PVMS intensity control system shall:

- Utilize one (1) photoelectric sensors, which are provided and installed as described in the PVMS specification
- LED intensity levels shall be available in a range of 1% to 100% of the maximum display intensity, and in increments of 1%
- Not cause any flickering of the LED display matrix
- Allow manual and automatic intensity control modes to be configurable using the PVMS control software or the keypad LCD interface, although the typical control mode shall be "automatic"
- Allow manual intensity control from both local and remote locations.

PVMS Message Verification
The PVMS field controller and LED module hardware shall be capable of enabling the PVMS Central Control operator to verify the actual message displayed on the PVMS on a real-time basis. This message verification shall be displayed on the PVMS in a WYSIWYG format. This shall be accomplished each time the PVMS is polled for status by the central control software. A graphical user interface (GUI) capable of displaying this type of information must be present in the central PVMS control software.

Response to Errors
In the event of a communication error between the PVMS field controller and the system control computer, the "communications loss message" will be displayed. This shall be factory set to blank the PVMS.

In the event of a power failure, the "power recovery message" will be displayed. This shall be factory set to blank the PVMS.

The PVMS field controller shall contain a hardware watchdog that automatically resets the controller’s microprocessor in the event of a controller lock-up.

SPECIAL PROVISION FOR NTCIP

IV. NTCIP Requirements

This portion of the specification defines the detailed NTCIP requirements for the Dynamic Message Signs covered by the procurement package. The variable message signs required for this project shall comply with the following NTCIP communication protocol specifications.

Definitions

The following terms shall apply within the scope of this procurement specification:

DMS - A Dynamic Message Sign, includes the sign display, controller, cabinet, and other associated field equipment. The specific type of dynamic message sign (i.e., blank-out sign, changeable message sign, character matrix sign, full-matrix sign, etc.) for this procurement is specified elsewhere within this procurement specification.

FSORS - Full, Standardized Object Range Support

Full, Standardized Object Range Support – Support for, and proper implementation of, all valid values of an object as defined within the object's OBJECT-TYPE macro in the subject NTCIP standard; this is further defined in two distinct sub-requirements. (1) If the ACCESS of the object is read-write, a Management System shall be able to set the object to any valid value as defined by the SYNTAX and DESCRIPTION fields (except that the value of 'other' need not be supported when such a value is defined) and the indicated functionality shall be provided. (2) The value indicated by the object (e.g., in response to a 'get'), regardless of the ACCESS, shall reflect the current condition per the rules specified in the object's DESCRIPTION.

Management System – A computer system used to control an NTCIP component. This includes any laptop software used for field control as well as the central control software.

NTCIP Component – A DMS or a Management System.

NTCIP System – A Management System plus the various ASCs and DMSs controlled by the Management System.

Response Time – The time to prepare and begin transmission of a complete response containing the requested Application Layer information. This is measured as the time from receipt of the closing flag of the request to the transmission of the opening flag of the response when the device has immediate access to transmit.

A. References

This specification references several standards through their NTCIP designated names. The following list provides the full reference to the current version of each of these standards. In many cases, the standard is more widely known by its original NEMA assigned number; in these cases, the NEMA number is also identified. The content of the NEMA standard is identical to that of the NTCIP standard.

Each NTCIP Component covered by these project specifications shall implement the most recent version of the standard that is at the stage of Recommended or higher as of October 1, 2003, including any and all Approved or Recommended Amendments to these standards as of the same date. It is the ultimate responsibility of the VENDOR to monitor NTCIP activities to discover any more recent documents.

Table 1: NTCIP Standards

Abbreviated Number	Full Number	Title	Known Amendments
NTCIP 1201	**NTCIP 1201:1997** (NEMA TS 3.4-1996)	*Global Object Definitions*	Amendment #1 dated November 2, 1998.
NTCIP1203	**NTCIP 1203:1997** (NEMA TS 3.6-1997)	*Object Definitions for Dynamic Message Signs*	The sign shall also comply to the NTCIP DMS WG Resolutions adopted at the May 2000 meeting.
NTCIP 2101	**NTCIP 2101v01.17 (Recommended)** (NEMA TS 3.SP PMPP232)	*Point-to-Multi-Point Protocol using RS 232 Subnetwork Profile*	
NTCIP 2201	**NTCIP 2201v01.03 (Working Draft)** (NEMA TS 3.3-1996 Clauses 3.4 and 3.5)	*Transportation Transport Profile* *Class B Profile* Clauses 3.4 and 3.5	Amendment #1 dated November 2, 1998
NTCIP 2301	**NTCIP 2301v01.07 (Recommended)** (NEMA TS 3.AP-STMF)	*Simple Transportation Management Framework (STMF) Application Profile*	

B. General Requirements

Subnet Level
Each NTCIP Component shall support NTCIP 2101 with data rates of 28.8 kbps, 19.2 kbps, 14.4 kbps, 9600 bps, 4800 bps, 2400 bps, 1200 bps, 600 bps, and 300 bps.
NTCIP Components may support additional Subnet Profiles at the manufacturer's option. At any one time, only one Subnet Profile shall be active on a given serial port of the NTCIP Component. If the NTCIP Component has a serial port that supports multiple Subnet Profiles, the NTCIP Component shall be configurable to allow the field technician to activate the desired Subnet Profile and shall provide a visual indication of the currently selected Subnet Profile.

Transport Level
Each NTCIP Component shall comply with NTCIP 2201.

NTCIP Components may support additional Transport Profiles at the manufacturer's option. Response datagrams shall use the same Transport Profile used in the request. Each NTCIP Component shall support the receipt of datagrams conforming to any of the identified Transport Profiles at any time.

Application Level
Each DMS shall comply with NTCIP 2301 as a Managed Agent and shall meet the requirements for Conformance Level 1 (NOTE - See Amendment to standard).

An NTCIP Component may support additional Application Profiles at the manufacturer's option. Responses shall use the same Application Profile used by the request. Each NTCIP Component shall support the receipt of Application data packets at any time allowed by the subject standardsInformation Level.

Information Level
Each NTCIP Component shall provide Full, Standardized Object Range Support of all objects required by these procurement specifications, unless otherwise indicated below or approved

by the Project Engineer. The maximum Response Time for any object or group of objects shall be 200 milliseconds.

The DMS shall support all mandatory objects of all mandatory Conformance Groups as defined in NTCIP 1201 and NTCIP 1203. Table 2 indicates the modified object requirements for these mandatory objects.

Table 2: Modified Object Ranges for Mandatory Objects

Object	Reference	Project Requirement
moduleTableEntry	NTCIP 1201 Clause 2.2.3	Shall contain at least one row with moduleType equal to 3 (software). The moduleMake shall specify the name of the manufacturer, the moduleModel shall specify the manufacturer's name of the component and the modelVersion shall indicate the model version number of the component.
communityNamesMax	NTCIP 1201 Clause 2.8.2	Shall be at least 3
dmsNumPermanentMsg	NTCIP 1203 Clause 2.6.1.1.1.1	Shall be at least 1*
dmsMaxChangeableMsg	NTCIP 1203 Clause 2.6.1.1.1.3	Shall be at least 100
dmsFreeChangeableMemory	NTCIP 1203 Clause 2.6.1.1.1.4	Shall be at least 25KB when no messages are stored.**
dmsMaxVolatileMsg	NTCIP 1203 Clause 2.6.1.1.1.6	Shall be at least 100**
dmsFreeVolatileMemory	NTCIP 1203 Clause 2.6.1.1.1.7	Shall be at least 100KB when no messages are stored.**
dmsMessageMultiString	NTCIP 1203 Clause 2.6.1.1.1.8.3	The DMS shall support any valid MULTI string containing any subset of those MULTI tags listed in Table 4
dmsControlMode	NTCIP 1203 Clause 2.7.1.1.1.1	The DMS shall support the following control modes: local central centralOverride

* The Permanent Messages shall display the content shown in Table 3.

Table 3: Content of Permanent Messages

Perm. Msg. Num.	Description
1	Permanent message #1 shall blank the display. It shall have priority of one (1).

Table 4: Required MULTI Tags

Code	Feature
f1	field 1 - time (12hr)
f2	field 2 - time (24hr)

f4	field 4 - temperature (F)
f8	field 8 - day of month
f9	field 9 - month
f10	field 10 - 2 digit year
f11	field 11 - 4 digit year
fl (and /fl)	flashing text; flash rates shall be controllable in 0.5 second increments and shall be accurate to within 50% of this value. The fl and /fl tags shall support flashing on a line-by-line basis
fo	font
jl2	justification - line - left
jl3	justification - line - center
jl4	justification - line - right
jp2	justification - page - top
jp3	justification - page - middle
jp4	justification - page - bottom
mv	moving text
nl	new line
np	new page; the sign shall support up to 2 instances in a message (i.e., up to 3 pages/frames in a message counting the first page)
pt	page time; these times shall be controllable in 0.5 second increments and shall be accurate to within 50% of this value

The NTCIP Component shall also implement all mandatory objects of the following optional conformance groups.

- Time Management, as defined in NTCIP 1201
- Timebase Event Schedule, as defined in NTCIP 1201. The following list indicates the modified object requirements for this conformance group.

Table 5: Modified Object Ranges for the Timebase Event Schedule Conformance Group

Object	Reference	Project Requirement
maxTimeBaseScheduleEntries	NTCIP 1201 Clause 2.4.3.1	Shall be at least 10
maxDayPlans	NTCIP 1201 Clause 2.4.4.1	Shall be at least 10
maxDayPlanEvents	NTCIP 1201 Clause 2.4.4.2	Shall be at least 10

- PMPP, as defined in NTCIP 1201. The following list indicates the modified object requirements for this conformance group.

Table 6: Modified Object Ranges for the PMPP Conformance Group

Object	Reference	Project Requirement
maxGroupAddresses	NTCIP 1201 Clause 2.7.1	(None Required)

- GUI Appearance, as defined in NTCIP 1203.

- Font Configuration, as defined in NTCIP 1203. The following list indicates the modified object requirements for this conformance group.

Table 7: Modified Object Ranges for the Font Configuration Conformance Group

Object	Reference	Project Requirement
numFonts	NTCIP 1203 Clause 2.4.1.1.1.1	Shall be at least 3
maxFontCharacters	NTCIP 1203 Clause 2.4.1.1.1.3	Shall be at least Each font shall support character numbers from 32 (0x20) to 90 (0x5A), inclusive. Upon delivery, each character shall be set to a bit pattern that resembles the associated ASCII character.

Table 8: Modified Object Ranges for the MULTI Configuration Conformance Group

Object	Reference	Project Requirement
defaultBackgroundColor	NTCIP 1203 Clause 2.5.1.1.1.1	The DMS shall support the following background colors: black
defaultForegroundColor	NTCIP 1203 Clause 2.5.1.1.1.2	The DMS shall support the following foreground colors: amber
defaultJustificationLine	NTCIP 1203 Clause 2.5.1.1.1.6	The DMS shall support the following forms of line justification: left center right
defaultJustificationPage	NTCIP 1203 Clause 2.5.1.1.1.7	The DMS shall support the following forms of page justification: top middle bottom
defaultPageOnTime	NTCIP 1203 Clause 2.5.1.1.1.8	The DMS shall support the full range of these objects with step sizes no larger than 0.5 seconds
defaultPageOffTime	NTCIP 1203 Clause 2.5.1.1.1.9	The DMS shall support the full range of these objects with step sizes no larger than 0.5 seconds
defaultCharacterSet	NTCIP 1203 Clause 2.5.1.1.1.10	TheDMS shall support the following character sets: eight bit

- Multi Error Configuration, as defined in NTCIP 1203
- Illumination/Brightness Control, as defined in NTCIP 1203. The following list indicates the modified object requirements for this conformance group.

Table 9: Modified Object Ranges for the Illumination/Brightness Control Conformance Group

Object	Reference	Project Requirement

dmsIllumControl	NTCIP 1203 Clause 2.8.1.1.1.1	The DMS shall support the following illumination control modes: photocell manual
dmsIllumNumBrightLevels	NTCIP 1203 Clause 2.8.1.1.1.4	Shall be at least 255

- Scheduling, as defined in NTCIP 1203. The following list indicates the modified object requirements for this conformance group.

Table 10: Modified Object Ranges for the Scheduling Conformance Group

Object	Reference	Project Requirement
numActionTableEntries	NTCIP 1203 Clause 2.9.1.1.1.1	Shall be at least 21

- Sign Status, as defined in NTCIP 1203
- Status Error, as defined in NTCIP 1203

The NTCIP Component shall also implement the following optional objects:

Table 11: Optional Object Requirements

Object	Reference	Project Requirement
globalSetIDParameter	NTCIP 1201 Clause 2.2.1	FSORS
defaultFlashOn	NTCIP 1203 Clause 2.5.1.1.1.3	The DMS shall support the full range of these objects with step sizes no larger than 0.5 seconds
defaultFlashOff	NTCIP 1203 Clause 2.5.1.1.1.4	The DMS shall support the full range of these objects with step sizes no larger than 0.5 seconds
dmsSWReset	NTCIP 1203 Clause 2.7.1.1.1.2	FSORS
dmsShortPowerRecoveryMessage	NTCIP 1203 Clause 2.7.1.1.1.8	FSORS
dmsResetMessage	NTCIP 1203 Clause 2.7.1.1.1.11	FSORS
dmsTimeCommLoss	NTCIP 1203 Clause 2.7.1.1.1.13	FSORS
dmsMemoryMgmt	NTCIP 1203 Clause 2.7.1.1.1.16	The DMS shall support the following Memory Management Modes: normal clearChangeableMessages
dmsMultiOtherErrorDescription	NTCIP 1203 Clause 2.7.1.1.1.20	If the vendor implements any vendor-specific MULTI tags, the DMS shall provide meaningful error messages within this object whenever one of these tags generates an error.
dmsIllumLightOutputStatus	NTCIP 1203 Clause 2.8.1.1.1.9	FSORS
watchdogFailureCount	NTCIP 1203 Clause 2.11.1.1.1.5	FSORS
tempMinSignHousing	NTCIP 1203 Clause 2.11.4.1.1.5	FSORS
tempMaxSignHousing	NTCIP 1203 Clause 2.11.4.1.1.6	FSORS

C. Documentation

Software shall be supplied with full documentation, including 3.5" floppy disk(s) and a CD-ROM containing ASCII versions of the following Management Information Base (MIB) files in Abstract Syntax Notation 1 (ASN.1) format:

- The relevant version of each official standard MIB Module referenced by the device functionality.

- If the device does not support the full range of any given object within a Standard MIB Module, a manufacturer specific version of the official Standard MIB Module with the supported range indicated in ASN.1 format in the SYNTAX and/or DESCRIPTION fields of the associated OBJECT TYPE macro. The filename of this file shall be identical to the standard MIB Module, except that it will have the extension ".man".

- A MIB Module in ASN.1 format containing any and all manufacturer-specific objects supported by the device with accurate and meaningful DESCRIPTION fields and supported ranges indicated in the SYNTAX field of the OBJECT-TYPE macros.

- A MIB containing any other objects supported by the device.

The manufacturer shall allow the use of any and all of this documentation by any party authorized by the Procuring Agency for systems integration purposes at any time initially or in the future, regardless of what parties are involved in the systems integration effort.

D. Acceptance Testing

The acceptance test shall use the NTCIP Exerciser (most current version), DeviceTestor by Intelligent Devices, Inc. or other authorized testing tool, and shall follow the guidelines established in the ENTERPRISE Test Procedures. The NDDOT reserves the right to enhance these tests as deemed appropriate to ensure device compliance.

E. Maintenance and Support

The NTCIP Component developer shall provide 40 hours of training on the NTCIP Component and Management System. In addition, the developer shall provide free software upgrades for a period of 24 months from acceptance of the components.

F. Interpretation Resolution

If the Project Engineer or NTCIP Component developer discovers an ambiguous statement in the standards referenced by this procurement specification, the Project Engineer shall provide an interpretation of the specification for use on the project.

V. Control Software for PVMS

The NDDOT can at it's discretion, use NDDOT's NTCIP control software, provided by Intelligent Devices, Inc., to control the PVMS for this project. If the NDDOT, at it's option, to use vendor supplied control software, the following are the requirements for PVMS control software.

A. General Software Specifications

- Operate on desktop or laptop control computers that are IBM or 100% compatible PC, with a Pentium II or better processor, and that contain a keyboard and mouse.
- Run on Microsoft Windows 2000
- Provide a user friendly multi-color GUI, suitable for use on a color computer monitor
- Must be a 32 bit application
- Control a network of at least 250 variable message signs
- Support PVMS communications via any combination of dedicated hardwired network, fiber-optict network, dial-up, telephone lines, leased phone line, cellular telephone and spread spectrum radio
- Support PVMS control, monitoring, and diagnostic functions as specified
- Control PVMS both remotely from a central location, as well as locally at the PVMS site
- Be accompanied by an easy to use software installation routine
- Comply with the communications protocol requirements of the NTCIP special provision

B. Software Security

PVMS control software shall support the creation of user IDs and passwords for up to 25 potential system users. User creation, as well as individual user access rights, shall be assignable only by a "System Administrator".

Before a system operator can use the PVMS control software, the software shall request a "user name" and user "password". If the correct user name and password are not provided, access to the software shall be declined.

C. PVMS System Database

PVMS CONTROL SOFTWARE SHALL PROVIDE A DATABASE THAT CAN BE FULLY EDITED, AND USED BY THE CONTROL SOFTWARE OPERATOR TO ACTIVELY MONITOR AND CONTROL ALL THE PVMS IN THE SYSTEM. THE DATABASE SHALL BE CONFIGURABLE FOR PVMS OF DIFFERENT MATRIX SIZES, PIXEL TECHNOLOGIES, PIXEL COLORS, CHARACTER FONT FILES, AND COMMUNICATION MODES. AN OPERATOR SHALL BE ABLE TO ADD OR DELETE A PVMS FROM THE DATABASE, AS WELL AS EDIT THE DATA FOR AN EXISTING PVMS.

THE DATABASE SHALL CONTAIN THE FOLLOWING INFORMATION FOR EACH PVMS AND SHALL BE CLEARLY DISPLAYED ON THE CONTROL COMPUTER MONITOR UPON COMMAND BY THE SOFTWARE OPERATOR:

- PVMS ID number, as "1" through "250"
- PVMS name, in a descriptive text format
- Type of communications used for the PVMS, as "Direct", "Dial-Up", etc.
- PVMS display matrix size, indicated in pixel rows by pixel columns (27x48, etc.)
- Name of message file being displayed
- Message priority
- Date and time of last status update to the database
- Communication status between the control software and the PVMS field controller, as "connecting", "transferring data", or "failed", etc.

D. Message Creation and Editing

A PVMS SYSTEM OPERATOR SHALL BE ABLE TO USE THE PVMS CONTROL SOFTWARE TO CREATE, EDIT, NAME, AND STORE MESSAGE FILES.

The message editor GUI shall present a scaled image of the PVMS display matrix, including a complete and accurate representation of the display matrix type (full or line) and the number of display pixels. The PVMS editor image shall actively show message content in a WYSIWYG format, while a new message is being created or an existing message is being edited.

The message editor shall provide the operator with the ability to program:

- The number of pages that the message is to contain (shall be a minimum of five)
- Message text content
- Character font type(s) used to construct the message
- The amount of inter-line spacing, measured in pixels
- Message justification on the PVMS display matrix, as "center", "left", or "right"
- The type of entry effect, as "static" or "scrolling"
- Message page hold time
- Message scroll rate, if a scrolling message
- The flash rate of all or part of a message page
- Message priority status
- The display status of any flashing beacons mounted to the PVMS

The message editor shall provide a method of incorporating real time data (RTD) fields into a PVMS message. The following RTD fields shall be provided:

- Time, in 12-hour format
- Time, in military format
- Temperature, F°
- Speed, in mph (vehicle speed, for PVMS sites that contain speed measurement equipment)
- Day of the week (Monday, Tuesday, etc.)
- Day of the month (1, 2, …….31)
- Month of the year (January, February, etc.)
- Calendar year, in both two-digit and four-digit formats
- Abbreviated versions of the above format, which require a smaller portion of the display matrix

The message editor shall provide a convenient means for the operator to:

- Insert, add, delete, or copy message text
- Clear the content of the editing page
- Save the message file under its existing name or a new name
- Delete a message file
- Save all new changes

It shall be possible to store message files in both the PVMS control computer memory and the PVMS field controller memory.

E. Message Libraries

PVMS CONTROL SOFTWARE SHALL SUPPORT THE CREATION AND STORAGE OF MESSAGE LIBRARIES (FILE DIRECTORIES), WHICH ALLOW THE SYSTEM OPERATOR TO CATEGORIZE MESSAGE FILES BY:

- PVMS MATRIX SIZE
- MESSAGE SUBJECT MATTER

The library editor feature shall allow a system operator to:

- Create a new library
- Store the same message in multiple libraries
- Select a message from an existing library and edit the message contents
- Move a message file from one library to another
- Delete a message file from a library
- Rename a library
- Delete a library
- Save all new changes

F. Schedule Creation and Editing

PVMS CONTROL SOFTWARE SHALL SUPPORT THE CREATION OF MESSAGE SCHEDULES, WHICH INSTRUCT THE PVMS FIELD CONTROLLER TO RUN SPECIFIC MESSAGES AT SPECIFIC PRE-DETERMINED TIMES AND DATES.

Software shall contain an editor, which allows messages to be scheduled via:

- Month of the year (January, February, etc.)
- Day of the week (Monday, Tuesday, etc.)
- Day of the month (1, 2, 3, …….31)
- Time of day.

The schedule editor shall provide a convenient means for the operator to:

- Create a new schedule
- Rename an existing schedule
- Delete a schedule
- Save all new changes

It shall be possible to store schedule files in both the PVMS control computer memory and the PVMS field controller memory.

G. System Default Settings

PVMS control software shall allow a system operator to establish and modify a number of system default settings, if the operator has been granted security access to editing those settings.

User-definable defaults shall include the following communication settings:

- The ability to establish a unique identification (ID) number for each computer that contains PVMS control software and that is authorized to communicate with the PVMS system; in this manner, the activities of various control computers can be logged and traced
- The maximum number of times that a control computer will re-attempt to send a request to the PVMS field controller in the event of a communication error
- The maximum time allowed by the control computer to read a single reply that has been requested from a PVMS field controller
- The maximum time allowed by the control computer to send a single request to a PVMS field controller
- The maximum time allotted to a PVMS field controller to respond to a request by the control computer to delete a message stored in the field controller's memory
- The maximum number of message file names that will appear on the control computer monitor, after a message table is requested from a PVMS field controller's memory
- The ability to specify modem related information
- The ability to enable or disable sign communications

User-definable defaults shall include the ability to establish which of the following events the control software will log:

- PVMS message display status changes, such as a new message has run or a PVMS has been blanked
- A change has been made to the message(s) stored in a PVMS field controller's memory
- A change has been made to the message schedule(s) stored in a PVMS field controller's memory
- The PVMS field controller's internal time-of-day clock has been updated by the control computer
- Polling status of a particular PVMS has been changed from "active" to "standby"
- Results of pixel and driver diagnostic tests

User-definable defaults shall allow a system operator to determine which of the following events will trigger an audio and visual (on-screen) alarm:

- Communication failure
- Priority status conflict
- Sign restart

User-definable defaults shall allow a system operator to configure PVMS with the ability to call the control computer if an error occurs at the PVMS site. Default settings shall establish:

- Which control computer COM port the PVMS field controller is to call
- The communications baud rate during call in
- Whether or not handshaking should be used

User-definable defaults shall allow messages to be assigned a priority classification of:

- Emergency
- High
- Normal
- Low
- Minimal

A numeric priority range shall also be assigned to each of these five priority classifications. In this manner, two different message files can be assigned the same classification, but within that classification, one message can still be assigned to have the highest priority.

The following user-definable defaults shall be assignable to the message editor, which will automatically utilize these settings during the creation of a new message file:

- Spacing between adjacent lines of text
- Display duration of a given message page
- Beacon activation status (for PVMS that contain flashing beacons)
- Effect rate, which shall determine the speed of scrolling messages
- Flash rate, which shall determine the speed of flashing messages
- Message priority classification
- Text justification, as centered, left, or right

H. Software Use and Reproduction Rights

The PVMS manufacturer shall provide a PVMS control software site license with the PVMS supplied for this contract. Ten (10) copies of the PVMS control software shall be provided to the engineer on CDROM within 30 days of contract award. The Engineer shall have the right to request or reproduce an unlimited number of software copies for use on the PVMS system installed for this contract.

Appendix C – Traffic Needs Survey

Background

SDDOT uses devices such as dynamic message signs (DMS) for traffic control and incident management, and has in its inventory 34 portable DMSs mounted on trailers. These sign trailers range in age from 5 to 12 years old, and most of them cannot be programmed remotely, and are used independently. Upgrading our existing signs so they can be used as a part of an integrated traffic management system would cost $3000-5000 per sign. Additional signs cost $20,000-26,000.

Task At Hand

Research study SD2003-16 "Use of ITS in South Dakota Work Zones" has been initiated to determine the temporary traffic management needs of SDDOT statewide. The study also seeks to define an inventory of equipment belonging to SDDOT and whether it is adequate for the Department's needs. I can use your help in answering several questions related to traffic control. You may enter your answers on this document and email it back to me, or if you prefer, call me (Jon Becker, 773-6242) and we'll discuss your answers over the phone. Please return this document or call by **April 23**.

Additional Information

You may already be aware that Intelligent Transportation System (ITS) devices are available for numerous transportation functions. Some systems that specifically help transportation engineers to improve the safety and efficiency of transportation are:

Portable Dynamic Message Signs -

Some DMSs are capable of integrating devices such as camera, radar, Highway Advisory Radio (HAR), and wind and moisture sensors into a system that transmits images and data to a project or traffic engineer's computer, allowing him to view real-time traffic conditions at several locations so he can make decisions regarding traffic control and traveler information;

Traffic sensors -

Sensors can detect traffic congestion at construction zones where traffic must merge, and inform upstream traffic to merge earlier. This system, called a dynamic lane merge system, has resulted in smoother traffic transitions and less aggressive drivers in states where it has been implemented. Sensors can also detect road conditions or low visibility conditions that cause DMSs to display reduced speed limits appropriate for those conditions;

Safety systems -

These systems alert workers of vehicles entering the work zone areas that pose a threat to workers.

Please answer the following questions regarding equipment present in your region.

DMS - SDDOT has in its inventory 32 portable dynamic message signs (DMS) mounted on trailers. These sign trailers range in age from 5 to 12 years old, most of which cannot be programmed remotely.

Do you see any benefit in having the capability to communicate remotely with the portable DMS?

Do you think we need more DMSs or ones with different capabilities? Should our portable DMSs be full matrix signs or 3 line signs?

Given the information on the attached map, are there any other locations where portable DMSs would compliment the permanent DMS locations for use during winter weather?

Traffic Management Needs - A traffic management system can be defined as a collection of sensors that measure speed, congestion, or road conditions, devices that display or transmit information to motorists, and software that integrate and control these devices. These devices may communicate wirelessly and be deployed quickly to wherever they are needed. Please use examples where appropriate.

Do you see a need for a traffic management system for:

Incidents such as vehicle crashes -

Forrest fires -

Special events – List events in your area that could use additional traffic control.

Lane merges -

Long work zones (delay information)-

Travel information -

Traffic management -

Do you see a need for the following technologies:

Camera monitoring for such things as vehicle detection, queue length or incidents -

Highway advisory radio -

Worker Safety

Do you see a need to provide the following safety devices in work zones? Where and when would they be used? Please give examples.

- Work zone intrusion alarms that alert workers when there is a vehicle within the work zone

- Devices that make the beginning of the work zone more visible to motorists

- Transmitters in the work zone that activate the approaching vehicles radar detectors indicating that the driver is approaching a work zone

- Changeable message signs giving driver information regarding the work zone

- Automated Speed enforcement that automatically photographs speeding vehicles and generates a citation which is mailed to the offender

- Any other ideas you can think of?

Have you used or is there a need to use some type of sensors such as RTMS (Remote Traffic Microwave Sensor), video detection, or some other means of detection to detect traffic volume, queue length or incidents? (Briefly explain)

Are you aware of any other state agencies in your area such as BIT, Department of Public Safety, or Emergency Management that possess this type of equipment or any equipment that could be beneficial to this effort? For example, it was discovered that Emergency Management possesses 2 HAR trailers which can be used to inform the public of potentially hazardous conditions.

Are there any other technologies you are aware of that SDDOT should consider?

Traveler Information

SDDOT currently provides roadway and weather condition information to drivers via 511, our website and dynamic message signs. Road conditions include things like lane closures, road construction and known delays.

Is there any other information we should be giving drivers?

How should the information be delivered?

Do you feel the level of enforcement in work zones is appropriate?

The project technical panel greatly appreciates your effort and time spent on this survey. Please email the survey back to me, or just call me and we'll discuss your answers.