SCAN 16 - MOISTURE, FROST, ICE EARLY WARNING SYSTEM
(First Progress Report)

MICHIGAN DEPARTMENT OF TRANSPORTATION

TESTING AND RESEARCH DIVISION
RESEARCH LABORATORY SECTION

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Problem

Motorists traveling on a roadway during the winter months may be subjected to the hazardous phenomenon known as bridge deck icing. This condition occurs when the bridge deck freezes prior to the adjacent roadway, and the sudden transition from the non-icy roadway to the frozen bridge deck may cause a motorist to lose control of his vehicle. It is difficult to predict when this condition will occur and as a result, maintenance personnel may often be sent out when it is not necessary, or not be sent out when it is. Surface Systems Inc. (SSI) of St. Louis, Missouri has developed a system for detecting these slippery conditions on bridge decks. An earlier version of this system has been available for a number of years and has been used by a number of agencies with varying results. This new version of the detection system, called "Scan 16," has been available for only a few years and is still classified as 'experimental' by the Federal Highway Administration (FHWA).

Objectives

The main objective of this project is to verify and document the ability of the Scan system to detect and predict the formation of ice on the bridge deck. Further, we wish to:

1) Evaluate the durability of sensors, electronic equipment, and other system components in Michigan's climate.

2) Obtain experience and information on conditions which result in bridge deck icing.

3) Evaluate the methods used to predict the formation of ice on the bridge deck.

4) Determine if the information output from the detection system can be used to effect a reduction of bridge icing accidents.

5) Determine the feasibility of implementing a District-oriented grid of sensors on strategically located bridges to monitor the movement of changing weather conditions across the state for the initiation of pavement salting.

System Description

Scan 16 is a system for detecting moisture, frost, and ice on a deck surface and relaying this information to a remote monitoring point. Since the control device for the system is a microcomputer, many different system configurations are possible. This report will describe the configuration of the system for monitoring surface conditions on four parallel bridges carrying I 496 and its service drives over Cedar St and the Grand River in Lansing. The block diagram of the system is shown in Figure 1. Figure 2 shows details of the bridge site.

The system uses four roadway sensors, two atmospheric sensors, and a remote processor unit all located at the bridge site. The roadway sensors determine the temperature of the surface and whether the surface is dry or if moisture is present. These sensors will also indicate how much deicing chemical is present providing there is sufficient moisture on the surface to form a solution and the temperature is below 40 F. The atmospheric sensors measure the relative humidity and the air temperature.

The output from all the sensors is fed into a microprocessor unit located near the sensors. This remote processor unit (RPU) processes and stores the sensor data and transmits the data to a central processing unit (CPU).

The central processor unit is located in the Testing and Research Laboratory and consists of a microcomputer and a cassette tape drive. The microcomputer gathers, processes, and stores data from the remote processor. It has the capability of handling up to 32 such remote processor units. The central processor also presents the data on a video display terminal and a printer located at the CPU site. There is also a video display terminal located in the MDOT Maintenance Garage in Mason.

Telemetry from the RPU to the central processor and from the central processor to the MDOT Maintenance Garage in Mason is accomplished by leased telephone lines. A standard dial-up telephone line and auto answer modem is also provided at the central processor. This allows access to the system from any telephone by using a portable computer terminal; such a feature enables the maintenance foreman to take a portable terminal home at night and check on conditions by dialing into the system using his home phone. It also allows the vendor access to the system to upgrade the software, or diagnose problems without visiting the site.

The system has five ways of displaying information that is accessible from the video display terminal keyboard. They are:

1) Menu Page - explains each keyboard entry and how to make it,

2) Status Page - displays the latest surface and atmospheric data from each remote processor unit,

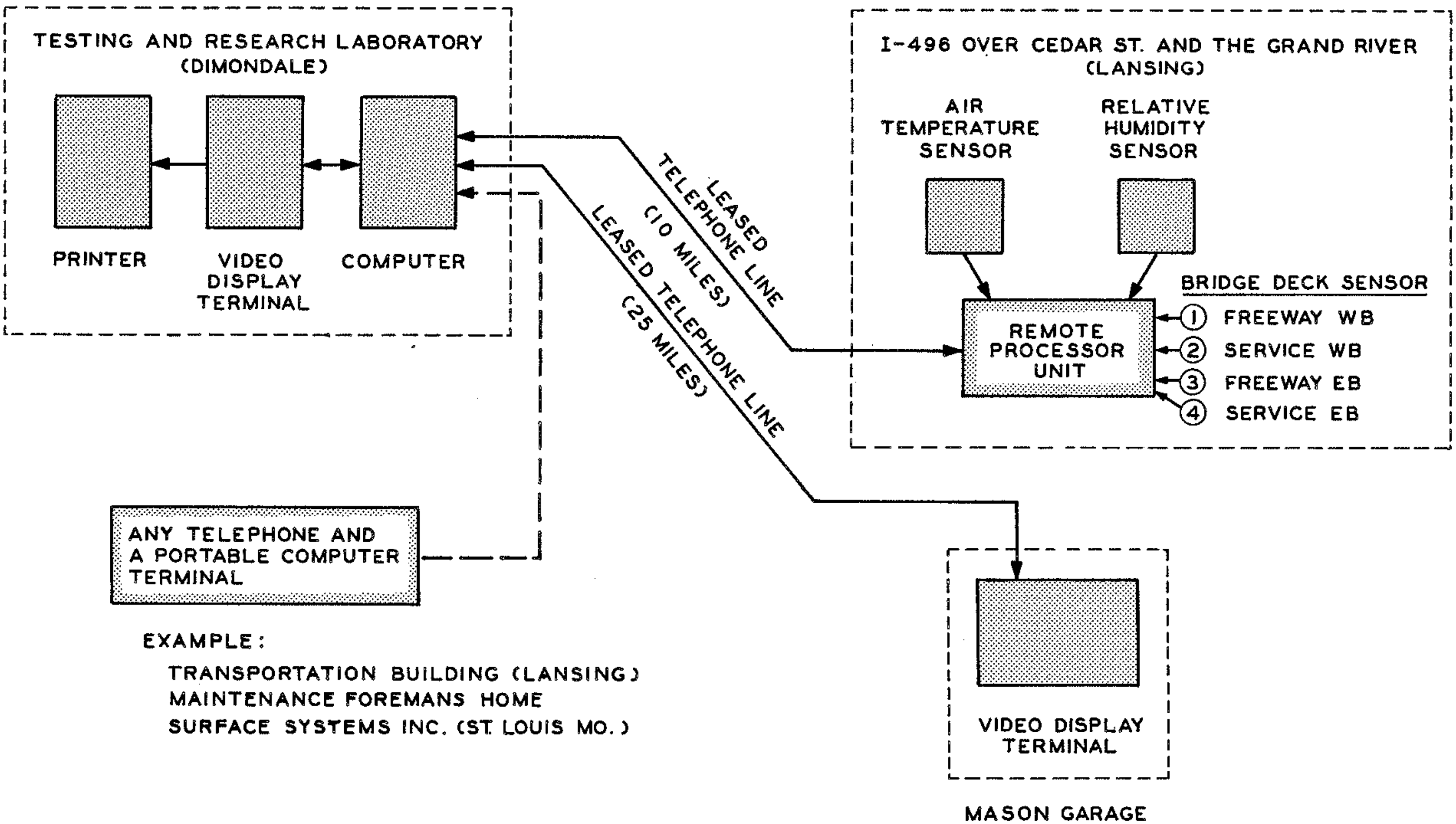

Figure 1. Scan 16 block diagram.

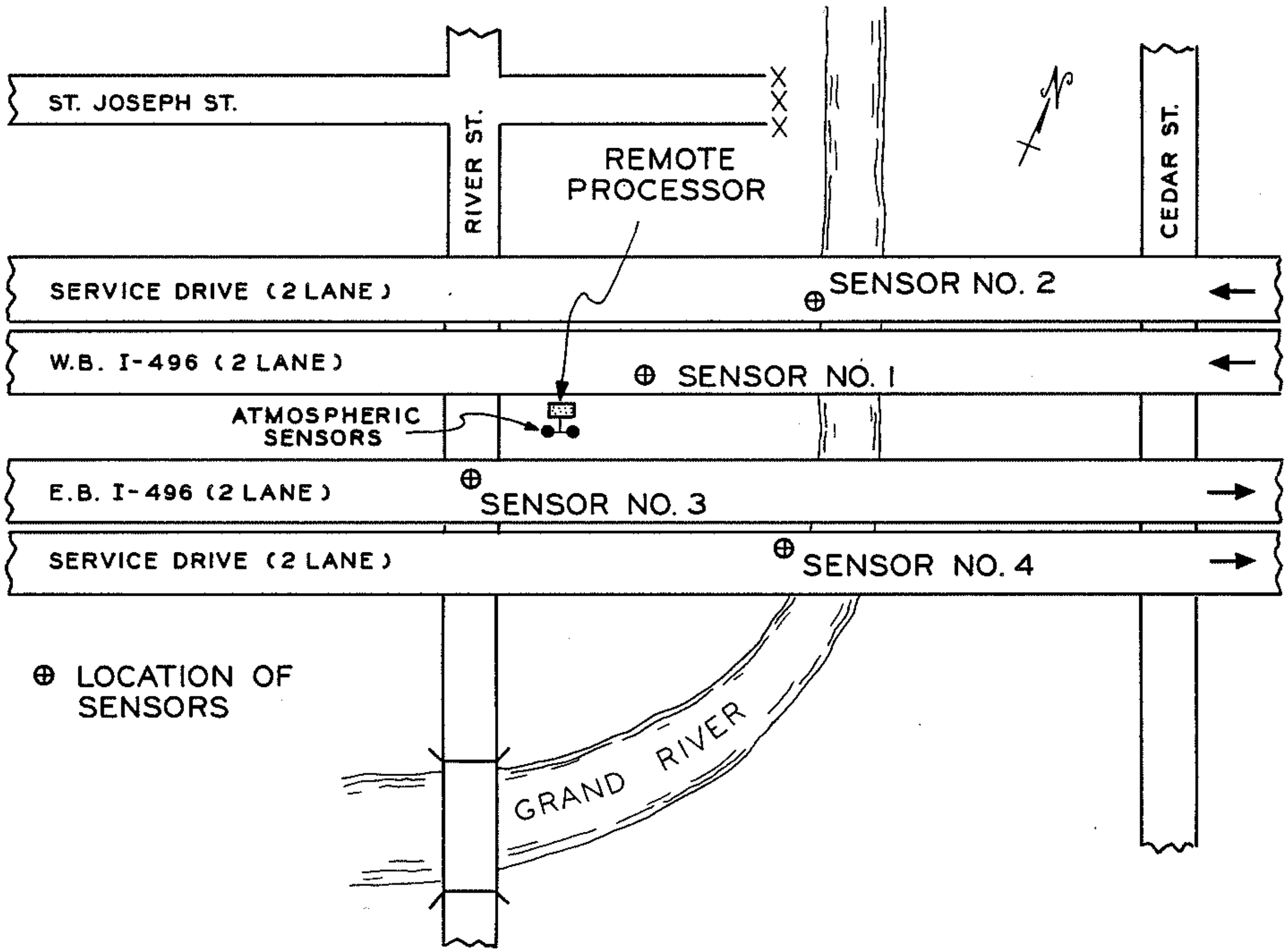

Figure 2. Location of ice detector sensors and remote processor unit.

3) History Page - shows the last 15 significant changes for each surface sensor,

4) Graph of Air Temperature - depicts a graph of the air temperature for the last 60 minutes, and

5) Graph of Surface Temperature – displays a graph of the surface temperature measured by the requested sensor for the last 60 minutes.

It can also display a 'Summary Page'—a different form of the status page—that allows up to 16 sensor outputs to be displayed simultaneously.

System Installation

Surface sensor installation is well described in the installation instructions provided by the manufacturer. All materials necessary for the work were supplied by the vendor. The only difficulty encountered was getting the epoxy to harden, since the installation was done in late October and surface temperature had cooled to the point where it inhibited the proper epoxy cure.

The installation of the atmospheric sensors and remote processor unit presented no unusual problems as the instructions provided by the manufacturer were quite descriptive.

The most time consuming aspect of the entire project was the telephone service. Installation was requested in the first part of October but was not completed until the middle of January. This service used standard telephone lines with auto answer modems. Then, because telephone charges were assessed on a per-call basis, the resulting costs for the service were quite large. It was necessary to convert the system from standard phone lines to a leased line system. Surface Systems Inc. also has a radio telemetry option which can be used in this system. Although we did not use it, this may be the best alternative for short distances. This is especially true for the link between the remote processor and the central processor.

Throughout the entire installation process, SSI was very helpful. When it was time for the final hookup of the system, SSI personnel made all the necessary connections and checked out the system to make sure all aspects were working correctly.

Final installation of the system was completed January 26, 1983. Total time devoted to the field work at the site amounted to about 300 MDOT man-hours. The surface sensor installation required about 130 man-hours which included a considerable amount of time for traffic control and waiting for the epoxy to cure. Another 100 man-hours was required to install conduit and cable for electric and telephone service. The remaining 70 man-hours were required to install the atmospheric sensors. These figures will vary considerably depending on the site and equipment available for installation. The above work was done by MDOT personnel. The time required to set up the central processor was about 16 man-hours. This time should not vary a great deal as all parts are modular and require a minimum amount of assembly. Surface Systems Inc. did this set-up with a minimum amount of assistance from MDOT personnel. Set-up of the remote monitor site at the Mason Garage required less than an hour.

System Costs

Costs for this system are itemized as follows:

		Total Package Price
Remote Processing Unit Package		$25,100
1 remote processor in weatherproof cabinet	*	
4 surface sensors with 150 ft of cable each	$2,400 ea	
1 air temperature sensor	*	
1 relative humidity sensor	1,100	
1 electronic rack	510	
1 modem	*	
Remote Monitoring Site Package		$ 4,660
1 video terminal	$1,685	
1 printer	1,575	
2 modems with portable board	1,400	
Central Processor Unit Package		$20,792
1 central CPU	*	
1 tape drive	*	
1 modem	*	
Telephone Service Installation		$ 350
Electric Service Installation		$ 500
		$51,402

Monthly costs amount to $71 for telephone service and $10 for electricity.

* Individual component prices not available.

Operational Experience

During the first month of operation, there were a total of four computer malfunctions. This condition was evidenced by the failure of the CPU to update the video display screen and respond to telephone communication signals. SSI has since provided us with a new version of the computer program, and we have not experienced any further problems of this nature. There has been a problem with occasional distortion of information on the video display terminal at the Mason Garage; however, this is due to noise on the telephone line and can generally be cleared up by turning the terminal's power off and back on again.

There have not been any problems with the sensors or the remote processor unit. The only operator interventions so far have been to perform the system resets, perform three time-of-day corrections, one of which was to correct for daylight savings time, and change the ribbon on the printer once. About four man-hours were required when the telephone lines were changed over from auto dial to leased line.

System Evaluation to Date

The system is being evaluated by Maintenance Division personnel making three to four daily visual observations of the bridge decks and recording these observations on the form shown in Figure 3. These observations are later compared with the results of the system printout. The system records the data for each surface sensor on the system printout (Fig. 4). Each visual observation does not necessarily include all of the variables being monitored. Therefore, it is necessary to count each sensor as an independent observation. The system has four status modes to identify surface conditions, they are: DRY, MOISTURE, SURFACE ALERT, and SURFACE CRITICAL. DRY means no moisture is present. MOISTURE means there is moisture on the surface and surface temperature is above 32 F. SURFACE ALERT means moisture is present in liquid form and surface temperature is at or below 32 F, or moisture or frost is forming on the surface and the surface temperature is at or below 32 F. SURFACE CRITICAL means moisture is present and starting to freeze or has already frozen or that the surface is heavily frosted.

Observations began on January 28, 1983 and continued through March 1, 1983. During this time, 165 observations were made; five observations had to be discarded because of missing time or date, and 13 observations were made during times when all or part of the system was not operational.

PAVEMENT SURFACE CONDITION FOR
I 496 BETWEEN US 127 AND CEDAR STREET

Name of Observer:				Date:	Time: a.m. p.m.
Westbound Roadway		Eastbound Roadway		Road Surface Condition Between Wheel Tracks (✓)	
Freeway	Service Road	Freeway	Service Road		
				Dry	
				Damp (no standing water)	
				Wet (rain or melted snow)	
				Frost	
				Snow	
				Icy patches	
				Ice covered	

Remarks: ______________________________

Figure 3. Surface condition evaluation form.

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--------------------------------------------------------------------------
Michigan State Highways                              Time 09:02         May 23, 1983
                                                     Power on at: 15:34 on 04/12/83
  I496 at Cedar St.                    RPU #1        Last report: 04:58 on 05/23/83

                              Atmospheric conditions

     Air              Dew point         Relative        Wind          Wind
  Temperature        Temperature        Humidity      Direction     Speed/MPH

      55                 52                93

                               Surface conditions

                                                                 Surface    Freeze
  No.        Sensor location              Status               Temperature Factor

   1       W.B.  Freeway                          Dry               60
   2       W.B.  Service                          Dry               61
   3       E.B.  Freeway                          Dry               60
   4       E.B.  Service                          Dry               61
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Figure 4. Typical printout of system.

This left 147 valid observations. The following table shows the frequency distribution of the surface conditions as reported by the Scan 16 system and by visual observation during the test period.

DISTRIBUTION OF CONDITIONS REPORTED

SCAN 16		Observers	
Dry	- 65	Dry	- 66
Moisture	- 18	Damp	- 39
Surface Alert	- 36	Wet	- 24
Surface Critical	- 28	Frost	- 0
		Snow	- 5
		Icy Patches	- 10
		Ice Covered	- 3

A comparative interpretation of the data showed 115 observations agreeing and 32 disagreeing with the SSI system results; translating to a 78.2 percent accuracy rate. The 32 observations in which there was a disagreement are shown in the table below, the following conditions were equated: frost, snow, icy patches, and ice covered are equated to SURFACE CRITICAL. Wet and damp at or below 32 F are equated to SURFACE ALERT, and above 32 F are equated to MOISTURE.

SCAN 16 Reported	Observer Reported	No. of Times
Surface Critical	Dry	10
Dry	Damp	8
Surface Critical	Damp	5
Dry	Wet	4
Dry	Icy Patches	2
Surface Alert	Ice Covered	1
Surface Alert	Dry	1
Moisture	Dry	1

Most important to note is the fact that only once did the observer report the roadway ice covered while the system remained in a SURFACE ALERT condition. Further investigation showed the system did change to SURFACE CRITICAL within 30 minutes of the time of the observation.

Maintenance personnel were more concerned about the SURFACE CRITICAL rating being reported when no moisture was present. This condition has been reported to SSI and should be correctable by an appropriate software adjustment.

Conclusions to Date

The Scan 16 system appears to be a working system. The system requires a minimum of operator intervention. The Surface Systems Inc. personnel were very helpful throughout the first year of this project, and show concern about ways to improve the system.

Maintenance personnel cannot rely solely on this system. Data presented by the system are not infallible and need interpretation. It should be used only as a tool in the decision making process. Like any tool, the user will become more familiar with it the more he works with it. Our experience this year was quite limited due to an extremely mild winter, and MDOT personnel were just becoming familiar with the system at the end of this first year.

We will continue to monitor the system throughout the summer using it to keep track of surface temperatures and then resume visual observations again in late fall. The final report should have enough data to make accurate assessments and final conclusions.