MICHIGAN DEPARTMENT OF TRANSPORTATION
M•DOT

EVALUATION OF ICE DETECTION AND WEATHER INFORMATION SYSTEMS

Progress Report

MATERIALS and TECHNOLOGY DIVISION

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EVALUATION OF ICE DETECTION AND WEATHER INFORMATION SYSTEMS

Progress Report

J. H. DeFoe
M. H. Close

FHWA Experimental Project No. 13 by the
Michigan Department of Transportation's
Maintenance and Materials & Technology Divisions
in cooperation with the Federal Highway Administration

Research Laboratory Section
Materials and Technology Division
Research Project 89 G-274
Research Report No. R-1308

Lansing, December 1990

ACTION PLAN

1. W. J. MacCreery, Deputy Director - Highways

   A. Transmit report to the FHWA in accordance with Experimental Project 13 Work Plan.

2. Materials and Technology Division

   A. Continue research to complete project as scheduled.

3. Engineering Operations Committee

   A. No action necessary upon approval of this report.

The Michigan Department of Transportation (MDOT), along with a number of other state highway agencies, has installed and evaluated ice detection and weather forecasting systems in recent years. Most of these evaluations have addressed the performance of the equipment. The purpose of this study is to assess the usefulness, effect on highway safety, and cost savings of the ice detection and weather information systems now used by MDOT.

This evaluation is being conducted at the request of the Engineer of Maintenance as part of Federal Highway Administration (FHWA) Experimental Project No. 13, "Ice Detection and Highway Weather Information Systems," initiated by the FHWA in 1988.

The Michigan Department of Transportation Weather Information System

Pavement Condition Sensors - The Department has sensors at eight locations and acquires information from sensors owned by other agencies at three other sites. Individual sensors are located on bridge decks, bridge approaches, and approach pavements (subsurface). The sensor systems were purchased from Surface Systems Inc. of St. Louis, MO. Sensors are located in four geographic areas, eastern Saginaw County, the Lansing area, Oakland County, and the Kalamazoo area (Fig. 1). The pavement sensors give surface temperature, moisture, and chemical concentration, thus allowing accurate predictions of the presence of frost or ice. Each of the four geographic areas also has at least one complete weather station which supplies air temperature, dew point temperature, humidity, precipitation (yes/no), wind direction, and wind speed. Each set of sensors has a remote processing unit (RPU) that transmits data by telephone or radio to one of four central processing units (CPU) for data storage and retrieval (one CPU for each geographic area). The Maintenance Division central office in Lansing can retrieve data from any CPU in the state by telephone. CPUs can also be called from any location by telephone using portable lap-top data terminals. These portable terminals are used by garage foremen at home or in the office and are a key part of this winter information system. The Kalamazoo CPU is located at the airport and data are shared with the airport.

Pavement Forecast Service - The Maintenance Division has a contract with Surface Systems Inc. to provide forecasts, called Scancasts, of pavement temperature, moisture, plus a complete weather forecast for each of the four geographic areas. The 24-hour Scancasts are obtained in the same way as the pavement sensor data by using portable data terminals. The pictorial line and bar graphs provided by the Scancasts are easy for the truck drivers to read and understand.

Weather Radar - The Capital City Airport and the Maintenance Divison share ownership of an X-band radar unit at the airport in Lansing. Information from the radar, including an area map showing storm movement, color coded by precipitation intensity, can be accessed by personal computer via telephone at the Lansing area maintenance garages.

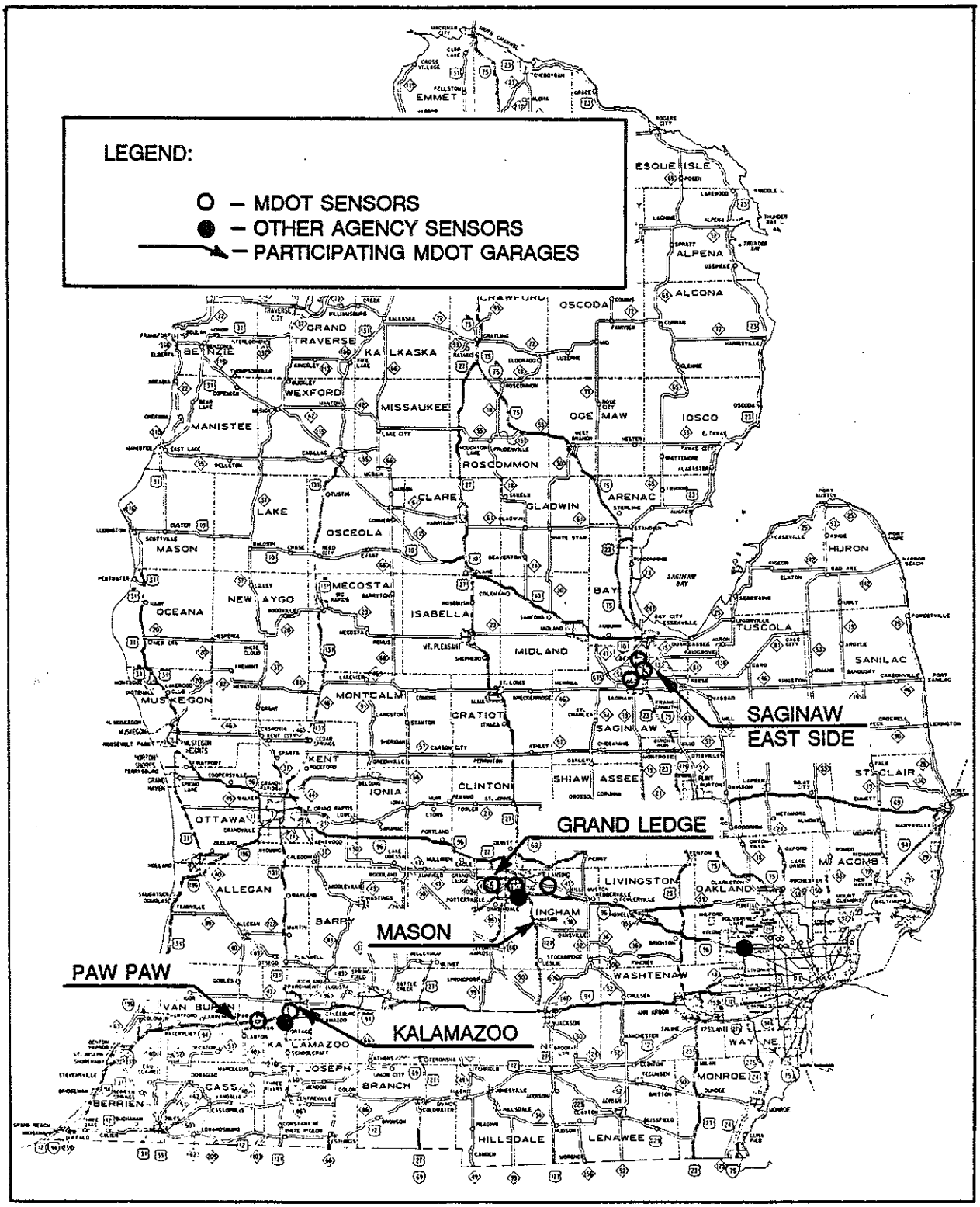

Figure 1. Location of weather information sensors and participating MDOT maintenance garages.

Cable Weather Channel - Television sets have been placed in three maintenance garages: Kalamazoo, Saginaw eastside, and Grand Ledge (just west of Lansing). The TVs have been locked onto the weather channel in order to provide additional weather information.

Weather Systems Costs - The capital investment by the Michigan Department of Transportation over the past decade in 1990 dollars is approximately $400,000. The installation of the weather channel information including the television and cable hook-up has cost about $1,000 per site.

The total Scancast pavement forecast cost is about $9,000 per year servicing the four areas. The maintenance costs of the pavement sensors and weather radar has run about $20,000 per year for parts and labor (including the consultant's repair technicians and in-house labor).

Evaluation Procedure

The evaluation thus far has been based on the information reported on the Winter Maintenance Event Forms (Fig. 2) along with interviewing the decision makers and other key personnel in the winter maintenance areas using the Weather Information systems.

Accident records will be summarized at the end of the study and analyzed to look for reductions in the proportion of accidents related to pavement surface conditions as compared with years prior to the Weather Information Systems.

Savings in manpower, equipment costs, and chemicals as reported on the Winter Maintenance Event Forms will be reviewed with persons reporting the savings to verify that equipment and material records were appropriately used in the calculations.

The Michigan Department of Transportation Winter Maintenance Program

Michigan's total highway network consists of approximately 117,400 miles of highways, streets, and roads. This includes approximately 9,500 miles of state highways, with the remaining miles under county and city jurisdiction. This network of state highways translates into approximately 13,825 miles of 24-ft wide road surfaces. Although only 8 percent of Michigan's roads fall under state jurisdication, these roads carry over 50 percent of the total vehicle miles traveled.

Winter Maintenance Operations - Winter maintenance operations for snow and ice control on the State trunkline system are carried out by state forces (MDOT) in 21 counties, while county road commissions perform maintenance operations in the remaining 62 counties. Maintenance contracts are also in place with over 150 cities and villages, although not all perform winter maintenance. With the contract agencies, the work crew and supervision, including foreman and superintendent, is carried out by the county and municipality. The overall contract administration,

FHWA-EP-13

WINTER MAINTENANCE EVENT FORM

Location Code: Form Date:
Decisionmaker:

GENERAL EVENT INFORMATION

Beginning Date: Beginning Time:
Notification Method:

Type of weather or highway/bridge pavement conditions: (circle one)

Frost Patchy Ice Rain/Sleet Snow Squall

Light Snow Heavy Snow Other:

Ending Date: Ending Time:

Inches of precipitation:

Maintenance Response/Activities

Mobilization Start Time: Ending Time: No. of Units:	Patroling Start Time: Ending Time: No. of Units:
Spot Sanding Start Time: Ending Time: No. of Units: Tons of Sand:	Snow Plowing Start Time: Ending Time: No. of Units:
Spreading Chemicals & Abrasives Start Time: Ending Time: No. of Units: Material Used: Application Rate: Total No. of Applications:	Other Description: Start Time: Ending Time: No. of Units:
False Alarm Start Time: Ending Time: No. of Units:	Standby Start Time: Ending Time: No. of Units:

Effects of Ice/Weather Information System on Decisionmaking

Comments:	Hours Saved Activity Reg Prem

Figure 2. Winter Maintenance Event Form.

control of work item budgets, and conformance with Department policy and maintenance level guidelines are under the supervision of MDOT's District Operations Engineer. In a typical year, winter maintenance operations account for approximately 28 percent of the total $106,000,000 spent on road and bridge maintenance. Snow routes range in length from 20 to 45 lane miles. Winter road patrols and second and third shifts are scheduled in snow belt areas where past experience has shown it is necessary to provide adequate winter maintenance and for general economy of operations.

Decision making during winter storm operations is controlled by the local garage foremen and/or the shift supervisors. These individuals review all the available weather information to schedule the work. A maintenance garage staff consists of between 10 and 25 equipment operators available for winter storm operations. The average garage has one or more trucks per snow route and between five and twelve snow routes per garage. Snow trucks are equipped with underbody blades and salt/sand hopper boxes. Front-end plows are available for heavy snow storms. Graders and loaders are used for pushing back snow, clearing ramps, banks, parking lots, and emergencies.

Salt and salt/sand mixtures are the primary deicers used in Michigan. Calcium chloride is occasionally added. Calcium magnesium acetate (CMA) is used exclusively on a special 1.5-mile concrete segmented bridge at Zilwaukee.

Winter Maintenance Policy - In order to provide adequate winter maintenance services and still keep expenditures within or below budgeted funds, each state trunkline has been placed into one of three winter maintenance classifications. These classifications are based on traffic volumes with each classification being assigned a minimum level of maintenance service to be provided as a goal during winter storm conditions.

As a general rule, winter maintenance operations begin as soon as hazardous road conditions develop and maintenance forces can be dispatched to respond. The first winter event usually occurs in late November or December with the last winter event usually occurring in April in the four areas of Michigan involved in this study.

The classifications and levels of service are as follows:

1) Green, 5,000 and over Winter ADT (Average Daily Traffic). Provide maintenance service as appropriate under prevailing weather conditions, with a goal of providing a pavement surface generally bare of ice and snow. It is intended that this work be accomplished using overtime labor as necessary.

2) Yellow, 2,500 - 5,000 Winter ADT. Provide maintenance service as appropriate under prevailing weather conditions, with a goal of providing a pavement surface generally bare of ice and snow in the center portion

wide enough for a one-wheel track in each direction. Clearing the pavement bare of ice and snow over its entire width will be accomplished as soon as reasonably possible without working overtime.

3) Red, 0 - 2,500 Winter ADT. Provide maintenance service as appropriate under prevailing weather conditions, with a goal of providing a pavement surface that is passable yet snow covered. Clearing the pavement bare of ice and snow will be accomplished as soon as reasonably possible without working overtime.

During the winter season, maintenance employees in both direct maintenance and contract counties are subject to 24-hour call. As a general rule, winter operations start as soon as hazardous road conditions develop. Every effort is made to clear highways of ice and snow prior to peak traffic periods, especially early morning commuter traffic. A second and third shift is scheduled in areas where past experience has shown this to be necessary to provide a desired level of winter maintenance service and is also an effective way to minimize overtime costs.

Winter Maintenance Equipment - The standard truck is a single-axle, 35,000-lb GVWR unit with a 6.5-cu yd dump box and underbody scraper. The trucks are also outfitted with a drop-in salt-hopper/spreader-box and a detachable quick hitch for the snow plow attachment.

The standard underbody scraper is Root Model F-44. MDOT uses right and left discharge plows, Model Michigan Special 571X from Root Scraper Co. Plows are generally not used until a storm's snow accumulation reaches 8 in. or more or severe drifting is encountered.

Snow wings are generally used only on motor graders, standard model size is JD 672-A, the snow wings are generally Henke Model JD 7 AW12. The same detachable hitch is used on trucks and motor graders so the plows can be interchanged.

Assessment of Benefits

A review of the Winter Maintenance Event Forms indicates that there are problems in getting the forms filled out correctly. Information reported on these Event Forms also shows a major problem with the reliability of the Weather Information System equipment (i.e., sensors, Scancast, and radar). The sensors and the radar have required frequent maintenance.

The frequency of the use of the Weather Information System in decision making during storm events during the 1989-90 winter season is summarized in Table 1. Information in this table was taken from the Winter Maintenance Event Forms as submitted by the decision makers at the five participating garages.

The Department's winter maintenance policy, based on traffic volumes, has resulted in the staffing of each garage with two shifts of road clearance

TABLE 1
INFORMATION SOURCES REPORTED BY DECISION MAKERS
AS INFLUENCING WINTER STORM OPERATIONS

Garage	No. of Events Reported	Information Sources					Equipment Failures Sensors	Scan-cast	Man-hours Saved	WIS Use, Percent of Events Reported
		Weather Information Systems				Traditional Methods *				
		Sensors	Scan-cast	Radar	More Than One					
Grand Ledge	21	1	1	0	(1)	18	2	1	—	4.7
Kalamazoo	32	12	22	0	(12)	17	6	0	612	68.8
Mason	24	(12)	(1)	(1)	0	18	0	0	4	58.3
Paw Paw	9	4	4	0	(4)	4	5	0	---	44.4
Saginaw	9	0	0	0	0	6	4	3	—	0

* Other observations, phone calls, radio/TV, police

workers and supervisors during winter months. Personnel on these two shifts are permanent full-time state employees. Any savings to be expected should, therefore, come from reductions in call-back or overtime hours for these employees and from the corresponding reduction in equipment, chemical, and abrasive usage.

Examination of Table 1 reveals some apparent discrepancies and suggests some corrective actions be taken before next winter. First, there is the disparity in the number of storm events reported with Kalamazoo reporting 32 events while Paw Paw (only 13 miles west of Kalamazoo) reported only 9 events, the same as Saginaw. From past experience in evaluating ice control measures, the number of winter storm events usually ranges from 20 to 30 during a winter season. It would seem that not all events were reported at Paw Paw and Saginaw.

A second area of concern involved the reliability of the Weather Information Service components. Of the 95 events reported, the equipment provided information to the decision makers 41 times (43 percent), but were reported to be malfunctioning 21 times (22 percent). On 17 occasions, two of the Weather Information components were used together in decision making so that there are only 41 events using some type of Weather Information Service. Usage reported by each garage ranged from 68.8 percent of events at Kalamazoo down to 0 percent at Saginaw. Equipment failure plagued the Saginaw garage throughout the season. Early failures may have discouraged any further reporting by the decision makers. Interviews, however, with personnel from the garage, indicate they are able to minimize the amount of chemical needed on the Zilwaukee Bridge because of sensor information. The Saginaw eastside garage maintains the Zilwaukee Bridge which opened in 1987 and has carried more than 27 million vehicles without any traffic tie-ups, closures or congestion. The 1-1/2-mile structure is kept free of ice and snow through the use of calcium magnesium acetate (no salt has ever been permitted on the structure) along with appropriate mechanical removal equipment dedicated for that structure.

Finally, another major concern is the fact that only two garages reported a savings in manpower, with one reporting 616 hours saved and the other 4 hours. No other savings were reported. It may be necessary to remove the overall burden of figuring these costs from the decision makers who, as a first priority, supervise the normal maintenance garage activities as well as direct ice control operations.

Use of the System

Decision makers use of the Weather System has apparently been strongly influenced by the reliability of the system as well as by the attitude of the decision maker about his need for supplemental information. The degree to which decision makers rely on the systems varies with the individuals involved. At one garage the decision maker, the garage foreman, carries his lap-top data terminal wherever he goes, bringing it home at night and on week-ends. His decisions are greatly influenced by information obtained in advance of the storms. Other foremen, however, avail themselves of the system's information after they arrive on duty at the garage. The first approach can be quite beneficial in situations where application of chemicals prior to the storm is appropriate. Wet, heavy snowfall with predicted accumulations which could result in a snow pack of several inches would be one example. Experience at the Zilwaukee Bridge has shown that pre-storm application of calcium magnesium acetate is essential to effective and efficient use of this expensive material.

Other Uses

At several locations there are temperature sensors placed in the top of the sand subbase material. Information from these sensors can indicate whether or not the supporting soil for the highway is frozen in connection with deflection testing operations.

The evaluation is to continue throughout the 1990-91 winter season. Modifications will be made to simplify and clarify the Winter Maintenance Event Form.