CHAPTER 14: COST IMPLICATIONS OF PAVEMENT TEMPERATURE SENSORS

Many highway agencies and state departments of transportation (DOTs) are facing staff cutbacks even as the public expects agencies to improve the level of service on roadways and increase their sensitivity to the environment. Advanced technologies on winter maintenance vehicles have the potential not only to improve roadway conditions but also to provide economic and environmental benefits to both the state DOTs and highway users, including reduced use of winter chemicals and abrasives, equipment, and labor.

Benefit/cost analyses of specific technologies implemented on the prototype maintenance vehicles will be conducted during Phase III. This chapter merely introduces some general cost implications of these technologies. First, development costs are listed for technologies selected for implementation. Then, using a salt application curve and a scenario-based decision-making process, potential savings in ice and snow control materials and other assets are estimated for particular scenarios. These potential savings derive from the implementation of one advanced technology: pavement temperature sensors. Pavement temperature is a major factor for material application on highways during winter storms. When advanced technologies provide accurate pavement temperature data, maintenance staff can more accurately determine appropriate materials to apply and rates and timing of application. Other assets to be considered in cost savings for winter maintenance operations are labor and equipment.

INITIAL COST OF TECHNOLOGY

The technologies selected for the prototype maintenance vehicles are listed in Table 14-1, along with their costs, technology providers, and implementation schedule. These are development costs for the prototype vehicles shared by the technology providers and study sponsors, not ultimate production costs. Detailed information concerning the initial prototype providers, budget, and schedule can be found in the Phase I report, Concept Highway Maintenance Vehicle, Final report Phase One, dated April 1997.

TABLE 14-1 Initial prototype providers, budget, and schedule

Item	Technology Provider	Provider Contribution	Project Contribution	Schedule
IOWA TEAM (Ames)				
50,000 GVW Truck, Plows, Box	Iowa DOT			10/01/96
Trip Master/AVL System	Rockwell			--
Two-way Communication	Rockwell			--
Material Application	Bristol	$12,500	$12,500	09/01/96
Incremental Power	Fosseen	1,500	Fuel	09/15/96
Friction Meter	Norsemeter	45,000	20,000	01/01/97
Surface Temp. Sensor	SXI	500		10/01/96
Vehicle Weight Sensor	SXI	1,500		10/01/96
	Sub Total:	$61,000	$32,500	
MICHIGAN TEAM (Cadillac)				
50,000 GVW Truck, Plows, Box	Michigan DOT			10/01/96
Fleet Advisor	Eaton	$25,000		09/01/96
AVL System/Communications	Eaton			09/01/96
Material Application	Monroe	8,000		09/01/96
Incremental Power	Fosseen	1,500	Fuel	09/15/96
Friction Meter	Norsemeter	45,000	20,000	01/01/97
Surface Temp. Sensor	SXI	500		10/01/96
Vehicle Weight Sensor	SXI	1,500		10/01/96
	Sub Total:	$81,500	$20,000	
MINNESOTA TEAM (St. Cloud)				
50,000 GVW Truck, Plows, Box	Minnesota DOT			08/15/96
Data Logger	SXI	$25,000		10/01/96
AVL System	Tyler Ice	42,000		09/15/96
Two-way Communication	SXI			10/01/96
Material Application	Tyler Ice			09/15/96
Incremental Power	Fosseen	1,500	Fuel	09/15/96
Friction Meter	Norsemeter	65,000		01/01/97
Surface Temp. Sensor	SXI			10/01/96
Vehicle Weight Sensor	SXI			10/01/96
Air Foil	Monroe			09/01/96
	Sub Total:	$133,500	$0	
	Project Totals:	$276,000	$52,500	

Note: Vehicle weight sensors and air foil technologies were not used on the prototype vehicles but are included here because this table, established in Phase I, documents all potential technology costs.

EFFECTIVE USE OF CHEMICALS AND ABRASIVES

Iowa DOT 1996 budget figures for snow and ice removal indicate that, statewide, material costs average $35,000 per hour, labor costs average $19,000 per hour, and equipment costs average $16,000 per hour, for a total average snow removal cost of $65,000 per hour for the state of Iowa. If the amount of chemicals and abrasives used for snow and ice control can be reduced while maintaining the level of service for roadway users, potentially large savings can be realized. As stated earlier, pavement temperature data control decisions about the type and amount of snow and ice control materials applied to the roadway.

Objective

Illustrate the potential reduction in winter chemical and abrasive usage when advanced technologies are used. The pavement temperature sensor is used as the example.

Measurement

Calculate cost savings or losses if the known pavement temperature is used to determine the salt application rate.

Discussion

During the winter of 1993-1994, the Vermont Agency of Transportation (VAT) conducted a study that correlated pavement temperature information to the melting capacity of salt. The results of the VAT work has application to this study and in actual winter maintenance activities. Table 14-2 shows the relationship between pavement temperature and pound of ice melted per pound of salt. When pavement temperature falls and the rate of salt application remains constant, less ice melts.

Table 14-2 Melting capacity of salt

Temperature (°F)	Pounds of Ice Melted Per Pound of Salt
30	46.3
25	14.4
20	8.6
15	6.3
10	4.9
5	4.1
0	3.7

The Vermont study, Smart Salting: A Winter Maintenance Strategy, recommended that maintenance crews do two things:

1. Determine pavement temperature before and during a storm through the use of infrared thermometers mounted on vehicles.

2. Utilize salt application rates based on the relationship between pavement temperature, melting capacity of salt, and the thickness of ice or snow on the pavement.

The study generated a graph, or curve, correlating recommended salt application rates with pavement temperatures. Figure 14-1 shows that salt quantities should increase as pavement temperature decreases. The salt quantities shown in the figure are expressed in pounds per lane mile (pplm), a unit commonly used to express salt application rates. An economic temperature range for salting activities was identified from 30° F to 20° F. The Iowa DOT estimates that 75 to 80 percent of Iowa's winter storms occur when pavement temperatures are above 20° F. The study team decided that states would not apply less than 100 pound of salt per 12-foot lane mile.

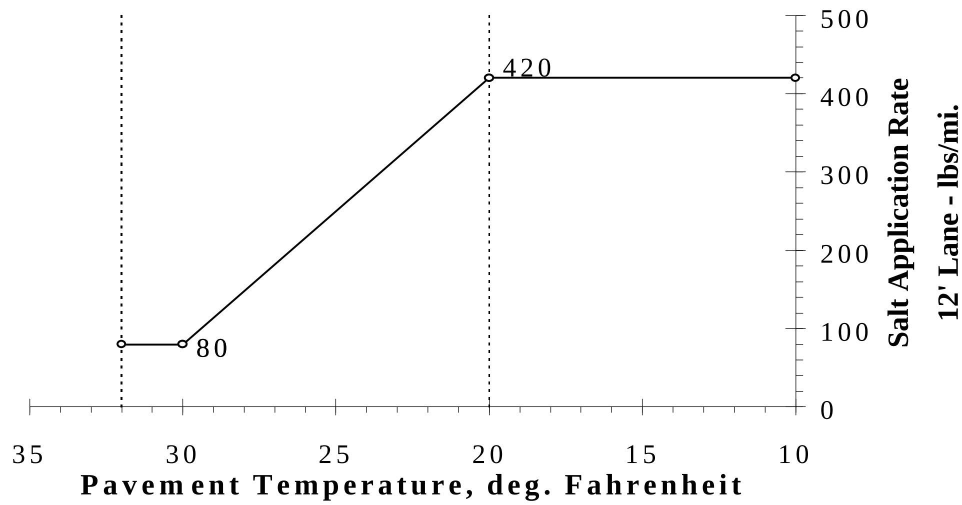

Figure 14-1 Vermont study recommended salt application rate curve

To estimate potential savings in salt usage based on more accurate knowledge of exact pavement temperatures in Iowa, the Vermont curve is applied to current practice in Iowa (i.e., using temperatures from the Roadway Weather Information System, or RWIS) and to recommended practice (i.e., using pavement temperatures all along the roadway as reported by sensors on a moving maintenance vehicle), and material usage is computed in each case.

Figure 14-2 shows a hypothetical pavement temperature plot (thermal trace) that illustrates differences in pavement temperature along a roadway segment as reported by a temperature sensor on a prototype vehicle. (A hypothetical plot is used because actual temperature data were collected by the prototype vehicles only during a non-winter period.)

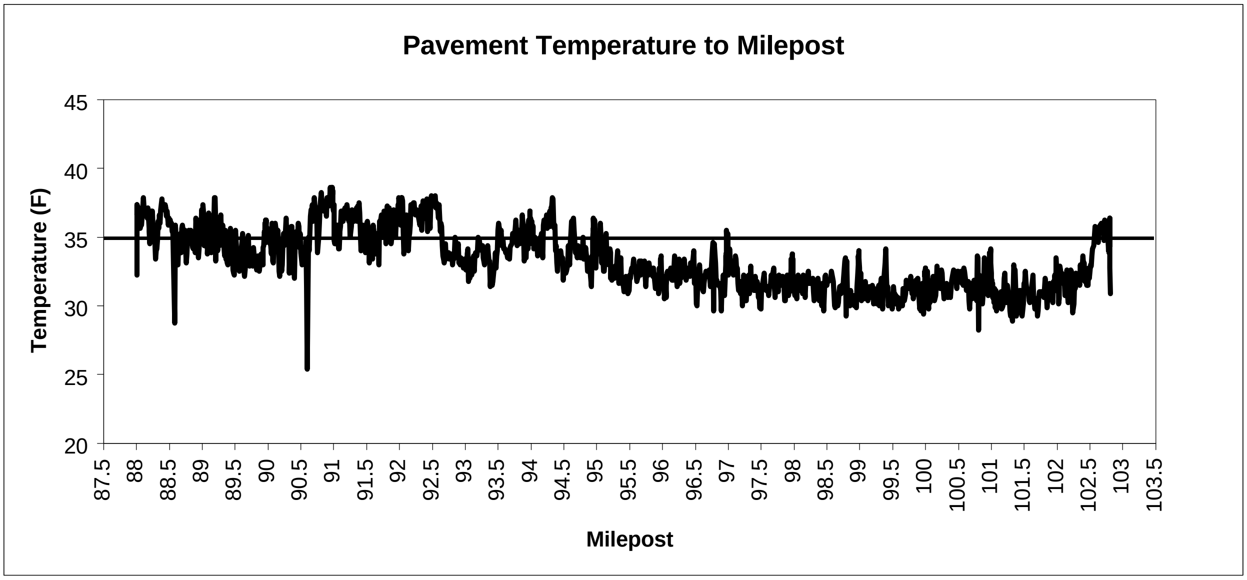

Figure 14-2 Pavement temperature vs milepost

In Figure 14-2, the average pavement temperature is 34° F, but the thermal trace indicates that spot freezing could be occurring on the highway at mileposts 88.5 and 90.5 and at various locations from milepost 95.0 to 103.0.

If the maintenance supervisor in this situation were relying on temperatures from an RWIS, the supervisor would have access only to temperatures reported from the location of the RWIS sensors, or 34° F. If a precipitation event were occurring, the supervisor might decide not to treat the pavement to prevent freezing.   However, most supervisors know their areas well enough to understand that a 34° F RWIS pavement temperature means that some highway spots are well below freezing and require some type of chemical treatment to maintain a non-slippery surface. The response of supervisors to this situation would vary; generally, they would treat the entire roadway but with differing amounts of chemical.

If a supervisor decided to treat the entire roadway based on the coldest spots, an application rate of 250 pounds of salt per 12-foot lane mile would be recommended by the Vermont study. This rate would require 3,750 pounds of salt for the 15-mile run for just one lane. If the supervisor decided to use less than 250 pounds per lane mile, there would be some spot-freezing, resulting in needless exposure for motorists and the DOT. However, if supervisors had access to temperatures all along the roadway, such as those in the temperature trace in Figure 14-2, they could finetune material application rates. Using the thermal trace to adjust the spreader rate according to Vermont’s salt application rate curve in Figure 14-1, the supervisor would apply an average of only 600 to 700 pounds of salt for the same 15-mile, one-lane run.

The challenge of tailoring salt application to ever-changing pavement temperatures is more than most supervisors or equipment operators can handle—unless their truck is equipped with pavement temperature sensing that is integrated with intelligent material application technology. The savings in materials that would result from the application of this advanced technology is obvious: fewer budget dollars to do the job right, less negative impact on the environment, and an increase in winter driving level of service.

When pavement temperature data become available in "real time" and maintenance vehicles have the capability to automatically adjust material application rates based on real-time pavement temperatures, savings such as those described above may be realized. Pavement temperatures, as shown in Figure 14-2, will be integrated with the distribution curve shown in Figure 14-1, and material cost savings will be maximized.

OBSERVATIONS

Knowledge of pavement temperature provides an opportunity to reduce the amount of salt applied during winter maintenance operations. The reduction translates to cost savings. Pavement sensor devices on winter maintenance vehicles can realize maintenance budget savings if the use of such devices results in less salt applied to roadways. In addition, automatically adjusting material applications based on pavement temperatures has the potential to provide drier, safer highways for the traveling public, resulting in improved mobility and fewer accidents during winter weather event, as well as more environmentally friendly maintenance operations.

CONCLUSION

The use of advanced technologies like pavement temperature sensors potentially reduces resources used in winter maintenance operations. By using pavement temperature data to determine salt application rate, less salt may be applied, resulting in cost savings.

Potential savings do need to be compared to the cost of acquiring, installing, and maintaining the technologies. The development costs provided at the beginning of this chapter are not production model costs and should be used cautiously for cost analyses. However, it appears that using pavement temperature to determine salt application rates would provide a cost benefit even if the sensors do not go down in price during production.

In Phase III, a more comprehensive benefit/cost analysis for selected technologies will be conducted.