
# Performance Measures for Snow and Ice Control Operations

**DETAILS**

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# Research Results Digest 335

## PERFORMANCE MEASURES FOR SNOW AND ICE CONTROL OPERATIONS

This digest summarizes the findings from NCHRP Project 6-17, "Performance Measures of Snow and Ice Control Operations." It was prepared by Amir N. Hanna, NCHRP Senior Program Officer, from the contractor's final report authored by T. H. Maze, Chris Albrecht, Dennis Kroeger, and Jon Wiegand of the Center for Transportation Research and Education, Iowa State University. T. H. Maze served as principal investigator.

## INTRODUCTION

This digest summarizes the findings of the research conducted under NCHRP Project 6-17 to identify methods and measures for assessing agency and contractor performance in snow and ice control operations.

Monitoring the performance in snow and ice control operations has become an increasingly important task for highway agencies and contractors because of the limited resources available to highway agencies and the increased outsourcing of these activities. Different performance measures have been used both in the United States and abroad with varying degrees of success; widely accepted measures applicable to different roadway classifications and storm characteristics have not evolved. Such measures are needed to help highway agencies and contractors monitor the level of performance and make adjustments to improve performance or reduce cost, thereby effectively managing resources for snow and ice control operations.

NCHRP Project 6-17 was conducted to identify, using readily available information, the measures used to evaluate the performance of winter maintenance activities (snow and ice removal from roadways) and to recommend the most promising measures for further development.

## PERFORMANCE MEASUREMENT

Transportation agencies often attempt to tie strategic direction and agency mission to performance measures making performance measurement a critical issue. However, performance measurement has not been sufficiently considered by transportation agencies because of two factors:

1. Transportation agencies have historically focused on standards and specifications for physical conditions or level of service (LOS) that were defined based on static standards (although recently, through asset management application, agencies began to treat LOS and conditions as variables against which other financial and condition considerations can be balanced).
2. The recent expansion of information technology and the ease of collecting information made the collection of performance-related data possible and increased the demand for collecting and reporting performance

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information both to the public and policy makers.

Winter maintenance of roadways is a core and critical business element of many state transportation agencies; measuring performance is essential for managing this critical business element.

## Measurement of Winter Maintenance Performance

Standard methods for measuring winter maintenance performance for either agency programs or those performed by contractors are not readily available. The lack of such standards makes it difficult or impossible to benchmark and make comparisons between and within maintenance programs to identify rational management trade-offs between agency costs and user costs. Performance measurement will help winter maintenance managers control and direct activities to achieve best use of available resources and reduce user costs.

Currently, agencies measure winter maintenance performance in terms of one or more of three factors: inputs, outputs, and outcomes.

### *Inputs*

Input measures represent the resources spent or utilized to perform snow and ice control operations. These resources include fuel, labor, equipment use, and materials (anti-icing materials and abrasives). The level of input is directly proportional to agency costs; they are most easily and commonly measured by transportation agencies. However, because inputs are applied at the beginning of the winter maintenance process, they do not provide a measure of efficiency, quality, or effectiveness of the winter maintenance operations.

### *Outputs*

Outputs quantify the physical accomplishment resulting from the work performed using the resources in winter maintenance. Outputs may be expressed in terms of the lane-miles plowed or sanded, the lane-miles to which deicing materials or anti-icing chemicals were applied, or the level of accomplishments of other winter maintenance operations. In contrast to the inputs, outputs help define the efficiency of winter maintenance operations and the level of input required to achieve a specific level of output.

### *Outcomes*

Outcomes generally assess the effectiveness of winter maintenance activity, often from the user or customer perspective. Desired outcomes may include improvements in safety, mobility, and/or user satisfaction. However, these outcomes can only be estimated through measurement of related indicators such as pavement friction or number of crashes. Other measures of outcomes include bare pavement regain time, duration and frequency of closure, advanced warning time to customers, and customer satisfaction as expressed in surveys. Although the methods used for estimating outcomes are often complex, they generally produce results that can be simply interpreted.

## Methods for Measuring Winter Maintenance Performance

Friction has become an acceptable performance measure for snow and ice control operations in Finland and Sweden, and in Japan it was found to correlate to crashes and traffic speed and volume. Different types of friction-measuring devices are available, some of which can be mounted under winter maintenance trucks or towed by a supervisor's vehicle. To understand snow and ice control performance within a network of roadways, the requirements for number of friction-reporting devices and frequency of measurement need to be identified.

In the United States, the time to bare pavement is frequently used as a measure of performance of winter maintenance operations. For example, the Minnesota Department of Transportation(Mn/DOT) measures the time to bare pavement throughout the state's trunk highway systems and sets different levels of acceptable time to bare pavement depending on the level of traffic, such that a shorter time to bare pavement is required on heavily trafficked routes than on lightly trafficked routes. Mn/DOT procedures for measuring winter maintenance performance specify data collection and reporting requirements and include standards for evaluating pavement surface conditions and identifying when it is considered bare.

In general, comparisons within and among jurisdictions require use of a common, reliable, repeatable performance measure together with a specific methodology for collecting and reporting relevant data.

Figure 1 illustrates the relationship among inputs, outputs, outcomes, and environmental conditions. It identifies the environmental conditions that influence

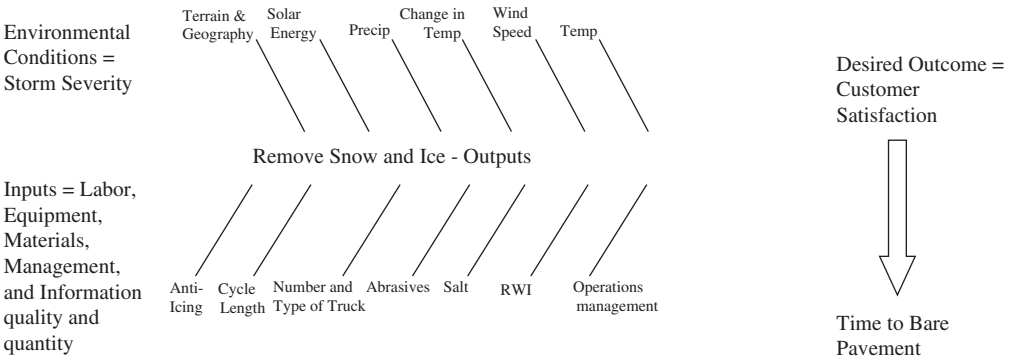


**Figure 1** Relationship between inputs, outputs, and outcomes.

winter maintenance operations (e.g., precipitation, temperature, wind speed, solar energy), the inputs (e.g., labor, equipment, and materials), the outputs (i.e., snow and ice removal), and outcomes as measured by customer satisfaction which is related to the time to bare pavement.

## ASSESSMENT OF PERFORMANCE MEASURES

A survey of winter maintenance practices in the United States, Canada, Europe, and Japan revealed that preferred performance measures are generally those related to accounting and management systems. These measures included length of plowed roadway, expended personnel and overtime hours, used materials and equipment, and cost of operations. Other measures included the time required to achieve bare pavement or to return to a reasonably near-normal condition, duration of lane closure, and expressed customer satisfaction. The survey also found that budget and staffing constraints make it difficult for state and local agencies to experiment with new technologies for measuring performance, such as use of friction meters.

The survey identified 4 input parameters, 5 output parameters, and 11 outcome measures used by public agencies to measure snow and ice control performance (see Table 1). The performance measures and approaches used to measure snow and ice control operations were assessed with consideration of relevant factors. Among the criteria that can be used for assessing performance measures are the ability to directly measure safety, mobility, or public satisfaction; the sensitivity to storm characteristics; and the potential for use in improving snow and ice control operations. The approaches used for measuring the performance measures can be assessed with consideration of such factors as the ability to provide quantified information, the expenditures associated with use, and the ability to provide similar results for different operators/observers.

Using the criteria for evaluating the performance measures and approaches, the 11 outcome measures identified in this research were reduced to 3 basic

**Table 1** Snow and ice control performance measures

**Input measures**

- Fuel usage
- Overtime hours
- Personnel hours
- Percent of salt spreaders calibrated

**Output measures**

- Lane miles plowed
- Tons of material used
- Amount of equipment deployed
- Plow-down miles traveled
- Cost per lane mile (efficiency)

**Outcome measures**

- Time to bare pavement
- Time to wet pavement
- Time to return to a reasonably near-normal winter condition
- Time for traffic volume to return to “normal” after the storm
- Time to provide 1 wheel track
- Friction
- Level of service
- Travel Speed during storm
- Customer satisfaction
- Crashes per vehicle mile
- Traffic volume during storm

categories, and 2 approaches were identified for each, as follows:

- Degree of clear pavement as measured by manual observation or camera-assisted observation;
- Traffic flow as measured by detectors of speed, volume and occupancy or by road closure; and
- Crash risk as measured by friction (slipperiness) or reported crashes.

## CONCLUSIONS AND SUGGESTED RESEARCH

The study provided information on performance measures for snow and ice control operations. Information obtained in the study indicated that winter maintenance agencies are expected to place more emphasis on performance measurement practices. Also, the public will continue to expect clear roads and less harm to the environment from snow and ice control operations. Use of automated vehicle location (AVL), global positioning systems (GPS), friction meters, road weather information systems (RWIS), and other technologies in snow and ice control operations will facilitate obtaining the data needed to enhance performance measurement practices. In addition to adopting performance measurement practices, agencies could establish targets toward which activities can be directed and, where necessary, identify and implement improvement strategies to achieve more effective winter maintenance programs.

Highway agencies are encouraged to conduct field tests for developing a performance measurement program and examine snow and ice control practices. Such tests should account for the inputs used in snow and ice control operations and the outputs achieved from these operations and assess operational efficiency and the extent of meeting expected goals in terms of safety, mobility, public satisfaction, and controlling adverse impacts on the environment.

The information obtained in this project provides a basis for evaluating performance measures used for snow and ice control operations. However, further research is needed to acquire or estimate the data needed for conducting a more thorough evaluation, particularly the costs associated with weather severity and the application of treatment alternatives. Also, research is needed to establish relationships between performance metrics and safety.

## FINAL REPORT

The contract agency's final report, titled "Performance Measures for Snow and Ice Control Operations," gives a detailed account of the project, findings, and conclusions including further information on the current practices regarding the methods and measures used for assessing agency and contractor performance in snow and ice control operations. The report, which was distributed to NCHRP sponsors (i.e., state departments of transportation) is available online as *NCHRP Web-Only Document 136* at http://trb.org/news/blurb/blurb_detail.asp?id=10053.

## ACKNOWLEDGMENTS

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