



Guide for Snow and Ice Control



American Association of State Highway
and Transportation Officials

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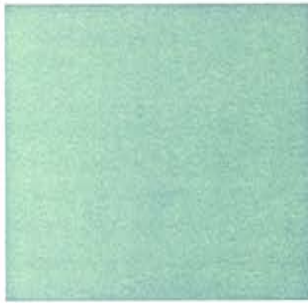
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Summary

State highway maintenance officials recognize that the adoption of a systematic approach to snow and ice control using available technology and research while implementing a proactive decision making process improves service and reduces costs. Snow and ice control is one of the most important functions performed by maintenance forces in many state, county, and local government highway agencies. This winter maintenance function is frequently resource intensive and often strains maintenance budgets. For some agencies, snow and ice control is the single largest line item in the highway maintenance budget.

Recognizing the potential savings and the opportunity to improve winter maintenance in general, the AASHTO Board of Directors, acting on recommendations by the AASHTO Standing Committee on Highways and the AASHTO Highway Subcommittee on Maintenance, approved an administrative resolution in November 1994 establishing a winter maintenance program. One element of this program supports the establishment of a project under the National Cooperative Highway Research Program (NCHRP) to develop a comprehensive guide for snow and ice control. As a result, a comprehensive outline of a proposed guide was developed under NCHRP Project 20-7, Task 71, "Winter Maintenance Program."

In 1998, this *Guide for Snow and Ice Control* was developed under NCHRP Project 20-7, Task 83 based on the outline developed in the earlier project. The authors of this guide used basic snow and ice control concepts and principles as a starting point and suggested new technologies and different and innovative procedures and practices that can help reduce costs and improve service. The guide provides a training tool to help operators, supervisors, and managers select and implement new methods or technologies to effectively and efficiently deal with snow and ice conditions and provide road users with safe conditions and timely information to make trip decisions.

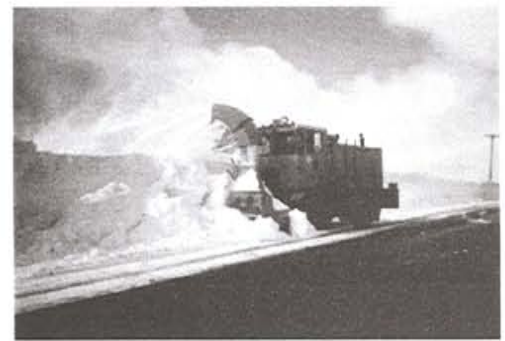


Figure 1. Snow blower operating in New York State.



The guide is not intended to specify any single standard, procedure, material, equipment, or regulation for all programs; rather it provides guidance for organizations responsible for roadway snow and ice control programs by presenting principles and practices for various environmental and operational conditions. The guide discusses state-of-the-art technologies and processes pertaining to snow and ice control for consideration and adoption by AASHTO member departments and other organizations responsible for roadway snow and ice control programs. Some of the material presented in the guide reflects the experience of the authors or are recognized practices that are not necessarily documented in writing. Individual agencies are expected to implement practices and procedures that allow them to provide the level of service established in agency policies and guidelines.

Characteristics of this Guide

This guide has been developed for use by organizations responsible for roadway snow and ice control programs, presenting principles and practices for various climatological, environmental, and operational conditions. The guide also provides concepts, processes, and references that may serve as a checklist and resource for agencies developing and refining a comprehensive snow and ice control program. The terms *roadways*, *highways*, *roads*, and *streets* are used throughout the guide with the intent that policies and procedures discussed in the guide are usually applicable to all levels of jurisdiction.

The guide contains ten chapters organized in a systematic fashion to provide insight into the components of a snow and ice control operations and management. Chapter 1 discusses the purpose and principles of a winter snow and ice control maintenance program, including agency responsibilities to their customers and accountability. It provides an overview of environmental considerations, describes the impact of weather on roads, and concludes with a discussion on the importance of new technology and innovation in improving snow and ice control.

Chapter 2 describes the need for good communications. Communications within an agency are crucial, but are also important with the public, media, and other agencies. Chapter 2 also describes the development of policies and procedures to establish a level of service (LOS) and the means to attain that level, the importance of monitoring agency performance, and methods for assessing performance.

Chapters 3 through 5 discuss the topics of labor, equipment, and material (LEM) respectively, as related to snow and ice control. Chapter 3 details the importance of good, comprehensive training

programs; discusses general personnel management issues, options, and concerns for establishing duty schedules; describes compensation issues for winter work forces; and includes a brief discussion of substance abuse. Chapter 4 covers equipment issues, including the types used for on-the-road operations, support systems, maintenance requirements, and equipment acquisition. Chapter 5 describes snow and ice control material (abrasives and chemicals) acquisition considerations, including storage, handling, and inventory of such materials as well as issues associated with the use of appropriate materials for various weather and pavement conditions.

Chapter 6 provides insight into the development and applications of weather information, specifically road weather information system (RWIS) information for snow and ice control. It points out that the knowledge of expected weather and pavement conditions can provide snow and ice control decision makers a tool to manage LEM more efficiently and effectively, and provide a better level of service or an established level of service at potentially reduced cost.

Chapter 7 describes the conduct of snow and ice control operations, including pre-storm preparation, during-the-storm operations, and post-storm activities. Chapter 8 continues the discussion of storm operations by presenting a concept of total storm management. Although used primarily for anti-icing, the total storm management concept can be used for all snow and ice control strategies.

Chapter 9 gives insight into safety and liability issues that need to be considered when developing agency snow and ice control plans and procedures. Safety is discussed in terms of both road users and maintenance crews. Material is presented from a fleet safety standpoint. Liability and risk management issues are discussed, including references to helpful materials for use in a safety program. Finally, Chapter 10 describes special topics, such as road design for maintainability and dealing with special hazards, and reiterates the need to consider environmental issues.

The guide includes three appendices that provide supplemental information, including:

- ❖ a comprehensive bibliography of publications of interest to snow and ice control professionals to help managers develop policies, guidelines, and procedural manuals;
- ❖ examples of processes and procedures that can be used by roadway maintenance agencies such as a suggested training curriculum, sample contract for snow and ice control services, sample public information release, spreader calibration procedures, vehicle maintenance checklist, and examples of

materials available from Local Technical Assistance Programs (LTAP) Centers;

- * sample material and equipment specifications that can be used by roadway maintenance agencies.

In addition, a list of references used in preparing the guide is located at the end of each chapter, although readers are encouraged to continually check for new information regarding snow and ice control management and practices.

The guide is a useful resource for winter maintenance program administrators, managers, and operators, and a tool for training winter maintenance personnel. This guide is a “work in progress” and will be revised as new technologies and innovations become available.

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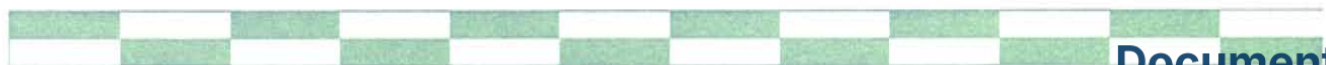


Purpose and Principles of a Winter Maintenance Program

Snow and ice control is a critical part of many highway maintenance agencies, but only one element in a complete winter maintenance program. In some agencies, snow and ice control is the largest single-line item in highway maintenance, determining budgetary allocations for the number of personnel, types of equipment, and materials to be used based upon anticipated needs for the coming year. Additional winter maintenance may also include pothole and damage repairs, drainage cleaning, debris removal, brush removal, facility inventory and condition assessments, certain types of bridge work, fabrication of units for summer work, and equipment maintenance. As a result, transportation agencies are typically responsible for:

- * creating and maintaining common transportation facilities (roadways, bicycle and pedestrian paths and sidewalks, airfields and runways);
- * resources committed and responsibilities undertaken in snow and ice control programs;
- * safety and well being of people using and maintaining transportation systems;
- * environment surrounding transportation facilities;
- * ensuring mobility and connectivity, and
- * national defense.

In addition, winter weather has a direct impact upon local and national economies. A Federal Highway Administration spokesman highlighted the urgency of snow and ice control when he stated that "highways are the warehouses of industry." Manufacturers, wholesalers, and retailers rely on surface transportation to deliver parts, commodities, and goods to the point of manufacture or sale when needed. Industry and commerce can grind to a halt if these



“just-in-time” deliveries, a practice employed by 45 percent of industry, are delayed or cannot move.

Impact of Winter Weather

The economic impact of effective snow and ice control is not well documented, however, the impact of a lack of snow and ice control, as well as the activities themselves, is well understood. Studies in Sweden and the United States indicate that snow and ice control activities significantly reduce accident rates. Winter weather is also responsible for increases in travel time, fuel consumption, and insurance costs as well as decreases in mobility and throughput on the roadways, and productivity and commerce in general.

Climate and Weather

Climate is the weather of a locality averaged over a time period (usually thirty years) plus statistics which include extremes in weather behavior recorded during that same period or even an entire period or record. Climate can vary over small areas, such as in the Pacific Northwest where rapid transitions in elevation and proximity to water sources change precipitation patterns drastically. Climate can also be similar over large areas such as states or regions.

Planning and budgeting for snow and ice control require knowledge of the climate. A typical winter can usually be defined in order to establish resource requirements. Different winter indices, specially calculated climate variables, have been developed to help managers assess their needs and perhaps to explain overruns. However, the wealth of experience of the people within an agency also can be used to establish a similar baseline for a particular climate.

Weather, in contrast to climate, is the state of the atmosphere at a given time. Weather can be expressed terms of temperature, humidity, precipitation, and wind. It can be thought of as a collection of phenomena that affect nature, such as tornadoes, thunderstorms, precipitation, or obstructions to vision.

For snow and ice control, weather provides both atmospheric conditions and resultant pavement conditions. Snow and ice control personnel have to deal with snow accumulation on roadways, as well as the formation of black ice, frost, and snow pack. Weather indirectly causes the problems, whereas pavement temperature contributes directly to ice or snow bonding to pavement. Additional discussion of the affect of weather on road conditions is provided in chapter 6.



Objectives of Snow and Ice Control Programs

Policy Guidance for Program Planning

All agencies responsible for snow and ice control should have written policies and guidelines that document the intent, capabilities, and procedures of their snow and ice control program. Such policies provide a common understanding between customers and the agency of what can be expected when weather and pavement conditions warrant implementing the snow and ice control activities. Guidelines provide the managers and operators with a basis for conducting specific operations under certain conditions, such as safety guidelines for using equipment and post-storm clean up. An effective snow and ice control program should include:

- * a vision of the goals and expectations, including the level of service that should be documented in agency policies and guidelines used as a basis for all planning and snow and ice control operations;
- * assignment of priorities for snow and ice control resource allocations and maintenance activities to achieve the established service levels;
- * fiscal accountability to the users/stakeholders/providers of funds (elected and appointed officials and the public) to ensure that agencies use labor, equipment and materials efficiently and effectively in achieving the service level goals;
- * understanding of legal responsibilities and constraints with respect to snow and ice control;
- * protection of the environment through wise use of chemicals and abrasives to minimize the impact on soil, vegetation, water, animals, and the infrastructure;
- * education of the public to ensure understanding of the capabilities and limitations of snow and ice control, thus creating a positive relationship and fostering public support;
- * willingness to implement changes and innovations to improve operations by adopting technological advances in equipment, chemicals, and methods for improving the conduct of snow and ice control.

It is important to gather a variety of input when developing policy. Policy development and periodic review should be a cooperative and participative process with involved parties, including

customers, media, highway agency management, equipment operators, contractors where applicable, and other agencies responsible for emergency management services, travel, and tourism. Policies must be practical and achievable. Serious liability concerns arise if the policy promises more than what can be delivered under all conditions. In addition, all employees need to know and understand adopted policies. A coordinated policy, agreed upon by the agency and its customers, will stand the test of time and bad weather incidents.

When developing the policy, it is difficult, but necessary, to consider the balance between cost, public and operational safety, and environmental issues. Budgetary constraints increasingly become a center of focus, while the customers seem to demand more service. Yet more service, especially dealing with snow and ice control and de-icing chemical applications, can potentially impact the environment. The policy must clearly define reasons for conducting (or not conducting) certain activities.

Environmental Considerations

Managers and operators need to maintain a special environmental awareness and sensitivity in the use of chemicals and other products and procedures for snow and ice control. Special consideration needs to be given to:

- *controlling runoff from roadway applications;
- *proper storage of chemicals and abrasives;
- *protecting groundwater, including wells and aquifers;
- *protecting vegetation;
- *protecting maintenance facilities and equipment against weather, corrosion;
- *protecting transportation facilities (bridges, pavement, appurtenances) against corrosion;
- *protecting employees from the potential dangers associated with snow and ice control materials; and
- *minimizing air quality and highway safety impacts associated with the use of abrasives;
- *minimizing the effects of traffic congestion and studded tire dust on air quality;



- * protecting surface water quality;
- * protecting habitat quality; and
- * coordinating with permitting agencies, e.g., Metropolitan Planning Organization, National Forest Service, and local departments of ecology and natural resources.

Level of Service

Because of the need for continued mobility and safety on the roads, it is important that snow and ice control programs establish a level of service that satisfies the customers and is attainable with available budget and resources. Level of service (LOS) refers to operational guidelines establishing maintenance activities associated with the prevention and removal of snow and ice from roadways. LOS may establish a prescribed end-of-storm condition, intermediate stages acceptable while obtaining that condition, or the frequency of snow and ice control maintenance operations. LOS results from an analysis of:

- * agency snow and ice control policy;
- * road classifications;
- * traffic data;
- * maintenance coverage time periods defined for various operations, including clean-up operations;
- * equipment types and amounts;
- * location of facilities;
- * personnel rules and regulations;
- * materials used; and
- * special circumstances and conditions.

Examples of levels of service, compiled from different agencies, are shown in table 1. Although a suggested description of road condition is given for each road classification, some agencies prefer to specify only the coverage time periods for snow and ice operations.

Table 1. Examples of Levels of Service for Highways, Roads and Streets

Classification	AADT (Veh/Day)	Hours per Day of Snow and Ice Control	Levels of Service
Super Commute	30,000 +	24	All lanes will have substantially bare pavement before coverage time is reduced
Urban Freeway	Regardless of Volume	24	All lanes will have substantially bare pavement before coverage time is reduced
Urban Commuter	10,000 - 30,000	24	All lanes will have substantially bare pavement before coverage time is reduced.
Urban Arterial Street	5,000-30,000	24	All lanes will have substantially bare pavement before coverage time is reduced
Rural Commuter	2,000 – 10,000	20	The right lane on divided roadways and both lanes on two lane roads will have bare wheel paths with intermittent bare pavement before coverage time is reduced. The left lane on divided roadways will have intermittent bare wheel paths with chemically treated or sanded hills and curves.
Urban Collector Street	500-5,000	18	75 % Bare Pavement (St. Louis, MO Co.)
Primary	800 – 2,000	18	Both lanes will have intermittent bare wheel paths with chemically treated or sanded hills and curves before coverage time is reduced.
Urban Residential Street	200-500	12	75 % Bare Pavement (St. Louis, MO Co.)
Secondary	Under 800	12	One wheel path in each lane will have intermittent bare pavement with chemically treated or sanded hills and curves before coverage time is reduced.
Suburban or Rural Residential Street	Under 200	12	75 % Bare Pavement (St. Louis, MO Co.)

For example, the LOS for the Colorado Department of Transportation is twenty-four-hour coverage for roads with more than 2,000 vehicles on average daily, and fourteen-hour coverage for roads with less than 2,000 per day. Determinations of attainment or non-attainment of LOS is based on visual observations of pavement conditions by either operators or supervisors.



Innovation in the Organization

It is important that managers and supervisors at all levels foster a culture of innovation within the organization. The organization, not just individuals, should be receptive to change by evaluating and perhaps implementing new technologies and methods. The organizational culture should proactively seek progressive changes — changes that improve processes, reduce resource expenditures, or both.

Ideally, the organization should possess a commitment to a continuous improvement in the quality of its work. Although top management support is essential for implementation of innovation, the entire organizational structure should be involved in the implementation process. This can be accomplished through periodic meetings of managers, supervisors, and operators, and recognizing and rewarding innovators for efforts to improve the effectiveness and efficiency of the organization. Quality initiatives, such as quality circles and total quality management can assist in solving local problems.

Innovation needs to be encouraged and recognized as a positive way of improving service to the customer. This process will require an acceptance of prudent risk-taking, and the recognition of the potential for occasional failures as the price of progress.

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2

Administration and Management

Communications

Effective communication is the key to the success of any organization. The priority/emergency nature of snow and ice control operations makes communications within and between maintenance organizations, adjacent maintenance providers, other impacted organizations, and the public even more critical.

The magnitude and complexity of communications systems usually depends on the size and resources of the maintenance organization. For example, truck-to-dispatcher/supervisor radio communication and telephone/fax communication between the dispatcher/supervisor and other interested parties may be adequate for a township with limited responsibility. However, an operations center with remote monitoring capability for equipment location, road and weather conditions, video traffic displays, etc., may be a more appropriate communications configuration for a state highway agency or large municipality with significant responsibility.

Internal Communications

Internal communications systems link the entire organization, from the crew level to the CEO. Integration of crew-level communications with supervisory- and management-level communications is vital to the coordination of emergency road operations. Supervisors need to know the locations of road crews, equipment, and current status of various operations in order to provide guidance and direction to crewmembers. Managers generally need to know anticipated weather conditions, progress of crewmembers, approximated cost of operations, significant incidents, road closures, traffic movement problems, and the estimated time to complete various operations. This information is required for management decisions, but can also be valuable to other interested parties, such as emergency managers and the



traveling public. Coordination of work at crew or jurisdictional interfaces is also very important. Abrupt changes in the snow and ice level of service can be a hazard to motorists.

For organizations that staff trucks with only one person, crew-level communications are particularly important. Snow and ice operations are physically demanding, sometimes performed alone in remote areas, and are potentially dangerous. At the crew level, the ability to communicate on matters of public safety, accidents, incidents, work coordination, personal safety, weather conditions, road conditions, and work progress is absolutely vital.

Team Building

Team building and recognition is often forgotten in the communications process. Most snow and ice control personnel exhibit a high level of commitment and knowledge. They should be routinely recognized through formal programs or a simple "well done" from their supervisors. Allowing workers to participate in policy development, planning, equipment acquisition, and work evaluation activities, if done positively, has training and team building value.

External Communications and Customer Considerations

External communications, often overlooked as an aspect of snow and ice control programs, can pay huge dividends in terms of public, political, and media support; public safety; institutional knowledge; operational cost; and operational effectiveness.

Communicating With the Public

Communication with the public is becoming more important as traffic volumes and communication methods increase. A well-informed public, coupled with customer-friendly service, is key to a successful snow and ice control program. Weather bulletins, press releases, and other public announcements emphasize the road users' responsibility to drive safely and appropriately for the conditions they encounter or can expect.

Effective dealings with the public also include "good neighbor" initiatives. Examples of efforts that can foster good relationships include:

- ❖ *Environmental Issues.* Effective pollution control at facilities is a must. Keeping ice control chemicals out of the surrounding environment prevents poor public trust and law suits. The

proper collection, treatment, and disposal of wash water, waste oils, engine coolants, and other waste substances are just plain good business practices.

- ❖ *Outreach.* Open houses and other community outreach programs are effective means to communicate the objectives and limitations of the maintenance programs. Depending upon the agency and community, snowplow competitions or rodeos might be suitable activities for open houses, building public confidence through demonstrations of operations and safety skills while providing valuable internal training. Public information brochures help establish an understanding of the purpose for snow and ice control and set the level of expectation for the winter.

Staff representing the maintenance organization, police, and emergency services agencies are effective outreach teams in communicating safety and policy information. Target audiences include such civic and community groups as automobile clubs (e.g., AAA), Kiwanis, Rotary Club, Veterans of Foreign Wars (VFW), Daughters of the American Revolution (DAR), Lions Club, Parent Teacher Associations (PTA's), churches, schools, volunteer fire organizations, and fraternal organizations. Maintenance organizations that have instituted outreach programs have seen a reduction in the number of service complaints.

- ❖ *Facility Appearance.* Maintenance facilities that have an acceptable appearance and do not pollute the environment are more likely to be appreciated by neighboring residents and the public. The nature of transportation maintenance requires the storage of equipment, fuel, aggregates, abrasives, ice control chemicals, scrap, waste products, metal, traffic protection devices, and other materials. Areas providing external storage should be kept neat, while scrap and other visually displeasing items should be screened to the extent possible. While there may be few choices in the facility structures, they should be securely fenced, well maintained, and painted. Landscaping can add significantly to the appearance of a facility.
- ❖ *Driving Schools.* Contacting driver training schools to ask them to emphasize winter driving hazards and techniques as winter approaches is a good means for encouraging safe driving and for appreciating snow and ice control efforts.

Communicating With the Media

Effective communications with the media has high customer service and public-relations value. The media can make or break a maintenance organization's image. By making the media part of the snow and ice control team (as well as construction and maintenance efforts), information on winter road conditions, weather data, and highway operations can be swiftly communicated to the public. Work with the media to convey information on:

- * snow emergency regulations;
- * use of studded tires;
- * tire tread depth regulations;
- * preparing vehicles for winter;
- * winter driving techniques;
- * interacting with snow and ice control equipment;
- * driveway policy;
- * sidewalk clearing policy;
- * damage caused by snow and ice operations (policy);
- * snow removal policy;
- * treatment procedures;
- * priority and policy;
- * new technology; and
- * driver responsibility and courtesy.

The media need to understand policies and operations. This can be accomplished through media days, open houses and snow rodeos, pre-season briefings, participation in policy development, and timely communication of accurate weather data, highway conditions and the status of operations. Agency spokespersons should be available to provide information on maintenance activities throughout the year, not just during snow emergencies.

If an operations center is in use, allowing media access to automated real time video data, weather data, traffic data, and pavement data enhances communications. There may be concerns associated with the release of this information, such as having media and road users

attempting to interpret data. Nevertheless, a maintenance agency that has a reasonable written policy for responding to the data and makes a good-faith effort to adhere to the policy should experience few legal problems. Periodic, timely, and accurate news releases or bulletins from the operations center by faxing information to a pre-selected phone list or posting it on a web site is another good way to communicate with the media/public.

Communicating, Coordinating, and Cooperating with Customers

Before determining how to communicate, coordinate, and cooperate with the customers of snow and ice control service, an agency should target its constituency and potential clients. A listing may include:

- * commuters;
- * users of school bus, transit and rail systems;
- * emergency services such as medical, fire, and police;
- * neighboring snow and ice service providers;
- * business travelers;
- * trucking companies and shippers (warehouses on wheels);
- * customer-oriented community businesses (health care, manufacturing, emergency and human service providers);
- * motor vehicle insurance industry;
- * inter-jurisdictional travelers;
- * food production industry;
- * recreational travelers;
- * media; and
- * automobile, motorcycle, and trucker clubs and associations.

With this broad a constituency, effective communications is a challenge. A good way to start is to bring representatives of this community into the planning and policy development process. They can also be recipients of the news bulletins, informational brochures, and releases described above.



Customer Input. It is very difficult to obtain input from the traveling public. Market research through questionnaires (oral, phone, e-mail, or written) is sometimes used to elicit public opinion. This is a science within itself and questionnaires should be designed and evaluated by people who are trained in this area. The goal of snow and ice market research and customer representation should be to obtain customer reaction and input relative to costs and benefits, level of service, operational policies, and communication effectiveness. Other market research tools include public hearings, local access cable TV channels, telephone hot lines, and as noted above, community outreach activities. Pre- and post-season meetings with representatives of the various customer groups can also provide valuable input and insights.

Another concept in the customer input process is to have the traveling public be part of the snow and ice control team. Customers can assist by not driving or parking on the roads while snow and ice operations are underway. They can communicate weather conditions, road conditions, requests for service, and complaints through hot lines, Internet web sites, and other similar forums. If these forums are used, it is vitally important to have investigations and follow-up responses to complaints or requests for service. Volunteers to staff phones and assist in other support activities can also be solicited from the public.

Communication with Customers. It is difficult to convey relevant highway and weather information to customers since no single forum will reach everyone. In addition to the media, other viable forums include web sites, customer groups, highway advisory radio, variable message signs, public access television, weather band radio (cooperation with the National Weather Service) and information displays such as computer touch screens or kiosks at rest areas, truck stops, and other establishments along the roadway.

Coordination of Activities. Coordination and cooperation activities range from local operational issues to multi-state corridor issues. At the local level, there needs to be coordination with adjacent maintenance jurisdictions on traffic and level of service issues, weather information, road closures, and available resources. Coordination with public transportation interests helps to ensure sufficient capacity and movement. Coordination with emergency services ensures mobility on priority routes and access to incidents that may require road treatment.

Command and communication centers in large jurisdictions perform data gathering, analysis, and dissemination tasks. These centers usually have operational representatives from other customer or service organizations to assist in coordination efforts. They also provide information to the media through a variety of communication methods. In smaller jurisdictions, this function may

be performed by a dispatcher/supervisor using radio communications with operational forces and telephone/fax communications with other interested parties.

Corridor-based or regional communications centers are being established in many areas. Here, a major highway (such as an interstate) and many parallel and perpendicular roadways throughout a fairly broad area are visualized as a highway transportation system, regardless of political boundaries. The intent is to inform travelers of situations well in advance, manage traffic flow by using alternate routing, and assure that necessary snow and ice control activities are performed in a timely and adequate manner.

Technology Transfer. Agency participation in forums sharing new technology, innovations, operational procedures and management techniques ensures that policies and procedures are as cost-effective job as possible. Maintenance agencies should attempt to participate in forums such as:

- * American Public Works Association;
- * National Association of County Engineers;
- * Local Technical Assistance Program (LTAP) centers;
- * Transportation Research Board;
- * American Association of State Highway Transportation Officials;
- * Circuit Rider Program (Minnesota); and
- * associations of various local government officials.

Operational Requirements and Policies for Snow and Ice Control

From the snow and ice control perspective, one of the most important things a political entity can do is to have a reasonable, written snow and ice control policy and to adhere to the terms of that policy. As indicated earlier, the development of policy should be a participative process. The policy should also be a "living" document that is reviewed and updated at least annually.



Level of Service

The most important policy issue pertaining to the application of snow and ice control treatments is level of service (LOS). Here, the policy makers have to balance cost, environmental impacts, the safety of the highway users, and the safety of the people performing snow and ice control operations. If that policy is reasonable, and the agency follows that policy to the extent possible, there will be very little successful litigation involving slippery roads or facilities.

Level of service may be defined in a number of ways. The most common method is to define the level of effort and/or the sequence, priority, and type of treatment at various locations for particular storm types. Another common technique is to define level of service in terms of results by evaluating the surface condition of a particular road (bare, a specified level of friction, passable, snow covered, maximum snow accumulation, wheel track bare, plowed, sanded, etc.) at specified times during and after the storms. This method may be less desirable as it usually does not account for the impact of severe weather conditions.

Priority of Treatment

Policy makers have many options to consider when deciding on the priority and type of treatment, including:

- * traffic volume;
- * functional classification of the street or highway;
- * plan and profile characteristics;
- * known problem areas;
- * school bus routes and schedules;
- * transit routes;
- * medical, police and fire facilities;
- * major sources of traffic at various points in time; and
- * storm history and storm type.

The policy must be flexible enough to allow for changing conditions and higher priorities. Weather can change rapidly and unexpectedly; traffic patterns vary over the course of a day and day-to-day; and emergency situations can develop any time, anywhere.



Types of Snow and Ice Events

Depending on the local climate, there may be thousands of types of snow and ice events. In terms of resource requirements, the list is much shorter and more general. We will try to define the important characteristics associated with snow and ice events and how they impact resource requirements and strategy.

Ice content, water content, or density can impact material requirements (type, amount and cycle), plowability, and compactability. Generally, higher density events such as freezing rain and sleet provide the most challenging road conditions. In contrast, cold, light fluffy snow is among the lowest density.

Event intensity is the rate of accumulation of the snow or ice. High-density events with rapidly accumulating precipitation are extremely difficult to deal with. Wind can be a significant contributor to the intensity of an event

Air temperature often influences the character of the snow or ice event and determines the direction of pavement temperature changes. Higher density and higher intensity events usually occur in the warmer temperature range. Pavement temperature will generally track air temperature at a delay of several hours (absent significant radiation, geo-thermal, and to some extent, traffic effects).

Wind direction and speed (natural and traffic generated) has many influences. The most recognized impact is the blowing and drifting of snow. Wind can also mix the air so that "pockets" of cold air, which would cause frost or black ice, do not accumulate. When spreading materials, wind must be taken into consideration so the materials end up where they were intended. Wind can also decrease pavement temperatures more rapidly through evaporative cooling and by slightly accelerating the heat exchange between the pavement and the air.

Traffic volume, speed, and character impact snow and ice control operations. Traffic-generated wind can cool the pavement and displace snow and ice control chemicals and abrasives. The mechanical agitation and impact of tires can help ice control chemicals work more effectively. Small increases in pavement temperature are associated with tire friction and radiation from engine/exhaust systems. Traffic congestion and reduced speed can impact the progress of snow and ice control operations. Point sources of traffic may require some form of priority snow and ice control measures.



Sky and solar radiation can increase pavement temperature to a level well above air temperature. Ice control chemicals work well with warmer pavement temperature. Cold night sky radiation can decrease pavement temperature below air temperature, an important factor when there is potential for frost or icing.

- ❖ *Pavement temperature* is arguably the single most important factor in snow and ice control operations. It dictates how well ice control chemicals will work and whether or not snow and ice will bond to the pavement.
- ❖ *Moisture sources*, such as lakes, rivers, oceans, cooling towers, industrial steam and vapor discharge, increase the moisture content or relative humidity of local air. Under these conditions, ice will form in the absence of liquid precipitation when pavement or bridge temperature is at or below the freezing point. Larger lakes and oceans can actually generate rain and snow (lake effect storms) if the wind and temperature regimens are right.
- ❖ *Cold spots* represent special atmospheric conditions that cause certain road surfaces to freeze or become slippery before other pavement surfaces. For example, in autumn, bridge decks usually cool more quickly than surrounding pavement since the ground temperature warms the adjacent pavements. In the spring, the process reverses and bridges warm more quickly than the surrounding pavements on cold earth. Many bridges have moisture sources associated with them making them susceptible to frost or ice. Low spots where cold air can pool and areas shaded from the sun can also be colder than surrounding areas.

It is important to incorporate these factors into effective strategies. For example:

- ❖ At certain times, various locations will require treatment immediately before peak traffic periods to assure traffic safety and operational efficiency.
- ❖ In urban areas, during peak flow periods in high volume areas, equipment can become gridlocked in traffic. Treatment is required in advance of these times. Shift changes might also be appropriate at these times if crews can get to work.
- ❖ Larger accumulations of snow or ice on the road between treatment cycles require more ice control chemicals to prevent critical dilution and bonding (unless the pavement is very warm).

- ❖ Cold and moist spots require priority treatment as most drivers are unaware of the potential for heightened slipperiness.
- ❖ Light powdery snow on a cold pavement or light snow on a warm pavement may require no ice control chemical treatment.
- ❖ If plowing is unlikely, fewer human and equipment resources need to be used.
- ❖ In very limited visibility situations (white outs), it may be safer to remove equipment from the road.

Although this list is incomplete, it should provide enough examples to get a general idea of how characteristics associated with snow and ice events can be reflected in strategic and operational policy.

Performance Measures

Snow and ice control is evolving from an art form to an engineering science. The ability to generate, transport, and analyze huge amounts of data has been evolving concurrently. The marriage of the science and data analysis into data-driven, performance-based management opportunities has made snow and ice control operations more efficient and effective. As a result, performance measures are becoming part of many snow and ice control management systems.

Establishing meaningful performance measures for snow and ice control work is a difficult task that must consider weather, traffic, equipment, available snow and ice control materials, budget resources, training, work rules, and overtime compensation. Over time, these items will become more definable and there is no reason not to move toward a performance based system.

One of the most common measures used to establish a performance-based system is the cost to perform various snow and ice control tasks, including:

- ❖ plowing snow;
- ❖ spreading abrasives;
- ❖ spreading ice control chemicals;
- ❖ patrolling;
- ❖ spot treatment;

- * benching or shelving (removing the top portion of a snow bank alongside a road with a wing plow);
- * mechanical (non-chemical) snow and ice removal;
- * loading and hauling;
- * clearing drainage facilities;
- * clearing safety features; and
- * thawing culverts.

For similar conditions, the cost of these tasks can be established by unit of accomplishment (lane-kilometer, kilometer, etc.) at the crew level and summarized for various internal jurisdictional levels.

Minnesota Department of Transportation uses a performance index which is computed by dividing the amount of time a pavement is less than 95 percent bare by the duration of a winter event. A high index would indicate poor performance because of little bare pavement over perhaps a short-duration event. Conversely, a low index indicates good performance. For example, ten hours of less than 95 percent bare pavement for a ten-hour event produces an index of 1, while one hour of less than bare pavement for a ten-hour event produces an index of 0.1. Other performance measures examples include:

- * accomplishment per unit of time;
- * time from end of event to various pavement conditions (bare, wheel track bare, specified friction number, etc.);
- * speed of travel in relation to posted speed limit; and
- * some index of customer satisfaction.

Once appropriate performance measures for an agency are chosen and implemented, they can be used in a variety of management applications. Performance measures can establish a basis of payment for contract performance of snow and ice tasks. They can also serve as a basis for performance and fiscal comparison between agencies, contractors, contract forces, agency crews, and zones or regions.

Performance Analysis

Performance analysis (storm specific and seasonal) is a valuable management tool used to assure continuous improvement and

justify resource investment. This should occur at all levels of a snow and ice control organization (crew to executive management). There are a number of tools and techniques that can assist in developing a performance analysis program.

Accident Analysis

Accidents are a definitive measure of snow and ice control performance. Since accidents are statistically rare occurrences, they are not easy to analyze. Many states have monetary thresholds above which accidents have to be reported, but many snow and ice incidents fall below this threshold and are not reported. Accidents that are reported are usually the most serious and include extensive property damage only (PDO), injury accidents, and involve fatalities.

Snow and ice accident data may be sorted by the pavement surface condition description on the accident report (snow, ice, slush, etc.). Analysis should go beyond this key to see if other factors (drug and alcohol, physical impairment, and other traffic law violations) were involved. Accident analysis is particularly useful when deciding on level of service priorities and evaluating changes in snow and ice control procedures and policy.

After-Action Reports and Performance Analysis

Analysis of resource investment, storm type and duration, and results are useful when evaluating the continuous improvement of work crews and other units, materials application policy, operational response procedures and resource levels. This is a very important management tool, as data can be discussed and analyzed at the crew level, gathered from work locations, and sent up through channels in larger maintenance organizations. The data gathered in this manner are useful in judging the performance of work units, contractors, managers and supervisors.

Management Debriefings

Anyone having a stake in snow and ice control operations should be part of pre-season, post-season and post-storm briefings and debriefings. Participants can include:

- * agency field and central office managers;
- * police (local municipal, county and state);

- * other emergency services such as fire, and emergency medical personnel;
- * National Guard;
- * contiguous agencies;
- * road user groups;
- * business community; and
- * emergency management personnel.

Strengths, weaknesses, and outcomes can be discussed along with suggestions for improvement. If additional resources are not available, better use of existing resources and cooperative ventures should be explored. The role of all parties in routine and severe incidents should be clearly defined and agencies must follow up these discussions with action. Periodic simulated exercises of emergency actions are helpful in preparing for the real thing.

Public Information

Performance analysis data can be used to provide information to the media and the public. Resource consumption and various performance indicators can be reported periodically and appear in annual reports or seasonal summaries. In this context, it is particularly important that the data be understandable, accurate, and supportable. Any changes in policy and procedures resulting from performance analysis can be shared with the public.

Record Keeping

Management decisions are increasingly based on data and data analysis. In snow and ice control, it is important to continuously record and analyze data on treatment, location, time, road and bridge conditions, weather and storm conditions, materials use, equipment use, personnel use, operational problems, cost, policy breaches (and their reasons), and measures of effectiveness. This is true regardless of contract or in-house crews are performing snow and ice control operations.

The most important document in this process is the trip ticket, the work report, or the duty record that is maintained by individual operators. Most of the data listed above originate on this record. Some automated record keeping capability exists in automatic spreader controllers and GPS/GIS systems, but these are not

currently in widespread use. Collecting and managing good data will help accomplish:

- * development of snow and ice control plans and policies;
- * record of activities for tort liability claims;
- * performance monitoring;
- * benchmarking procedures; and
- * training program development.

Bench Marking

Bench marking is the setting of performance standards, fiscal standards, or goals based on data-driven criteria that are proven, reasonable, and achievable. Defining, in measurable terms, the accomplishments of individuals, crews, groups, external agencies, and contractors who appear to be performing the task well develops the criteria. The same things that make it difficult to establish snow and ice performance measures have to be considered when establishing benchmark goals and standards.

The ability to collect and analyze meaningful data is critical to work management. The routine acquisition and recording of cost and accomplishment data is critical to the success of any management system. There are a variety of proprietary and in-house computer-based work management and work order systems being used. It is best to choose one that adapts well to the particular needs of the user. When the system is operating properly, there are several advantages to this approach, including:

- * improved monitoring and evaluations of assignments;
- * accomplishment levels that can be set and evaluated;
- * determination of the cost of any task or operation;
- * performance-based budgets that can be developed and analyzed; and
- * identification of the impact of budget shortfalls in real terms.

Factors That Influence Performance

Resource Requirements

Once the desired level of service is determined for the various components of the highway system, the necessary levels of personnel, equipment, and materials can be determined.

Resource Requirements

Requirements for personnel, equipment, and material resources are discussed in detail in chapters 3-5. Additional consideration must be given to ensure that size- and efficiency-appropriate loading equipment is available to load spreaders, work stockpiles, load snow, and clear special areas. Depending on the extent of loading and hauling requirements, snow blowers, large capacity trucks, and possibly melters have to be available as well as additional support equipment, including service trucks, tow trucks, and trailer transporters. Not all of this additional equipment requires additional personnel. Truck drivers can load their own trucks. Loading, hauling, and snow pack removal operations are usually not concurrent with plowing and spreading operations and operators should be available.

Contingency Resource Requirements

The availability of contingency resources to deal with emergency and catastrophic situations is an important consideration. If the responsible agency is large and covers a wide geographic area, in-house resources may be sufficient, as disasters tend to be somewhat local in nature. Additional contingency resources include:

Stand-by or contingency contractors selected in advance on the basis of unit prices for estimated quantities of work or best hourly rates for personnel, materials, equipment, and overhead. The contractor is paid a standby fee and must mobilize for work within a specified period of time.

Emergency Management Offices, administered at the county or sub-area level, already exist in most states to coordinate the distribution of available resources.

Emergency Management Plan should be developed by the agency coordinated annually with emergency management agencies and surrounding transportation agencies. The plan should include, at a minimum, procedures to direct resources; rescue stranded motorists; remove and transport people to shelter and emergency

medical services; remove vehicles that are interfering with snow and ice control operations; mobilize all available resources; and close highways. Sufficient details of the emergency plan should be communicated to the road users through the media and informational brochures so that the travelers know what to do if stranded by winter weather.

Cooperative agreements for sharing various resources (emergency and otherwise) are becoming popular. Rental rates or other bases for exchange of services are defined in a written agreement. These agreements present some difficulties due to conflicts in availability, but in a true emergency, logical priority usually prevails.

Contracted Snow and Ice Control

There are a variety of contract options for obtaining resources to perform snow and ice control. The contracts may be with the private sector or other governmental agencies. The choice will depend on economic analysis, political agenda, climatology, level of service requirements, in-house resources, etc. The options for various combinations of in-house and contract work are discussed below.

Mix of In-house and Contractor Forces

A popular strategy for providing snow and ice control in moderate or light snow and ice activity areas is to have sufficient in-house capacity to perform materials spreading and snow plowing for a light snowfall. When moderate to heavy snowfall occurs, private sector contract forces are brought in to supplement the plowing capability.

The contract plowing forces may be integrated with in-house forces (particularly in multiple-plow operations on wider streets and roadways) or assigned to particular plowing routes. If assigned to particular routes, the contract drivers should be thoroughly familiarized with the routes well before winter, and there should be sufficient inspection to make sure that the job is being done in accordance with the terms of the contract. When public sector contractors are used, they are usually given total snow and ice responsibility for a designated area or route. As with private sector contractors, quality assurance should be part of the process.

It is usually difficult to obtain private sector contractors that have proper equipment and materials to perform snow and ice control operations. The contracting agency may have to supply some of the specialty items, including: plow frames, plow hitches, plows, self-powered material spreaders, ground speed spread controls, abrasives, and ice control chemicals.

Generally, contractors do not have access to government communications. Consideration should be given to assigning agency personnel with radios or cellular phones to contractors' crews to report progress and to assist in overall communications.

Fully Contracted Snow and Ice Control

Snow and ice control can be fully contracted through the private sector, other municipalities, in-house employees (contract with union), or a combination of these options. The challenge is to have contracts that adequately define requirements and provide for performance-based payments.

Choosing contracting option(s) should be the result of a comprehensive cost and performance analysis. All agency support activities, additional equipment and facility needs, level of service implications, and impacts on other agency programs should be included in the analysis.

A concept gaining in popularity is allowing agency unions or in-house forces to bid on snow and ice work. Some agencies will award to in-house agency forces if they are within a certain percentage of the low private sector or municipal bid. This procedure brings an element of managed competition to the public service marketplace.

Route Optimization

Route optimization technology has been around for many years in the delivery business and is beginning to gain popularity in the snow and ice control field. Various proprietary and public software programs are available to the snow and ice community.

A key element in route optimization is having work sites and stockpiles in the strategic locations. Partnering with other agencies or jurisdictions within an agency, in terms of materials management and exchange of route responsibilities, is a great way to start. Partnering might initially create problems with materials policies and the ability to deliver an appropriate level of service, but they are not insurmountable.

Routes for spreading and plowing operations have different requirements. Spreading operations can treat a certain number of lane-kilometers much more quickly than plowing operations. This typically requires less equipment. There may also be priority treatment locations for spreading operations that are not the same as priority plowing locations. These factors have to be addressed when performing route optimization studies.

Training Programs

Training programs are discussed in detail in chapter 3. It should be noted that training of contract personnel is just as important as for agency personnel.

Management Information Systems

Good data are crucial to effective snow and ice control management information systems. These systems can generate a variety of analyses that are useful in judging: crew performance, contractor performance, policy, policy breaches, procedures, costs and benefits, and reasonableness of resource expenditure.

Claims and Litigation

The most important factor in successful claim defense is good records. Written records of snow and ice control operations should reflect what was done; operator observations; and Road Weather Information System (RWIS) sensor output of weather and road conditions. Additional information that should be recorded would include weather forecasts, applicable level of service policy, policy breaches and their reasons, and a description of reasonable efforts to cure deficiencies.

Budgeting

"You get what you pay for" is an axiom often heard. This is particularly true in snow and ice control. Good records support resource allocation decisions and budgetary analyses required to determine the equipment, personnel, and materials needed to deliver the level of service chosen by agency.

Due to the inability to predict weather for a winter season, developing accurate budgets for snow and ice control is difficult. Historical costs per lane-kilometer, or the various level of service classifications with adjustments for the current cost of personnel equipment and materials is a common method. The level of funding relative to average conditions has to be chosen and methodology for dealing with budget underruns and overruns should be part of the process.

3

Personnel Training

Acquiring a capable workforce requires the recruitment and training of qualified personnel. Although in some instances the workforce is acquired through a political process, recruitment of qualified personnel, combined with a strong training program, is the best way to build a competent snow and ice control team. One way to ensure an effective and efficient workforce is to require minimum levels of training, education, experience — including a Commercial Drivers License (CDL) at the entry level — to develop and maintain a high quality workforce through comprehensive skill-based training programs. Agencies should work with community colleges or vocational training programs to develop a pool of pre-qualified individuals.

Training Benefits

There are many benefits to having a well-trained snow and ice control workforce, including improved safety, less downtime of equipment, environmental advantages, and cost savings. Snow and ice control equipment operators, the traveling public, roadside users, and roadside property owners all receive safety benefits from having a highly-trained operational workforce. Highly-trained operators make fewer mistakes and errors in judgment than less-trained operators, thus causing fewer accidents and injuries and less damage to roadside features. Operators skilled in defensive driving techniques are more likely to avoid potential accidents, and those trained in the proper use of snow and ice control chemicals, abrasives, and plowing procedures make roads safer for the traveling public.

Operators educated in the proper use of equipment, pre- and post-operational inspections, and equipment maintenance practices ensure that equipment has less downtime and lower overall repair costs. Proper operation results in fewer accidents and less equipment damage while pre- and post-operational inspections identify easily correctable problems before they become big or



expensive repairs, thus resulting in lower overall maintenance costs. Timely, routine maintenance on equipment, including proper lubrication, also results in less downtime.

Appropriate training at all organizational levels results in less use of ice control chemicals, abrasives, and motor fuel. Most ice control chemicals have some negative environmental consequence that impact roadside vegetation, groundwater, and surface water. Abrasives result in air quality degradation and siltation of watercourses. Motor-driven equipment impacts the environment through exhaust emissions, crank case emissions, lubricant leakage, and cargo spillage/waste.

A properly trained snow and ice control workforce uses fewer material, equipment, and personnel resources to achieve the appropriate level of service — real cash savings that can help offset the cost of training.

Training Forums and Primary Target Audience

There are many ways to conduct effective training. The selection of an appropriate forum and a target audience is based largely on fiscal resources and training objectives.

Large maintenance organizations can establish comprehensive training programs with full-time trainers, resulting in uniformly trained, highly skilled people who can be deployed in emergency or disaster situations. Full-time trainers can also be used for training other maintenance organizations on a cooperative or for-fee basis. Specific examples of training forums and their primary target audience are presented below.

Snow Schools, Colleges, or Academies (Operators and Crewmembers)

Snow schools, colleges, or academies are comprehensive training forums lasting one to two weeks and generally conducted away from the normal work locations. Such training forums are expensive since they usually involve a large instructor staff and lodging and meals for students must be provided. Generally, class size is small, providing a low student-to-instructors ratio. If resources are limited, the best use of this forum is to train people who in turn provide training at their local work site. Although expensive, it is certainly desirable to send as many people as possible to this type of forum. Because of their benefits, state departments of transportation, e.g., Maryland and Pennsylvania, sponsor snow colleges, sometimes annually. The authors have developed a suggested curriculum for a snow college, included in appendix B-1.

Classroom Training (Operators, Crew Members, Supervisors and Managers)

Classroom training is usually less costly than snow schools because student-to-instructor ratio is generally higher and the training is usually conducted in closer proximity to the home work locations. This arrangement drastically reduces subsistence costs since only the instructors are away from their home location. Typically, classroom training produces a lower level of effectiveness since it is difficult for the trainer to hold student interest and the opportunity for interactive discussion is limited. Instructors with good presentation skills and knowledge of the subject should be selected to reduce such effects.

To achieve a higher level of uniformity in operations, it is wise for the same instructor(s) to discuss policy and level of service issues at agency-wide classroom snow and ice control sessions. Minnesota and Pennsylvania Departments of Transportation have excellent training programs, resulting in training materials that are useful resources to other agencies. Details are provided in references 1-6.

Mentor Training (Operators, Crew Members, Supervisors and Managers)

In mentoring, senior workers or higher level staff members work one-on-one or in small groups with less experienced people. This arrangement is usually voluntary, although it can be accomplished by assignment. Here, the mentors meet with the protégés on a scheduled basis and discuss a wide range of job-related topics, including the tricks of the trade associated with snow and ice control. This approach can be very effective due to the one-on-one nature of the relationship. Mentors should work from a manual or checklist to assure uniformity in the process.

Peer Training (Operators, Crew Members, and Supervisors)

More experienced workers in the same job classification can train less experienced people. This is an effective process, as peers are perceived to be highly credible, particularly when they come from another work location and are not part of the social structure of the local workplace. This approach also provides a good opportunity for people who have more advanced training to share knowledge. Manuals or checklists should be used to assure uniformity.

On-The-Job Training (Operators and Crew Members)

Learning the job by actually doing it may be the most common and effective training forum. However, inexperienced personnel should be placed under the watchful eye of more experienced staff until some basic level of competence is achieved. Periodic performance evaluation and training should be a continuing process.

Dark Hours Training (Operators and Crew Members)

In locations where snow and ice events are very common, personnel are sometimes assigned to day or night shifts for the snow and ice season. As a result, part of the workforce works during the dark hours when on-highway tasks other than snow and ice control are generally not done, thus providing a unique opportunity for training during those time periods when there is no snow or ice activity. Many of the training forums previously defined may be used at these times as long as they can adapt to a flexible schedule.

There are many training videos — available from technology transfer centers, other agencies, and the private sector — than can be shown and discussed. A listing of Local Technical Assistance Program (LTAP) videos is available on the Internet at <http://iti.acns.nwu.edu/clear/tech/ltap6.html>. Examples of LTAP training video titles are provided in appendix B-6.

Basic skills can also be enhanced through agreements with local cooperative education centers and other schools.

Skill-Based Certification Programs (Operators and Crew Members)

Many maintenance organizations use a skill-based certification system to decide when a contractor or in-house staff member is qualified to perform certain tasks or operate certain equipment. Combinations of training, operational experience, and demonstrated operational competence usually form the basis for certification. Due to the complexity of operating snow and ice equipment, certification of operators should be considered, as well as annual re-certification of operators prior to the winter season.

Dry Runs and Rehearsals (Operators, Crew Members, Supervisors and Managers)

Operators should test-drive their routes prior to actually commencing winter operations. If the operator is new, someone with snow and ice control experience on that route should go along.

Items that should be noted, and even put on a map of the route, include:

- * obstacles along the highway (mark them if possible);
- * bridges;
- * turnaround locations;
- * pipes, drainage inlets, box culverts, and cattle guards;
- * raised features on or along the highway, including medians, access covers, grates, speed control bumps, curbs, etc.;
- * special plowing situations and ways to deal with them;
- * low overhead clearance features, including wires that may sag with a snow or ice load (this is particularly important when using spreaders that require the dump body to be raised);
- * priority treatment locations;
- * locations requiring special attention, such as super elevated horizontal curves and sag portions of vertical curves;
- * public telephones in the event of communication failures; and
- * safe havens for use during blizzard or whiteout conditions.

Managers and supervisors can also develop and exercise a mock snowstorm to test weather information usage, agency decision-making, and command and control systems before they actually have to be utilized.

Rodeos and Open Houses (Operators and Crew Members)

Conducting rodeos, sometimes called "roadeos," or snowplow competition prior to winter operations has training and awareness value. A field course that will actually be used during snow and ice operations should be used to test operator skills. Skills such as proficiency in pre- and post-operational equipment inspections, the location of plow ends and their height during operation, safety procedures, backing procedures, accuracy of material spread rate, and distribution should be evaluated. Written or oral tests of agency policy, procedures, and safety guidelines may also be part of the competition.

To the extent possible, these competitions should be made interesting by setting them in an open-house environment with other activities to keep participants informal and relaxed. Senior agency staff should attend and elected officials and the media should be invited for awareness and interaction. These competitions can be used to evaluate the agency training program as analysis of the scores in both the field course and test areas will identify training needs and successes.

Storm and Seasonal Debriefings (Operators, Crew Members, Supervisors and Managers)

The use of debriefing sessions as a training tool and a vehicle for continuous improvement is recommended. Such sessions should be conducted in a very positive manner to help implement quickly recommended changes that make sense. Storm-specific debriefings are very helpful in identifying operational problems and solutions. End-of-season debriefings can be used to identify policy issues and potential changes. These post-season debriefings should involve as many of the partners having a stake in snow and ice control as possible, including a cross section of agency people such as police, fire, emergency management, emergency medical, business groups, highway users, snow and ice contractors, and weather forecast providers.

Conferences and Workshops (Supervisors and Managers)

There are numerous conferences and workshops available, but they may involve significant travel and expense. The knowledge and networking opportunities associated with these forums can be well worth the investment. A partial list of potential conference opportunities includes:

- * American Public Works Association (APWA) Eastern, Western, and North American Snow Conferences (Annually);
- * Transportation Research Board (TRB) Annual Meeting and sponsored conferences;
- * Technology Transfer Centers (T²) training seminars and workshops;
- * conferences sponsored by government officials associations, e.g., county or municipal highway superintendents, state highway officials (AASHTO), city maintenance officials, and associations of towns, cities, or counties;
- * vendor-sponsored training workshops;

- * conferences sponsored by environmental groups or councils;
- * conferences sponsored by International organizations, e.g., World Road Association - PIARC, Pacific RIM Road Organizations; and
- * university or school sponsored events.

Training Topics

It is essential that training provided to agency members be thorough and appropriate. Training should be provided to both field operational personnel and decision-makers. The following sections provide suggested topics for each group of personnel.

Training Topics for Operators and Crew Members

The following is a partial list of snow and ice control related training topics of interest to equipment operators and crewmembers. Agency guidelines and deficiencies will dictate the priority order of the topics.

- * agency safety policies;
- * equipment operation, inspection, and calibration;
- * defensive driving techniques;
- * route specific issues;
- * agency snow and ice control policies and guidelines;
- * fundamental snow and ice control concepts;
- * agency equipment operation policies;
- * environmental concerns and responsibilities;
- * operators awareness on physical and mental wellness required during snow removal activities;
- * winter survival in open rural country;
- * operator family's understanding of hours and demand on an individual on snow removal;
- * radio and other communications practices;



- * legal rights and responsibilities; and
- * agency personnel and staffing policies, including drug and alcohol policy.

Training Topics for Managers and Supervisors

The following is a list of potential snow and ice control related training topics of interest to supervisors and managers. Agency guidelines and identified deficiencies will establish the priority order.

- * decision-making process (including the use of road and weather information);
- * fundamental snow and ice control concepts;
- * emergency and disaster management procedures;
- * agency equipment operation policies;
- * agency personnel management policies;
- * agency drug and alcohol policy;
- * communications with the public and the media;
- * formal incident command training;
- * relationships with other agencies; and
- * management system and reporting.

Personnel Management Issues

Because few agencies enjoy a surplus of staff, providing and managing sufficient personnel to accomplish timely, effective, and efficient snow and ice control operations is a challenging task. Overall staffing needs depend on the magnitude and character of the highway system, organizational structure, level of service, equipment, operational safety considerations, emergency/disaster/contingency considerations, and sources of personnel for snow and ice control operations. As a result, developing a staffing plan can be an overwhelming task that requires the consideration of many factors.

Magnitude and Character of the Highway System

The more extensive the road system, the more people and equipment it will take to provide a level of service equivalent to that required for a smaller system. The features of the system, such as stop-and-go operations, dead ends, cul-de-sacs, turning lanes, ramps, deadheading, grades, contiguity of the route, and curvature, will ultimately impact production rate and therefore have to be considered.

Organizational Structure

Larger maintenance organizations usually require a higher ratio of manager/supervisor/ technical personnel to operational personnel. The level of privatization utilized by the agency also impacts in-house staff requirements

Agencies in areas receiving few snow or ice events may not choose to staff for operations at the same levels as those of agencies with heavy snow and ice control needs. Staffing becomes a matter of practicality and economics and agencies must be creative in providing high levels of service when such events occur.

Level of Service

All other factors being equal, level of service and cycle time are interrelated. Cycle time depends on the amount of people and equipment available per unit of highway. The shorter the cycle time, the higher the level of service. Level of service must also include materials storage locations and materials handling considerations.

Equipment

Once the level of service is chosen, the amount of equipment required to provide appropriate cycle times can be determined. Sufficient staff to operate the equipment must then be provided.

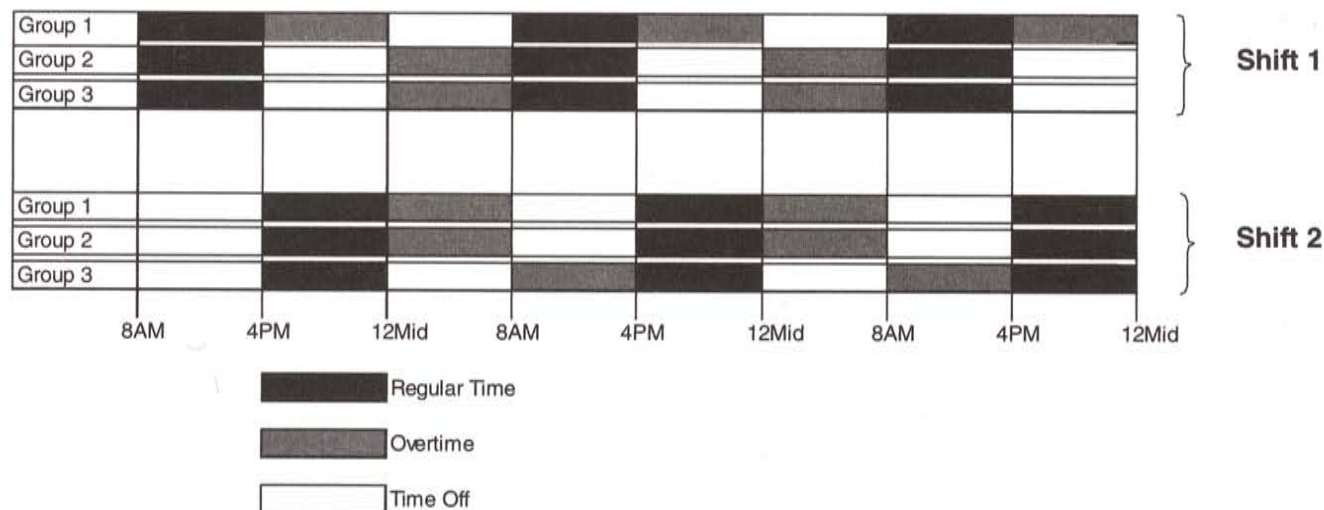
Operational Safety Considerations

In heavy continuous snowfall areas, if policy states that workers can work no longer than twelve continuous hours without twelve hours of continuous rest, two operators with different non-overlapping shifts must be assigned to each piece of equipment. This arrangement will also allow for continuous operations. In lighter

snowfall areas, agencies may elect to assign one operator per piece of equipment, limit continuous duty, and either provide operations during certain time periods only or continuous operations at a reduced level.

Agency safety considerations usually focus on the length of continuous duty/rest periods, the number of people assigned to snow and ice equipment, and materials loading safety policy. Commercial vehicle laws stipulate maximum number hours of operations followed by eight hours of rest. For emergency and snow and ice control purposes, this ruling is often set aside. Some agencies typically have 1.5 operators for each piece of equipment, e.g., twelve operators and eight trucks. If the agency transitioned to two twelve-hours shifts, some equipment would be idle. By maintaining a maximum sixteen-hour shift with an eight-hour rest, as required by agency safety policies in some states in moderate snowfall areas, continuous around-the-clock equipment utilization can be maintained. Figure 2 illustrates this arrangement.

Some agencies provide two individuals per snow and ice control truck as a routine practice or in special circumstances. Also, some agencies choose to have dedicated operators for materials loading equipment. Others require that spreader truck operators load their own trucks. These considerations impact staff requirements.



1.5 operators per truck, full fleet operation, with 16 hours on and 8 hours off. Assumes a 4PM full mobilization.

Figure 2. Time line example for shift development.

Emergency/Disaster/Contingency Considerations

Agencies in areas that frequently experience severe weather year-round sometimes choose to have extra capability to assure timely recovery. This may occur through in-house equipment and staff or a variety of private sector options.

Sources of People to Staff Snow and Ice Control Operations

There are some options for obtaining staff to perform snow and ice control operations. Once the staff is acquired, they must be thoroughly trained for snow and ice operations.

Permanent-Year Round Staff

The number of people required for snow and ice control operations typically exceeds the amount of permanent staff available in most maintenance organizations, though some agencies have sufficient permanent staff. Permanent staff usually works out best, as they are familiar with agency equipment, policy, procedures, and the characteristics of the local highway system. Agencies must estimate additional personnel needs based on the history of the workforce. This includes their experiences with sick and other leave during winter seasons. The agency must also develop a policy for vacation authorization during the winter season in order to ensure sufficient permanent personnel are available to perform the work.

Staff from other Units within the Agency

Depending on the agency, there may be loan staff available for the winter season or for specific snow and ice events, including staff from other departments such as

- * sewer;
- * water;
- * parks and recreation;
- * sanitation, recycling and waste centers'
- * specialty crews (bridge, guide rail, signs, traffic marking, soil boring, herbicide, trees);
- * engineering;