SCAN TEAM REPORT

NCHRP Project 20-68A, Scan 07-03

Best Practices in Winter Maintenance

Supported by the

National Cooperative Highway Research Program

Executive Summary

Overview

The purpose of the Winter Maintenance Scanning Tour was to seek out and observe the progress that state and local highway agencies are making in advancing today's technology in the area of winter roadway maintenance. While this was the first tour in the United States, it was tailored after three previous scanning tours that had been conducted in European and Asian countries in 1994, 1998, and 2002. Much of what had been learned from these earlier international scans had become a new benchmark to several U.S. counterparts, inspiring them to pursue similar advances.

NCHRP 20-68A, U.S. Domestic Scan Program, was developed under the auspices of American Association of State Highway and Transportation Officials (AASHTO), Federal Highway Administration (FHWA), and NCHRP to assess the state of the practice of a variety of transportation subject areas in the U.S. and to evaluate the extent to which the international scanning tours had an impact on domestic operations. One of the tours included in this program is Scan 07-03, *Best Practices in Winter Maintenance.*

The Winter Maintenance Scan was conducted from March 25 to April 7, 2009, by a team that consisted of:

- William Hoffman, AASHTO Co-Chair, Nevada Department of Transportation (NDOT)
- Ben McKeever, FHWA Co-Chair, United States Department of Transportation (USDOT)
- Steven Lund, Minnesota Department of Transportation (Mn/DOT)
- Terry Nye, Pennsylvania Department of Transportation (PennDOT)
- David Ray, Ohio Department of Transportation (ODOT)
- Mike Schwartz, Virginia Department of Transportation (VDOT)
- Rodney A. Pletan, Subject Matter Expert (SME) Principal Author

Also traveling with the team was Armando Perez, American Trade Initiatives, who arranged for and coordinated all logistics relative to the tour.

Early in the process, the scanning team met and decided which locations to visit, primarily based on a desk scan prepared by the SME in October 2008. The following locations were selected and are listed in the order that they were visited:

- Minnesota Department of Transportation (Mn/DOT)
- Colorado Department of Transportation (CDOT)
  - City of Denver
  - City of Fort Collins
  - City of Grand Junction
  - E-470 Public Highway Authority (PHA) (toll highway)
  - Eisenhower/Johnson Memorial Tunnels
  - Hanging Lake Tunnel Operations Centers

- Utah Department of Transportation (UDOT)
- Indiana Department of Transportation (INDOT)
- Virginia Department of Transportation (VDOT)

To help the host locations prepare for the visits, the scanning team provided a list of topical areas it wanted to focus on, together with a listing of amplifying questions. The focus areas were:

- Maintenance Decision Support Systems (MDSSs)
- Automatic Vehicle Location (AVL) Systems
- Equipment Technologies
- Training and Development
- Management Issues
- Integration of Weather, Traffic, and Maintenance Operations

Summary of Initial Findings

While the objective of the scanning tour was to seek out and observe best practices, once the tour limited itself to a specific number of sites to visit, it is probably not completely correct to assume that "the best of what was seen" is the same as "the best there is." The desk scan did not identify every best practice that exists because the scan was only conducted from the desk and thus was limited to the phone calls and information gathered from the desk.

Nonetheless, this scanning tour did see a lot of the best, and it can report on the best of what was seen. So, for the purposes of this report, "findings" and "best practices" are often used synonymously to mean that the scan team found them to be the best that was seen compared to what was seen at the other places visited.

Initial findings of the Winter Maintenance Scanning Tour are listed below by topical areas.

Maintenance Decision Support Systems

- Data are being communicated successfully between the snowplow truck, the dispatch center, the MDSS provider (which generates treatment recommendations and the site-specific weather/pavement forecasts), and others.
- A multitude of data elements are being exchanged before, during, and after winter events including, for example, truck location and movement characteristics, current road conditions, and chemical application rates.
- New MDSS applications are being pursued during the summer (e.g., chip seals, paving, grass mowing, weed spraying, lane striping, and roadside assistance).
- Some agencies are beginning to identify cost benefits, with potential savings from, for example, saving chemicals, adjusting the number/length of shift deployments, and force accountability.
- Management is successfully using various marketing and implementation strategies to implement change.
- MDSS could be used to establish, supplement, or replace the winter severity index.
- MDSS is having a positive impact on management and employee culture.

Automatic Vehicle Location (AVL) Systems

- A variety of vendors is involved with AVL and AVL-related systems, like MDSS.
- It is being used for multiple purposes, from route reporting to resource consumption to incident response.
- Its potential value is dependent on how the resolutions are used. Low resolution (> 5 minute intervals) meets some real-time decision-making needs; however, high resolution (< 30 second intervals) is required if an agency wishes to automate data-collection systems that will generate time sheets and work-accomplishment reports.
- Its benefits to both management and operators are becoming more universally understood.

Equipment-Related Technologies and Facilities

- **Plows and wings:** Agencies are trying out wider plows on the front and dual wings on the sides; underbody plows are becoming more common. The scan team saw power brooms on the front of a tandem snowplow truck. Other tandems are pulling tow-plows, allowing a full two lanes per pass. Hydraulic-assist engineering is being used to reduce plow weight on the blade when conditions warrant, reducing cutting edge wear and extending life up to two winter seasons.
- **Plow cutting edges (plow blades):** Composite carbide and rubber blades are getting good reviews. Multiple-blade configurations, including triple blade setups (carbide, serrated, and rubber slush blade combinations) are being tried.
- **Saddle tanks** containing liquids for prewetting solids are being designed and integrated into dump boxes and beds on both tailgate and V-box spreader trucks, leading to better weight distribution and higher carrying capacity and allowing for longer route coverage during prewetting operations at the agency's optimized application rate. Prewetting application rates vary; for example, CDOT applies 4 to 12 gallons/ton.
- **Chemical and sand spreaders:** The zero-velocity solid-chemical spreader concept is continuing to be pursued. Slurry augers are being used so that chemicals in slurry form can be distributed. Large tankers (5,000 gallons) are being used as anti-icing spreaders preceding storms as well as to resupply liquid storage stations between storms. Off-season rental water tank trucks are used as anti-icing units.
- **Equipment accessories:** Several innovative accessories were noted during the tour., like:
  - Video cameras on plow trucks to provide front, side, and rear views from the cab
  - Wiper blade vibrators to reduce ice buildup
  - Air blowers to keep side mirrors clear of snow
  - High-intensity discharge (HID) headlights to provide three times the light and 10 times the life of other lights
  - Simple home-made "fog busters" to lift fog above the driver's line of sight
  - Laser beam guides to tell the operator how far out the wing or tow-plow is
  - Collision-avoidance systems to provide protection during white-out conditions
- **Fixed automatic spray technology (FAST):** These systems have developed and are proven to the point that they are no longer experimental.
- **Equipment funding mechanisms:** Equipment replacement purchases are funded by a variety of mechanisms, including annual appropriation from legislature or council, revolving accounts (where user units pay rent to owning units), and escrow accounts (where agencies put money every year for every unit so that they are fully funded when replacements are due).

- **Road Weather Information System (RWIS):** Advancements in RWIS include new low-cost portable units, solar- and wind-powered units, stations that include remote-controlled cameras providing streaming video, and noninvasive sensors to replace pucks embedded in the pavement.
- **Friction measurement systems:** These systems, which measure winter performance, continue to be developed both domestically and internationally.
- **Chemical storage:** Progressive and environmentally sensitive agencies store all solid chemicals under roof year-round with have space in the same building for loading trucks.
- **Brine making:** Brine manufacturing, commonly done in house and sometimes housed in the same building as solid salt, has become automated and controlled. Some agencies dispense brine using fuel-management systems to permit easy sales to other local agencies and to keep track of the amounts loaded onto individual trucks.
- **Truck washing:** Some washing facilities now use sediment traps and reuse their wash water. Contaminated water at equipment and chemical storage sites (e.g., water contaminated by truck washing and runoff from stockpile sites and loading areas) is now being collected both to protect the environment and to make brine.

Training and Development

- Government downsizing is leading agencies to set up flexible workforces, with a generic transportation worker classification replacing separate construction and maintenance classifications at the time of hire. Other agencies are cross-training nonmaintenance employees to operate snow and ice equipment during winter storms or to otherwise supplement/support the winter maintenance effort. In both scenarios, these changes are causing both challenges and opportunities for training and retraining workers for winter emergencies.
- Several agencies are setting up training programs using simulators, training academies, symposiums, and other methods (e.g., MP3-based training) to incorporate internally and externally developed training programs like the AASHTO computer-based training (CBT) program.

Management Issues

- Special funding for maintenance operations research and development is being promoted, more in some agencies than in others.
- Culture and management/employee relations are especially important during times of change.
- Outsourced and in-house work need to be managed the same, yet are often managed differently.
- Measuring winter maintenance performance is best done at the outcome level.
- Customers measure government by the consistency or inconsistency of levels of service (LOS) between winter plow routes, across internal organizational lines, and even across jurisdictional boundaries.
- Internal and external communications are important to the success of winter service providers.
- During winter events, one agency provides designated drop zones so that stalled and stranded vehicles can be moved off the highway.

Integration of Weather, Traffic, and Maintenance Operations

- Traffic Operations Centers (TOCs[3]) are being designed and organized to physically integrate representatives of several disciplines during winter and other emergency/incident-management type events. Example

personnel already incorporated on-premises in one or more TOCs are:

- Meteorologist
- Maintenance Operations Dispatcher
- 511 Coordinator
- Highway Patrol Dispatcher
- Courtesy Patrol Dispatcher
- Snow and Ice Operations Coordinator
- Traffic Signal Control Coordinator
- FM Radio Announcer

- Some of the above integration is full-time, year-round, and other integration is only during incidents, including winter events.
- When an agency has a full-time meteorologist, that position manages a private (i.e., under contract) meteorology team that does the actual forecasting from space provided in the TOC. The staff meteorologist teams with the agency's Maintenance Operations to best utilize the forecasts.
- The key benefit of having up-to-date weather forecasting and road conditions in the TOC is that it allows for more timely updates to 511, Web sites, and other sources of information to which the public has access.
- Some agencies have converted to statewide 800 MHz for all emergency services, including Maintenance Operations. Mn/DOT's voice-over Allied Radio Matrix for Emergency Response (ARMER) system was extremely valuable during the Minneapolis 35W collapse.
- Traffic signal timing on key corridors is adjusted in response to winter events.

Recommendations and Conclusions

Based on the above-listed findings, the preliminary general recommendations of the scanning team are as follows:

Maintenance Decision Support Systems

- MDSS has proven that it adds effectiveness and efficiency to winter operations. Its return on investment (ROI) will greatly increase as it is applied to summer activities as well.
- To be successful and able to implement MDSS expediently, some marketing and implementation strategies have been tried and proven more effective than others, like those that involve top-down direction and support and those that achieve high employee buy-in.

Automatic Vehicle Location (AVL) Systems

- AVL systems have multiple uses, many of which are beneficial to employees and operations, and their use is expected to be universally expanded into maintenance operations. The higher the resolution (i.e., the frequency at which readings are recorded), the higher the cost; however, the lower the resolution, the lower its potential value.

[3] For the purposes of this report, the abbreviations TMC and TOC are used interchangeably. In practice, Mn/DOT and CDOT refer to their facilities as TMCs and UDOT and VDOT use TOC.

Equipment Technologies

- Indications are that tow-plows have great potential in many areas. They can be operated with a single driver and crashes have not been a problem. Tow-plows do, however, require that trucks meeting certain minimum specifications pull them; these trucks are probably not available in existing winter maintenance fleets.
- Hydraulic assist has the potential to extend the life of some cutting edges (i.e., plow blades) up to two years.
- The carbide blade with a rubber insert is well liked and shows promise nationwide.
- Poly (plastic) plow blades should be considered for use in certain environments.
- Video cameras can expand a snowplow truck operator's range of view and should be considered for use as safety enhancers.
- Laser beams that extend to the front of the snowplow truck, showing the operator how far out the wing or tow-plow is, are economical and most probably cost effective.
- Though research was limited, vibrating wiper blades show promise.
- Fog busters, HID headlights, and other technologies that enhance operator visibility (i.e., both the ability to see and to be seen) should always be pursued and used once they are proven successful.
- Agencies should do whatever is necessary to:
  - Prevent the formation of salt brine at stockpile sites
  - Collect any brine formed from runoff or truck washing at storage sites (Sediment traps permit salt brine runoff to be reused or recycled.)

Training and Development

- Flexible workforces should be considered as demand for services continues to rise and government continues to downsize.
- Cross-training can be successful in supplementing snowplow operators.
- Generic and customized state-of-the-art training programs are available for use at training academies or symposiums. Real-life simulators, coupled with classroom lectures and computer-based training programs (e.g., AASHTO CBT), can be used for both initial and retraining purposes.

Management Issues

- Inter-jurisdictional relationships are important for promoting consistent LOS between otherwise invisible governmental boundaries.
- More work needs to be done to develop improved, outcome-based, customer-oriented performance measurements (e.g., regain time, friction measurement, speed monitoring, and road closure frequency/duration). These measurements should be implemented, applied, and reported to better manage both in-house and outsourced winter maintenance services.
- More winter maintenance agencies should copy models of dedicated and recurring funding for operational maintenance research funding. Successful models lead to grassroots ownership, thus creating a continuous improvement culture and improved relationships between employees and management.

Integration of Weather, Traffic, and Maintenance Operations

- Integrating traffic operations, weather forecasting, maintenance operations, highway patrol, media, and incident management into TOCs is proving to be a best practice.
- Better approaches are emerging for conveying real-time information (i.e., traffic and surface conditions and weather forecasting) to the traveling public using 511, Web sites, e-mail alerts, text messaging, and other methods.
- Implementing special signal timing plans during winter events has the potential to improve traffic flow for both the traveling public and the snowplow operators.

Overall conclusions from the scanning tour are as follows:

- MDSS has proven itself as an effective winter maintenance tool and was shown to improve operational efficiency through resource savings. Implementing MDSS is not easy, and it requires the agency to make deliberate financial and cultural commitments. Agencies that decide to implement MDSS should have their top staff openly declare their full support of the effort and develop specific implementation strategies that foster support and understanding at all maintenance staffing levels.
- Attitudes toward AVL systems have changed from resistance to "big brother is watching" to an appreciation that they provide an advantage to both management and workers. AVL increases the ability of operational managers and dispatchers to better adjust operations during a winter event, thus reducing the number of decisions that operators have to make on their own. AVL allows operators to focus instead on driving their vehicles safely in heavy traffic during the toughest conditions that exist. Tough economic times have pushed winter service agencies away from having all snowfighters be experienced professionals to situations where plow operators are generalists or shared workers who are often used only intermittently. In some cases, drivers and trucks are being provided by the private sector. AVL technology can help agencies bridge the gaps created by these new challenges. Using AVL to automate labor, material, material usage, and work-accomplishment recording is a further benefit to both workers and management.
- Considerable development and enhancement of existing technology have improved the performance, efficiency, and durability of ice- and snow-fighting equipment. Cost-effective means of increasing productivity and reducing equipment downtime, while at the same time extending equipment service life with innovative wash facilities, are common themes in the organizations the team visited. Advancements have been made in plow blade technology and configuration, winter chemical manufacturing and, chemical application systems. Almost all winter service organizations can relate to the successful, cost-effective innovations cited within the findings of this report to improve their own operations. The next step will be to provide funding to test and incorporate new technologies appropriately into current operations.
- As the pressure for governmental agencies to downsize continues, they need to seek out and study the models of flexible workforces and cross-training. The challenge of maintaining a trained workforce is magnified by the need to capitalize on new methods and new technology, all requiring enhanced training and retraining. The worst-case scenario for training is where winter maintenance is outsourced and, at least initially, core competencies differ even more, at least to the extent that their attitude toward public service may need to be nurtured. As a result, today's agencies need to emphasize training and development; benchmarking based on proven lesson plans and techniques is one way to minimize cost and, at the same time, expedite curriculum development.
- Customers continue to have high expectations, but their trust in and support of government-provided services is eroding. Their willingness to pay has deteriorated as government fails to measure itself from the

same point of view as the customer. Customers expect seamless LOS from route to route, from district to district, and even from city to city. In-house crews seek new ways to be efficient while political pressure suggests that the private sector can produce work more effectively, irrespective of cost. Managers need to develop performance levels that are measurable and correlate with customer expectations. Furthermore, government managers need to align their cost system so that it can correlate and be compared with the private sector system with enough accuracy to select which activities, if any, are most susceptible to being outsourced.

- TOCs can and should serve as the hub from which all existing and emerging road weather management advisory, control, and treatment strategies and technologies are dispatched.
  - Advisory – 511, Web sites, and e-mail alerts
  - Control – special signal timing and changeable message boards
  - Treatment – maintenance operation and incident management

This will improve the daily operations and decision-making capabilities of transportation agencies. Integrating maintenance operations, professional weather forecasting, incident response, and enforcement into the TOC during winter emergencies has great potential to prevent gridlock and reduce the number of crashes, enhancing the safe mobility of the traveling public.

Planned Implementation Actions

The winter maintenance community provides many conduits for disseminating the findings and recommendations of this scanning tour, including, but not limited to, the following:

Short Term

- Presentations at scheduled conferences (most scheduled at least annually)
  - Permanent International Association of Road Congresses (PIARC) World Road Association Winter Road Congress (2010, Quebec City)
  - Transportation Research Board (TRB) Annual Meeting
  - TRB Winter Maintenance Committee
  - TRB Committee on Surface Transportation Weather
  - TRB Snow and Ice Symposium (2012)
  - AASHTO Subcommittee on Maintenance
  - Pacific Northwest Snowfighters (PNS) Association
  - American Public Works Association (APWA) (Winter Maintenance Committee)
  - National Association of County Engineers (NACE)
  - AASHTO Eastern Snow Expo
  - APWA National Congress (September 2009, Columbus, OH)
- Presentations to pooled fund organizations
  - Snow and Ice Cooperative Program (SICOP) Winter Maintenance Technical Service Program (WMTSP)

- Clear Roads
- Aurora
- Clarus Initiative
- PNS

- Other meetings
  - National Winter Maintenance Peer Exchange
  - MDSS Showcase
- Webinar

Medium Term

- Identify potential projects with pooled fund organizations
- Coordinate activities with Lee Smithson, SICOP Coordinator
- Promote more MDSS-type showcases
- Establish a Winter Maintenance Best Practices Web site to post final report and presentations, plus add new best practices as they are identified

Longer Term

- Assist in developing Problem Statements for NCHRP
- Identify funding source for covering travel and other expenses for the above activities
  - NCHRP 20-68A
  - One or more already-in-place pooled funds
  - FHWA