

Clear Roads Problem Statements January 2009

Page	Title	Description	Estimated Cost	Estimated Duration	Proposer
3	Develop Laboratory Tests, Tools or Methods to Simulate Deicing Chemical Performance during Actual Winter Storm Conditions	While several performance specifications exist for de-icing materials, none have been developed with an operational perspective. A new laboratory test, tool or method is needed to evaluate the performance of de-icing materials in conditions similar to those seen on the actual roadway.	\$200,000	2 years	Dennis Burkheimer - IA-DOT
6	National Peer Exchange 2009	National Winter research groups began working on the research problems identified in the 2007 Peer Exchange and holding another Peer Exchange in 2009 would allow attendees to see the progress being made in some of these areas.	\$30,000	Will be complete in August 2009	Dennis Burkheimer - IA-DOT
7	Salinity Sensor Development and Evaluation	Salinity and freeze point sensors which can accurately sense the amount of chemical or the solution's freeze point would be useful tools for winter maintenance decision makers to assess whether a sufficient amount of chemical is present on the pavements.	\$50,000	15 months	Dennis Burkheimer - IA-DOT
10	National Driver Education Training Curriculum	Develop driver education curriculum and materials to support a short course on winter driving safety for new drivers	\$150,000-200,000	2 Years	Dennis Burkheimer - IA-DOT
12	Deicing Chemical Blends and Their Contribution to Reduced Friction on Roadways	The purpose of this project is to investigate what factors influence slipperiness or refreezing on the road when using deicing chemical blends.	\$200,000	2 years	Dennis Burkheimer - IA-DOT
15	Liquid Snow Removal Routes	The research would determine if anti-icing liquids with squeegee type blades are effective and efficient. In addition, any cost/material savings resulting from the use of brine versus solid salt would be identified.	TBD	12 to 24 months	Dennis Belter - IN DOT

17	Effectiveness of Anti-icing Liquids in Maintenance Decision Support Systems (MDSS) Maintenance Recommendations	This project would conduct field research on the effectiveness and length of time liquid anti-icers are effective and determining the affect on MDSS recommendations	TBD	12 to 24 months	Dennis Belter - IN DOT
21	Snow College for Frontline Managers	This project would develop a training curriculum to address frontline supervisors' training needs, as well as a training plan that can be used by DOTs. It would also recommend different methods for delivering the training and potential funding sources.	\$50,000	12 months	Linda Taylor - MN DOT
24	The Use of Liquid Deicers and Roadway Traction	This project would compare, water, mag-chloride and salt brine under different application rates on different roadway conditions, such as asphalt, vs. concrete at different humidity levels to evaluate skid resistance.	\$25,000	6 to 12 months	Paul DeJulio - CO DO
26	Development of a Standard Storm Severity Index and Snow and Ice Removal Performance Standard.	Develop an automated method to calculate storm severity indexes and performance measures after each winter event.	\$200,000	18 to 24 months	Shane Larson - IL DOT
27	Correct Recording of Material Usage for Snow & Ice Operations	Develop an automated program and printer for recording material usage at the end of operator shifts.	\$100,000 to 150,000	12 months	Shane Larson - IL DOT
31	Survey and Synthesis of Zero Velocity Spreaders	Conduct a survey and literature search to determine what type of distribution equipment is available and who is using that type of equipment around the world.	\$20,000	3 months	Tim Croze - MI DOT; Paul Brown - Mass Hwy
32	Comparison of Zero Velocity Spreaders	The intent of this research is to compare different types of deicing material spreaders. These systems are intended to reduce the amount of salt that bounces off the road during application, but they have a significant expense.	\$250,000	2 years	Tim Croze - MI DOT; Paul Brown - Mass Hwy
35	Demonstration of a National Winter Maintenance Testing Program	To conduct a demonstration of the NWMTP investigating committee in conjunction with Aurora, Clear Roads, SICOP, and PNS.	Total Project Cost: \$40,000 Requested Funding: \$10,000	2 years	Paul Brown - Mass Hwy

2009 Research Proposal Form

Proposer name, organization and e-mail address:

Dennis Burkheimer
Iowa Department of Transportation
Dennis.burkheimer@dot.ia.gov

Tony McClellan
Indiana DOT
TMCCLELLAN@indot.IN.gov

Title of proposed research project:

Develop Laboratory Tests, Tools or Methods to Simulate Deicing Chemical Performance during Actual Winter Storm Conditions

1) Background:

While several performance specifications exist for de-icing materials, none have been developed with an operational perspective. A new laboratory test, tool or method is needed to evaluate the performance of de-icing materials in conditions similar to those seen on the actual roadway. Laboratory tests have been developed to measure eutectic curves, environmental effects, corrosion and other chemical characteristics of deicing chemicals and blends, but none have been developed to replicate the real world. Due to the lack of definitive laboratory research, guides on the use of anti-icing and de-icing materials have predominantly been based on anecdotal information. While this information is useful and is often developed with the help of experienced snow and ice fighters, the information lacks good scientific research. Because the information is largely anecdotal it also includes bias from regional and cultural workplace influences. Finally, this information is insufficient for advanced pavement modeling applications.

2) What is the specific problem or issue?

Research on deicer materials has primarily focused on environmental and corrosion impacts. As decision support systems are developed, better scientific information is needed to support correct application recommendations for snow and ice removal. Decision makers need better information about the influence of time, humidity, particle size, precipitation, temperature, and traffic on the performance of de-icing materials. How does the particle size of de-icing materials affect their performance? How long is a chemical effective when subjected to 10,000 vehicles per day? Does a specific particle size work quicker in removing snow and ice than others? These questions and many more need to be addressed in the laboratory to give snow and ice decision makers the answers needed to help fight snow and ice effectively and efficiently. A test method is needed that accounts for the effects of traffic, humidity, particle size, wind, long and short range radiation, effective time, and effective temperatures in performance measures of snow and ice fighting materials. A full or small scale testing apparatus is needed to facilitate laboratory experiments that measure performance characteristics of de-icing and anti-icing materials.

3) List the proposed research objectives and tasks.

- Conduct literature search (identify laboratory tests, tools or methods used to replicate real world situations- The literature search needs to focus on areas related to snow and ice removal operations where the effort is attempting to develop tests, tools or methods that can replicate traffic, pavement surface, heat balance, weather and other variables on deicing chemicals)
- Identify the key laboratory tests, tools or methods from the literature search or other inputs that seem to have the most promise for success.

- Based on the results from the literature search and the selection of the most promising test, tool or method, develop a detailed evaluation plan of how the best test, tool or method will be evaluated in its effort to simulate real world situations. (the plan should include a very comprehensive list of the test equipment needed in a lab to simulate weather, roadways and other variables along with a recommended base set of tests to measure deicing chemical performance.
- Final report with recommendations for development of actual laboratory tests, tools or methods to simulate real world situations.

If the results from this work are promising, we would then ask for additional funding to actually move the best tool, test or method to a real world situation to see if it works.

4) What would be the product(s) of the research?

The product of this project should be a laboratory test(s), tool or method that can be used to determine how a deicing chemical or deicing chemical blend would function under true field conditions.

5) How would the results benefit DOTs? How would they be used?

States would have the ability to conduct quick laboratory tests to identify deicing products or blends that would work best for their environment, traffic and weather conditions.

6) List the estimated funding needed.

\$200,000

7) List the estimated timeline for completing the research.

Completed in December 2011 (two year project)

8) Are you aware of any related research on this topic? If so, please list below.

Deicer Test Lab

Lyondell Chemical Company, 2006

<http://equistar.com/techlit/techlit/3263.pdf>

Lyondell provides a complete line of propylene glycol-based aircraft deicing and anti-icing fluids in North America. The company supplies deicing fluids to many of the largest U.S. passenger and cargo carriers as well as fixed base operators.

From the text: Now, we are increasing our commitment to provide customers with the latest in aircraft deicing technology and service with the completion of a new state-of-the-art deicing fluid testing facility located at our research and development site in Newtown Square, Pennsylvania. The new facility enables Lyondell to perform all tests required by the Society of Automotive Engineers Aerospace Material Specification (SAE AMS) for aerodynamic and anti-icing performance and fluid deicing and anti-icing effectiveness in simulated ice and snow conditions. The core of the facility is a room-sized climatic chamber designed to create the sub-ambient conditions (as low as -40° F) needed for SAE deicing, anti-icing and aerodynamic tests. A computer-controlled mini-wind tunnel within the chamber enables the simulation of adverse weather conditions comparable to those experienced by many of the country's airports during the winter travel season. In conjunction with various monitoring and application devices, the chamber and its components allow the laboratory's research chemists to evaluate the real world performance of a variety of deicing and anti-icing fluid formulations.

Laboratory Melting Performance Comparison: Rock Salt with and Without Prewetting

Craig Luker, Barry Rokosh and Timothy Leggett, Forensic Dynamics Inc.

TRB Transportation Research Circular E-C063, June 2004, pp 585- 601

<http://trb.org/publications/circulars/ec063.pdf>

From the introductory statement: Prewetting road salt with liquid deicing chemicals has been suggested as a way to improve the melting performance of the salt and potentially reduce the amount of salt required to clear a roadway. Forensic Dynamics Inc. undertook this research to explore these possibilities. A protocol for manufacturing repeatable compact snow and for trafficking this snow to

simulate rolling tire compaction was developed following a literature review and experimentation. Tests were conducted at four, eight and 12 gallons of liquid chemical per ton of rock salt, and at -1, -5, and -10 degrees C. Three application rates were tested for most chemicals.

Development of a Method to Test Holdover Times of Deicing and Anti-icing Fluids in a Cold Room Using Artificially Generated Snow

Federal Aviation Administration, Office of Aviation Research

DOT/FAA/AR-98/74, January 1999

<http://handle.dtic.mil/100.2/ADA359759>

Abstract: A new method to test deicing fluids under laboratory conditions has been successfully demonstrated. This method generates artificial snow by grinding an ice core fed into a horizontally oriented rotating drill bit. The system is capable of producing snowfall rates from 5 to 50 gm/dm(exp 2)/hr over the area of a 30x50-cm frosticator plate. Since the snowfall rate can be accurately controlled, other variables such as temperature and fluid type can be varied independently in order to determine the dependence of failure time on each of the variables separately. The current version of the system produces failure times shorter than outdoor and indoor test results of the same fluid type under similar conditions. Preliminary analysis suggests that this may be due to the continuous nature of the snow generation method used in the current system compared to the intermittent snow application techniques used in previous tests.

Frictional Characteristics of Sand and Sand-Deicer Mixtures on Bare Ice

M. Makbul Hossain, Peter Bajorski and Wei-Shih Yang

TRB Transportation Research Record 1585, Paper No. 970496, 1997

[See the attached PDF, "Frictional Characteristics of."](#)

From the introductory statement: Frictional characteristics of sand and sand-deicer mixtures were investigated as functions of temperature, gradation and application rate. Results of a laboratory cold-room study in which sliding friction was measured with a British pendulum tester are described. Four temperatures, three sand gradations, four brine concentrations, and four sand-application rates were investigated. All tests were performed on an ice sheet in a cold room, where sand temperatures were maintained close to ice temperatures. Three categories of materials were tested: sand alone, sand-salt mixtures, and sand-brine mixtures. Results showed that sand-brine mixtures outperformed the other two, with significantly greater sliding friction. Two brine concentrations were found suitable in two temperature ranges. Below -12°C , 2.5 percent brine (by weight) gave good results with a fine sand (passing the No. 30 U.S. sieve but retained on the No. 50 sieve) at a sand application rate of 1 g over a test area of 100x200 mm, with a sand-to-brine ratio of 1:1 by weight. This rate is equivalent to field application of 183 kg of sand per lane-km. Friction was achieved by generating a bond between sand and ice by using a low-concentration brine (2.5 percent by weight). At temperatures above -12°C , satisfactory results also were obtained with 25 percent brine mixed with the same sand at a ratio of 2:1 by weight. In this case, friction was increased by roughening the ice surface with a higher-concentration brine (25 percent by weight).

2009 Research Proposal Form

Proposer name, organization and e-mail address:

Dennis Burkheimer
Iowa Department of Transportation
Dennis.burkheimer@dot.ia.gov

Title of proposed research project:

National Peer Exchange 2009

1) Background:

In August 2007 the first National Peer Exchange was held in Columbus, Ohio in conjunction with the Eastern Snow Conference. The Exchange was jointly sponsored by Clear Roads, Aurora, FHWA, SICOP and PNS which allowed two representatives from each state to meet to develop and prioritize national winter research needs. Thirty five states attended the Exchange and provide a list of research problems for others to address.

In August 2009 the Eastern Snow Conference will be held in Madison, Wisconsin. The Peer Exchange, if approved, could be held in conjunction with the Eastern Snow conference which would allow attendees the opportunity to attend the Peer Exchange and the Eastern Snow conference.

2) What is the specific problem or issue?

The first Peer Exchange allowed attendees the opportunity to learn about research being conducted by the various winter research groups and also identify and prioritize research needs for the winter maintenance community. Many attendees felt the Peer exchange was a good opportunity to talk with others about winter maintenance issues but felt there was not adequate time to have thorough discussions on key topics. National Winter research groups began working on the research problems identified in the Peer Exchange and holding another Peer Exchange in 2009 would allow attendees to see the progress being made in some of these areas.

3) List the proposed research objectives and tasks.

Update attendees on research conducted since the Peer exchange in 2009
Allow research groups to provide updates on the work they have been doing
Select state presentations
Allow attendees time to network and learn from others through classroom or other settings
Allow attendees time to attend Eastern Snow Conference in Madison, WI

4) What would be the product(s) of the research?

Written report

5) How would the results benefit DOTs? How would they be used?

States would have the opportunity to learn about the work of the different winter research groups, hear the progress on research problems identified in the first Peer Exchange and also have the opportunity to meet their peers.

6) List the estimated funding needed.

\$30,000 (joint funding with Aurora (already approved), FHWA and SICOP).

7) List the estimated timeline for completing the research.

Completed in August 2009

8) Are you aware of any related research on this topic? If so, please list below.

No, this would be a follow-up to the national Peer Exchange held in 2007

2009 Research Proposal Form

Proposer name, organization and e-mail address:

Dennis Burkheimer and Tina Greenfield (on behalf of Aurora)

Iowa DOT

Dennis.burkheimer@dot.iowa.gov and tina.greenfield@dot.iowa.gov

Title of proposed research project:

Salinity Sensor Development and Evaluation

1) Background:

Winter maintenance professionals must ensure that an appropriate amount of deicing chemical remains on the road. Enough chemical must be present to prevent bonding of snow and ice to the pavement and to prevent slush from refreezing on the pavement, while at the same time care must be taken to avoid the cost of over-application, which includes the cost of salt and labor to spread unnecessary salt, as well as the unnecessary cost to the environment and corrosion to highway infrastructure and vehicles. Salinity and freeze point sensors which can accurately sense the amount of chemical or the solution's freeze point would be useful tools for winter maintenance decision makers to assess whether a sufficient amount of chemical is present on the pavements.

2) What is the specific problem or issue?

In August 2007, the National Winter Maintenance Peer Exchange attendees identified the lack of reliable fixed and vehicle-mounted salinity sensors as a significant operational problem (group rank placed 9 out of 27). While salinity sensors of various forms have been on the market for some years, they are said to not be reliable enough to assist in winter maintenance decision making. The 2005 NCHRP 6-15 study "Testing and Calibration Methods for RWIS Sensors" concluded that most of the available sensors were able to provide reasonable freeze point data in the laboratory environment.

Development and evaluation of new sensors is a potentially difficult and expensive endeavor for vendors. Furthermore, it may be difficult for an agency wishing to purchase some new salinity sensor technology to determine whether the new sensor is as good as claimed, especially when the technology is new enough that few other agencies have any long-term experience with it.

The Aurora Consortium has approved an FY 2009 project to assist in the development/modification and testing of salinity or freeze point temperature sensors. Aurora proposes to select several companies (via RFP) to develop new salinity or freezing temperature sensors for in-pavement, remote, or on-vehicle use. The sensors will be tested according to common criteria, as defined by Aurora. Aurora will partially or completely fund the research and testing and require that the testing results be published, and that the sensors be multi-platform compatible. Aurora would like to invite Clear Roads to participate as partners on this endeavor.

3) List the proposed research objectives and tasks.

The objective is to encourage vendors or universities to create improved salinity sensors by providing funding and guidelines for sensor performance, which can be adapted for use on existing RWIS systems and vehicle logging systems. The tasks would include defining the guidelines for sensor performance, developing an RFP, tracking the progress of the developers, and evaluating the performance results.

4) What would be the product(s) of the research?

Market-ready sensors which can be used on a variety of platforms, with known performance characteristics.

5) How would the results benefit DOTs? How would they be used?

A DOT could use the improved sensors on their RWIS or maintenance vehicles to help monitor road chemical concentration and treatment strategies.

6) List the estimated funding needed.

At least \$50,000.

Aurora has already approved \$50,000 for this project.

7) List the estimated timeline for completing the research.

RFPs out by summer 2009, project complete by Fall 2010.

8) Are you aware of any related research on this topic? If so, please list below.

Noninvasive Road Weather Sensors

Paul Bridge, Vaisala Inc.

From: TRB Transportation Research Circular E-C126, June 2008, pp 407-415

<http://onlinepubs.trb.org/onlinepubs/circulars/ec126.pdf>

Abstract: Many road authorities have invested in roadway weather information systems (RWIS), which provide data from locations around their road networks 24/7. Most of these systems are based on 30-year-old technology, in the form of sensors embedded in the road surface to provide information about surface conditions and temperature. Along with atmospheric sensors, the majority of these road weather stations provide authorities with information to help tackle the problems of ice and snow. The 2003 American Meteorological Society Forum on Weather and Highways noted that RWIS significantly benefit highway maintenance operations, particularly winter maintenance. The consensus of transport professionals was that there would be clear benefits from a denser network of road weather observation sites. At the same time it recognized that deployment of RWIS has been limited by their cost and the strong competition for limited funds within state departments of transportation. The recent introduction of noninvasive road temperature and condition sensors is providing a cost effective solution for authorities to both obtain improved road weather information and increase the density of RWIS observations. This paper explores the applications and benefits of non-intrusive road sensors with a particular focus on (a) winter maintenance key performance indicators, (b) decreasing environmental impact of deicing agents, and (c) sensor deployment.

Detection of Water and Ice on Bridge Structures by AC Impedance and Dielectric Relaxation Spectroscopy - FY08 NATSRL

TRB Research in Progress database, <http://rip.trb.org/browse/dproject.asp?n=19960>

This research aims to develop low-cost sensing systems for monitoring ice and water on bridge deck surfaces. These sensing systems are based on the measurement of impedance of the sensor in contact with or in close proximity to ice, water or aqueous solutions of deicing chemicals. The researchers will explore two alternative technologies: impedance analysis at lower frequencies will determine the presence of deicing electrolyte solutions (a sort of "conductivity measurement"), while high-frequency dielectric relaxation using time domain reflectometry will probe the physical state of precipitation and deicing chemicals on the deck or road surface (via dielectric relaxation). In both approaches, the methodologies will use low-cost electrodes in the impedance analysis schemes.

Maintenance Decision Support System Is Not Just for State Departments of Transportation

William (Pat) Kennedy, City and County of Denver Public Works

From: TRB Transportation Research Circular E-C126, June 2008

<http://onlinepubs.trb.org/onlinepubs/circulars/ec126.pdf>

Scroll to "Other Technologies," p 246 --

Denver has invested in other technologies that tie directly and indirectly to MDSS and winter snow operations. One of the direct links is the use of pavement sensors to augment and validate the predictions of pavement conditions made by MDSS. MDSS uses the typical pavement structure to predict surface and subsurface temperature profiles and how these will affect and be affected by snow or ice accumulations. The city has installed sensors in four intersections that provide surface and

subsurface temperature; phase of surface moisture; and, from the conductivity of the moisture, the concentration of chemical deicers on the roadway surface. MDSS can use these data and data from other sources in the models to predict the changes that will occur to pavements during the course of an event and to validate the current model. Forward error corrections are made based on the measured current conditions.

Intelligent Transportation Systems and Winter Operations In Japan

FHWA International Technology Exchange Programs, September 2003

Chapter 3, Key Findings

http://international.fhwa.dot.gov/Pdfs/converted_to_html/scanreports/intelligent/chapter3.htm#winter

Scroll to "Advanced Maintenance Equipment / Vehicle-Mounted Performance-Monitoring Systems" --

The advances of note in this category include salinity sensor development. Prototype devices to measure the salinity content of liquid and slush on the road surface are under development by two Japanese companies. The concepts employed use spectral analysis of refractive light measurements and electrical conductivity measurements. These approaches complement the chemical detection devices under development in Sweden for the past four years.

A Portable Method to Determine Chloride Concentration on Roadway Pavements

Norman Garrick, Nikolaos Nikolaidis and Jianhui Luo

Report No. NETCR 17, Prepared for The New England Transportation Consortium, September 2002

<http://docs.trb.org/00939363.pdf>

Abstract: Sodium chloride (NaCl) is by far the most commonly used deicing chemical. More effective use of deicer chemical could result in significant economical and environmental benefits. Studies have shown that the ability to measure the salt concentration on the roadway surface would bring dramatic advances in the effective use of deicer. Concentration measurement devices currently in use are only for point measurement and are dangerous for field measurement personnel because they require manual on site measurement. Our new portable concentration system in this project which is mounted on a truck enables safe and continuous measurement of salt concentration.

This study adopts the principle of collecting the tire splash to measure the residual salt concentration on the road surface. A conductivity probe is used to detect salt concentration because it is simple to use and is suitable for rugged field applications. Field test results show that the system was able to continuously detect the salt concentration and distinguish the difference between two areas of different salt concentration under field conditions. We observed delay in the salt concentration detection due to the inflow fluid detained in the snow collection box. However, we developed an analytical method to model this delay and to predict the inflow concentration.

2009 Research Proposal Form

Proposer name, organization and e-mail address:

Dennis Burkheimer
Iowa DOT
dennis.burkheimer@dot.iowa.gov

Title of proposed research project:

National Driver Education Training Curriculum

1) Background:

Every year hundreds of thousands of new drivers are driving on snow and ice covered roadways for the first time. In most states driver education training classes are conducted during the summer months and the curriculum covered in the training is often mandated by the Board of Education or some other agency. Very little is taught on how to operate a vehicle safely when roads are covered with snow and ice.

2) What is the specific problem or issue?

Many driver education training programs lack good information on how to operate motor vehicles when roads are covered with snow and ice leaving many new drivers unprepared for the hazards they face during winter driving conditions.

3) List the proposed research objectives and tasks.

- Survey of states to determine extent of winter driver education training currently available
- Develop curriculum and accompanying materials for a short course on safe winter driving
- Develop test questions for driver license examinations
- Provide self-help kits for individual states to use to encourage adoption of the winter driver education training program in their states
- Develop Strategic plan for technology transfer

4) What would be the product(s) of the research?

Driver education curriculum and materials to support a short course on winter driving safety for new drivers

5) How would the results benefit DOTs? How would they be used?

Properly trained young drivers would hopefully reduce the number of young people involved in winter crashes. Hopefully the product would be a stand alone product that could be distributed to driver education trainers or made available online.

6) List the estimated funding needed.

\$150,000-200,000

7) List the estimated timeline for completing the research.

2 Years

8) Are you aware of any related research on this topic? If so, please list below.

Operation Lifesaver has been successful in making training about crossing railroad tracks a requirement in some driver education classes.

Driver Education for Safety in Adverse Driving Conditions

FHWA-AZ-08-609, February 2008

http://www.azdot.gov/TPD/ATRC/publications/project_reports/PDF/AZ609.pdf

The purpose of this research was to 1) identify best practices for teaching drivers how to safely negotiate adverse conditions including sleet and blowing snow, and roads with snow, ice or slush cover, and 2) develop a realistic module for a driver education program that addresses adverse conditions. The study consisted of four main tasks, which included a literature review, statistical

analysis of Arizona crash data, a survey of other states regarding their driver education programs, and targeted case studies of selected states and other private or semi-government agencies involved in driver education curriculum development and implementation.

Intelligent Transportation Systems and Winter Operations In Japan

FHWA International Technology Exchange Programs, September 2003

Chapter 3, Key Findings, Driver Education for Winter Conditions

http://international.fhwa.dot.gov/Pdfs/converted_to_html/scanreports/intelligent/chapter3.htm#driver

Driver education is taken seriously in Japan and is considered more of a social responsibility than in the United States. Special driver programs are offered in Hokkaido for wintertime driving conditions. A winter condition driving course is being developed in Hokkaido for students enrolled in driver training during milder times of the year. Through its law enforcement branch, the Prefecture Government develops the training content and bears the cost for publicly offered driver education courses. The Prefecture Traffic Safety Association and the Japan Automobile Federation provide the instructors. Both agencies are the primary sources for publicly available driver education. Private and professional driver education programs also exist. Other positive attributes of driver education in Japan include the following:

- A road information center at a Hokkaido Regional Development Bureau rest area contains a variety of winter driving educational tools. These include four fully functional driving simulators to demonstrate driving on three different winter roads. The simulators feature an interactive 12-question driving test. Other educational tools include numerous posters and graphical displays of driving and safety topics located throughout the center, including the restrooms.
- Winter driving information is also available for motorists on the Web and at strategically located kiosks.
- The Japanese government encourages motorists to use modern snow tires through winter safety programs. These tires, which use a soft rubber compound and a porous tread surface, provide superior traction on ice and snow. In the United States, the tires are marketed primarily to sports car owners.

Chapter 5, Recommendations

http://international.fhwa.dot.gov/Pdfs/converted_to_html/scanreports/intelligent/chapter5.htm

Scroll to "F- Driver Education for Winter Conditions" --

- Survey states on the timing requirements, content and jurisdictional responsibilities for driver education on driving under wintertime conditions.
- Survey professional driver education programs for content related to wintertime conditions.
- Develop an AASHTO resolution to FHWA on the importance of a multidisciplinary effort to increase public awareness of the potential dangers of driving during winter weather using such methods as PSAs, rest area placards etc.
- Develop incentives for states to promote the use of better tires for winter road conditions.

2009 Research Proposal Form

Proposer name, organization and e-mail address:

Dennis Burkheimer
Iowa Department of Transportation
Dennis.burkheimer@dot.ia.gov

Title of proposed research project:

Deicing Chemical Blends and Their Contribution to Reduced Friction on Roadways

1) Background:

In recent years deicing chemical manufacturers have introduced new deicing products that contain additives or blends of common deicing chemicals. There is some question as to whether these new products may contribute to slipperiness or refreezing on pavement surfaces under certain atmospheric conditions, application rates or application timing. Limited lab and field research has been conducted in this area to determine what factors contribute to slipperiness on the roadway.

2) What is the specific problem or issue?

Snow removal agencies are purchasing deicing products blended with other ingredients or being blended with other deicing chemicals to create new deicing products. Some of these products appear to contribute to roadway slipperiness under certain conditions. The purpose of this project is to investigate what factors influence slipperiness or refreezing on the road when using deicing chemical blends. The investigation should determine the various factors that may cause refreezing or slipperiness on the roadway in the lab and field environments. Weather, previous applications, pavement type/structure, product type, application rates, pavement temperature, air temperature, relative humidity, etc all may contribute to slipperiness or refreezing on the roadway surface.

3) List the proposed research objectives and tasks.

- Literature search
- Lab testing- define lab tests that can identify a deicing chemicals potential to contribute to slippery conditions
- Field testing- Verify the lab tests are valid in field tests

4) What would be the product(s) of the research?

The product of this project should be a laboratory test that can be used to determine a deicing chemical or deicing chemical blends potential to contribute to slipperiness on the roadway. A general guide could also be developed that can help users determine what generic factors create slippery conditions on the roadway when using deicing chemicals or deicing chemical blends. All deicing chemicals go through a transition stages from dry to liquid or liquid to dry and will often create slippery conditions on the roadway. Some of these slippery conditions are short term but many may be long term events that can create hazards on the roadway. The guide should provide guidance on several standard deicing chemicals and blends.

5) How would the results benefit DOTs? How would they be used?

States would have the ability to conduct quick laboratory tests to identify deicing products or blends that have the potential to contribute to roadway slipperiness. The results of the field tests may also provide further guidance beyond the lab tests if the slippery conditions occur only under certain atmospheric conditions or application rates. This would then provide guidance to operations to help avoid creating slippery roadways.

6) List the estimated funding needed.

\$200,000

7) List the estimated timeline for completing the research.

Completed in December 2011 (two year project)

8) Are you aware of any related research on this topic? If so, please list below.

Levelton Engineering has done some work in this area. The PNS group has done extensive work in the area of deicing chemicals and should be heavily involved in this project on the Technical Advisory Committee.

Minnesota Snow and Ice Control: Field Handbook for Snowplow Operators

Minnesota Local Road Research Board et al., Manual Number 2005-01, August 2005

<http://www.mnltap.umn.edu/pdf/snowicecontrolhandbook.pdf>

Scroll to "Before the Storm / Anti-icing / What Not to Do," p 6 --

- Don't anti-ice under blowing conditions, in areas prone to drifting, and anywhere else you would refrain from using salt. Be aware of areas that are prone to wind issues.
- Reapplication isn't always necessary if there is still a residual. The residual effect can remain for up to five days after application if precipitation or traffic wear-off does not dilute the initial application.
- Remember that the surface can refreeze when precipitation or moisture in the air dilutes the chemical.
- Don't apply MgCl₂ or CaCl₂ to a warm road (above 28°F pavement temperature). It can become slippery and cause crashes.
- Don't apply before predicted rain.
- For the first application or after a prolonged dry spell, apply liquids at half the rate (not half the concentration). On dry roads, liquids tend to mix with oil from vehicles and cause slippery conditions.
- Don't apply too much or the roadway may become slippery. Less is better. Always follow application recommendations.

Vehicle Crashes After De-icer Makes Road Slick

Jennifer Wilson, The Colorado Springs Gazette, Feb. 5, 2008

http://findarticles.com/p/articles/mi_qn4191/is_/ai_n24311662

Colorado Springs officials are trying to figure out why anti-ice chemicals meant to make roads safer instead turned at least one of them slippery Monday.

A quarter-mile of Austin Bluffs Parkway east of Union Boulevard became slick a few hours after crews applied deicing liquid to 20 miles of dry city roads in anticipation of a snowstorm, said Bard Lower of the city's streets division. "We're doing a full investigation into what happened," he said. Meanwhile, the city won't use the de-icer, Lower said.

The only reported problem was along the short stretch of Austin Bluffs. "There's 193 miles that's working exactly like it's supposed to," Lower said. "In general, it's working perfect."

Colorado Springs police reported one crash on the slick area -- a rollover with no injuries, Sgt. Carlos Montoya said. Crews applied sand to the area after the crash. A similar incident happened in November in El Paso County, when de-icer applied before a storm created slippery conditions. In that instance, officials determined the chemical drew moisture out of the air as the humidity jumped from 20 percent to 80 percent, said John McCarty, county transportation director.

"Then we got a front going through that cooled the temperature down and caused it to freeze," McCarty said.

The county uses calcium chloride, and the city uses a mixture of magnesium chloride, Lower said. The city's de-icer, called Caliber, is distributed by EnviroTech Services of Denver. It costs 72 cents per gallon, and the city has about 6,000 gallons on hand. EnviroTech trainer and salesman Mike Hern,

who's investigating Monday's incident, said Caliber can also make newly built roads slick. On roads with normal wear and tear, it soaks into the road's pores, he said, but new asphalt has a layer of oil on top -- keeping the de-icer from sinking in. Construction crews are building roads at Austin Bluffs and Union for the intersection's new overpass.

The Colorado Department of Transportation uses Caliber on some state roads near Castle Rock, Greeley and Grand Junction, spokesman Bob Wilson said. CDOT uses other forms of magnesium chloride elsewhere. But CDOT crews never spray de-icer before the snow falls, Wilson said.

2009 Research Proposal Form

Proposer name, organization and e-mail address:

Dennis Belter
Indiana DOT
dbelter@indot.in.gov

Title of proposed research project:

Liquid Snow Removal Routes

1) Background:

Rising costs and decreasing revenues are a constant for maintenance officials. Cost saving options are needed to stretch limited resources.

2) What is the specific problem or issue?

Snow removal has been performed by traditional methods for many years. Anti-icing with liquids is a relatively new process that saves limited resources. Additional research is needed to identify effectiveness, efficiencies, and limitations of increasing the use of liquid routes.

3) List the proposed research objectives and tasks.

The proposed research is to test liquid materials to determine effectiveness, limitations and efficiencies of liquid only applications.

Field testing would be performed using only liquids (salt brine, magnesium chloride, calcium chloride, salt brine blend, others) to identify when liquid routes are effective. Testing would establish guidelines on the types of events that using liquid routes are effective.

4) What would be the product(s) of the research?

The research would determine if the liquid route is effective and efficient. In addition, any cost/material savings resulting from the use of liquids (by type) versus solid salt would be identified.

5) How would the results benefit DOTs? How would they be used?

If effective, reduction in material costs could result.

6) List the estimated funding needed.

\$150,000

7) List the estimated timeline for completing the research.

At least one year for design and field testing during one season, preferably two seasons.

8) Are you aware of any related research on this topic? If so, please list below.

Iowa is doing some related research (not published), also Ohio

Evaluation of a Fixed Anti-icing Spray Technology (FAST) System

Brandon Ward, Project Manager, New York City Department of Transportation, Division of Bridges
http://ops.fhwa.dot.gov/weather/best_practices/NYCDOTanti-icingSys.pdf

Abstract: This paper describes the in-house development (Phase I) of the Fixed Anti-icing Spray Technology (FAST) systems to apply less corrosive liquid chemical freezing point depressants on portions of the south roadway (Manhattan-side span) of the Brooklyn Bridge.

Scroll to "Recommendations," p 16 --

- Expand and develop the FAST system on the Brooklyn Bridge...

- Initiate initial treatment application closer to the event start. This is achieved via a FAST system. Trucks will be used for plowing, subsequent treatments (if needed), and spreading of solid (granulate) deicers.
- Implement plowing operation. This task should be performed utilizing plows with slush blades. This approach and strategy would have the resultant effect similar to a squeegee-like cleaning (scraping) of the roadway. This “scraping” procedure is recommended for snow accumulation <1 inch and performed utilizing an underbody scraper.
- Implement and use a Road Weather Information System (RWIS)...
- Evaluate and implement the East River Bridges Winter Incident Management Plan: Phase II.

2009 Research Proposal Form

Proposer name, organization and e-mail address:

Dennis Belter, Indiana Department of Transportation, dbelter@indot.in.gov

Title of proposed research project:

Effectiveness of Anti-icing Liquids in Maintenance Decision Support Systems (MDSS) Maintenance Recommendations

1) Background:

Liquids are being used for anti-icing prior to snow, frost and ice events. This strategy has been effective in preventing frost on bridges, providing a buffer time for crews to treat roads and preventing snow/ice pack. Salt brine is the most common anti-icer, but other liquids have been used also.

2) What is the specific problem or issue?

To my knowledge, no field tests have been made to determine the effectiveness of the treatment, how long it lasts and how treatments should affect MDSS recommendations.

3) List the proposed research objectives and tasks.

Field research on the effectiveness and length of time liquid anti-icers are effective and determining the affect on MDSS recommendations. Test salt brine, Magnesium Chloride and Calcium Chloride in field conditions.

4) What would be the product(s) of the research?

The end result should provide data to providers of MDSS that will improve maintenance recommendations. Maintenance recommendations would include when to anti-ice and be incorporated into recommendations at the start of an event.

5) How would the results benefit DOTs? How would they be used?

As identified here, it would provide DOTs using MDSS improved recommendations. However, results would provide all DOTs data on the benefits of anti-icing.

6) List the estimated funding needed.

Unknown.

7) List the estimated timeline for completing the research.

At least one year, including minimum of one winter season, but preferably two winter seasons.

8) Are you aware of any related research on this topic? If so, please list below.

Durability of Brine Applications for Winter Maintenance on Asphalt and PCC Pavements

Andrew Russ, Gayle Mitchell and Wallace Richardson, Ohio University.

Paper Number 08-2608, TRB 87th Annual Meeting Compendium of Papers DVD, 2008

[The paper is attached, see "Durability of Brine."](#)

From the Abstract and Conclusions:

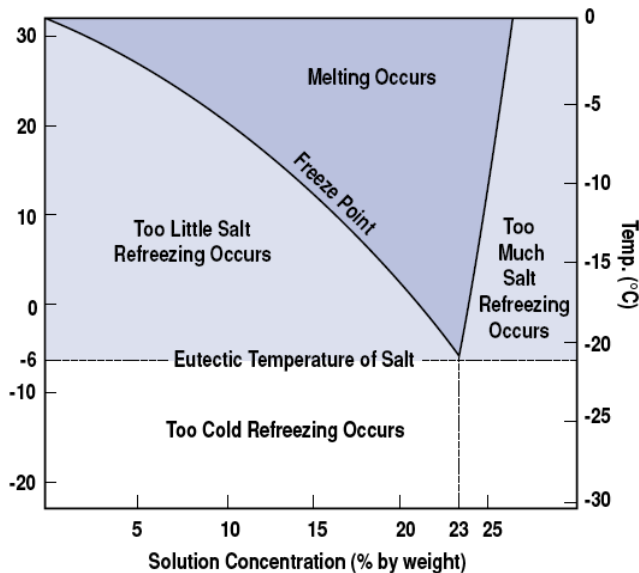
Experiments on asphalt concrete and Portland cement concrete pavements were conducted to determine the lifetime of brine residue from pretreatment. The amount of salt residue on the road was measured using Boschung SOBO-20 salt measuring devices with rehabilitated electronics. The decay of salt over time on both pavements was found to be consistent with an exponential decay. Research results also suggest that brine pretreatment wears off (or disappears into voids within) asphalt more quickly than grooved PCC, meaning that for asphalt roads it is more important that pretreatment be timed closer to an anticipated winter weather event. In cases where pretreatment must be scheduled earlier than the day before the event, a higher application rate may be warranted.

The Snowfighters Handbook

Relevant excerpts --

- Research has shown that timely applications of anti-icing materials can cut the cost of maintaining a safe road surface by 90 percent compared to traditional deicing.
- Liquid sodium chloride (NaCl) is the most effective choice for anti-icing above 15°F.
- Salt brine is effective to -6°F and is a proven anti-icing agent in use throughout the snowbelt.
- Some agencies use calcium or magnesium chloride in a brine solution which is effective down to -6°F.
- The proportion of salt to water is critical to the effectiveness of brine. Too much or too little salt affects the freeze point depressing qualities of the brine. The proper brine mixture is 23.3 percent salt content by weight.
- Understanding the freeze point depressing qualities of brine is important to its use and application as an anti-icing agent. As indicated in the phase diagram below, the minimum freeze point of salt brine is -6°F at a concentration of 23.3 percent. Road surface temperatures are indicated on the side of the chart, solution concentrations along the bottom. The line represents the freeze point of the solution at a given temperature. The colored portion in the center of the chart shows the melting range of brine solutions. The area to the left shows the results of a solution with too little salt -- the road surface will refreeze unless more salt brine or deicing salt is applied. The area to the right shows the results with too much salt, and once again the surface will freeze without the introduction of more moisture. Additional precipitation and heavy traffic can dilute the brine solution allowing the road to refreeze.

Phase Diagram for Salt



Friction Trends of Anti-Icing Chemicals on Tined Concrete

Gerald Sdoutz and Timothy Leggett, Forensic Dynamics, March 2001

[The paper is attached, see "Friction Trends."](#)

From the Abstract: This latest set of anti-icing chemical friction tests was conducted on a tined concrete surface. Most of the chemicals tested in their liquid state provided a friction equivalent to, or greater than, 0.5. Relative humidity levels between 25 and 40 percent caused most of the chemicals to transition through a minimum friction slurry state. During this transition a number of chemicals produced a friction significantly below 0.5. Some of the chemicals appeared to be absorbed by the porous concrete. Others appeared to form a bond with the concrete, allowing them to remain in a liquid state even at extremely low relative humidity levels, and therefore provide a constant friction.

Road Safety Benefits of Liquid Anti-icing Strategies and Agents

Graham Gilfillan, Insurance Corporation of British Columbia, 1999

[The paper is attached, see "Road Safety Benefits."](#)

From the report: The Insurance Corporation of British Columbia (ICBC), in partnership with the City of Kamloops (British Columbia), tested the effectiveness of a liquid anti-icer for the purpose of decreasing motor vehicle accidents caused by slush, snow or ice on the roadways. The study predicts that up to 54 percent of collisions on arterial roads and 77 percent of collisions on the highways were considered preventable by using a liquid anti-icer. It was then determined that the average claims savings to ICBC for these preventable accidents, based on previous claims costs, would be \$334,000 per month or \$1.3 million per year (average cost of arterial collision \$16,040, average cost of highway collision \$20,506). A test was also conducted and preliminary results show that there were 3 percent to 28 percent fewer collisions during days when an anti-icing agent was applied. The results of this study show a very promising trend in reducing motor vehicle accidents through the use of a liquid anti-icer. However, these results cannot be deemed "totally conclusive" as a result of different winter conditions, less reporting of accidents by local police and differing application methods.

Alternative Snow and Ice Control Methods: Field Evaluation

Richard Parker, Oregon DOT Research Unit

Report No. FHWA-OR-RD-98-03, September 1997

http://www.oregon.gov/ODOT/TD/TP_RES/docs/Reports/AlternativeMethodsSnow.pdf

This document is the result of a two-year study to evaluate the emerging technologies in snow and ice control and determine their economic and operational effectiveness. Operational, environmental and economic factors were evaluated to compare Oregon's "plow and sand" strategies to emerging chemical-based anti-icing strategies. The strategies examined included the use of calcium magnesium acetate (CMA) and magnesium chloride (MgCl₂) known for their effectiveness, low corrosion and low environmental impact. The 10 evaluation sections in this study represented the various climate conditions found throughout the state. Results show that an anti-icing strategy with either CMA or MgCl₂ is effective and cost-efficient under a wide range of climatological and traffic conditions when compared to traditional "plow and sand" strategies.

Anti-Icing Study: Controlled Chemical Treatments

Russell Alger, Edward Adams and E. Phillip Beckwith, Michigan Technological University

Report No. SHRP-H-683, April 1994

<http://onlinepubs.trb.org/Onlinepubs/shrp/SHRP-H-683.pdf>

The objective of this study was to develop correlations between meteorologic parameters and chemical effectiveness, to better understand the optimum conditions for which a particular chemical application is most effective. This information is of practical benefit when used in conjunction with predictive meteorologic information. The emphasis on the chemical treatment was anti-icing, since chemicals are more efficiently utilized for adhesion prevention, than for removing ice or compacted snow already in place. By anti-icing, it is not inferred that chemical treatment alone will, in general, be sufficient to maintain an acceptable level of performance. Instead, it implies that pre-treatment will allow a satisfactory road condition to be maintained by the chemical when used in conjunction with mechanical means of removal. Although the major emphasis of this study was to assess the anti-icing properties of each chemical for different scenarios, some tests included deicing to some extent, out of necessity. There will likely be cases in which anti-icing is insufficient to maintain acceptable conditions throughout a storm and chemical re-application may be required if attempts to remove the ice and snow are not successful by highway crews.

Development of Anti-Icing Technology

Robert Blackburn, Erin McGrane, Cecil Chappelow and Douglas Harwood, Midwest Research Institute; and Edward Fleege, Minnesota Department of Transportation

Report No. SHRP-H-385, April 1994

<http://onlinepubs.trb.org/Onlinepubs/shrp/SHRP-H-385.pdf>

Nine state highway agencies conducted anti-icing experiments when possible during the 1991-92 and 1992-93 winters. These tests were used to develop a better understanding of both the conditions under which anti-icing will be effective and how to conduct anti-icing efficiently to ensure the greatest success. Prewetted salt and liquid chemicals were used during the anti-icing experiments. The project also involved evaluating specialized equipment for applying controlled quantities of solid, prewetted or liquid chemicals at minimum application rates required for effective anti-icing treatment. Limited field tests were conducted with some DOT spreaders to determine important variables associated with evaluating spreader application rates and distribution patterns. A limited cost-benefit analysis was performed, comparing anti-icing effectiveness with deicing operations, considering such factors as accidents and material, equipment, and labor costs. The report also presents meteorological criteria and support items that are important for anti-icing operations at potential test sites.

2009 Research Proposal Form

Proposer name, organization and e-mail address:

Linda Taylor, MN-DOT, Linda.Taylor@dot.state.mn.us

Title of proposed research project:

Snow College for Frontline Managers

1) Background:

Maintenance supervisors are promoted from within the agency. The superintendent's leadership style and how progressive they are toward technology determines whether or not the individuals are mentored and trained on the job. In a lot of cases, the new supervisor learns on the job with little or no knowledge or background on what is available and how to use the tools.

2) What is the specific problem or issue?

There is no formal training currently available to prepare supervisors for the additional responsibilities for winter operations when they are promoted. There are various tools (AASHTO Suite of Winter Maintenance CBTs, CTAP courses, and workshops, Salt Symposium, internet courses, Managing Snow & Ice Operations, Eastern Snow Expo, Anti-icing/RWIS scenarios etc.) that are available but new supervisors may not be aware of or given the opportunity to participate.

3) List the proposed research objectives and tasks.

Literature search of course available

Conduct five to seven focus groups at various state DOT agencies to identify training needs, gaps and inconsistencies in operational procedures.

Establish a training curriculum to address frontline supervisors' training needs.

Develop a training plan that can be used by DOTs.

Recommend different methods for delivering the training and potential funding sources.

Final Report

4) What would be the product(s) of the research?

Summary of literature search

Focus group questions & summary report of findings

Training Curriculum

Training Plan

Final Report

5) How would the results benefit DOTs? How would they be used?

Frontline supervisor would be properly training and knowledgeable on Winter Operations

Saving tax payer dollars by better and more effective use of resources for Snow & Ice Operations

Consistent training being provided to managers that equips them with knowledge and skills to better perform their job responsibilities

6) List the estimated funding needed.

\$50,000

7) List the estimated timeline for completing the research.

Approximately One year

8) Are you aware of any related research on this topic? If so, please list below.

Wilfred Nixon – Snow College

Dale Keep - Ice & Snow Technologies

Diana Clonch –Ohio DOT training program

Dennis Burkheimer – Ohio training program

Road Weather Management Web-based Course

<http://www.citeconsortium.org/courses/RoadWeatherMgmt.html>

FHWA and the Consortium for ITS Training and Education have developed an interactive Web-based course on the "Principles and Tools for Road Weather Management" that provides highway maintenance and highway operations professionals with training to develop tools and strategies for addressing road weather problems. This course provides the same content as the National Highway Institute classroom version of the course, but in an online format. Instruction begins with an overview of the types of road weather problems and their associated costs, as well as basic meteorology for non-meteorologists. Participants are exposed to various strategies for addressing road weather problems, including RWIS and the development of crosscutting decision support systems to respond effectively to weather situations. Road weather solutions unique to maintenance management, traffic management, traveler information and emergency management are discussed.

Snow School

<http://www.ogra.org/education/resultnew.asp?track=vs&eventsess=3451>

This on-site training opportunity has been offered annually by the Ontario Good Roads Association since 2006. Participants receive a comprehensive overview of the latest winter maintenance practices, equipment and materials. Course topics slated for the Sept. 28 to 30, 2009 session include Snow and Ice Control; Weather and RWIS; Salt Management; and Minimum Maintenance Standards, Level of Service, Record Keeping, Safety, Hours of Service. The target audience includes winter maintenance supervisors; technicians, technologists and others responsible for salt management plans; and patrollers. (The Engineering Institute of Canada honors this course with 2.1 continuing education units.)

Winter Operations Training Programs

<http://www.saltinstitute.org/snowfighting/training-ltap.html>

The Salt Institute is offering free of charge a suite of four training programs developed in cooperation with winter operations specialists at five LTAP centers: Winter Operations -- Survival Lessons for Public Officials, Winter Planning and Organization, Materials, and Equipment. Each program can stand alone or be presented in conjunction with the others as a full half-day training session to inform and prepare local government officials, snowfighting management, supervisors and equipment operators for winter operations. The third and fourth programs are of particular interest:

- "Materials" is directed to supervisors and operators. It reviews how various materials used in winter maintenance work and how they should be applied. It includes a discussion of proper storage, use of liquids for pre-wetting, and introduces the concept of anti-icing and use of liquids. This program has a training outline and a handout.
- "Equipment" is also for supervisors and operators and reviews the variety of snowfighting equipment available to winter maintenance professionals. This program also has a training outline.

The sessions were developed to be introductory, and to create an interest in further, more detailed training.

Suggested Program Outline For Fall Training Sessions

From: The Snowfighters Handbook, Salt Institute, 2007, p 21

<http://www.saltinstitute.org/publications/snowfighters.pdf>

I. The Importance of Coordination

- Know Your Plowing and Spreading Routes
- Effective Radio Communication
- The Storm Warning System
- Working with Police, other Public Agencies and the Media

II. Equipment Operation and Maintenance

- Plows
- Spreaders, Sprayers and Their Controls
- Loaders

- Emergency Repair and Refueling Stations
 - The Importance of Preventive Maintenance
- III. Application Procedures
- How Salt Works
 - How and When to Salt
 - Anti-Icing vs. Deicing
 - Application Rates
 - Special Storm Conditions
 - Special Deicing Problems (Bridges, Elevated Curves, Ramps, Intersections)
 - When to Reapply Salt
- IV. Review of Winter Maintenance Policy
- Snow Emergency Routes
 - Parking Ordinances
 - Procedures for Helping Motorists
 - Importance of Personal Public Relations by Maintenance Personnel
- V. On-the-job Safety
- Safety Equipment
 - Safety Practices
- VI. Discussion, Questions and Answers

To assure yourself that your department is ready for winter, you might have superintendents or foremen complete a checklist showing their progress in pre-winter preparations. A suggested checklist similar to that used by a number of cities and states is illustrated on pages 22 and 23.

2009 Research Proposal Form

Proposer name, organization, and e-mail address:

paul.dejulio@dot.state.co.us

Title of proposed research project:

The Use of Liquid Deicers and Roadway Traction.

1) Background: Several of the states that use mag-chloride have experienced over application of the product along with high humidity, can make the roadway slick, and could cause vehicle accidents.

2) What is the specific problem or issue? There are several liquid-dicers being used by several states that are hydro-scopic, Since these product are hydro-scopic, there is a potential that the roadway can become slick when dew points or humidity is high.

3) List the proposed research objectives and tasks.

Compare, water, mag-chloride and salt brine under different application rates on different roadway conditions, such as asphalt, vs. concrete at different humidity levels to evaluate skid resistant

4) What would be the product(s) of the research?

Water, Salt Brine, and mag-chloride.

5) How would the results benefit DOTs? How would they be used?

DOT's through out the snow related states will have an understanding how different liquid deicers can impact roadway traction. This information can be used to help train our employees on the proper use of material, to avoid secondary accidents of liquid deicers.

6) List the estimated funding needed.

\$25,000.

7) List the estimated timeline for completing the research.

One winter season.

8) Are you aware of any related research on this topic? If so, please list below.

Norwegian Experience with Use of Magnesium Chloride

Torgeir Vaa, SINTEF Roads and Transport

From: TRB Transportation Research Circular E-C063, June 2004, pp 516-528

<http://trb.org/publications/circulars/ec063.pdf>

Abstract: The main goal of the magnesium chloride project was to verify how the amount of salt was affected by alternative salting methods and to study which possibilities magnesium chloride gave for operation at temperatures for which sodium chloride did not work. In addition it was an aim of the project to investigate the duration of an action and time to dry the road surface after salting with different chemicals. Solid sodium chloride prewetted with magnesium chloride liquid has been compared with the standard method, which is to use liquid sodium chloride as agent to solid salt. One of the hypotheses was that magnesium chloride in some circumstances resulted in slippery road conditions, because it is a hygroscopic salt. One of the purposes was therefore to study how different methods affect friction and friction development under varying winter road conditions.

Temperature and Humidity Effects on the Co-efficient of Friction Value After Application of Liquid Anti-icing Chemicals

Timothy Leggett, Forensic Dynamics Inc., September 1999

<http://www.transportation.org/sites/sicop/docs/slicknessrpt.pdf>

The purpose of this research was to determine whether there existed a chemical “slipperiness” as a result of a transition from liquid to a solid, and vice versa, of typical anti-icing chemicals presently in use. Temperature and humidity above those values required to cause the transition phase appear not to affect the friction dramatically. However, at humidity levels in the high 20s to low 30s, most chemicals will begin to dry out (after application as a liquid), potentially resulting in somewhat lower friction values during the transition phase. Additional research is required before definitive conclusions can be made with respect to application on asphalt and concrete surfaces, but it appears that prudent use of the chemicals (particularly with regard to application rate and frequency), bearing in mind incoming humidity levels, can further reduce the likelihood of slickness developing, particularly in the fall season when most incidents are reported to have occurred. Originally, four pure chemicals were tested: magnesium chloride, calcium chloride, calcium magnesium acetate and sodium chloride. Additionally, the following chemicals were tested: Ice Stop and Ice Stop 2000, MCP De-Icer, LiquiDow Armor, FreezGard 0, FreezGard 0 and TEA, FreezGard 0 and SHIELD LS, and FreezGard 0 and Ice Ban.

This research flowed as a result of a technical working group meeting sponsored by AASHTO’s Snow and Ice Cooperative Pooled Fund Program (SICOP) in spring 1999. The group’s mission was to address the potential problems of chemical slipperiness when liquid chemicals are applied to the road. Members reviewed approximately 30 reported incidents in which roads reportedly became slippery after application of liquid chemicals used in anti-icing operations. The group determined that, based on the number of incidents which had been documented and the volume of liquids then used in anti-icing, the likelihood of slickness occurring was likely less than 1/1000th of 1 percent of all applied liquid chemicals. The group’s report is available at <http://www.transportation.org/sites/sicop/docs/Chem%20Slip%20TWG%20report.pdf>.

2009 Research Proposal Form

Proposer name, organization and e-mail address:

Shane Larson, IL Department of Transportation (IDOT), shane.larson@illinois.gov

Title of proposed research project:

Development of a Standard Storm Severity Index and Snow and Ice Removal Performance Standard.

1) Background:

Several states have developed storm severity indexes and performance standards.

2) What is the specific problem or issue?

A performance standard for snow and ice removal activities is needed. With the use of numerous different deicing chemicals, techniques and equipment, it would be beneficial for agencies to be able to accurately determine their performance. The different weather conditions have to be taken into account when determining performance; therefore, it is important that a standard storm severity index is also developed along with the performance standards.

3) List the proposed research objectives and tasks.

The primary objectives would be to develop an automated method to accurately determine storm severity indexes along with a standard performance measures.

4) What would be the product(s) of the research? The research would provide an automated method to calculate storm severity indexes and performance measures after each winter event.

5) How would the results benefit DOTs? How would they be used?

Storm Severity Indexes and performance measures are currently being used throughout the United States. The data to calculate these items is being collected manually and often inaccurately. The results of this research could provide an automated collection and calculation of storm indexes and snow and ice removal performance measures. An accurately calculated performance measure will assist DOTs determine the effectiveness of their snow and ice removal operations.

6) List the estimated funding needed.

\$200,000

7) List the estimated timeline for completing the research.

18 to 24 months.

8) Are you aware of any related research on this topic? If so, please list below.

The Winter Severity Index for New England

From: TRB Research in Progress database

<http://rip.trb.org/browse/dproject.asp?n=18335>

Researchers at Plymouth State University's Judd Gregg Meteorology Institute will develop a New England Winter Severity Index (NEWSI) for use by New England Transportation Consortium member states. The NEWSI will assist in answering questions about the cost benefits of new technologies, as well as the efficiency of winter road maintenance efforts throughout the region. The work will build on research performed on similar indices over the past 15 years. Beginning with an in-depth literature search and discussions with transportation professionals in the six New England states, a NEWSI will be developed that predicts winter road maintenance costs in discrete winter weather zones with 95 percent confidence. A GIS-based computer application that automatically calculates and displays the NEWSI for each zone will be developed and installed on appropriate computers in each state's transportation offices. The application will be accompanied by a user manual that provides instructions on the use of the application and describes a methodology for future revisions to the NEWSI. One-day training seminars will be provided for users in each state.

Modeling Winter Maintenance Activities Using Classification Trees

Jean Andrey, Alexander Brenning and Denis Kirchhoff, University of Waterloo; Brian Mills, Meteorological Service of Canada, Environment Canada; Max Perchanok, Ministry of Transportation, Government of Ontario.

From: TRB Transportation Research Circular E-C126, June 2008, pp 483-498

<http://onlinepubs.trb.org/onlinepubs/circulars/ec126.pdf>

Abstract: Winter severity models have been developed by and for road authorities throughout North America and northern Europe. These models are reviewed with particular attention given to the modeling approach, the temporal-spatial unit of analysis, the characterization of winter weather and winter maintenance activity, and both the robustness and the usefulness of results. A new approach that addresses many limitations of past models is then explored by using automatic vehicle locator data for one season and one patrol near Ottawa, Canada. With hourly salt application rates as the dependent variable and various sources and types of forecast and observed weather conditions as the independent variables, five different treatment modes are modeled by using classification trees. Results are promising in terms of both the accuracy of predictions and the ability of this inductive approach to identify key explanatory variables and related threshold values that affect the probability of different treatment options.

Performance Measures for Snow and Ice Control Operations

Thomas Maze, Chris Albrecht and Dennis Kroeger, Iowa State University

From: TRB Transportation Research Circular E-C126, June 2008, pp 625-637

<http://onlinepubs.trb.org/onlinepubs/circulars/ec126.pdf>

Scroll to "Putting Winter Maintenance Performance Measurement into Context," p 627 --

To make comparisons between and among jurisdictions, differences in the severity of storms must also be taken into account. The severity of a storm impacts the performance of winter maintenance. To illustrate the relationship between inputs, outputs, outcomes and the environment, a fishbone diagram is shown in Figure 1. The top of the figure shows some of the environmental inputs. On the bottom are labor, equipment and materials inputs for removing snow and ice from the roadway network. At the arrow, the results of the interaction between the environmental variables and the inputs to snow and ice removal are shown. In this case, we have identified satisfying the customer (the road users) as our desired outcome, and because shorter time to bare pavement is related to higher levels of satisfaction, time to bare pavement is the resulting performance measure. The measurement of time to bare pavement must be supported by a specific data collection methodology.

2009 Research Proposal Form

Proposer name, organization and e-mail address:

Shane Larson, IL Department of Transportation (IDOT), shane.larson@illinois.gov

Title of proposed research project:

Correct Recording of Material Usage for Snow & Ice Operations

1) Background:

There is a continually occurring problem in reconciling the amount of material an operator reports applying to a route(s), to what the truck controls are recording, to what is actually subtracted from our stockpiles. These amounts are continually being adjusted and modified to reconcile our stockpiles at the end of the year and the odd amounts are being added or subtracted equally over the various snow plow routes resulting in inaccurate information.

2) What is the specific problem or issue?

Operators are unsure how much material they are really applying or they do not record the information until a different date and time and the information they remember is different than that actually utilized.

3) List the proposed research objectives and tasks.

- a. Develop an automated download type of program that will print for the operator some type of hard copy report of the material usage for their shift that lists the material used and the amount.
- b. Design and develop a small printer that can be mounted by the Dickey John controls in the truck that will print out a material usage ticket/report for the operator.

4) What would be the product(s) of the research?

- a. Small user friendly printer for amount usage tickets.
- b. User friendly program to automatically download the material usage into the printer.

5) How would the results benefit DOTs? How would they be used?

A. the information would help DOTs more accurately track material usage, application rates, and result in more accurate usage reports and less "adjusted material" occurrences.

6) List the estimated funding needed.

\$100,000 to 150,000

7) List the estimated timeline for completing the research.

12 months

8) Are you aware of any related research on this topic? If so, please list below.

RCA programming is developing a function to automatically deduct the amount of material an operator enters for snow and ice operations from the stockpile of the location selected. The total amount of material located at each stockpile would be updated by a WMS Representative.

Syntheses of Best Practices- Road Salt Management: 7.0 Design and Operation of Road Maintenance Yards

Transportation Association of Canada, September 2003

<http://www.tac-atc.ca/English/pdf/design.PDF>.

This is one in a series of Syntheses of Best Practices related to the effective management of road salt use in winter maintenance operations. Scroll to: Monitoring (Page 8) Monitoring may include the following:

- The use of weigh-in-motion (WIM) sensors at the entrance and exit of the maintenance yard to confirm recorded amounts and track dispatches.

- WIM would work well in conjunction with a loader scale sensor so the operator is in control of the load and his good judgment can be confirmed.

McHenry County implements GIS technology to enhance snowplow application

American Public Works Association Reporter Online, October 2005

http://www.apwa.net/Publications/Reporter/ReporterOnline/index.asp?DISPLAY=ISSUE&ISSUE_DATE=102005&ARTICLE_NUMBER=1147.

McHenry County is one of the fastest growing counties in Illinois. The county developed a GIS Web site to manage the snowplow fleet and to analyze the application of salt along routes in an effort to maximize the use of limited resources. This article covers the implementation of wireless, GPS, laser and other latest technologies for data collection, n-tier distributed system architecture powered by ArcIMS and ArcSDE software, benefits achieved and lessons learned from the county's experience.

Scroll to:

- Going wireless with the development of the Drive by Download system McHenry County Division of Transportation worked with a vendor to develop a system that would download the data using a wireless connection as the vehicles entered the maintenance shed. The result was the Drive by Download system, consisting of several components that allow the wireless transfer of data from one or many trucks to a central computer. Formatted data can be used to determine how much material (salt, brine, etc.) was used in snow removal and ice prevention, where the vehicles were located, what time, speed vehicle was traveling, and equipment fault codes, etc.
- Component 2: Developing the Intranet Administrative Application After the data is uploaded to ArcSDE through the uploader it is automatically pulled by an ArcIMS Web site. An intranet application allows users within the county, with appropriate permissions, to access the snowplow trucks' information. Using ESRI ArcIMS technology, this intranet system is built with ArcIMS Java Connector, HTML and JavaScript. Functions of the intranet Web site include:
 2. User can use identify tool to get information such as spray mode, pavement temperature, speed, salt applied and etc.

Ground speed applicators ease winter maintenance

Technology News (Iowa LTAP), November / December 2000

http://www.ctre.iastate.edu/pubs/Tech_News/2000/novdec/groundspeed.pdf.

Ground speed applicators... record the amount of each material type used daily and even keep a year-to-date total.

Modeling Winter Maintenance Activities Using Classification Trees

Jean Andrey, Alexander Brenning and Denis Kirchhoff, University of Waterloo; Brian Mills, Meteorological Service of Canada, Environment Canada; Max Perchanok, Ministry of Transportation, Government of Ontario.

From: TRB Transportation Research Circular E-C126, June 2008, pp 483-498

<http://onlinepubs.trb.org/onlinepubs/circulars/ec126.pdf>

This paper presents the preliminary results of a new method of predicting winter maintenance activities at the truck-hour level based on forecast and observed weather conditions.

Scroll to "Dependent Variable," p 486 --

Winter maintenance activity data were extracted from the InterFleet Internet-based system of AVL data. These were extracted by using the "Query" and "Winter operation report" functions and were downloaded as CSV spreadsheets. The Query function, which provides readings in time intervals as short as 5 s, was used to extract details on maintenance operations. Each reading provides information on materials used, driving speed and exact location. Data were extracted for one season, from Oct. 1, 2004 to April 30, 2005. During this time period, there were 133,251 readings for truck 7815 and 110,532 for truck 7818. Winter operation reports were used to validate daily and seasonal materials usage. They provide information on trips, such as vehicles entering and leaving Ministry of

Transportation, Ontario yards and include the date of the report as well as the start time and return-to-yard time. They also include total kilometers serviced, material usage and average rate of application.

Automated Vehicle Location, Data Recording and Applicator Control for Winter Road Maintenance

TRB Research in Progress database

<http://rip.trb.org/browse/dproject.asp?n=15328>

This project proposes to develop and evaluate an automatic anti-icing/deicing applicator control system based on the use of real-time RWIS data. The proposed system will also continuously record data on the rates of chemical/abrasive application together with measurements of vehicle location and road geometries.

2009 Research Proposal Form

Proposer name, organization and e-mail address:

Tim Croze
Michigan DOT
CrozeT@michigan.gov

Paul Brown
Mass Highway
Paul.Brown@state.ma.us

Title of proposed research project:

Survey and Synthesis of Zero Velocity Spreaders

1) Background:

With the prices of salt and fuel drastically increasing over the past few years the need has arisen for state DOT's to become more efficient at placing deicing materials on the roadway and placing these materials in such a manor that they will not bounce off the road. One way to help reduce the bounce and scatter of salt from a truck is to use a zero velocity spreaders. Several types and manufactures of zero velocity spreaders are on the market in North America and many DOT's have been using these systems for years.

2) What is the specific problem or issue?

Many types of distribution systems for deicing materials are currently on the market. It would be beneficial for decision makers for purchasing winter maintenance equipment to know what type of distribution equipment is available and who is using that type of equipment around the world. Also, we would like to know how effective each system is at keeping salt on the road when applied and the average range of speeds that each system is effective in.

3) List the proposed research objectives and tasks.

Perform a survey of agencies that perform snow removal using that technology
Perform a literature search on research already performed on this type of technology

4) What would be the product(s) of the research?

Phase 1
Survey of North American and European Winter maintenance organizations and create a summary of responses from around the world
Literature Search of research performed on Zero Velocity spreading technology

5) How would the results benefit DOTs? How would they be used

Information would be readily available for state agencies to better make decisions on the material distribution systems available and the agencies that are using these systems.

6) List the estimated funding needed.

\$20,000

7) List the estimated timeline for completing the research.

3 months

8) Are you aware of any related research on this topic? If so, please list below.

None available

2009 Research Proposal Form

Proposer name, organization and e-mail address:

Tim Croze
Michigan DOT
CrozeT@michigan.gov

Paul Brown
Mass Highway
Paul.Brown@state.ma.us

Title of proposed research project:

Comparison of Zero Velocity Spreaders

1) Background:

With the price of salt and fuel drastically increasing over the past few years the need has arisen for state DOT's to become much more efficient at placing deicing materials on the roadway and placing these materials in such a manor that they will not bounce off the road. One way to help reduce the bounce and scatter of salt from a truck is to use a zero velocity spreaders. Several types and manufactures of zero velocity spreaders are on the market in North America

2) What is the specific problem or issue?

The intent of this research is to compare different types of deicing material spreaders. These systems are intended to reduce the amount of salt that bounces off the road during application, but they have a significant expense.

3) List the proposed research objectives and tasks.

Utilize the cost-benefit analysis toolkit developed by the current ClearRoads research project to analyze the cost/benefit of several different types salt distribution systems. Part of the research would also be to study how much salt bounces of the roadway utilizing different spreaders at different speeds.

4) What would be the product(s) of the research?

Phase 2
A comparison of salt distribution system performance at various speeds

5) How would the results benefit DOTs? How would they be used?

The placement of deicing materials is of paramount importance to better deicing operations. With the steady increase of deicing materials costs, state agencies will have to look for proven economical methods of application. The extended study of the zero velocity technology will evaluate the economic as well as the practical use of these tools. The cost benefit toolkit will confirm or deny the economic value of the specific spreader. The data will be collected and transferred via the use of wireless data transfer and gps/avl, thus accurately assessing data integrity.

6) List the estimated funding needed.

\$250,000

7) List the estimated timeline for completing the research.

24 months

8) Are you aware of any related research on this topic? If so, please list below.

Evaluation of Methods for High-speed Application of Road Salt

Max Perchanok, Ontario Ministry of Transportation

From: TRB Transportation Research Record No. 1741 (2001), pp 193-198

[Article is attached, see PDF file "Evaluation of Methods"](#)

Abstract: Tests were undertaken to examine the feasibility of high-speed material application on bare pavement by using traditional and newly developed methods and equipment. The study included measurement of spread patterns and material loss against operating speeds using ground-speed spreaders and using prewet materials, in comparison with conventional methods. The equipment comparisons included a vertical chute, a conventional, slowly rotating spinner, and two ground-speed spreader mechanisms. The chute, conventional spinner, and one ground-speed mechanism were carried on conventional, rear-drive tractors with a front-discharge, V-shaped spreader box. Material was carried forward in the spreader box by a central chain drag, then gravity fed through a trap door at the front of the box onto a cross-moving conveyor, which dropped it through a vertical funnel. The other ground-speed spreader was fed from a forward-tilt dump box, a cross conveyor and a vertical funnel. One of the ground-speed mechanisms (spinner type) consisted of a veined spinner within a cowling. Material ejection velocity, direction and spread width were controlled by varying the spinner rotation velocity and direction and the cowling orifice. The other ground-speed spreader (air-jet type) consisted of a horizontal cowling at the base of the vertical funnel, through which a high-speed air jet was directed. Material placement was controlled by the air-current velocity and direction and the cowling placement. All the equipment was used in the distribution pattern observation tests. The vertical chute and spinner-type ground-speed spreaders were used in the mass measurement tests. Before the tests, all equipment was calibrated by the equipment suppliers for the specific materials used.

Evaluation of Zero Velocity Deicer Spreader and Salt Spreader Protocol

Tommy Nantung, INDOT Research Division

FHWA/IN/JTRP-2000/24, June 2001

<http://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=1566&context=jtrp>

The purpose of this research project is to determine the effectiveness of the zero velocity deicer spreader through a "real performance" in the field, based on an unbiased evaluation. So far, there are no guidelines or standard procedures to evaluate the performance of this equipment based on safety, time, cost and environment.

The equipment testing arrangements are:

Unit Number	Unit Description	Spread Quantity (lbs./mile)
62589	1994 International Tyler Zero Velocity	200
62313	1991 International Industrial Hydraulic System	250
62741	1997 Ford Swenson Zero Velocity	250
62740	1997 Ford Muncie Hydraulic System	205
62276	1990 Ford Pengwyn Zero Velocity	200
62258	1990 International Y Chute with Industrial Hydraulic System	250

Based on the tests, the Zero Velocity systems will give excellent performance with a large number of cost savings due to the accurate placement of salt particles on the roadway. However, on the slower truck speed, a modified system such as the Y system or Muncie system can give a satisfactory result as well.

Environmental Stewardship Practices, Procedures, and Policies for Highway Construction and Maintenance

Prepared as part of NCHRP Project 25-25, Task 4, September 2004

http://www.trb.org/NotesDocs/25-25%284%29_FR.pdf

This report presents a compendium of environmental stewardship practices in construction and maintenance, developed from the literature, state transportation agency manuals and procedures, and the contributions of state DOTs and practitioners.

Scroll to “Rearward Casting Spreaders (including Ground-Speed and Zero-Velocity Spreaders),” pp 8/33-8/34 [PDF pp 595-596] --

At PENNDOT, during the 1995-1996 winter season, the use of four trucks equipped with the [zero velocity] system resulted in average material savings of about 50 percent and a cost savings of about \$2 per mile per truck. In 1997-1998, PENNDOT purchased 95 additional ZVS units and another 150 units in 1998-1999, equipping all of Pennsylvania’s interstates and limited access highways with ZVS. The systems were expected to pay for themselves in about 1.5 years. PENNDOT also equipped every new dump truck with a ground speed control salt spreader system known as the AS2 system -- an on-board computer adjusts the discharge rate of salt and anti-skid material according to the speed of the truck.

Zero velocity and salt brine: One state garage's experience

Mark Sharrock; Coshocton County Manager; Ohio Department of Transportation, District 5; Jacksontown, Ohio

From: American Public Works Association Reporter, October 2002

https://www.apwa.net/publications/reporter/ReporterOnline/index.asp?DISPLAY=ISSUE&ISSUE_DATE=102002&ARTICLE_NUMBER=484

In 1998, Ohio DOT’s Coshocton County Garage began testing and experimenting with innovative methods for improving the efficiency and effectiveness of its snow and ice removal program. Armed with one dual zero velocity spreader system, the garage built a homemade brine-making system and began a journey of experiments involving pre-wetted salt and dual zero velocity placement. To date, the garage has two anti-icing units and five trucks modified for dual zero velocity application with plans to modify its remaining nine units over the next five years.

2009 Research Proposal Form

Proposer name, organization and e-mail address:

Paul Brown
Mass Highway
Paul.Brown@state.ma.us

Title of proposed research project:

Demonstration of a National Winter Maintenance Testing Program

1) Background:

Aurora has been actively researching a number of surface transportation weather projects while Clear Roads is researching materials, equipment and practices related to winter maintenance operations. It is apparent that many agencies are interested in scientific testing and there are some research facilities already available for this purpose. However, it appears that the objectives and results of some winter maintenance research projects and the capabilities and existence of some research facilities are not well known amongst the national research groups or agency managers. Research in other classically non-winter maintenance areas, such as agriculture, work environments and ergonomics, sensor hardware/software, and human decision-making may have distinct parallels to winter maintenance problems, but may be difficult for project champions to find.

2) What is the specific problem or issue?

It would be beneficial to have a common constantly updating database of completed and on-going winter maintenance research projects which can be used by project managers to obtain background for future projects and refine project scopes. In March 2008, representatives from Aurora, Clear Roads, PNS, AASHTO SICOP, and FHWA met in an informal teleconference to discuss these existing and emerging testing and evaluation issues, and the possibility of creating a coordinated national plan for meeting all of the various winter maintenance testing needs. The attendees decided that cooperation may indeed be beneficial and began developing a plan to accomplish this, herein called the National Winter Maintenance Testing Program (NWMTP). The September 8, 2008 draft of the NWMTP outlines the need for a project investigating committee (consultants) whose job is to review projects on demand, and use their expertise to provide the requesting agency information regarding:

- Complimentary past or current projects which can be used to refine the scope of work or determine the originality of the proposed project and avoid duplication
- Facility components and infrastructure complimentary to the proposed research/test/evaluation
- Contact information for the various facility managers and researchers
- Facility location relative to the agency
- Agency affiliation (university, organization, etc)

3) List the proposed research objectives and tasks.

To conduct a demonstration of the NWMTP investigating committee in conjunction with Aurora, Clear Roads, SICOP, and PNS. The role of the NWMTP is being defined but significant uncertainty exists in its makeup, requirements, and budget on a national scale. A smaller-scale demonstration of the capabilities and challenges of an investigating committee will help define these issues, discover potential pitfalls, and illuminate potential benefits so that the nationally-deployed NWMTP can be developed on tested foundations. It is proposed that the demonstration include development of a research list and project background and facility-finding assistance for one Aurora Project, one Clear Roads project, one PNS project, and one SICOP project to get a full spectrum of potential research needs.

4) What would be the product(s) of the research?

1. A functional project investigating committee to assist on four demonstration projects and develop a catalog of facilities and research
2. A document describing the things that worked and those that did not and provide a clear

understanding of what the scope, capabilities, and budget should be on a national scale.

3. A modified scope of work and budget which can be used to request funding for establishing the investigating committee which would be available as needed nationally.

5) How would the results benefit DOTs? How would they be used?

This information will help an agency select the best possible facility for the work and help agencies learn about other research projects, especially as they pertain to their proposed research. Additionally, the investigating committee would be responsible for maintaining a website of past and current winter maintenance projects which would be available online. Unfortunately some winter maintenance research goes unpublished and undistributed. This web catalog would serve as a place for states and local agencies to post information on some of their local projects without the need for formal publication.

6) List the estimated funding needed.

Total Project Cost: \$40,000 (US)

Requested Funding: \$10,000 (US)

7) List the estimated timeline for completing the research.

2 years

8) Are you aware of any related research on this topic? If so, please list below.

Literature search is in progress.