IMPROVING WINTER MAINTENANCE OPERATIONS

USING INTERNATIONAL SCANNING TOUR TECHNOLOGY

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1. Abstract

Organizations such as the World Road Association (PIARC), American Association of State Highway and Transportation Officials (AASHTO), Transportation Research Board (TRB), Federal Highway Administration (FHWA), American Public Works Association (APWA), National Association of County Engineers (NACE), and others, have encouraged the international exchange of research and new ideas in their conferences, workshops and publications. In March 1994, FHWA/AASHTO/TRB/APWA/NACE organized and conducted the first international winter maintenance scanning tour to Japan, Germany and Austria and participated in the 9th PIARC International Road Congress in Seefeld, Austria. A second scanning tour was conducted in March 1998 to Switzerland, France, Norway and Sweden and participants attended the 10th PIARC International Road Congress in Luleå, Sweden.

The results of the scanning tours showed that while each country had similar operational and environmental problems, each had developed unique approaches and solutions to those problems. The face-to-face technical discussions that took place during the scanning tours resulted in each participating country being able to expand its knowledge base without going through the rigors of basic research and equipment development processes. This greatly reduced the time to test, evaluate, and implement these newly discovered technological advances.

This paper will report on how various State Departments of Transportation in the United States have utilized the technological information discovered on the 1994 and 1998 winter scanning tours to improve the efficiency and effectiveness of winter maintenance equipment and operations. It will also show how this improved technology is being integrated with the developing Intelligent Transportation System.

2. Introduction

The timing of the first international winter maintenance scanning tour in 1994 was ideal. The United States had just completed the Strategic Highway Research Program (SHRP) where substantial resources had been allocated to researching winter maintenance service technology. Research on road weather information systems (RWIS), snow fence design, anti-icing, snow plow design, and ice bonding and disbonding had been completed, but not yet field implemented. FHWA had just completed Test and Evaluation Project 28 that consisted of two winters of field testing anti-icing chemicals and procedures in 18 trial states. An excellent research foundation had been laid, but the processes to effective market those state-of-the-art developments in winter maintenance technology and techniques needed to be developed.

In Japan and Europe, the scanning team received operational briefings and observed snow and ice control materials, methods, equipment, and information and traffic management systems in action. During these briefings, the scanning team observed that some of the SHRP research findings were already, to various degrees, being practiced in these countries. They also found areas where the SHRP work could supplement the visited country's basic understanding of the technology. Issues on environmental impact, winter maintenance policy and financing were also examined.

The primary recommendation of the 1994 scanning tour was that a Winter Maintenance Program (WMP) be established. The principal mission of the WMP was to ensure that appropriate testing and evaluation of potentially implementable technologies would be accomplished and the results effectively disseminated to state and local governments. Beyond that principal mission "…the WMP should work toward establishing a systems approach to snow and ice control in the United States—one involving the vehicle, the driver, and the equipment, the materials, and practices—for managing roadway and bridge snow and ice." (1). Projects were identified in a workshop of national snow and ice control experts and a voluntary pooled funding mechanism was established.

3. Accomplishments

A. Establishment of a National Winter Maintenance Program

AASHTO made rapid progress and established the National Winter Maintenance Program (WMP) in November 1994. Funding was provided to conduct a National Winter Maintenance Workshop that would develop a work program and produce a comprehensive guide for establishing a systems approach to snow and ice control that addressed the vehicle, the driver, and practices for managing roadway and bridge snow and ice. A voluntary AASHTO Snow and Ice Pooled Fund Cooperative Program (SICOP) was established to fund projects and experiment with snow and ice control technology and systems not now in use in the United States. SICOP would locate these new technologies, determine their suitability, introduce them to the snow and ice control community, and help promote their acceptability and use.

B. Work Program Progress

A Winter Maintenance Policy Coordinating Committee (WMPCC) was established to guide the WMP. The following presents details about the accomplishments which have been made during the past five years.

1) *Guide for Snow and Ice Control*—this comprehensive 270 page guide was published and distributed to state and local governments in December 1999. The guide is based on the outline developed at the April 1996 National Winter Maintenance Workshop. The guide is used by state and local governmental agencies responsible for snow and ice control programs, presenting principles and practices for various climatological, environmental and operational conditions. The Guide's ten chapters are organized in a systematic manner to provide insight into the components of a snow and ice control program. Chapter 1 opens with a discussion of purpose and principles of a snow and ice control program and the agency responsibilities to their customers and accountability. Chapter 2 deals with the importance of communications and the designation of level of service expectations and measurement. Chapters 3 through 5 have a comprehensive discussion of labor, equipment and materials. Chapter 6 provides insight into the importance of Road Weather Information Systems (RWIS) in the decision making process. Chapter 7 provides tips on pre-winter preparation, storm management and special customer considerations. Chapter 8 further expands the discussion in Chapter 7 on storm management by presenting a concept on total storm management and the proactive approach of anti-icing operations. Chapter 9 provides insight into the safety and liability issues that need to be considered when developing a snow and ice control program. Chapter 10 deals with special considerations such as road design, remedial measures to solve operational problems, prevention and protection systems for specific hazards and environmental considerations. Three appendices provide supplemental information on: comprehensive bibliography of publications of interest to snow and ice control; examples of processes and procedures such as training programs, sample contracts, public information releases, vehicle maintenance checks, etc; and sample material and equipment specifications. AASHTO made an original distribution of 550 copies of the guide to member departments and Local Technical Assistance Program Centers. An additional 1,100 copies have been sold by AASHTO Publications. This highly successful project is reaching well into the ranks of state and local governments. Copies of the "Guide for Snow and Ice Control" can be ordered by visiting the AASHTO web at

http://www.aashto.org, click on “bookstore” and enter either the title or GSIC-1. Cost is $44 per copy for AASHTO members and $55 for non-members.

2) Next Generation Snow Plow—the State Departments of Transportation of Iowa, Minnesota, and Michigan formed a consortium in 1995 to design, build and field test an optimized technology snow plow truck. The State Departments of Transportation of Pennsylvania and Wisconsin joined the consortium in 2000. Advance technologies employed on a field data acquisition vehicle and a next generation snow plow in Japan provided the computerization and global positioning system concepts for this project. European spreader design using stainless steel construction and material pre-wetting systems provided the vision for improved precision and more effective material delivery. Five focus groups consisting of snow plow operators, mechanics, supervisors, highway patrol and emergency responders were shown color slides of the field acquisition vehicle and the next generation snow plow being developed in Japan, European spreader technology and other discovered technological advances. Attendees were then asked to identify the elements that should be included in a next generation snowplow truck to be built in the United States. A total of 180 promising ideas for technologies that would increase the safety, efficiency and effectiveness of a snow plow truck were identified. A meeting with vendors who could supply those technologies followed to determine the practicality of adapting them to snow plowing operations. Available technologies were then field harden to meet the rigors of snow plowing operations and installed on what was then labeled as the “Maintenance Concept Vehicle”. These technologies are shown in Figure 1. All technologies except the chemical detector have been on the truck and utilized in snow and ice control operations for three winters and have performed very well.

   The friction measuring device has been tested at the National Air and Space Administration (NASA) Runway Friction Workshop at Wallops Island Flight Facility in May 1999 and the North Bay, Canada Joint Winter Runway Friction Measurement Program in January 2000. Although the friction measuring device experienced some mechanical problems (insufficient water film thickness during high speed testing in May 1999 and insufficient down pressure in January 2000 due to extreme cold of –30 degrees below zero causing freezing in the down-pressure air lines) the friction data did compare favorably with the more costly and traditional airport runway friction measuring equipment. At the writing of this paper further testing is on hold pending the outcome of the potential sale of the vendors business. Also, further integration of friction measurement into snow and ice control operations will depend on the outcome of National Cooperative Highway Research Program (NCHRP) Project 6-14, “Feasibility of Using Friction Indicators to Improve Winter Maintenance Operations and Mobility”. Studies conducted by the Swedish National Road Administration concluded that drivers determine what speed is a safe operating speed based on the appearance of the roadway. Their research also indicates that drivers are poor judges of roadway slipperiness, therefore the establishment of a quantitative measure of road surface safety is urgently needed (2). The NCHRP project will determine if the implementation of standardized friction information in highway winter maintenance is feasible. While the art of measuring friction on airport runways seems reliable and is being used in cold regions to assist pilots in determining how much braking resistance is available for stopping the aircraft, that same degree of precision may not be required for highway operations. A contaminant classification approach may even be a reasonable approach for highway application.

   The chemical concentration measuring device worked well in the Iowa DOT Materials Testing Laboratory, but experienced problems when it was installed on the Maintenance Concept Vehicle. The unit will need at least one more winter to adequately field test the reliability of the device. The Swedish National Road Administration field tested six of the chemical concentration measuring devices mounted in light weight vehicles this past winter and obtained good data. The unit needs further field hardening of the computer to withstand the additional vibration encountered in snow plow truck application.

Figure 2 depicts how the technologies are integrated and how the field data is communicated to local garages for fleet and storm management. The storm manager can see depicted on the monitor where the fleet has operated, if the plows were up or down, the spreader was turned on or off, the spreader application rate, the type of material applied, and a thermal trace for pavement and air temperatures. This information is currently only available for internal use, but it is envisioned to be downlinked to rest areas and state DOT web sites.

Figure 2 also shows how air and pavement temperature data is linked to the new National Pavement Condition Forecasting models being developed in FHWA's FORETELL Project. The 10 kilometer forecast grid produced by FORETELL will result in the operator usually conducting snow and ice control operations in two forecast areas. The number of parameters that will go into the decision making process (air and pavement temperatures, chemical concentration, friction measurements, two FORETELL forecast areas, etc) make the use of GPS and the on-board computer and material distribution intelligence essential for optimizing operations and reducing operator stress.

Figure 3 illustrates how the data from the Maintenance Concept Vehicle interfaces with the National Intelligent Transportation System (ITS). Further details on the three phases of this project that have been completed are posted to
http://www.ctre.iastate.edu/Research/conceptv/index.htm.

3) Single-Lane-Obstructing Rotary Snow Plow—the Pennsylvania DOT had a great need to build a rotary snow plow that could remove and load deep snow at interchanges and overpasses in their mountain regions and load snow from narrow city streets while only blocking one lane of traffic during snow removal operations. A rotary snow plow capable of removing 1,700 tons of snow per hour was discovered on the 1994 winter scanning tour operating in the city of Sapporo. Articulation between the front and rear section of the conveyor made the equipment very maneuverable. The plow was especially suited for Japan's northern island urbanized areas with considerable lengths of bridges and elevated roadways. A manufacturer was located to partner with Penn DOT to retrofit an existing rotary snow plow and build the first such rotary self-loading/snow plow in 1998. The plow/loader, shown in Figure 4 has now been in operation for three winters and has demonstrated capability to move large volumes of snow. The plow/loader can load the truck shown in Figure 4 in 11 seconds. The disadvantage of the current design is its large size and highly specialized use which means the unit stands idle most of the time waiting for a heavy snowfall to occur.
4) Snow Plow Shield—the snow plows on display at the European PIARC Winter Road Congress exhibits were very similar in design to those used in the United States, except for the addition of a canvas shield mounted on top of the plow to catch the snow that sprays over the top of the plow. This over spray was a problem in the United States, fouling the air flow in radiator fins, reducing operator visibility and causing a build up of ice and compacted snow on the trucks windshield and wipers. Using photos of these plow shields, an Iowa DOT welder designed and fabricated a similar plow shield. After field demonstrations were conducted, orders were taken and a contact was let to build 200 shields to retrofit existing snow plows. Discussions were then held with snow plow manufacturers to see if they could design and build a plow with a curved moldboard similar to the Japanese design which would plow with less over spray. They responded with a plow that could perform very well with little over spray and with quantity purchasing, cost only slightly more (about 10%) than the current plows. The new design is now the standard purchase snow plow.
5) Automated-Fixed Snow and Ice Control Liquid-Spray System—a common problem in the United States and other parts of the world is bridge decks freeze before the adjacent roadway and can become hazardous before truck mounted snow and ice control operations are initiated. An automated system was being used in Europe controlled by sensors that monitored both pavement and climate conditions and responded by spraying snow and ice control materials on the deck when needed. Several companies and one university in the United States have since taken the concept of those systems discovered

on the winter scanning tours and developed a variety of systems that have now been implemented for both roadway and bridge applications. The four major companies have systems installed in 12 states. The University of Utah developed a system for the Utah DOT based on the designs found in Europe and placed it in service in 1996. A variety of anti-icing chemicals are being used with magnesium chloride or potassium acetate the most popular. Systems use both passive and active sensors. Most sites have fully automated operation.

6) Blowing and Drifting Snow—the Japanese demonstrated their snow engineering analysis techniques used at the Hokkaido Construction Bureau to the 1994 winter scan members. They used a combination of principles documented in their snow engineering manual and a wind tunnel with scale models of road cross sections to design appropriate snow drifting counter measures. The SHRP studies completed in 1994 showed that properly designed snow fence can store snow for one percent of the cost of plowing. A SHRP "Design Guidelines for the Control of Blowing and Drifting Snow" (3) was published in 1994 for state and local road designers. This 1994 guide while technically correct and complete at the time of publication was difficult to use. A SICOP project is underway to update the 1994 guide and simplify snow fence system design. The revision will include the use of topographic mapping databases, integrated global positioning system, software and new algorithms, fence materials and construction techniques. To make the information even more accessible, the individual chapters of this guide will be posted (about January 2002) on the AASHTO SICOP web at http://www.sicop.net.

7) Road Weather Information Systems (RWIS)—use of RWIS in Japan and Europe in 1994 provided considerable guidance for ways to improve and expand beyond present use in the United States. RWIS information was collected, processed and provided to the public over assigned radio frequencies and at rest areas and information centers. Data from RWIS and other sources were being used by traffic management center personnel to advise motorists and change speed limits and variable message signs. In the U.S. however, RWIS information was only used internally to support the maintenance manager's decision process and was not made available to the public. Data from RWIS is now made available to the public in the United States in most rest areas and through the internet by visiting each states web site. Data from most states RWIS can also be accessed through <truckerweather.com> or <roadweather.com>.

   The 1998 winter scan revealed a new standard of excellence for training all maintenance personnel in using RWIS and RWIS data. Meteorological training of all employees involved in winter service in Switzerland is required every three years (4). Re-training is accomplished before each winter. At the training center in Les Salles, France, the trainers are meteorologists, supervisors, and network operators who have practical experience in the winter service area for which they provide training. New employees receive a three-day training course and are retrained on a three to five year interval. The training uses a laboratory demonstrating RWIS equipment in action and emphasizes the development of tools for individual decision making and an understanding of equipment, chemicals and weather.

   An effort is underway by AASHTO to bring United States maintenance employees to a similar level of excellence. Currently, AASHTO SICOP is developing a RWIS/Anti-Icing, computer-base training program (RWIS/AI CBT). The RWIS/AI CBT is a self-paced individual training program or it can be used in a group teaching mode. Agencies desiring to participate in the voluntary SICOP pooled fund were given an option to purchase a generic training package for $5,000 or a customized package specifically tailored to their snow and ice control operations for $30,000. Twenty-six states participated at the $30,000 level and APWA participated at the $5,000 level. The CBT is a menu-driven, hyper-linked, interactive, content manager. The user, once logged in, can work through the content from beginning to end, like a book, returning to the menu at intervals, as desired, to select another path. The content is photographs, illustrations, text, video, charts, animation interaction, narration and other means of communication. A control panel or button bar is perpetually available to enable the user to alter the flow or get additional help. Additionally, there are opportunities at various points to assess the progress the user is making educationally, including quizzes, scenario-based problem cases, exercises, and the like. The content is focused on three levels; first line management; middle management; and equipment operators. Because of the complexity of the content, where judgement and problem-solving are as much the goal as new information retention, the interactive aspect of the CBT is intended to respond to the CBT's stimuli which is scenario driven. Scenarios will be configurable and structured to present random, realistic numerical data and problems in a non-repetitive manner. The goal is to improve students' thinking processes, not foster memorization of repetitive sequences in order to provide the correct response.

4. New Challenges Facing the Winter Maintenance Program

New challenges facing the Winter Maintenance Program can be divided into two categories, those needing near term (1 to 2 year) solutions and those that because of institution issues or requiring research which will place them into the medium term (3 to 5 year) for solving.

A. Near Term Projects

1) Development of common RWIS communications protocol
2) Promote standardized road condition reporting
3) Promote the integration of RWIS and National Weather Service data to provide surface temperature forecasts without limitation of state or regional boundaries
4) Integration of snow and ice control operations information into the National ITS architecture

B. Medium Term Projects

1) Introduction of winter driving techniques into driver training programs
2) Pursue thermal mapping to further improve operating efficiencies from pavement forecasts
3) Development of improved avalanche protection and control
4) Support the development of management information systems that will provide sufficient information on costs, productivity, efficiencies and outcomes to allow relevant comparisons across public and private work units

5. Conclusion

The two winter scanning tours discovered that snow and ice control operations used in other countries, differed from those used in the United States. Further, the winter maintenance technology and practices used in Japan and Europe appear in several areas to be superior to those of the United States. The AASHTO Winter Maintenance Program was established to provide a means for identifying and evaluating promising technologies and practices and to assist in the timely application of those suitable for incorporation into domestic practice.

Since its establishment in November 1994, steady progress has been made on promoting a systems approach for snow and ice control operations in state and local governments, implementing advanced equipment technology in government snow and ice control fleets and developing comprehensive snow and ice control training.

While much has been accomplished since the first international winter scanning tour in 1994, many new challenges to increase efficiency and effectiveness and solve environmental problems await the attention of the AASHTO Winter Maintenance Program. The SICOP Snow and Ice List Serve which can be found on the SICOP web site or at snow-ice@list.uiowa.edu keeps more than 600 snow and ice control experts worldwide in contact and exchanging ideas and solving problems. The list serve combined with the valuable international contacts the Winter Maintenance Policy Coordinating Committee has developed during the past seven years provide valuable assistance in solving the most difficult global snow and ice control problems.

References

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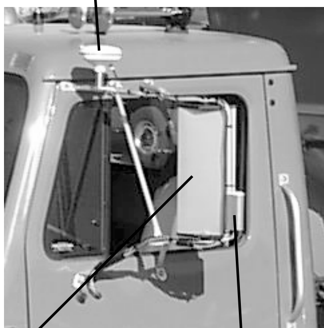
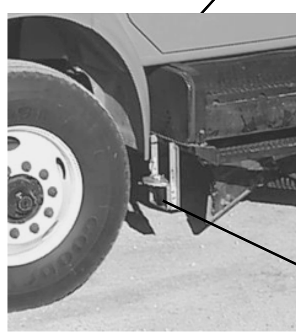
3. Tabler, Ronald, "Design Guidelines for the Control of Blowing and Drifting Snow," Strategic Highway Research Program, National Research Council, Washington, D.C. (1994)
4. "Report on 1998 Scanning Review of European Winter Service Technology," *NCHRP Research Results Digest 204,* Transportation Research Board, National Research Council, Washington D.C.

Maintenance Concept Vehicle





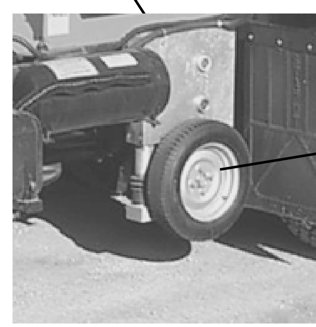


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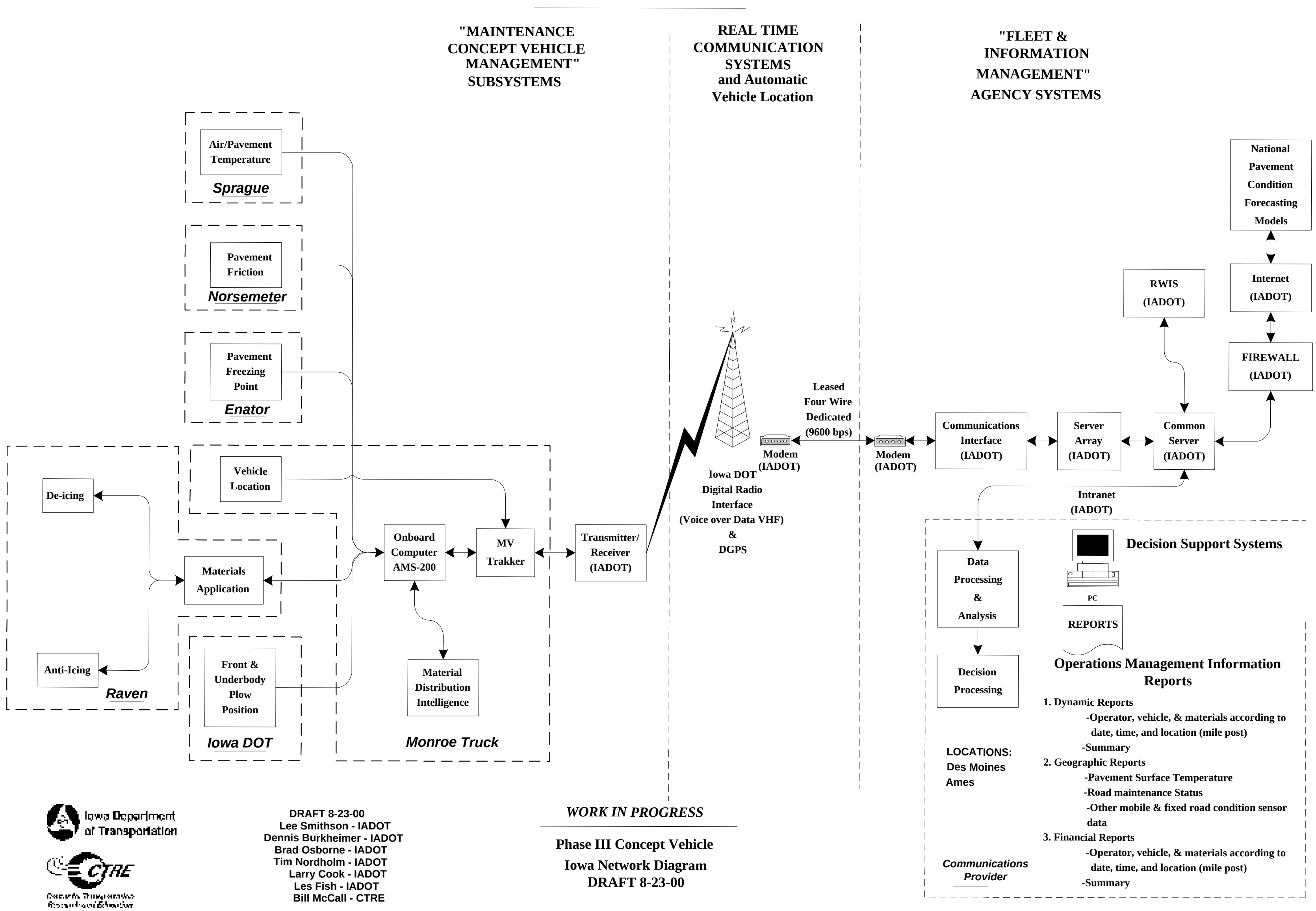
Figure 1



WORK IN PROGRESS

Phase III Concept Vehicle
Iowa Network Diagram
DRAFT 8-23-00

Figure 2

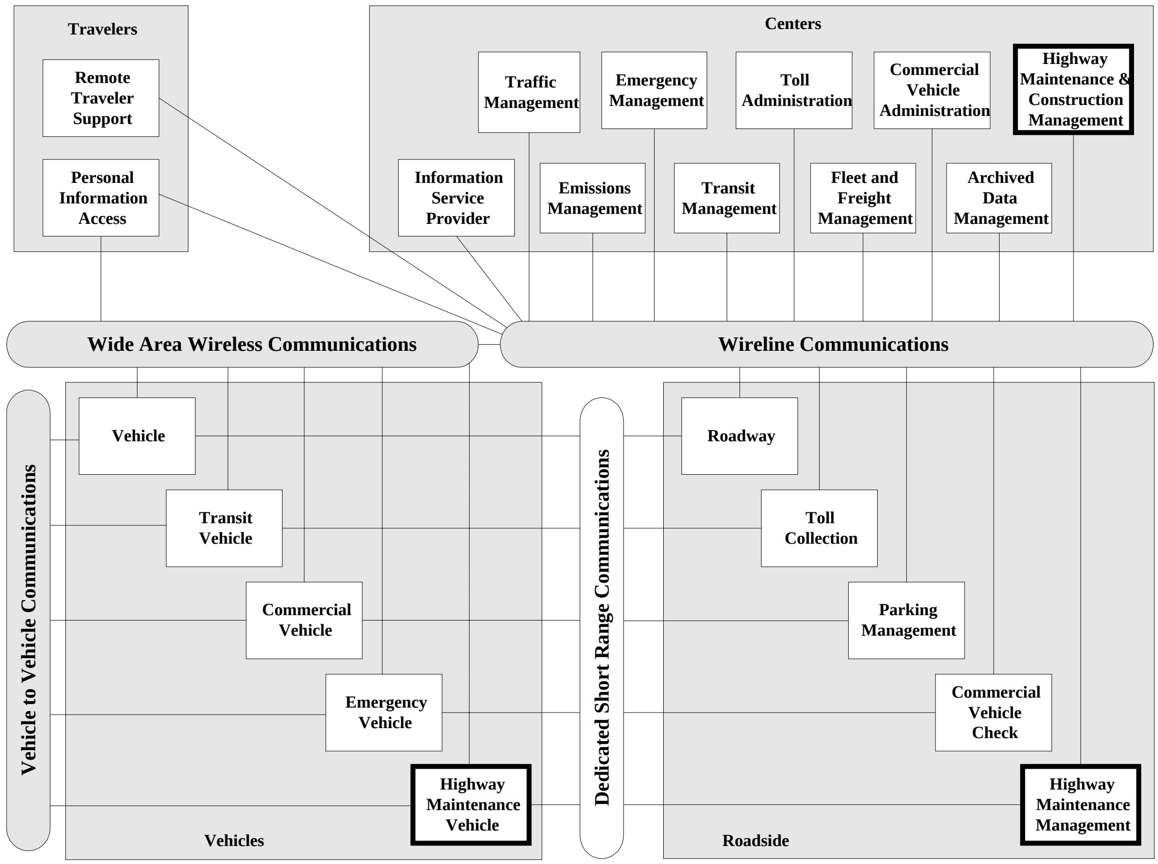


Figure 3

National ITS Architecture Subsystem and Communications Vision for the Iowa DOT Highway Maintenance Concept Vehicle

MCCALL - CTRE 1-30-00

Figure 4: Single-Lane Obstructing Rotary Snowplow
(Photo Courtesy of Pennsylvania Department of Transportation)