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Intelligent Transportation Systems and Winter Operations In Japan

U.S. Department of Transportation
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16. Abstract
U.S. transportation agencies seek to improve the efficiency and effectiveness of winter maintenance operations by developing advanced systems and equipment. The Federal Highway Administration, American Association of State Highway and Transportation Officials, and National Cooperative Highway Research Program sponsored a scanning study of Japan to investigate advanced technologies for winter maintenance operations and implementation of those advances in Japan's intelligent transportation system (ITS) architecture.

The U.S. delegation visited Hokkaido, Japan, to review advances in winter operations procedures, winter maintenance equipment development, and road weather data collection. The team also observed that significant advances are being made in Japan on improving communication systems and protocols used between road weather information system sensors and operations centers.

The scanning team's recommendations for U.S. application include testing several advanced winter maintenance vehicle systems, investigating integration of weather-related information into ITS corridors, developing performance-based standards for winter maintenance, and establishing a data-sharing project involving the National Weather Service and transportation agencies.

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Intelligent Transportation Systems And Winter Operations In Japan

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The Federal Highway Administration's (FHWA) Technology Exchange Program accesses and evaluates innovative foreign technologies and practices that could significantly benefit U.S. highway transportation systems. This approach allows for advanced technology to be adapted and put into practice much more efficiently without spending scarce research funds to recreate advances already developed by other countries.

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FHWA and AASHTO jointly determine priority topics for teams of U.S. experts to study. Teams in the specific areas being investigated are formed and sent to countries where significant advances and innovations have been made in technology, management practices, organizational structure, program delivery, and financing. Scan teams usually include representatives from FHWA, State Departments of Transportation, local governments, transportation trade and research groups, the private sector, and academia.

After a scan is completed, team members evaluate findings and develop comprehensive reports, including recommendations for further research and pilot projects to verify the value of adapting innovations for United States use. Scan reports, as well as the results of pilot programs and research, are circulated throughout the country to State and local transportation officials and the private sector. Since 1990, FHWA has organized more than 50 international scans and disseminated findings nationwide on topics such as pavements, bridge construction and maintenance, contracting, intermodal transport, organizational management, winter road maintenance, safety, intelligent transportation systems, planning and policy.

The International Technology Scanning Program has resulted in significant improvements and savings in road program technologies and practices throughout the United States. In some cases, scan studies have facilitated joint research and technology sharing projects with international counterparts, further conserving resources and advancing the state of the art. Scan studies have also exposed transportation professionals to remarkable advancements and inspired implementation of hundreds of innovations. The result: large savings of research dollars and time, as well as significant improvements in the nation's transportation system.

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Abbreviations and Acronyms

AASHTO	American Association of State Highway and Transportation Officials
AHS	advanced cruise-assist highway system
APWA	American Public Works Association
ATI	American Trade Initiatives
ATIS	advanced traveler information system
AVL	automated vehicle location
CCTV	closed-circuit television
CERI	Civil Engineering Research Institute
DEC	Hokkaido Development Engineering Center
DMS	dynamic message system
DOT	Department of Transportation
ESS	environmental sensor station
ETC	electronic toll collection
FHWA	Federal Highway Administration
GPS	global positioning system
HAR	highway advisory radio
HRDB	Hokkaido Regional Development Bureau
ITS	intelligent transportation systems
JHPC	Japan Highway Public Corporation
JMA	Japan Meteorological Association
JWA	Japan Weather Association
LED	light-emitting delineator
MDSS	maintenance decision support system
MICOS	meteorological information comprehensive on-line service
NACE	National Association of County Engineers
NWS	National Weather Service
PC	personal computer
PIARC	Permanent International Association of Road Congresses
PSA	public service announcement
R&D	research and development
RWIS	road weather information systems
RWML	Road Web Markup Language
SICOP	Snow and Ice Pooled Fund Cooperative Program
SIRWEC	Standing International Road Weather Commission
SNET	Sapporo Information Network
STIP	scan technology implementation plan
U.S.	United States
VAMS	value-added meteorological service
VICS	vehicle information and communications system
WAP	wireless application protocol
XML	eXtensible Markup Language

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EXECUTIVE SUMMARY

BACKGROUND

A number of U.S. State departments of transportation (DOTs) and the Federal Highway Administration (FHWA) are involved in the development and field evaluation of advanced systems directed at enhancing winter road operations. This body of work is part of State and national efforts to improve the efficiency and effectiveness of snow- and ice-control operations and to better inform motorists of wintertime driving conditions. The advanced systems under investigation include winter maintenance equipment with enhanced sensors and control devices, information systems for measuring and communicating winter road conditions, higher-resolution winter weather forecasting tools, winter maintenance decision support systems, and improved ways of alerting motorists to wintertime driving conditions and educating them on the potential dangers of driving during winter weather. Work is under way in the United States to integrate some of these advances with other aspects of transportation operations and maintenance as part of the development of intelligent transportation systems (ITS). Research indicates that Japan and several European countries likewise are making significant advances in winter road operations, particularly in the areas of motorist information and system integration.

OBJECTIVES AND TEAM COMPOSITION

The objectives of this scanning study were twofold. The first was to review and document advanced technologies, techniques, and procedures used in Japan for winter maintenance operations and the implementation of those advances within Japan's ITS architecture. The second objective was to evaluate those significant advances for potential application in the United States. To this end, the team met with representatives of four major Japanese road authorities in Hokkaido, the Civil Engineering Research Institute of Hokkaido, the Hokkaido University, private sector organizations, and two private weather agencies involved in ITS and winter operations. The team also had in-depth technical discussions on advanced technologies with European counterparts in connection with its participation in the Standing International Road Weather Commission (SIRWEC) and Permanent International Association of Road Congresses (PIARC) Conferences in Sapporo, Japan, before its meetings with the Japanese agencies and organizations.

FHWA and the American Association of State Highway and Transportation Officials (AASHTO) jointly sponsored the Intelligent Transportation Systems and Winter Operations in Japan Scanning Study. The delegation included representatives of FHWA; the U.S. National Weather Service; state DOTs in Idaho, Nevada, New York, and Virginia; the National Association of County Engineers (NACE) from the Henry County, Illinois, Highway Department; the American Public Works Association (APWA) from the City of Columbus, Ohio; the University of Iowa; and two private sector research agencies.

KEY FINDINGS

The Japanese organizations visited were thorough in their preparations for the scanning team's visit and generous in sharing their experiences and advances. The visits with selected European researchers also yielded valuable information on their experiences. Based on these discussions, the team recorded many general observations and documented several key findings applicable to ITS and winter operations in the United States. Key findings include the following:

- Advanced winter maintenance equipment continues to be developed and evaluated in Japan and Europe. The equipment falls under the categories of advanced maintenance vehicle systems, automated vehicle location (AVL) and navigation systems, and vehicle-mounted performance-monitoring systems. Some equipment has advanced to the implementation stage. While several projects to evaluate equipment are under way in the United States, no agency has taken the lead in supporting and encouraging research and development of winter maintenance equipment as in other countries. Japan is exploring a number of measurement methods to determine the surface condition of snow- and ice-covered pavements. Officials believe measurements from these methods will work better than mechanical friction measurements in making winter maintenance operational decisions.
- Significant advances continue to be made in Japan and Europe on improving communication systems and protocols used between road weather information system (RWIS) sensors and operations centers. This work is part of an ITS effort to use RWIS not only for winter road management, but also for traffic information and control. A Road Web Markup Language (RWML) has been developed in Japan based on the next-generation eXtensible Markup Language (XML). In the RWML system, road-related information is grouped into four categories: road, weather, disaster, and regional information. RWML enables road weather information to be distributed easily on the Internet to personal computers (PCs) in road administration offices and maintenance garages.
- Road weather data in many countries are collected centrally, where they are combined with meteorological forecast data to provide guidance to local road maintenance and traffic control authorities. Many European countries have not yet achieved full data sharing between their RWIS sites and national meteorological agencies, but they are working toward that end. In Japan, road weather data are provided only to local private meteorological forecast companies. Also, Japan has no direct sharing of road weather condition information with other transportation modes or with agencies outside of the highway agency's jurisdiction. Outside agencies, however, can obtain the road weather information via the Internet or get e-mails by special request.
- In the United States, the term maintenance decision support system (MDSS) is used to describe a management system designed to gather, assemble, and organize information on highway conditions, winter storm conditions, and winter maintenance resources to help maintenance engineers and supervisors make effective decisions about staffing, equipment, and

chemical use in support of winter maintenance operations. Both European countries and Japan are developing MDSS, portions of which are undergoing field-testing and evaluation in preparation for implementation. U.S. contact with foreign efforts is slight, and efforts of the United States and other countries to develop MDSS would be enhanced by closer contact.

- Many European countries are moving toward privatization of winter maintenance operations. The relationships between the national agencies and contractors appear to be more partnerships than sponsor-client relationships. The contractual relationships force a clear definition of wintertime service levels expected for the various road systems and lead to a method of evaluating performance of winter maintenance operations. These methods of performance evaluation can be valuable to a winter maintenance organization, even if it does not privatize operations. Several European countries have developed their own performance measures for winter maintenance operations, but no universally accepted performance measures are apparent.
- A considerable effort has been made in Hokkaido to provide wintertime travelers with information on weather and driving conditions. This information is available by various means, both before and during travel through an extensive advanced traveler information system (ATIS). Winter road conditions are available through hardwire and wireless access to various Internet Web sites via PCs and I-mode (Internet-accessible) cellular phones. The development of RWML has made it possible to distribute road weather information over the Internet. The pervasiveness of wireless communications in Japan in general, and in Hokkaido in particular, has allowed for convenient distribution of urban traveler information. For a small monthly subscription fee, the I-mode phone provides the user with Web-browsing capability that includes graphics, pictures, and text information. Road weather information also is available to the public through extensive use of dynamic message signs, road information boards, highway advisory radio (HAR), kiosk terminals, and vehicle information and communications systems (VICS). In-vehicle navigation deployment is advanced in Japan, with both original equipment manufacturer and after-market devices in use. Web-based ATIS is accessible in some vehicles, but it is not clear how many of the 8 million in-vehicle navigation systems in Japan contain this function.
- Driver education is taken seriously in Japan and is considered more of a social responsibility than it is in the United States. Special driver programs are offered in Hokkaido for wintertime driving conditions. A winter condition driving course is available in Hokkaido for students enrolled in driver training during milder times of the year. The Prefecture Government develops the training content and bears the cost for publicly offered driver education courses through its law enforcement branch. 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. A road information center within a rest area of the Hokkaido Regional

Development Bureau contains a variety of winter driving educational tools, including four fully functional driving simulators to demonstrate driving on three different winter roads and numerous posters and graphical displays of driving and safety topics. Winter driving information also is 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 with a porous tread surface, provide superior traction on ice and snow. In the United States, the tires are marketed primarily to sports car owners.

RECOMMENDATIONS

Team members met at the end of the scanning trip to review their findings and developed an extensive list of efforts that have potential in the United States. The initial set of potential efforts was divided into major topics of interest. The team discussed the areas further and gave several more priority. The team then voted on the remaining recommendations and only those receiving the largest number of votes were retained. The final recommended areas were consolidated into six applications that deserve further investigation:

- Winter maintenance equipment review
- Road Web Markup Language (RWML)
- Integrated intelligent transportation systems (ITS) corridor review
- Environmental sensor station (ESS) siting standards and implementation guidelines
- National Weather Service/Department of Transportation collaborative project
- Baseline winter maintenance performance standards

IMPLEMENTATION PLANS

The team developed a scan technology implementation plan for each of the six applications. Each plan includes a brief problem statement, objectives, output of the recommended investigation, technical approach, and estimated cost.

CHAPTER ONE
Introduction

BACKGROUND

Several U.S. State departments of transportation (DOTs), some county DOTs, and the Federal Highway Administration (FHWA) are involved in the development and field evaluation of advanced systems directed at enhancing winter operations. This body of work is part of State and national efforts to improve the efficiency and effectiveness of snow- and ice-control operations and to better inform motorists of wintertime driving conditions. The advanced systems under investigation include winter maintenance equipment with enhanced sensors and control devices, information systems for measuring and communicating winter road conditions, higher-resolution winter weather forecasting tools, winter maintenance decision support systems, and improved ways of alerting motorists to wintertime driving conditions and educating them on the potential dangers of driving during winter weather. Work is under way in the United States to integrate some of these advances with other aspects of transportation operations and maintenance as part of the development of intelligent transportation systems (ITS).

Research indicates that Japan and several European countries likewise are making significant advances in winter road operations, particularly in the areas of motorist information and system integration. For several years, Japanese and European transportation officials have used advanced road condition measuring equipment and data to improve their management of snow- and ice-control operations and to advise motorists of hazardous winter road conditions. For instance, various types of sensors are being developed and, in some cases, deployed on snow- and ice-control equipment to determine the freezing point of roadway moisture, road surface conditions, and roadway obstacles during poor visibility conditions. In addition, work is under way to standardize road weather information for use in advanced traffic management and traveler information systems.

Little has been written or published about the technical progress in these areas. Likewise, no details are available on equipment or information system design, testing, and evaluation. A few details are available on the processes used to educate the Japanese motoring public on how to drive on snow- and ice-covered roads.

It was decided that a scanning study of Japan was necessary to help the U.S. transportation community understand more fully the Japanese advances in the area of ITS and winter operations. It was further decided that the scanning team would participate in the Standing International Road Weather Commission (SIRWEC) and Permanent International Association of Road Congresses (PIARC) Conferences in Sapporo, Japan, in connection with the scan visits with Japanese agencies and organizations in Hokkaido, Japan. The panel attended the two conferences from January 26 to 31, 2002, and made scanning study visits from February 1 to 7, 2002.

SCAN OBJECTIVES

The scanning study's objectives were twofold. The first was to review and document advanced technologies, techniques, and procedures used in the host country for winter operations and the implementation of those advances within Japan's ITS architecture. The second objective was to evaluate those significant advances for potential application in the United States.

SCAN TEAM METHODOLOGY

The technology scanning team met before the scanning trip to develop a set of amplifying questions and to plan its itinerary around seven topics of interest. Five of these were associated with winter operations and two were associated with motorist information and education. Topics included the following:

- Winter maintenance equipment
- Measuring and communicating winter road conditions
- Coordinated use of weather forecast data
- Use of winter maintenance decision support systems (MDSS)
- Performance evaluation of winter maintenance operations
- Winter traveler information
- Driver education for winter conditions

A set of amplifying questions was developed for each topic area. These questions are listed in Appendix A. The questions were forwarded to Japanese road authorities, research agencies, and weather agencies in Hokkaido, Japan, before the trip. Portions of the amplifying questions were sent also to selected European governmental agencies that were sending delegates to the technical conferences.

The amplifying questions provided the Japanese agencies in Hokkaido with an understanding of the topics of interest to the team and enabled the Japanese to plan their presentations and site visits accordingly. The team met with representatives of four major Japanese road authorities in Hokkaido, the Civil Engineering Research Institute of Hokkaido, the Hokkaido University, private sector organizations, and two private weather agencies involved in ITS and winter operations management. The team also had in-depth technical discussions on advanced technologies with European counterparts at the SIRWEC and PIARC Conferences in Sapporo, Japan.

TEAM COMPOSITION AND SPONSORING AGENCIES

The following were members of the team:

- Paul Pisano (co-chair), team leader of the Road Weather Management Program in FHWA's Office of Transportation Operations.
- Richard Nelson (co-chair), district engineer for the Nevada DOT, representing

the American Association of State Highway and Transportation Officials (AASHTO).

- Robert Blackburn (report facilitator), principal research engineer for Blackburn and Associates.
- Steven Brandau, county engineer for the Henry Country, Illinois, Highway Department, representing the National Association of County Engineers (NACE).
- Diana Clonch, operations manager for the Engineering and Construction Division of the Columbus, Ohio, Department of Public Service, representing the American Public Works Association (APWA).
- Joseph Doherty, program manager for snow and ice control for the New York State DOT.
- David Jones, state maintenance engineer for the Idaho Transportation Department.
- Carl Kain, principal electrical engineer for the Intelligent Transportation Systems Division of Mitretek Systems, Inc.
- Paul Lariviere, division administrator for the FHWA Maine Division Office.
- Gregory Mandt, director of the Office of Climate, Water, and Weather Service for the U.S. National Weather Service.
- James McCarthy, traffic operations engineer for the FHWA Minnesota Division Office.
- Dr. Wilfrid Nixon, professor and research engineer for the Iowa Institute of Hydraulic Research at the University of Iowa.
- Daniel Roosevelt, research scientist for the Virginia Transportation Research Council of the Virginia DOT.

Biographical information on team members is in Appendix B.

FHWA, through its International Technology Exchange Program, AASHTO, and the National Cooperative Highway Research Program, through its Panel 20-36, jointly sponsored the Intelligent Transportation Systems and Winter Operations in Japan Scanning Study.

The team members shared their experience, expertise, and opinions among themselves and with the hosts. As a result of these exchanges, excellent formal presentations, and informative site visits, the team developed general observations and key findings relating to intelligent transportation systems and winter operations in Japan and elsewhere. The team also developed recommendations and implementation plans for efforts that may have potential application in the United States.

The technical information gathered during the study is included in this report. Chapter Two on General Observations covers information about the agencies visited and conferences attended that may be of interest to the highway community engaged in intelligent transportation systems and winter operations. Chapter Three on Key Findings summarizes findings applicable to needs in the United States. Chapter Four on Recommendations covers an extensive list of areas of potential development. Chapter Five on Implementation Plans provides a brief description of plans developed for six applications. Conclusions are discussed in Chapter Six and supporting information is included in the appendices.

Team members met before the trip and during the course of their travels. In addition, a formal meeting at the end of the trip and subsequent correspondence added further refinements to the material in this report.

CHAPTER TWO

GENERAL OBSERVATIONS

The team members gathered valuable information throughout the study, during both the formal presentations by their hosts and the question-and-answer sessions that followed. The team met with the four major Japanese road authorities in Hokkaido (Hokkaido Regional Development Bureau, Hokkaido Prefecture Department of Construction, Hokkaido Branch of the Japan Highway Public Corporation, and the City of Sapporo Development and Construction Department), Civil Engineering Research Institute of Hokkaido (CERI), Hokkaido University, private sector organizations, and two private weather agencies involved in ITS and winter operations. The team also had in-depth technical discussions on advanced technologies with European counterparts at the SIRWEC and PIARC Conferences in Sapporo, Japan, immediately before the meetings with the Japanese agencies and organizations. General observations made during these formal and informal meetings are outlined in this chapter. A brief description of Hokkaido, Japan, and the ITS initiative under way in Hokkaido is followed by information categorized by agency and conference proceedings.

BACKGROUND ON HOKKAIDO

Hokkaido is one of 47 prefectures in Japan. It is Japan's largest and northernmost prefecture, accounting for 22 percent of the nation's land area. About the size of Austria, Hokkaido is half flat and half mountainous. It lies roughly between the latitudes of 41 and 45 degrees north and is surrounded by the Sea of Japan on the west, the North Pacific Ocean on the east and south, and the Sea of Okhotsk on the north.

Hokkaido is in the northern limit of the temperate zone and the southern limit of the subarctic zone. The temperate zone is characterized by mild weather, some precipitation, and four distinct seasons. The subarctic zone is characterized by abundant precipitation throughout the year, with heavy snowfall in winter.

In winter, cold air masses from Siberia cause the temperature in Hokkaido to drop. In many areas of the prefecture, the average daily high temperature in the January-February period is below freezing and the average monthly temperatures in winter range from 18 to 25 degrees Fahrenheit.

The first snowfall of the season normally arrives between late October and early November. The snow cover remains for four or five months, before disappearing between late March and early April.

Hokkaido has 34 cities, 154 towns, and 24 villages—the largest number of municipalities of any prefecture in Japan.

Sapporo, the largest city in Hokkaido, is located in the southwestern part of the island near the Sea of Japan. In the winter, Sapporo experiences strong northwesterly winds and heavy snowfalls, and the air temperature drops below freezing almost every day. Sapporo, a city of almost 2 million residents, receives more than 16 feet of snowfall a year—about the same as Buffalo, New York. The cold and snowy region of Hokkaido, in general, and of Sapporo, in particular, poses many challenges to the transportation needs of the residents during wintertime. A number of ITS programs are being developed to address the safety and mobility of Hokkaido residents, especially during winter.

HOKKAIDO ITS

A Hokkaido ITS Planning Committee was established to address problems associated with traffic hazards from severe winter weather conditions and emergency management issues. The committee is composed of members from the four major road authorities in Hokkaido, CERI, four universities or schools of higher learning, Hokkaido Economic Federation, and a Hokkaido town mayor's office. Dr. Keiichi Sato, professor of urban and environmental engineering at Hokkaido University, is the committee chairman.

The committee formulated the Hokkaido ITS Promotion Plan to broadly and systematically promote the introduction of ITS in Hokkaido. Hokkaido ITS refers to a consolidated social system linking people, roads, and vehicles by means of the latest information and communication technology. The promotion plan contains nine categories of ITS development:

- Advances in navigation systems
- Electronic toll collection (ETC)
- Public assistance for safe driving
- Optimization of traffic management
- Increased efficiency in road administration
- Support for public transportation
- Increased efficiency in commercial vehicle operations
- Support for pedestrians
- Support for emergency vehicle operations

The ITS work under way that relates to winter operations falls into two of the above categories: advances in navigation systems and public assistance for safe wintertime driving. In the first category, a light-emitting roadside delineator and millimeter wave sensor for detecting obstacles in front of moving vehicles under low-visibility conditions have been developed and are being evaluated at a special test site. In the other category, road weather information is provided to the wintertime traveler both before departure and while en route. Drivers can obtain real-time image data, information about road surfaces, and weather conditions around mountain passes before departure using Internet and communication line terminals at home, in the office, and in roadside rest areas. These modes of communication make it possible for wintertime travelers to adjust departure times and change routes appropriately. Storm and related road weather information can be provided automatically through mobile phone and the Internet to drivers for a user fee. Road information also can be transmitted automatically to drivers (and passengers) through mobile terminals, such as car navigation systems. Information provision services using vehicle information and communication systems (VICS) have been put into operation in Hokkaido.

MAJOR ROAD AUTHORITIES IN HOKKAIDO

The four major road authorities in Hokkaido are the Hokkaido Regional Development Bureau, Hokkaido Prefecture Department of Construction, City of Sapporo Development and Construction Department, and Hokkaido Branch of the Japan Highway Public Corporation (JHPC). Formal meetings with these agencies were preceded by a formal greeting and welcome by Hokkaido Regional Development Bureau Director General Michio Hirano. He provided a brief overview of the road system in Hokkaido.

In 1950, the government of Japan created the Hokkaido Development Agency with headquarters in Tokyo to promote comprehensive improvements in infrastructure in Hokkaido. A year later, the Hokkaido Development Bureau was established as a local organization to implement public works of the national government. The Hokkaido Regional Development Bureau, as it is now called, is a local branch office of the Japanese Ministry of Land, Infrastructure, and Transport.

Roads in Hokkaido range from national highways to municipal roads and cover a distance of more than 53,400 centerline miles. The Hokkaido Regional Development Bureau manages the national highways, which consist of almost 4,000 centerline miles. The bureau promotes improvements for high-speed traffic networks and enhancement of road management. It also ensures efficient traffic flow, especially during periods of severe winter weather. It works closely with the other three major road authorities in Hokkaido.

The bureau also promotes research and development on new ITS-related technologies, such as the advanced cruise-assist highway system (AHS) being tested by CERI at the Ishikari Snowstorm Experiment Site. The system includes light-emitting roadside delineators, roadside message signs, and various sensors, including the millimeter wave radar, visual sensors, and infrared sensors.

Following the meeting with the director general, a formal meeting was held with representatives of the Hokkaido Regional Development Bureau, Hokkaido

Figure 1. U.S. scanning team members meet with representatives of the Hokkaido Regional Development Bureau and Civil Engineering Research Institute of Hokkaido.

Prefecture Department of Construction, City of Sapporo Development and Construction Department, and CERI. The purpose of this meeting was for our Japanese hosts to provide answers to the amplifying questions listed in Appendix A. These questions covered six areas of interest to the scanning team:

- Winter maintenance equipment
- Measuring and communicating winter road conditions
- Coordinated use of weather forecast data
- Use of winter maintenance decision support systems
- Performance evaluation of winter maintenance operations
- Driver education for winter conditions

Copies of the amplifying questions were sent to various Japanese agencies and research contacts before the scanning trip.

The Japanese hosts did an excellent job of thoroughly answering each question. The meeting with the Hokkaido road authorities provided the team with a good overview and details of Japanese ITS and winter operations programs and progress. Items covered in significant detail included the following:

- Ongoing work to develop an advanced snow removal execution plan.
- Development of winter maintenance equipment, such as a high-speed snow removal vehicle with cab-over truck engine and double front axles, automated down pressure plow blade control, millimeter wave radar sensor, ground view sensor, and light-emitting roadside delineators.

- Development of road communication protocol standards for transmission of data among various highway agencies, organizations, and communities.
- Development of Road Web Markup Language (RWML) based on the next-generation eXtensible Markup Language (XML) to standardize road weather information.
- Development of an extensive advanced traveler information system (ATIS) to provide road weather information to winter travelers before and during travel.
- Education of drivers on travel during winter road conditions.

A number of the items covered during the presentation are discussed further in the following sections of this report.

A meeting between representatives of the Hokkaido Branch of the Japan Highway Public Corporation (JHPC) and the team members followed the meeting with the other three major highway agencies of Hokkaido. The JHPC was established in 1956 as an organization that designs, builds, operates, and maintains all the expressways and other toll roads in Japan.

The headquarters of the JHPC is in Tokyo. It uses tolls collected on the expressways and other roads in its operation. It has installed more than 800 road weather stations on its expressway network both in and out of snowy regions.

The Hokkaido Branch of JHPC operates and maintains more than 1,100 miles of expressways. In the winter, this includes conducting snow- and ice-control operations and disseminating traffic guidance. Snow- and ice-control operations include plowing and spreading both solid and pre-wetted sodium chloride. Liquid brine is also applied when appropriate.

The JHPC is conducting research and development associated with new ITS technology for the economical and efficient management of snow- and ice-control operations. The technology includes advanced weather forecasting capability, global positioning system (GPS) sensors, satellite communications, mobile road surface condition measurements, and reporting of snow- and ice-control vehicle operations.

The JHPC uses special orange patrol vehicles (see Figure 2) to monitor wintertime road surface conditions. These passenger-type vehicles contain a laptop computer, GPS equipment, a charge-coupled device (CCD) camera, sensors to measure air and road surface temperature, a road surface screening device, and a salinity indicator. The screening device classifies road surface conditions as dry, damp, or frozen and snowy based on the illumination and unevenness of the road surface. The salinity indicator, still under development, collects water and ice mixtures splashed from the road surface by the vehicle's rear tire and measures the mixture's residual salinity in the range of 0 to 15 percent concentration. A light refraction technique is used to determine salinity.

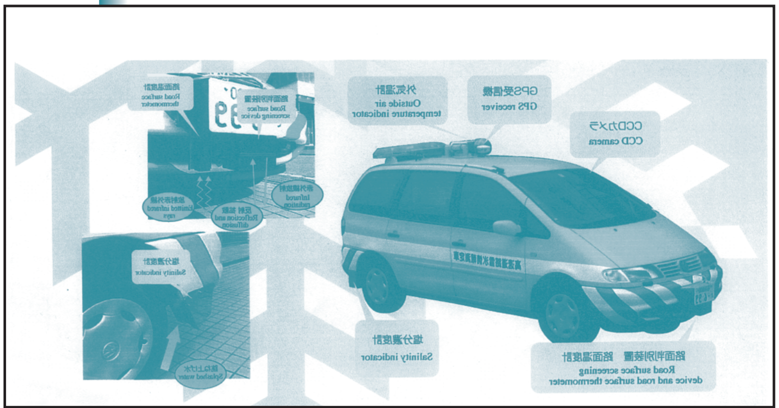


Figure 2. The Japan Highway Public Corporation uses specially equipped patrol vehicles to monitor wintertime road surface conditions.

The information collected by patrol vehicles is transmitted to traffic control centers, which operate 24 hours a day (see Figure 3). The centers also receive road weather information collected by weather observation equipment along the expressways and direct feeds from closed-circuit television (CCTV) cameras at critical locations. The centers then transmit the information to emergency vehicles, winter maintenance vehicles, roadside variable message signs, rest area kiosk terminals, and the highway radio system. Information such as wind speed and air and pavement temperature is displayed digitally on selected roadside message signs on a real-time basis. Vehicle information and communication system (VICS) service has been available on the expressway network since early 1996 to provide road weather information to drivers and passengers through car navigation systems installed in vehicles.

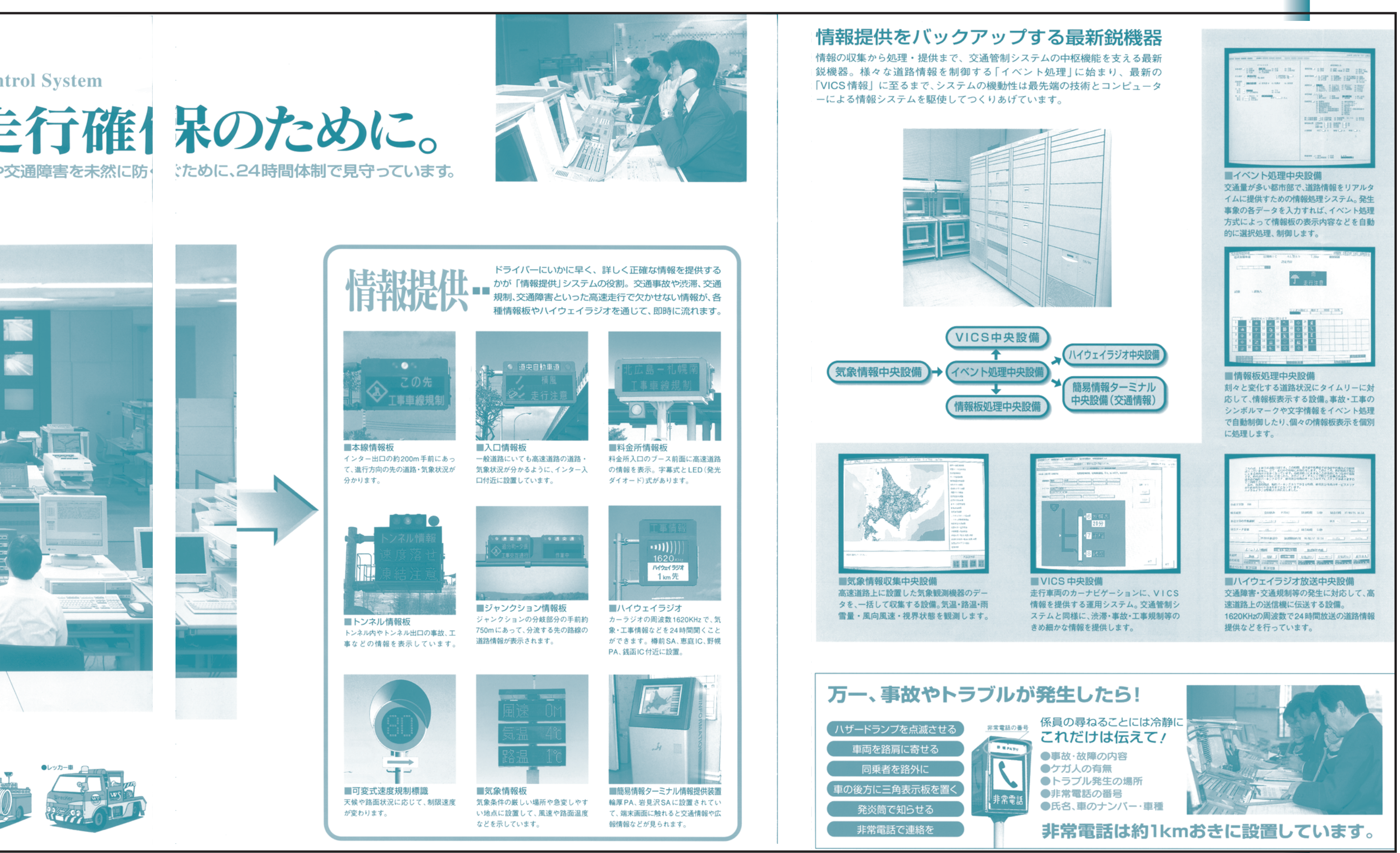
Figure 3. Traffic control centers in Japan collect information on winter road conditions and retransmit it to maintenance vehicles, variable message signs, and rest area kiosks.

Expressways have variable speed limit signs that the traffic control centers can change in response to wind speed, visibility, air, and road temperature conditions. The variable speed limit signs, which have replaced static signs, use colored light-emitting delineators (LEDs) to mimic the look of static signs so that drivers know they are regulatory and not advisory signs.

CIVIL ENGINEERING RESEARCH INSTITUTE OF HOKKAIDO

CERI was founded in 1937 as the Testing Laboratory of the Civil Engineering Department of the Hokkaido Prefectural Government. In 1947, it was renamed the Civil Engineering Institute, Hokkaido Prefectural Government. In 1951, it became part of the newly established Hokkaido Development Bureau. The institute was reorganized and renamed the Civil Engineering Research Institute in 1988. In 2001, it was again renamed the Independent Administrative Institute Civil Engineering Research Institute of Hokkaido. CERI's objective is to improve civil engineering technologies that contribute to the development of Hokkaido through investigations, experiments, research, and development of civil engineering technologies related to projects performed by the Hokkaido Regional Development Bureau.

Institute activities are conducted by specialists organized into four research departments and 13 divisions working on projects involving rivers, dams, erosion control, ports, airports, roads, bridges, land improvement, agricultural land development, and marine and coastal development. The institute also is involved in



technological development of plans, design, construction, and operation and maintenance of the infrastructure in cold, snowy districts.

The team held a formal meeting with representatives of the three divisions of CERI's Road Department—Traffic Engineering, Disaster Prevention and Snow Engineering, and Maintenance and Management. The meeting's purpose was for CERI division directors and researchers to provide an overview of division programs and answer in more detail selected amplifying questions covered briefly during the meeting with the Hokkaido Regional Development Bureau.

The research focus of the Traffic Engineering Division is on road structures, road maintenance (including winter maintenance), traffic flow characteristics (capacity, speed, etc.), safety measurements, and road information. Selected areas of investigation include the following:

- Pavement-tire friction measurements using a friction test bus and a SAAB friction tester.
- Development of a wintertime driving simulator.
- Impact studies related to the 1991 ban of studded tires.
- Traffic accident countermeasure studies involving use of illuminated raised pavement centerline markers.
- Development of winter road management standards, including service level goals for various highway classes using, in part, visual observation of wintertime pavement surface conditions.
- Development of recommended chemical and abrasive application rates.

The pavement friction tests conducted by this division are mainly for research purposes. Some work is still under way on how to use friction measurements in making decisions on chemical and abrasive application treatments. The division also operates a cold-region test-driving course in Tomakomai.

The research focus of the Disaster Prevention and Snow Engineering Division is on studies involving cold region ITS and advanced cruise-assist highway systems (AHS), development of RWML based on XML, behavior of drivers during low-visibility snowstorms, and the use of road weather information for better road management in the Sapporo area. The division conducts field experiments using the millimeter wave radar and ground view sensors plus light-emitting roadside delineators at the Ishikari Snowstorm Experiment Site near Sapporo. The division, as such, is the focus of many cold region ITS research projects conducted by CERI.

The research focus of the Maintenance and Management Division is on studies involving noise countermeasures for roads in snowy regions; advanced, inexpensive construction and maintenance techniques for roads in snowy regions; sidewalk pavement structures and maintenance techniques to enhance snow removal, use by mobility-impaired pedestrians, and resistance to frost-heave damage; use of recycled materials in road construction; and freeze-resistant pavements and road-heating systems.

The CERI hosts did an excellent job of describing their research activities and answering the team's questions. The CERI meeting provided the team with significant details of the progress of ITS and winter operations programs in Hokkaido.

HOKKAIDO DEVELOPMENT ENGINEERING CENTER AND HOKKAIDO UNIVERSITY

The panel met jointly with representatives of the Hokkaido Development Engineering Center (DEC) and Hokkaido University to learn about their activities related to ITS and winter operations management. Selected members of both organizations made formal presentations on activities.

DEC was founded in 1982 by Hokkaido civic leaders to play an important role in supporting and promoting engineering for cold regions development. DEC conducts research and planning studies, and disseminates the results of its activities. It also conducts international exchanges and holds lectures, short courses, symposia, and other events to distribute and promote relevant knowledge and information on engineering in snowy areas.

The presentations by DEC researchers focused on issues related to pedestrian clothing protection and falling accidents in Sapporo during wintertime conditions. All sidewalks in downtown Sapporo are equipped with roadway heating, but the systems are not being used to their full capacity for economic reasons. The unheated surfaces permit ice to accumulate and create slippery, dangerous surfaces that contribute to falling accidents, particularly for elderly and physically handicapped pedestrians. DEC officials hope that improved forecasting and warning of slippery road and sidewalk conditions through ITS initiatives will improve the safety and mobility of Sapporo pedestrians. Other DEC presentations covered economic issues associated with snow removal and environment-oriented traffic education.

The presentations given by the researchers at Hokkaido University concerned traffic safety issues during wintertime driving conditions. One study is a joint project with CERI that covers two areas: the influence of road surface conditions on traffic characteristics and driver behavior; and the analytical prediction of pavement surface skid resistance under a known range of weather, road, and traffic conditions.

PRIVATE WEATHER FORECASTING AGENCIES IN HOKKAIDO

The team had separate meetings with two private weather forecasting agencies in Hokkaido, Japan Weather Association (JWA) and Sapporo Information Network Co., Ltd (SNET). The purpose of these meetings was to understand the coordinated use of weather forecast data in Hokkaido and to get additional background on selected amplifying questions covered during the meeting with the Hokkaido Regional Development Bureau.

JWA was established in 1950 as a private public-service corporation and is under the supervision of the Japan Ministry of Land, Infrastructure, and Transport. JWA is Japan's biggest private sector organization in the meteorological field. It provides all kinds of commercial meteorological, hydrological, oceanographic, geological, and environmental services, such as making observations, processing and analyzing data, and providing forecasting, disseminating, engineering, and consulting services to domestic users. It receives global and regional atmospheric forecasts down to a 20-kilometer grid provided by the Japan Meteorological Agency (JMA), and provides atmospheric forecasts down to a 10-kilometer—and in some cases a 1-kilometer—grid using its own models. JWA has 250 weather reporting stations in Hokkaido.

The specific weather forecast information developed by JWA is for road management purposes and is not provided to the traveling public. JWA provides detailed weather forecast information to the Hokkaido Regional Development Bureau and JHPC through dedicated terminals installed in the office of the road administrators and to other members of these agencies through Internet Web sites and mobile I-mode phones by means of the meteorological information comprehensive online service (MICOS) developed by JWA.

SNET is a licensed private weather forecast service. It was founded to conduct research and development on improved snowfall forecasts and obtain data on Sapporo's winter weather conditions. SNET provides weather forecasts based on weather data from JMA; snow cloud movement monitored by meteorological radar; and real-time data of atmospheric conditions, snowfall intensity, and snow depth from 52 weather observation sites in and around Sapporo. Snowfall prediction information is used by the city of Sapporo to plan its snow removal operations. Current and forecasted weather information provided by SNET is used also in the automatic control of Sapporo's 680 road-heating systems.

SIRWEC AND PIARC CONFERENCES

The panel had an excellent opportunity to have in-depth technical discussions on advanced technologies with European counterparts in connection with its participation in the SIRWEC and PIARC Conferences. These discussions were held in response to presentations made at both conferences and in specially arranged meetings. Presentations were made in six technical areas at the 11th International Road Weather Conference of SIRWEC:

- Sensors, equipment, road weather information systems, and ITS
- Forecast technology
- Road weather climatology
- Road weather information for customers
- Weather and road management policy and cost benefit
- Severe weather conditions

Presentations also were made in six technical areas at the 11th International Winter Road Congress of PIARC:

- Winter road policies and strategies

- Snow and ice management and costs
- Winter road issues and traffic safety in urban areas
- Environment and energy
- Telecommunications technology
- Development of snow-removal and ice-control technology

Team members learned from the conferences that European developments in ITS and winter operations are worthy of further investigation. Developments of most interest to the panel include winter maintenance equipment, measuring and communicating winter road conditions, coordinated use of weather forecast data, use of winter maintenance decision support systems, and performance evaluation of winter maintenance operations. Selected items of interest include the following:

- The global positioning/automated vehicle location system (GPS/AVL) installed on Italian snow- and ice-control equipment has potential application for U.S. snow- and ice-control operations.
- The Finnish Road Administration's use of RWIS information for automated traffic management and control decisions on European road E18 is also of interest. This road is located in the southern coastal area of Finland and carries cross-border goods between Finnish harbors and Russia. The weather-related traffic management system covers a 25-kilometer section of the highway with RWIS, variable speed limit signs, and variable message warning signs.
- COST Action 344 is a European initiative to improve snow and ice control on European roads and bridges. Nineteen European countries are involved in the multiyear project, which began in 1999. The project consists of six areas of research (task groups) to generate improvements in program management, quality of operations for planning, operational practices, anti-icing products and spreading controls, measures to treat modern surfaces, and driving information. Full-scale European experiments and associated evaluations of improved snow- and ice-control measures will be conducted. Officials anticipate that implementation of project findings will lead to more effective management of winter operations and, consequently, to reduced traffic delays and accidents for road users during wintertime conditions.

More information about the proceedings of both conferences is available at the following Web sites:

http://www.sirwec.org

http://www.piarc.org

http://www.dot.state.mn.us/maint/piarc

Following the conferences, the team obtained information about driver education for winter conditions from Swedish researchers. Both Sweden and Norway include winter driving techniques, such as controlled skidding, in their driver-education classes. Officials believe that training and practice on a skidpan is the best educational method for teaching winter driving skills. Classes in Norway for private driver's licensing include a compulsory two-hour practice on a skidpan and an hour of theory on skidding. Classes for commercial driver's licensing include a compulsory nine-hour practice on the skidpan and associated theory. In the fall, skidpans in Sweden offer training to the public and highway maintenance workers.

CHAPTER THREE
KEY FINDINGS

The Japanese organizations the scanning team visited were thorough in their preparations for the team's visit and generous in sharing their experiences and advances. The visits with European researchers also yielded valuable information. Based on these discussions, the team documented many key findings. These findings are those that have potential applicability to U.S. needs in ITS and winter operations. The findings are presented in five topic areas associated with winter maintenance operations, followed by two topic areas associated with motorist information and education.

WINTER MAINTENANCE EQUIPMENT

Advanced winter maintenance equipment continues to be developed and evaluated in Japan and Europe. Some equipment has advanced to the implementation stage. While several projects to evaluate winter maintenance equipment are under way in the United States, no agency has taken the lead in supporting and encouraging research on equipment as in other countries. Snow- and ice-control equipment sensors used in Japan and various European countries generally are available and used in the United States (i.e., automated controls, radar, GPS, etc.). Advanced snow- and ice-control equipment and sensors under evaluation in Japan and Europe fall into one of the three categories described below.

Advanced Maintenance Equipment

Two advances of note are in this category:

- **Modified snow plow vehicle design with cab-over truck engine and double front axles.** This design allows for efficient high-speed snow-removal operations. The cab-over engine configuration provides the operator with an unobstructed forward view of the roadway and helps keep snow blown over the top of the front plow from accumulating on the windscreen.
- **Modified plow designs with automated down pressure control and floating wheel.** This design automatically controls the down pressure applied to the plow blade during snow and ice removal.

Automated Vehicle Location and Navigation Systems

Three advances of note are in this category:

- **Millimeter wave radar sensor.** This sensor can be mounted on the front of vehicles such as snowplows to detect obstacles in the roadway during low-visibility conditions, such as blowing snow and fog.
- **Edge-of-pavement sensors.** These light-emitting delineators (LEDs) are used to indicate the pavement edge to motorists during low-visibility conditions from heavy snowfall and blowing snow. The LEDs, installed at specific intervals along the roadway, flash to provide motorists with a visualization of the road alignment. The brightness of the illumination is adjusted according to background light, so that the brightness during clear weather is less than that during snow-

storms. The brightness is also reduced at night. On divided roadways, the LEDs are installed in the center strip and are orange. On two-lane roads, the LEDs use green illuminating elements and are installed at the roadside.

- **AVL units.** An AVL unit produced in Italy is combined with GPS and appropriate software to provide chemical spreaders with enhanced capability. This capability includes automated, preprogrammed chemical application rate variation and automated tracking and billing for dispensed snow- and ice-control materials. A mobile weather station mounted on the truck also can be connected to the AVL/GPS system to automatically report to a maintenance facility the road surface temperature, air temperature, relative humidity, and dew point along the route.

Vehicle-Mounted Performance-Monitoring Systems

Three advances of note are in this category:

- **Road surface condition sensor.** These sensors indicate wintertime pavement surface conditions, such as icy or snow-covered.
- **Salinity indicator sensor**. 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.
- **Ground view sensor.** These sensors have been developed to identify eight different wintertime road surface conditions and eventually will be used to automatically adjust spreader chemical applications.

Other key findings in this topic include the following:

- Japan has been working over the past 10 years on methods to make mechanical measurements of friction on snow- and ice-covered pavements. Friction measurements under wintertime pavement conditions now are made for research purposes only and are not released to the public. Japan is moving away from mechanical friction measurements and is exploring a number of indirect measurement methods. Officials believe that mechanical measurements of friction cannot be used to make operational decisions. Some European presentations and discussions appear to support this view.
- A number of human factor improvements have been incorporated in the design of sensors and controls used on Japanese snow- and ice-control equipment, but all of the improvements appear to parallel those under consideration in both Europe and the United States.

MEASURING AND COMMUNICATING WINTER ROAD CONDITIONS

Japan relies heavily on frequent visual observations of winter road conditions by patrols to verify conditions detected by an extensive road weather information systems (RWIS) sensor network. Data coming from roadway and atmospheric sensors in Japan are used as secondary information in decisions on winter maintenance operations, traffic control, chemical application treatments, and information disseminated to the public. Other key findings in this topic area include the following:

- Significant advances continue to be made in Japan and Europe on developing improved communication systems and protocols used between RWIS sensors and operations centers. This work is part of an ITS effort to use road weather information systems not only for winter road management, but also for traffic information and control.
- In Japan, RWIS data, video surveillance of mountain passes, and weather information are monitored on a continual basis during developing adverse winter road conditions. Also, road surface conditions on expressways are monitored by road patrols at least six times a day before, during, and after a winter weather event.
- In Japan, RWIS sensor data and observational data of road surface conditions are sent to maintenance headquarters for the decision-making process. A Road Web Markup Language (RWML) has been developed based on next-generation eXtensible Markup Language (XML). In the RWML system, road-related information is grouped into four categories: road information, weather information, disaster information, and regional information. RWML enables road weather information to be distributed easily on the Internet to PCs in road administration offices and maintenance garages.
- No data communication exists between the Japanese winter maintenance vehicles and the operations centers.
- Road condition information such as road surface condition, road closure, disaster prevention information, and weather information is issued by each road administrator. Information such as traffic restrictions is issued by the prefecture police.
- For avalanche-prone areas, patrolling criteria have been established on the basis of weather data at the time past avalanches occurred. No sensing equipment is used to determine avalanche danger. Particularly dangerous sections are designated as special traffic control sections. These sections are closed when avalanches are predicted.

COORDINATED USE OF WEATHER FORECAST DATA

Road weather data in many countries are collected centrally and combined with meteorological forecast data to provide guidance to local road maintenance and traffic control authorities. Many European countries have not yet achieved full data sharing between their RWIS sites and their national meteorological agencies but they are working toward that end. In Japan, road weather data are provided only to local private meteorological forecast companies. Also, Japan has no direct sharing of road weather condition information with other transportation modes or with agencies outside the highway agency's jurisdiction. Outside agencies, however, can obtain road weather information via the Internet or get e-mails by special request. More key findings in this topic area include the following:

- The Japan Meteorological Agency (JMA) provides global and regional atmospheric forecasts down to a 20-kilometer grid. Private meteorological companies such as the Japanese Weather Association (JWA) use this output to drive higher-resolution atmospheric models. For example, JWA runs models at 10-kilometer, 5-kilometer, and 1-kilometer resolutions.
- JMA also provides weather advisories and warnings, while private meteorological firms like JWA provide specific road forecasts and disseminate specific weather information to the public and various agencies.
- JMA has a program to certify forecasters at private meteorological companies.
- Japanese road administrators appear to have established long-standing relationships with specific providers of road weather forecasts. These private meteorological firms appear to operate under sole-source arrangements.
- Private meteorological companies in Japan develop and operate road surface temperature forecast models. Japan uses thermal mapping and heat budget modeling approaches in its road surface temperature forecasts. Japan has a high density of RWIS stations on the expressways (about one set of sensor sites every 10 kilometers).
- Japan has installed many automatic snowfall rate and snow depth sensors that report the data in real time to control centers.

USE OF WINTER MAINTENANCE DECISION SUPPORT SYSTEMS

In the United States, the term maintenance decision support system (MDSS) is used to describe a management system designed to gather, assemble, and organize information on highway conditions, winter storm conditions, and winter maintenance resources to help maintenance engineers and supervisors make effective decisions on staffing, equipment, and chemical use in supporting winter maintenance operations. Both European countries and Japan are developing MDSS, portions of which are undergoing field-testing and evaluation in preparation for implementation. The U.S. contact with foreign efforts is slight, and efforts by the United States and other countries to develop MDSS would be enhanced by closer contact. More specific findings in this area are highlighted below:

- The Hokkaido Regional Development Bureau (HRDB) is developing MDSS to integrate JMA weather forecasts with RWIS sensor data to provide appropriate road weather information to the road administrator, road patrols, and maintenance garages via Web-based access. This information also includes pavement temperature forecasts derived from an algorithm developed by HRDB. The pavement temperature algorithm appears to be as sophisticated as European ones, but no data were presented to verify the accuracy of the model.
- JWA has developed MDSS for site-specific forecasts. The meteorological information system (MICOS) developed by JWA provides weather forecast information to all Japan Highway Public Corporation offices through dedicated terminals for road weather management. The weather forecast information received by the

road administrators appears to be more detailed and site specific than provided in U.S. National Weather Service forecasts. The pavement temperature and condition forecast provided by MICOS depends on manual observations and subjective judgment. No data were available to verify the accuracy of the system. General weather information, as opposed to forecast information, is provided to the public by MICOS via a Web site and mobile I-mode phones.

- Sapporo has used MDSS with data from more than 50 snowfall sensor sites around the city. These sites do not contain road surface condition sensors. The sensor data plus snowfall precipitation forecasts are used by maintenance forces to decide when to pretreat certain roads with chemical application. Limited data from the operation of the system indicate the city achieved a 7.3 percent reduction in instances of inappropriate chemical application. These instances include those when chemicals would have been applied but were not needed, and those when no chemicals were applied but were needed.

PERFORMANCE EVALUATION OF WINTER MAINTENANCE OPERATIONS

Many European countries are moving toward privatization of winter maintenance operations. The relationships between the national agencies and contractors appear to be more partnerships than sponsor-client relationships. The contractual relationships force a clear definition of wintertime service levels expected for the various road systems and lead to a method of evaluating performance of winter maintenance operations. These methods of performance evaluation can be valuable to winter maintenance organizations even if European countries do not privatize their operations.

The United States appears to have higher winter maintenance service standards and expectations for given highway classifications than many foreign countries. This is true from the perspective of both the road maintenance agency and the driving public. More specific findings in this area are highlighted below:

- The Japan Highway Public Corporation has developed a national maintenance manual and is developing regional manuals. The HRDB also has developed a winter road surface maintenance guideline. The documents describe recommended levels of service during wintertime conditions. The HRDB guideline includes road management goals for various highway facilities defined by combinations of average daily traffic volume and area type. The management goals are defined in terms of five classes of road surface conditions. Charts relate the classifications of road surface conditions to ranges of friction coefficients determined by research. The performance evaluation of winter maintenance operations in Hokkaido is based on a visual inspection of road surface conditions by patrolling inspectors.

- The Cost 344 project, a European initiative, is developing a description of best practices for a large number of transportation topics, including measurements and performance evaluations of winter maintenance activities.

- A number of European countries have developed their own measures of performance for winter maintenance operations, but no universally accepted performance measures are apparent.

WINTER TRAVELER INFORMATION

Considerable effort has been made in Hokkaido to provide wintertime travelers with information on weather and driving conditions. This information is available by various means both before and during travel through an extensive advanced traveler information system (ATIS). Winter road conditions are available through hardware and wireless access to various Internet Web sites via PCs and I-mode (Internet-accessible) cellular phones. The development of RWML has enabled road weather information to be distributed over the Internet. Standardization of RWML sensor data and road weather information provided to the public is under development in Japan as part of its ITS applications. Other specific key findings include the following:

- Cellular telephone deployment of third-generation (broadband) services is advanced in Japan with more than 60 million mobile Web users. For a small monthly subscription fee, the I-mode phone provides the user with Web-browsing capability that includes graphics, pictures, and text information.

- The pervasiveness of wireless communications in Japan in general, and in Hokkaido in particular, has allowed for convenient distribution of urban traveler information. Researchers from CERI, HRDC, and the Hokkaido Branch Office of the Japan Weather Association ran an ITS experiment in the Sapporo metropolitan area in January and February 2001 as part of the Smart Sapporo Snow Info Experiment. The purpose of the experiment was to examine the effectiveness of using the latest communication technology to improve traffic flow during expected winter weather events. In the experiment, forecasted snowfall and winter road conditions were provided to commuters over mobile phones to help them choose various transportation modes. The results of a survey showed that 68 percent found the information useful and 71 percent changed commuting patterns based on the information provided. The results of the experiment were presented at the 2002 PIARC Conference in Sapporo.

- Road weather information also is shared with the public through extensive use of variable message signs, road information boards, highway advisory radio (HAR), kiosk terminals, and vehicle information and communications systems (VICS). In-vehicle navigation deployment is advanced in Japan, with both original equipment manufacturer and after-market devices in use. Web-based ATIS is accessible in some vehicles, but it is not clear how many of the 8 million in-vehicle navigation systems in Japan contain this function.

- The Hokkaido Regional Development Bureau, through its road information Web site "Northern Road Navi," provides photographic images of and road weather information on three major mountain passes and the Hidaka expressway. The Web site also displays weather information. The road information center of the Hokkaido Regional Development Bureau provides weather information on its Web site. The Northern Road Navi site provides winter driving guidance and addresses of related organizations, which also provide winter road information through the I-mode phone.

- The speed limit on the expressways can be changed during wintertime and other hazardous driving conditions through the use of variable speed limit signs.

DRIVER EDUCATION FOR WINTER CONDITIONS

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 FOUR

CONCLUSIONS

The Japanese organizations the scanning team visited were generous in sharing their experiences with and advances in ITS and winter operations. The visits with selected European researchers also yielded valuable information. A number of conclusions were drawn from the team findings generated during these discussions.

Advanced winter maintenance equipment continues to be developed and evaluated in Japan and Europe. Advances in vehicle-based technologies have created great potential for improving operations and saving money. The scanning team believes a need exists to further examine advanced maintenance vehicle systems, AVL and navigation systems, and vehicle-mounted performance-monitoring systems for potential implementation in the United States. Japanese and some European agencies are coming to the conclusion that mechanical measurements of friction on snow- and ice-covered pavements cannot be used to make operational decisions. This is reinforced by interest in vehicle-mounted road surface condition monitoring systems that do not rely on friction measurements.

Significant advances continue to be made in Japan and Europe on improving the communication systems and protocols used between RWIS sensors and operations centers. A Road Web Markup Language (RWML) has been developed in Japan based on the next-generation eXtensible Markup Language (XML). RWML has enabled road weather information to be distributed easily on the Internet to PCs in road administration offices, maintenance garages, and traffic control centers.

Integrated ITS corridors are developing in various countries that include surveillance systems (monitoring environmental, traffic, and road conditions) and automated corridor management systems. The scanning team believes these integrated ITS corridors need to be investigated for weather-related inputs.

While siting standards exist for weather information systems such as those used by the National Weather Service, no such standards exist for environmental sensor stations (ESS) installed along or near roadways. The scanning team sees a need for developing ESS siting standards and associated implementation guidance.

Many European countries have not yet achieved full data sharing between their RWIS sites and their national meteorological agencies, but they are working toward that end. Examples across the United Stated demonstrate the benefits of collaboration between the NWS and State DOTs on road weather information. The scanning team sees a need to develop a collaborative, data-sharing effort involving FHWA, NWS, State and local DOTs, and private sector partners to improve weather information for the highway environment.

Finally, the team sees a need to document domestic and international winter maintenance performance standards by road classification and evaluation measures used. Compiling performance-based standards and identifying the circumstances under which the measures work best will help maintenance management with internal assessments and contract monitoring.

CHAPTER FIVE

Recommendations

The scanning team was provided with a wealth of information at the formal presentations, during informal discussions and gatherings, and in written documents and materials. Throughout the study, team members discussed the findings and their potential applicability for ITS and winter operations in the United States. Team members met at the end of the scanning study to review their findings and created the following list of efforts that have potential in the United States. The observations, findings, and recommendations are those of the scanning team and not of FHWA.

A. Winter Maintenance Equipment

1. Investigate and evaluate the following equipment:
   - Modified truck designs with cab-over truck engine and double front axles
   - Automated floating plow design
   - Millimeter wave radar sensor
   - Light-emitting roadside delineators
   - GPS/AVL system installed on Italian snow- and ice-control equipment
   - Salinity indicator sensor
   - Ground view sensor
2. Designate a lead agency for equipment issues.
3. Develop training and education material on equipment use.

B. Measuring and Communicating Winter Road Conditions

1. Investigate the applicability of Road Web Markup Language (RWML) for use in the United States.
2. Further investigate the Finnish Road Administration's use of RWIS information for automated traffic management and control decisions on Highway E18.
3. Conduct testing of protocols such as wireless application protocol (WAP) and M-mode (the U.S. complement to Japan's I-mode service) to communicate severe weather conditions to mobile phone users.
4. Promote the use of arterial dynamic message systems (DMS), especially implementation policy.
5. Investigate variable speed limit use based on road weather conditions.

C. Coordinated Use of Weather Forecast Data

1. Develop implementation guidelines for road weather standards, considering such items as performance, RWIS siting, and communications.

2. Conduct a weather forecasting pilot project for a defined area by coordinating the needs of State, county, and city DOTs, NWS, and value-added meteorological services.

3. Conduct evaluations of the following:

   - Advanced weather radar algorithms

   - Snow rate/depth instrumentation

   - Travel information needs in connection with wireless Web protocols

4. Encourage coordinated use of weather forecast data through a training and education session at an Intelligent Transportation Society of America meeting.

D. Use of Winter Maintenance Decision Support Systems

1. Maintain contact with other countries (i.e., Japan and European) on MDSS developments:

   - Expand national laboratory work in this area to investigate the work of other countries.

   - Seek financial support from AASHTO for this effort.

2. Continue to document and investigate the uses of road weather and other related information by maintenance managers, traffic managers, emergency management, and drivers.

E. Performance Evaluation of Winter Maintenance Operations

1. Follow the Cost 344 project:

   - Track issuance of the final report.

   - Consider joint efforts with European consortium.

   - Encourage the addition of U.S. terminology to the WINTERTERM dictionary.

2. Increase the U.S. role in international efforts pertaining to winter maintenance:

   - Consider a Cost 344-type effort between the United States and Canada.

   - Increase participation in PIARC activities, especially at the maintenance practitioner level.

3. Develop a synthesis of technical papers and research on performance evaluation of winter maintenance operations.

F. Driver Education for Winter Conditions

1. Survey States on the timing requirements, content, and jurisdictional responsibilities for driver education on driving under wintertime conditions.

2. Survey professional driver education programs for content related to wintertime conditions.

3. 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.

4. Develop incentives for States to promote the use of better tires for winter road conditions.

G. Other

1. Develop long-term partnerships with research institutions in other countries on ITS and winter operations.

2. Collaborate with the U.S. insurance industry on an education campaign on winter driving, safety, and property damage.

3. Repeat the Snow and Ice Pooled Fund Cooperative Program (SICOP) project definition process.

The team further discussed the initial set of development areas with potential application in the United States and gave several areas more priority. The team then voted on the remaining recommended areas and only those receiving the largest number of votes were retained. The final recommended areas were consolidated into six applications that the team believes deserve further investigation:

- Winter maintenance equipment review
- Road Web Markup Language (RWML)
- Integrated intelligent transportation systems (ITS) corridor review
- Environmental sensor station (ESS) siting standards and implementation guidelines
- National Weather Service and Department of Transportation collaborative project
- Baseline winter maintenance performance standards

CHAPTER SIX

IMPLEMENTATION PLANS

The team developed a scan technology implementation plan (STIP) for each of the six applications with potential for adoption in the United States identified in Chapter Five. A brief problem statement, objectives, and output of the recommended investigation are outlined below for each implementation plan.

WINTER MAINTENANCE EQUIPMENT REVIEW

Advances in vehicle-based technologies have created great potential for improving operations and reducing costs. What to implement, how to implement it, and how to connect the pieces into a system are challenges facing State and local transportation agencies. Specifically, the scanning team sees a need to develop operational concepts for advanced winter maintenance technologies for use in the United States. The following systems require further examination:

- Advanced maintenance vehicle systems
- Automated vehicle location (AVL) and navigation systems
- Vehicle-mounted performance monitoring systems

The items to be examined under each of these systems are identified in the Key Findings in Chapter Three.

The objective of this STIP is to continue the investigation of advanced winter maintenance technologies through testing and evaluation, including the study of system integration. The output of this investigation will be operational test results and implementation recommendations.

ROAD WEB MARKUP LANGUAGE

As road weather information systems (RWIS) expand beyond use primarily by maintenance garage personnel and are incorporated into other information systems (e.g., advanced traffic management and traveler information systems), a need exists for uniformity in data formatting in support of information exchange, dissemination, and presentation. Work is under way in Japan on Road Web Markup Language (RWML), which is based on eXtensible Markup Language (XML). Related work is taking place under the ITS Standards Program. The scanning team sees a need to pursue this in greater detail by investigating the applicability of the draft RWML standard in the United States (i.e., determining the link to the National ITS Architecture and ITS Standards programs, and examining the impact on statewide information networks and dissemination systems).

The objective of this STIP is to investigate the potential functionality and benefits of RWML, including the following:

- Varying data sources, types, and formats (e.g., ESS and RWIS, human observations, traveler information systems, external meteorological sources).
- Varying data structures (e.g., gridded data, model outputs, probability statistics).

- Varying degrees of processing (e.g., raw observations, assimilated information, human interpretations, video image processing, decision support system output).

The output of this investigation will be a comprehensive road weather data object dictionary, including all types of weather-related data objects (i.e., observations, nowcasts, and forecasts of atmospheric, pavement subsurface, water level, and air quality conditions) in XML.

INTEGRATED INTELLIGENT TRANSPORTATION SYSTEMS CORRIDOR REVIEW

Effective winter operations are a function of coordinated highway maintenance, traffic management, and traveler information. The team believes further study is needed to determine which rules of practice to employ and how best to implement technology to support these rules. Given the varying levels of deployment of such systems around the world, the team recommends starting with these systems and building from there. The following work is planned:

- Investigate and describe Finland's E18 integrated ITS corridor. The corridor includes surveillance systems (monitoring environmental, traffic, and road conditions) and automated corridor management systems.
- Investigate and describe implemented technologies in the United States and Canada (e.g., detection systems, variable speed limit systems, advanced traveler information systems), and the benefits of those technologies. Assess other international corridors, as appropriate.

The objective of this STIP is to investigate integrated ITS corridors pertaining to weather-related inputs. The output of this investigation will be a system design concept (including maintenance management and traffic management functions) and a preliminary operational test plan.

ENVIRONMENTAL SENSOR STATION SITING STANDARDS

Environmental sensor stations (ESS) are a fundamental part of road weather information systems (RWIS) and are fast becoming a key observation component to others (e.g., the National Weather Service, researchers, etc.). While siting standards exist for other formal weather information systems, no such standards exist for devices installed along or near roadways. The team sees a need for development of such standards and associated guidance for implementation.

The objective of this STIP is to publish ESS siting standards and implementation guidelines. The output of this investigation will be a draft standard, operational test plan, and revised standard based on test results.

NATIONAL WEATHER SERVICE/DEPARTMENT OF TRANSPORTATION PROJECT

Both the National Weather Service (NWS) and transportation agencies have public safety missions that overlap when a weather event affects the public's use of the highway system. Examples across the country demonstrate the benefits of collaboration between the NWS and State DOTs. The team sees a need to build on this beneficial working relationship by documenting success stories, promoting good practice, and identifying opportunities for cross-fertilization. Specifically, this could include the following:

- Assess observation and forecasting capabilities of the NWS, State and local transportation agencies, and possibly value-added meteorological services, such as private vendors of weather information.
- Discuss how forecasts could be improved by integrating atmospheric and pavement condition data from RWIS owned by State and local DOTs.
- Describe how public safety could be improved through more effective information management and dissemination, and explore potential mobility, productivity (i.e., cost savings), and environmental benefits.

The objective of this STIP is a collaborative, data-sharing effort involving FHWA, NWS, State and local DOTs, and private sector partners to improve weather information for the highway environment. The output of this investigation will be State and local DOT guidelines for institutional collaboration with local forecast offices of the NWS and private sector.

BASELINE WINTER MAINTENANCE PERFORMANCE STANDARDS

Many DOTs are moving toward performance-based standards on winter maintenance, whether for internal assessments or contract monitoring. Some measures work better than others, and agencies have learned many lessons in the process of applying them. The team sees a need to compile these experiences and identify the circumstances under which the measures work best.

The objective of this STIP is to document domestic and international performance standards applicable to winter maintenance. The output of this investigation will be a synthesis including winter maintenance standards by road classification, if possible, and evaluation measures.

APPENDIX A

AMPLYFING QUESTIONS

The following is a list of questions covering six areas that the U.S. scanning study team would like to discuss with you during its trip to Sapporo, Japan, between January 26 and February 7, 2002. These questions are intended to clarify and expand on topics of interest to the team under the subject of intelligent transportation systems (ITS) and winter operations.

A. Winter Maintenance Equipment

1. What types of sensors (such as global positioning systems) are installed currently on snow- and ice-control equipment for use in winter maintenance operations?
2. What new types of sensors are you planning to install on snow- and ice-control equipment?
3. How do your winter maintenance data gathering procedures fit within your media architecture for ITS in Japan?
4. How are you using the data collected by the roadway sensors and the sensors on the snow- and ice-control equipment?
5. What procedures are used to control the quality of wintertime road condition reporting?
6. How are ergonomics and human factors incorporated into the design of sensors and controls used on snow- and ice-control equipment?
7. Is your agency experimenting with any type of friction measurement equipment or other means to determine pavement friction to support winter maintenance operations?

B. Measuring and Communicating Winter Road Conditions

Measuring Winter Road Conditions

1. How much advance notice of developing winter road conditions is given for maintenance operations? Ideally, how much advance notice do you hope to have and why?
2. Please describe how you assess the overall wintertime conditions of road segments or lengths of highways.
3. What data (received from the sensing equipment used to determine road weather conditions) are sent to maintenance headquarters? How is this information shared with the public?
4. What are the communication media and protocols used for the roadway sensors, winter maintenance equipment, and operations centers? Please provide concept figures showing communication sources, destinations, paths, and media used.

5. If friction measurements are made to determine wintertime pavement conditions, are these data provided to motorists for their use?
6. Which agency determines what information on wintertime road conditions and associated driving conditions is provided to motorists?
7. What sensing equipment is used to determine the avalanche danger in remote mountainous terrain?
8. Is the avalanche danger sensing equipment used to activate warning or notification systems for motorists and maintenance/traffic operations personnel?

Traveler Communication Issues

9. What information do you provide to winter travelers?
10. What methods are used for the public to access winter road and weather condition data? Please describe the data viewed by travelers.
11. What efforts have you made to standardize the types of information and presentation formats for road weather conditions and forecasts given to the winter traveler?
12. How do drivers respond to the messages provided to them on winter driving conditions?
13. What are the various winter storm-warning categories given to travelers to alert them to severe winter weather or significant winter emergency driving conditions?
14. How often is road and weather information updated?
15. Are major roadways or freeways closed during winter storms? If so, how are the road closures communicated to travelers?
16. Is the government liable for providing incorrect road and weather condition information to travelers?

C. Coordinated Use of Weather Forecast Data

Sharing of Meteorological Data

1. What type of data sharing takes place between your transportation agency and the various providers of meteorological data?
2. Is there sharing of meteorological data with other transportation modes, such as transit, airlines, marine, and rail? If so, how?
3. Is there sharing of road weather condition information with other transportation modes, such as transit, airlines, marine, and rail? If so, how?
4. Is there sharing of meteorological data with agencies outside your highway jurisdiction? If so, how does that work?

5. Who is responsible for quality control, quality assurance, and assimilation of the shared data?

Meteorological Products and Services

6. Do you have competing commercial providers of meteorological services? Are defined roles established between various publicly funded meteorological agencies and the commercial providers? If so, what are they?

7. What agency does atmospheric modeling?

8. Who or what agency does pavement temperature modeling, and how is it done (heat balance, thermal mapping, etc.)?

Dissemination of Meteorological Products and Services

9. What agreements exist between your transportation agency (regional and national) and your national meteorological agency? Does a written agreement exist covering this arrangement?

10. What information, data, or other services are provided to you by your national meteorological agency? By commercial meteorological providers?

11. Are different sources of weather information sent over the same communication media? Is information from different sources displayed on computers in the same format?

12. How are winter weather forecasts from competing providers of meteorological services provided to highway authorities? Are the same forecasts provided to the general public?

D. Use of Winter Maintenance Decision Support Systems

Note: In the United States, we use the term maintenance decision support system (MDSS) to mean a management system designed to gather, assemble, and organize information on highway conditions, winter storm conditions, and winter maintenance resources to help maintenance engineers and supervisors make effective decisions on staffing, equipment, and chemical use in support of winter maintenance operations.

1. What MDSS or protocols have you developed or are you developing?

2. What data do you collect for your MDSS for winter maintenance operations? Where and how often do you collect this data?

3. Is your MDSS automated? If so, do all levels of maintenance management have access to the systems for during-storm and/or post-storm review?

4. Who has authority to make winter maintenance decisions?

5. How much use has been made of MDSS for winter maintenance operations? Please describe your documented successes and challenges with MDSS.

6. How applicable are systems to the variety of areas and climates in your country? How many systems do you operate?
7. How is your MDSS evaluated?
8. What personnel levels use your MDSS?
9. Are snow plans commonly used to provide guidance to maintenance engineers and supervisors during winter storm events? If so, how detailed are the plans?
10. What winter weather criteria are used for closing a roadway? How were these criteria developed?
11. How are maintenance activities coordinated with emergency management, traffic management, and traveler information systems?

E. Performance Evaluation of Winter Maintenance Operations

1. Does your agency have different performance standards for different types of highway facilities during wintertime conditions? If so, what are they?
2. What data are collected to measure the performance of winter maintenance operations (clean pavement conditions, number of crashes, environmental impacts, etc.)?
3. How are these data processed and used in the performance evaluation of winter maintenance operations?
4. How is the performance of operators, foremen, and other decision-makers measured and monitored, whether public agencies or contract staff?
5. Is the MDSS used in the performance evaluation?

F. Driver Education for Winter Conditions

1. What efforts are made to educate motorists about the potential dangers of driving during winter weather?
2. Are winter driving techniques included in driver education classes?
3. Are there educational and training programs to teach winter driving to the general public and/or to highway maintenance workers?
4. If you have such educational and training programs, then:
   - What specific classes of motorists, if any, are identified for these programs?
   - Who sponsors, develops, and presents the winter driving programs?
   - How long have the programs been available? Can we obtain copies of the programs?
5. What educational methods work best? Are the results documented?

APPENDIX B

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BIOGRAPHIC SKETCHES

Paul Pisano (FHWA Co-Chair) is the team leader for the Road Weather Management Program in the Federal Highway Administration's (FHWA) Office of Transportation Operations. Pisano has worked in several FHWA offices over the past 16 years. He worked at the Turner-Fairbank Highway Research Center for 10 of those years, where he led the Traffic Safety Research Team. In this capacity, he was responsible for the Rural Intelligent Transportation Systems Research Program, as well as visibility and traffic control device research. In 1999, Pisano moved to the Office of Transportation Operations, and is now responsible for the program that addresses the impacts of weather on all aspects of the highway system, including winter maintenance. Pisano has bachelor's and master's degrees in civil engineering from the University of Maryland. He serves on several technical committees for such organizations as the World Road Association

(PIARC), the American Association of State Highway and Transportation Officials, and the Transportation Research Board.

Richard Nelson (AASHTO Co-Chair) is district engineer for the Nevada Department of Transportation's District 2 office in Reno, Nevada. Nelson directs construction and maintenance operations for the western third of the State, including the eastern Sierra Nevada and Lake Tahoe areas. In the past, he served as assistant district engineer for maintenance in District 2. Nelson has a bachelor's degree in civil engineering from the University of Colorado at Boulder. He is a licensed professional engineer in Nevada and California, and serves on several technical committees of the Transportation Research Board.

Robert Blackburn (Report Facilitator) is a principal research engineer for the Midwest Research Institute and owner of Blackburn and Associates, a highway winter maintenance consulting group. Blackburn directs research efforts to develop guidelines for selecting roadway snow- and ice-control materials and methods for conditions found in the United States. This research is being conducted under the National Cooperative Highway Research Program Project 6-13. His research emphasis includes highway snow- and ice-control operations, chemical and abrasive applications, material spreader/snow removal equipment and their controls, techniques and equipment to quantify and communicate winter road conditions, and the use of decision-support systems for effective winter maintenance operations. Previously, he contributed to the development of the American Association of State Highway and Transportation Officials' Guide for Snow and Ice Control and the Federal Highway Administration's Manual of Practice for an Effective Anti-Icing Program. He has worked as an applied research engineer for more than 30 years on contracts for national, State, and private organizations in the field of highway winter maintenance. Blackburn is an engineering graduate of the University of Kansas and holds a master's degree in applied mathematics from the University of Missouri at Kansas City. He is associated with the Winter Maintenance Committee of the Transportation Research Board.

Steven Brandau is a county engineer for Henry County in Cambridge, Illinois. Brandau directs the design, construction, and maintenance operations for the Henry County Highway Department. He serves as the National Association of County Engineers' (NACE) representative on the Winter Maintenance Policy Coordination Committee of the American Association of State Highway and Transportation Officials. Brandau has a bachelor's degree in civil engineering from the University of Illinois. He is a licensed professional engineer in Illinois and serves on several committees of the Illinois Association of County Engineers. He is a State director of NACE and serves on several NACE committees.

Diana Clonch is the operations manager for the Engineering and Construction Division of the Columbus, Ohio, Department of Public Service. Clonch is responsible for managing the city's street maintenance and cleaning operations, which cover 5,000 lane miles of roadway. Maintenance responsibilities include sweeping, mowing, landscaping, pavement and bridge repairs, snow and ice control, and emergency response. Before joining the city in 1999, Clonch worked for the

Franklin County Engineer's Office for 17 years. Clonch has an associate's degree in civil engineering and is pursing a degree in business management and organizational leadership. She is a member of the State of Ohio Board of Directors, the American Public Works Association (APWA), and the Street Maintenance and Sanitation Officials. She also is vice-chair for the National APWA Winter Maintenance Subcommittee.

Joseph Doherty is the program manger for snow and ice control for the New York State Department of Transportation (NYSDOT). He oversees the acquisition of resources (staff, materials, and equipment) and development of operational guidelines for winter maintenance activities. He also is responsible for identification and implementation of new technologies for snow and ice control. Doherty holds a bachelor's degree in civil engineering from Cornell University and a master's degree in business administration from the State University of New York at Albany. He is a licensed professional engineer in New York and Colorado. He was one of New York State's representatives to the Lead States Program, serves as the monitor for the National Cooperative Highway Research Program 6-13 snow and ice research project panel, is a project manager for NYSDOT's Transportation Infrastructure Research Consortium, and is a member of the American Association of State Highway and Transportation Officials' Maintenance Policy Coordinating Committee.

David Jones is the state maintenance engineer for the Idaho Transportation Department in Boise, Idaho. Jones directs the maintenance policy, procedure, and budget activities for the department. His emphasis areas include maintenance, equipment and fuel management systems, equipment procurement, hazardous materials, volunteer and roadside programs, new maintenance technology applications, emergency management, maintenance research studies, and winter maintenance technology and practices. Jones has presided over a rapidly expanding anti-icing program, promoted winter weather decision support methods, improved avalanche forecasting and preparedness, and sought to minimize the impacts of blowing and drifting snow in Idaho. He has a bachelor's degree in civil engineering from the University of Idaho. Jones is a licensed professional engineer in Idaho and serves as the American Association of State Highway and Transportation Officials (AASHTO) Safety and Winter Operations Task Force leader, a member of the AASHTO Winter Maintenance Policy Coordinating Committee, and a member of the Pacific Northwest Snowfighters Association.

Carl Kain is a principal engineer in Mitretek Systems' ITS Division. He specializes in technologies that provide vehicle-to-roadside, vehicle-to-traffic management center, and center-to-center communications for ITS. He has published papers on integration of public safety computer-aided dispatch (CAD) systems with traffic management CAD systems, commercial wireless data technologies for use by public safety agencies, and dedicated short-range communications (DSRC) technology issues. He also has investigated location-based technologies for wireless E911 and their applications for ITS advanced travel management, traveler information, and archived data. He is the author of the U.S. Department of Transportation's petition to the Federal Communications Commission (FCC) that resulted in assignment of a three-digit abbreviated telephone number (511) for ITS advanced traveler information. Kain has a bachelor's degree in electrical engineering from the University of Cincinnati and a master's degree in electrical engineering from George Washington University. He is a registered professional engineer in Ohio, and a member of the IEEE Communications Society, the ITS American Telecommunications Committee, the American Society for Testing and Materials Standards Committee for 5.9 GHz DSRC for ITS, the Public Safety National Coordination Committee (Federal advisory group to the FCC), and the National Association of Broadcasters' National Radio Systems Committee.

Paul L. Lariviere is the division administrator for the Federal Highway Administration (FHWA) Maine Division Office in Augusta, Maine. Lariviere is responsible for administering the $150 million-a-year Federal-aid highway program in Maine. Lariviere has provided leadership for the Maine Department of Transportation's rural ITS efforts, which have included remote weather information systems. He also provided the critical early leadership for the Three State Rural Advanced Traveler Information System project being advanced by Maine, New Hampshire, and Vermont. He has participated in Rural ITS Scanning Tours to review operational motorist information systems tied to weather monitoring systems. Lariviere holds a bachelor's degree in civil engineering from the University of Massachusetts and a master's degree in transportation engineering from Rensselaer Polytechnic Institute in Troy, New York. He is a licensed professional engineer in New York and chairs the FHWA National Freight Council.

Gregory A. Mandt is director of the Office of Climate, Water, and Weather Service in the National Weather Service (NWS). He is responsible for establishing policy for the nation's operational weather forecast services (including aviation, climate, flood, marine, and public), training the NWS workforce, establishing requirements for implementing all new observing systems, and achieving an effective outreach program for the diverse user community of NWS products and services. Mandt was the chief of the Science Branch, Office of Meteorology from 1996 to 2000. Before coming to the NWS, he served at the National Environmental Satellite and Data Information Service from 1992 to 1996. Before that, he served 14 years in the U.S. Air Force. He has a bachelor's degree in engineering mechanics from the U.S. Air Force Academy and master's degrees in systems engineering and electrical engineering from the Air Force Institute of Technology.

James McCarthy is a traffic operations engineer with the Federal Highway Administration (FHWA) in St. Paul, Minnesota. McCarthy works with intelligent transportation systems (ITS) development and deployment in Minnesota. He is working on a number of ITS projects, including ITS operational tests, new traffic operation centers, deployment of roadside devices, and creation of advanced traveler information systems. He also has worked with the road weather information systems research program known as AURORA for the past four years. McCarthy has a bachelor's degree in civil engineering and a master's degree in civil engineering from the University of Minnesota. He is a licensed professional engineer in Minnesota, holds a professional traffic operations engineer certificate from the Institute of Traffic Engineers, and is on the board of directors of ITS Minnesota and Minnesota Guidestar.

Dr. Wilfrid Nixon is a professor and research engineer at the Iowa Institute of Hydraulic Research at the University of Iowa. His responsibilities include teaching at the undergraduate and graduate levels, and conducting research on winter highway maintenance. He has conducted research under the Strategic Highway Research Program, and served on the American Association of State Highway and Transportation Officials (ASSHTO) Lead States Team for Road Weather Information Systems (RWIS) and Anti-Icing. Further, he has performed work for a number of State DOTs on winter maintenance and RWIS. Nixon serves as a member of the Winter Maintenance Policy Coordinating Committee, a steering committee for the AASHTO Snow and Ice Pooled Fund Cooperative program. He also is chair of the Transportation Research Board Committee A3C09 on Winter Maintenance, and is a member of Committee A5001 on the Conduct of Research. He developed and runs the snow and ice list-serve database, which has more than 600 subscribers, most of whom are winter maintenance practitioners. He has bachelor's and doctoral degrees from Cambridge University in England. He is the author of more than 80 articles, papers, and reports. He is registered as a professional engineer in Iowa.

Daniel Roosevelt is a research scientist with the Virginia Department of Transportation (VDOT) at the Virginia Transportation Research Council (VTRC) in Charlottesville, Virginia. Roosevelt is part of the VTRC team responsible for research in the areas of operation and maintenance of transportation facilities. His research emphasis is on winter maintenance activities. In the past, he was a field operations engineer responsible for more than 1,000 miles of interstate, primary, and secondary highway in a two-county area. His responsibilities included administering highway system maintenance and construction engineering for highway improvement, reconstruction, rehabilitation, and replacement projects. Roosevelt has a bachelor's degree in civil engineering from the University of Delaware. He represents Virginia on Aurora, which seeks to implement and improve road weather information systems, and is on the Winter Maintenance Committee of the Transportation Research Board.

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