



**Review of the
Institutional Issues relating to
Road Weather Information Systems (RWIS)**

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Review of the Institutional Issues relating to Road Weather Information Systems (RWS)

FINAL REPORT

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EXECUTIVE SUMMARY

This project, funded by the Aurora Program, aimed to identify and document institutional issues relating to the implementation and development of Road Weather Information Systems (RWIS). For the purposes of this study, RWIS can be briefly defined as a collection of technologies which are used to assist transportation agencies in determining road condition and weather events. These technologies include pavement sensing and precipitation monitoring systems, for example. RWIS also encompasses various levels of sophistication from the utilization of a particular RWIS technology to a statewide network of weather prediction and pavement temperature detection stations.

The RWIS Institutional Issues project comprised two main phases. The first phase involved performing a review of existing documentation of RWIS institutional issues, and summarizing these findings. From the review of previous research, four categories of widely encountered issues relating to RWIS were identified, as follows:

- funding,
- staffing,
- partnerships, and
- the expandability, transferability, and compatibility of RWIS.

The information contained in this report is structured according to these types of issues. In the case of exploring the issues pertaining to the expandability, transferability, and compatibility of RWIS, the intent of the project was to explore the coordination and standardization issues of RWIS taking place within and between agencies, for example, rather than the technical aspects of RWIS.

Using the literature review findings as background information, the second phase of the project commenced. This second stage involved gathering information on the status of RWIS developments in a variety of agencies with responsibilities for RWIS, and also documenting first-hand experiences in implementing and deploying RWIS. Interviews of Aurora member agencies were conducted by telephone and in-person. Finally, the products of both these stages were incorporated into this final report.

It was found that although the agencies who are members of the Aurora consortium may be considered relatively advanced in their implementation of RWIS, various levels of implementation were in place in their respective jurisdictions. The findings from the interview process reflect the experiences of agencies at different points in the journey to implement RWIS, and therefore the information contained in this report should be of use both to agencies who are already active with RWIS and those agencies yet to explore the potential of RWIS.

It is hoped that these findings can be distributed to a wide range of interested organizations, so that they might benefit from the information contained in this document when planning, implementing and operating their own RWIS.

1. INTRODUCTION

Public agencies are looking toward innovative and more automated means of addressing snow and ice control as optimization of resources continues to be a high priority. Traditionally, methods of snow and ice control were reactive in nature, such as applying chemicals and abrasives, and plowing after heavy snow falls. The reactive approach to snow and ice control often translated into the over-application of chemicals and abrasives. With the advent of improved weather prediction and monitoring systems, agencies have been able to gauge weather patterns more accurately. As a result, agencies can pre-treat road surfaces and take a much more proactive stance to snow and ice control.

Agencies have also witnessed cost-savings and have lessened the environmental impact of applying chemicals and abrasives. The rapid evolution of technology has made it possible to implement effective and efficient methods of snow and ice control through Road and Weather Information Systems (RWIS). However, the process which agencies must undertake to introduce RWIS can be challenging.

1.1 Definition of RWIS

For purposes of this study, a Road Weather Information System (RWIS) can be defined as a combination of technologies and decision making techniques that uses detailed, historical and real-time road and weather information to:

- improve the efficiency of highway maintenance operations; and
- distribute effective real-time information to travelers.

The three main elements of RWIS, therefore, are environmental sensor system (ESS) technologies, forecasts, and information dissemination and display. This broad definition allows ample room for individual state Departments of Transportation (DOTs) to create an RWIS that meets their needs, whether implementing several components or a complete network.

Environmental sensing stations (ESS) are components of RWIS that provide environmental information which assists in the decision making process of applying labor, equipment and materials as cost-effectively as possible during the course of a storm event. The following types of data are commonly collected:

- weather data , including air temperature, amount and type of precipitation, visibility, dew point, relative humidity, and wind speed and direction; and
- surface data, including pavement temperature, subsurface temperature, surface condition (dry, wet, frozen), amount of deicing chemical on the roadway, and freezing point of the road surface.

These data are collected by sensors placed at the roadside or in the roadway itself. Remote processing units (RPUs) placed along the roadway contain some or all of the road and weather sensors. In some cases, the pavement sensors are located apart from the RPU, with several pavement sensors capable of being linked to one RPU. However, these RPUs have limited local intelligence

for processing so data is transmitted to a central server, which could be generically termed a central processing unit (CPU). This central server is typically located in a highway maintenance facility and provides for communication, collection, archiving, and distribution of information. The raw data are used directly or in coordination with a service provider to prepare nowcasts or forecasts. Forecasts then can be used to predict site-specific weather and pavement conditions. Real-time weather information is important, although tailored forecasts aimed specifically at supporting maintenance operations are also an integral component of RWIS.

The data from the ESS's and reports of current and future conditions are compiled and disseminated to maintenance personnel and travelers. Maintenance personnel customarily use the information to monitor and forecast weather and surface transportation conditions, for example, snow and ice control and visibility. The information is also used for monitoring and planning operations such as scheduling personnel, timing operations, selecting roadway control materials, and deploying equipment cost-effectively. Furthermore, the information assists with budgeting and programming. Several distribution mechanisms used for information dissemination include the Internet, Intranet, satellite, and dial-up lines. Additionally, this information can be disseminated to the traveling public through a number of means including the Internet, television, radio stations, kiosks, other data display terminals, telephone information centers, and truck stops, with the intent of providing travelers with effective real-time information and forecasts on surface conditions.

1.2 Project Overview

This project represents an outreach activity of the Aurora Program, the product of which is this compendium of findings and lessons learned relating to the institutional issues involved in the development and implementation of RWIS. The study consisted of two primary tasks:

- a review of existing documentation on RWIS institutional issues; and
- a survey of the Aurora Program consortium members.

This document summarizes the findings of each phase of the study and presents some high level recommendations on how RWIS-related institutional issues may be addressed. It should be noted that this report represents initial activities in this area of study, and it is hoped to update and expand upon these findings in future, follow-up activities. In addition, the study was somewhat constrained by the relatively small amount of pre-existing information available. Consequently, this report is intended to provide an overview of some key issues, and is not considered to represent an exhaustive inventory of all such issues.

2. REVIEW OF PREVIOUSLY DOCUMENTED INSTITUTIONAL ISSUES

This first phase of the project involved reviewing previous research pertaining to RWIS institutional issues. This involved referral of sources by the Aurora Program consortium members, using data from RWIS workshops, and extracting information from RWIS related literature. The available documentation applicable to RWIS institutional issues was quite sparse. The primary sources used in preparing the first project deliverable included:

1. Road and Weather Information Systems (RWIS) Feasibility Workshop Summary of Findings (Mn/DOT and ENTERPRISE sponsored. January 1996);
2. Proceedings of the FHWA Surface Transportation Weather Information Workshop (June 17-18, 1997);
3. Road Weather Information Systems Volume 1: Research Report 1993 (SHRP-H-350, The Matrix Management Group, University of Birmingham - School of Geography, and University of Washington - The Washington Transportation Center (TRAC));
4. Guidelines for Siting Road Weather Information System Sensors 1992 *DRAFT* (SHRP, The Matrix Management Group, University of Washington -The Washington Transportation Center (TRAC)); and
5. Missouri Weather Collection and Dissemination Study (Missouri Department of Transportation, QED Airport and Aviation, and Spectrum Resources, Inc. November 1996.)

In the case of the first two publications, the information concerning institutional issues was derived from comments given by the workshop participants. The Mn/DOT and ENTERPRISE sponsored workshop involved 43 private sector and 38 public agency participants (1). Forty-four people attended the FHWA Workshop, representing Federal and State agencies, the private sector, AASHTO, ITS America, educational institutions, and research centers (2). The information on institutional barriers obtained from the Road Weather Information Systems Research Report were the results of actual interviews conducted with snow and ice personnel and from a review of field tests conducted during the winter of 1990. The interviews encompassed personnel from every level of the State agency (3).

2.1 Findings of Literature Review

After reviewing these sources, several recurring institutional issues themes were apparent. These themes are as follows:

- funding;
- staffing ;
- partnerships; and
- expandability, transferability, and compatibility.

In addition, additional relevant issues - not necessarily fitting within the above categories - are also documented here. The following pages summarize the findings of the literature review. In most

cases, the institutional issues were only identified, and not necessarily resolved. In other instances, suggested resolutions were offered.

Funding Issues

Two particular funding issues were evident from the research conducted. The first issue concerned the source of funding. This was of particular concern when more than one agency, state, or other entity is involved in funding a system. The other issue dealt with competition for funds. In the RWIS arena, it was generally perceived that there is a lack of funding, therefore creating more competition for available resources. Some resolutions to these issues were presented in the workshops whose proceedings were researched. It was suggested that before the start of any program, the financial responsibilities of the participating agencies should be clearly defined and agreed upon before proceeding. Another proposed way of addressing this funding issue is to create new tax laws which would support funding of RWIS and perhaps develop creative funding schemes. Creative finance options suggested include "using a state infrastructure bank, industrial revenue bonds, lease arrangements with payments tied to financial performance of private sector partners, and the profit sharing on the sale of value-added products and services" (5). Alternatively, a recommendation was presented, within the *Road and Weather Information Systems (RWIS) Feasibility Workshop Summary of Findings*, that the initial costs could be Federally-funded to promote a nationwide system. However, it should be recognized that there are various limitations as to the use of Federal-aid funds for RWIS implementations. Importantly, it was noted that the benefits of any system must be quantifiable wherever possible and well-documented in order to justify funding. (1,2,5)

Staffing Issues

The issues relating to personnel involved the acceptance of RWIS by maintenance operators and the fear of losing jobs because of the implementation of a new system. One concern was that maintenance operators were resistant to change and since development and deployment of RWIS involved technologically advanced equipment, there was sometimes hesitation in learning how to use the new technology. It was noticed that personnel were limited in their perspectives on RWIS. Within the documentation examined it appeared that within some agencies there was a belief that the current systems were sufficient to meet the demands of the agency so there was no immediate need for a new system. (1,2)

Attitude was a major barrier in RWIS implementation, including general feelings of cynicism, a lack of knowledge of what RWIS can accomplish for the various agencies, and a lack of appreciation for the benefits of RWIS. The issue of understanding encompasses many factors such as the ineffective dissemination of weather information and the lack of understanding who the customer is and what it is they need. Some documentation seemed to suggest that there is a perceived lack of clear leadership, and not enough value attached to public recognition of the potential benefits of RWIS. There seemed to be a clear need for personnel to overcome change and alter their attitudes towards RWIS and technology. (1,2)

In the Road Weather Information Systems Research study led by The Matrix Management Group, several interesting staff and behavioral issues were noted. Decision-makers at the lower levels

deemed RWIS implementation to be “upper-management directed” initiative. Those at the lower decision-making levels, commonly, have moved up from the foremen and supervisory levels. It was believed that this is the reason for general skepticism towards the management-led initiatives concerning RWIS implementation. Another staffing matter involved the reluctance to accept RWIS system by new personnel. This was especially the case when new technology was involved. In both cases, “there was no acceptance of technology at the decision-maker level.” (3)

Maintenance personnel and operators were observed to have distinct pride in their jobs and dedication to their existing ways of performing their tasks. Winter storms were not considered necessarily an unfortunate occurrence by these personnel due to the opportunities to work overtime during inclement weather. Documentation suggested that some individuals were unwilling to depart with or cut back on their overtime check as a result of new technology. RWIS implementation was seen as an invasion on their ability to work overtime to increase their income. Operators also perceived RWIS as a “technological toy”, too fancy to work. They would rather rely on their own judgment as to what the proper application rate was for chemicals and abrasives than on the rate calculated by a computer. This attitude was also observed at other levels than the maintenance personnel level within some state agencies. (3)

At the upper management level, the issue that arose was not allowing RWIS data to be accessed remotely by portable computers on the road or at home, as these options were seen as too costly. By not allowing remote access, the “decision-making capabilities at the appropriate lower levels were removed.” Another issue regarding institutional issues involved personnel rules and labor agreements. It was felt that they were too restrictive and “stifle creativity and initiative in devising appropriate responses to snow or ice situations.” Snow and ice control was perceived as a normal and routine activity, therefore timely attention to finding new ways of dealing with these situations was not a high priority. (3)

A resolution to the issues presented above was suggested by the authors of the research report. They advised initiating proper training at all levels so “that everyone agrees that part of the action is owned at that level. In most cases, behavioral changes are required on the part of decision makers to move from widespread reactive decision processes to the anticipative decision processes necessary to take advantage of RWIS information.” (3)

Overall, it was suggested that educating either or both management and maintenance workers, depending on differing levels of RWIS implementations, on RWIS and benefits would create more understanding and support. Moreover, systems need to be user-friendly and flexible enough to be readily accepted by users who are accustomed to performing their jobs without RWIS technologies. Systems should also be tailored to end users needs, and be intuitive enough for those who use the systems to retrieve the information that they require simply and easily. In doing so, the user buy-in to the RWIS system will likely be more widespread. If the system seems practical and not too state-of-the-art, user acceptance will be increased. (1,2)

Partnership Issues

Partnership issues proved to be broad, encompassing and overlapping other issues such as funding, liability, and ownership. Most issues involved all types of partnerships, whether public / public or public / private. Other issues addressed specifically public / private partnerships. The challenges between public agency partnerships mostly involved the issues of funding, including concerns over cost sharing. Concerning partnerships between States or other among public agencies, an issue was the possibility of statutes within an agency not allowing such partnerships. Furthermore, timing may be a factor of concern. Each State may have their own RWIS system at different stages of implementation and progressing at different rates, which would complicate State partnerships. (1)

There was concern over DOTs' commitments for long-term financial obligations within partnerships. A solution posed was to develop RWIS using a modular approach thereby allowing an incremental implementation process. This was perceived as being a more efficient approach to the process. While the public sector was concerned over private sector monopolization of data, the private sector had concerns over giving information away. There were also issues over the role of the public sector. Documentation suggested that their role should be defined as either the information provider or the user of the RWIS generated information. Generally it was suggested that stringent, agreed-upon definitions of the roles of partners (such as which agency will take the lead in particular aspects of a project or program, and which agency possesses ultimate authority and responsibility) agreed before initiating partnerships may prevent some of these issues from arising. (1,2)

Some of the barriers that were of concern involved the private sector profit-driven market. There were concerns over maintaining competition and how to make money with RWIS. Some organizations wanted mechanisms to ensure investors recoup development and deployment costs, saying this could be achievable by limiting the availability of RWIS information by offering it for a fee thereby increasing return on investment. Others stated a need for a balanced relationship with all vendors. Those apprehensive towards partnerships felt they were too exclusive, not creating enough competition, and thus "decreasing sources of system support." (1, 5)

A controversial issue that drew much attention concerned the legal and liability aspects of freely disseminating information to the public. In the Road Weather Information Systems Volume 1: Research Report, several specific concerns were identified. Vendors were distressed over being liable for the improper use of data since data can be construed as public domain. The private sector also voiced a need for government agencies to "indemnify the vendor from liability for other vendors' equipment tied to an existing or future Central Processing Unit (CPU)." Additionally, there were concerns over control of dissemination and manipulation of data. Issues arose as to how much, what kind, and what forms of information should be provided to the public. References were made to the practices of other countries where sensitivity to these issues is not so acute: "In Europe, in a less litigious environment, RWISs are directly connected to variable message signs to give indications of road conditions." (3)

On the part of DOTs, forecasts on road conditions can be perceived as "constructive knowledge, requiring agencies to take action to correct deficiencies." That is, if an accident occurred on a segment of a roadway where RWIS sensors detected ice and the DOT was aware of the icy

conditions but did not take measures to control the situation, they could be at fault. Another argument was that RWIS are at the forefront of snow and ice control and by not implementing such technologies DOTs are put in a “liable” situation. (3)

The source documents revealed several possible resolutions to some of the partnering issues presented above. The determining factors between good and bad relationships of potential partners were said to be effective communication and mutual understanding. To forge strong partnerships, communication and understanding needs to be improved. A possibility to ensure that everyone’s needs are met and that the partnership is heading in the right direction is to develop a “multi-agency oversight board.” For partnerships between the public and private sector, if the market can be identified as strong enough, private sector involvement would be stronger. Conducting targeted market research may also facilitate the privatization of certain RWIS components. (1)

Expandability, Transferability, and Compatibility of RWIS Issues

An identified opportunity area concerning RWIS was the need for flexibility and the eventual compatibility with other systems, whether those of other states or other agencies within the same state. There was concern over data accessibility issues such as the centralization of data into an information hub, and determining who should have access to the information. It has been suggested that there is a need for a central clearinghouse with a coordinating organization responsible for interpreting and presenting data in an easy-to-understand format. With that, the question arose as to how the precision and correctness of data can be ensured in addition to confidentiality concerns. (1)

For compatibility of RWIS-related information and systems to occur in the future, agreement has to be achieved regarding specifications and protocol formats. There were some opinions reported that the information should be available only to those who have the skills to use it, to prevent the abuse of the information. The issue of timing of implementation was outlined above in relation to partnerships, but it also could impede process to develop a standard protocol. In terms of expandability of RWIS, the main issue remains as to who will manage and who will pay for the system as it grows. (1)

The standards issue was of foremost concern. In order for RWIS to be compatible, transferable and expandable; the standards, architecture, and protocols must be addressed and agreed upon prior to any other implementation activities. This process must take into consideration what systems and processes are already in place. The push for standardization will create competition and lower the cost per unit of RWIS and may resolve many other related issues. While public / private partnerships may seem like unknown territory, perhaps lessons can be learned through a trial partnership. This might be accomplished through partnering via an ITS demonstration program. In this capacity, technical issues as well as institutional challenges can be addressed. Another benefit of the trial run may be “to provide inputs to the USDOT in its role of facilitating the deployment of ITS technologies by the public and private sector.” (5)

Other Issues

Aside from the issues mentioned above, various other pertinent issues were raised. It was widely believed that RWIS will not only benefit state highway agencies, but that the information can serve other purposes and be of value to other agencies. Other agencies such as the Federal Aviation Administration (FAA), the National Oceanic and Atmospheric Administration (NOAA), and the National Weather Service (NWS) have their own weather sensors. It was felt that increased levels of coordination between these and other agencies concerned with transportation and meteorology could result in less overlap of partially duplicative systems in the future. It was reported that it would be ideal if the exchange of information was kept as simple as possible, nevertheless it was recognized that the needs and goals of the different agencies are not altogether similar. For example, DOTs generally have an interest in ground temperature since their main goals involve pavement snow and ice control. The FAA may locate their sensors on poles or at higher altitudes since their main concern is with atmospheric conditions. Information may be specific to a particular site but may not be applicable elsewhere. The issue remains, how do agencies share sensors and data as to reduce the redundancy of efforts? (4)

The technological aspect of RWIS was an issue also. With technology changing rapidly, how do transportation agencies stay abreast of the changing times and keep their technology current? One recommendation involved developing a system that is “relatively inexpensive and easily upgraded. Software that would be easily maintained as system changes, with constant off-the-shelf upgrades to system components.” This seems more potentially feasible in rural environments where technology can sometimes be implemented at a slower pace. In urban areas, it is difficult to stay in pace with technology since access and the presence of technology is much more visible. (1)

In the Road Weather Information Systems Volume 1: Research Report, a recurring problem that was typically experienced by state highway agencies was a lack of access to experts to consult for weather advice. A meteorologist, whether part-time, full-time, or shared with other agencies may prove valuable to a highway agency, in answering general weather-related questions and providing more specific weather-related advice. It was felt that an in-house meteorologist would not play a part in making operational decisions, which would be left to those maintenance personnel with the knowledge, skills and expertise in these areas. However, it was suggested that access to an in-house meteorologist may prove useful in assisting agencies in acquiring and using RWIS technologies effectively. (3)

Suggested Approaches to Dealing with RWIS Issues

In the literature reviewed, a limited number of recommendations was provided as to how resolve some generic institutional issues, although these suggestions tended not to relate to specific situations.

One recommendation was to attempt to pass new laws aimed to make the process of implementing RWIS more simple, but it was recognized that this could be a lengthy and time consuming option.

Another recommendation was to try to foster participation of all affected agencies within a given state and also to encourage the participation of neighboring or other pioneering states in an agency's own RWIS programs. Depending on the laws and statutes of the individual states, a fee could be charged for the information provided to the public. It was strongly believed that overall support for RWIS initiatives could be accomplished by clearly defining the benefits through education and outreach. (1,2)

3. FINDINGS FROM SURVEY OF AURORA PROGRAM MEMBERS

As a supplement to the literature review of previous investigations into RWIS institutional issues, members of the Aurora consortium were interviewed to gain insights into these agencies' own experiences with developing and implementing RWIS-related systems. It was anticipated that these interviews would serve two purposes. First, it was hoped that the findings of the literature review would be reinforced by the survey results. Second, it was hoped to identify further issues which had not been documented in previous studies. Thus, the resulting product would not only summarize previous related work but would also add value by incorporating up-to-date information direct from agencies currently active in RWIS.

3.1 Approach

After completing the phase 1 literature review, a survey was developed around the previously identified themes. The survey comprised two main parts. General background information on the current status of each agency's RWIS activities was gathered. Then, further questions covered the four types of issues outlined previously. Additional questions served to cover any additional issues that the agencies may have experienced, and to give them the opportunity to add any other comments. A copy of the survey is reproduced in the appendix of this report.

The survey was administered via telephone and in-person interviews. Interviewees included those individuals that serve in the Aurora Program consortium representing state Departments of Transportation in the United States, and Canadian and Swedish agencies. In all 11 individuals were interviewed. This number included seven DOT personnel representing four different states (Iowa, Minnesota, South Dakota, and Virginia), and representatives of the Swedish National Road Administration, Environment Canada, and the Ontario Ministry of Transport. A representative of the Federal Highway Administration was also interviewed to gain a national perspective on RWIS institutional issues.

It should be noted that this number of subjects was not intended to be statistically significant, and that the agencies involved were not necessarily representative of all those agencies active in RWIS across the North American continent and Europe. Indeed, by dint of their involvement in a program such as Aurora, many of these agencies could be considered progressive in their attitudes to and levels of adoption of RWIS.

Nevertheless, given that the survey was intended to provide qualitative information on RWIS institutional issues, and given that the products of this process were intended to give a general insight to other agencies starting to implement or considering implementing RWIS it is believed that the findings are both valid and useful.

3.2 Survey Findings

The following pages contain a summary of the interview results from the survey administered to Aurora members. A brief description of RWIS activities is presented for each of the agencies interviewed followed by a synthesized overview of the findings relating to the institutional issues.

3.2.1 Agency RWIS Activities

All of the agencies that were interviewed have been involved with the development and implementation of RWIS to varying degrees. Their involvement ranges from operating sophisticated inter-connected networks of hundreds of RWIS stations to being at the initial stages of installing a limited number of stations. Summary descriptions of the status of RWIS in the interviewed agencies' jurisdictions are provided below.

Iowa Department of Transportation (Iowa DOT)

RWIS technologies have a long standing record with the Iowa Department of Transportation. This progression can be traced back 25 years when Iowa DOT built their own frost detector for bridge decks, which communicated frost alerts to maintenance supervisors at their homes. At that time, the other method for obtaining this information was to have the state patrol cruise the roads, noting potentially hazardous conditions, and then radioing the information to the proper agencies.

Both these methods provided useful data, but problems were sometimes caused when false readings and false alarms were provided. Instrumentation that could be considered modern RWIS equipment was first installed 10 years ago, when a total of 11 RWIS stations were installed. Currently, Iowa DOT would like to augment this number of existing stations. These RWIS stations provide the data that makes it possible for maintenance supervisors to be aware of next-day frost forecasts before going home at the end of the day, and have also enabled them to make proactive decisions about road surface treatments before leaving work.

RWIS is mainly used for snow and ice control, therefore operating and maintaining the systems have been the responsibility of the Maintenance Division within Iowa DOT. Aside from snow and ice control, these systems have also been used in the summer months for construction purposes. Providing the forecasts from RWIS data is contracted out to Surface Systems, Incorporated (SSI) while the stations themselves are owned by the state.

Elected officials have reported their satisfaction with the efficiency of the snow / ice removal process in Iowa. Recently, a Subcommittee of a Legislative Blue Ribbon Task Force was charged with analyzing maintenance procedures. The subcommittee determined that privatizing the snow / ice removal process of the DOT would prove detrimental not only to the economic stability of the state, but would also compromise the safety of the citizens. It was concluded that turning these responsibilities over to the private sector posed too much risk, and was unnecessary as the DOT was already performing well in this area.

Environment Canada (EC)

Environment Canada (EC) is a government department which was originally formed in 1971 bringing together the Department of Fisheries and Forestry, the weather service from the Department of Transport, the air pollution control division from Health and Welfare, the water sector from Energy, Mines and Resources, and the Canadian Wildlife Service from the Indian and Northern Affairs. RWIS activities within EC started in earnest in around 1994. Active involvement in RWIS ventures commenced during the winter 95/96 season when EC provided forecasting services for the Regional Municipality of Ottawa / Carleton (RMOC). The municipality had installed two full and three partial (without towers) RWIS stations in and around Ottawa.

Originally, these RWIS were used primarily for weather forecasting, rather than for pavement temperature detection or decision-making for proper advance treatment of road surfaces in the event of severe weather. Since then, there has been a fairly dramatic expansion in RWIS activities in Ontario. For the winter 97/98 season, EC will have forecasting responsibilities for 10 different sites involving the RMOC, the Ministry of Transportation of Ontario (MTO), Canadian Highways Management Corporation (CHMC), and Integrated Maintenance Operations Services (IMOS).

The position of EC differs from that of many other state and federal transportation agencies in that their main focus in the area of weather has been dealing with information on atmospheric conditions. This was the case historically as EC's mandate did not include work on surface weather conditions. However, increasingly EC's emphasis is moving to surface weather conditions information as this is perceived as a proactive approach to addressing the safety issues of the traveling public. Within Canada, it is becoming more widely appreciated that agencies operating RWIS should take advantage of weather information to positively impact transportation and travel safety, especially when the majority of road accidents occurring in the winter months are attributable to or affected by weather.

EC's involvement with RWIS remains on the forecasting level and is done on a cost recovery basis. In a recent study, the agency explored the possibility of operating a nationwide network of its own RWIS stations and then, in turn, selling the data. The study concluded that deploying such a network would put EC at a huge financial risk. In effect, the study emphasized risk management and it was determined that it was not within EC's mandate and scope of responsibility to operate RWIS installations as such, rather that this was within the remit of the Department of Transport or other agencies. Therefore, the role that EC will continue to play consists of providing specific services relating to RWIS such as providing forecasts, designing and providing training, setting up instrumentation, integrating hardware, and providing equipment recommendations.

Swedish National Road Administration (SNRA)

The Swedish National Road Administration owns and operates approximately 650 RWIS field stations. The installation of this network of stations commenced in 1982. RWIS is mainly used for snow and ice control in the winter season and in the summer months for construction purposes. Aside from snow and ice control, the collected data is also used when a contractor of winter road maintenance for a specific area is being paid. Currently, the agency is working on a new way to deliver RWIS data via the Internet. Switching to Internet connectivity will facilitate changes to local RWIS software. At present, the software is updated by operators traveling into the field to make the

appropriate modifications. The Internet platform being developed will also offer security features to restrict access to proprietary information. However, selected RWIS information intended for public consumption is accessible by anyone with an Internet link. SNRA and the Swedish Meteorological and Hydrological Institute (SMHI) exchange a lot of information. SMHI supplies the system with weather and radar forecasts, radar and satellite images, and cloud forecasts. In return, SNRA delivers RWIS data back to SMHI.

The Ministry of Transportation of Ontario (MTO)

The Ministry of Transportation of Ontario's (MTO) first three RWIS stations were installed in around 1992 in the Kitchener area, in the south west of the province. All these stations comprised technology from SSI. In the fall of 1996 a test site, known as "Maintenance 2001", was established west of Barrie, just north of Toronto. This initiative was launched to expand MTO's knowledge of RWIS technologies for specific application in their jurisdiction, as well to provide a site to test new winter maintenance equipment, approaches, operations and practices. There are two SSI RWIS installations at this site. In the summer of 1996, MTO also installed two additional sites west of the three Kitchener installations, along the Highway 401 corridor. A further site was installed in the Ottawa area.

The Maintenance 2001 program is coordinated by the Maintenance Operations Office, the Research and Development Division, and the Operations Divisions of the Ministry. These divisions are partnering with SSI of St. Louis for the supply of the hardware and operational software, and with EC for the supply of pavement forecasts. IMOS, their maintenance services contractor for the Chatham District, in southwestern Ontario, has recently installed a system of six RWIS sites. MTO is currently in the process of developing a Memorandum of Understanding that will allow the exchange of information and data between the IMOS and MTO systems. The RMOC has been operating a system of five RWIS stations for two years. The site MTO installed in mid-1997 ties in with their server. MTO is also developing a Memorandum of Understanding with RMOC to permit the exchange of data and information between their systems.

Minnesota Department of Transportation (Mn/DOT)

In the late 1970's Mn/DOT tested its first sensor. Early tests were not wholly successful as the technologies were still in their infancy. In 1988, the DOT installed their first "modern" sensor in the Minneapolis / St. Paul metropolitan area. Another sensor was then installed at their MnROAD facilities, followed by one installed at Thompson Hill in Duluth in 1989. Currently, there are 17 sensors in place across the state from four different vendors. Six of the sensors located in the metro area are networked. The purpose of the using four different vendors was to gain experience with the different vendors and also with different applications. Vendors supplying to Mn/DOT include Vaisala, SSI, Coastal Environmental and Climatronics. Mn/DOT's field stations provide some or all of the following: pavement temperature, subsurface temperature, pavement conditions (wet, frozen, dry, etc.), precipitation (type and quantity), road surface chemical presence, wind speed and direction, visibility, and dew point temperature.

In 1992, a task force internal and external to Mn/DOT was established to investigate implementation of a statewide integrated RWIS system. Mn/DOT felt that RWIS technology had gone beyond

research to become a technology that would prove beneficial to the agency. The intent was to install a network of 300 sensors with coverage forming a 30 km grid. In August 1996, an RFPP was released to attract potential partners. It was hoped by Mn/DOT that a private sector organization or team of organizations would own, operate, and maintain the statewide system, with the DOT acting as one of a number of clients, although the RFPP left it open to responders to propose an approach.

After a year long negotiation process, which involved different private sector teams at different stages, these plans were put on hold as mutually satisfactory agreements could not be reached. At the time of writing of this report, Mn/DOT has just issued an RFP for a reduced scope, to design and implement the "backbone" of the statewide RWIS system consisting of between 70 and 75 of the originally proposed 300 stations; integrating existing data from other information sources such as Automated Weather Observing Systems (AWOS), and other states; and focusing on the information required by maintenance staff and traveler information needs. Rather than pursuing a partnership, it is envisioned that the RWIS work will be completed on a contractual basis. Mn/DOT is hoping to have this streamlined system operational by November 1998.

Other divisions within Mn/DOT and external agencies are interested in the data obtained from RWIS. These include the Department of Natural Resources, the Department of Public Safety - Division of Emergency Management, and, from within Mn/DOT, the Office of Advanced Transportation Systems, Electronic Communications, and Information Resource Management.

South Dakota Department of Transportation (SDDOT)

In 1991, the South Dakota Department of Transportation (SDDOT) installed their first RWIS stations, four at both the eastern and western ends of the state. These systems were provided by SSI. Since then, the agency has been incrementally adding supplementary sites. Currently, there are 31 sites interconnected on a Wide Area Network (WAN), providing reasonable coverage of the whole state. The information from the RWIS stations assists in producing road reports to the public and is used by maintenance crews in determining appropriate winter maintenance activities. RWIS activities are mainly the responsibility of the Operations and Maintenance Departments within SDDOT. In the winter months, the Planning Division assists in some of the activities, workload permitting.

Virginia Department of Transportation (VDOT)

The Virginia Department of Transportation (VDOT) operates 40 RWIS stations comprising a total of 150 sensors on roads and bridges throughout the state. All these systems were provided by SSI. The first of these stations were installed in the late 80's as a pilot test. The remainder were installed in the early 90's, with the 40 current stations in operation by the end of 1994. Thirty-eight of the stations are "basic" stations, consisting of pavement temperature, air temperature, and humidity sensors, and sensors detecting whether or not precipitation is occurring. The other two stations comprise these sensors, plus instrumentation to measure precipitation amount and visibility. The stations are divided among seven central processing units (CPUs), which control between 3 and 14 stations each. To obtain data from these stations, the user is required to dial up the appropriate CPU. Each CPU must be connected with individually to obtain data on the stations which report to it.

Until recently, VDOT had contracts with SSI for the provision of forecasts from the RWIS data and the maintenance of the 40 stations, although these contracts have now expired. VDOT does not plan to renew these contracts. VDOT noted that the capabilities to do this forecasting in-house are not currently available. Over the next year, VDOT plans to use general weather information, such as that provided by Data Transmission Network Corporation (DTN), for forecast information. A Request for Proposal for contract system maintenance is being developed. Plans are to develop a contract for weather and pavement temperature forecasting next year. Within Virginia, all RWIS-related activities are handled by the Maintenance Division of the DOT.

Federal Highway Administration (FHWA)

The U.S. Federal Highway Administration is not directly involved with the deployment or implementation of RWIS in the same manner as state DOTs. However, there are many RWIS-related activities supported by FHWA. Currently funded interest in RWIS, within the Federal Highway Administration, has been largely from the perspective of how these systems can be combined with or interconnected with intelligent transportation systems (ITS). At the headquarters level, RWIS has been traditionally dealt with from the Office of Engineering. However, in early 1997, a cross-agency group called the Weather Team was chartered. Its purpose was to shape a coordinated program amongst the various internal FHWA agencies, identifying and addressing issues relating to the use of weather information for surface transportation decisions. The focus has been on RWIS, mainly snow and ice treatment decisions, but also involves the visibility as an area of interest. Currently, aside from the FHWA personnel comprising the Weather Team, there is participation by one state Department of Transportation employee in order to provide FHWA with a state agency perspective on RWIS.

3.2.2 Funding

The questions that were asked of the interviewees relating to funding were designed to ascertain who was funding the operations and maintenance of RWIS-related systems, and general financial, cost-sharing, and political issues.

The 11 RWIS stations in **Iowa** were originally funded from the operations budget of the Maintenance Division. Currently, the hardware is funded through the Information Processing Plan which is part of the overall Iowa DOT budget. RWIS hardware is funded through this Plan since RWIS deals with computers and the Plan covers computer-related needs. The benefit of funding RWIS through the Iowa DOT Information Processing Plan is that these resources do not have to come out of the DOT's operations budget. However, the disadvantage in this arrangement is that there is more competition for funds, since the Information Processing Plan spans the entire DOT.

Funding for the system software and data processing / synthesis from the RWIS sites remains within the scope of the Maintenance Division. The Iowa DOT has been fortunate not to have had any major opponents of funding RWIS, once the benefits of RWIS had been shared with decision-makers. Within maintenance and operations, RWIS spending is said to represent a small part of the overall budget. No additional funding from other state or Federal agencies is received. The internal politics within an agency have affected funding in that there are so many different departments competing for funds, but this factor will always be present.

Environment Canada (EC) reported that the operations and maintenance of RWIS-related systems are being funded on private, provincial, regional levels. As of yet, no funding has been provided at the Federal level. Recently, there has been a push to encourage participation at the national level, by example of other international organizations such as SIRWEC, but nothing of that magnitude has yet taken off within Canada. On a general note, it was reported that an international trend has been towards an increased belief in free enterprise and less government involvement. Additionally in Canada, many government divisions are being amalgamated. The various Federal departments are decreasing in number and sections are breaking away as agencies. It is hoped that by these means, the agencies will run more efficiently due to their increased freedom with human resources, and decreased operating costs and tax burden by being able to provide services on a cost recovery basis. There is also focus in Canada on Alternate Service Delivery which has a market driven structure and less government involvement. This type of political environment trend is perceived as positive for RWIS.

In Sweden, the **Swedish National Road Administration** (SNRA) is funded entirely by the Swedish government. RWIS has always enjoyed popular and political support in Sweden and has always been viewed as an invaluable means of improving road safety.

The **Ontario Ministry of Transport** (MTO), comparable to a state DOT, funds the purchase of hardware, installation costs, weather forecasts and maintenance of their sites. Although MTO works in collaboration with IMOS and RMOC, each agency funds their own respective sites. Any additional costs associated with connectivity of systems, such as communication lines, hardware, etc., that is required by one authority to access the information of the other is paid by the authority requesting and receiving the information. Currently, MTO's RWIS activities are funded out of "non routine" maintenance development funding. The RWIS funding has to be justified and secured every year. Staff and equipment resources are also provided from both the Research and Development and Operations Divisions.

Eventually, the intention of MTO is to "operationalize" the system and have the funding come out of their "routine" maintenance funding. MTO is interested in developing funding partnerships with other agencies and the private sector, but to date has not pursued this aggressively. The agency also noted that it is not sure what the most appropriate way to proceed with partnering would be. At present, there is no cost sharing for RWIS other than internally within the ministry. Changes in the political environment have not affected RWIS funding, however the interest in RWIS technologies, the potential for cost savings in the future, and the potential for lower salt use is raising significant expectations within the ministry and other maintenance service providers. The Minister has personally visited MTO's Maintenance 2001 Demonstration site, and the Deputy Minister and two Assistant Deputy Ministers also plan to schedule a visit.

Within the state of **Minnesota**, the funding of RWIS within the DOT has been provided through research allocations and safety funding. It is intended that the planned RWIS backbone system and its installation will be funded through the DOT's Program Delivery budget. Other funding options within Mn/DOT include "piggy-backing" RWIS components onto construction projects and obtaining resources through the Operations budget. In terms of cost-sharing between Mn/DOT and other agencies, in the instance of a sensor located on the border of Minnesota and another state, funding has been typically split equally. It was reported that external politics have not affected project

funding but that on occasion, the internal political environment has been a factor. It was noted by interviewees that a significant effort has been required to secure RWIS funding within the organization, as internal decision makers required convincing of the positive benefits / costs ratio of RWIS.

In **South Dakota**, obtaining funding from within the DOT was not problematic after the benefits of implementing the first sensor station were demonstrated. Prior to this installation, high-level DOT managers visited Wyoming and Colorado to witness how systems in these states operated, and also met with vendors to learn more about the systems. After the installation of the initial sensors, SDDOT apportioned supplementary funding within their maintenance and operations budget for each fiscal year. While there was no cost-sharing between the DOT and other agencies or with Federal sources, the cost of the last 11 sensors installed were split between the Office of Research and the Office of Maintenance within SDDOT. The motivation of the Office of Research in cost-sharing was mainly due to the systems playing a role in supporting the Advanced Traveler Weather Information System (ATWIS). Aside from this, the SDDOT has an agreement with Wyoming along US Route 85 to equally split the costs of the sensors along the shared border.

Within **Virginia DOT**, the Maintenance Division funds the operation and maintenance of the RWIS. It was reported that no particular financial issues arose during the planning, development and deployment of the RWIS in Virginia - recommendations made by the Maintenance Engineer were approved by the executive decision-making body of the DOT. In addition, as the Maintenance Division funds RWIS, no cost-sharing issues between agencies arose.

It was reported that within Virginia, it was unlikely that any changes in the state's political environment would affect funding for RWIS. Nevertheless, it was felt that politics internal to the DOT could maybe affect RWIS funding. Since 1983, the procedure by which maintenance projects are selected for funding has evolved, such that now, a Maintenance Leadership Group, comprising representatives from Virginia's nine districts, works collaboratively to assemble funding requests. Thus, prior to funding requests being submitted this group must agree to the initiatives to submit, rather than this preliminary decision being solely the State Maintenance Engineer's, as was previously the case.

In the United States, on the Federal level, the formation of the Weather Team was quite smooth since the group had the support of management, although the financial commitment to the team remains modest. Aside from the Weather Team, various other Federal programs provide some level of funding or other support for RWIS-related activities. These programs are not solely dedicated to RWIS but rather support weather information projects as a whole. The following are the seven "Research and Development" type programs that provide support:

- **Test and Evaluation Program (T&E).** Evaluates innovative or emerging technologies identified as having great potential for use nationwide;
- **Priority Technology Program (PTP).** Offers states a means of testing new technologies without the long process of requesting funding;
- **Intelligent Transportation Systems (ITS).** Funds an array of projects that apply technological solutions to transportation problems, including weather projects that utilize ITS technologies;

- **Small Business Innovative Research Program (SBIR).** Assists small businesses in developing projects (administered by the Volpe National Transportation Systems Center); and the
- **National Cooperative Highway Research Program (NCHRP).** Makes research results available to all states (administered by the Transportation Research Board (TRB)).

The Snow and Ice Cooperative Program (SICOP) is a program aimed at identifying areas of snow and ice control in need of further research and development and has participation from 34 states. SICOP does not initiate projects and is administered by American Association of State Highways and Transportation Officials (AASHTO). Other initiatives include the Aurora program itself, which is a program dedicated to collaborative research, development and deployment in the field of RWIS, reflecting the interests and needs of US and international governmental agencies and the private sector. Additional programs within which RWIS funding may be available include:

- the U.S. DOT's Strategic Highway Research Program (SHRP);
- the Lead State Program within SHRP;
- the Interstate Construction and Maintenance Programs;
- the University Centers Program
- the Federal Aviation Administration's (FAA) National Aviation Weather Program; and the National Weather Service (NWS).

A sign of increased interest and national support in RWIS-related initiatives is the recent \$1.3 million funding of the FORETELL project - a combined ITS-RWIS endeavor.

3.2.3 Staffing

With respect to staffing issues, interviewees were asked to provide input on if and how the implementation of RWIS has affected how their staff do their jobs, the training required for working with RWIS, and the general receptiveness of personnel to these innovations.

From **Iowa DOT's** experience, RWIS has become another tool used in aiding the decision-making process of which roadways require treatments, and which treatments are the most appropriate. The use of RWIS has not eliminated the need for experienced and knowledgeable maintenance personnel to interpret the data provided by the systems. Within the department, there are currently two full-time people who devote 15% of their time to RWIS, and through a cooperative agreement with Iowa State University, a graduate student in meteorology monitors forecasts. At Iowa DOT, RWIS-related duties have been added on to the tasks of maintenance staff. There is a great sense of pride in the work that is accomplished by snow / ice removal staff.

With the implementation of the 11 original RWIS stations, the initial reaction to the technology was that it was considered a novelty. The mindset at the time, from the supervisors' standpoint, was that they had no time for this type of system. It should be noted that at the outset, although most of the time the RWIS stations provided accurate data, there were some problems with false readings from sensors, and those problems were usually publicized throughout the division. When the equipment proved inaccurate, the staff was generally quite unforgiving of the system. However, it was reported that with time, these sentiments have evolved. It was reported that now, most personnel are

accepting of the RWIS technologies and are utilizing the data and forecasts in their snow and ice control decisions, but there are others who would rather remain casual observers of the technology.

Effective training seemed to be key to RWIS acceptance at Iowa DOT, although it was noted that the amount of training currently provided could be greatly increased. Iowa DOT currently provides internal workshops presented by its own staff or by the private sector. These training sessions cover the topics of anti-icing procedures and salt-brine concentrations, for example. Iowa DOT also sends staff to the International Weather Workshop where they learn to interpret RWIS data. The Iowa DOT has trained two trainers in each of their six Transportation Regions and gives training accomplished by peers. This was noted to be quite effective. Future training will concentrate on data interpretation. The Iowa DOT also produced four snow and ice control videos in 1997 and is in the process of producing two more, which will concentrate on anti-icing, RWIS and general weather. This will hopefully provide employees with a better understanding of the critical points of radar and the importance of barometric pressure, for example.

Another useful endeavor has been to determine the effectiveness of RWIS data compared with information broadcast by the media. In a cooperative effort with the Federal Highway Administration, Iowa DOT compared decisions that would be made by maintenance personnel using different sources of information. For this exercise, which was carried out retrospectively using data from five storm events in 1996-97, data from three RWIS stations and public information from media broadcasts were considered independently as the basis for maintenance decision-making scenarios. The estimated number of hours of labor and materials used were calculated for both scenarios in order to determine the cost savings for using RWIS over traditional methods. Another five are being analyzed in for winter 1997-98. It was reported that increased awareness of the results of this project, which demonstrated the value of using RWIS information for decision-making, will assist the staff in promoting the expansion of RWIS technologies.

At the commencement of the **SNRA's** RWIS program in 1982, some difficulties were experienced with convincing staff to readily accept the technology and the techniques of the new systems. It was reported that the mindset of personnel was that they saw "an enemy in the typewriter". More generally, there were parallel issues connected with the introduction of computer-based technologies into the agency. It was noted that personnel had concerns with trying to use new techniques to interpret and read RWIS data. Another issue involved the liability of the system. Traditionally, the method employed in determining winter maintenance was to simply apply chemicals whenever staff felt it was necessary. They used their own judgment rather than relying on data from any sensor systems. However, in the intervening time, working with RWIS has become institutionalized to the extent that maintenance personnel are now fully at ease with these technologies, and many staff now with the agency have always worked with RWIS.

Within **Mn/DOT**, it was felt that the implementation of RWIS components has not affected the way maintenance workers perform their jobs as such, but that better informed decisions were being made. For example, Mn/DOT reported a reduced use of salt and other chemicals, that crews were often sent home earlier than prior to the RWIS installations, and generally, that maintenance workers and supervisors tended to ask more questions. From Mn/DOT's experiences with RWIS, it was observed that it took staff approximately three years to develop a reasonable level of confidence with using the system. Generally, there has been a mix of support and skepticism among staff concerning RWIS.

It was reported that there has been no explicit opposition to RWIS innovations, rather it seems some staff are reserving judgment until the system can be proven to perform up to expectations. It was also reported that there may be a lack of knowledge of the benefits of RWIS particularly in non-metro districts, which may contribute to skepticism.

For Mn/DOT, training is provided annually. When RWIS were first installed, some technical training was provided, covering how to use the system, how to access information, and how to maintain the field equipment. Since then, interviewees reported that additional training on how to use and interpret the information from RWIS should have been provided.

For **MTO**, a degree of training is provided by the RWIS equipment vendor, at the time of the installation of systems. On the job training for MTO's operational staff was provided by their R&D staff. The receptiveness to RWIS innovations by MTO personnel has been mixed. The staff has been generally positive, curious, and even excited to be part of new developments. However, some staff see RWIS as a contributor to future job losses.

In the case of MTO, the implementation of RWIS has not affected how staff do their jobs since the agency is still at the testing and demonstration stage. The testing currently underway at the Maintenance 2001 test site is increasing the staff time and costs connected with RWIS in the short-term. However, MTO's objective is ultimately to reduce staff effort by minimizing the amount of patrolling, and to achieve greater efficiency in the application of anti- and de-icing materials.

EC is heavily involved in specialized RWIS training, both for their own staff and for the personnel of other agencies. Types of training include self-guided reading of RWIS information; attending conferences and workshops; one day workshops for staff from other regions from EC; and "train the trainers" sessions. Within EC, there is a significant emphasis on and investment in training. The department finds that they have to initially sell the fundamental concepts such as the economical impacts of RWIS and safety issues to promote participation in training by their own staff.

Training is also greatly valued within **SNRA**. Every year **SNRA** and **SMHI** are involved in arranging courses for maintenance personnel that aim to increase the understanding of using the information supplied by the system. The understanding of what the data displayed by PCs actually signify is felt to be the most important factor in improving winter road maintenance using RWIS. A typical training session spans three days. The first day is spent by staff surveying, attempting to use, and trying to understand the system and reviewing training materials. The second day usually involves training by a meteorologist about the data that is collected by RWIS. The third day tries to integrate the first two sessions by allowing staff to apply their knowledge and skills to solve case studies. The emphasis of the training is not only on how to use the RWIS system, but on developing an understanding of how the weather can affect road conditions.

Training is seen as crucial within **SNRA**. If education is not emphasized, then the RWIS system is, in effect, another extremely expensive thermometer rather than a tool that will aid in better maintenance decision-making. The staff within **SNRA** have come to rely heavily on the RWIS system to help make snow and ice control decisions. Personnel have changed their mindset since the initiation of RWIS and have come to accept and trust the system. They have also expressed reservations about being able to make decisions effectively if the system is non-operational for more

than two hours. Therefore, since 1993, personnel have been assigned to monitor and maintain the system around the clock.

For **SDDOT**, the implementation of RWIS has provided some information to field maintenance personnel to use as a tool for winter maintenance activities, but staff do not solely depend on RWIS data to make their decisions concerning snow and ice control. Training has mainly been provided by the vendor of the system when new sensors are installed. In 1994, when personal computers were installed in every maintenance shop, training was provided to staff on the usage of computers.

It was reported that technical memoranda are sometimes circulated to maintenance employees on when to look at forecasts, and about other RWIS-related topics. Informal discussions on how to use RWIS information in conjunction with maintenance activities have also been held from time to time. The receptiveness to of RWIS innovations by staff within SDDOT has been generally good, but it was reported that some individuals have not yet openly accepted change.

Within **Virginia**, it was reported that very few maintenance personnel use the data from RWIS for maintenance decision-making. Rather, most personnel instead rely on tried and tested "rules of thumb" and more "traditional" information sources, such as the Weather Channel or other popular media. The training given to most maintenance managers covered only how to access the system and a basic description of the display options. It was reported that most managers received no training concerning interpretation of the data, although several managers were provided with advanced training, including instruction in data interpretation at SSI headquarters in Missouri. In terms of personnel's receptiveness to RWIS it was reported that very few staff believed in the benefits of RWIS. This may be due to the fact that difficulties had been experienced with gaining access to the CPUs, as busy signals were sometimes obtained. In addition, it was noted that as sensors grew older, some had become less reliable, and that it was not always possible to repair these promptly.

Given the role of the **FHWA** in RWIS implementation and operation, the FHWA's interaction with RWIS staff has remained at a minimal level. Although, at a recent FHWA-sponsored weather related workshop consisting primarily of state maintenance personnel, the enthusiasm for RWIS from the attendees was extremely encouraging. It was thought that the reaction was positive mostly due to the fact that those involved in the workshop were mainly the champions of RWIS technologies and concepts.

3.2.4 Partnerships

During the survey process, it was found that many agencies are potentially interested in pursuing partnerships for RWIS, but that they have not had very much experience in such situations. The survey was designed to probe such issues as any applicable local laws that determine if and how partnerships can be set up, in addition to issues or experiences related to revenue-sharing, liability, minimum standards for quality control, and data ownership and control. The majority of the insights concerning partnership issues came from the agencies in Canada and Sweden. Minnesota's work to establish a public / private partnership also provides valuable lessons for future efforts.

In **Canada**, agencies are allowed by law to set up partnerships, but the process is rather lengthy. For example, in order for EC to join the Aurora Program, seven different agencies had to review the

Memorandum of Understanding and approve participation. In EC's partnerships, public and private, the raw RWIS data have remained the intellectual property of the other agencies or companies, with EC having ownership of the processed forecast information. The partners have access and viewing rights to the forecasts, but cannot sell that information. The revenue attributable to forecasts would benefit EC. EC and IMOS have considered a partnership to resell the forecasts processed from RWIS sensor data to the agricultural community. If this was attempted, the profits from the sale of forecast data would be split between the two agencies. EC's stance is to not make a profit nor to drive down the market cost of forecast information, rather it is their intent to recover their costs in weather forecasting. This does not include the cost of hardware which is borne by other agencies.

The **MTO** has a partnership with EC, EC providing forecast services. Aside from EC, MTO is involved in partnership efforts with both IMOS and RMOC. The extent of the partnership with IMOS and RMOC involves mainly information and data sharing. MTO is working with IMOS to ensure that their systems are compatible, in terms of hardware and communications, to allow the exchange of information to take place. The only restrictions placed on partnerships in Canada that MTO is currently aware of includes conflict of interest policies of the government. In addition, the proprietorship of data accumulated by an agency and the inability or limitations imposed on another agency to use, modify, sell or transfer that information for their use or profit may restrict a potential partnership.

In terms of the ownership of data or information, MTO owns the RWIS stations, having paid for and installed them. The hard data collected by the SSI sensors is the property of SSI. In order for EC to access this hard data to produce their forecasts, they have to purchase the rights from SSI. The forecasts produced by EC, using the SSI data, is provided to the Ministry but is the property of EC. Those involved in the partnerships have accepted this arrangement for the time being. However, the ministry is interested in investigating innovative revenue sources for the new and more timely pavement forecasts that are now becoming available. It was reported that MTO sees the proprietorship of the data by multiple authorities as a barrier to developing simple revenue streams.

In terms of liability within partnerships, there was some uncertainty as to who would be liable for the data generated from the system. This has not been legally tested. For example, MTO is not sure what position the courts would take in a case of failure to provide the correct maintenance operation causing property damage or injury because of reliance and dependency on a faulty sensor. It is suspected, that the courts would go for the 'deep pocket', that is, the Ministry. However, in theory, if found guilty, the Ministry's insurer could take legal action against the supplier of the defective equipment.

In Canada, there are no laws that interviewees were aware of to prevent an arrangement or partnership to be formed where revenue could be shared. Revenue could be derived from the sale of the pavement forecasts in the winter and localized weather forecasts in the summer, for example. As mentioned previously, Canadian agencies have not yet explored these options. It was thought that possibly through the Aurora program, minimum standards for control may be set. It was noted that the partnerships that MTO has with other agencies are working out well so far, but that some of these partnerships are relatively new.

The **SNRA** has a partnership with SMHI. SMHI supplies the system with weather and radar forecasts, radar and satellite images and cloud forecasts. SMHI is also involved in meso-scale analyses of RWIS data. These will be used as a quality check of the data. Aside from SMHI, SNRA is involved in partnerships with Bergab, a spin-off company formed by staff of the University of Gothenburg, concerning development of temperature models for forecast of dew points and surface temperatures; and with Enator Telub Östersund, concerning the progress of developing new measuring techniques. The partnership with the University of Gothenburg Earth Science Centre centers on basic research into road climatology, including the physical factors affecting the risk of road slipperiness, the interaction between present parameters for the formation of road slipperiness, and the modeling of local climates. One result of this research is the Local Climatological Model (LCM), a model dealing with "stretch-wise" surface temperatures.

In the state of **Minnesota**, there is a law that governs partnerships. It is called the Special Partnership Legislation which stipulates the partnership process and allows public partners to receive revenue. Had Mn/DOT's efforts to privatize RWIS proceeded, the private sector would have owned and controlled the information. In addition, the private sector would have been liable for the data generated from the system. It was envisioned that the private sector would recoup their costs from fees for service. It was also hoped that through legislation Mn/DOT would be able to share revenue with the private sector. However, Mn/DOT found that the process of attracting private industry partners was difficult and that the agency had to work very hard to promote its plans. Mn/DOT had high hopes and expectations for pursuing a public / private partnership, but negotiations could not be satisfactorily concluded. As outlined previously, Mn/DOT now hopes to fulfill its RWIS vision by "contracting out" rather than seeking a partnership solution.

In **Virginia**, VDOT has not entered into any partnerships with either public or private sector organizations, and so this agency had no direct experience of partnering. The RWIS in Virginia are operated and maintained under a contract with the vendor. In terms of system ownership, VDOT owns both the systems and the resulting data, although the vendor owns the proprietary program which collects and processes data at the RPU's and transmits these to the CPU's. It was reported that there are laws within the state of Virginia that determine if and how public agencies can partner with the private sector, and that at present the political climate is very favorable towards working in partnerships and through privatization.

It was also noted that the maintenance of 150 miles of interstate had recently been privatized within Virginia, and that the organization now maintaining this roadway had asked to be provided with RWIS information. VDOT will allow maintenance contractors access to their station data for free, but these contractors will have to pay a fee to SSI for additional access privileges. That fee is currently around \$500.

In the United States, at the **Federal** level, FHWA promotes the Lead State Program which grants financial support for a state that is a leader in a particular field to transfer their knowledge and experiences to other states less advanced in this field. Another Federally-funded program is known as Test & Evaluation Project 28 which basically aims to develop processes to evaluate RWIS. The goal is to evaluate innovative or emerging technologies that have been identified as having a great potential for use nationwide.

3.2.5 Expandability, Transferability, and Compatibility

The interviewees were queried about their participation in any standardization processes relating to RWIS, components or protocols. In addition, questions were asked concerning coordination among states, provinces, and countries with similar RWIS projects; de-facto standards emerging as a result of vendor strongholds on the market; and the compatibility of new systems with existing equipment. Overall, there is some participation in the formal standardization process relating to RWIS, components and protocols, although this participation is not widespread. Nevertheless, it was reported that there is a need for such standardization in order to give agencies greater freedom in expanding their current systems due to the proprietary nature of current products.

The **Iowa DOT** views most of the onus for the standardization process for RWIS being on AASHTO. The NTCIP Environmental Sensor Station Working Group, which comprises representatives from AASHTO, ITE, and NEMA, is working on developing draft standards for the passing of data between Remote Processing Units (RPUs) and Central Processing Units (CPUs). Iowa DOT perceives the Federal role is as a liaison for the working group and also to provide funding.

Mn/DOT has been active in the standardization of RWIS, components, and protocols. There is participation by Mn/DOT in the ESS Working Group, mentioned above, involving communications protocol. Mn/DOT is also involved in work to define graphics presentation standards for information relating to road and weather conditions through an informal group of states consisting of the DOTs of Wisconsin, Illinois, Iowa, Nebraska, and Minnesota. Mn/DOT also participates in developing guides for SHRP utilization of RWIS.

Informally, Minnesota has been working with Wisconsin and South Dakota on exchange of information. The states provide each other with the dial-up codes for their respective RWIS CPUs. For South Dakota, in addition to allowing Minnesota access to their RWIS CPU, the other surrounding states have that privilege as does the National Weather Service, and various agencies who periodically request this information.

Mn/DOT representatives also reported that they believe involvement in the Aurora consortium is step towards greater coordination among states and countries. It was stated that there is an ever-increasing need for an open architecture and standardization due to more RWIS vendors entering the arena.

To some extent, consistency of RWIS in the U.S. Midwest has occurred as many agencies have procured systems from SSI. Coordination efforts are also evident with the formation of the group of Midwest states which functions to standardize information presentation formats, referenced above. The Aurora Consortium itself also provides a forum for the exchange of information on RWIS standardization, as well as directly funding a Program representative's participation in the process.

EC uses and encourage others to use SHRP standards to help determine RWIS basics such as sensor sitings. It was reported that default standardization has resulted from the adoption of these SHRP recommendations. Otherwise, EC is not aware of standards for formats of weather reports in Canada. Likewise, in the case of MTO, standardization has occurred primarily by default. The

ministry, IMOS, and RMOC all decided independently to purchase equipment from the same vendor. Communication and data transmission is, however, becoming a problem. The ministry is utilizing long distance telephone lines and the ministry LAN / intranet (Ontario government Internet) to provide communication between the RWIS sites, the server, EC and the patrol locations. RMOC is using telephone lines exclusively and IMOS is using telephone lines and the Internet. The development of consistent communication systems and protocols as well as fully compatible hardware and sensors will be essential for information sharing and compatibility of systems in the future.

Across **Canada**, it was reported that coordination between agencies could be improved, in general. It was stated that there is little or no coordination among states, provinces, and countries who have similar projects. For example, across the whole country, a variety of types of instrumentation from a variety of vendors has been procured and installed over time, resulting in an uncoordinated and largely incompatible collection of systems. It was stated that the only consistency occurs when equipment is procured from the same vendor. For example, it was reported that SSI has a 70 per cent market hold in Canada. A number of provinces, not interviewed within this project, were said to be developing RWIS, and although provinces were open to cooperation, no formal coordination was taking place.

MTO can see de facto standards emerging due to the proprietary protocols used by the major vendors. In Ontario, MTO purchasing policies encourage tendering of generic products and discourage the purchase of single source products. However, as the sensors currently available “don’t talk to each other”, MTO has been forced to continue to purchase from the same suppliers when needing to expand its system. The agency has, in fact, approached other suppliers, expressed its concern with this situation, and encouraged suppliers to develop a compatible product to the technology currently in use.

In **Sweden**, it was reported that there has not been much coordination among the Scandinavian countries in terms of cooperative RWIS projects. Norway and Finland have their own separate systems and protocols. This may be a problem if, in the near future, there is a need for information exchange.

For **SNRA**, in the initial stages of developing their RWIS system, they made a conscious decision to purchase field stations from one specific company. Due to this decision, the SNRA does not perceive de facto standards to be emerging in Sweden. Also, as a result, compatibility is not an issue for systems within Sweden.

Compatibility of information formats is a big concern for **SDDOT**. There have been issues concerning only being able to use one vendor because new systems from different vendors are not compatible with the existing installed system. SDDOT representatives also reported seeing reorganization within the vendor company resulting in a decreased level of service. SDDOT has considered sending out bids for future installation of RWIS sites, but that does not resolve the issue of compatibility. CPUs provided by different vendors need to communicate with one another, and the only way this can be achieved is through the standardization of protocols.

It was reported that **VDOT** does not at present play an active role in the formal standardization process, and that part of the motivation for this agency joining the Aurora program was to become

involved in the standardization arena through this consortium of public agencies. VDOT representatives also noted that although there is no active coordination between the agency and its neighboring states, New Jersey had recently contacted Virginia and had expressed an interest in working together to share information, and this collaboration was likely to be pursued by VDOT.

VDOT representatives also expressed the opinion that the RWIS marketplace is very restricted due to the limited number of vendors supplying systems. Although the agency intends to put out an invitation to bid for the maintenance and operation of its RWIS, it remained to be seen if bids from any organizations other than the original vendor would be received.

Most protocols in the RWIS arena have been proprietary to specific vendors, and generally, interviewees believed that the current position of some vendors having a stronghold on the market will force the emergence of de facto standards. One participant felt that FORETELL, a FHWA-sponsored regional initiative to incorporate advanced weather systems and ITS, will be an off-setting force for the potential vendor monopoly.

3.2.6 Other RWIS-related Issues

To conclude the survey, interviewees were asked to comment on various additional topics, including what they felt is the greatest benefit that their agency would gain from RWIS, the greatest challenge each agency will have or had in implementing RWIS, and any general remarks they wished to add concerning the institutional impacts of developing and operating RWIS.

Generally speaking, RWIS is seen as a valuable tool in the winter maintenance decision-making process. The information gathered from these systems and distributed to maintenance staff and the general public cannot reduce the severity of weather and winter storms, but it can help reduce the effects. One respondent believed that the greatest benefit of RWIS is the ability to utilize information provided by these systems to apply the correct treatments at the right time. This may be considered precision delivery or “getting under the storm.” All interviewees saw pretreatment of roads as important in managing storms. RWIS was seen as a mechanism for getting consistent weather and road condition information without having to go out into the field to travel every mile of a route to gather conditions data. Decisions could be made conveniently from a computer at a remote location. For **SNRA**, it was reported that the greatest benefit that could be reaped from RWIS is improving the safety of the traveling public since this is its foremost concern in a country very much affected by severe winter weather.

RWIS benefits to **MTO** were listed as:

- less patrolling by staff;
- reduction in staff;
- more efficient salting operations and consequently less salt usage;
- less salt contamination, salt damage and claims;
- providing better information to motorists; and
- providing a more consistent level of service.

One individual felt that the greatest benefit of RWIS would be in increasing the operating efficiency of an agency. Integrated with other weather systems, it was reported that RWIS along with other tools will further aid in the decision-making process in terms of addressing the effects of weather on roads.

From the meteorological perspective of EC, RWIS information helps provide the best weather service to clients, including the traveling public. Traditionally, the focus of the meteorological community has been on predicting atmospheric conditions such as tornadoes. In a country such as Canada where tornadoes are not as much of a threat as hazardous snow and ice conditions, the benefit of the agency's work to the public would be more tangible if EC's efforts were concentrated in areas such as RWIS. It was also reported that through the use of RWIS, there are potentially more useful information products which can be provided to the public, rather than relying on end users knowing how to take the appropriate actions during an emergency. In this way, RWIS becomes a proactive tool.

On the other hand, the greatest challenges in implementing RWIS were reported to be the training of operations and maintenance staff and also the shortage of funds to provide sufficient and proper equipment. It was felt that funding will always be an issue, and competition for resources is likely to increase rather than diminish. Nevertheless, effective snow / ice control was felt to be key to the economy of states situated in the snow-belt region. It is also important in meeting customers expectations. It was reported that no matter how good a job DOT of other agency does, customer expectations keep rising. It was felt that agencies "need to use every tool in the tool box," and RWIS is one of these tools.

Another reported challenge is trying to change the cultural climate of agencies and the mindsets of those decision-makers who have control of funding that could be utilized for RWIS. Another challenge arises from the lack of coordination between agencies, which results in disjointed and parallel efforts. It was felt that more progress in RWIS could be made if various projects were implemented cooperatively. The combined resources invested in a cooperative and coordinated arrangement could also produce better results. Funding could be more concentrated on RWIS efforts rather than being spread so thinly among various related efforts.

Implementing new techniques and technologies was also seen as a challenge. It was appreciated by interviewees that there will always be issues of staff acceptance of new technologies and procedures. In addition, though staff may be accepting of change and technology, persuading personnel of the merits of switching to a new system when they feel the current one is working perfectly will always be difficult. It was reported that an agency may also find it similarly difficult to meet the internal expectations it has itself created: that the resources invested in RWIS will result in tangible cost savings.

Education and cultural change needed within an agency is also seen as a challenge. It was thought that this may be an easier process if as many people within an agency as possible were involved from the initial stages to achieve widespread buy-in. Interviewees reported that when implementing a system, there needs to be a focus and a charge to keep the initiative moving ahead since it is easy to get sidetracked. It was also felt that installing RWIS is the easy part, but it is more of a challenge to have personnel use and apply the resulting data and information. It was suggested that providing

tailored training is a way to accomplish this. On another level, a challenge of implementing RWIS was seen to be obtaining the desired service from the vendor.

As a final observation, in **Sweden** where RWIS data is owned, maintained and controlled by the government, it was reported that the integrity of the information is never compromised. It was noted that in order for data and information to be consistently of the highest quality, very stringent controls should be placed upon the providers and processors of this information, so as not to compromise the safety of end users.

4. CONCLUSIONS

From the combined results of the literature search and interviews with Aurora members, several conclusions can be drawn. These conclusions are provided below:

- **Finding sources of funding for RWIS, especially in the initial stages of implementation, is a major issue.** The competition for funds will always remain an issue as agencies struggle to prioritize projects to match their goals and vision. For some agencies, obtaining continued funding has become easier as a result of being able to present the benefits of previously implemented RWIS technologies to upper management.
- **There is a general reluctance of personnel to accept RWIS innovations.** This reluctance is due to a lack of comfort with new technology, processes, and procedures, and can be overcome by targeted education and training. When systems are first implemented, it is expected that users may not be immediately comfortable with the new processes, procedures, and physical components, as is the case with many technology-related applications and methods. A level of familiarity and confidence in the new systems needs to be built up over time and bolstered through training to help staff understand the systems and observe the benefits for themselves. For example, within SNRA, the agency is reportedly now at the stage where employees recognize the value of RWIS in assisting with snow and ice control activities to such an extent that they cannot imagine performing these activities without RWIS. While the training efforts in the initial stages of RWIS implementation will assist in familiarizing staff with new procedures and technology, continued education efforts will be the key in sustaining a successful RWIS program.
- **Public / private partnerships to implement RWIS have been attempted only in Minnesota within the United States and proved unsuccessful.** The lack of success in creating a public/private partnership at the time Minnesota attempted to do so was generally due to concerns over liability, ownership issues and assumption of risk. To establish a successful partnership venture, the timing must be right for everyone involved. While the climate in 1996 did not foster such a partnership, the project team members recommended that others consider this approach again in the future.

The true essence of a partnership typically stems from meeting the needs of both participating parties. Before public agencies seek out partnerships, they must determine the needs of their potential partners and be able to clearly define the roles each will play and how each will benefit from the alliance. For instance, private sector partners need to be confident that their cooperative venture will prove profitable. However, it should be recognized that government agencies need to maintain the competitive bid process and be continually cognizant of not intentionally favoring one company over another in the quest for potential partners.

- **Standardization of system protocol formats and specifications are a major issue to agencies.** The lack of standardization is hindering the spread and coordination of RWIS between agencies and states. Presently, the technology exists to implement RWIS at a statewide and even nationwide level, but the incompatibility of systems from different vendors is one factor which impedes full-scale deployment at an acceptable cost. Protocol formats

and specifications are still in the developmental stage for RWIS technologies currently being introduced, partly due to the nature of the standardization process. It should be recognized that identifying what needs to be standardized is the first step in this process.

5. RECOMMENDATIONS

From the conclusions drawn, recommendations have been provided for overcoming some of the key problems when implementing RWIS. The action items presented are targeted at two primary groups: agencies looking to implement RWIS and the Aurora Consortium. As such, separate recommendations are provided below.

It is recommended those agencies in the process of, or contemplating, implementation of RWIS take the following actions:

1. Draw upon the previous experiences of other agencies and present to their organization a clear picture of how RWIS can benefit their agency. **This can be accomplished through:**
 - distributing the findings of this study; and
 - using the SHRP Lead State Program for the implementation of anti-icing and RWIS.
2. Enhance the use of RWIS. It is recommended that implementing agencies:
 - allocate sufficient resources and time to training of agency personnel;
 - distribute findings of this study within their agency; and
 - support SICOP's efforts to develop training to utilize RWIS.
3. Promote the standardization of system protocol formats and specifications. It is recommended that agencies promote the standardization of system protocol formats and specifications by:
 - supporting and using newly adopted NTCIP protocols for Environmental Sensor Systems (ESS) where feasible; and
 - supporting joint efforts, to research, evaluate and deploy systems and hardware that seek to standardize system protocols, formats and specifications.

Further, it is recommended that the Aurora Consortium should take the following actions:

1. Share the successes of Aurora members and others with the implementation of RWIS with agencies involved with winter road maintenance and other National programs and related agencies. This can be done through:
 - distributing the findings of this study to these agencies; and
 - presenting the findings at conferences and through newsletters and journal articles.
2. Share the successes of Aurora members and others with the use of RWIS with agencies involved with winter road maintenance and with other National programs and related agencies. This can be done through:
 - distributing the findings of this study to these agencies; and
 - presenting findings at conferences and through newsletter and journal articles.

3. Investigate further the interest in partnerships within both the public and private sectors nationally. Such a study should also determine the needs, benefits and concerns of both parties.
4. Support standardization of system protocol formats and specifications. It is recommended that Aurora:
 - support, use, and assess newly adopted NTCIP (National Transportation Communications for ITS Protocol) protocols for Environmental Sensor Systems (ESS) where feasible and to provide feedback to organizations in charge of these standards; and
 - support joint efforts to research, evaluate and deploy systems and hardware that seek to standardize system protocols, formats and specifications.
5. Partner with other national efforts to enhance implementation, use, partnerships and standardization. This partnering effort should extend to financial as well as moral support. Examples of these efforts are:
 - SHRP Lead State Program for the Implementation of anti-icing and RWIS; and
 - Snow and Ice Cooperative Program (SICOP) efforts to develop training to utilize RWIS.

From what little has been documented on institutional issues within the realm of RWIS, many lessons can be learned. The survey of the Aurora members conducted within this project proved beneficial in supporting the limited number of documented issues, and served as a valuable method of drawing upon actual, first-hand experiences of various agencies. Some of the issues identified may be easily resolved, but still others remain quite complex and difficult to address. Nevertheless, with the identification and documentation of some key institutional issues in this report, it is hoped that agencies can learn from the experiences of the organizations involved in Aurora. Recognizing the existence of an issue which may impede smooth RWIS implementation and operation may be half the battle.

6. DISSEMINATION OF PROJECT FINDINGS

This project was intended not only to consider the institutional issues relating to the development, implementation, and operations of RWIS, but also to propose some mechanisms to distribute the project findings. It is anticipated that this report, and summary information taken from this report, will be distributed to interested audiences as widely as possible. By this means, agencies can be informed of the issues that other agencies have encountered, and also the approaches taken to address issues, and whether these approaches proved successful. Through this outreach process, it is hoped that agencies that are considering implementing RWIS, and agencies at various stages of RWIS implementation, will benefit from others' experiences in the area.

Table 1 provides several possible means of disseminating the information gathered within the project. Dissemination mechanisms are grouped according to the possible target audiences to be reached.

The performance of the information dissemination activities is not within the remit of the current project. In order to perform the activities outlined below, it will be necessary to acquire additional funding from either the Aurora Program, individual Aurora member agencies, or other sources.

TARGET AUDIENCES	DISSEMINATION MECHANISMS	EXAMPLES
RWIS and transportation professionals and researchers	Conference papers, presentations, and poster sessions	<ul style="list-style-type: none"> • Rural ITS Conference • Transportation Research Board Annual Meetings and any other specialized TRB events • PIARC's International Winter Road Congresses • Annual Meetings of ITS America • ITS World Congresses • American Meteorological Society Annual Meetings and any other specialized AMS events • Annual Meetings of ITE
	Newsletter and journal articles	<ul style="list-style-type: none"> • Meteorological / maintenance publications • ITS publications, such as ITS International, ITS World, Traffic Technology International, etc. • Public agencies own internal publications
Public agency management / decision makers	"Executive summary" mailings / handouts	
	Presentations / poster sessions	<ul style="list-style-type: none"> • Agencies own annual meetings, maintenance / technology expos., etc
	Newsletter and journal articles	
District and Maintenance Engineers	Newsletter and journal articles	<ul style="list-style-type: none"> • Maintenance publications • Public agencies own internal publications • State Technology Transfer (T²) / Local Technical Assistance program (LTAP) publications
	"Executive summary" mailings / handouts	

Table 1 Potential Dissemination Methods for Project Findings

APPENDIX

Aurora Program Institutional Issues Project Survey

General Information

Name: _____

Organization: _____

1. Could you give a general description of the RWIS activities in your agency?
2. Do you work with other divisions or states agencies in operating and maintaining RWIS related systems? If so, who?

Funding Issues

1. Who is funding the operations and maintenance of RWIS -related systems?
2. Were there any particular financial issues that arose during the planning, development, and deployment of RWIS?
3. Were there any cost sharing issues between agencies, states, etc? If so, what was the state/federal cost-sharing undertaken? Were there problems encountered with administering funding from multiple sources? If so, what types?
4. Have any changes in the political environment affected the project funding (i.e. increased / decreased the competition for funds)?

Staffing Issues

1. Has the implementation of RWIS affected how your agency's staff do their jobs in any way?
2. Have you had to undertake any special training for staff using or affected by RWIS? If yes, what type of training was involved and how was this received?
3. How receptive have staff generally been to RWIS innovations? What is their attitude towards RWIS?

Partnership Issues

1. Was your agency involved in any partnerships in developing or operating RWIS, whether public-public or public-private?
2. Are there any laws in your state/province that determine if and how you can partner with the private sector? If yes, could you give some details? If no, do you have any interest affecting changes in the law?
3. If so, who owns the RWIS and data? Who is going to operate and maintain the system?

If the partnerships were public-public, then skip to question 10. If the partnerships were public-private, then:

4. Were there concerns over who controlled the data? Can the information available to the "public" be turned "private"?
5. Is the public sector regulating the private sector's ability to make a profit by providing information?

6. Did you find it was easy to attract the private sector to work with you? How did you do it?
7. Who is going to be liable for the data generated from the system? Private or public agency?
8. Can the public and private sectors share revenue?
9. How will they recoup their costs?
10. Who is going to set up minimum standards for quality control? Who will enforce it?
11. Was there reorganization within a participating partner that affected the project? Was there a delay due to this?
12. Did the partnership work well? Were any mid-term corrections needed? If so, were these determined and easily agreed upon?
13. Have any conflicts risen between partners? How have they been resolved?

Expandability, Transferability, and Compatibility

1. Are you involved in the standardization process related to any RWIS, components, or protocols, for example?
2. Is there coordination among states, provinces, and countries who have similar projects?

3. Do you see de facto standards emerging in any RWIS areas due to particular vendors having a firm hold on the market?
4. How have you addressed issues of compatibility of new systems with existing equipment?

Other Issues

1. What is the greatest benefit you see your agency gaining from RWIS?
2. What is the greatest challenge your agency has, or will have in implementing RWIS?
3. Are there any other comments you'd like to add concerning the institutional impacts of developing and operating RWIS?
4. Are there any other people within your agency we should talk to or other sources we could pursue for information pertaining to institutional issues?