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information systems technology**

Synthesis of Road Weather Forecasting

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February 2001

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16. Abstract <p>The Aurora Consortium surveyed several countries to document the relationship between their national surface transportation agencies and meteorological agencies. Intuitively, one feels highways are safer and more efficient when there is strong coordination between the two agencies. Consequently, this project sought information on the arrangements that transportation agencies have with their national meteorological agencies to supply weather information to the transportation agencies. This includes observation data and forecasts about both the weather conditions and weather-related conditions – collectively known as “road weather”.</p> <p>The countries surveyed were identified through a literature search as having active road weather information systems (RWIS). Not all of the countries originally identified for the study responded to our inquiries. Those that did were Canada, Denmark, Finland, Germany, Japan, New Zealand, Norway, Sweden, and the United Kingdom. The responses from Denmark, Finland, Germany, New Zealand, Norway, and Sweden are from federal-level road agencies. The responses from Canada are from the province of Ontario; those from Japan are from the regional Hokkaido Development Bureau; and those from the United Kingdom are from Lancashire County. All of the responding agencies except in Japan have close cooperative arrangements with their national meteorological agency. In Japan, the meteorological agency sells weather data to weather companies, who in turn provide the data to end-users.</p> <p>The meteorological agencies for each country were identified first. They were asked whether they have formal arrangements with their road agencies, and if so, to provide the name of a contact in the road agency to whom we could send a questionnaire. In cases where the meteorological agency did not respond with a road contact, the national road agency was contacted directly to ask for a contact person who works with road weather information. The questionnaire (see Appendix A) consists of nine questions regarding the arrangements between the road agency and the meteorological agency, and details regarding the data and information received.</p>			
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SYNTHESIS OF ROAD WEATHER FORECASTING

Final Report
February 2001

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1. INTRODUCTION

The Aurora Consortium surveyed several countries to document the relationship between their national surface transportation agencies and meteorological agencies. Intuitively, one feels highways are safer and more efficient when there is strong coordination between the two agencies. Consequently, this project sought information on the arrangements that transportation agencies have with their national meteorological agencies to supply weather information to the transportation agencies. This includes observation data and forecasts about both the weather conditions and weather-related conditions – collectively known as “road weather”.

The countries surveyed were identified through a literature search as having active road weather information systems (RWIS). Not all of the countries originally identified for the study responded to our inquiries. Those that did were Canada, Denmark, Finland, Germany, Japan, New Zealand, Norway, Sweden, and the United Kingdom. The responses from Denmark, Finland, Germany, New Zealand, Norway, and Sweden are from federal-level road agencies. The responses from Canada are from the province of Ontario; those from Japan are from the regional Hokkaido Development Bureau; and those from the United Kingdom are from Lancashire County. All of the responding agencies except in Japan have close cooperative arrangements with their national meteorological agency. In Japan, the meteorological agency sells weather data to weather companies, who in turn provide the data to end-users.

The meteorological agencies for each country were identified first. They were asked whether they have formal arrangements with their road agencies, and if so, to provide the name of a contact in the road agency to whom we could send a questionnaire. In cases where the meteorological agency did not respond with a road contact, the national road agency was contacted directly to ask for a contact person who works with road weather information. The questionnaire (see Appendix A) consists of nine questions regarding the arrangements between the road agency and the meteorological agency, and details regarding the data and information received.

1.1 Agreements between Road and Weather Agencies

Most of the transportation agencies surveyed have formal arrangements with their national meteorological agencies. In Canada, the respondent to the survey was from the Ontario Ministry of Transportation, a member of the Aurora Consortium. The Ministry has a written contract with the Meteorological Service of Canada (MSC) for forecast services. MSC is a part of Environment Canada, also a member of the Aurora Consortium.

In Denmark, the Danish Road Directorate has had an arrangement with the Danish Meteorological Institute since 1983. They have a written agreement among the members of a system called the Icy Road Warning System, which is installed at 14 centers throughout the country. The Finnish National Road Administration has written agreements with both the Finnish Meteorological Institute and a private forecasting company called Weather Service Finland.

In Germany, the German Meteorological Service is an executive agency of the Federal Ministry of Transport, Building and Housing. It provides road weather forecasts for the federal roadways

at no charge, and also to road authorities of the federal states, which construct and maintain federal trunk roads on behalf of the federal government. This arrangement with the federal states was developed as a pilot project and is now part of regular operations. As yet, however, there are no written directives or administrative agreements in place.

In Japan, the national meteorological society is the Japan Meteorological Agency (JMA). They collect weather data and forecasts and transfer them to the Japan Meteorological Business Support Center (JMBSC). Private weather companies then purchase the data and forecasts from the JMBSC and use them to provide forecasts to their specific customers. The Hokkaido Development Bureau receives weather information from one of the largest weather companies, the Japan Weather Association (JWA).

In New Zealand, the agency responsible for the operation of the state highway network, Transit New Zealand, contracts out all of its day-to-day operational work to consultants and contractors. The consultants arrange written agreements with the meteorological agency, MetService, for specific weather services.

The Norwegian Public Roads Administration purchases weather forecasts and climatological data from the Norwegian Meteorological Institute. A written agreement exists concerning the products that they purchase on a regular basis. The Swedish National Road Administration, a member of the Aurora Consortium, has a written agreement with the Swedish Meteorological and Hydrological Institute. They purchase forecasts, radar and satellite pictures from the meteorological agency, and in turn sell RWIS data to them.

The respondent in the United Kingdom is from Lancashire County, and was recommended as being a very prominent figure in the anti-icing scene in the UK. Lancashire County has a written contract with the Met. Office (the national meteorological agency) to supply them with forecasts and other weather data.

1.2 Information, data, or other services supplied by the weather agencies

All of the road agencies receive weather forecasts of various types, and most receive weather radar images. They listed a number of other types of information, data, and services as follows:

1.2.1 Canada

- Pavement forecasts
- Web page display
- Radar
- General forecasts
- Faxed forecasts to Patrol Yard
- Data archiving
- Consultation services

1.2.2 Denmark

- Weather station forecasts
- Three-hour forecasts
- Radar images

1.2.3 Finland

- Satellite pictures (from Finnish Meteorological Institute)
- Radar pictures (from Finnish Meteorological Institute)
- Road weather forecast products (from Weather Service Finland)
- Weather analysis (from Weather Service Finland)
- General weather forecast charts (from Weather Service Finland)

1.2.4 Germany

- Medium-range road weather forecast (noon on the following day until noon on the third day)
- 24-hour road weather forecast, valid until noon on the following day
- Detailed road area weather forecast in three-hour blocks for the next 24 hours for narrowly defined climate areas in tabular form (clouds, precipitation, air temperature, road surface temperature, wind direction & speed, road conditions)
- Warnings of unexpected, critical weather situations

1.2.5 Japan

- Air temperature
- Wind speed and direction
- Precipitation
- Duration of sunshine
- Wide area forecast
- Lowest and highest temperature prediction in major cities
- Weather forecast for every 3 hours until 24 hours ahead
- Prediction of precipitation up to 3 hours in areas 1km squares, etc.

1.2.6 New Zealand

- Forecast for following night/day
- Short term (3-day) forecast covering a specific area subject to extreme winter conditions
- Notice of any significant events not covered by or changed since the forecast
- Direct access at any time to a forecaster to discuss any event

1.2.7 Norway

- Graphical forecasts (wind speed & direction, precipitation, air temperature & pressure, dew point, and cloud cover)
- Written forecasts
- Wind, temperature, and precipitation fields for ground level and 1500m above sea level
- Radar images
- Satellite images
- Special products for parts of the country, e.g. special written forecasts for Oslo and special forecasts for polluted air in five cities during the winter
- Historical data for different projects, e.g. development of a winter index for Norwegian conditions

1.2.8 Sweden

- Radar pictures
- Satellite pictures
- Written 24-hour forecasts
- Weather maps for 6, 12, 18, and 24 hours
- Forecasts for precipitation (0-6 hours), air temperature (7 hours), and clouds (7 hours)
- Ability to make direct contact with a meteorologist from our seven traffic information centers around the clock
- Quality control of all data collected in the last 24 hours in the RWIS system, with the results shown on a web site at the meteorological agency

1.2.9 United Kingdom

- Manual site specific graphs and written forecasts at road weather station sites
- Automatic site specific forecasts at road weather stations with general text synopsis for the area
- Thermal mapping of the primary road network, linked to individual weather stations
- Morning summary of preceding 19 hours and thoughts for the following 29-hour period until issue of site specific graphs
- A 2-5 day forecast detailing general forecast for tomorrow and the next three days

1.3 Format and Communication Systems Used by the Meteorological Agency to Present and Communicate Information

Both web-based systems and other file transfer methods are used. Canada uses a password-protected web system. In Norway, the information is sent by satellite to five main locations, and then transmitted to users via their Intranet and presented in a web application. Finland uses both Internet and file transfer services.

Denmark receives information by file transfer to users' PCs. Germany transmits information by FTP to the mainframe computers in the road authority of each federal state. The information is then distributed to maintenance depots by fax. Sweden also sends information by FTP, and then SNRA creates its own web presentations.

New Zealand transmits forecasts by email and fax. Japan uses an Integrated Services Digital Network (ISDN) leased line and TCP/IP telecommunications protocol. Lancashire County, UK, uses TR2020C Protocol, but is looking into web-based systems.

2. UPDATING OF THE WEATHER INFORMATION RECEIVED

The weather information that the road agencies receive is updated anywhere from continually to once a day. The answers, in order from the most frequent updates, are as follows:

2.1 United Kingdom

- Continually to defined parameters

2.2 Japan

- Varies with type of information, provided on a continual basis

2.3 Canada (Ontario)

- The WEB page itself does an auto refresh every 2 mins.
- The RPUs are polled by the central server every 10 mins. It may take up to 30 mins to display the info on the WEB site by the time they are all polled.
- The pavement and weather forecasts are generated at 3:00am and 3:00pm daily. There can be updates in between depending on the forecaster. However they are required to produce it at least 2 times a day.

2.4 Finland

- Radar every 15 minutes
- Forecasts at 3- to 9- hour intervals, and also when especially necessary

2.5 Norway

- Radar every 15 minutes
- Satellite images four times a day
- Written forecasts and meteorological fields three times a day

2.6 Sweden

- Radar every 30 minutes
- Satellite images every hour
- Precipitation, air temperature, and cloud forecasts every hour
- Written forecasts every three hours
- Weather maps updated around midnight and noon

2.7 Denmark

- Hourly, on a continual basis

2.8 Germany (October-March)

- Medium range forecast daily at 10 a.m.
- General forecasts and detailed area forecasts, daily in the morning
- Unexpected or critical weather situations, around the clock if necessary

2.9 New Zealand (May-September)

- Forecasts daily about noon
- Significant events as needed

3. WEB SITES FOR VIEWING INFORMATION DISTRIBUTED TO ROAD AGENCIES BY METEOROLOGICAL AGENCIES

Canada, Finland, Norway and Sweden have password-protected web sites for this information that are not accessible by the public. Germany, Hokkaido (Japan), Lancashire County (UK) and New Zealand do not currently have web sites for this information, although a web site is under consideration in New Zealand. Denmark has a site sponsored and coordinated among the Road Directorate, the meteorological agency and the counties that is available during the winter season. It provides road users with information and forecasts of weather and road conditions. The URL is <http://www.vintertrafik.dk>. (Danish only) The more general web sites relating to weather information from the countries in this survey are included in the Bibliography.

4. ROAD WEATHER DATA COLLECTED BY THE ROAD AGENCIES, AND DATA SUPPLIED TO THE METEOROLOGICAL AGENCIES

All of the road agencies surveyed also collect some weather data at their own weather stations. The number of weather stations ranged from 14 in Denmark and 17 in Lancashire and an adjacent county, to 180 in Norway and 600 along the German federal motorway network. In addition to basic air temperature, humidity, wind and precipitation measurements, most of the stations also include road surface temperature and condition information. The full list of data collected by each agency is in Appendix B, Question 7.

Almost all of the data from the road agency weather stations is made available to their meteorological agencies. In the case of Japan, where the Hokkaido Development Bureau is supplied by a private weather company, HDB does not provide its own data to that company. Ontario makes pavement structure data available in addition to sensor information. In Sweden, the meteorological institute has access to the station data and to SNRA's web site, and they also purchase data from the 25 RWIS systems to cover gaps in their system. New Zealand provides only daily air temperatures and visual actual weather reports to MetService. The other countries all make whatever data is collected at the weather stations available.

5. WEATHER INFORMATION NEEDED BUT NOT CURRENTLY AVAILABLE OR SUPPLIED

Canada (Ontario), Denmark, Germany, and UK (Lancashire County) did not offer any specific needs that are not being met for weather information. Finland needs more information related to road surface:

- More information on road surface friction
- More exact information on the rain and road surface state
- More exact forecasts of the road surface state

Japan needs:

- More detailed real-time data and weather forecast
- Wide area prediction of winter road conditions
- Real-time observation and forecast of snow blowing

In New Zealand, the meteorological service only operates radar stations in major cities, so large areas are not covered. Transit New Zealand would like to see increased radar coverage. With development of their RWIS, they also plan to pursue obtaining more graphical output images that MetService can provide. In Norway, only two counties are on the IceCast system that has access to forecasts on road surface temperatures and road surface condition. They would like to see coverage extended to all counties. They also desire forecasting related to weather radar images. Sweden is looking for better forecasts on radiation (cloudiness) in order to make better surface temperature forecasts.

6. CONCLUSION

The most common situation in the countries surveyed is for the road agency to have a direct written agreement with the national meteorological agency to be supplied with weather forecasts and other information and data. This direct relationship is the case with: the Ontario (Canada) Ministry of Transportation; the Danish Road Directorate; the German Federal Ministry of Transport, Building and Housing; the Norwegian Public Roads Administration; the Swedish National Road Administration; and the Lancashire County (UK) Council.

The Finnish National Road Administration and Transit New Zealand do have agreements with their meteorological agencies, but it works a little differently. For many years, the national meteorological agency in Finland was the sole provider of weather services for the Finnish National Road Administration. However, FinnRA recently contracted with a private firm to provide weather forecasts. They still have an agreement with the meteorological agency as well, to purchase radar data and satellite information. The two agencies also cooperate with each other in the fields of research and safety.

Transit New Zealand contracts all of its work out to consultants and contractors. The consultants who provide professional services for Transit New Zealand make the arrangements with the meteorological agency, MetService. Transit New Zealand does, however, meet with MetService and the consultants to discuss current services and any new initiatives that may be available.

With the Hokkaido Development Bureau in Japan, the situation is a little different. Weather information that originates from the national meteorological agency is provided through private weather companies that purchase the information from the meteorological agency and pass it along to the end-users.

The overall picture, though, is of strong relationships between the road agencies and national weather agencies. The Danish Road Directorate, for example, made a point in the survey of stressing major cooperation between the agencies. Lancashire County described a “Best Value Partnership” with the Met Office to continually develop services and measure performance in relationship to what they want now and in the future. The data and technologies vary somewhat from country to country; full answers to all of the survey questions follow in Appendix B.

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APPENDIX A: QUESTIONNAIRE

1. Please describe the arrangement that exists between your agency and [insert name of weather agency].
2. Does a written agreement exist covering this arrangement?
3. Please describe the information, data, or other services that are supplied to you by [insert name of weather agency].
4. Please describe the format and communication systems used by the meteorological agency to present and communicate information to you.
5. How often is this information updated? Is it provided on a continual basis?
6. Do you have a web site that we can access to view information your meteorological agency distributes to you? If so, what is the Universal Resource Locator (web address)?
7. Please describe any road weather data that is collected by your own agency.
8. Please describe any data you supply to the meteorological agency to assist them in supplying you with road weather information and forecasts (i.e. pavement surface temperatures.)
9. Is there weather information that you need that is not currently available or supplied? If so, please describe it.

APPENDIX B: COMPLETE ANSWERS TO QUESTIONNAIRE

1. Please describe the arrangement that exists between your agency and the national meteorological agency.

- **CANADA (ONTARIO MINISTRY OF TRANSPORTATION)**
The Ontario Ministry of Transportation has a contract with the Meteorological Service of Canada for forecast services.
- **DENMARK (DANISH ROAD DIRECTORATE)**
The arrangement between the Danish Road Directorate and the Danish Meteorological Institute (DMI) has existed since 1983. The objective is to use road weather forecasts to maintain a satisfactory level of service and safety on the roads during the winter season.
- **FINLAND (FINNISH NATIONAL ROAD ADMINISTRATION)**
The Finnish National Road Administration (Finnra) purchases weather information from the Finnish Meteorological Institute (FMI) and from a private forecasting company called Weather Service Finland (WSF).
- **GERMANY (FEDERAL MINISTRY OF TRANSPORT, BUILDING AND HOUSING)**
The German Meteorological Service (DWD) is an executive agency of the Federal Ministry of Transport, Building and Housing. It provides road weather forecasts for the federal trunk road sector (federal motorways and federal highways) free of charge. At the instigation of the Federal Ministry of Transport, Building and Housing, it also provides road weather forecasts to the road construction authorities of the federal states, as it is they who construct and autonomously maintain federal trunk roads on behalf of the federal government. This includes winter maintenance, the costs of which are borne by the federal government. The federal government thus bears the costs of road weather forecasts by funding the DWD and the costs of winter maintenance, even though winter maintenance is organized by the road construction authorities of the federal states.
- **JAPAN (HOKKAIDO DEVELOPMENT BUREAU)**
The Japan Meteorological Agency (JMA) is the national weather agency in Japan. For further information on JMA, see <http://www.kishou.go.jp/english/index.html>. We don't have an arrangement between the Hokkaido Development Bureau (HDB) and the JMA. First, I have to explain how we get the weather information. The JMA collects weather data and wide area weather forecast in short-range (today, tomorrow, day after tomorrow), one-week, etc. These data and forecasts are transferred to the Japan Meteorological Business Support Center (JMBSC) to provide for private weather companies. Weather companies buy these data and forecasts from the JMBSC and they predict specific weather for customers. HDB is provided weather information by the Japan Weather Association (JWA), which is one of the biggest weather companies in Japan.
- **NEW ZEALAND (TRANSIT NEW ZEALAND)**
All of Transit New Zealand's day-to-day operational work is contracted out, to consultants for the provision of professional services and to contractors for provision of the physical services. The consultants make arrangements with the meteorological agency, MetService, for specific highway requirements needed to fulfill the consultant's responsibilities. Transit New Zealand meets with MetService and the consultants to discuss current services and any new initiatives that may be available to enhance road management.

- **NORWAY (NORWEGIAN PUBLIC ROADS ADMINISTRATION)**
The Norwegian Meteorological Institute (DNMI) provides the Norwegian Public Roads Administration (NPRA) with weather forecasts and climatological data at a market value
- **SWEDEN (SWEDISH NATIONAL ROAD ADMINISTRATION)**
The Swedish National Road Administration (SNRA) purchases forecasts, radar and satellite pictures from the Swedish Meteorological and Hydrological Institute (SMHI) and sells RWIS data to them.
- **UNITED KINGDOM (LANCASHIRE COUNTY COUNCIL)**
Lancashire County has a supply contract with the Met. Office (the national meteorological agency).

2. Does a written agreement exist covering this arrangement?

- **CANADA (ONTARIO)**
Yes.
- **DENMARK**
A written arrangement exists between all of the members of a system called the Icy Road Warning System, which is installed in a series of computers at 14 winter centers. These receive and present data from the recording stations and from the DMI.
- **FINLAND**
Yes, there are written agreements with both FMI and WSF.
- **GERMANY**
The DWD's road weather forecasts for federal trunk roads were developed within the framework of a pilot project and are now provided as part of regular operations. As yet, there is no written directive from the Federal Ministry of Transport, Building and Housing to the DWD, and no administrative agreements between the federal states (as the authorities to whom administrative powers have been delegated) and the DWD.
- **JAPAN**
No.
- **NEW ZEALAND**
The consultants under contract to Transit New Zealand contract with MetService through a written agreement for specific services, and manage their performance.
- **NORWAY**
A written agreement exists between NPRA and DNMI concerning the products that NPRA buys from DNMI on a regular basis.
- **SWEDEN**
Yes.
- **UNITED KINGDOM (LANCASHIRE COUNTY)**
Yes.

3. Please describe the information, data, or other services that are supplied to you by the meteorological agency.

- **CANADA (ONTARIO)**
Pavement forecasts; Web Page display; Radar; General forecasts, Faxed forecasts to Patrol Yard; Data archiving; Consultation services.
- **DENMARK**
Weather station forecasts, 3-hour forecasts, radar images.
- **FINLAND**
FMI provides satellite and weather radar pictures. WSF provides road weather forecast products and some weather analysis and general weather forecast charts.
- **GERMANY**
The DWD provides the following information to the road authorities:
 - Medium-range road weather forecast, predicting the conditions likely to be encountered from noon on the following day until noon on the third day. This is especially helpful for planning operations on weekends.
 - General road weather forecast, providing information on weather developments over the next 24 hours, valid until noon on the following day.
 - Detailed road area weather forecast, including clouds, precipitation, air temperature, road surface temperature, wind direction and speed, and road conditions in three-hour blocks for the next 24 hours, in each case for narrowly defined climate areas in tabular form.
 - Warnings of unexpected, critical weather situations.
- **JAPAN**
We get the following information, which the JMA provides to the JWA via the JMBSC:
 - Air temperature
 - Wind speed and wind direction
 - Precipitation
 - Duration of sunshine
 - Wide area forecast of weather
 - Lowest and highest temperature prediction in major cities
 - Weather forecast every 3 hours until 24 hours aheadWe also get following detailed information, which the JWA forecasts:
 - Prediction of precipitation up to 3 hours in areas 1km squares, etc.
- **NEW ZEALAND**
Through the winter period (May-September) MetService provides:
 - Following night/day forecast covering a specific area subject to extreme winter conditions
 - Three day forecast
 - Notification of any significant events not covered by or changed since the forecast
 - Direct access to forecaster to discuss any eventApart from specific highway requirements, MetService provides national storm warnings that

are faxed to all interested parties, including Transit, at no cost. They also provide a public service for national forecasts charged per minute and run a web site with charges for specific information.

- NORWAY

The NPRA buys the following forecasts from DNMI:

- Graphical prognoses for wind speed, wind direction, precipitation, air temperature, air pressure, dew point temperature and cloud cover
- Written forecasts
- Wind, temperature, and precipitation fields for ground level and 1500m above sea level
- Weather radar images
- Satellite images

These products cover the whole country and are provided on a regular basis throughout the year. We also buy special products for parts of the country, for example special written weather forecasts for Oslo and special forecasts for polluted air in five cities during the winter season. Besides the forecasts we buy a lot of historical data for different projects. An example of that is the development of a winter index for Norwegian conditions, which requires a lot of historical data. Data are available both in tables and visualized on maps.

- SWEDEN

- Radar pictures (JPEG)
- Satellite pictures (JPEG)
- Written weather prognoses for 24 hours
- Weather maps (GIF) for 6, 12, 18, and 24 hours
- Precipitation prognoses for 0-6 hours
- Air temperature prognoses for 7 hours
- Cloud prognoses for 7 hours
- Ability to make direct contact with a meteorologist from our seven traffic information centers around the clock
- Quality control of all data collected in the last 24 hours in the RWIS system; the result is shown on a website at SMHI

- UNITED KINGDOM

The following are received on a daily basis between October 1 and April 30:

- Manual site specific graphs and text (forecasts) at road weather station sites
- Automatic site specific forecasts at road weather stations with general text synopsis for the area
- The primary road network is thermally mapped and linked to individual weather stations
- Morning summary of preceding 19 hours and thoughts for the following 29-hour period until issue of site specific graphs
- A 2-5 day forecast detailing general forecast for tomorrow and the next three days.

4. Please describe the format and communication systems used by the meteorological agency to present and communicate information to you.

- CANADA (ONTARIO)
Password protected Web page.
- DENMARK
The forecasts and radar images are received by PCs in the municipalities, counties, the road authority, and the Road Directorate's Traffic Information Centre as part of the Icy Road Warning System.
- FINLAND
We use both file transfer and Internet services.
- GERMANY
The DWD transmits the information electronically, as text or table using ASCII characters, to the central computer of the Road Condition and Weather Information System (SWIS) of the road authority of each federal state. Transmission is software-controlled, using dial-in via the public telephone network with ISDN technology. The transfer protocol is FTP to UNIX standard. One of the tasks of the SWIS is to send this information via the telecommunications cables of the federal motorways, using a special protocol, to the motorway maintenance depots. The maintenance depots of federal and state highways are not connected to the telecommunications cable and receive the information primarily from the central SWIS computer by fax via the public telephone network.
- JAPAN
We use the Integrated Services Digital Network (ISDN) with the lease line between the HDB and the JWA. The communication protocol is TCP/IP. I don't know the data format because it is peculiar to the JWA.
- NEW ZEALAND
Communication of the specific forecasts is by email and fax to those on the circulation list, including Transit, consultant and contractors.
- NORWAY
The forecasts bought on a regular basis are sent from DNMI to five different places in NPRA via satellite. From these places, the forecasts are spread to our users via our Intranet and presented in a web application.
- SWEDEN
Datafiles are sent (JPEG, GIF, and TXT) using FTP over the Internet. We have made our own presentation where we show the products as a Web presentation, in motion or as a still of the latest picture.
- UNITED KINGDOM
TR2020C Protocol, although we are currently looking at Web based systems.

5. How often is this information updated? Is it provided on a continual basis?

- CANADA (ONTARIO)
The RPU's are polled by the central server every 10 mins. It may take up to 30 mins to

display the info on the WEB site by the time they are all polled.

The WEB page itself does an auto refresh every 2 mins.

The pavement and weather forecasts are generated at 3:00am and 3:00pm daily. There can be updates in between depending on the forecaster. However they are required to produce it at least 2 times a day.

- DENMARK

The information is updated each hour on a continual basis. The Traffic Information Centre provides information on traffic, weather and road conditions to motorists partly on the basis of the above-mentioned winter centres and partly on the basis of information from the DMI.

- FINLAND

Weather radar information every 15 minutes; forecasts at three- to nine-hour intervals, and also when especially necessary.

- GERMANY

From October to March, as follows:

- Medium range road weather forecast, once a day at 10 a.m.
- General road weather forecast, once a day in the morning.
- Detailed road area weather forecast, once a day in the morning.
- Unexpected or critical weather situations, around the clock if necessary.

- JAPAN

The update frequency is different in information. It is provided on a continual basis.

- NEW ZEALAND

Forecasts of specific areas are provided daily about noon. Notice of significant events is as needed, and forecaster can be contacted at any time to discuss any event.

- NORWAY

The graphical prognoses, the written forecasts and the meteorological fields are updated three times a day. The radar images are updated every 15 minutes. The satellite images are updated four times a day.

- SWEDEN

Radar pictures every 30 minutes; satellite pictures every hour; written weather prognoses every three hours; weather maps updated around midnight and noon; precipitation, air temperature, and cloud prognoses every hour. All of these are on a continual basis.

- UNITED KINGDOM

Continually to defined parameters.

6. Do you have a web site that we can access to view information your meteorological agency distributes to you? If so, what is the Universal Resource Locator (web address)?

- CANADA (ONTARIO)

There is a password protected web page.

- DENMARK

The web site <http://www.vintertrafik.dk/>, sponsored and coordinated among counties, Road

Directorate and DMI, is only available during the winter season. It provides road users with information and prognoses about current road conditions (traffic, salting, icy roads, snowfall) and temperature (weather and road). **[Note: web site is in Danish language.]**

- FINLAND
The web site <http://vip.weather.fi/tieh/demo/saapalvelu.html> is inside our local network and not allowed to the public. However, for administrative purposes you may look at the address: <http://forum.inet.fi/tielaitos/trb2000/trb2000.htm> and <http://www.tielaitos.fi/alk/english/> (available only with Internet explorer). **They are both in English and have good information on road weather information in Finland.]**
- GERMANY
No.
- JAPAN
Neither the JMA nor the JMBSC has such a web site. The JWA provides information at <http://www.north-jwa.gr.jp/eweather/>.
- NORWAY
We do not have a web site that is accessible outside NPRA. The DNMI's web site is <http://www.dnmi.no>. **[Note: there is an English language option for that page.]**
- SWEDEN
The web site is protected with user id and password.
- UNITED KINGDOM (LANCASHIRE COUNTY)
No. Web based systems are currently under development.
[Note: the OpenRoad web site at the meteorological agency is:
<http://www.metoffice.com/index.html> and <http://www.metoffice.com/roads/openroad>

7. Please describe any road weather data that is collected by your own agency.

- CANADA (ONTARIO)
All station data is archived.
- DENMARK
There are recording stations at the 14 winter centers, but the response did not describe exactly what data is collected at those centers.
- FINLAND
 - Information from road weather outstations on wind; air and surface temperatures; dew point; humidity; precipitation; visibility; road surface condition; plus some signals of conductivity and polarisation.
 - Still video pictures from road side stations of road surface condition.
 - Testing floating car friction measurements.
 - Some manual information from maintenance personnel.
- GERMANY
Around 600 site-specific road measuring stations, located at selected points on the federal

motorway network, collect the following data:

- Air temperature and humidity
- Wind speed and direction (at a few measuring points only)
- Precipitation, snow depth
- Roadway surface temperature and condition
- Temperature at a depth of 30 cm (at a few measuring points only)

These data are permanently available to the related motorway maintenance depots online via the telecommunications network of the federal motorways.

- JAPAN

The Hokkaido Development Bureau has 189 sensing stations in the Hokkaido area as of April 2000. We call them “road weather telemeter.” The system observes air temperature, road surface temperature, wind direction, wind speed, snow depth and the amount of precipitation.

- NEW ZEALAND

Transit New Zealand operates a few basic weather stations to provide information on ice conditions and has a few basic pavement sensors with data telemetry operating “ICE” signs. We are in the process of installing the first purposely made RWIS station and propose carrying out thermal mapping this year.

- NORWAY

NPRA has approximately 180 road weather information stations spread throughout the country. Most stations have sensors for: air temperature; relative humidity; precipitation; and road surface temperature. Some stations also have sensors for: road surface condition; wind direction; wind speed; long wave emission; and video.

- SWEDEN

Surface temperature; air temperature; humidity; dew point; wind speed and direction; precipitation type and amount; visibility; sublimation; freezing point; camera pictures.

- UNITED KINGDOM (LANCASHIRE COUNTY)

The following data is collected from 11 road weather stations within Lancashire and an additional 6 stations in an adjacent council: air temperature; relative humidity; dew point; wind speed and direction; road surface temperature and condition; precipitation type; and at some locations, visibility.

8. Please describe any data you supply to the meteorological agency to assist them in supplying you with road weather information and forecasts (i.e. pavement surface temperatures).

- CANADA (ONTARIO)

All sensor information is available, and also pavement structure data.

- DENMARK

No specific response was given to this system, but it appears that the data collected at the 14 winter centers is available to all members of the Icy Road Warning System, including the DMI.

- FINLAND
All outstation information is supplied to FMI.
- GERMANY
All of the data listed for question 7 above are collected via the telecommunications network of the federal motorways in the central SWIS computers and automatically transmitted to the DWD in a special ASCII format every 15 minutes.
- JAPAN
The HDB doesn't provide any data to the JMA.
- NEW ZEALAND
We provide daily air temperatures only to MetService from the specific forecast area, plus visual actual weather reports. The proposed RWIS will provide data automatically and receive MetService data for ice prediction.
- NORWAY
DNMI has access to data from about ten of our road weather information stations. They use the data to calibrate the graphical prognoses for these places. DNMI also uses data from road weather information stations in two counties (approximately 23 stations) to provide these counties with forecasts through Vaisalas IceCast system (forecasts for road conditions).
- SWEDEN
All of the data listed for question 7 above are available. SMHI has access to SNRA's web site, and they purchase data from 25 RWISs to cover "holes" in their system.
- UNITED KINGDOM (LANCASHIRE COUNTY)
All of the data listed for questions 7 above are passed along to the Met Office.

9. Is there weather information that you need that is not currently available or supplied? If so, please describe it.

- CANADA (ONTARIO)
No.
- DENMARK
If we need more information we simply request it. There has been no problem receiving it. We have major cooperation between the road authorities and the Danish Meteorological Institute.
- FINLAND
We need more information on the road surface friction all through the road network. We also need more exact information on the rain and road surface state, and possible more exact forecasts of the road surface state.
- GERMANY
No.
- JAPAN
 - More detailed real-time data and weather forecast

- Wide area prediction of winter road conditions
- Real-time observation and forecast of snow blowing
- NEW ZEALAND

MetService operates radar stations only based on major cities; therefore, we have large areas not covered. Due to cost, MetService has no plans to increase the radar coverage. We have also discussed MetService's model output images, which can provide three-hourly graphical images to 10m or even 1.67m resolution for such things as rain, freezing level, low clouds, middle clouds, high clouds and temperature for specific areas. We will pursue these with the development of RWIS.
- NORWAY

Currently, only the two counties using the IceCast system have access to forecasts on road surface temperature and road surface condition. It is highly desirable that all counties have similar forecasts. It is also desirable to have some kind of forecasting related to weather radar images.
- SWEDEN

In order to make better surface temperature forecasts, we might need better forecasts on radiation (cloudiness).
- UNITED KINGDOM (LANCASHIRE COUNTY)

We currently have a "Best Value Partnership" with the Met Office to continually develop forecasting services and indices to realistically measure their performance in relationship to what we both want now and in the future.

APPENDIX C: RESPONDENTS TO QUESTIONNAIRE

- **CANADA (ONTARIO)**

Paul Zimmerman, Maintenance Officer

Ministry of Transportation

2nd Floor South, 301 St. Paul Street

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- **DENMARK**

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- **FINLAND**

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Helsinki, FINLAND

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- **GERMANY**

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GERMANY

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- **JAPAN**
Masaru Matsuzawa
Disaster Prevention and Snow Engineering Section
Hokkaido Development Bureau, Civil Engineering Research Institute

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- **NEW ZEALAND**
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Hamilton, NEW ZEALAND

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Email aburkett@transitnz.govt.nz

- **NORWAY**
Cecilie Stenersen
Norwegian Public Roads Administration

Email cecilie.stenersen@vegvesen.no

Note: The new Road Weather contact in NPRA effective January 1, 2001 is Anette Heiberg Mahle, anette.mahle@vegvesen.no.

- **SWEDEN**
Dan Eriksson
Swedish National Road Administration
SE-781 87 Borlange
SWEDEN

Email dan.eriksson@vv.se

- **UNITED KINGDOM**
Chris Page
Lancashire County Council

Email cpage@env.lanscc.gov.uk

APPENDIX D: METEOROLOGICAL AGENCIES

CANADA

Meteorological Service of Canada
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Toronto, Ontario M3H5T4
CANADA

Contact: Paul Delannoy, Ottawa weather office
Phone (819)997-8561
Email paul.delannoy2@ec.gc.ca

DENMARK

Danish Meteorological Institute
Danmarks Meteorologiske Institut
Lyngbyvej 100
DK-2100 Copenhagen
DENMARK

Email dmi@dmi.dk
Web site <http://www.dmi.dk/eng/index.html>

Contact: Torben Strunge Pederson, Project Coordinator, Forecasting Services Dept.
Email tsp@dmi.dk

FINLAND

Finnish Meteorological Institute
P.O. Box 503
FIN-00101 Helsinki
FINLAND

Web site <http://www.fmi.fi/>

Contact: Marja Aarnio-Frisk

Email marja.aarnio@fmi.fi

GERMANY

German Meteorological Service
Deutscher Wetterdienst
Frankfurter Str. 135
63067 Offenbach
GERMANY

Email info@dwd.de

Web site http://www.dwd.de/e_dwd_home.html

Contact: Dr. Wolfgang Raatz

Email wolfgang.raatz@dwd.de

JAPAN

Japan Meteorological Agency
1-3-4, Ote-machi
Chiyoda-Ku, Tokyo, 100-0004
JAPAN

Email pro@hq.kishou.go.jp

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NEW ZEALAND

Meteorological Service of New Zealand (MetService)

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NEW ZEALAND

General Manager & Chief Meteorologist, Neil Gordon

Email gordon@met.co.nz

NORWAY

Norwegian Meteorological Institute

Det norske meteorologiske institut

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NORWAY

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SWEDEN

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