

Development of Winter Road Maintenance Management Support System about Anti-freezing and Snow Removing Work Based on Web and E-mail.

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【Abstract】

We have constructed and operated the “Road Weather Information System” targeting the Greater Sapporo in Hokkaido, Japan. Greater Sapporo is known as a city that undergoes severe cold and heavy snowfall. The system enables us to connect the road management organizations and weather information organizations using internet technology and information sharing wherein each party can reference each other’s information.

Upon the base, we are providing further insights into the “Winter Road Management Support System” which creates and provides direct information about road management on the basis of road management information, road telemeter information, and weather information in order to increase the efficiency and level of road management in winter.

1. Introduction

We are based in Greater Sapporo, Hokkaido. Greater Sapporo has inclement weather and a high amount of snow fall without parallel among cities with a population reaching almost 2 million. Surrounded by such an environment, we have worked on ITS from the view of developing a road traffic environment in a snow fall cold district.

Since low visibility occurs frequently due to slippery frozen road surfaces, snow storms, and other reasons, a higher level of road management is needed in the winter road traffic environment in Greater Sapporo. Occurrence of these traffic dangers in winter is closely connected to the weather conditions. Thus, the role of weather information is very important to develop and increase efficiency in winter road management.

Also, in terms of methods of information distribution, recently it is becoming possible to share information and systems between different organizations by the development and the worldwide penetration of internet technology.

Within the framework of such technical development, we have made it possible to share road management information and weather information and to exchange bi-directional information by positively utilizing internet technologies. By utilizing the high-value added information acquired thus, we have created and operated the “Road Weather Information System”, aiming to develop and increase the efficiency of winter road management.

On top of the foundation, with road management information, road telemeter information, and weather information, we have examined a system which creates and provides support information directly connected to winter road management, such as anti-freezing work support, snow removing work support, and other supports. Then we examined the winter road management support system, which highly utilizes the weather information.

2. Road weather information system

The road weather system is characterized by the ability of both parties to share of the information with each other by connecting the information system between road management organization and weather information organization by internet technology. Utilizing internet technology enabled us to build the system relatively easily and reasonably with existing multipurpose goods and technologies. Furthermore, it is an open, scalable and flexible information system.

In road management organization, by accumulating all kinds of observed and collected local observation information on a communal open server, road management organization information becomes available.

The local observation information on the communal open server of the road management organization can be reviewed by the weather information organization. Then, the weather information organization creates new high value information in conjunction with their own weather information. This new information is designed for the road management organization. The information is then transmitted to the road management organizations shortly after being created.

Since transmitting to the road management organization is done through the road weather information system network, it can be delivered instantly. Also, the information is released on the weather information organization internet server (to the road management organization). The road management organization can access the internet server and see the high-value information when they wish.

On the road management organization side, on the occasion of road management work, as well as taking advantage of the information having been acquired in the past, utilizing this high-value information can make the road management work quicker and more efficient. By utilizing the road weather information system, it is conclusively possible to contribute to the reduction of road management work costs and the increase of the service quality for those who use the roads.

As the weather information used by the road management organization, there are road weather (road surface freezing) predictions, snowfall short period predictions, road surface monitoring image information, and general weather information. The former three are the road weather system's own information specialized for the road management organizations: the information is created and provided by referring the local observation information which is shared with the road management organization and the information which the weather information organization itself has obtained. This information is shared between the weather information organizations and the road management organizations through the internet server of the weather information organization for the road management organizations. The road management organizations refer

to the data bands opened on the internet with a browser.

Since general internet technologies are used in the system, the information can be seen with the browsers in the actual road management work front as well as in the office of the road management organization if the access environment with TCP/IP and display terminal are prepared.

As an example, the display example of the road weather prediction is shown in Figure 1. This shows the weather prediction and road surface aspect prediction from late at night to the early morning in the main points of the Sapporo area.

The road weather prediction: The first weather prediction is performed in the coverage points with the general weather information and the local observation information from the road management organization. Then the road surface condition is estimated per prediction time period with the weather prediction and the local road surface actual conditions, which are based on the prediction method developed from previous survey results.

道路気象情報 全地点予測一覧
 [1998年12月07日18時発表]

【気象概況】
 日本海から発達中の低気圧が近づいている。今夜は南よりの風が強くなり、明日未明にかけては雨が降るが、初めのうちは一時雪となる。今夜は降雪量がほとんど無く、雨で路面は湿潤状態が続く。

【各地点の予測】

予測地点	対象時刻	天気	風向	風速 (m/s)	降雪量 (cm)	気温 (度)	路面第1候補 (雪水対策なし)	路面第2候補 (雪水対策なし)	路面第1候補 (雪水対策あり)	路面第2候補 (雪水対策あり)
【札幌西3】	8日0時	雨	南東	4	0	5	湿潤	-----	湿潤	-----
	8時	曇り	南西	4	0	4	乾燥	-----	乾燥	-----
【札幌東1】	8日0時	雨	南東	4	0	4	湿潤	-----	湿潤	-----
	8時	曇り	南西	4	0	4	乾燥	-----	乾燥	-----
【宮の沢】	8日0時	雨	南東	4	0	3	湿潤	-----	湿潤	-----
	8時	曇り	南西	4	0	3	湿潤	-----	湿潤	-----
【苗穂】	8日0時	雨	南東	4	0	2	湿潤	-----	湿潤	-----
	8時	晴	南西	4	0	-2	湿潤	非常に濡りやすい水膜	湿潤	-----
【札幌】	8日0時	雨	南東	4	0	3	湿潤	-----	湿潤	-----
	8時	曇り	南西	4	0	3	湿潤	-----	湿潤	-----
【狸ヶ塚】	8日0時	雨	南東	4	0	2	湿潤	-----	湿潤	-----
	8時	曇り	南西	4	0	2	湿潤	-----	湿潤	-----
【狸ヶ塚】	8日0時	雨	南東	4	0	2	湿潤	-----	湿潤	-----
	8時	曇り	南西	4	0	2	湿潤	-----	湿潤	-----
【狸ヶ塚】	8日0時	雨	南東	4	0	2	湿潤	-----	湿潤	-----
	8時	曇り	南西	4	0	2	湿潤	-----	湿潤	-----

Figure1. Example of road weather (road surface freezing) prediction
 (List of prediction on each prediction point performed in Greater Sapporo.)

In this road weather information system, the main aim is providing information which is created by sharing the information from the road management organizations and the meteorological organizations. The actual road management is done after the road administrators make decisions based on the information acquired from this road weather information system and their patrols.

3. Winter road management support system outline

Aiming at providing more direct information on winter road management and building a system by making the road weather information system more advanced, the winter road management support system has been examined.

By examining the relationships among the actual winter road management work, the occurrence of frozen road surface, and snowfall, as well as by generating winter road management work guidance, which road administrators need in response to the weather condition, from the weather condition prediction information, road surface conditions, it also aims at developing a support system which is directly suggested with the road administrators. We examined the e-mail reporting system, which was set up to monitor and evaluate road and weather conditions using such instruments as road telemeters so that when conditions have deteriorated beyond specified safety levels the weather bureau can advise the highway maintenance office, via email, of the sudden weather changes.

As a result, the winter management support system is to consist of the support systems of anti-freezing and snow removing work, and the emergency notifying system.

The fundamental design for the winter road management support system sets a "support system server" inside the intranet of the road management organization, and performs content generation for a display in the server to open to the persons concerned (road administrators as well as involved operating trust contractors) with a web base. Fig. 2 shows the basic structure.

Surrounding the support system server, the emergency notification server which sends out e-mail upon receiving emergency occurrence signals, each data server which provides information on the weather as well as observations and meteorological organization are on-line, so that required data go between each seamlessly.

However, if data exchange is possible by being on-line, the installation place of each server does not necessarily have to be restrained by Fig. 2. In the points mentioned above, besides ease of application, the road management support system has pliant flexibility which can change in structure according to each organization's needs

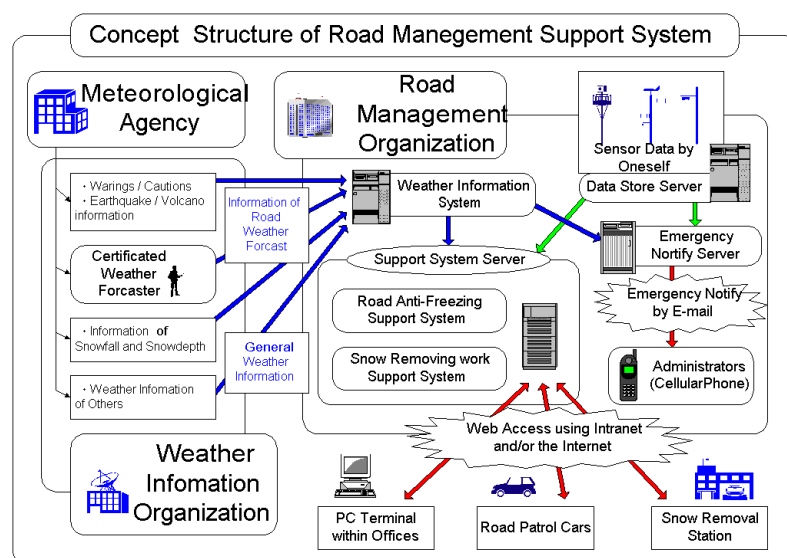


Figure 2. Road Management Support System Conceptual Structure

4. Road anti-freezing support system

The “Anti-Freezing work support system” is an information providing system which aims at supporting operation and content judgment in road anti-freezing work during the winter season. The system mainly provides the following information: “road-surface freezing index”, “road surface slippery index”, and “anti-freezing work guidance”. In addition to these three types of information, we made it a point to build a multidisciplinary support information system for the winter road management by combining the information factors such as existing road weather prediction information and road surface freezing prediction information that has been provided to the road administrators through the conventional road weather information system.

The system displays the information as the following forms: displaying information or value described by each point on a map, displaying inclusive information about all the factors at a certain point, and displaying inclusive information about a certain factor at all the points.

-“Road-surf Figure 2. Road Management Support System Conceptual Structure

This describes the potential of road surface freezing occurrence at a certain point during the prediction period of “18:00-24:00” and “24:00-06:00” by digitizing the road surface condition at an initial time and the weather condition prediction into 0-100. The index is to be released once per day at 18:00. This information contains the probability prediction-implications about the road-surface freezing within the prediction period.

-“Road surface slippery index”

This index describes the potential of a road surface at a certain point turning to “slippery road surface” during the prediction period of “18:00-24:00” and “24:00-06:00” by digitizing the road surface condition at an initial time and the weather condition prediction into 0-100. The index is to be released once per day at 18:00. This information contains the probability prediction-implications that the road surface at a certain prediction point turns to “slippery road surface”.

“Slippery road surface” mentioned here indicates “very slippery ice coat”, “very slippery hardened snow”, and “very slippery ice barn”, which are defined as especially slippery road surfaces in the 13 road surface condition classifications of the Hokkaido Development Bureau, and have significant meanings in road management.

-“Anti-freezing work guidance”

This information is to be announced once per day at 18:00, and is used to aid in deciding what should be done for anti-freezing work which will be done from the late afternoon till early next morning. This information will be created judging from observed road surface conditions, snowfall amount prediction, and temperature prediction.

-“Road surface condition prediction”

This information is equivalent to the one used by the Sapporo Road Office, Sapporo

Development and Construction Department, Hokkaido Development Bureau. It is released once per day at 18:00 and is used to provide road administrators with road surface condition predictions at a certain point until the next morning by observed road surface condition and weather prediction. The road surface conditions are described based on the 13 road surface condition classifications of the Hokkaido Development Bureau. Corresponding to "needed" or "not needed" of the measure against snow ice on a road surface, presumption of a road surface condition is made respectively, and the 2nd candidate of a road surface condition can be shown if necessary.

-“Weather”, “Snowfall amount”, “Temperature”, “Wind direction/speed”

This is a local weather prediction at a certain point, and while being used as basic information when deriving each already described information factor, it is provided to road administrators as basic information.

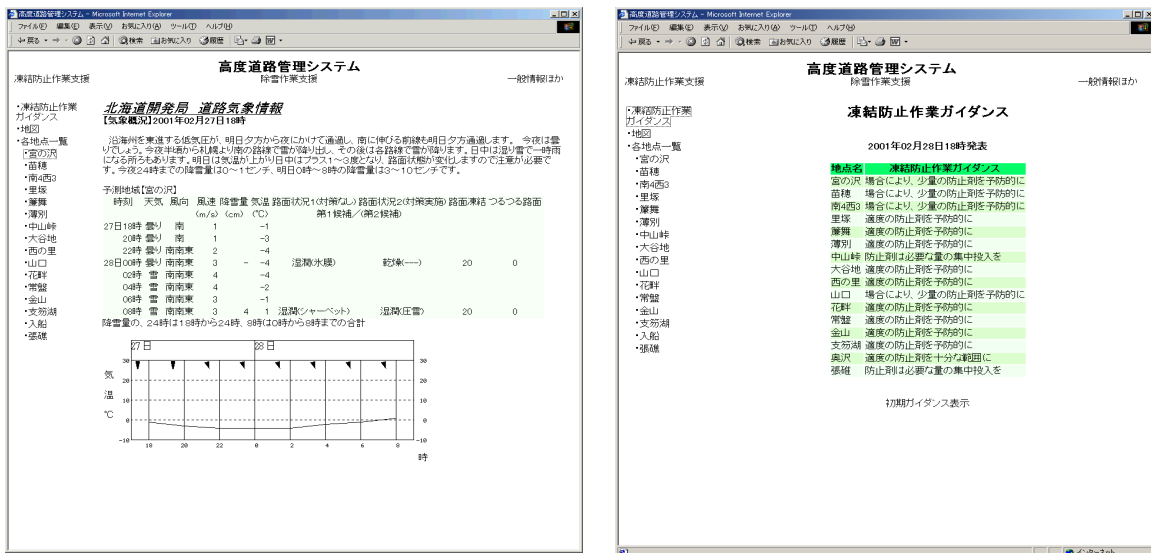


Figure 3. Example of a display of anti-freezing work support system (Left: road weather information displayed in each point, right: anti-freezing work guidance)

5. Snow removing work support system

The “Snow Removing Work Support System” is the information system that supports the planning and deciding of the operation system and the start time of snow removing work based on the actual amount of snowfall and the snowfall amount prediction. This time, we have made contents intended for main work supports for the work from the night to the next morning.

As the style of displaying the information, we have prepared a map displaying the snowfall distribution in a certain hour, a graph to show the snowfall time flow in a selected point, and text which lists the support guidance.

This snow removing work support system provides the road administrators with the following information factors and supports the work in the aforementioned forms.

-“Snow removing work guidance”

With the basis of an announcement per day at 18:00, this information is to support the decision for the snow removing work details performed from the evening to the next morning.

Details are created based on the integrated amount of snowfall for the 12 cumulative hours before the announcement and the prediction of the snowfall amount between 18:00 and 24:00, 24:00 and 8:00 the next day provided by the road weather prediction from the aforementioned snow removing work support system.

-“The actual amount of snowfall”

In this system, area distribution information of the snowfall amount (also known as the mesh distribution information) is utilized. The actual amount of snowfall is accumulated onto the server per hour. The information for the last 48 hours is used for time series table displays and distribution map displays. The amount of snowfall for the last 12 hours is used for creating the snow removing work guidance.

-“Snowfall amount prediction”

This prediction information is the short period prediction of a real distribution form updated every hour. The next three hours predictions are prepared. With the snowfall amount prediction, it is used for time series table displays and distribution map displays.

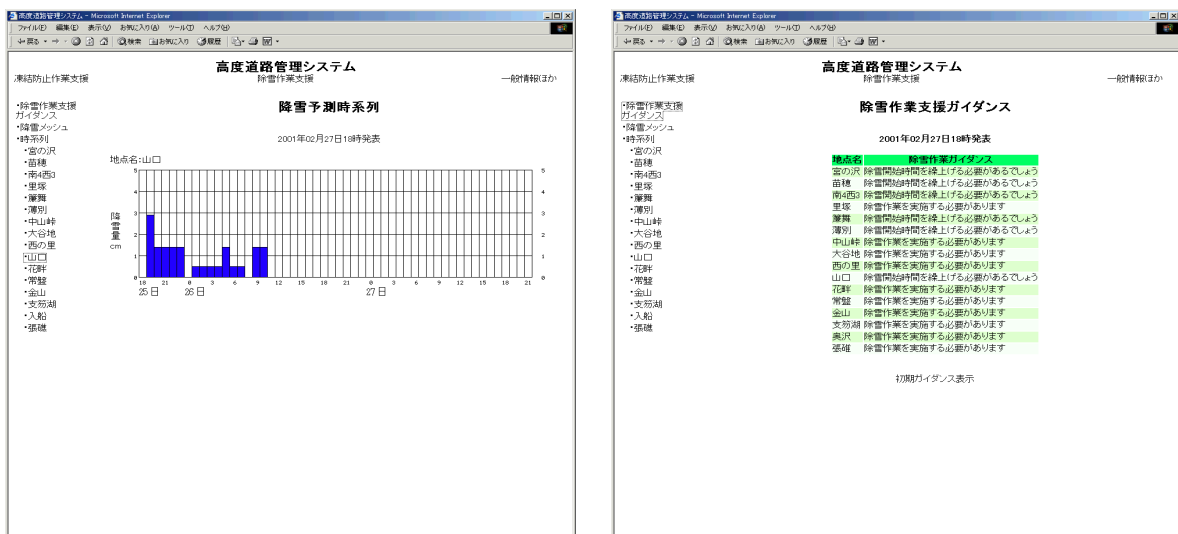


Figure.4 Display example of the snow removing work support system (Left: snow amount time flow, right: snow removing work guidance)

6. Emergency notifying system

To enhance the guideline of initial action and surveillance in preparation for sudden weather changes, this system is to set up criteria in the weather prediction information and the road telemeter observed value and to notify the administrators by e-mail at when the criteria is exceeded. By installing a structure which amends and customizes notification factors and the

criteria about the notified details corresponding to the individual needs, flexible correspondences for the different managed routs and weather conditions become possible. By designating the notification to mobiles, this system enables road administrators to receive the necessary information smoothly.

-“E-mail advance notice for icing”

When the “road-surface freezing index” and the “road surface slippery index” which is announced at 18:00 everyday exceed certain set values, the conditions are sent by e-mail.

This notification is sent in every area. The e-mail is sent based on each area’s setting. Its setting can be done on the web through the set-up screen individually depending on individual preference. Figure 5 shows an example of an e-mail announcement.

**Announced at 18:00
02/26**
[Miyanosawa]
**Degree of risk in
road-surface freezing**
0:00 : 40
8:00 : 40
Slippery road surface
0:00 : 40
8:00 : 40

Figure 5. Example of an e-mail announcement.

-“Snowfall warning e-mail”

This is to observe the actual amount of snowfall acquired each hour and to send warnings by e-mail at the stage that a certain set-value is exceeded.

For the current snowfall warning, as observation factors, we have prepared two kinds: one is for the integrated amount of snowfall for the last 48 hours and the other is for the amount of snowfall between 18:00 in the evening to 8:00. “The amount of snowfall between 18:00 in the evening to 8:00” means basically the amount of snowfall from 18:00 up to the present time. In this case, we considered “the present time” to be up to 8 a.m. because of the implication of observing the snowfall from the evening towards dawn (for snow removing work). Thus we used such expressions like above.

[Miyanosawa]
**The last 48 hours
integrated amount of
snowfall**
1.0cm
**Cumulative amount of
snowfall from 18:00 to
8:00**
1.0cm

Figure 6. Example of a warning e-mail

This e-mail is also sent to each area. The e-mail is sent based on each area’s setting, as in the case of “e-mail advance notice for icing”. Its setting can be done on the web through the set-up screen individually depending on individual preference. Figure 6 shows an example of a warning e-mail.

- “Road telemeter information warning e-mail”

This is to observe the observation information from the road telemeter on a steady basis and to send the notification of phenomenon occurrence by

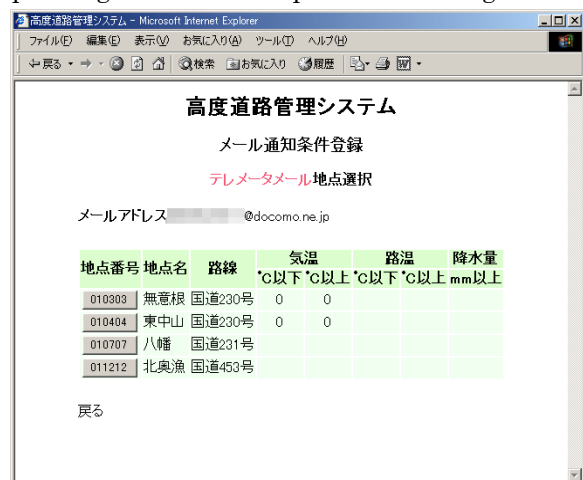


Figure 7. Condition set-up area selection screen

e-mail at the stage of reaching a certain criterion. In this case, we observed three observation factors: “temperature”, “temperature of the road surface” and “the amount of rainfall” as a system trial. Telemeter observation is also done in each area. The e-mail is sent based on each area’s setting, as in the aforementioned “e-mail advance notice for icing” and “snowfall warning e-mail”. Its setting can be done on the web through the set-up screen individually depending on individual preference. Figure 7 shows an example of a condition set-up area selection screen and Figure 8 shows an example of a notification condition set-up screen as a set-up screen example display.

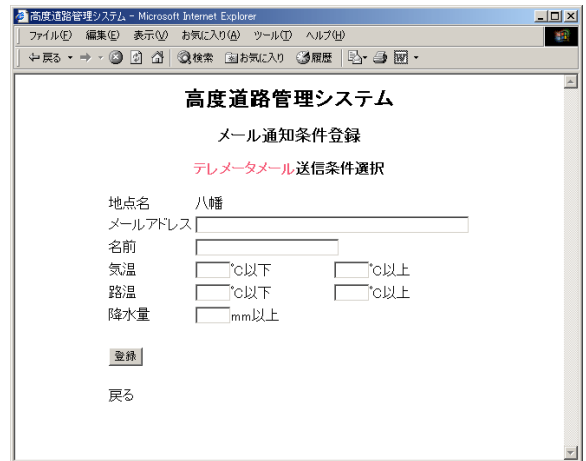


Figure 8. Notification condition set-up screen

6. After word

The winter road management system is constructing a prototype system. Its evaluation experiment will be performed this winter and discussion will be carried out for the practical use of the system.

At present, aiming at developing and increasing the road management mainly in the winter season in the Greater Sapporo, “White-net liaison conference of Greater Sapporo” is established by the Hokkaido Regional Development Bureau, Hokkaido, Sapporo, and the Japan Highway Public Corporation Hokkaido office. The communization of road management information is done by between road administrators by utilizing the internet. It is thought that the interactive use of the winter road management support information between road administrators will increase efficiency.

Reference

- 1) Kagaya, Uekusa, Takitani, Kajiya (1999) Development of Road Weather Information System (RWIS) and Utilization for Road Maintenance: The 6th ITS World Congress 1999 Toronto, November 1999.