# MANAGEMENT OF ROADS IN WINTER USING CCTV CAMERA

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## 1. Abstract

Sapporo (pop. 1.8 million) has developed as a city central to the politics, economy and culture of Hokkaido. However, its climate is severe. Although at a more southerly latitude than much of North America and Europe, the city is extremely snowy in winter. Annual mean snowfall is nearly 5 m, and the daytime winter temperature can drop below -10º C.

Road traffic hindrance in winter has been and remains the most pressing issue for the residents.

For this reason, the introduction of cold urban region ITS is a priority in various ITS projects under examination in Sapporo. Such a system would mitigate the effects of snow by ensuring smooth operation of urban infrastructure when road surfaces are frozen or snowfall is heavy.

The use of real-time images from CCTV (industrial television) cameras holds particular promise for winter road management of the future.

This report outlines major systems that use CCTV cameras.

## 2. Winter Weather and Traffic Problems in Sapporo

Sapporo is characterized by heavy snowfall. Among cities of the world, Sapporo is the only one with a population of more than 1.8 million and an annual snowfall of more than 5 m. Sapporo averages 123 days of snowfall per winter, meaning that snowy days occur about one third of the year. In general, snow covers Sapporo for four months, from late December to late March.

### 2.1 Characteristics of Snowfall

Annual snowfall has fluctuated around the 5-m mark since 1953. However, it varies substantially year to year. Some years see snowfall of more than 6.5 m; others only 4.0 m. This variation greatly affects winter road management. In Sapporo, December through March is designated as the period of winter snow removal.

## 2.2 Challenges of Winter Road Management

### 1) Traveling Speed in Winter According to Mode

The required travel time increases for each mode in winter: 1.4 times for car, 1.2 times for bus and 1.1 times for railway (including bus or car to/from station).

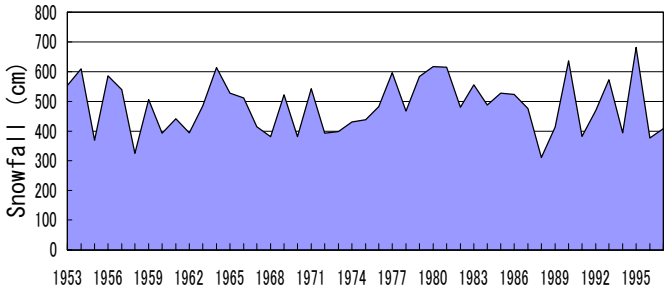



**Figure 1 Annual Snowfall (1953-1997)**

### 2) Decline of the Traveling Speed of Car in Winter

Traveling speed survey conducted for trunk roads in Sapporo shows that the average traveling speed in winter decreases to 19 km/h, about 70% of that in autumn (27 km/h). Winter mornings show a particularly great decrease of 60% versus autumn mornings.

The traveling speed within the beltway, where more traffic concentrates, is lower than that beyond the beltway, both in autumn and winter, and the rate of decline from autumn to winter is larger.

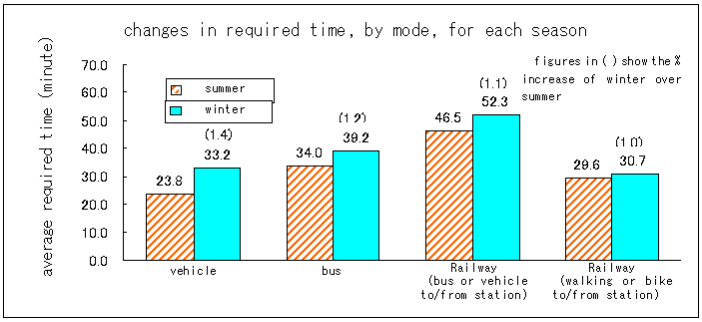



**Figure 2 Comparison of Travel Speeds Between Different Modes in Winter**

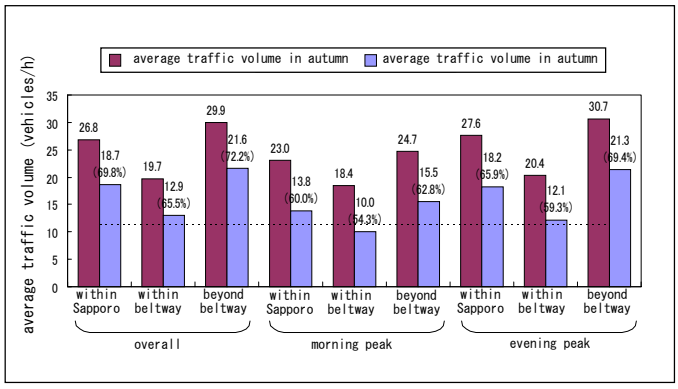



**Figure 3 Travel Speed in Winter**

## 3. ITS for Cold, Snowy Regions

### 3.1 Active Utilization of ITS Technologies

The major road traffic problems in cold, snowy regions can be divided into the three shown in figure 1.

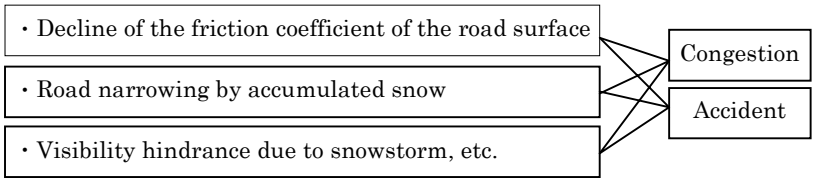



**Figure 4 Road Traffic Problems in Cold, Snowy Regions**

These three hazards, causes of traffic congestion and accidents, need effective management. In the future, beyond improving conventional winter road management, we plan to promote more pleasant and safe winter driving by actively using ITS technologies.

### 3.2 Development of Systems Based on Numerical Data (Development of the Snowfall Forecast System)

Placing top priority on overcoming problems of winter and snow, the City of Sapporo is now developing subsystems within the Snowfall Information System (shown in figure 5), whose development started in 1988. The snowfall information system, which uses sensor data (numerical data), is roughly divided into a snowfall forecast system and a snowfall, snow cover and freezing sensing system. These comprise four subsystems.

#### 1) Snowfall Forecast System

In this system, snowfall amount, temperature, wind velocity and other items of core blocks set in Sapporo are forecast and provided. This system, utilized for snow removal operation, includes long-range forecasting (12 hours ahead) and short-range forecasting (three hours ahead).

#### 2) Snow Removal Operation Support Subsystem

This system comprehensively identifies the state of snow removal operations (snow removal on roadways, snow removal on sidewalks, carrying and dumping of snow) within the city, as well as supporting the planning of snow removal operation by linking with long- and short-range forecast.

#### 3) Multisensor Subsystem

This compact automatic surface meteorological observation system integrates various meteorological sensors. Installed at 50 points with about 5-km of mesh, this system enables composite analysis processing of meteorological radar and the understanding of accurate environmental conditions.

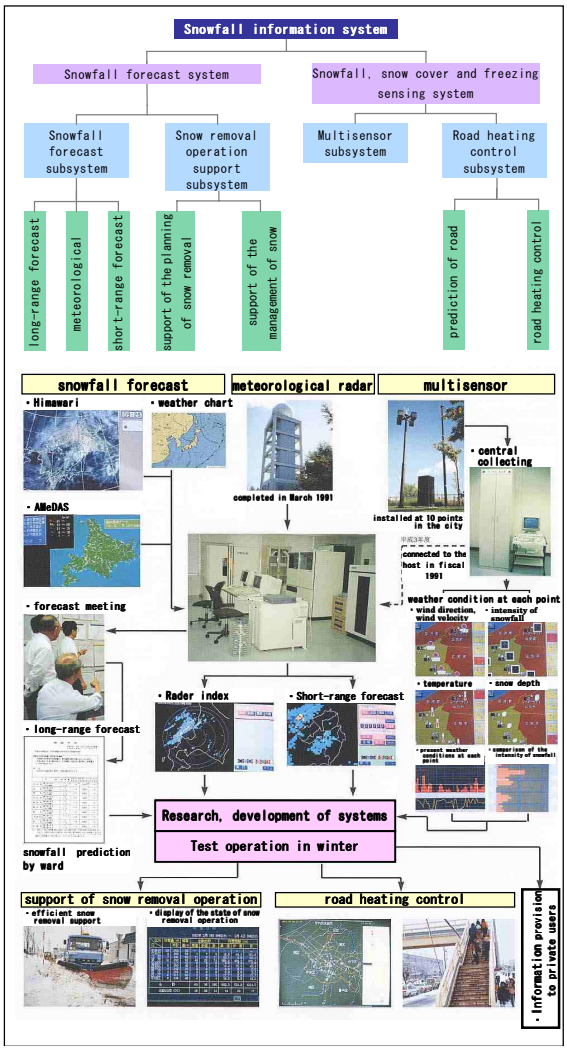



**Figure 5 Snowfall Information System**

**4) Road Heating Control Subsystem**

Combined with multisensors and meteorological forecasts, this system efficiently controls and collectively monitors heating at the center, while simultaneously saving energy.

### 3.3 Development of Systems Based on Camera Images

A snowfall forecast system covering the whole city has been installed to collect and analyze numerical data. For the future, we plan to develop systems that are based on more localized image data. More specifically, we will do the following:

(1) Select points where road traffic conditions are to be identified comprehensively. These would include major traffic points with large traffic volume or serious congestion, and points where accidents occur frequently.

(2) Install CCTV cameras or environment sensors (frozen road surface detectors, visibility meters, etc.) at these points.

(3) Build a network of these sensing systems and install monitoring systems at each road authority and snow removal authority, as well as at the city hall.

(4) Automatically detect road surface conditions and the thickness of accumulated snow by analyzing CCTV camera images.

## 4. Concept of the Development of CCTV Camera System

### 4.1 Concept of the Development

Basing the systems to be developed on CCTV camera systems, we plan to build the systems comprehensively by organically linking them.

### 4.2 System Development Program

The development program for systems based on CCTV cameras is described in figure 6.

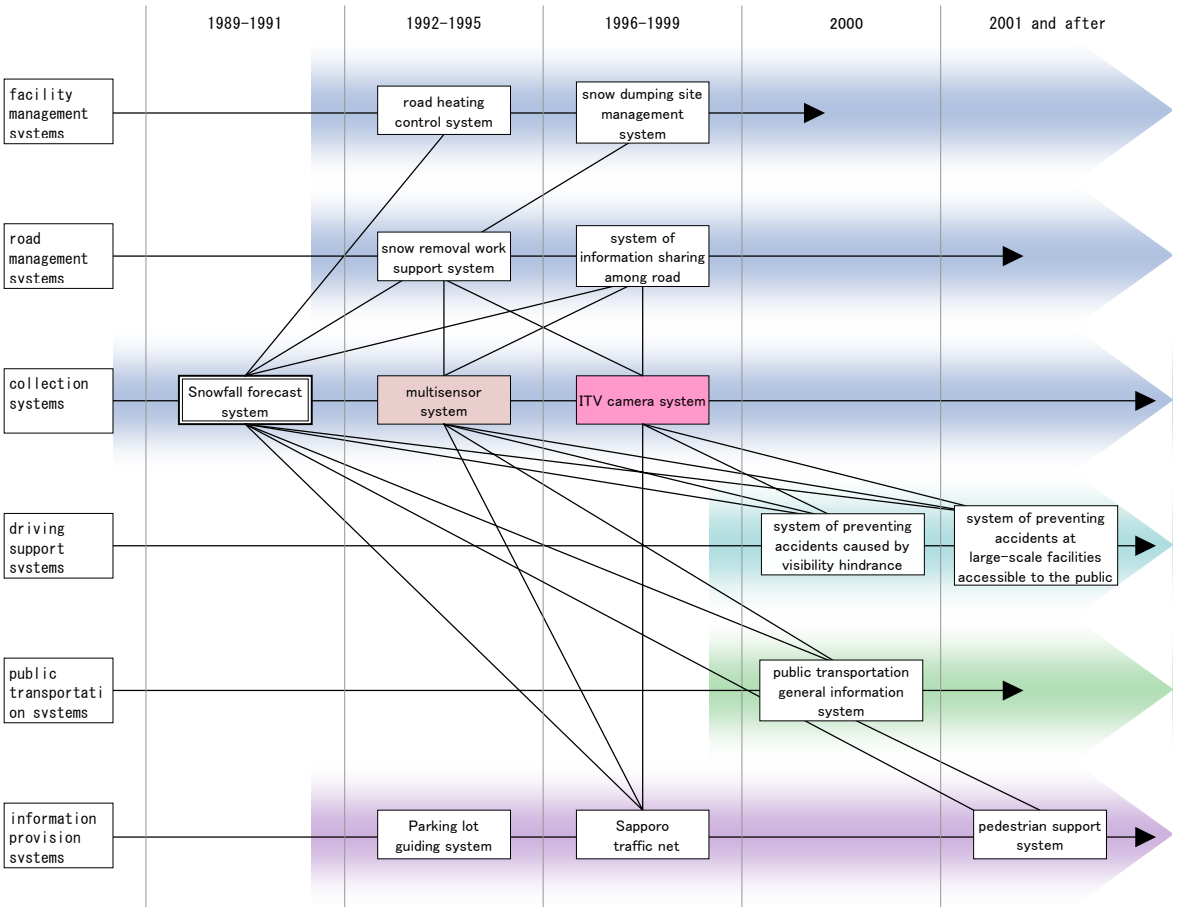



**Figure 6　System Development Program**

## 5. Group of System Based on CCTV Cameras

### 5.1 Frozen Road Surface Management System

#### 5.1.1 Emergence of Slippery Road Surfaces

Since regulation went into effect in April 1991, studless tires have superseded metal-studded ones, and coarse particulate air pollution has in turn decreased sharply. However, on trunk roads or downtown, where traffic is heavy, the problems of slippery road surfaces caused by compacted snow and ice and of skidding accidents and traffic congestion have become serious social issues. On such roads, even careful drivers find it difficult to start and stop, and skidding accidents and congestion often hinder traffic. Clearly, more intensive winter road management is needed.

In conjunction with road patrols and the weather information system, measures such as snow removal and dumping, and spreading of anti-freezing agents (calcium magnesium acetate, etc.) have been taken to address these problems. However, with only a few patrols dispatched daily and limitations on the accuracy of weather forecasts, an effective solution remains elusive. Particularly challenging is the current situation in which the constantly changing winter road surface conditions can be clarified only by patrols. This limitation makes it difficult to handle problems quickly.

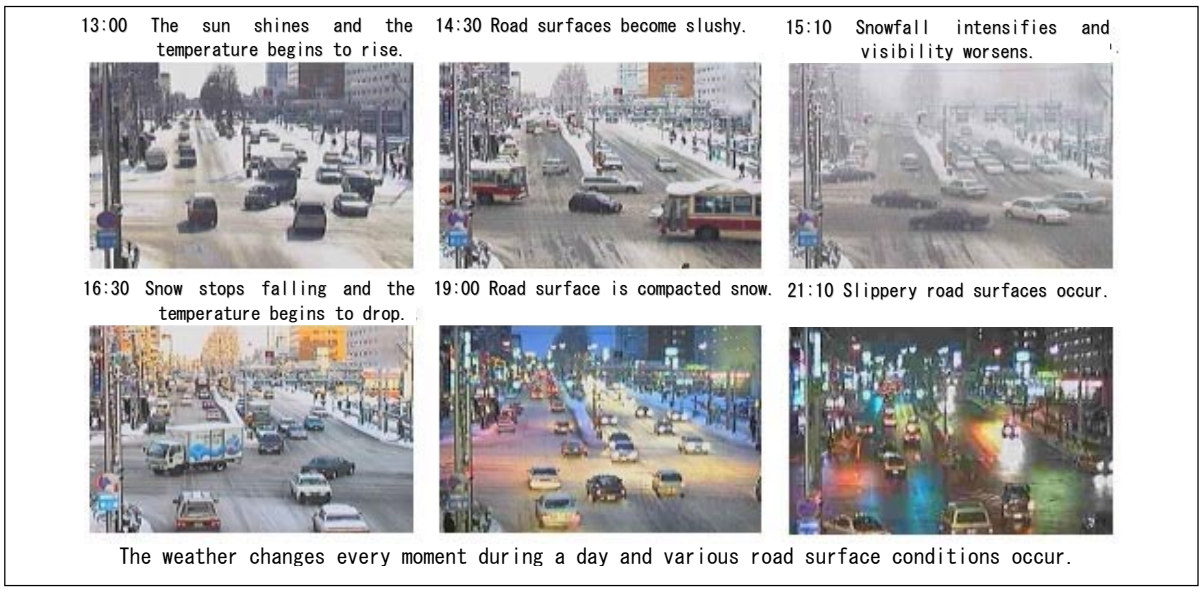



**Figure 7　Weather Condition and Road Surface Image**

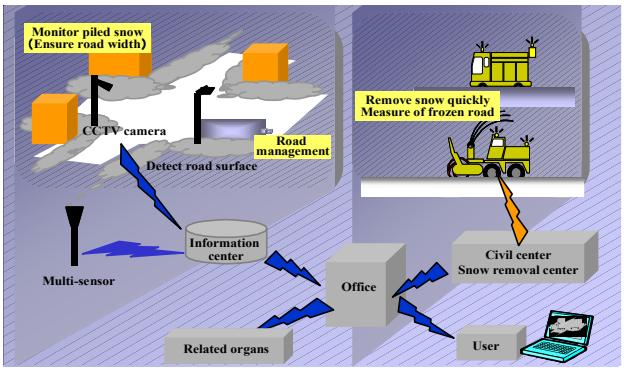
### 5.1.2 The System for Managing Frozen Road Surfaces

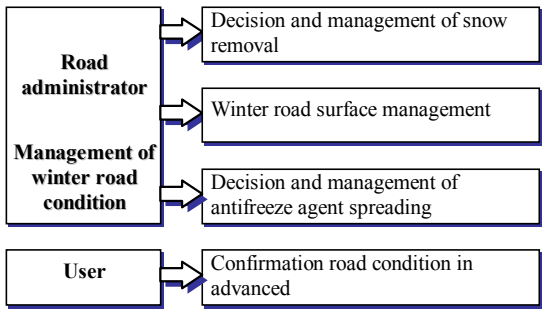
The System for Managing Frozen Road Surfaces using CCTV Cameras affords an accurate understanding of site conditions in real time. It employs CCTV cameras installed at intersections to remotely monitor the emergence of slippery road surfaces mentioned above and the condition of accumulated snow caused by snow removal. It supports appropriate snow removal and disposal operations and systematic pre-application of anti-freezing agent, important steps toward advanced and efficient winter road management

Currently, the facilities necessary for image transmission are under construction. One example under consideration is a potential fiber-optic network for road management within the city.

However, it is not necessarily efficient for those in charge to monitor all the CCTV images from cameras installed throughout the city. Future systems will need to automatically process images, automatically detect unsafe road and road surface conditions, and warn road users.

In addition, the use of image information would allow a grasp of conditions at only specific points because of the limited places where CCTV cameras can be installed. A future challenge is to evolve the system by incorporating thermal mapping technology and a observation vehicle to predict road surface conditions of wide areas, instead of only at specific points.




【Network image】　　【Effect of CCTV camera】

**Figure 8　System for Management Frozen Road Surface**

### 5.2 System of Preventing Accidents Caused by Visibility Hindrance

An increase in traffic demand is expected for Sapporo-Tobetsu Prefectural Route, a major six-lane trunk road in Sapporo. It is an urgent necessity to devise measures against visibility hindrance and snowdrift occurring at some sections of this route in winter.

Although the improvement of facilities such as snowbreak forests and snow fences is recognized as a countermeasure to these problems, it is physically difficult to install these along wide trunk roads in urban areas.

**Figure 9 The State of Visibility Hindrance**

Consequently, a system that uses real-time images from CCTV cameras and existing meteorological observation sensors was developed in order to complement conventional intermittent patrols and support efficient snow removal and disposal.

In addition, road information boards installed at major intersections alert drivers to the traffic entering the road section and to emergency snow removal and disposal. Drivers can then decide whether to detour.

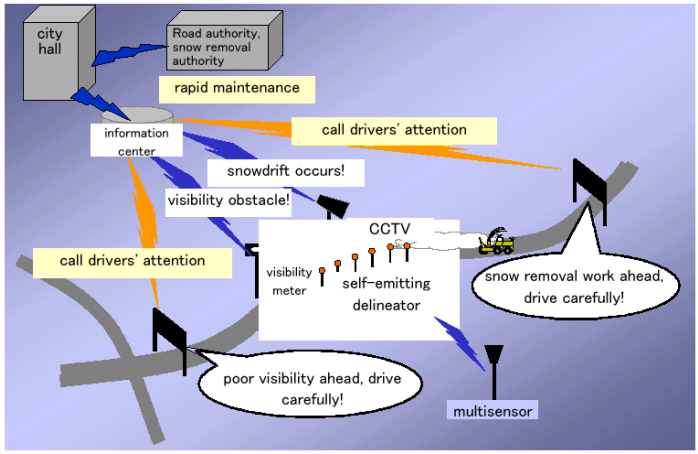



**Figure 10 System of Preventing Accidents Caused by Visibility Hindrance**

Furthermore, the system guides drivers safely during times of poor visibility through self-emitting delineators on median strips. Because they are interlocked with visibility meters, the self-emitting delineators begin to provide appropriate luminance during the early stages of poor visibility.

**Figure 11 Condition of Self-emitting Delineators**

The system in Sapporo- Tobetsu Route is roughly divided into the following three functions:

a) Adjustment of light emission and luminance of self-emitting delineators

Using visibility meters and illuminance meters, they automatically adjust according to visibility conditions and background

luminance so that optimum lighting for drivers is achieved.

b) Real-time monitoring of the site conditions

A real time grasp of the site conditions is made possible by transmitting images from CCTV cameras to the city hall, Public Works Center in each ward, etc.

c) Display of information on information boards

From the CCTV camera images and visibility conditions, the Public Works Center in each ward remotely adjusts the contents on the information boards. Also, messages to alert driver are automatically displayed according to visibility conditions.

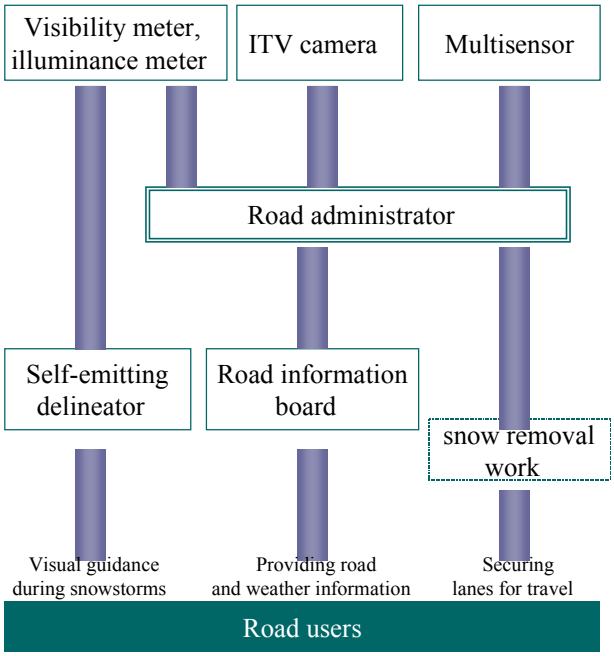



**Figure 12 Information flow: Fushiko-Takuhokukita St.**

### 5.3 Snow Protection System

Otaru-Jozankei Prefectural Route, which extends from Jozankei, Sapporo, to Sapporo International Ski Ground and on to Otaru city, is an inter-city trunk road with a length of about 34.5 km.

Although this route had been closed to traffic in winter between Sapporo International Skiing Ground and Otaru, it opened to year-round use in fiscal 2000, as a result of snow mitigation measures such as the construction of a tunnel at a mountain pass and the installation of fences to protect against avalanche.

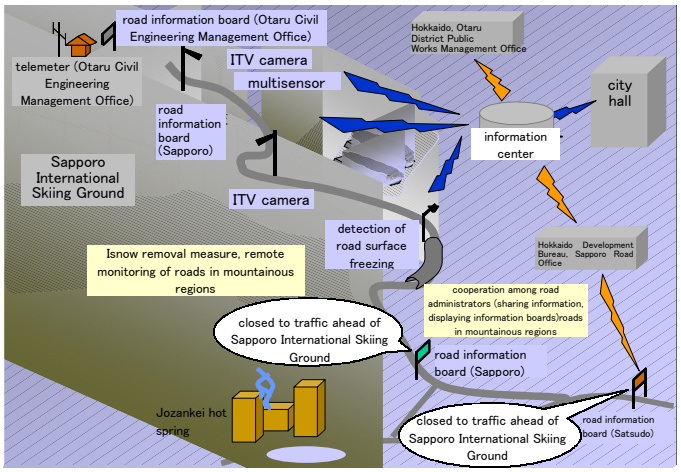



**Figure 13 Snow Protection System**

However, further road measure are necessary in winter because annual snowfall at Sapporo International Skiing Ground approaches 17 m and avalanches occur regularly in late winter. Although road monitoring by patrols and the like has been strengthened, these efforts have their limits. Therefore, to support safe driving, we developed a system which monitors real-time road conditions remotely using meteorological observation facilities or CCTV cameras and which provides this information properly to drivers via road information boards (shown in figure 13).

## 6. Conclusion

Sapporo's severe natural environment, unique to a city of this size, urgently demands complete winter road management if Sapporo is to be considered an eminently livable Northern city. A snowfall information system was put into practical use by Sapporo, ahead of other cities. It promotes efficiency and labor reduction of snow removal and disposal and has proven effective in reducing the snow removal cost.

The Sapporo Information Networking Concept was drafted in 1997 in Sapporo, and partnership between citizens or companies and the administration is being promoted by improving information systems and sharing information.

In developing ITS for Cold, Snowy Regions in Sapporo, we plan to successively develop winter road management systems that utilize CCTV cameras, with the Snowfall Information System as a basis. In this way we will promote ITS for cold regions.

These systems are expected to comprise a leading project that promotes information networking in Sapporo, which is considered an opportunity to promote ITS in earnest.

## References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2) City of Sapporo: Report of the Sapporo ITS Promotion Basic Plan, 1999.
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