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 -10 □.

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

For this reason, the introduction of urban cold region ITS that mitigates the effects of snow, such as by ensuring smooth operation of urban infrastructure at times of frozen road surfaces or heavy snowfall, is a priority in various ITS projects under examination in Sapporo.

The effective use of real-time images from CCTV cameras is considered particularly promising for winter road management of the future.

This report outlines major systems that use CCTV cameras.

2. CHARACTERISTIC OF WEATHER AND SNOW REMOVAL 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. Sapporo is covered with snow for four months, from late December to late March, in general.

2.1 Characteristics of Snowfall

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

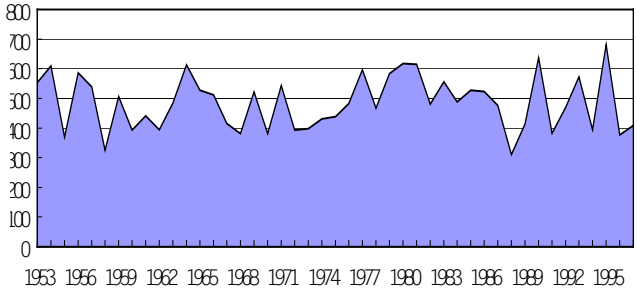


Fig.1 Annual snowfall(1953-1997)

3. WINTER ROAD MANAGEMENT

Toward solving problems of winter roads and ensuring smooth operation of urban infrastructure at the time of heavy snowfall, the following photographs show the measures that have been taken by road administrators.

snow removal on roadways

hauling snow from roadways

sprinkling anti-freezing agent

road heating on slopes

snow-flowing gutter

large snow-melting tank

The length of road from which snow is removed and from which it is hauled has tended to increase with increase in the population and the length of road in Sapporo. Between fiscal 1960 and fiscal 1999, the population quadrupled, the length of managed roads tripled, the length of road from

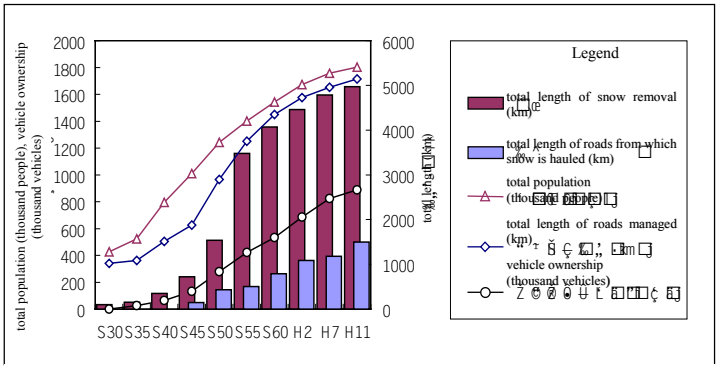


Fig.2 Change of snow removal index

which snow is hauled increased tenfold and the length of road where snow is removed increased fifty fold.

4. CHALLENGES OF WINTER ROAD MANAGEMENT

4.1 Traveling Speed in Winter, by 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).

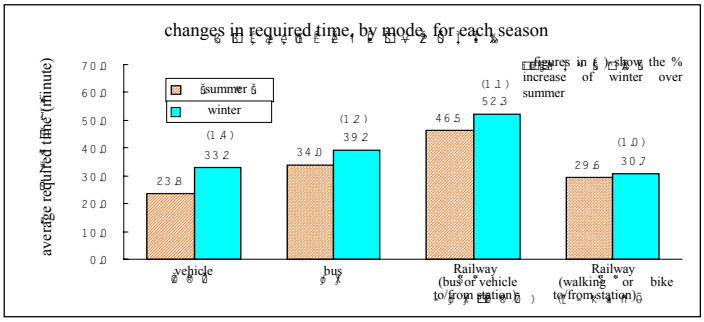


Fig .3 Comparison of travel speeds between different modes in winter

4.2 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.

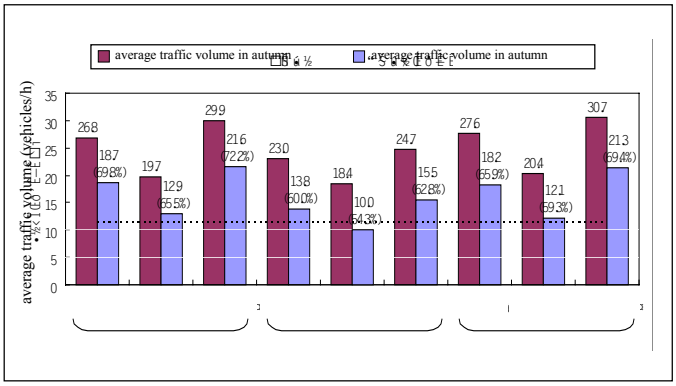


Fig.4 Travel speed in winter

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.

4.3 Emergence of Slippery Road Surfaces

Since regulation on the use of metal-studded tires went into effect, in April 1991, studless tires have superseded studded ones, and air pollution by coarse particulate has 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, it is difficult to start and stop vehicles, even for careful drivers, and traffic hindrances such as skidding accidents and traffic congestion occur. Therefore, more intensive winter road management is being demanded.

To address these problems, measures such as snow removal and dumping, and sprinkling of anti-freezing agents (calcium magnesium acetate, etc.) have been taken with the help of road patrols and by utilizing the weather information system, including snowfall forecast. However, with only a few patrols dispatched a day and limitations in accuracy of

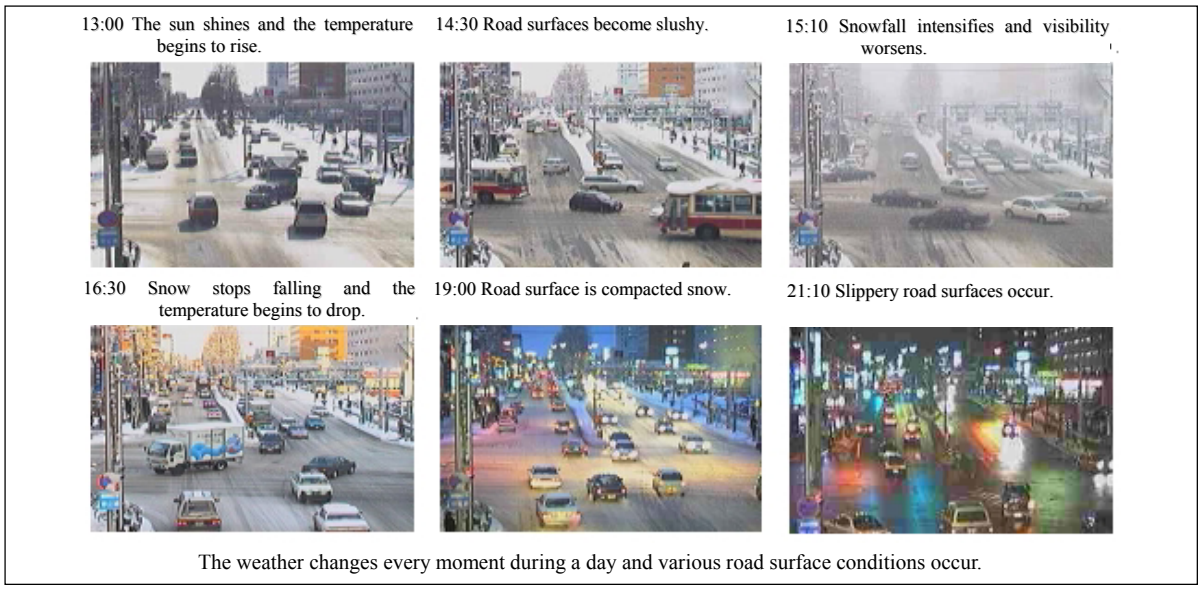


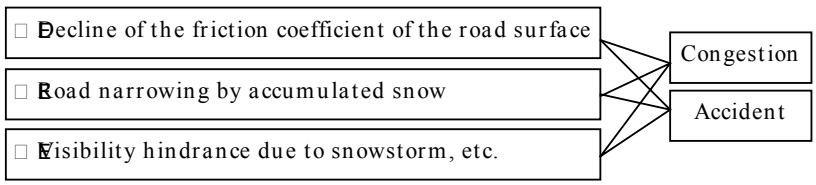
Fig.5 weather condition and road surface image

weather forecast, 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 makes it difficult to handle problems quickly.

5. ITS FOR COLD, SNOWY REGIONS

5.1 Active Utilization of ITS Technologies

Major problems of road traffic in cold, snowy regions can be divided into the three shown at right. The control of traffic congestion and accidents resulting from these three has been demanded. In the future, in addition to the improvement of conventional winter road management, we plan to promote more pleasant and safe winter driving by actively utilizing ITS technologies.

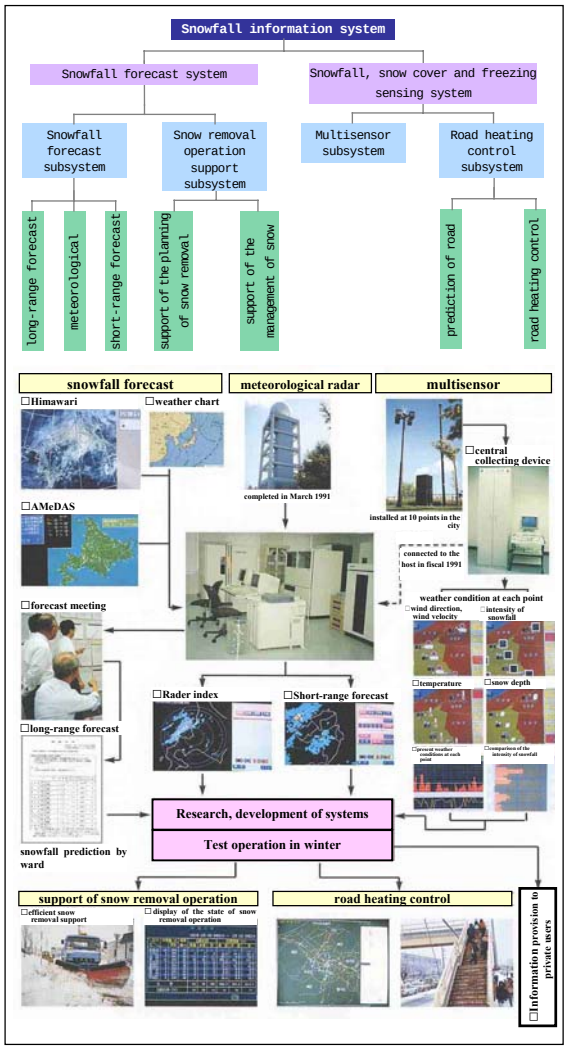


5.2 Development of Systems Based on Numerical Data (Development of the Snowfall Forecast System)

Placing top priority on overcoming problems of winter and snow, the City of Sapporo is now developing subsystems within the Snowfall Information System, 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. This consists of 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 is utilized for snow removal operation, with a long-range forecast system forecasting conditions 12 hours ahead and a short-range forecast system forecasting three hours ahead.



2) Snow Removal Operation Support Subsystem

This system comprehensively identifies the state of snow removal operation (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 mesh, this system enables composite analysis processing of meteorological radar and the understanding of accurate environmental conditions.

4) Road Heating Control Subsystem

Combined with multisensors and meteorological forecasts, heating is efficiently controlled in this system, while it saves energy. At the same time, heating is monitored collectively at the center.

5.3 Development of Systems Based on Camera Images

A snowfall forecast system that collects and analyzes numerical data has been installed to cover the whole city. 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 congestion points with large traffic volume or serious congestion, and points where accidents occur frequently.

(2) Install CCTV cameras or environment sensors (frozen road surface detector, visibility meter, 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 the width of accumulated snow and road surface conditions by analyzing images from CCTV cameras.

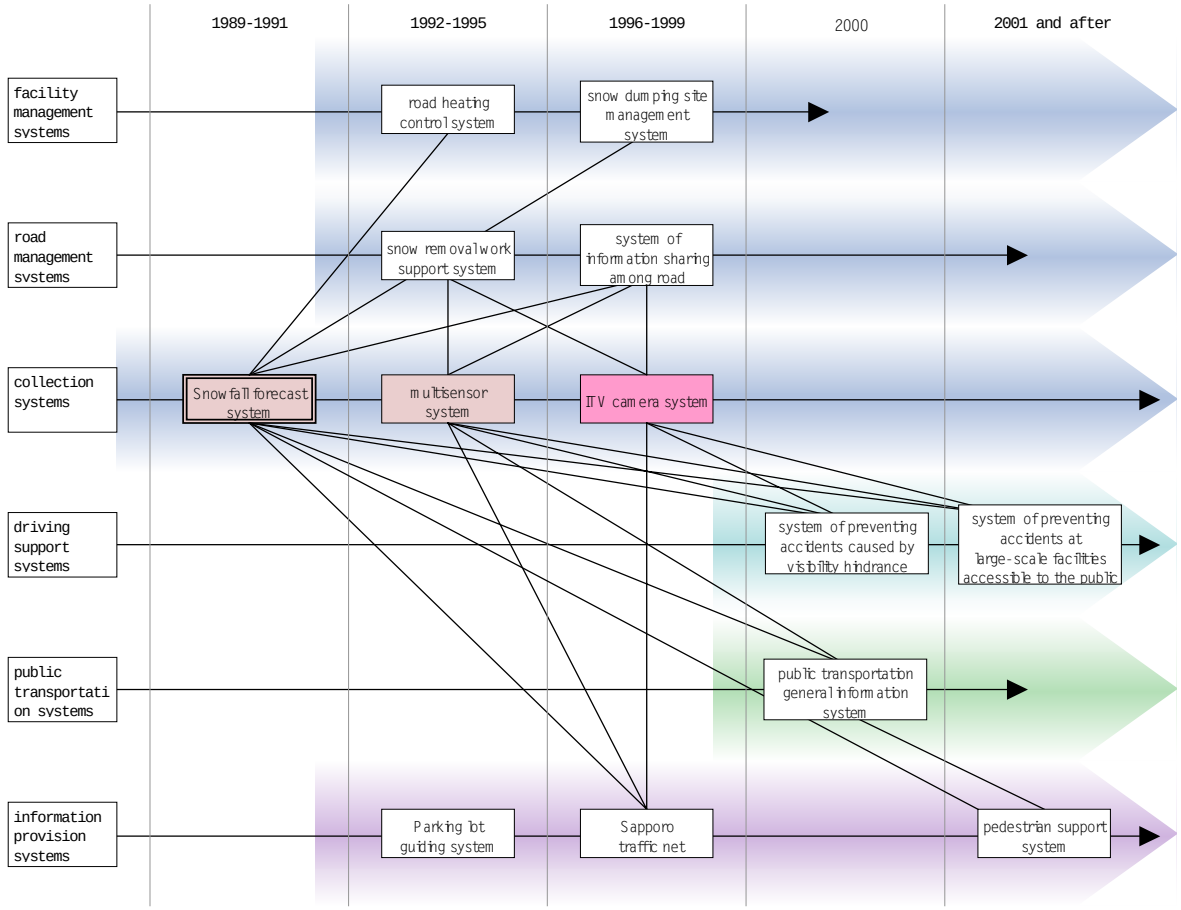
6. CONCEPT OF THE DEVELOPMENT OF CCTV CAMERA SYSTEM

6.1 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.

6.2 System Development Program

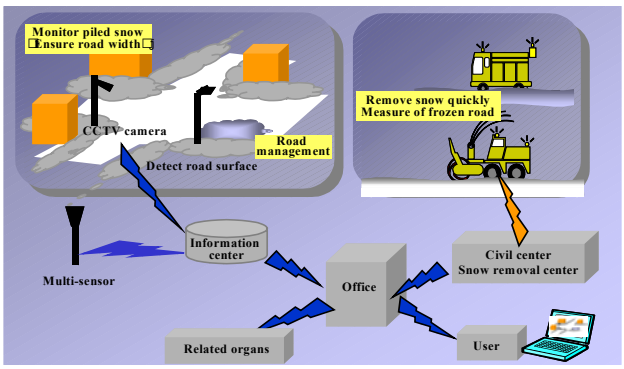
The program for development of systems based on CCTV camera is described below.



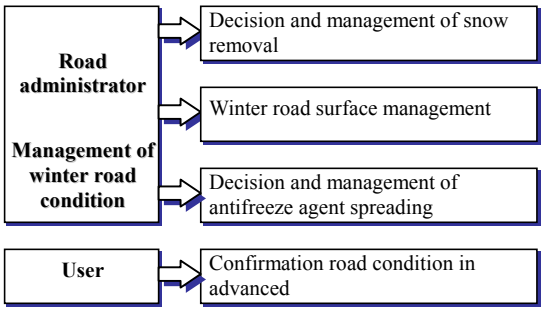
7. GROUP OF SYSTEMS BASED ON CCTV CAMERAS

7.1 Frozen Road Surface Management System

The System for Managing Frozen Road Surface Using CCTV Camera enables site conditions to be understood in real time by remote monitoring of sites. It supports appropriate snow removal and disposal operation and systematic pre-application of anti-freezing agent, toward advanced and efficient winter road management.



□Network image□



□Effect of CCTV camera□

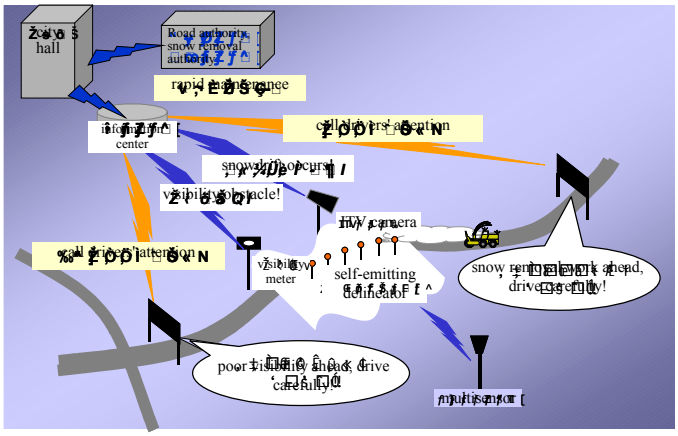
7.2 System of Preventing Accidents Caused by Visibility Hindrance

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.

□The state of Visibility hindrance□

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



□System of preventing accidents caused by visibility hindrance□

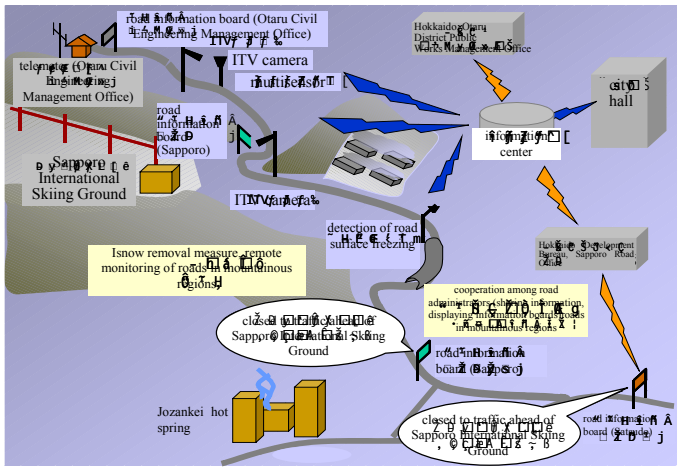
In addition, road information that alerts a driver to the traffic entering the road section and to emergency snow removal and disposal, and that gives drivers data for deciding whether they should detour is provided on road information boards installed at major intersections around that section.

7.3 Snow Protection System

Otaru-Jozankei Prefectural Route, which extends from Jozankei, Sapporo, to Sapporo International Skiing 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.



However, further road measure are necessary in winter because annual snowfall at Sapporo International Skiing Ground approaches 17 m and avalanche occurs 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.

8. 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.

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