THE INTRODUCTION OF THE SNOW VEHICLE POSITION MONITORING SYSTEM AND ITS EFFECTIVENESS

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ABSTRACT

East Nippon Expressway Company Limited (hereafter NEXCO East) Niigata branch introduced a snow vehicle monitoring system for greater efficiency in dealing with snow and ice.

The purpose is to gain a round-the-clock understanding of the snow work situation and to respond immediately and without fail to the changing snowfall situation.

This system uses road management radio and GPS. The terminal mounted on the vehicle displays the position of the vehicle visually on a simple chart. Operation is via an easy-to-use touch panel. There is also a working data storage function.

At the snow work base the position of each vehicle on the map and the details of the work are available and this information is automatically recorded. In addition, when there is a report of an accident it is possible to order a response by the nearest vehicle.

With this system it is planned to make snow work more efficient and improve the on-the-ground work environment.

KEYWORDS

SNOW VEHCLE / GPS / ROAD MANAGEMENT WIRELESS

1. INTRODUCTION

NEXCO East, Niigata Branch (‘the Niigata branch’) undertakes the management and construction of some 438.6 km of expressway covering Niigata Prefecture and parts of Toyama, Gunma and Nagano Prefectures. Every route runs through cold areas that experience snowfall, and ensuring the safe and smooth flow of traffic during winter is something that is demanded by society and an essential part of NEXCO management policy. Strategies to deal with snow and ice exert a huge influence on company operations, and as such need to be made more efficient.

This paper is a report on the ‘snow vehicle position monitoring system’ being introduced on a trial basis by the Niigata branch in order to move around and control with greater efficiency the snow and ice apparatus (both machinery and vehicles) that forms the key part of the strategy to deal with snow and ice control operation in winter.

2. THE STRUCTURE OF NEXCO’S SNOW AND ICE CONTROL OPERATION

Snow and ice operation on the expressways covered by the Niigata branch is centered on the snow and ice control headquarters set up during the winter in each of the four bases, known as operation offices, located in Yuzawa Town, Niigata City, Nagaoka City and Joetsu City.

The snow and ice control headquarters (what could be called the snow removal command center) brings together data on road surface conditions, weather observation and weather forecasts in the area covered by the operation office and assembles the necessary workers and snow vehicles, etc. The headquarters also makes the decision to spread anti-freezing agents on the roads and actually mobilize snow removal operations.

A number of snow and ice operation stations are located within the area covered by the operation office, and at these bases are stationed the workers and snow vehicles. The vehicles are actually put into service and snow and ice control operations carried out on the basis of specific instructions from the snow and ice control headquarters.

In order to be able to respond accurately to the constantly-changing snow removal situation and ensure a better road surface, the snow and ice control headquarters is expected to make judgements with an eye firmly fixed on what is about to happen. To be able to do this, it is essential for it to have a real-time grasp of the state of snow and ice operations throughout the area under its control.

3. METHODS FOR KNOWING THE POSITION OF SNOW VEHICLES

The simplest method for knowing the position of snow vehicles and the state of operations is to use some method of communication with each vehicle on the road to verify the position of individual vehicles as necessary.

For road administration purposes, most of the snow vehicles in the possession of the Niigata branch are fitted with wireless equipment that uses NEXCO’s private frequency. This wireless equipment is used for ordinary maintenance and management work as well as for snow and ice control operation, and calls over this wireless equipment have long been used to grasp the position of snow vehicles and the state of operations.

However, when snow and ice operation is being carried out from each station at the same time there is an increase in the volume of calls, causing radio congestion. The Yuzawa operation office in particular, being located in an area that experiences heavier snowfalls than almost any other place in the country through which an expressway passes, undertakes snow and ice operation at a markedly high level of frequency and has over 100 vehicles; the use of vocal wireless communications alone had started to be an impediment to operations.

For this reason, in 1997 a snow vehicle position monitoring system was introduced to the

Yuzawa operation office. (Fig.1). This system uses a GPS (Global Positioning System), similar to that used by the taxi and transport industries, as a means of keeping automatic track of the position of snow vehicles. The system uses an item that was originally developed and put into use as a consumer product, customized to meet our needs.

Fig.1 - Snow vehicle control system vehicle-mounted terminal

Fig.2 - Kilo post display

The current position of the vehicle is measured by GPS; when the vehicle is blocked off from the sky (in a tunnel, etc) an estimated position is calculated using a speed pulse sensor.

The positioning data calculated from the terminal mounted on each snow vehicle is forwarded to the snow and ice control headquarters located in each operation office using NEXCO's road management wireless. In addition to sending out the vehicle's position, it is also possible to include details of the work (snow removal, spreading of anti-freezing agent, etc) in which the vehicle is engaged.

Further, inside the snow vehicle are displayed the kilo posts on the expressway converted from the positioning data (Fig.2), which has proved effective in aiding position verification during stormy weather such as a snowstorm and in giving accident reports.

4. THE SWITCH TO A NEW SYSTEM

In 2005 the deterioration through age of the wireless equipment in use in the area covered

by the Niigata branch had become marked, and was updated and digitized; but the snow vehicle position monitoring system continued to be used as it was, with some remodeling of the vehicle-mounted terminals.

However, due to the technological innovations that have taken place since the time the system was introduced, when it was decided in 2008 to expand the same system to all the operation offices under the Niigata branch the function of the system not merely as a means of gaining positional information but as a tool capable of providing further support to snow and ice control operation was reviewed, leading to the development of the new snow vehicle position monitoring system (Fig. 3).

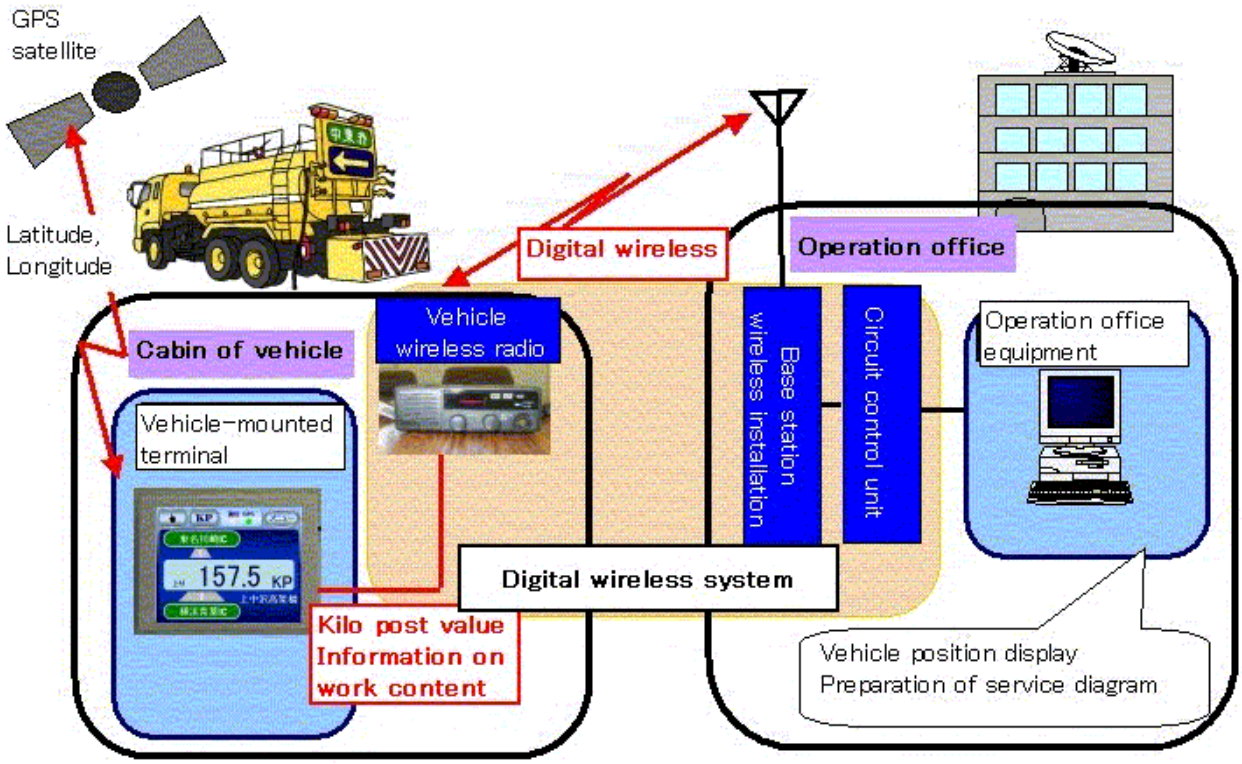

Fig.3 - The new snow vehicle position monitoring system

5. FEATURES OF THE NEW SNOW VEHICLE POSITION MONITORING SYSTEM

One of the major features of this snow vehicle position monitoring system is that the terminal mounted in each snow vehicle has been completely changed (Fig.4). This was brought about thanks to the technological innovations of recent years and the advent of inexpensive products.

The position of the vehicle is displayed not only in terms of the usual numerical kilo post, but also visually, by means of a simple diagram. In addition, bridges in the immediate vicinity can also be shown (Fig.5). As it is necessary when removing snow to adjust the ground pressure so that the snow plough does not catch on the expansion joints on either side of the bridge, the crew of the vehicle need to be able to know the exact position of the bridge. This is something that was left up to the experience and capability of the individual crew member, but now it is possible to provide support.

Fig.4 - The new snow vehicle position monitoring system

Further, in comparison with the embankment the bridge itself tends to be more susceptible to cooling, so that anti-freezing work needs to be carried out with care. Since the pattern of cooling differs depending on the form of the bridge, when giving work instructions the name of the specific bridge in question is indicated; this is also easier to understand under the system.

One more feature of the vehicle-mounted terminal is that the screen is touch-sensitive. The same kind of touch panel that is already widely used in car navigation systems and bank ATMs is also made use of in the vehicle-mounted terminal.

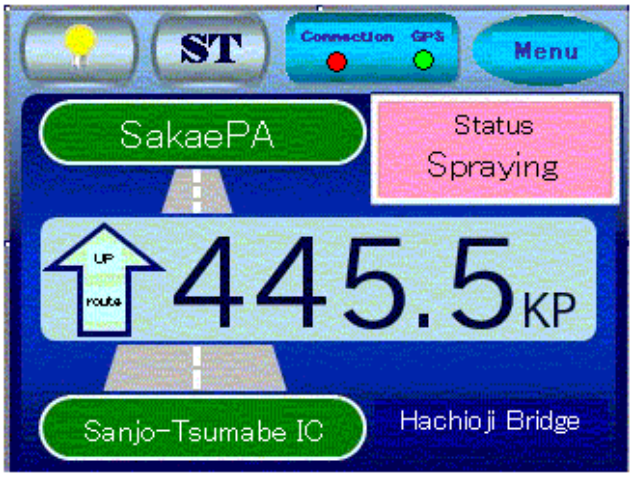

Fig.5 - Screen showing vehicle's position

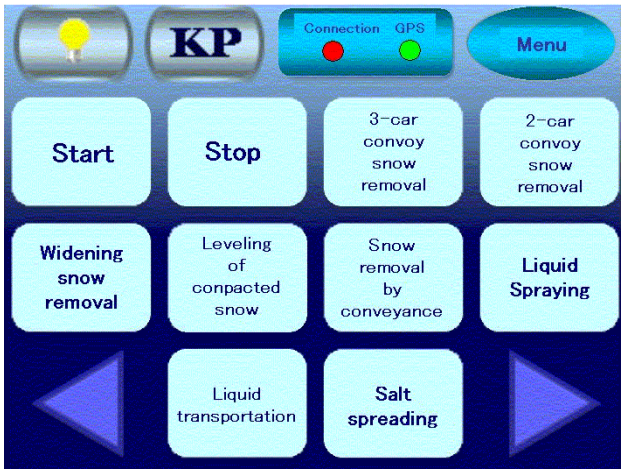

Fig.6 - Work input screen

In the past a numerical code indicating the work status and work content of the snow vehicle (snow removal, spreading anti-freezing agent etc) would be input, but the introduction of the touch-sensitive screen has made it possible to input these by simply selecting the work content directly (Fig.6). That is to say, just by operating the touch-sensitive screen just twice – once when the snow vehicle is sent out and once when it returns to the station – the whole chain of operations is transmitted automatically via wireless.

Even in the event of a temporary wireless communication failure due to radio congestion or any other reason, half the day's data is stored in the vehicle-mounted terminal and is transmitted when wireless communication is restored, so that data can be collected accurately, with no loss.

Once a minute the position of each snow vehicle, together with its work status and content, is transmitted from the vehicle-mounted terminal to the snow and ice control headquarters established in each operation office. Here the data is both stored and displayed in real time on a map, making it possible to understand at a glance the work status of the snow vehicles. This map can be displayed as required either as a simple schematic diagram (Fig.7) or as a realistic map as used in a commercial car navigation system (Fig.8). Together these make it possible to draw a diagram that provides very easy visual understanding of the working hours of the snow vehicles(Fig.9).

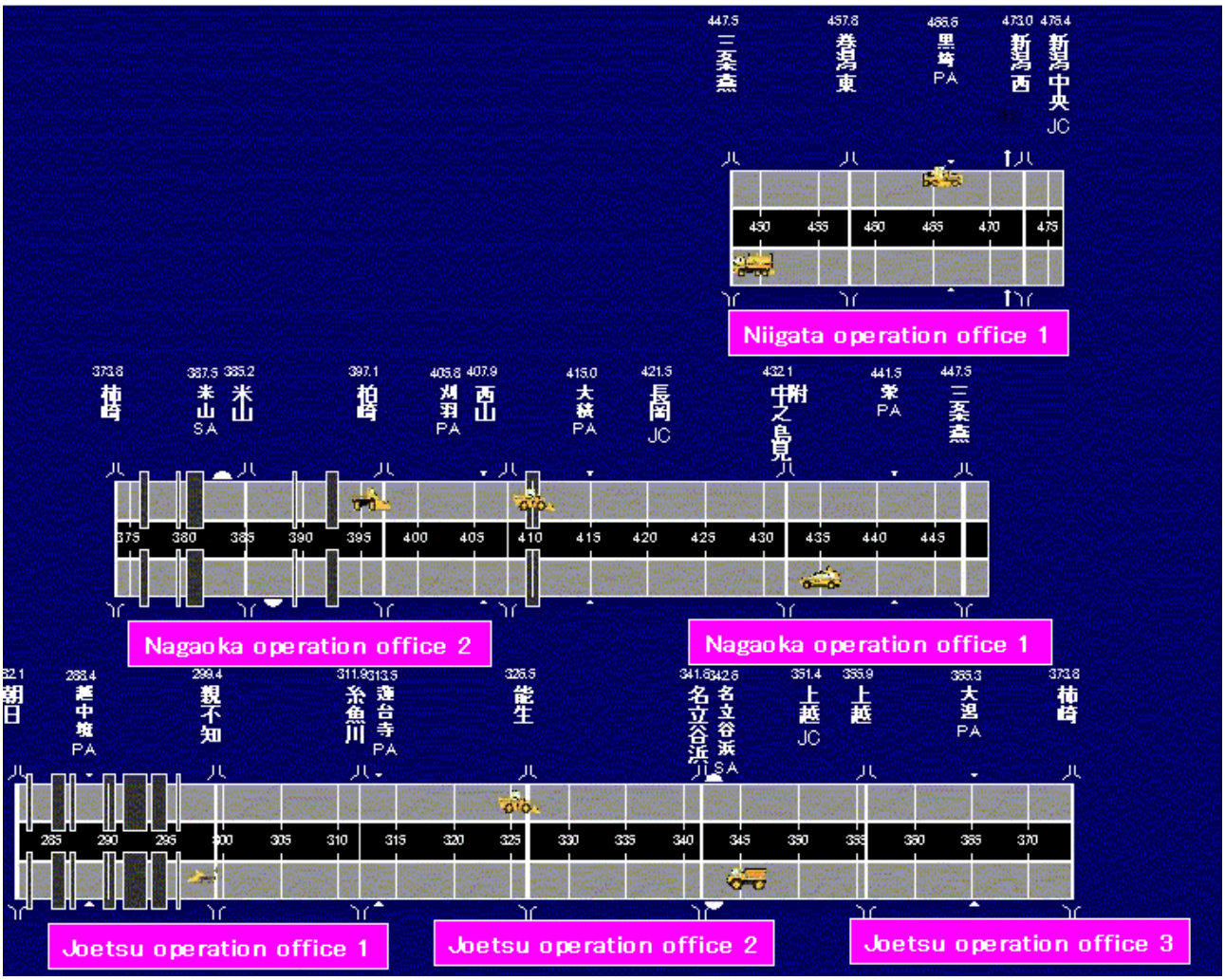

Fig.7 - Screen showing snow vehicle positions
by means of a simple schematic diagram

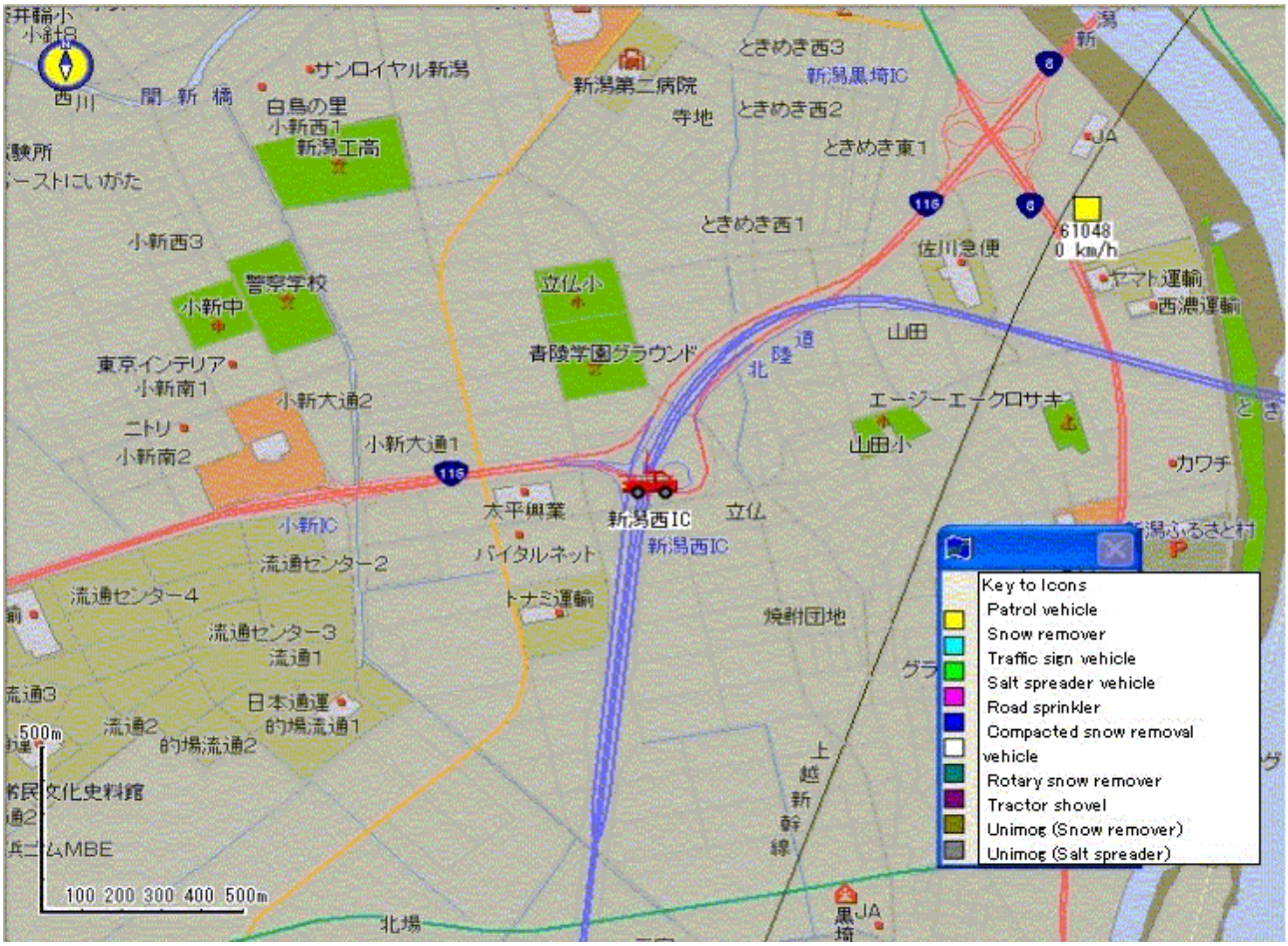

Fig.8 - Screen showing current positions（detailed map display）

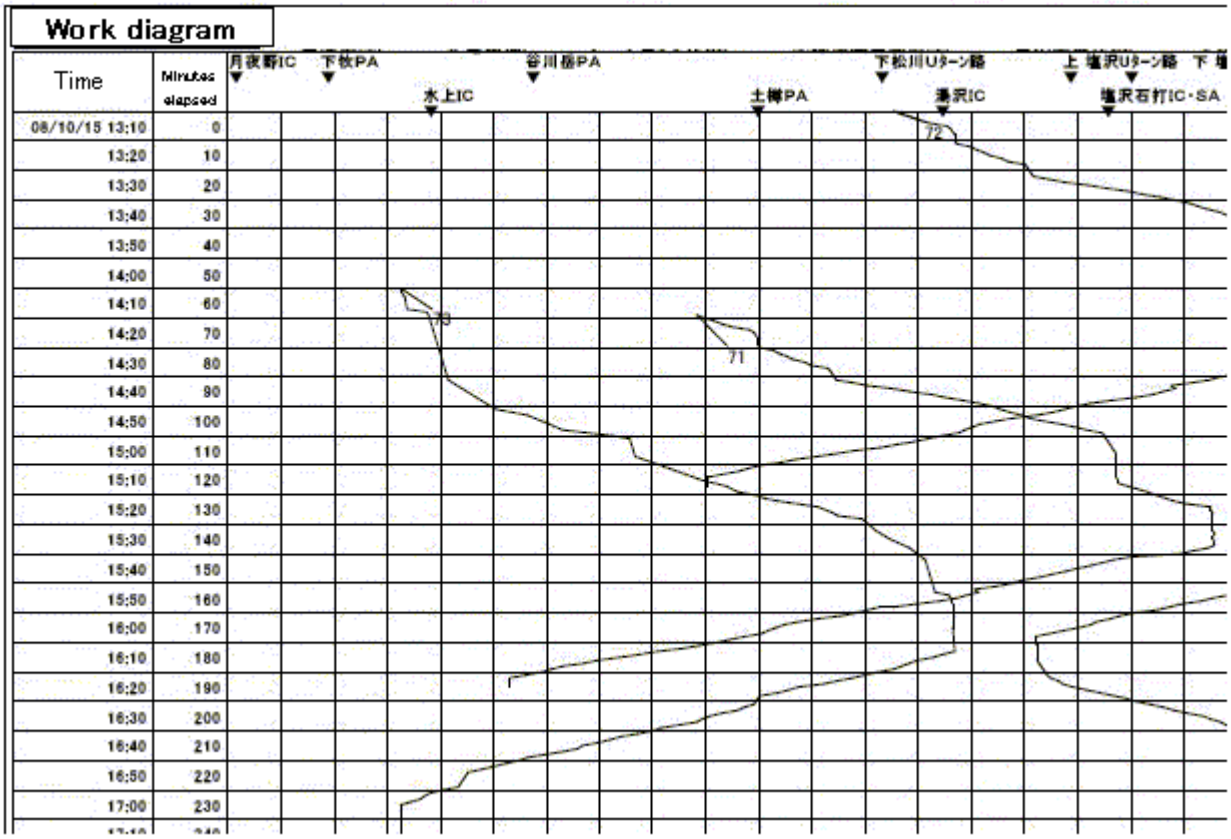

Fig. 9 - Diagram

6. IMPROVED CRISIS-MANAGEMENT CAPACITY THROUGH UNDERSTANDING OF VEHICLE POSITIONS

Snow removal work at the Niigata branch is carried out, from the perspective of safety, using 2 or 3 snow removers to clear all traffic lanes at the same time. This method is called 'convoy snow removal'. Since snow removal work cannot of course be carried out at speed, the convoy pulls over at interchanges and at passing-places set up at regular intervals, in order to minimize inconvenience and stress caused to drivers following behind the convoy.

This means that should an accident occur on the road ahead, police cars and other emergency vehicles coming up behind the snow removers sometimes have no choice but to follow on behind. However, using this new system it is possible to pull the convoy over into the nearest passing place; or if it is learned that emergency vehicles are coming up behind when the convoy is already pulled over, to instruct it to remain in place until they have passed (Fig. 10). In addition, should information be received of an accident on the road ahead or in the opposite lane, it is possible to give notice of this to the nearest snow remover or vehicle and instruct it to gather information and make an initial response (Fig. 11). Especially in the case of an accident that has occurred in conditions of poor visibility, the speed and appropriateness of the initial response is key in avoiding a secondary accident. Here too, the new system proves its effectiveness.

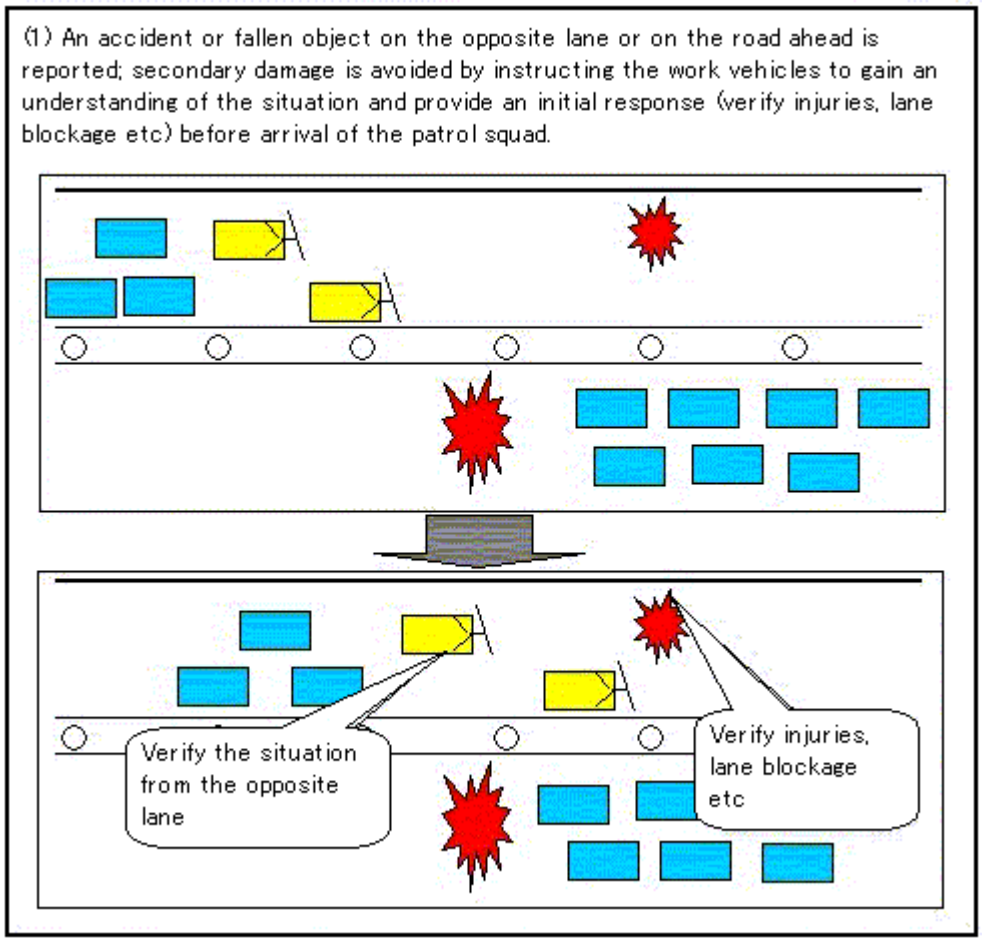

Fig.10 - Dispatch of vehicles to opposite lane or near vicinity

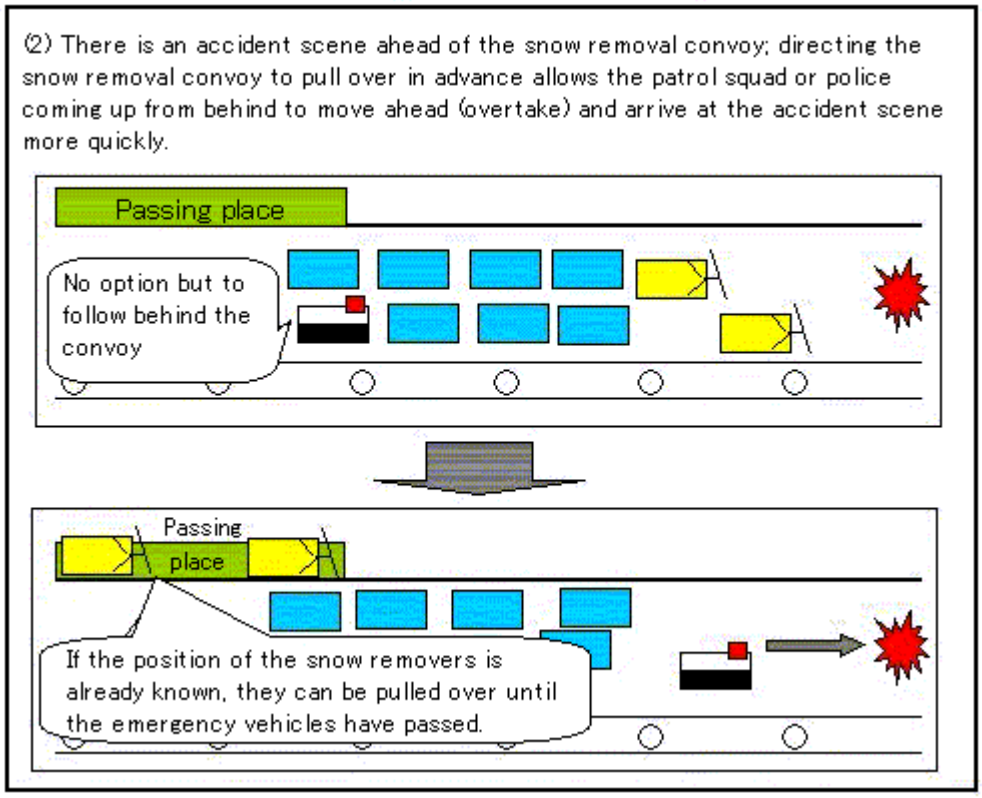

Fig.11- Pulling over for emergency vehicles

Furthermore, when an accident has occurred there is an increase in the amount of wireless traffic in order to report on the situation; and in the case of a particularly serious accident it may be necessary to restrict wireless use in order to ensure that the most important communications can get through. However, this snow vehicle position monitoring system basically makes the issuing of verbal instructions during snow and ice control operation very nearly unnecessary, so that its implementation will result both in smoother snow and ice operation and in smoother accident response operations; snow and ice operation will not be delayed due to wireless communications priority going to accident response services, nor will accident response services be delayed due to the congestion of wireless communications.

7. CONCLUSION

The newly-introduced system is a watershed innovation, contributing greatly to greater efficiency in snow and ice control operation of course, as well as to improving the working environment on the road. During fiscal 2009 a number of improvements are planned, such as the integration of the many different kinds of monitors installed in the operation offices so that it will be possible to draw diagrams in real time and to display and select all the information on a single screen. It is also intended to work to make improvements to make the system easier to use, and to conduct a quantitative assessment of how labor-saving the system is.