



XIII
INTERNATIONAL
WINTER ROAD
CONGRESS

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SUSTAINABLE WINTER SERVICE FOR ROAD USERS

*Development of a System for the Flexible Shifting
of Snow Removal Sections Using Real-Time
Positioning Information on Snow Removal
Machinery*

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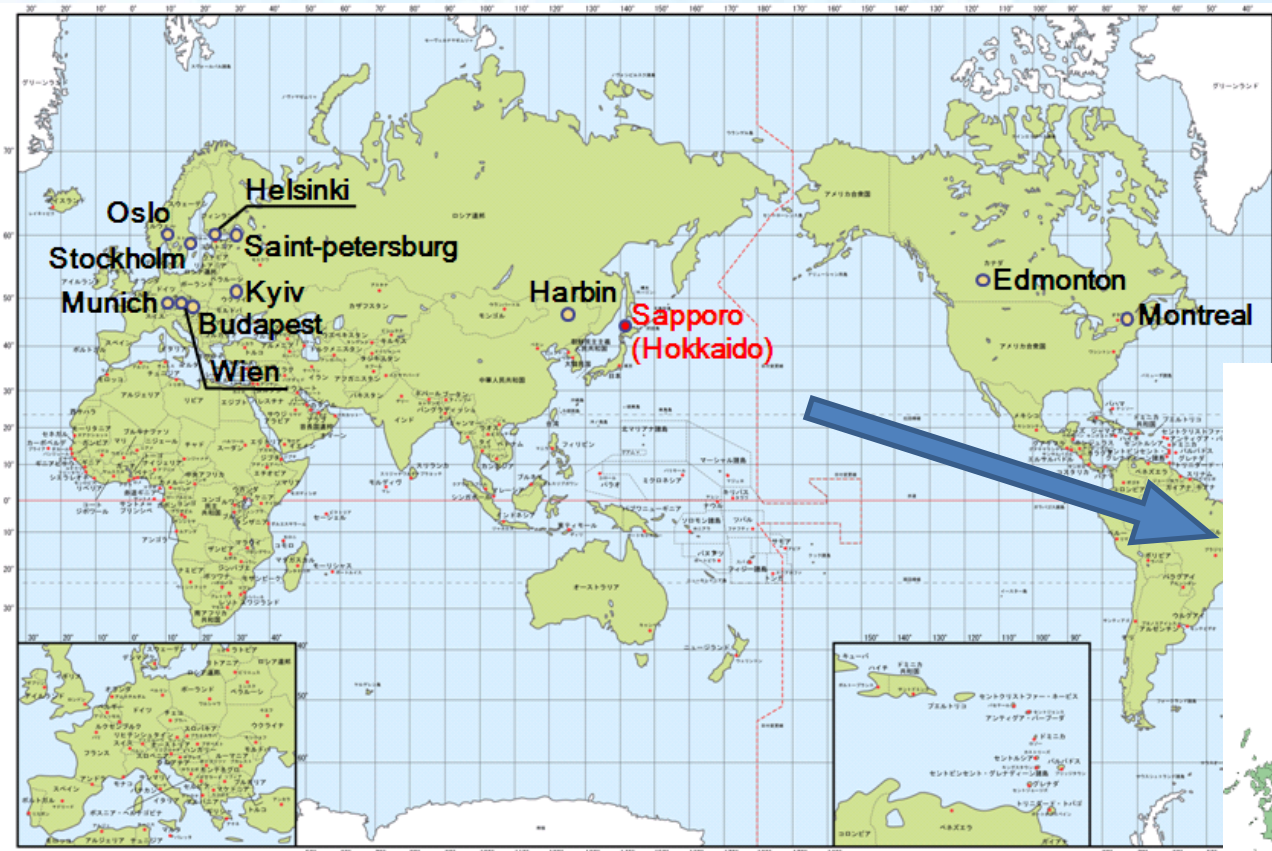
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OUTLINE

- Background
Hokkaido and snow removal on national highways
- Objectives
- Method and Results
Development and testing
- Conclusion

BACKGROUND 1



- Hokkaido

Area: 83,500 km² (22% of Japan's total landmass)

Average intercity distance: 140 km

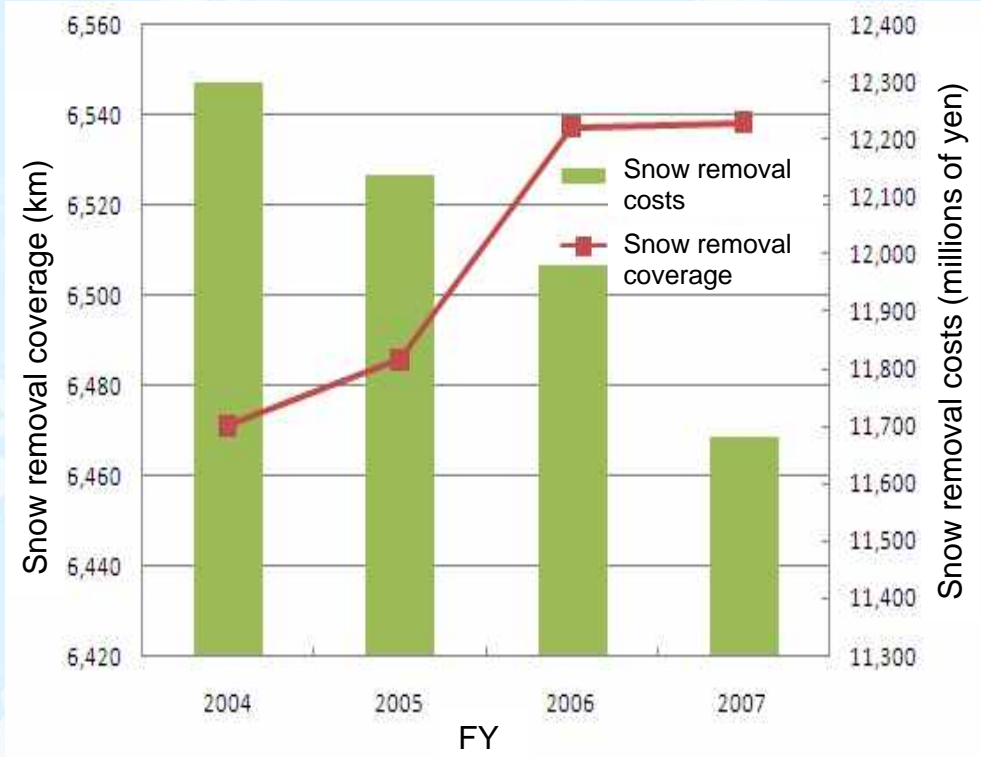
Number of days with snow cover: over 100 in most cities

BACKGROUND 2

- Snow removal project by the Hokkaido Regional Development Bureau
FY 2008 (national highways)
Snow removal machines: 1,023
Snow removal coverage: 6,550 km

Snow removal coverage
→ increasing yearly

Snow removal costs
→ decreasing trend



- Guaranteed travel speeds for winter road users
- Prompt snow removal operations during abnormal weather



A system is necessary to monitor changes in snow accumulation and snow removal conditions in real time and support flexible snow removal operations.

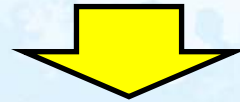
OBJECTIVES

- Hokkaido Regional Development Bureau

Introduction of a core system (FY 2005)

Enables monitoring of snow removal machinery movement using GPS and operation sensors.

Enables confirmation of past operation records.

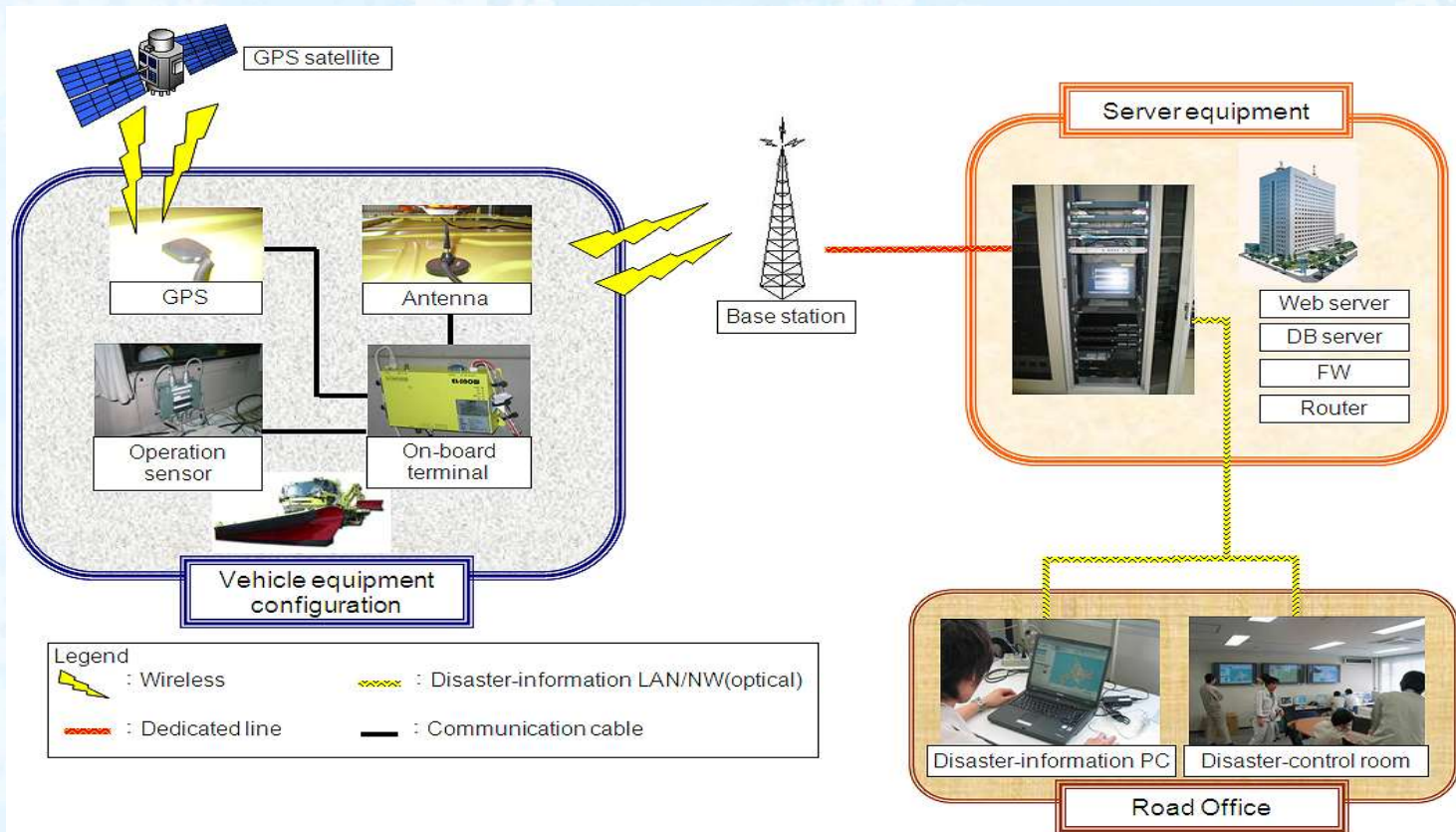


- Civil Engineering Research Institute for Cold Region

Development of a management system for snow removal machinery based on the core system

Introduction of a more efficient and upgraded road maintenance and management service by supporting flexible operation of snow removal machinery

EQUIPMENT CONFIGURATION OF THE CORE SYSTEM



- Real-time snow removal progress monitoring by collecting and managing location/operation data from snow removal machinery
- Confirmation of snow removal operation results from accumulated data

MONITORING OF SNOW REMOVAL MACHINE LOCATIONS AND OPERATION RECORDS

Monitor screen for snow removal machinery locations

• Real-time display of machines in operation.
 • Operation conditions are color-coded.
 • The arrows indicate the direction of travel.

Detailed information on currently operating machines is displayed in the list.

車種	データ取得時刻	車両管理番号	除雪機種別	道路種別	道路番号	現在位置	現田新	上下	位置(KP)	作業状態	速度 (km/h)	事務所	所管	除雪ST
<input type="checkbox"/>	03/16 1059	17-2183	小形除雪車兼用式	一般国道	国道391号	現速	-	-	113.838	回送中	2km/h	北見道路事務所	小清水ST	
<input type="checkbox"/>	03/16 1103	13-2151	ロータリ除雪車22+2軸	一般国道	国道243号	現速	-	-	26.164	拡張除雪	14km/h	北見道路事務所	美幌ST	
<input type="checkbox"/>	03/16 1104	13-2135	除雪トラック10t3M	一般国道	国道243号	現速	-	-	26.297	回送中	2km/h	北見道路事務所	美幌ST	

Monitoring screen for operation records

• Placing the cursor over the mark of a snow removal machine displays detailed information related to it.
 • Operation conditions are color-coded.
 • The arrows indicate the direction of travel.

Operation records can be displayed in three forms – operation locus, animation and list.

作業時刻	作業区間	作業機種	速度 (km/h)
2006/02/14 04:40:00	144000	01 04P	0
2006/02/14 04:41:00	144000	01 04P	0
2006/02/14 04:42:00	144000	01 04P	0
2006/02/14 04:43:00	144000	01 04P	0
2006/02/14 04:44:00	144000	01 04P	0
2006/02/14 04:45:00	144000	01 04P	0
2006/02/14 04:46:00	144000	01 04P	0
2006/02/14 04:47:00	144000	01 04P	0
2006/02/14 04:48:00	144000	01 04P	0
2006/02/14 04:49:00	144000	01 04P	0
2006/02/14 04:50:00	144000	01 04P	0
2006/02/14 04:51:00	144000	01 04P	0
2006/02/14 04:52:00	144000	01 04P	0
2006/02/14 04:53:00	144000	01 04P	0
2006/02/14 04:54:00	144000	01 04P	0
2006/02/14 04:55:00	144000	01 04P	0
2006/02/14 04:56:00	144000	01 04P	0
2006/02/14 04:57:00	144000	01 04P	0
2006/02/14 04:58:00	144000	01 04P	0
2006/02/14 04:59:00	144000	01 04P	0
2006/02/14 05:00:00	144000	01 04P	0

BASIC CONCEPT OF THE MANAGEMENT SYSTEM FOR SNOW REMOVAL MACHINERY

- Snow removal planning support
- Dispatch judgment support
- **Dynamic section shift support**
- Support for measures against disaster conditions caused by heavy snow
- **Support for daily reports on de-icer application**

In FY 2008, the setup was developed and field-tested in terms of its **dynamic section shift support system** and its **support system for daily reports on de-icer application**.

BASIC CONCEPT OF THE MANAGEMENT SYSTEM FOR SNOW REMOVAL MACHINERY

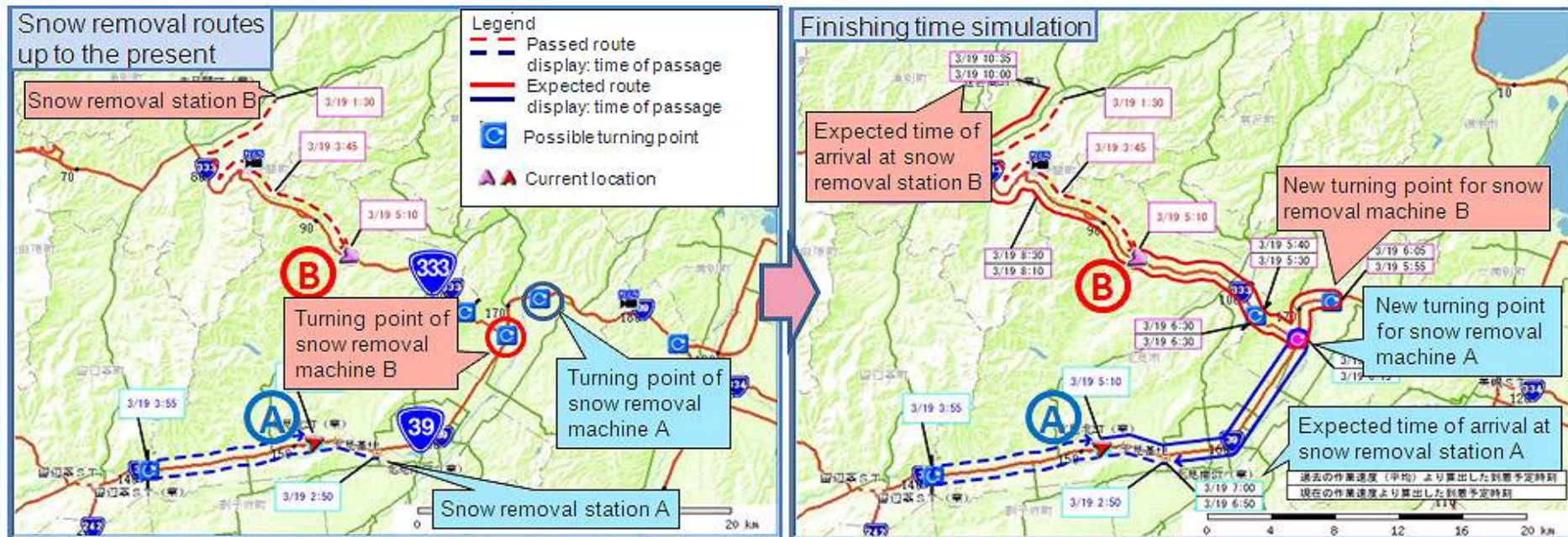
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DYNAMIC SECTION SHIFT SUPPORT SYSTEM 1

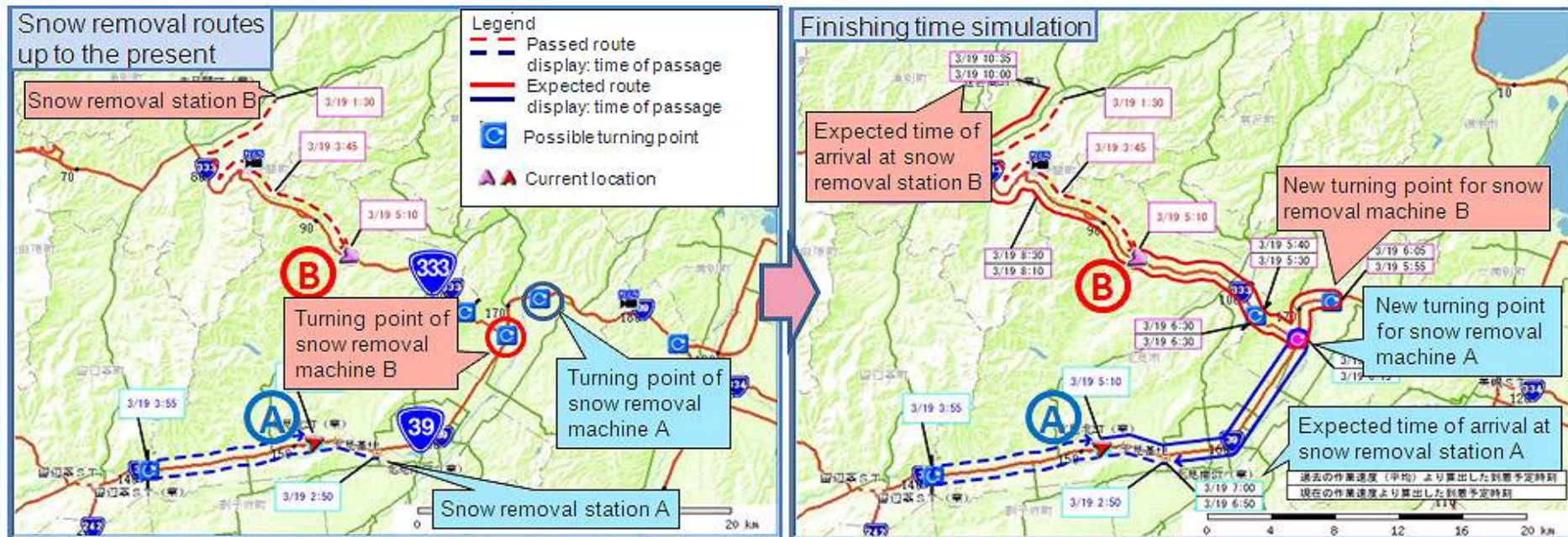
- Since snow removal operations are usually conducted only in designated sections, it is impossible to monitor operation conditions in other areas.
 - ↳ This situation may cause **significant differences in snow removal finishing times between adjoining sections** during localized heavy snowfall or other abnormal weather conditions, and may lead to **delays in snow removal over the entire route.**
- The progress of snow removal is monitored, and support is provided for removal in adjoining sections by shifting section borders (i.e., the turning points of snow removal machinery).
 - ↳ This support enables **a reduction in the snow removal time for the entire route.**

DYNAMIC SECTION SHIFT SUPPORT SYSTEM 2



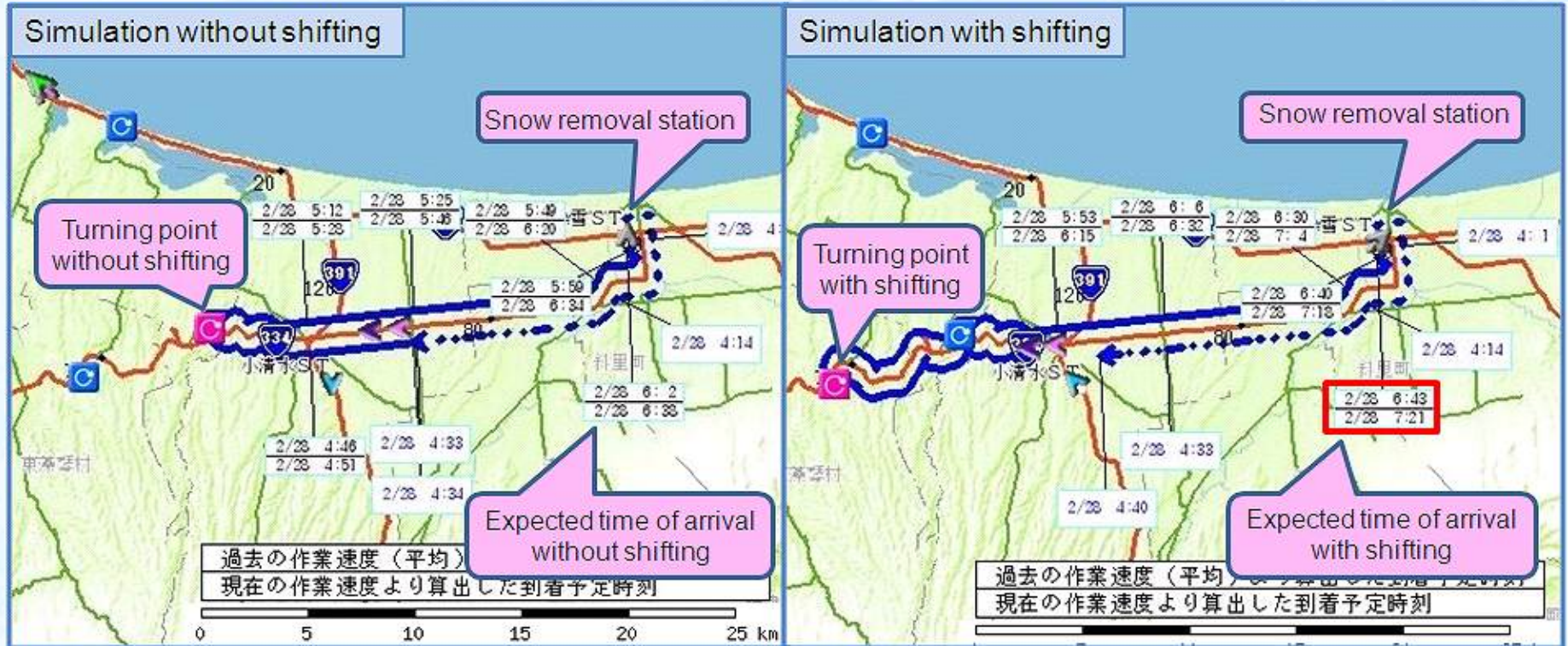
- Several turning points are registered on the map in advance.
- **The supervisor designates a turning point** for a snow removal machine on the map during snow removal operation.
- **The system presents the expected finishing time** at which snow removal machines on both sides of the section border will return to the starting points (i.e., the snow removal stations).

DYNAMIC SECTION SHIFT SUPPORT SYSTEM 3




- There are **two types of expected finishing time**:
 - The time for snow removal operations in normal conditions, which is **estimated from past average operation speeds**.
 - The time for operations during heavy snow conditions or abnormal weather in specific locations, which is **estimated from current average operation speeds**.
- **The supervisor judges the shifting of section borders** based on these expected finishing times.

SECTION SHIFT SIMULATION



Section shift simulation at 4:53 a.m.

- The expected time of arrival was 6:43 a.m., and the actual time was 6:22 a.m.  **The result was basically valid.**
- Problems: Errors occurred when snow removal machines deviated from their pre-registered scheduled operation route, and it **took too long to display estimation results.**



These problems will be addressed.

EFFECTS OF DYNAMIC SECTION SHIFT

	Shift section①		Shift section ②	
	Koshimizu section (supporting side)	Memambetsu section (supported side)	Memambetsu section (supporting side)	Abashiri section (supported side)
Normal snow removal operation time (h)	1.5	1.7	1.2	3.6
Snow removal operation time at the time of shifting (h)	2.0	1.2	2.1	2.4
Difference in amounts of congestion loss between normal time and time of shifting (x 10,000 yen)	2.9	-5.8	10.4	-104.3
Total amount of difference in each shift section (x 10,000 yen)	-2.9		-93.9	
Total (x 10,000 yen)	-96.8			

- The total amount of congestion loss for the two shift sections of ① and ② decreased by 968,000 yen.
- The snow removal operation times in the sections were 2 to 2.4 hours, indicating equalization.



In this case, section shift was conducted during normal snow removal operations. When there is a delay in such operations due to abnormal weather, the amount of congestion loss will also be cut by reducing the snow removal time for the entire route through dynamic section shift.

SYSTEM FOR DAILY REPORTS ON DE-ICER APPLICATION 2

List of application records

District: Sapporo Road Office, Sapporo Development and Construction Department

Type of snow removal machinery : De-icer spreader vehicle

Specification: 4.0m3 wet

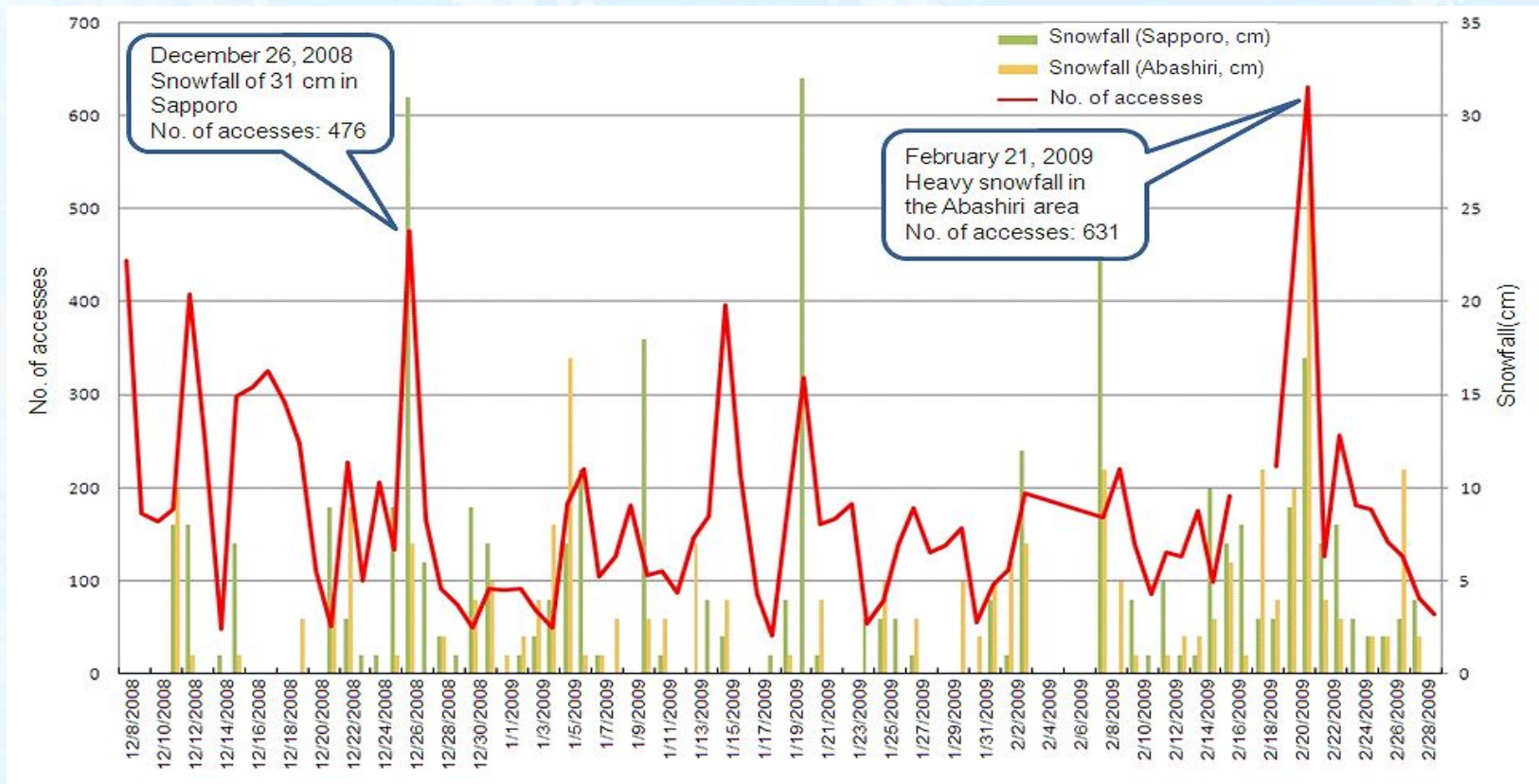
Control number: 14

Total application amount (kg) : 7509 [de-icer] 0[anti-slippery] 311[water solution]

Application time	Application location	Types of de-icer	Amount (g/m2)	Width (m)
2009/01/ 05:58:04~2009/01/ 05:58:29	(国)36 10.481KP ~ (国)36 10.293KP	凍結防止剤	10	3.5
2009/01/ 05:59:14~2009/01/ 06:01:10	(国)36 10.282KP ~ (国)36 9.178KP	凍結防止剤	10	3.5
2009/01/ 06:01:10~2009/01/ 06:01:26	(国)36 9.178KP ~ (国)36 9.073KP	凍結防止剤	10	3.5
2009/01/ 06:01:26~2009/01/ 06:01:29	(国)36 9.073KP ~ (国)36 9.043KP	凍結防止剤	15	3.5
2009/01/ 06:01:29~2009/01/ 06:03:17	(国)36 9.043KP ~ (国)36 7.829KP	凍結防止剤	20	3.5
2009/01/ 06:03:37~2009/01/ 06:04:45	(国)36 7.826KP ~ (国)36 7.160KP	凍結防止剤	20	3.5
2009/01/ 06:04:45~2009/01/ 06:06:28	(国)36 7.160KP ~ (国)36 5.889KP	凍結防止剤	20	4.5
2009/01/ 06:06:28~2009/01/ 06:07:02	(国)36 5.889KP ~ (国)36 5.555KP	凍結防止剤	20	5.0
2009/01/ 06:07:29~2009/01/ 06:08:23	(国)36 5.542KP ~ (国)36 5.020KP	凍結防止剤	20	5.0
2009/01/ 06:08:24~2009/01/ 06:08:42	(国)36 5.009KP ~ (国)36 4.832KP	凍結防止剤	20	5.0
2009/01/ 06:09:16~2009/01/ 06:10:07	(国)36 4.799KP ~ (国)36 4.297KP	凍結防止剤	20	5.0
2009/01/ 06:10:53~2009/01/ 06:12:21	(国)36 4.296KP ~ (国)36 3.485KP	凍結防止剤	25	5.0
2009/01/ 06:13:07~2009/01/ 06:14:56	(国)36 3.481KP ~ (国)36 2.391KP	凍結防止剤	25	5.0
2009/01/ 06:15:43~2009/01/ 06:16:00	(国)36 2.384KP ~ (国)36 2.279KP	凍結防止剤	25	5.0
2009/01/ 06:16:00~2009/01/ 06:16:21	(国)36 2.279KP ~ (国)36 2.127KP	凍結防止剤	30	5.0

- Acquisition of application records in CSV format
 - ➡ Can be used for preparing daily reports on de-icer application.
- Difference between amounts in daily application reports and those calculated by the system
 - ➡ Further studies will be conducted on possible causes.

SYSTEM USE CONDITIONS AND QUESTIONNAIRE SURVEY 1

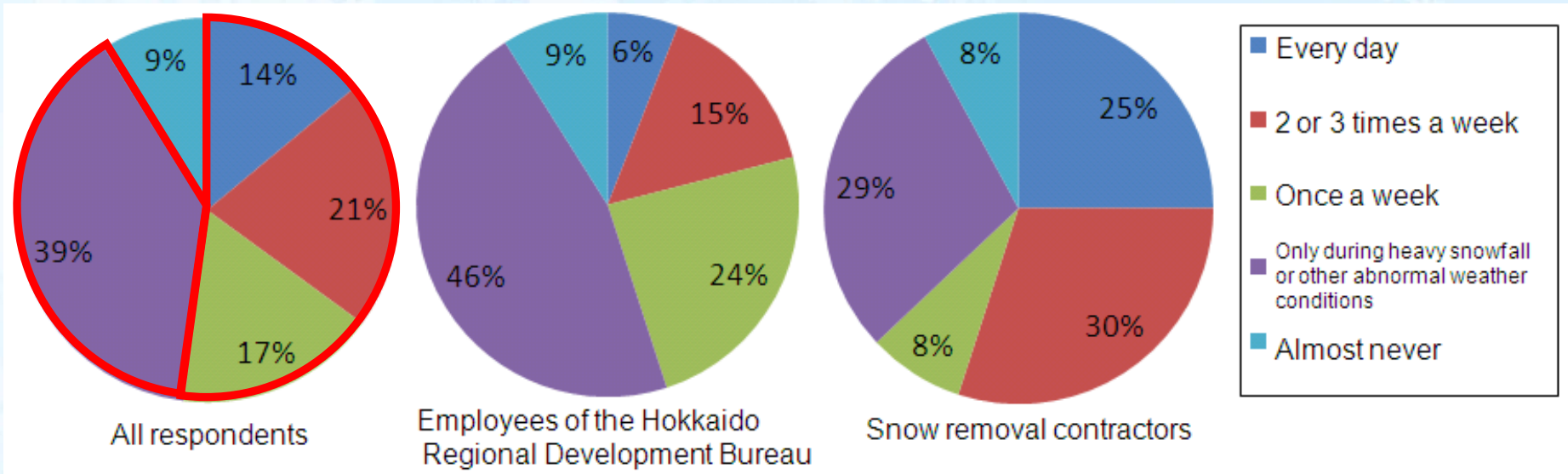


- Investigation of the number of accesses

The number of accesses was **higher on days with large amounts of snowfall.**

The screens for monitoring operation conditions and snow removal machinery locations were frequently used.

SYSTEM USE CONDITIONS AND QUESTIONNAIRE SURVEY 2



- System usage frequency

Those who used the system every day to once a week accounted for 52% of the total. Users including those taking advantage of the system only during heavy snowfall accounted for 91%.

This shows that **location information is used in practice.**

- Purpose of using the system

Monitoring of locations and operation conditions of snow removal machinery in local and other sections.

SYSTEM USE CONDITIONS AND QUESTIONNAIRE SURVEY 3

- Examples of system usage

Location of a snow removal machine operating nearby to **lead ambulances during heavy snowfall.**

Direction for support following judgment from the system of a delay in snow removal **in the adjoining section.**

- Requests for system improvement

There were **many requests concerning the slowness** of the system.

Many users also asked for **the display of weather observations, traffic regulations and roadside camera image data as an additional function.**

CONCLUSION

- This system enables supervisors and contractors in adjoining sections to **monitor the progress of snow removal in each other's areas.**
- **The operation efficiency of snow removal can be improved by shifting section boundaries to support sections with delays, as such support reduces congestion loss caused by snow removal.**
- The system also enables **monitoring of detailed information on de-icer application, and such information can be used as basic data to set guidelines** for appropriate application.
- Future plans include the promotion of system development to enable more efficient support for snow removal machinery operations and efficient road maintenance and management.