EFFICIENT WINTER ROAD MANAGEMENT USING A CONTACT AREA INFORMATION SENSING (CAIS)-BASED ROAD SURFACE CONDITION JUDGMENT SYSTEM

Tomonori Ohiro
Techno Center
Nexco-Engineering Hokkaido Co., Ltd., Japan
t.ohiro.sa@e-nexco.co.jp

Kiyoshi Takakura
Maintenance Department
Nexco-Maintenance Hokkaido Co., Ltd., Japan

Tadashi Maruyama
Hokkaido Regional Head Office
East Nippon Expressway Co., Ltd., Japan

Hiroshi Morinaga
Central Research Research Department VII
Bridgestone Corp., Japan

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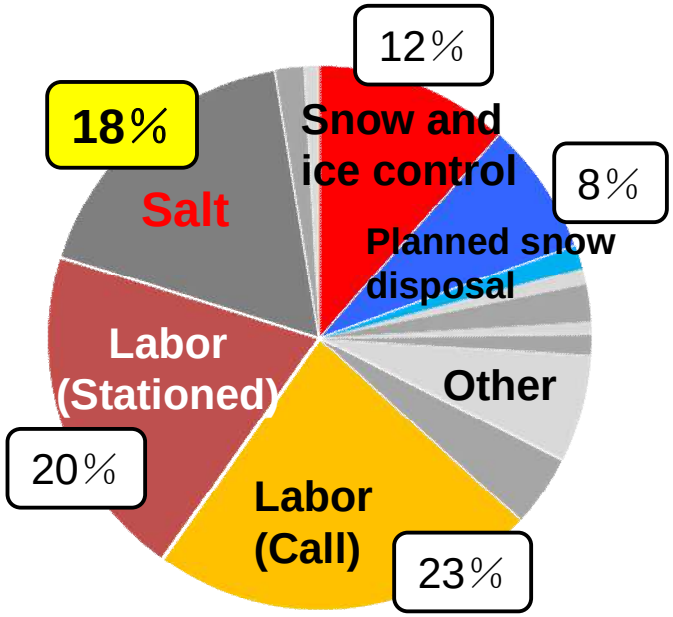
1. Background

- FY 2012 Outline of snow- and ice-control expenditures in Hokkaido

(1) FY 2012 Breakdown of snow- and ice-control expenditures in Hokkaido

(2) Salting cost (only for salt)
＝18% of total expenses

Rapid increase in salt price
FY 2011□FY 2012＝70％ increase
FY 2013: 8％ increase



Breakdown of snow- and ice-control expenditures in Hokkaido

- Salting is indispensable for safety, however...
- □ Adverse effects on road structures

Salt reduction is an urgent task

2. Objectives

- Idea: Mitigate adverse salt effects, reduce snow- and ice-control costs

(1) Immediate task: Reduce salt use. (Reduce costs.)

Salt spreader cannot keep the leftover salt. (Salt becomes clogged.)

- Pre-loading decision on loading salt (to avoid left-over salt)
- Effective salt reduction by optimal salting that meets road conditions

(2) In future

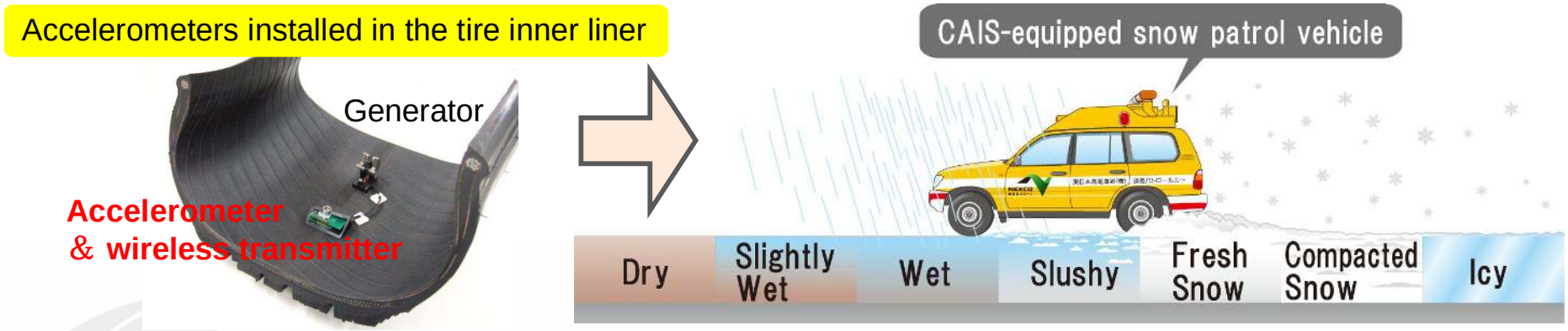
- Automated salting for operation without a driver's assistant (labor cost reduction)

3. Road Surface Condition Judgment System(RSCJS)

- Tire sensor technology is being developed by a tire company.
- The road surface is classified into seven conditions in real-time.
- Only one type and size of tire is used for snow patrol vehicles.

  Calibration is made from the results.

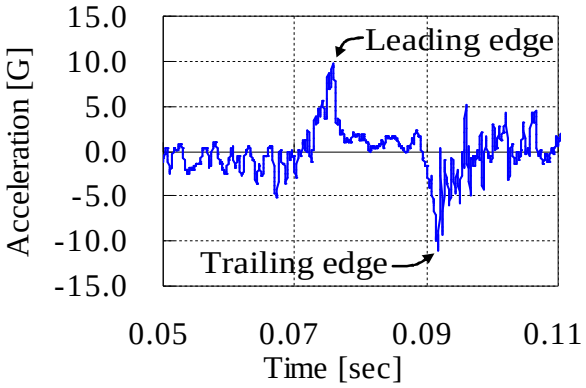
  □ Classify ambiguous conditions into the more hazardous category.



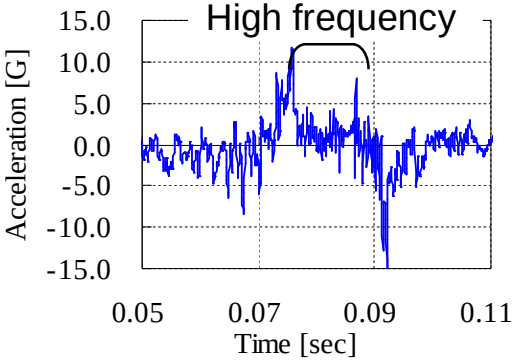
CAIS (Contact Area Information Sensing)® technology:
The name of a tire sensor technology that is based on the analysis of signals from a sensor installed in the inner liner

【Flow for classifying the road surface condition 】

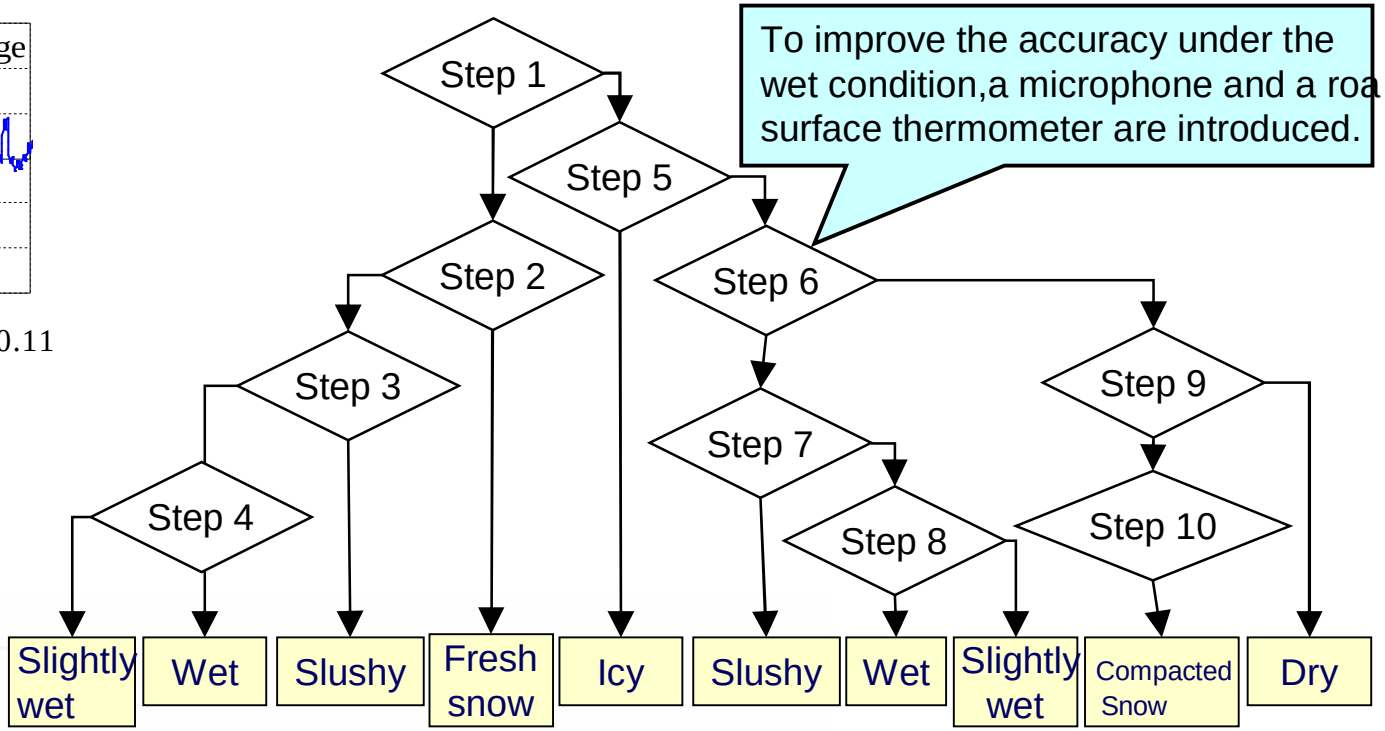
- Need to readjust the discrimination parameters for each tire



dry



icy

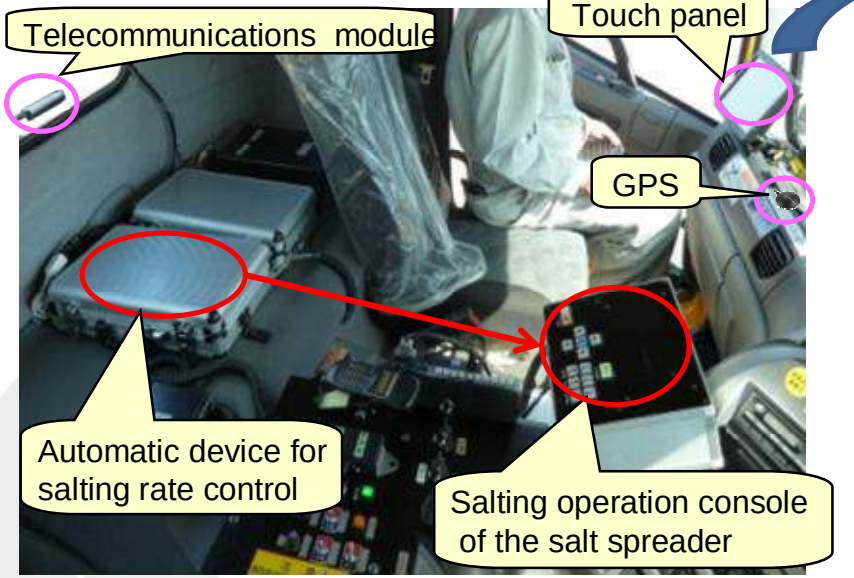


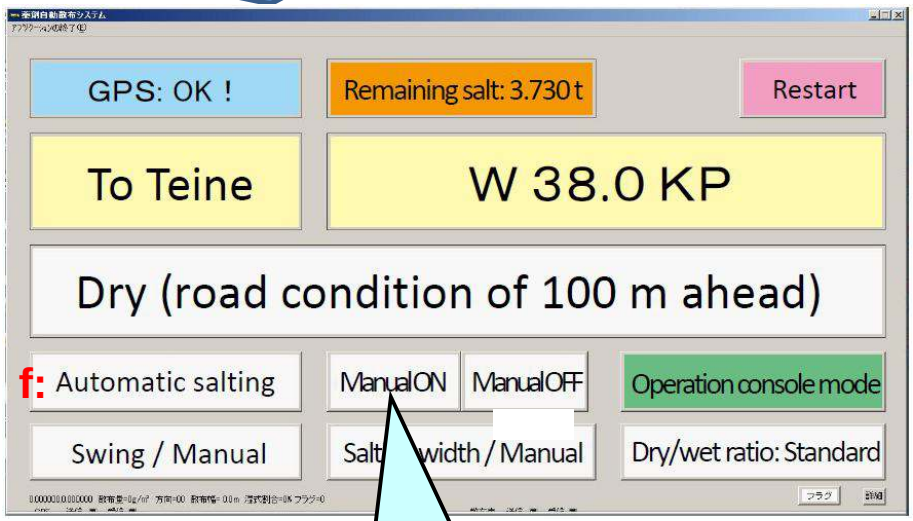
Flow of salt application

Classify the road surface into seven conditions based on visual observation.

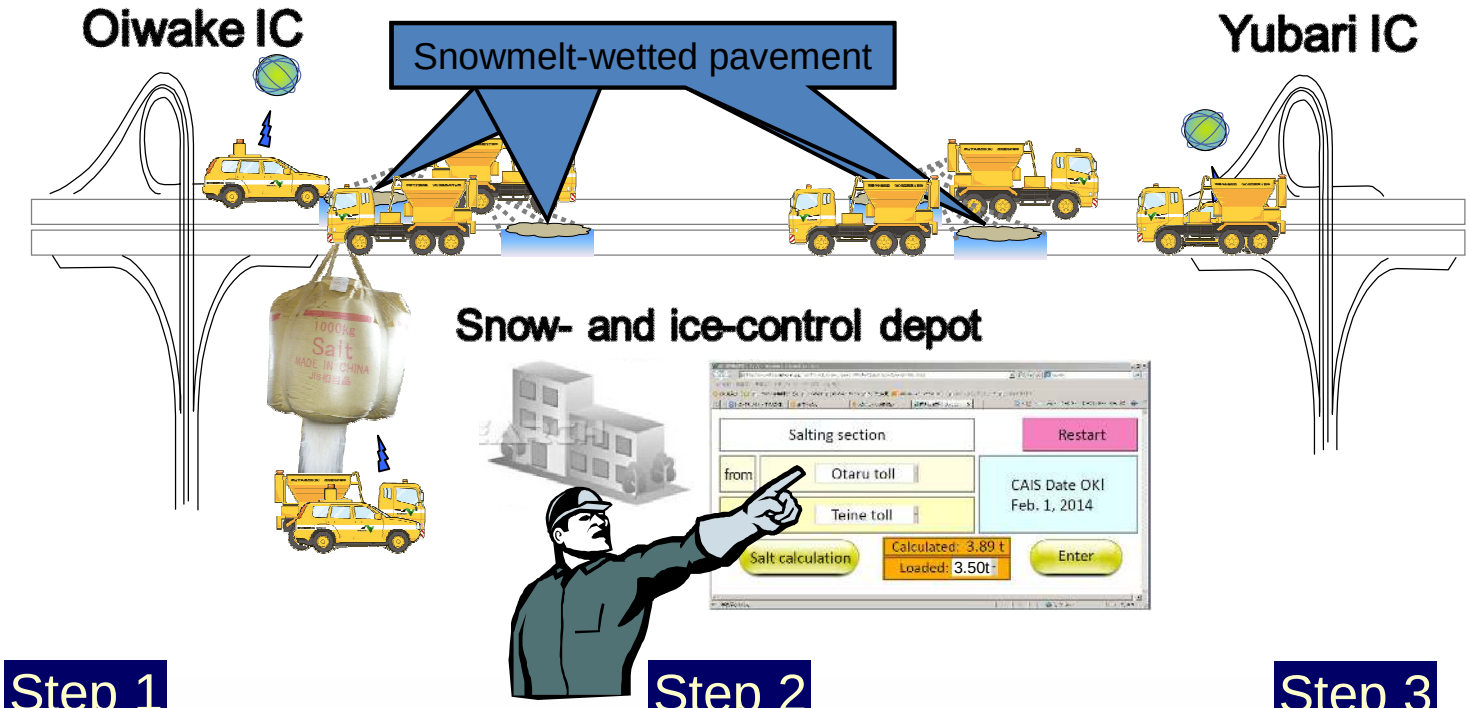
4. Automatic salting control system(ASCS)

- Automatic salting control device, touch panel, GPS, telecommunications module
- Automatic salting rate control by the serial connection between the automatic device
  for salting rate control and the salting operation console of the salt spreader
- Data input using the touch panel of the spreader (capable of real-time processing)





5. Optimum spreading method



Step 1

CAIS-equipped snow patrol vehicle makes a pre-salting trip.
- Constructing a Web-database in real time

Step 2

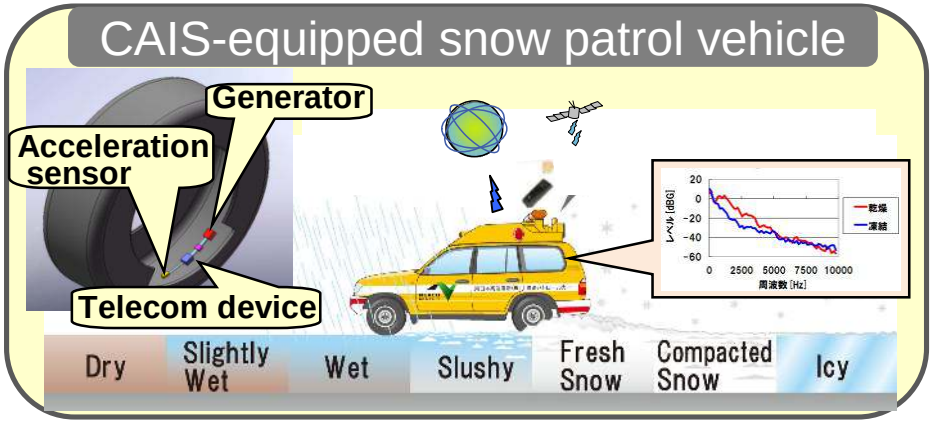
Control device on spreader telecommunicates via web with the server to pre-determine salt loading amount.

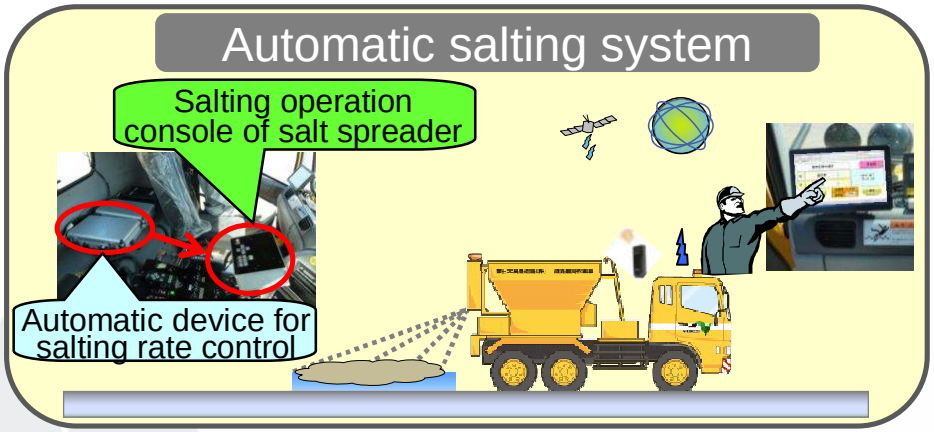
Step 3

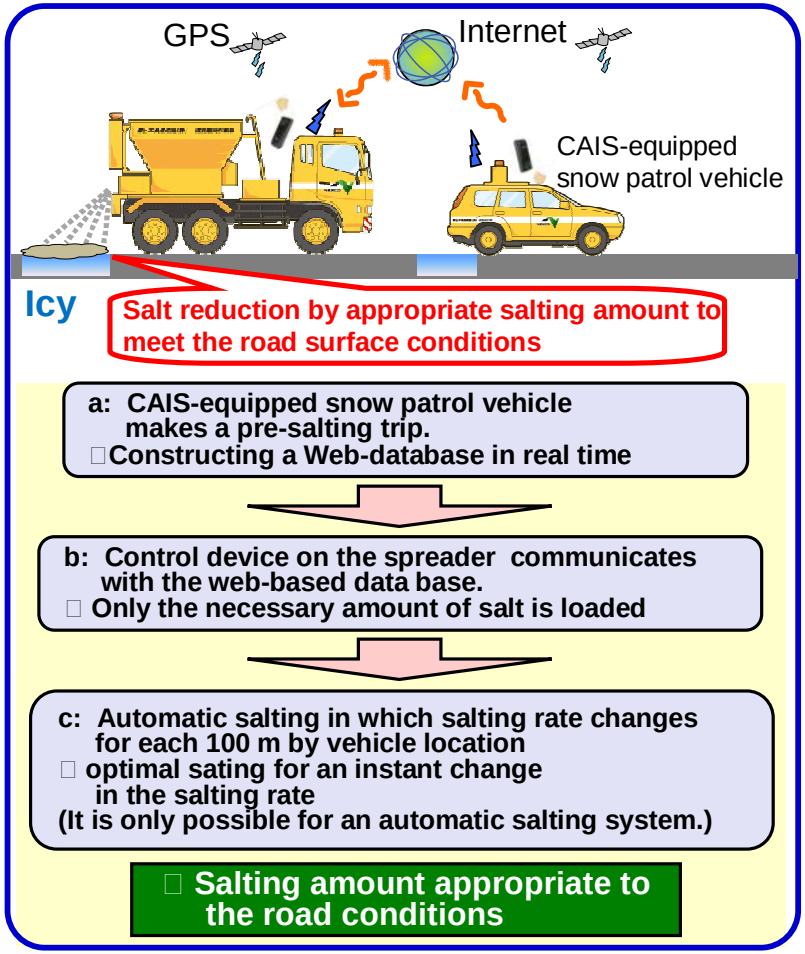
GPS location system facilitates salting rate changes with 100-m precision.

Optimal salting only where necessary Reductions in salting amount

5. Optimum spreading method







Optimal salting＝CAIS-equipped snow patrol vehicle ＋ Automatic salting system

6. Field verification test

- 2012 Winter automatic field salting test at some locations of pavement wetted by snowmelt from nearby snow piles

Pre-salting trip determines the road surface conditions and sends the data to the server via the web.

Only the necessary amount of salt is loaded, and salting is automatic.

(1) Test section: Oiwake IC - Yubari IC (Eastern Hokkaido Expressway), Sapporo W. IC - Asari IC (Sasoon Expressway)

(2) Date: Mar. 27 (Wed.), Apr. 4 (Thur.), Apr. 10 (Wed.)

(3) Contents: Confirmation

a: The spreader salt only snowmelt-wetted pavement.

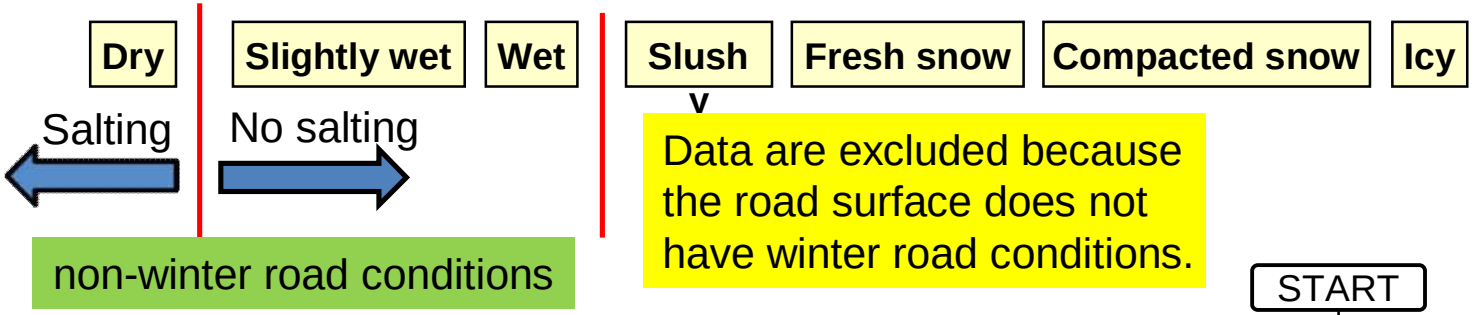
b: The salting amount was the same as pre-calculated.

c: How the salting operation by Automatic Salting-Control System compare with salting decision by visual observation?

Test with a simple algorithm

- Simple salting control: engaged or disengaged

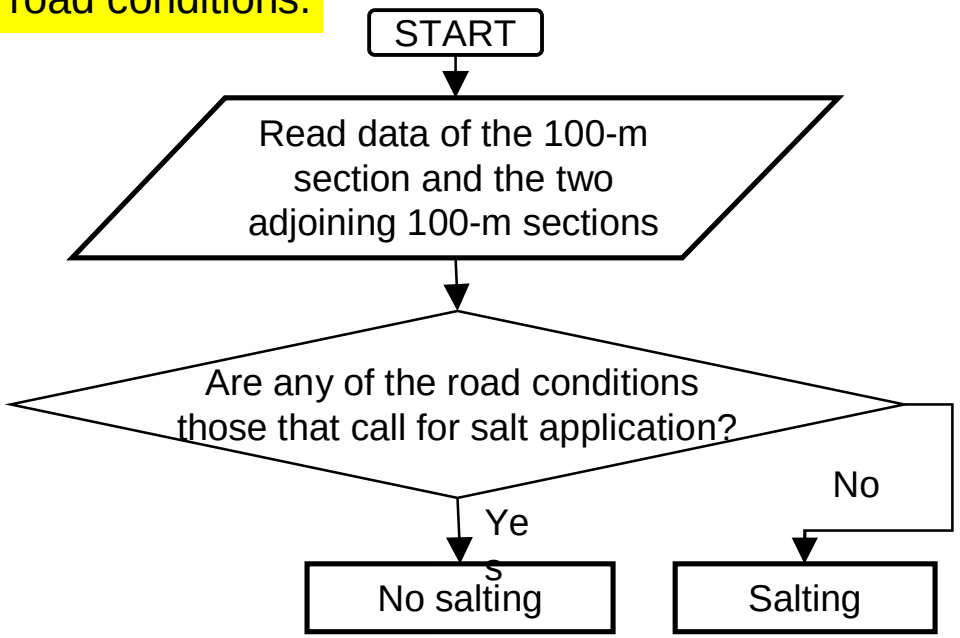
(1) Salting decision-making



(2) Flow of salt application

a: Classify into a safer classification
- Additional salting of 100 □ on both sides of wet pavement sections

b: Change salting rate automatically every 100 m using the GPS-based vehicle location system



【Automatic salting test】

【Test results】

1. Did the system salt only on pavement wet by snowmelt?
   - Yes. The three tests were successful.
2. Was the salting rate as planned?
   - Mar. 27; Salt applied： 0.50 t ≒ Calculated amount of salt： 0.49 t
   - Apr. 10； Salt applied： 0.24 t ≒ Calculated amount of salt： 0.23 t
   - Roughly the same as planned
3. Automatic salting vs. manual salting (decision made by an assistant operator)
   - Apr. 4； Manual salting ： 0.18 t ＜ a: Additional salting on the 100-m sections on both sides of snowmelt-wetted pavement: 0.22 t ＞ b: Automatic salting only on the snowmelt-wetted pavement： 0.13 t ≒ c: 100 m section preceding the snowmelt-wetted pavement + the snowmelt-wetted pavement: 0.19 t

Note: A skilled assistant operator applies salt from the section preceding that of snowmelt-wetted pavement.

- By modifying the salting settings, salt use can be reduced to simulate a skilled assistant operator.

7. Optimum spreading method

- Optimal salting realized by automated salting

Assuming salting conditions that meet the road surface conditions

Dry	Slightly wet	Wet	Slushy	Fresh snow	Compacted snow	Icy
Salting	Salting with varied salting rate and wet/dry salt ratio			Salting	Without salting	

Plan for optimal salting decision-making (draft)

Road surface condition	Dry	Slightly wet	Wet	Slushy	Fresh snow	Compacted snow/ice (standard)
a: Salting rate (g/㎡)	No	15.0	15.0	18.0	No	20.0
b: Solid salt (g/㎡)	No	12.0	13.8	14.0	No	14.2
c: Salt brine (g/㎡)	No	3.0	1.2	4.0	No	5.8
d: c/a (%) (c/a×100)	No	20	8	22	No	29

【Actual salting rate vs. optimal salting rate】

№	Date	Section	Actual salt application amount		Calculated optimal salting amount (theoretical)		Road surface condition
		KP	Solid (dry salt)	Brine	Solid (dry salt)	Brine	
a	14:00~15:30	32 - 42	2.2 t	0.8 m^3	2.0 t	0.7 m^3	icy/compacted snow: 98%
b:	17:00~18:30	53 - 67	3.1 t	1.1 m^3	3.0 t	0.3 m^3	Wet: 85%
c:	17:00~18:30	32 - 53	4.8 t	1.6 m^3	2.2 t	0.3 m^3	Dry: 54% Wet: 27% Slightly wet: 17%

a: No difference in salting amount was observed for the icy road surface.

b: For the wet road surface, no difference can be expected for the use of solid salt, but brine can be reduced.

c: When there is a high percentage of dry surface over the entire road section, salt reduction by optimal salting can be expected.

8. Conclusion

(1) Field tests have proven the system (CAIS＋automatic salting system) effective for salt reduction.

(2) Calculations show that salt application can be reduced by optimal salting.

Setting opimal sating rates realizes highly controlled salting that delivers higher safety and less cost, for effective winter

This winter, automatic salting field tests have been made in midwinter to clarify the salt reduction and effectiveness of the automatic salting system in addressing various road conditions.

Thank you!

【Accuracy of road condition classifications】

Tire No.		1	2	3	4	5	6	7	8
Accur-acy	Dry	98.8%	92.6%	95.0%	82.9%	74.9%	94.8%	90.3%	94.1%
	Ice	85.6%	93.5%	75.3%	83.5%	89.2%	94.5%	81.1%	88.1%
	Snow	80.8%	85.5%	83.0%	78.8%	59.2%	82.1%	78.0%	96.4%

- Despite discrepancies in the tire properties, the accuracy is about 85%.
  - For the tire sensor, the relationship between sensor measurement and road condition discrimination holds only for a tire of the same size and type installed on the same type of vehicle.

【Durability: 2012 Winter test results】

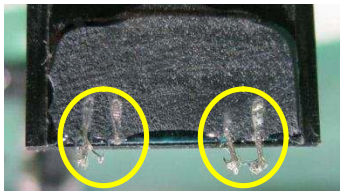
- A large load is exerted on the sensor-installed tire when the vehicle travels over crunching ice, rumble strips and ditches.

Ditches

Crunching ice

Rumble strips

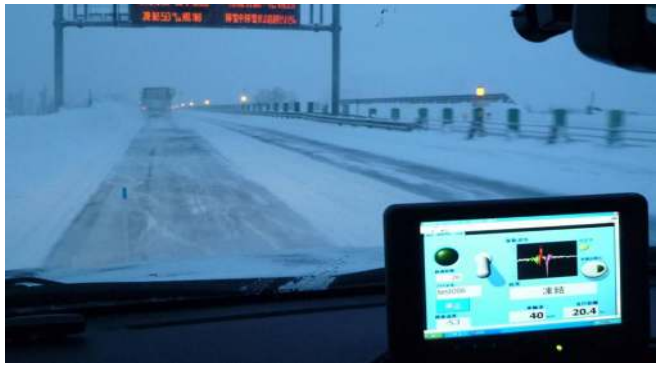
Driving speed: 65 km/h



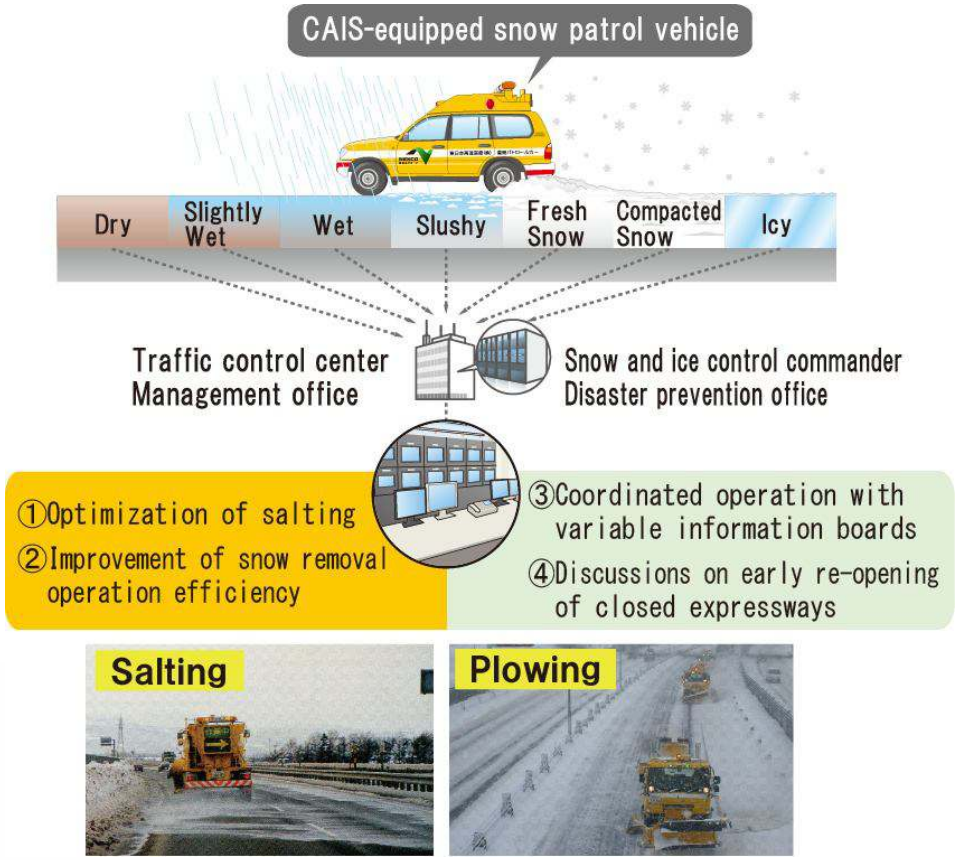
Broken wire

Wires in the tire frequently break from abnormally severe impact.

【Uses of CAIS】

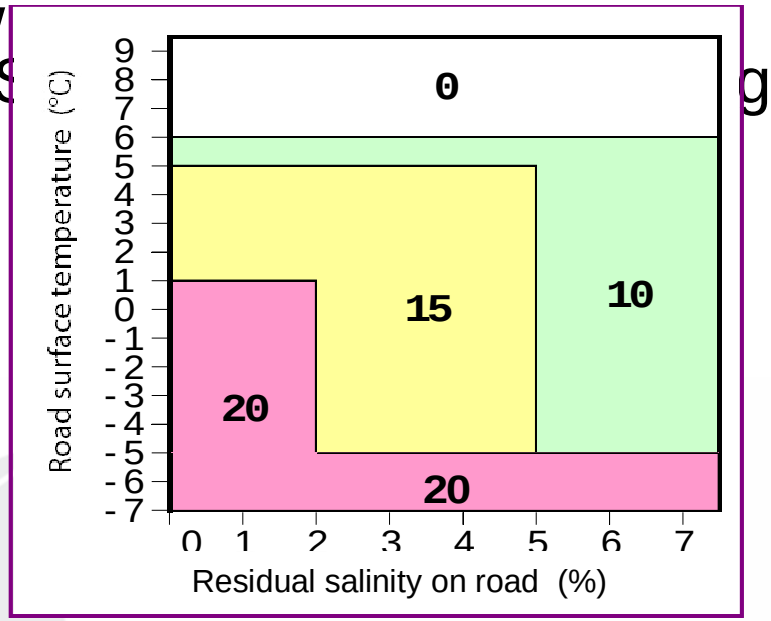


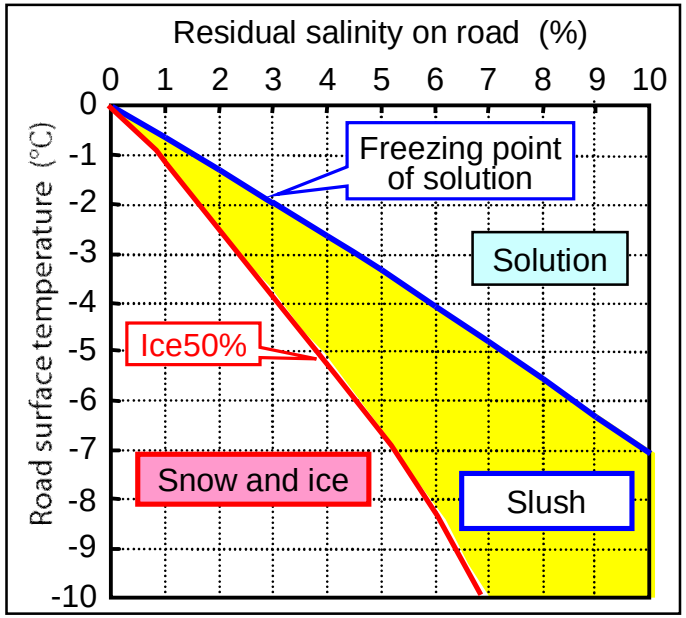
Currently, CAIS is planned to be used for the following four items:
(1) Optimization of salting
(the objective of this study)
(2) Improvement of snow removal operation efficiency
(3) Coordinated operation with the variable information boards
(4) Discussions on the early re-opening of closed expressways



【Salinity on the road】

- When residual salinity on the road is low
  - Salting rate needs to be higher
- When road surface temperature is low
  - S gher





Rd.surf.temp.	Salinity of brine(total salinity)
-2℃	2.5% (5%)
-5℃	5% (10%)
-8℃	8% (15%)

Determine optimal salting rate from the relationship between the road surface temperature and the residual salinity on the road.

Q&A

Q：路面状態を把握してから凍結防止剤を自動散布するまで
タイムラグがあると思いますが支障はありませんか？

Q: Is there a problem with the time lag between patrol and salting?

A：　凍結防止剤の自動散布は、雪氷巡回後、1～1時間30分程度タイムラグが生じますが、厳冬期であれば路面状態が著しく変化することは少ないと考えています。

A: Salting is done about 60 to 90 minutes after the snow patrol. In midwinter, the road conditions don't change much in that time, so we don't see much of a problem.

Q：製品化しておりますか？ 価格を教えて下さい。

Q: Do you have any plans to make the system commercially available? How much will it be?

A：製品化や価格設定はこれからです。
今冬期の実地検証が終わった後、どの程度課題が解決できているか？
新たな課題が発生していないか？ を把握し設定して行きたいと考えております。

A: We haven't decided yet when to do with it. After the tests this winter, we'll see how many of the issues we've been able to solve and whether there are any new issues. Then we'll think about commercialization.

Q&A

Ｑ：本システムにより、どの程度凍結防止剤を削減できると予測していますか？

Q: How much salt can be reduced by this system?

Ａ：路面状態に応じて凍結防止剤の散布量や散布幅を変化させ、きめ細かく散布のＯＮ/ＯＦＦを繰り返すことにより、目標として2割削減したいと考えております。

A: We've set a target of 20% reduction. This can be realized by changing the salting rate and width and by frequently turning the spreader on and off, according to the road conditions.

Ｑ：特許を出願していますか？

Q: Have patented the technology?

Ａ：ＣＡＩＳで判別した路面状態に応じて凍結防止剤の散布量を変化させて自動で散布するシステムとして㈱ブリヂストンと共同出願しております。

A: Yes, we've patented it jointly with the tire sensor manufacturer. The patent is for an automatic salting system that varies the salting rate based on the road conditions as determined by CAIS.