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XIII INTERNATIONAL WINTER ROAD CONGRESS

QUÉBEC, FEBRUARY 8 TO 11, 2010

WORLD ROAD ASSOCIATION
MONDIALE DE LA ROUTE
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Québec

SUSTAINABLE WINTER SERVICE FOR ROAD USERS

Assessment of Winter Road Traffic Performance using Taxi Probe Data

Kazunori Munehiro, Ph.D

CERI, PWRI, JAPAN

Senior Researcher, Traffic Engineering Research Team

k-munenehiro@ceri.go.jp

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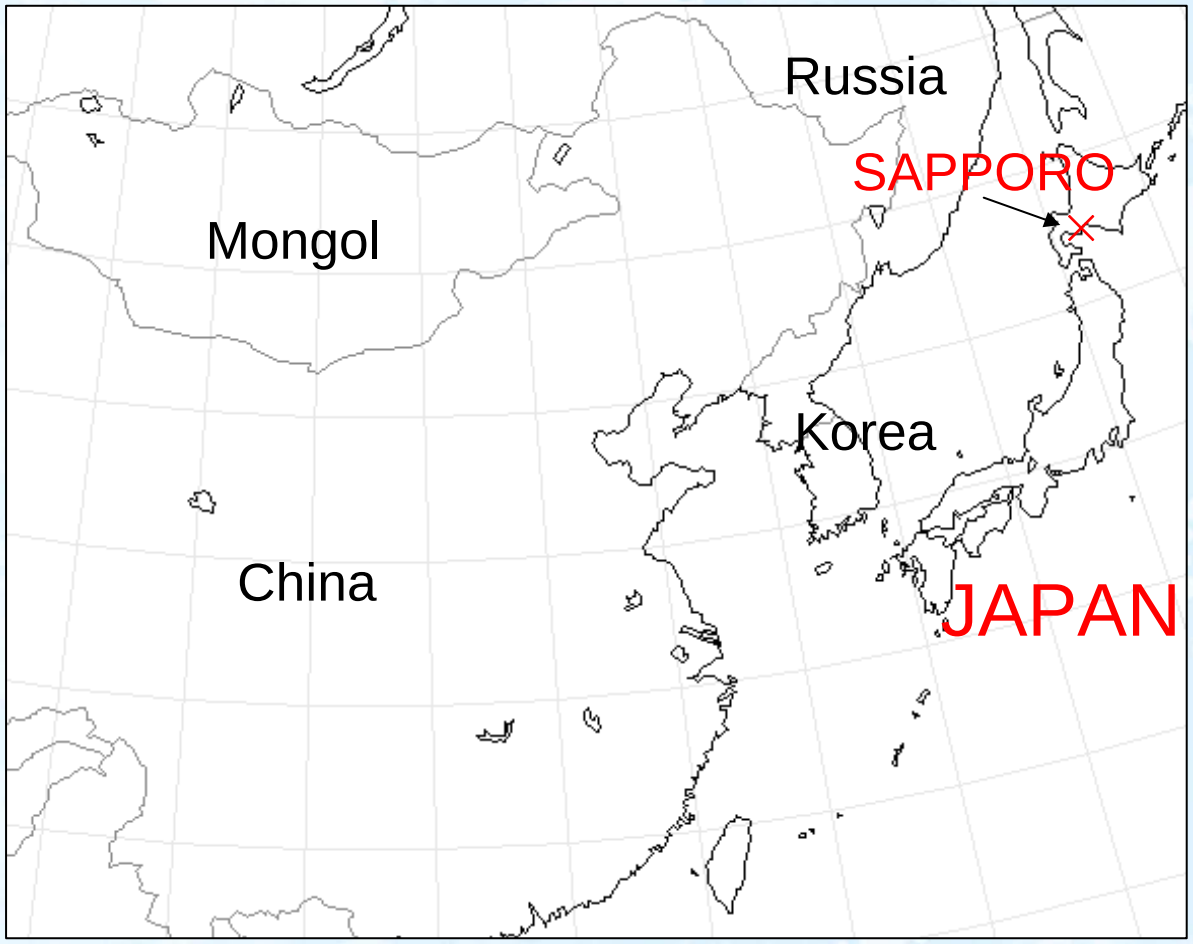
OUTLINE

1. **Introduction**
2. **Methods**
3. **Study Results**
   - -Annual changes in ATS (Average Travel Speed)
   - -Calculation of the time loss due to traffic congestion in winter
4. **Consideration**
   - -Benefits of Winter Road Management Operations
   - -Considerations of Adequate Winter Road Management Service
5. **Conclusion**

INTRODUCTION



-Sappro City is lacated in 42°North latitude 141°East longitude.

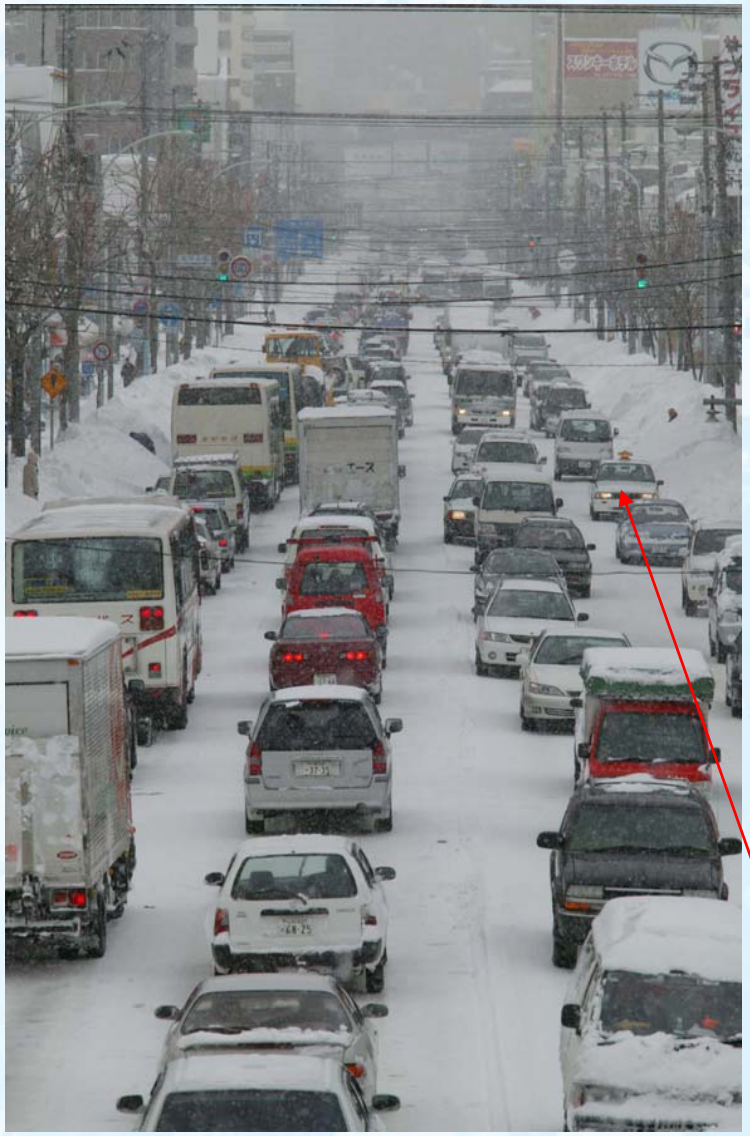
-1.9 million population

-Annual mean temp. is 8.5℃.
Mean temp.in January is -4.1℃.

-The city is in one of snowiest areas in the world, having the annual snowfall of about 5 meters.

TRAFFIC CONGESTION IN WINTER

[Traffic Jam in Sappro City]



-In cold, snowy regions, **vehicle travel speeds decrease due to snowfall, snow cover and icy road surface.** Traffic congestion in winter is a serious problem, particularly in urban areas.

-We have been studying methods of practically applying **taxi probe data (TPD)**, i.e. floating car data collected from taxis, **such as for monitoring and analyzing winter road traffic conditions.**

Taxi is running.
(365 days and 24 hours)

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OBJECTIVES

1) To analyze road traffic characteristics **using taxi probe data (TPD)**, especially **travel speeds in the snowy season and non-winter season.**

2) To calculate **the time loss due to traffic congestion in winter,** using of average travel speeds in various road sections.

3) To calculate **cost-benefit analysis of snow disposal/hauling** as an example of a winter road management operation.

PREVIOUS STUDIES

1) Yu Liu, Francois Dion, Subir Biswas: “Dedicated Short-Range Wireless Communications for Intelligent Transportation System Applications: State of the Art,” Journal of the TRB No. 1910, 2005.

2) Meenakshy Vasudevan, Karl Wunderlich, James Larkin, Alan Toppen: “Comparison of Mobility Impacts on Urban Commuting Broadcast Advisories Versus Advanced Traveller Information Services,” Journal of the TRB No. 1910, 2005.

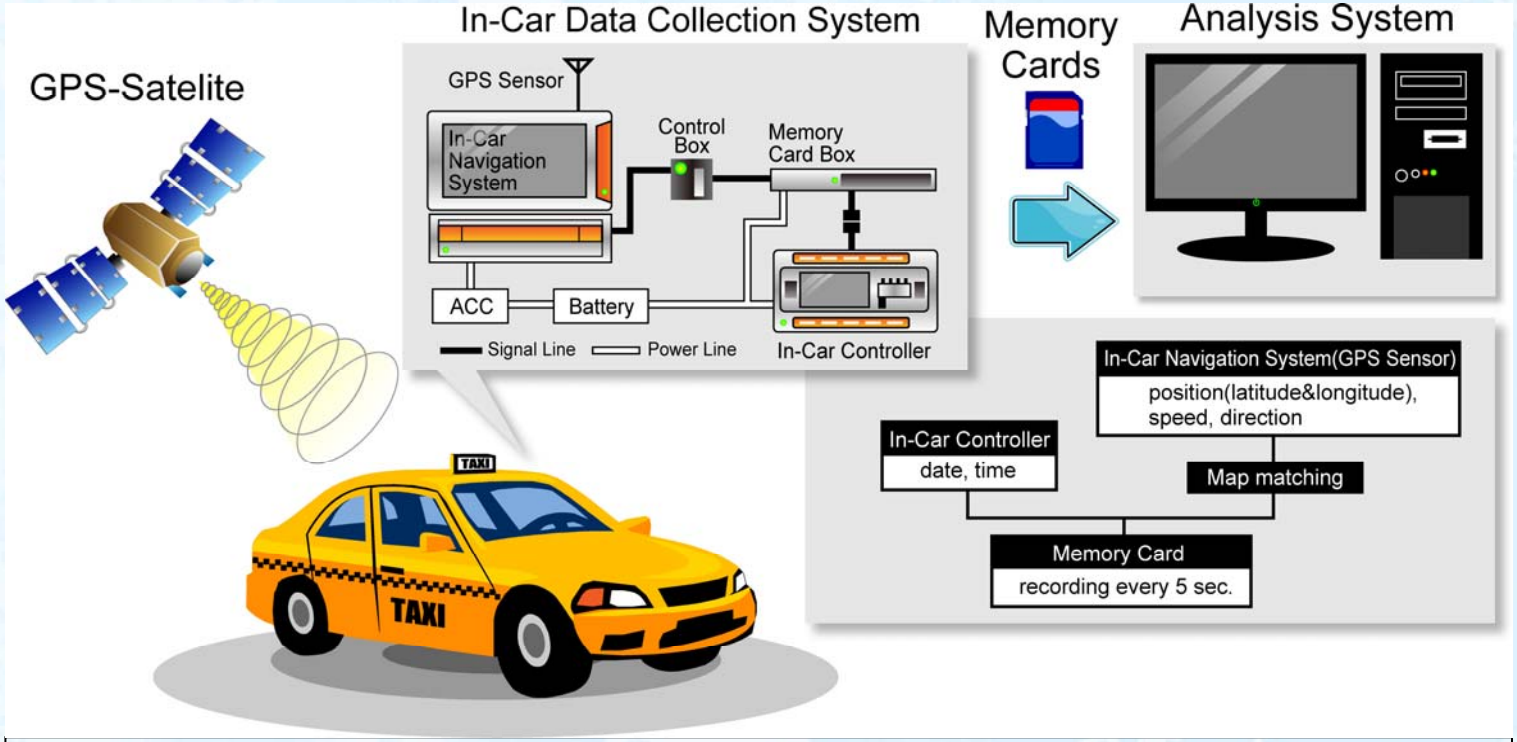
3) Makimura K., Nakajima Y., Sato H., Ishida H.: “Road Performance Measurement Using Car Navigation Systems,” Journal of Infrastructure Planning and Management No. 758, 2004.

And the others.

However, few studies have used probe-car data to examine how winter weather and road surface conditions affect winter road traffic.

METHODS

[Outline of TPD Survey]



-115 Taxies

-Car navigation system for taxies (CU-5890B) + memory card unit

-Compact Flash Card

-Data updating cycle : 5 seconds

-Data items : Date, Time of date, Location (latitude and longitude), Speed, Direction (in 16 directions)

ANALYZING SYSTEM FOR TPD

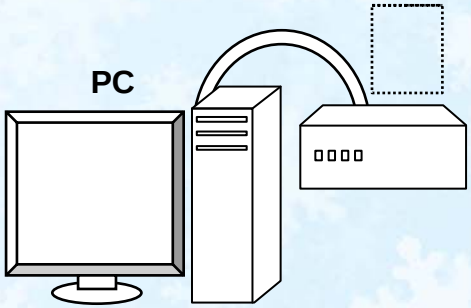
[System for Analyzing Taxi Probe Data]

- Data collected while taxies were not driving (waiting for customers, stopped for a break, stopped to pick up fares, etc.) **are excluded**, **for into the database**.
-**Oracle Database** format is used for TPD into a database.
- A system is used for calculating ATS under various analysis conditions, **winter road traffic characteristics as well as for assessing applied winter road management measures.**

[Database Format]

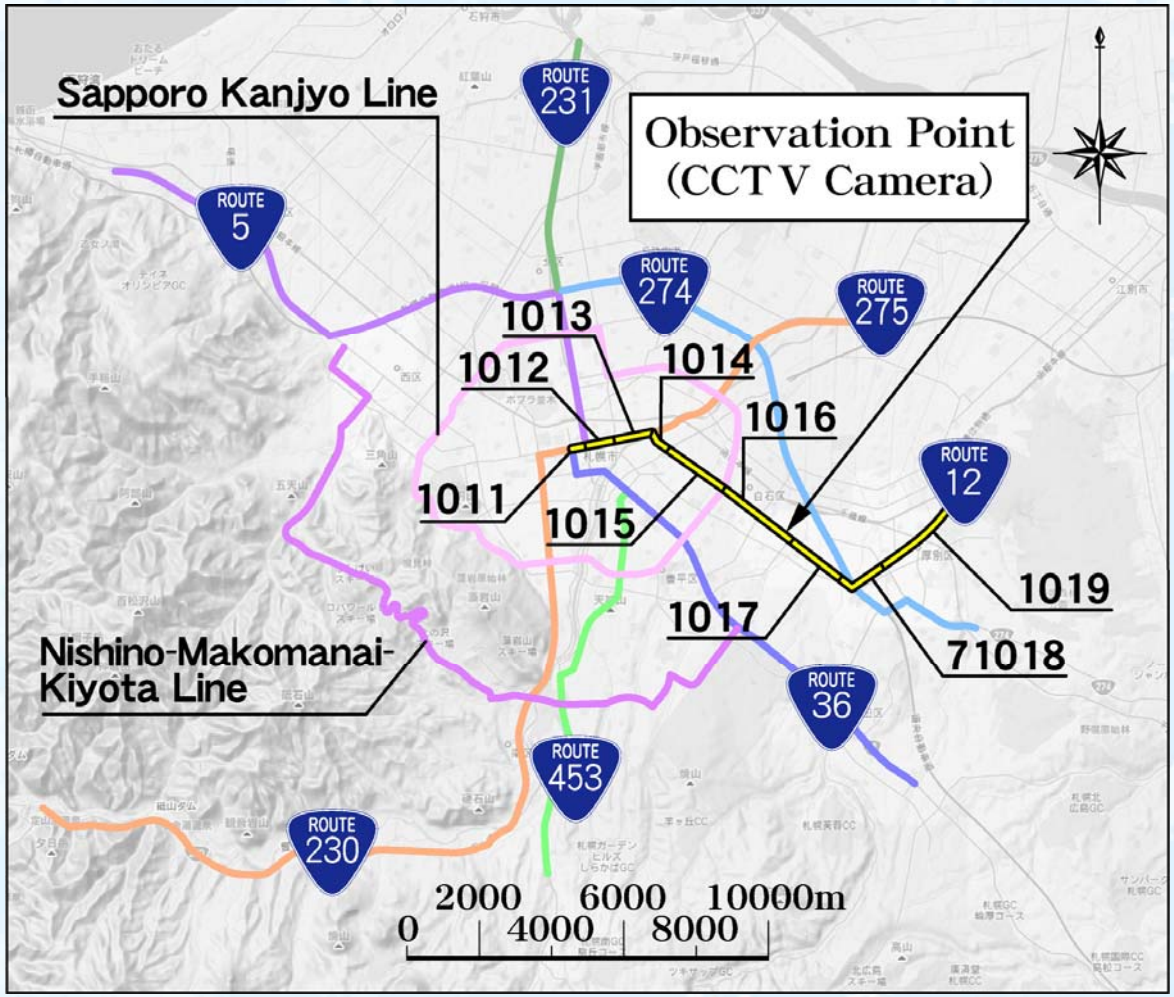
	Date	Time	Latitude	Longitude	Speed	Direction	……
1							
2							
3							
4							
5							
…							
…							
…							
n							

Database using Oracle software



SURVEY SITE

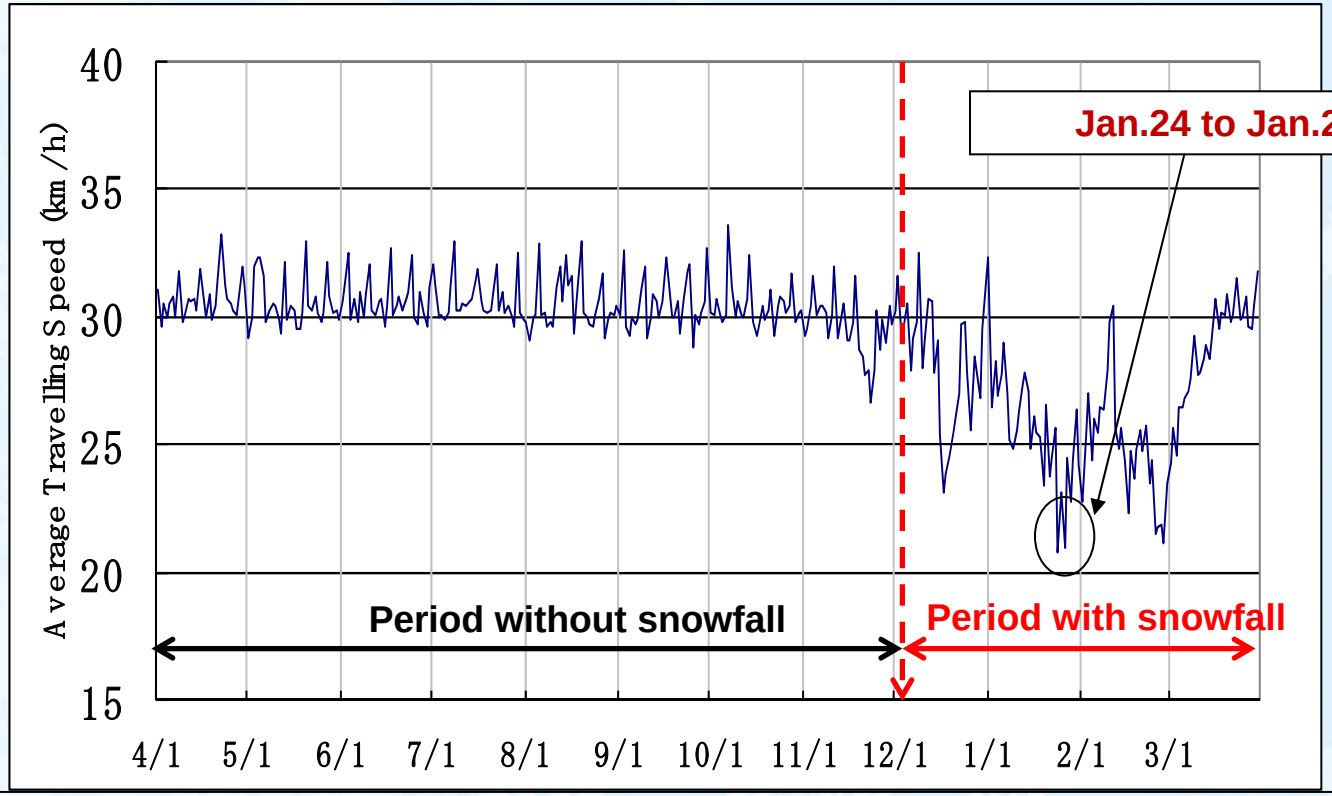
[Target Roads : Urban Sapporo Area]



STUDY RESULTS

Annual Changes in ATS between April 1, 2007 and March 31,2008

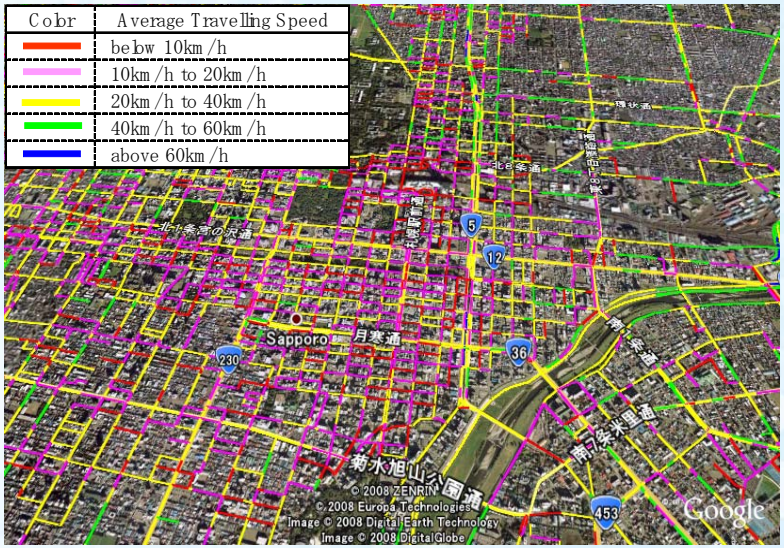
ATS for 12 hours, Including national, prefectural and municipal roads



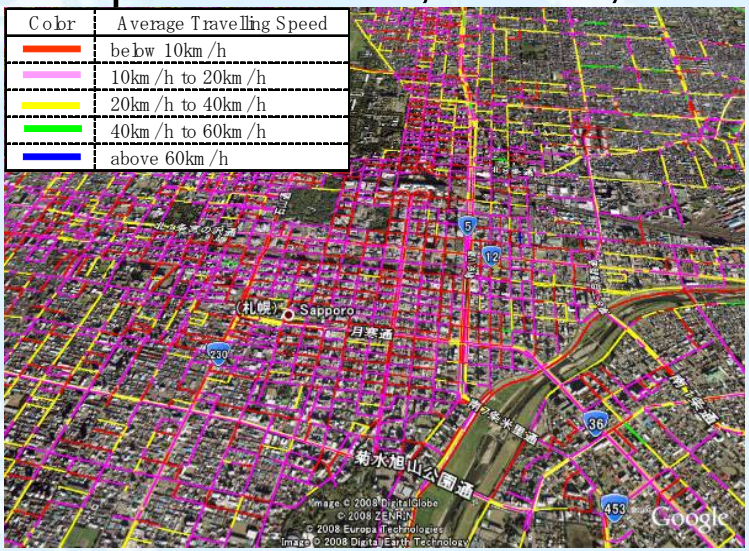
1) Between April and November, the ATS was roughly 30 km/h.
2) The ATS began to decrease in early December, and it stayed at around 25 km/h between December and February.
3) In the winter period, the ATS changed greatly from day to day. Particularly between Jan. 24 and 26, the ATS decreased significantly due to a heavy snowfall event of 10~30 cm in the

ATS FOR 12 HOURS IN THE INNER-CITY AREA

[Dry,Oct.24, 2007]



[Compacted Snow, Jan.24, 2008]



[CCTV Camera in Route 12]

[CCTV Camera in Route 12]

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ATS FOR 12 HOURS IN THE INNER-CITY AREA

[Compacted Snow, Jan.24, 2008]

Color	Average Travelling Speed
	below 10km/h
	10km/h to 20km/h
	20km/h to 40km/h
	40km/h to 60km/h
	above 60km/h

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CALCULATION OF THE TIME LOSS DUE TO TRAFFIC CONGESTION IN WINTER

$$T_L = \sum \left(\frac{L_S}{V} - \frac{L_S}{V_{STD}} \right) \times Q_S \times N_{Ave}$$ .....Equation (1)

L_S: Road section length (km)

V: Travel speed (km/h)

V_{STD}: Standard travel speed (km/h)

Q_S: Road section traffic volume (vehicles)

N_{Ave}: Average number of persons in a car (persons/car)

By The Manual for Calculating the Present-State Values of Major Indicators (Draft) issued by the MLITT, JAPAN.

L_S: Length of each road section

V: 12-hour ATS in winter

V_{STD}: 12-hour ATS in autumn

Q_S: Traffic volume in a road section

N_{ave}: 1.3 persons/passenger car; 17.6 persons/bus; 1.2 persons/small freight truck; 1.2 persons/standard freight truck

TIME LOSS DUE TO TRAFFIC CONGESTION IN WINTER （R12）

[No. of road section]

	1011	1012	・・・	・・・	・・・	・・・	・・・	・・・	1019
ATS in autumn	**19.1**	**28.0**	・・・	・・・	・・・	・・・	・・・	・・・	**40.5**
ATS in winter	**15.2**	**25.4**	・・・	・・・	・・・	・・・	・・・	・・・	**39.4**
(ATS in Dec.)	16.7	26.6							40.7
(ATS in Jan.)	15.5	24.2							38.4
(ATS in Feb.)	14.0	23.5							36.3
(ATS in Mar.)	14.4	27.3							42.3
Road section length (km)	**0.4**	**0.8**	・・・	・・・	・・・	・・・	・・・	・・・	**1.0**
Traffic volume (vehicles)	**36,416**	**38,140**	・・・	・・・	・・・	・・・	・・・	・・・	**39,984**
Passenger cars as ratio of all vehicles	0.73	0.69							0.79
Buses as ratio of all vehicles	0.02	0.02							0.02
Small freight trucks as ratio of all vehicles	0.18	0.22							0.12
Standard freight trucks as ratio of all vehicles	0.07	0.07							0.07
Time loss due to traffic congestion in winter (h)	**0.022**	**0.012**	・・・	・・・	・・・	・・・	・・・	・・・	**0.003**
(Time loss in Dec.)	0.003	0.002							0.000
(Time loss in Jan.)	0.005	0.004							0.001
(Time loss in Feb.)	0.008	0.005							0.003
(Time loss in Mar.)	0.007	0.001							-0.001
Time loss in winter (winter periods/road section)	**143,392**	**85,407**	・・・	・・・	・・・	・・・	・・・	・・・	**21,066**
Time loss in winter (winter periods/km)	**358,481**	**106,758**	・・・	・・・	・・・	・・・	・・・	・・・	**21,066**

-Time loss in winter was calculated by Equation (1).

- It is more reliable than winter census data for specific days.

WINTER ROAD MANAGEMENT OPERATIONS

[Plowing]

[Disposal／Hauling]

[Spraying Salt]

-Winter road management operations are such as snow removal, disposal/hauling, spraying salt.
-Benefits of such operations can be calculated by daily ATS from TPD.

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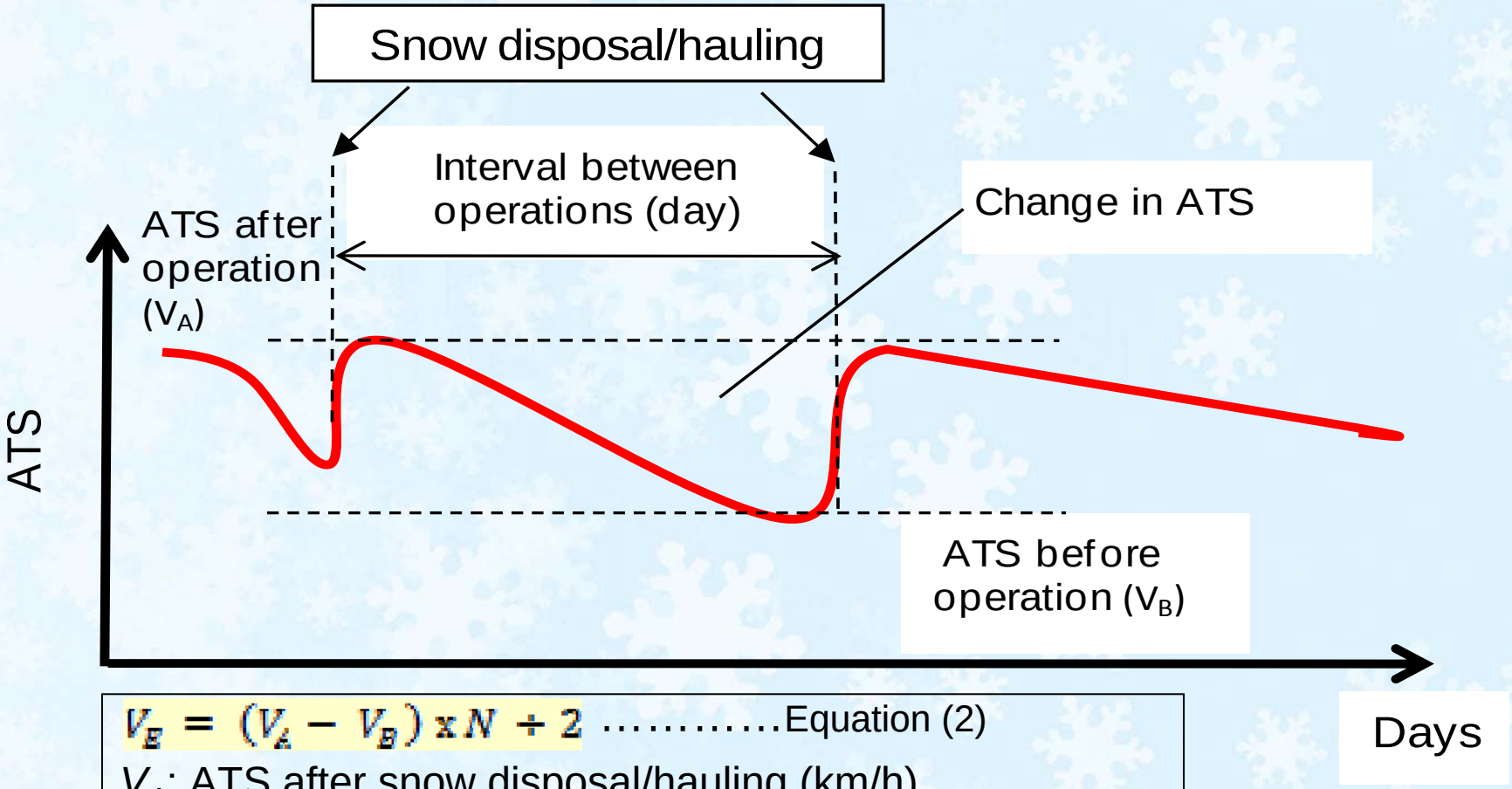
ATS CHANGES AFTER SNOW DISPOSAL AND HAULING



$$V_E = (V_A - V_B) \times N \div 2 \quad \text{.....Equation (2)}$$

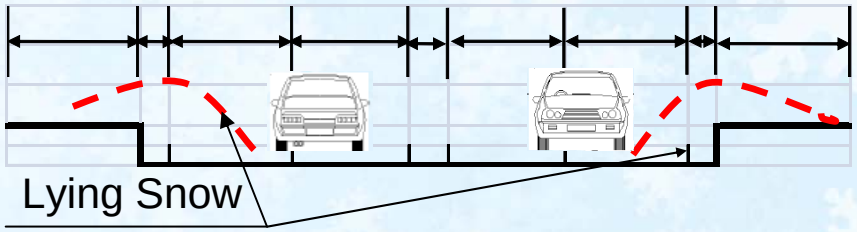
V_A: ATS after snow disposal/hauling (km/h)
V_B: ATS before snow disposal/hauling (km/h)
N: Interval between snow disposal/hauling (days)

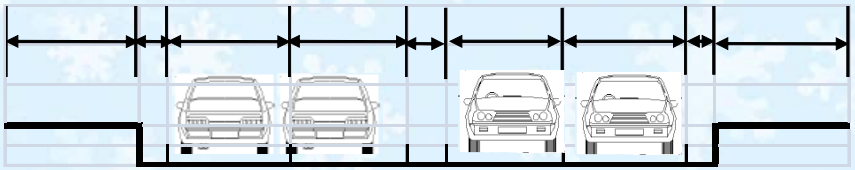
- After snow disposal/hauling, the ATS increases.

TRAFFIC FLOW BEFORE/AFTER OPERATION

[Before Opeartion]

[After Opeartion]





BENEFITS OF SNOW DISPOSAL/HAULING

[Decrease in travel time (BT)]

$$BT = BT_O - BT_W \quad \text{.....Equation (3)}$$

$$BT_i = \sum_i \sum_l \left(Q_{ijl} \times T_{ijl} \times \alpha_j\right) \quad \text{...Equation (4)}$$

BT_i: Total travel cost with snow hauling *i* (yen)
Q_{ijl}: Traffic volume of a vehicle type *j* on road section *l* with snow hauling i (vehicles/day)
T_{ijl}: Travel time of a vehicle type *j* on road section *l* with snow hauling *i* (min.)
α_j: Basic unit value of time for vehicle type *j* (yen/min.-vehicle)
i: ***W*: With snow hauling *i*,**
O*: Without snow hauling *i
j: Vehicle type
l: Road section

[Reduction in travel cost (BR)]

$$BR = BR_O - BR_W \quad \text{.....Equation (5)}$$

$$BR_i = \sum_i \sum_l \left(Q_{ijl} \times L_l \times \beta_j\right) \quad \text{...Equation (6)}$$

BR: Benefit of reduction in travel cost (yen)
BR_i: Total travel cost with snow hauling *i* (yen/year)
Q_{ijl}: Traffic volume of a vehicle type *j* on road section *l* with snow hauling *i* (vehicles/day)
L_l: Length of road section *l*
β_j: Basic unit of travel cost for vehicle type *j* (yen/vehicle-km)

[Benefit of snow disposal/hauling(BH)]

$$BH = (BT + BR) \times N \div 2 \quad \text{...Equation (7)}$$

BH: Benefit of snow disposal and hauling
N: Interval between snow disposal/hauling(days)

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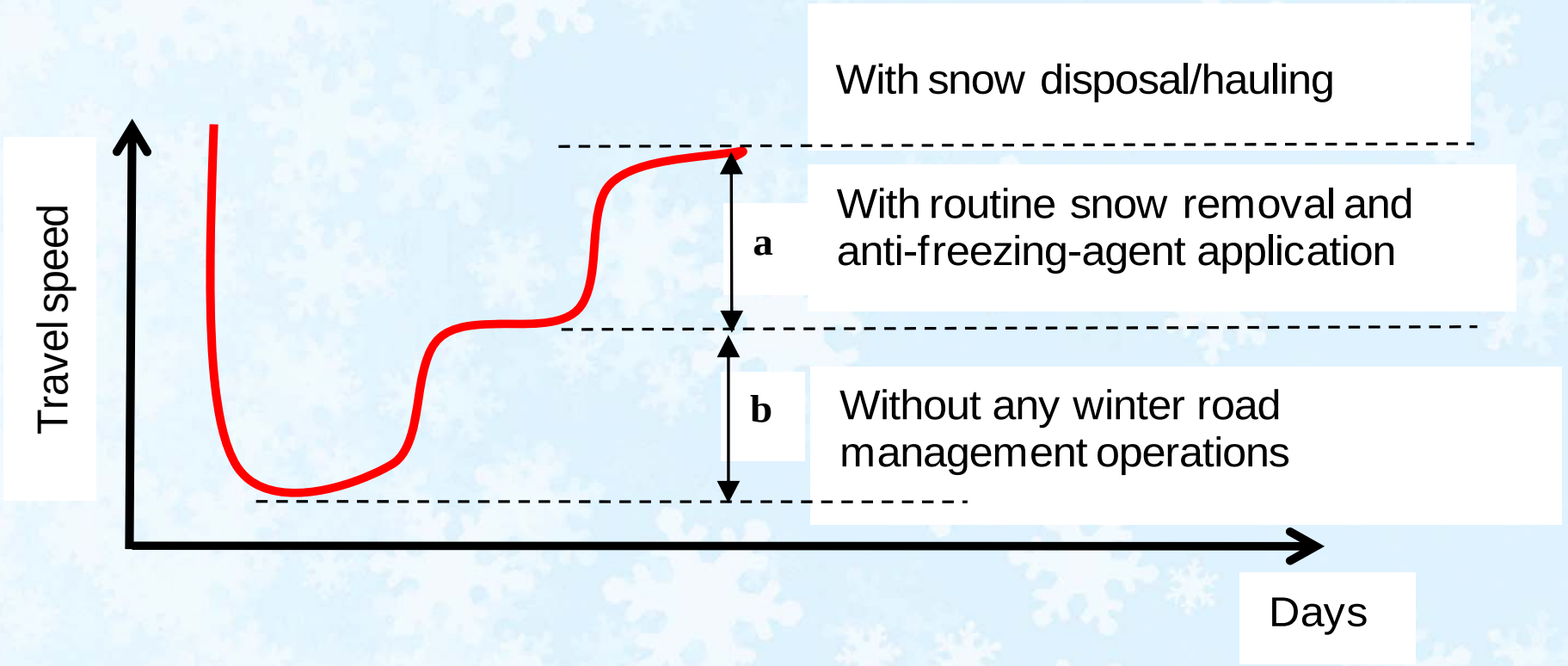
ESTIMATED BENEFITS OF SNOW DISPOSAL/HAULING ON ROUTE 12

[No. of road section]

	1011	1012	・・・	・・・	・・・	・・・	・・・	・・・	1019	Total
ATS before snow disposal/hauling	12.0	21.3	・・・	・・・	・・・	・・・	・・・	・・・	32.5	
ATS after snow disposal/hauling	14.3	23.6	・・・	・・・	・・・	・・・	・・・	・・・	38.4	
Road section length (km)	0.4	0.8	・・・	・・・	・・・	・・・	・・・	・・・	3.9	14.1
Traffic volume (vehicles)	36,416	38,140	・・・	・・・	・・・	・・・	・・・	・・・	39,155	
Passenger cars as ratio of all vehicles	0.73	0.69							0.80	
Buses as ratio of all vehicles	0.02	0.02							0.01	
Small freight trucks as ratio of all vehicles	0.18	0.22							0.13	
Standard freight trucks as ratio of all vehicles	0.07	0.07							0.06	
Reduction in time (h)	0.005	0.004	・・・	・・・	・・・	・・・	・・・	・・・	0.019	0.044
Benefit of reduction in time (BT) (1,000 yen)	830	2,471	・・・	・・・	・・・	・・・	・・・	・・・	6,016	16,202
Benefit of reduction in travel cost (BR) (1,000 yen)	20	57	・・・	・・・	・・・	・・・	・・・	・・・	104	273
BT+BR(1,000 yen)	850	2,528	・・・	・・・	・・・	・・・	・・・	・・・	6,120	16,475
BH=(BT+BR)×N/2 (1,000yen), N=21										172,988
Snow disposal/hauling operation cost (C) (1,000 yen)	532	6,554	・・・	・・・	・・・	・・・	・・・	・・・	27,115	83,709

$$B / C = 172,988 / 83,709 = 2.07 > 2$$

OUTCOME WITH AND WITHOUT WINTER ROAD MANAGEMENT OPERATIONS



-Winter road management operations consists of two steps.

The first is routine snow removal and anti-freezing-agent application (spraying salt) .

The second is snow disposal/hauling operation.

SUSTAINABLE WINTER ROAD MANAGEMENT

P :Plan

1) -To propose target service levels of the winter road management by indicating specific ATSs with the cost of the winter road management operations

-To establish **consensus on target service levels** in terms of ATSs between road administrators and local residents

D :Do

2) - To implement winter road management operations

C :Check

3) - To assess management performance from the viewpoint of **the ATS, using TPD** and the effectiveness of the implemented operations

A :Act

4) - To review the entire process from 1 to 3 above.

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CONCLUSION

1)To analyze road characteristics using TPD

-Because **TPD are available from taxies, which operate 24 hours a day, 365 days** a year in the Sapporo city. The annual ATS changes is found by TPD in the city.

-The ATS **greatly decreases in early December**, when fallen snow begins to stick, and it **gradually increases in mid-March**, when the accumulated snow begins to melt.

-This study confirmed that TPD reveal the changes in trafficability in a city's extensive road network under **various seasonal, weather and road surface conditions.**

2) To calculate the time loss due to traffic congestion in winter

-The monthly time loss due to traffic congestion **on various sections of Route 12** in winter was calculated for the four months between December 2007 and March 2008.

- It was in the **range of 20,000 ~ 360,000 winter periods /km**.

CONCLUSION

3)To calculate cost-benefit analysis of snow disposal/hauling

-Use of TPD affords **more reliable cost-benefit calculation** of snow disposal/hauling.

-According to the **calculation for snow disposal/hauling on Route 12 in fiscal 2007**, **the cost-benefit ratio was much greater than 2.0.**

4) To provide sustainable winter road management service

-**The winter road surface**, being dry, wet, frozen or covered with compacted snow, **changes frequently.** Snow removal/disposal/hauling, as well as the amount of snowfall, affect road traffic conditions.

- **The use of TPD will contribute to sustainable winter road management service.** Because it is expected that TPD will be used for **defining the quality of winter road management service desired by road users** as well as for **setting the implementation standard of winter road management operations provided by road administrators.**

ACKNOWLEDGEMENTS

- Sapporo Development and Costruction Dept.
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Thank you very much for your attention !!!

CONTACT ADDRESS

Dr. Kazunori Munehiro
Senior Researcher
Traffic Engineering Research Team
CERI, PWRI
JAPAN
Tel.+81-11-841-1738
Fax.+81-11-841-9747
E-mail: k-munehiro@ceri.go.jp