

DEVELOPMENT AND APPLICATION OF AUTOMATIC WINTER TIRE DISCRIMINATION DEVICE

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Outline

1. Background

2. Development of the automatic winter tire identification device

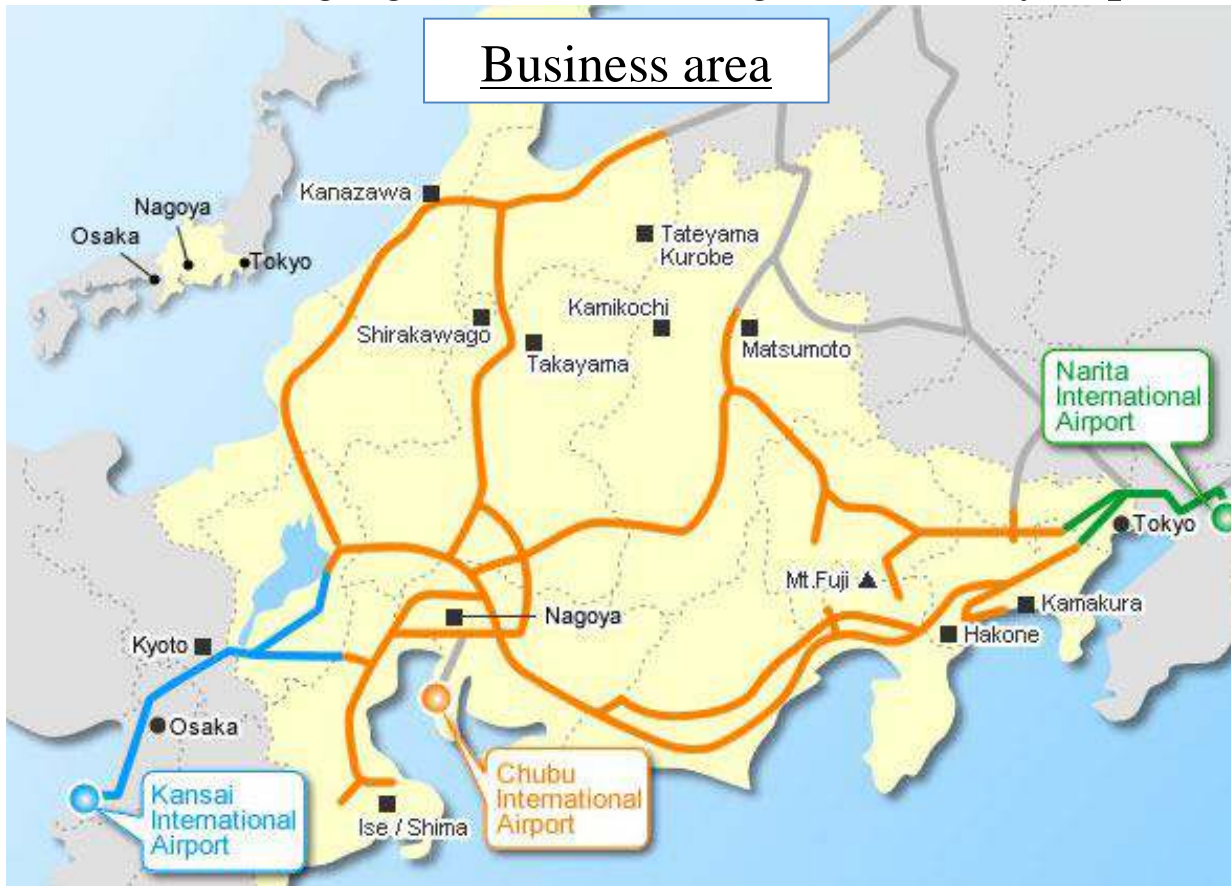
3. Pavement suitable for this device

4. Conclusion

Background

- **our company overview**

- Founded on 1st Oct, 2005
- Managing and constructing the intercity expressways in the central area of Japan.

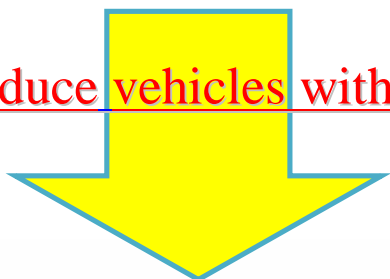


Background

- **For safety driving on icy roads**
 - Drivers need to install winter tires on their vehicles.
 - Some drivers don't install winter tires.
 - It may causes traffic accidents.



Need to reduce vehicles without snow tires

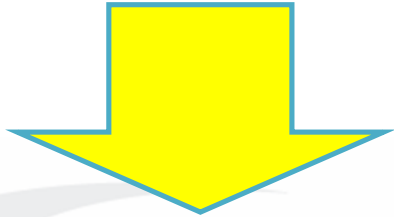


Visual tire inspection

- | | | | |
|--------------|---|---|---|
| Winter tires | ⇒ | ✓ | Travel on main lane |
| Summer tires | ⇒ | ✗ | Get off the expressway or install tire chains |

Back ground


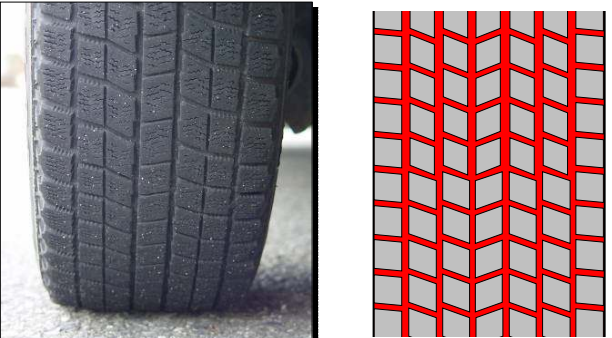
- **Problems of Visual tire inspection**
 - Cut smooth traffic flow
 - Increase in CO2 emission caused by stopping cars
 - Severe work conditions
 - Risk of being involved in traffic accidents



We develop the automatic winter tire identification device

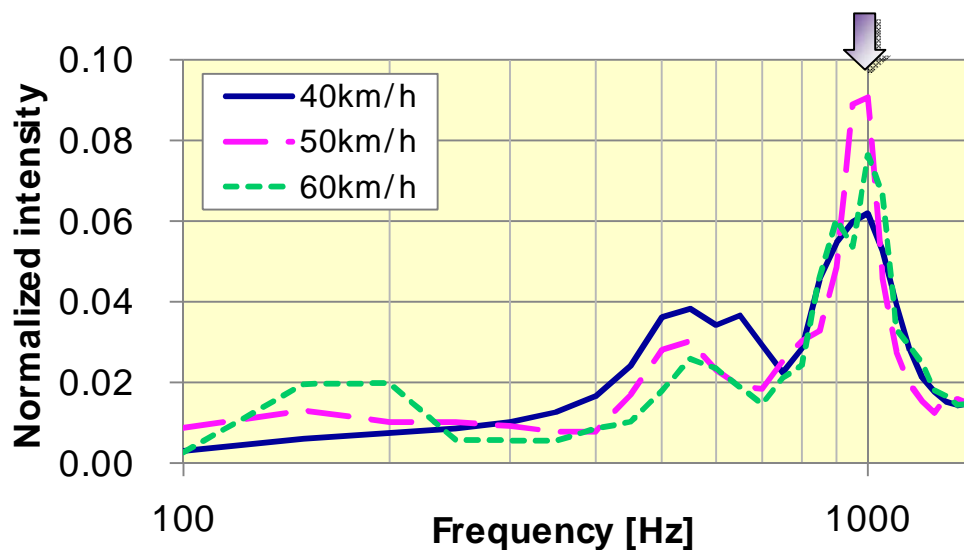
Development of the automatic winter tire identification device

- Difference in tread tire pattern

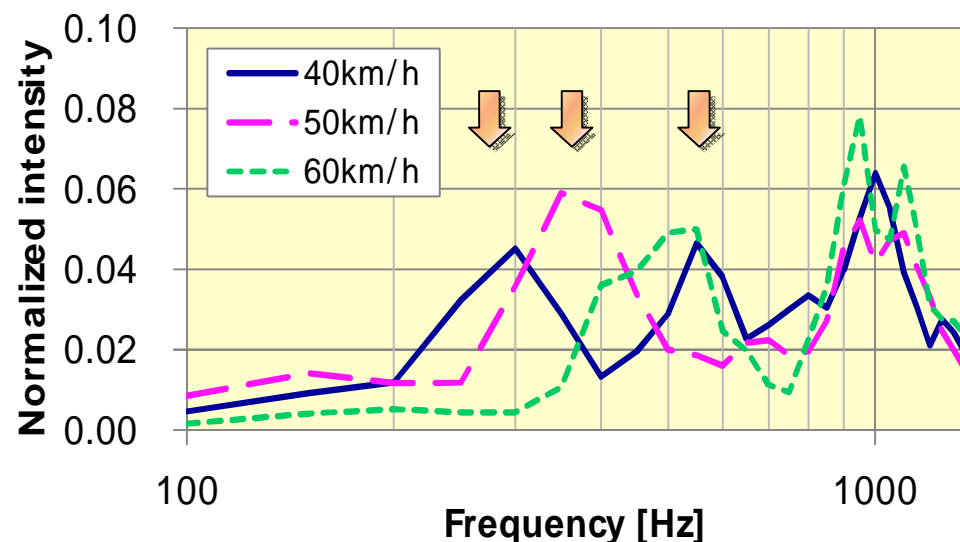
| | Summer tire | Winter tire |
|---------------|--|---|
| Tread pattern |  |  |
| Structure | Rib structure | Block structure |
| Requirement | Stability & Drainage | Grip & Traction |
| Rubber | Hard | Soft |

Development of the automatic winter tire identification device

- Frequency analysis of tire noise



Summer tire

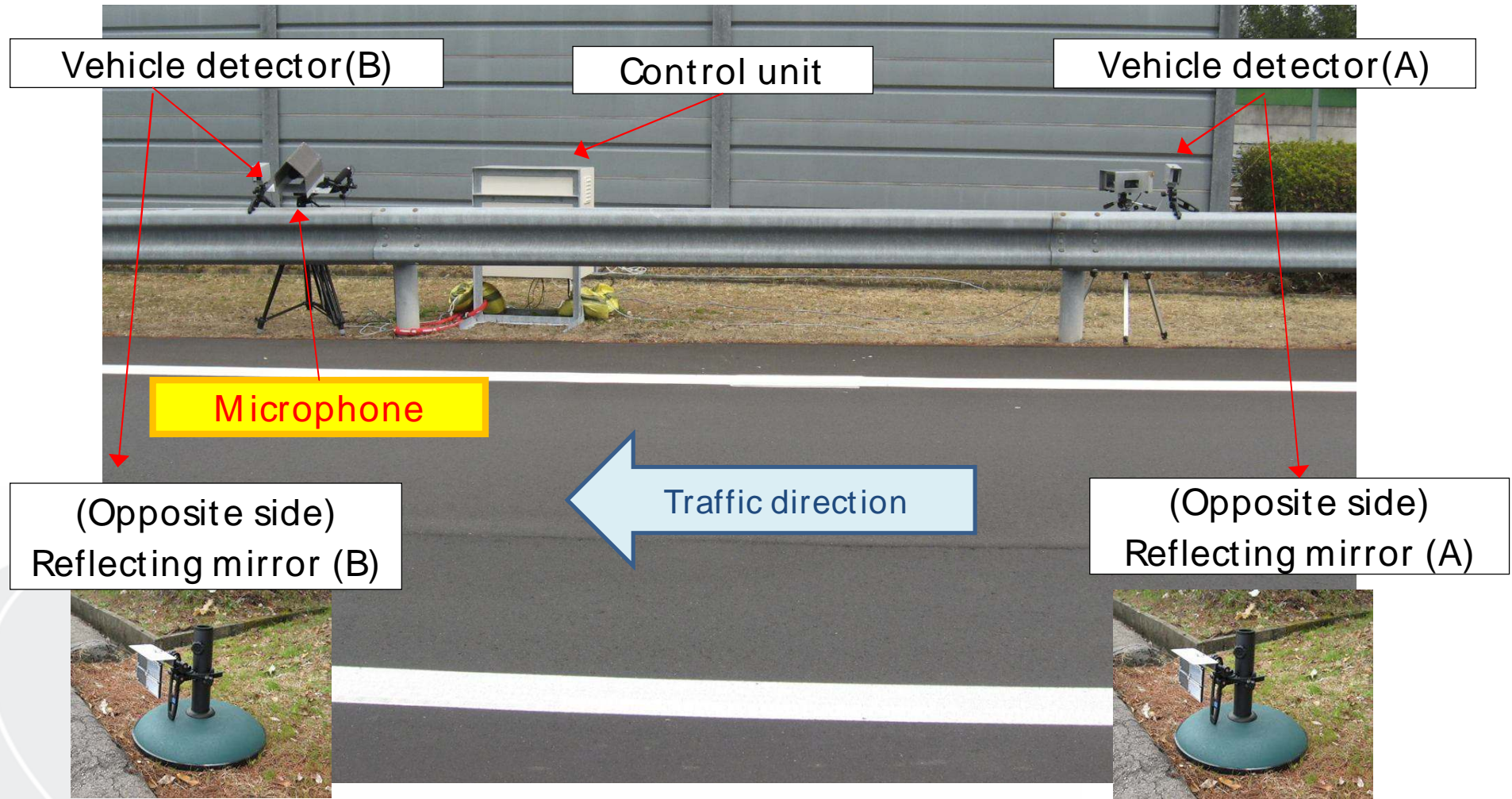


Winter tire

- Characteristic noises caused by tread pattern.
- Possible to identify the tire type whether or not the **peak frequency** of traveling noise is **constant** or **proportional to the vehicle speed**.

Development of the automatic winter tire identification device

- Function and process of the automatic winter tire identification device



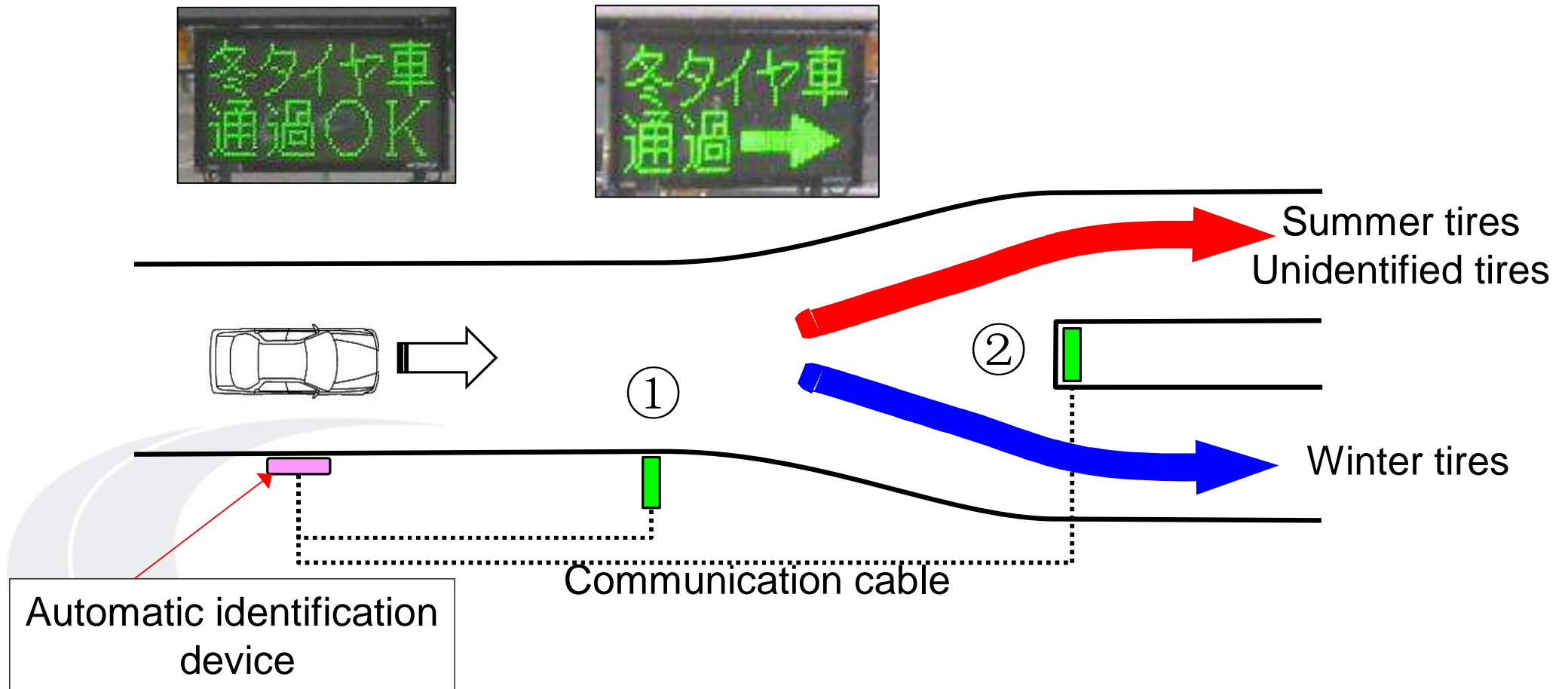
Development of the automatic winter tire identification device

- Drivers are indicated automatically by roadside displays

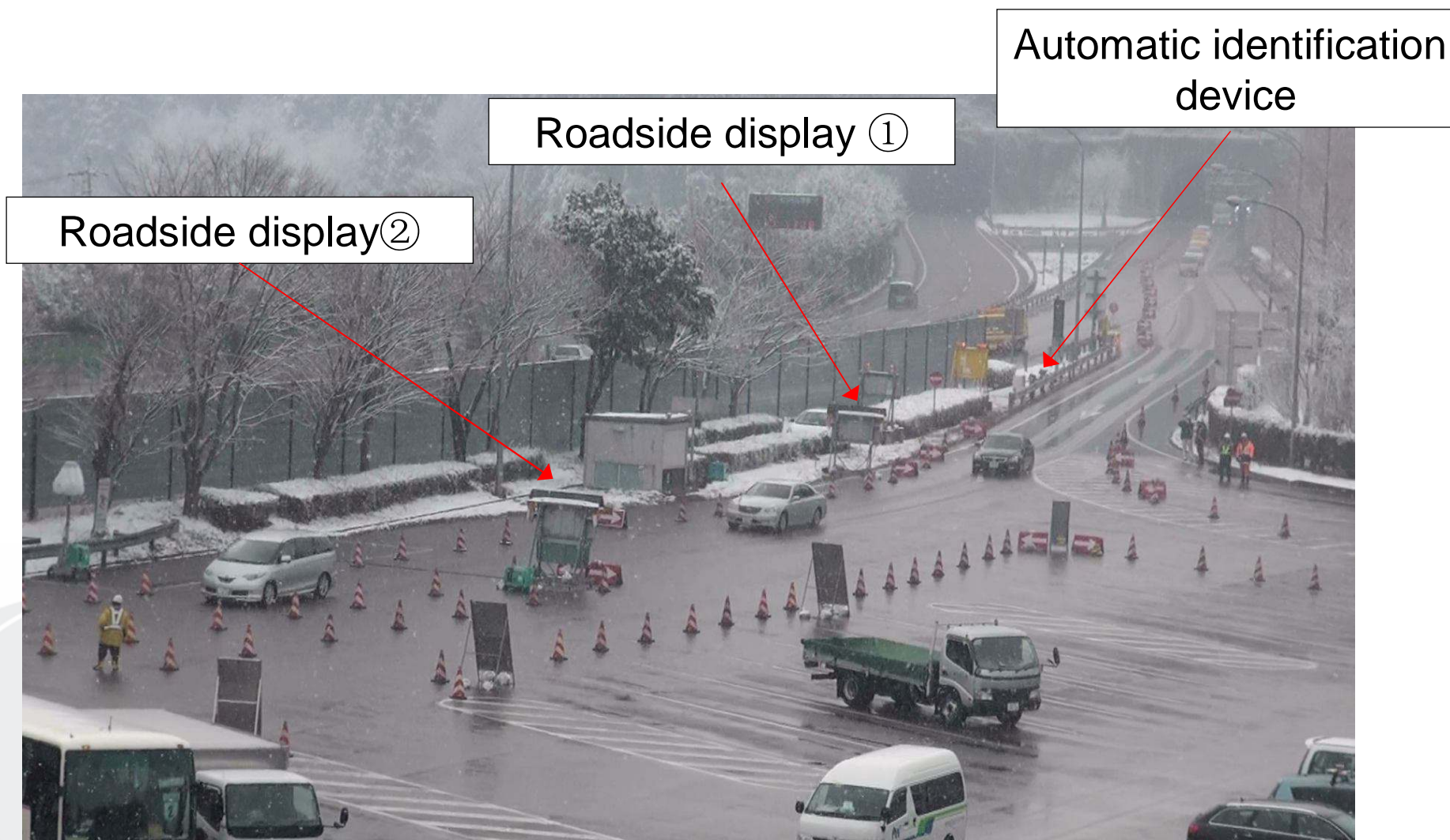
① Display the type of tires



② Indicate the route



Development of the automatic winter tire identification device

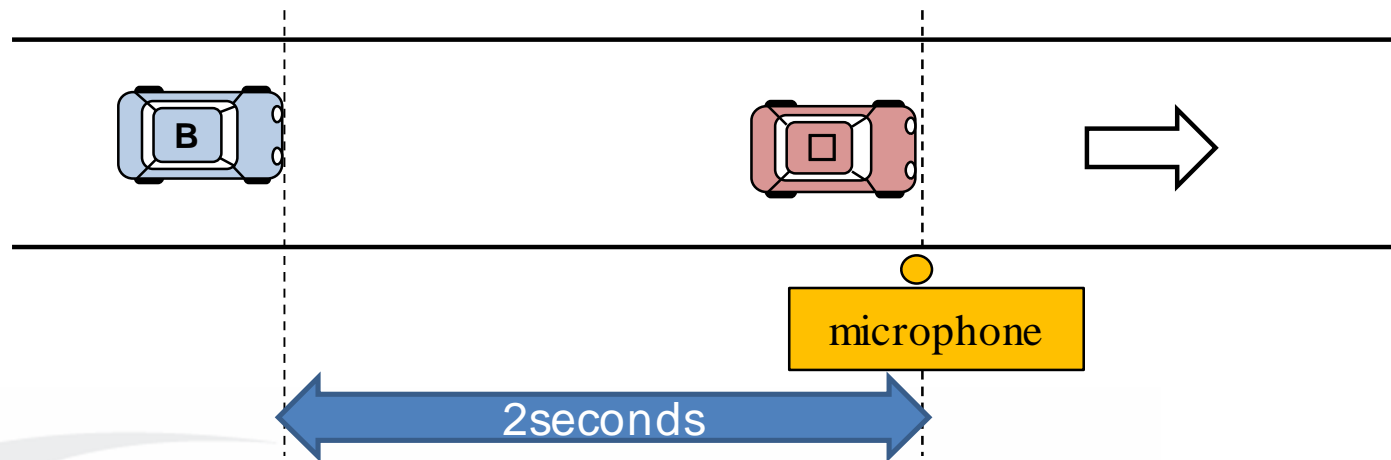


Development of the automatic winter tire identification device

- **Test condition**

- Time interval between vehicles is 2 seconds or longer.

To prevent noise affected by other vehicles.



- Vehicle speed is at 35km/h or over.

Because low speed causes the noise too small

Development of the automatic winter tire identification device

- **Identification accuracy** ※except non-identifiable vehicles

| | Vehicles num. (veh) | Correct vehicle num. (veh) | Identification accuracy (%) |
|--------------|---------------------|----------------------------|-----------------------------|
| Winter tires | 1,050 | 773 | 74% |
| Summer tires | 1,136 | 876 | 77% |
| Total | 2,186 | 1,649 | 75% |

- **Reason of low accuracy**
 - Microphone picked up other noises like other vehicles and wind.
 - The frequency is influenced by other noises.

Development of the automatic winter tire identification device

- **Non-identifiable vehicles rate**

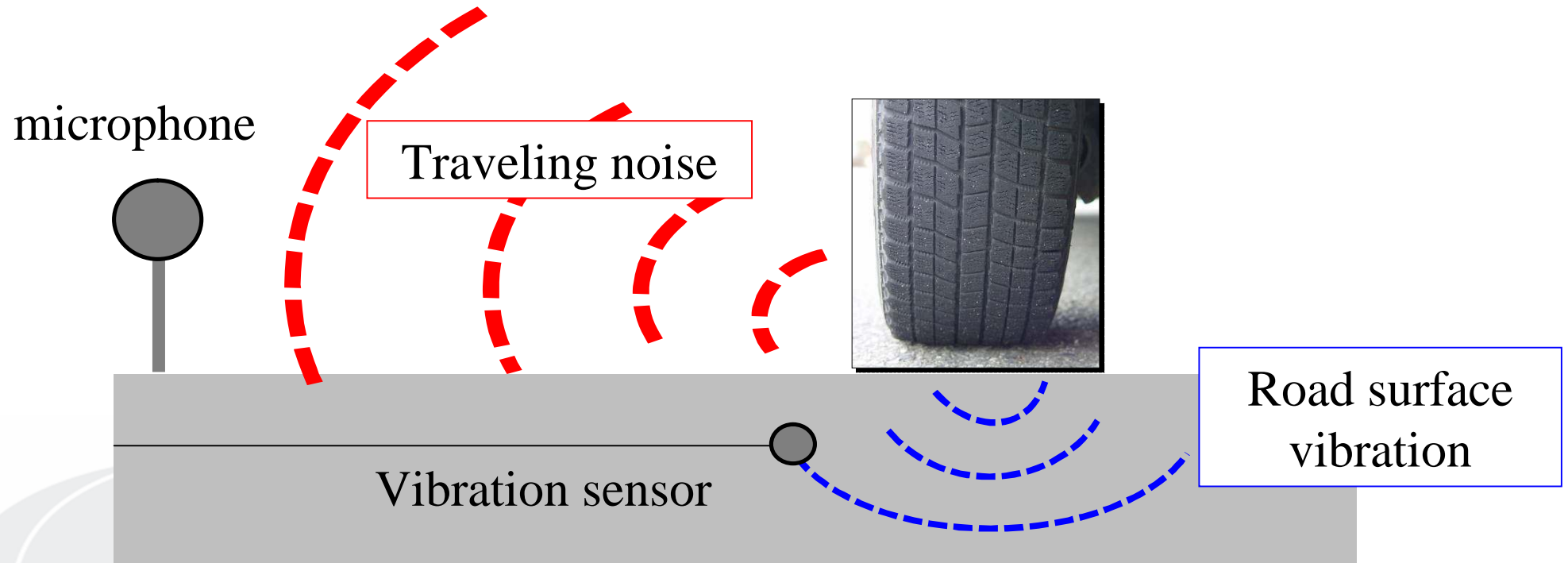
| | Vehicles num. (veh) | Non-identifiable vehicles (veh) | Non-identifiable vehicles rate (%) |
|----------------------|----------------------------|--|---|
| 1 st time | 2,434 | 1,000 | 50.8% |
| 2 nd time | 7,324 | 1,661 | 28.1% |
| 3 rd time | 3,427 | 1,424 | 47.8% |
| total | 13,185 | 4,085 | 31.0% |

- As traffic volume increases, time interval of vehicles sometimes become shorter and many vehicles fail to satisfy the test condition.

The device need to be improved in order to reduce the effects of external factors and apply to the vehicles traveling in low speed with short time interval.

Development of the automatic winter tire identification device

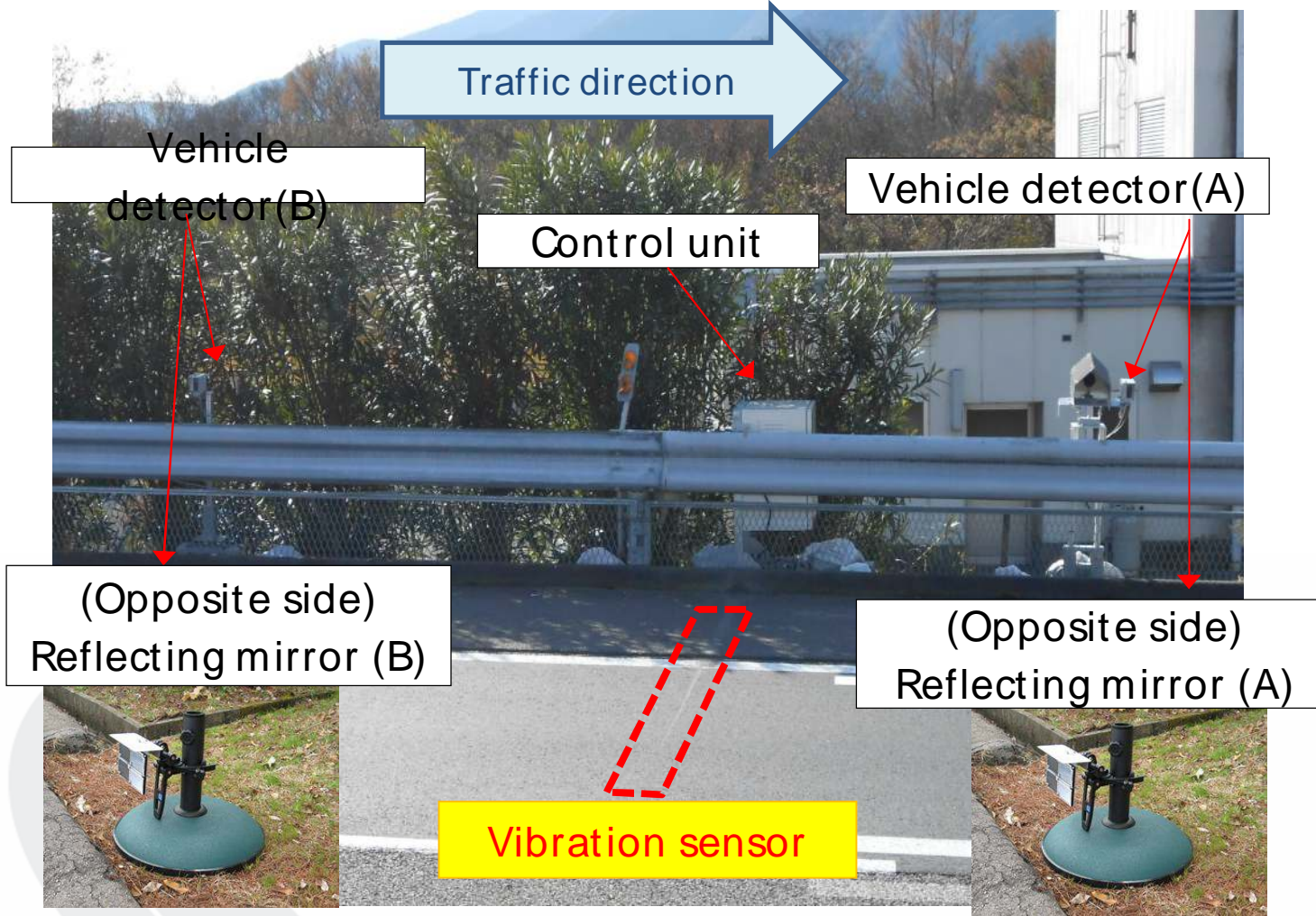
- **The Frequency of traveling noise and road surface vibration**



- By utilizing the vibration sensor, the effect caused by external factor can be reduced.

Development of the automatic winter tire identification device

- **New device utilizing the vibration sensor**



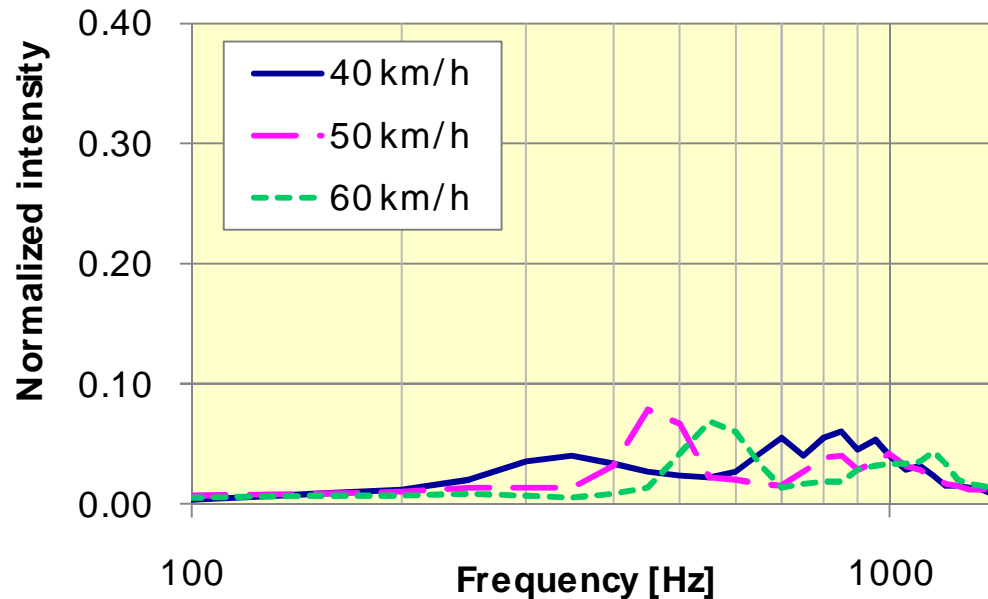
- vibration sensor



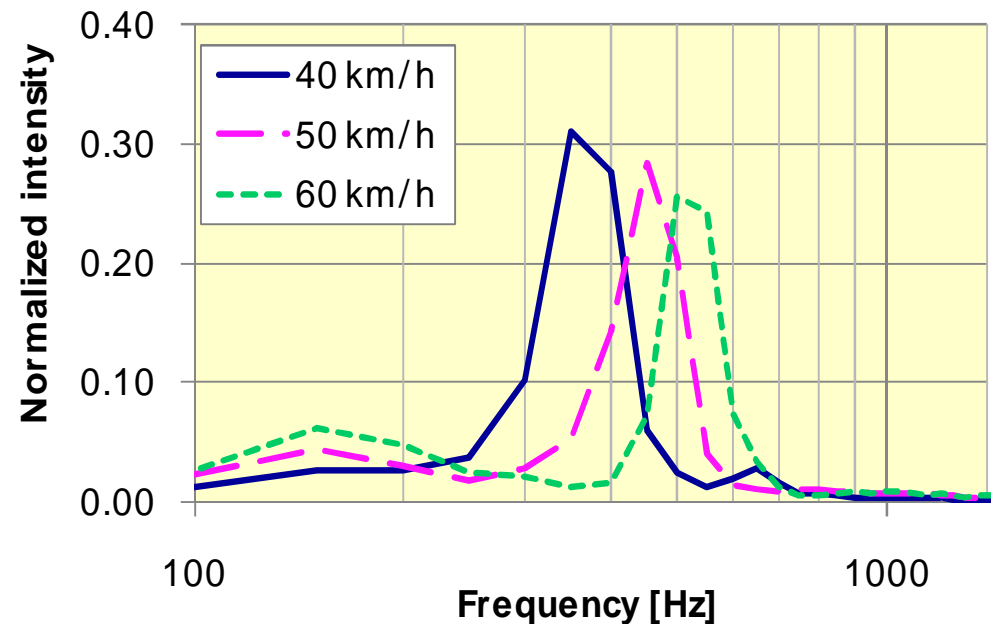
30mm underground

Development of the automatic winter tire identification device

- **The comparison of the traveling noise and the road surface vibration**



Travelling noise



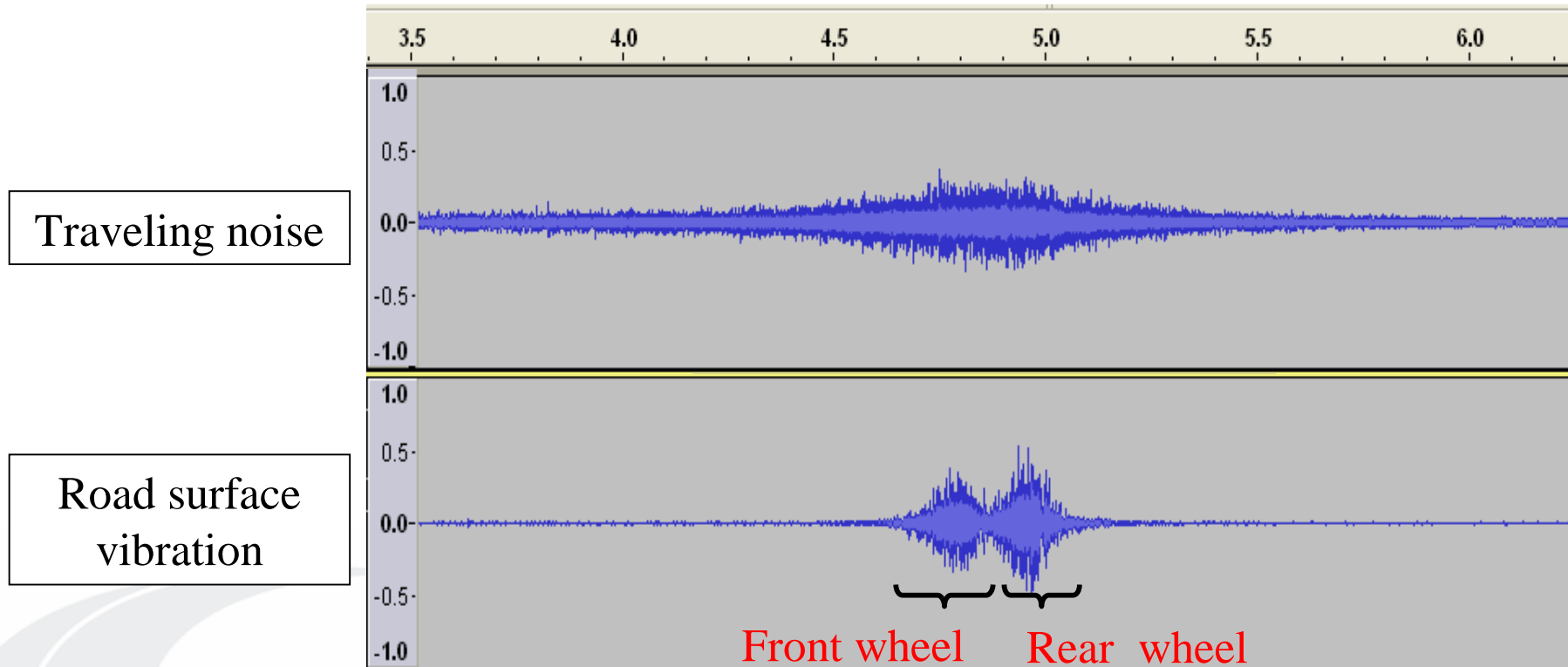
Road surface vibration

- The road surface vibration has winter tire characteristics.
- The wave profile of the road surface vibration is more distinctive than that of traveling noise.

Development of the automatic winter tire identification device

- **The comparison of wave-form**

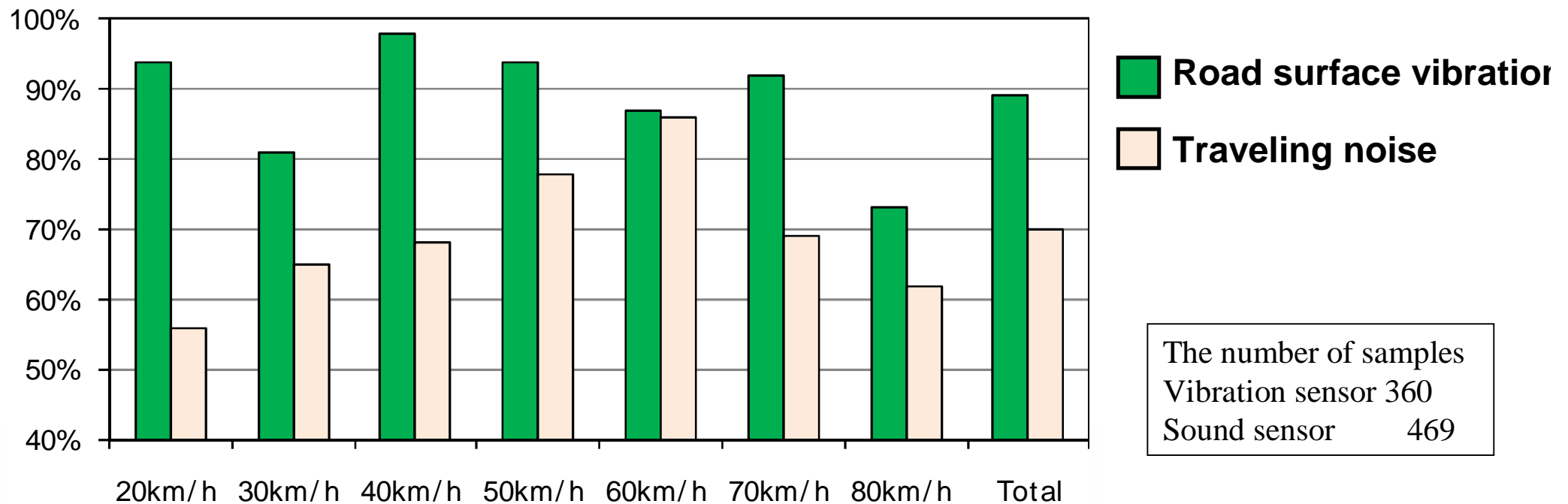
(t)



- The road surface vibration is largely reduced with distance
- Vibrations not affected by other vehicles even time interval is 1second.

Development of the automatic winter tire identification device

- Comparison of accuracy of 2 methods in each speed.



- The road surface vibration is better than the traveling noise .
- The results of the road surface vibration show high accuracy even under low speed (20km/h)

Development of the automatic winter tire identification device

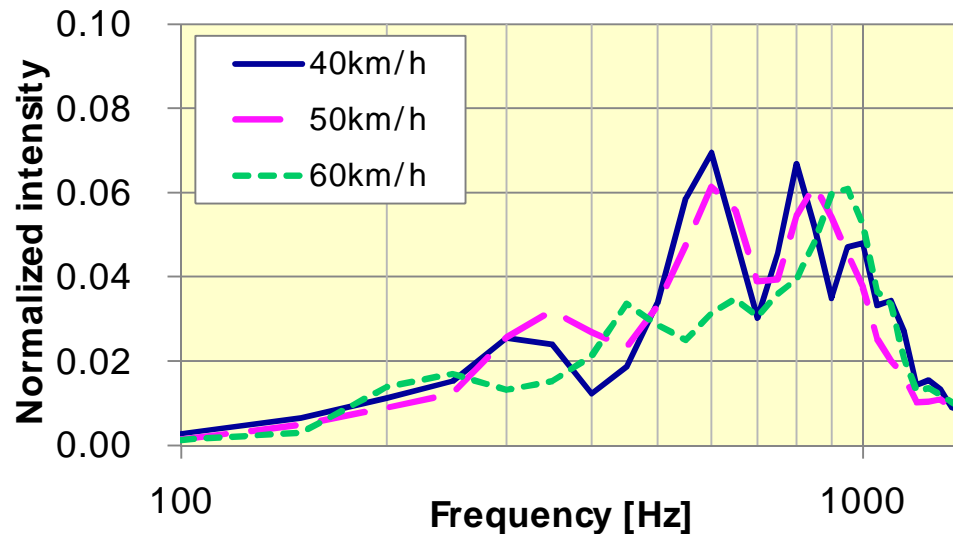
- Identification accuracy ※except non-identifiable vehicles

| | Fields | Identification accuracy (%) |
|---------|---------|-----------------------------|
| 1 | Field A | 82% |
| 2 | Field B | 94% |
| 3 | Field C | 77% |
| Average | | 85% |

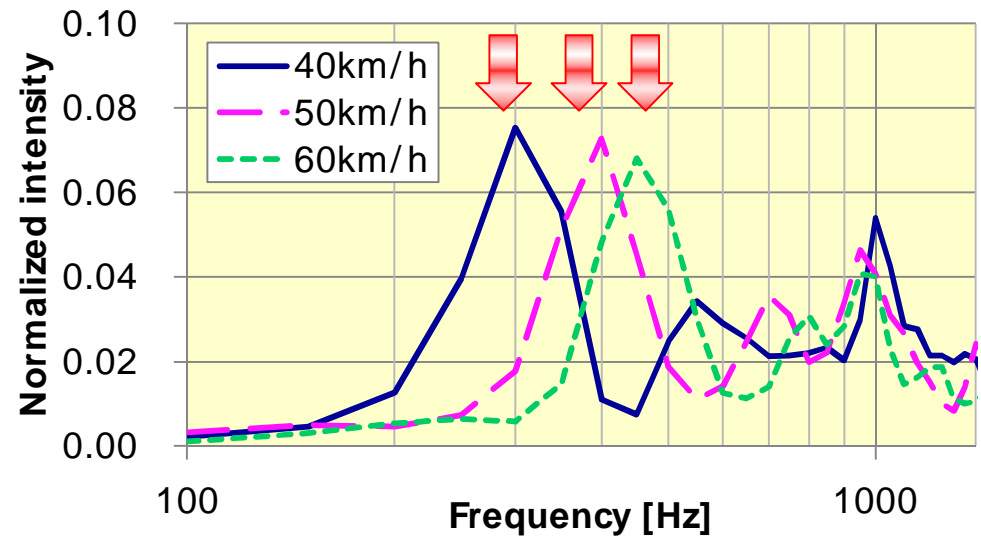
- Non-identified vehicles rate □□□ 13% (previous test :31%)
 - The accuracy rate increased 10% compared with utilizing the traveling noise device.
 - Tire types can be identified under low speed and short interval condition.

Suitable pavement for tire identification

- The result of the frequency analysis of winter tire noise.



Dense graded asphalt concrete



Fine graded asphalt concrete

- Fine graded asphalt concrete pavement is more suitable for identifying tire type.
- The difference of frequency is more obvious on fine graded asphalt concrete.

Conclusion

- Type of tires can be identified by utilizing traveling noise or road surface vibration

| Item | Identification by tire noise | Identification by vibration |
|--------------------------------|------------------------------|-----------------------------|
| Applicable speed | Over 35km/h | Over 20km/h |
| Time interval | Over 2seconds | Over 1second |
| Identification accuracy | About 75% | About 85% |
| Non-identifiable vehicles rate | About 31% | About 13% |

- In the future , we'll improve the identification accuracy and achieve safe and efficient tire check.

Thank you for your kind attention.

If you have any questions about this presentation , please send me an E-mail

E-mail : e.nakahara.aa@c-nexco.co.jp

What is the price(s) for the judgment equipment?

- Unfortunately I am not able to answer your question because it's a company secret.
- The prices for the microphone and the vibration sensor are as follows

| Item | Develop automatic winter tire discrimination device utilizing tire noise | Develop automatic winter tire discrimination device utilizing vibration |
|--------------------|---|--|
| Judgment accuracy | About 75% | About 85% |
| Cost of facilities | Microphone 150,000YEN =1500USD | Vibration sensor 30,000YEN/spot =300USD/spot |

What is your future aspect for the judgment using the sound sensor and the vibration sensor?

- Accuracies of judgment by the sound sensor and the vibration sensor are almost the same as long as we have examined in our laboratory.
- However, the accuracy of the sound sensor might get lower because it tends to be affected by the outside noise at the actual sites.
- We will try to improve the accuracy of the vibration sensor.



Measures to improve the judgment accuracy of the vibration sensor.

- The judgment accuracy gets lower when a vehicle runs far from the sensor, due to the distance attenuation of the entire pavement. Therefore, improvement of the accuracy is expected by leading vehicles to pass nearby the sensor.



【写真】
Example of vehicle
leading by lane markings.

Does snow affect to judge the sorts of tires?

- Our experiments shows that the sorts of tires are not be able to be judged when the surface conditions are either compacted or freeze
- Currently, the condition needs to be either dry, wet or muddy for accurate judgment.

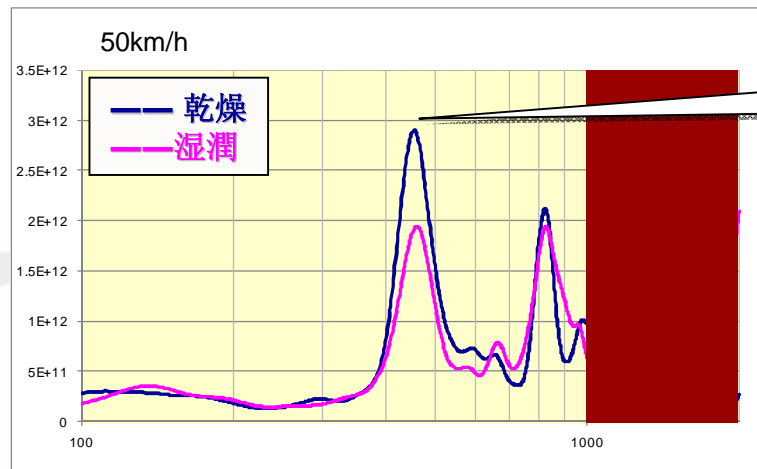


【写真】

Unfavorable surface condition
Muddy and freeze partially

Is the frequency affected when the surface condition is wet?

- When it is wet, the frequency over 1 KHz is affected.
- However, the accuracy of the judgment is secured because the judgment for tires requires the frequency below 1 KHz.



the frequency of tires is below 1kHz

How do you use the automatic tire sort judgment?

- Survey for the rate of vehicles with winter tires
The rate can be figured out by using the automatic tire sort judgment system
- Winter tire regulation
To mitigate workers burden by using the system in the winter tire regulation areas.
- Advices for drivers in a vehicle without winter tires
To advice drivers in a vehicle without winter tires to leave the expressway or to equip winter tires by using LED message sign boards,

Why the subject of the system is only passenger vehicles?

- When we used then sound sensor at the beginning, the accuracy was affected by the big engine noise of larger vehicles.
- In addition, it is difficult to find the features of winter tires because tires of large vehicles have wide varieties in their sizes and tread patterns.
- However, we are confident in accurate judgment by using vibration sensor. We will study further.

How long does it take for the judgment process?

- 0.5 seconds after a vehicle passes the sensor (either sound or vibration) completely.

What is the pavement condition necessary for the judgment?

- Needs to be fine or dense-graded pavement
- Needs not to be rough (less unevenness) . The system is not available for permeable pavement



How do you currently carry out the system?

- The judgment is still mainly done by workers
- When the system is used, judgment by workers also applied for double-checking and study the accuracy of the system.