

Activity of acceleration standards toward automobile field at NMIJ

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National Metrology Institute of Japan (NMIJ)
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Outline

1. About NMIJ
2. Japanese automobile market
3. NMIJ's Activity together with automobile field
 - Round robin test
 - Issue of ISO 16063-17
4. Summary

NMIJ is in Tsukuba city of Japan.

There are many institutes and researchers in the city.



NMIJ is one organization of AIST.



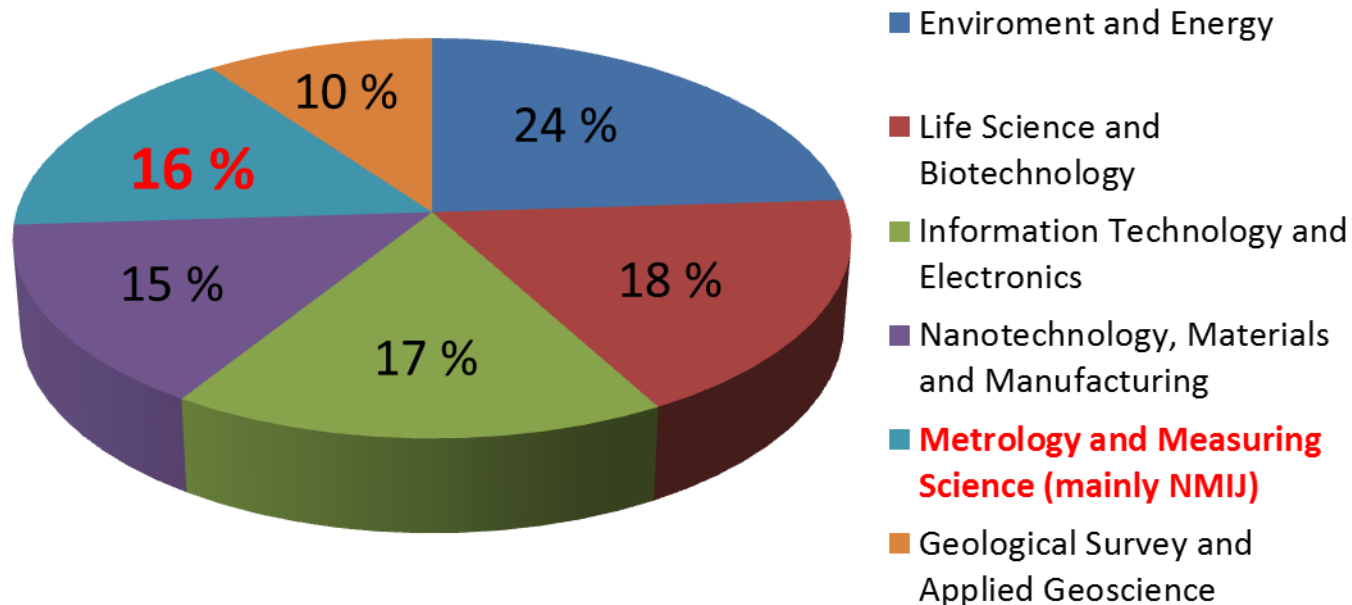
Composition of AIST researchers

AIST Researchers : 2337

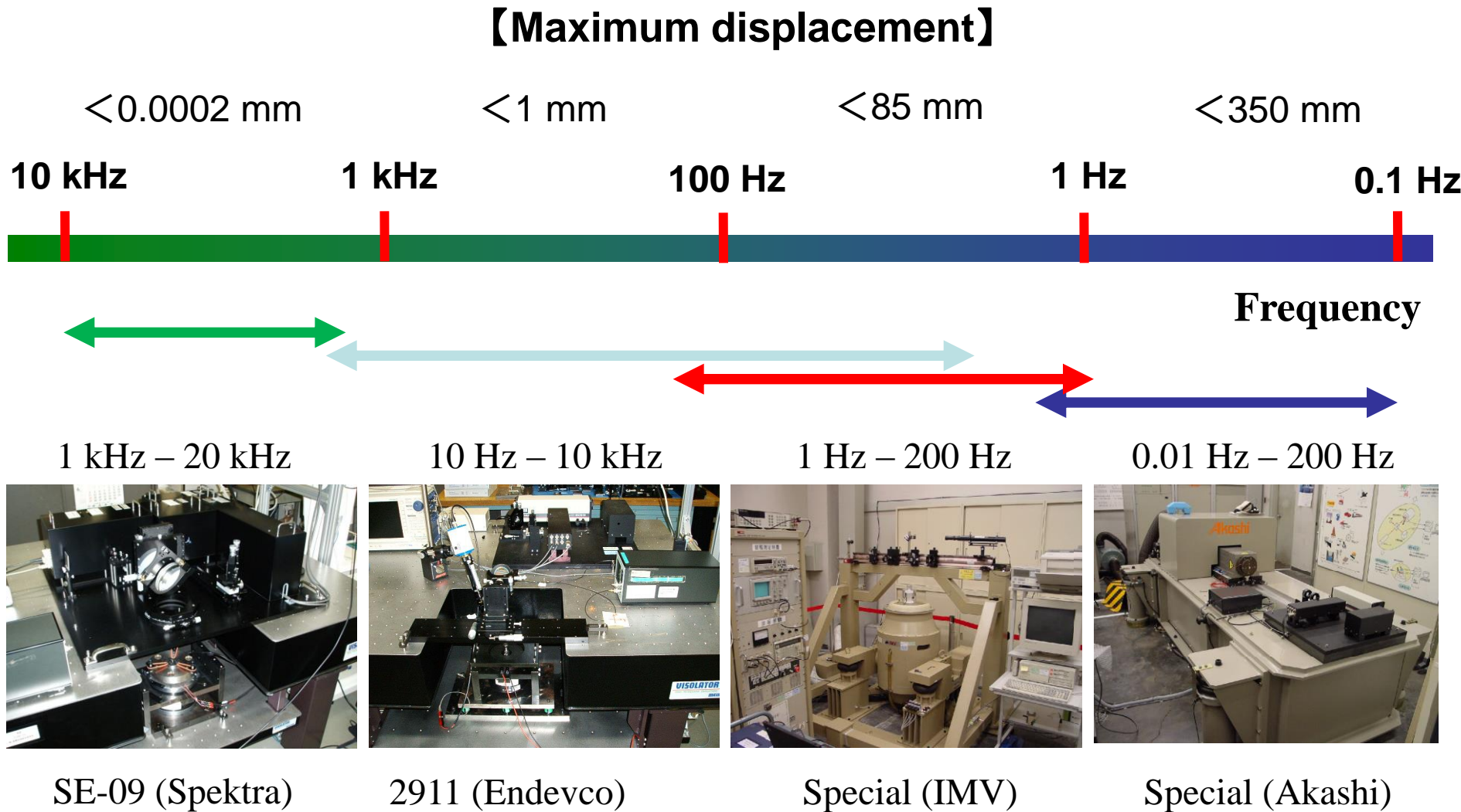
(NMIJ Researchers : around 250)

Administrative employees : 638

Technical staff : 1671, Visiting researchers 177, Postdoctoral fellow 318



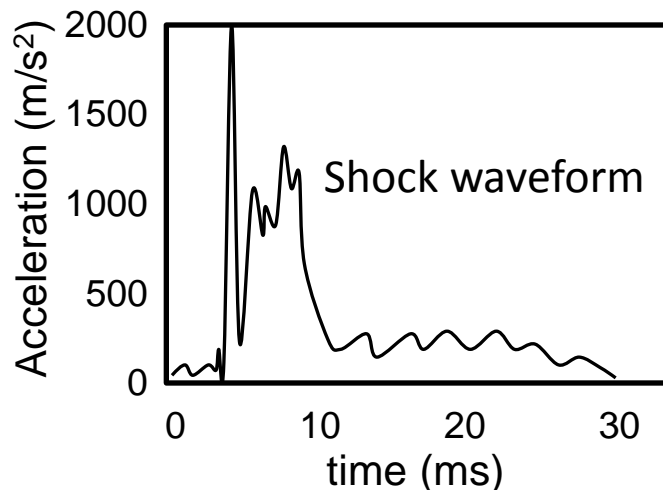
Four vibration facilities of NMIJ



Necessity of high acceleration measurement



Piezoresistive accelerometer



Representative assessment criterion
HIC (Head Injury Criterion)

$$HIC = \left[\frac{1}{t_2 - t_1} \int_{t_1}^{t_2} a dt \right]^{2.5} (t_2 - t_1)$$

FMVSS 208, ECE R94, TRAI47 : $HIC < 1000$

ISO 6487 requests the accuracy below 2.5 %.



Automobile industries request calibration uncertainty below 1 %.

Purpose of this study

Reliability assurance of acceleration measurement in car crash test



Evaluation of calibration validity to piezoresistive accelerometers

Shock calibration : global standard

Centrifuge calibration : domestic de facto standard



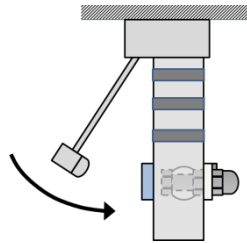
Implementation of round robin test to piezoresistive accelerometers

Documentations of safety test for car crash

Europe
ECE R94

Accuracy: below 2.5 %
Head: below 1960 m/s²
Chest: below 588 m/s²

ISO 16063-22
shock calibration

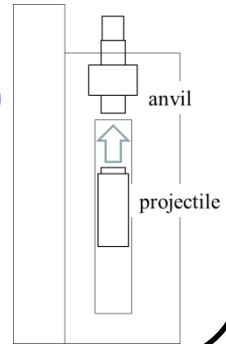


USA

FMVSS No. 208
NHTSA Document 49

Accuracy: below 2.5 %
Head: below 1960 m/s²
Chest: below 588 m/s²

ISO 16063-22
shock calibration



Europe assessment test
for car crash test
Request of ISO 17025

Japan
TRAIAS 47

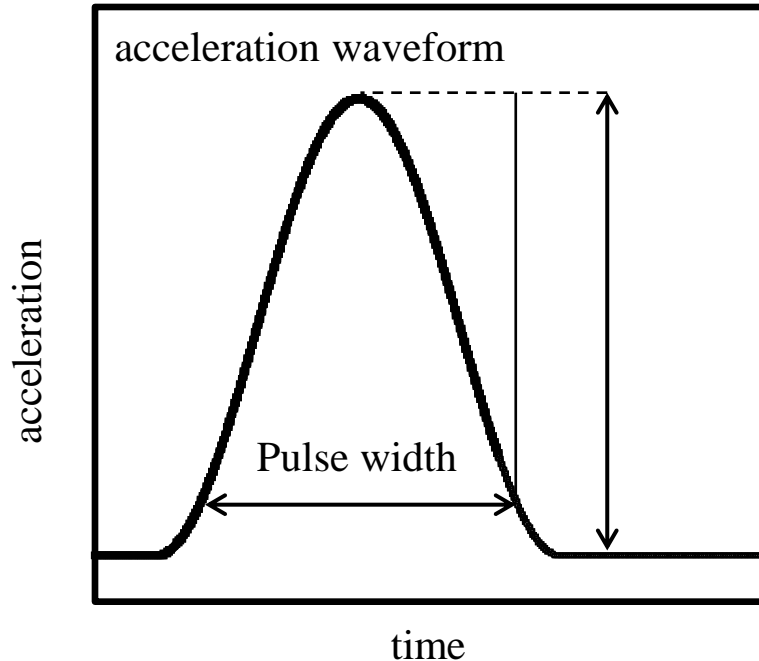
Accuracy: below 2.5 %
Head: below 1960 m/s²
Chest: below 588 m/s²

ISO 5347-7
centrifuge calibration

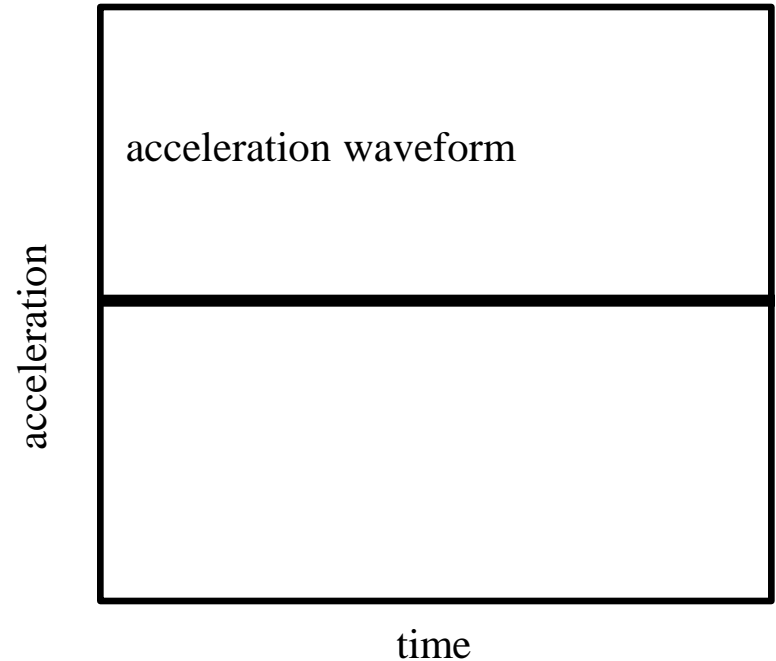


Difference of acceleration waveform between shock and centrifuge calibrations

shock calibration

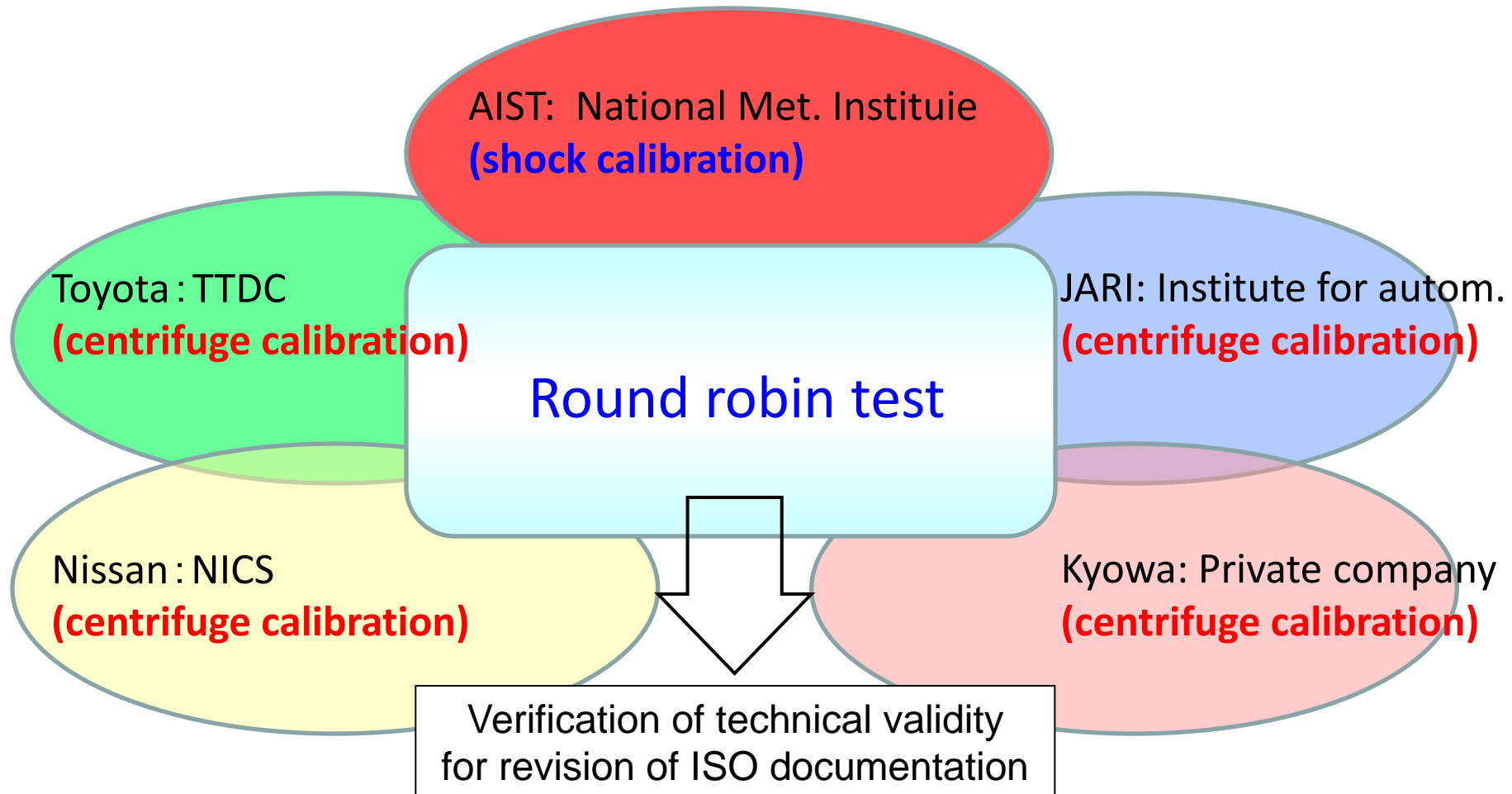


centrifuge calibration

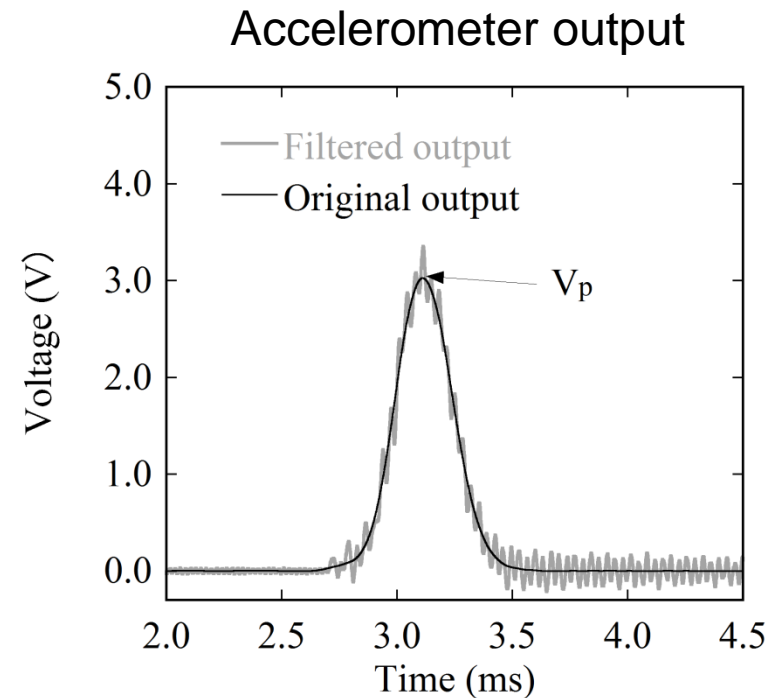
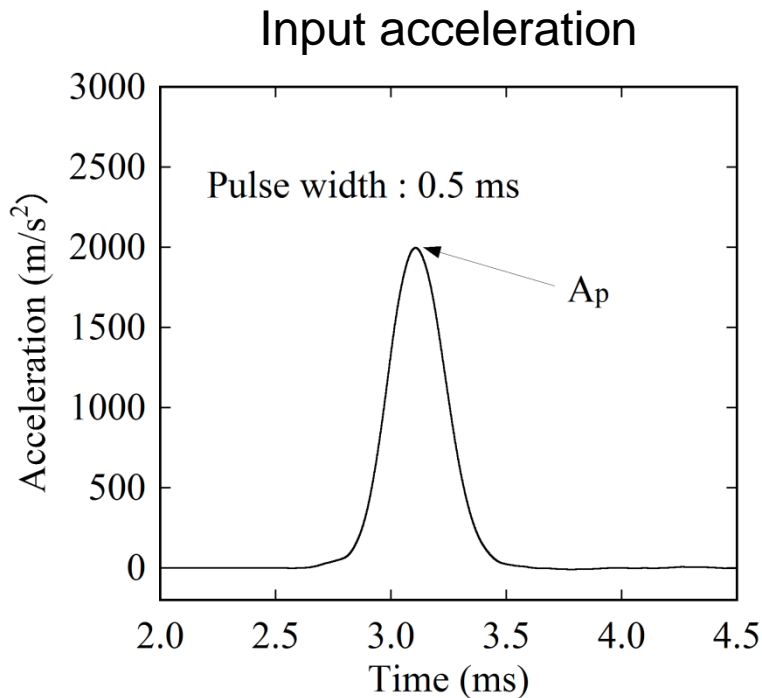


Shock calibration has various frequency components,
but centrifuge calibration has only DC component.

Participants of round robin test



Shock sensitivity in shock calibration



Shock sensitivity of accelerometer (defined in ISO 16063-13)

$$S_s = \frac{V_p}{A_p}$$

V_p : peak voltage of accelerometer output

A_p : peak acceleration of input acceleration

Test condition

Acceleration level:

1000 m/s², 2000 m/s², 3000 m/s², 4000 m/s², 5000 m/s²

Fixing torque for accelerometer: 2 N·m

Environmental condition

Temperature: 23 °C ± 3 °C

Humidity: 50 % ± 25 %

Measurement span: 1 – 2 weeks

Circulating schedule of devices under test

Participants	Time span of measurement
AIST	2013/11/26 – 2013/12/6
KYOWA	2013/12/10 – 2013/12/13
TTDC	2013/12/17 – 2013/12/20
KYOWA	2013/12/25 – 2014/1/17
JARI	2014/1/21 – 2014/1/24
KYOWA	2014/1/28 – 2014/1/31
NICS	2014/2/4 – 2014/2/7
KYOWA	2014/2/10 – 2014/2/14

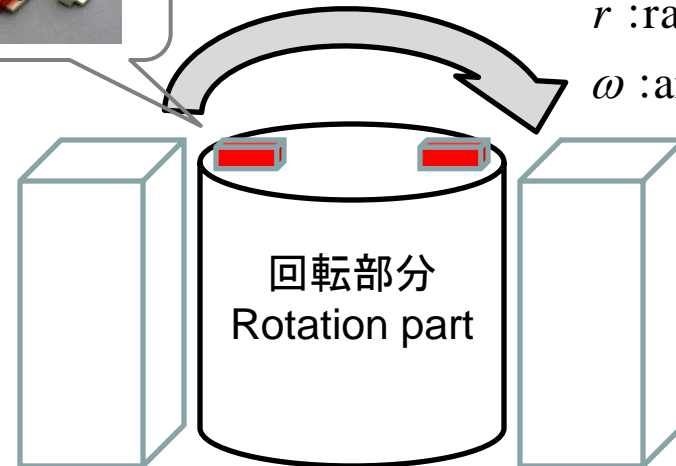
Centrifuge calibration system

Compliance with ISO 5347-7
Acceleration: $10 \text{ m/s}^2 - 10000 \text{ m/s}^2$
Rotation speed: 2156 rpm
Accuracy (calibration system): 0.1 %

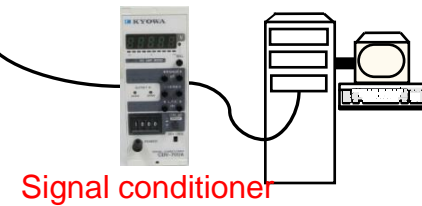
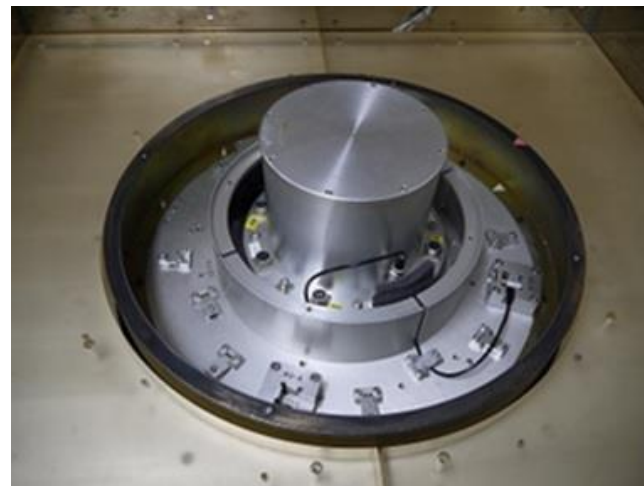


$$\text{acceleration} = r\omega^2$$

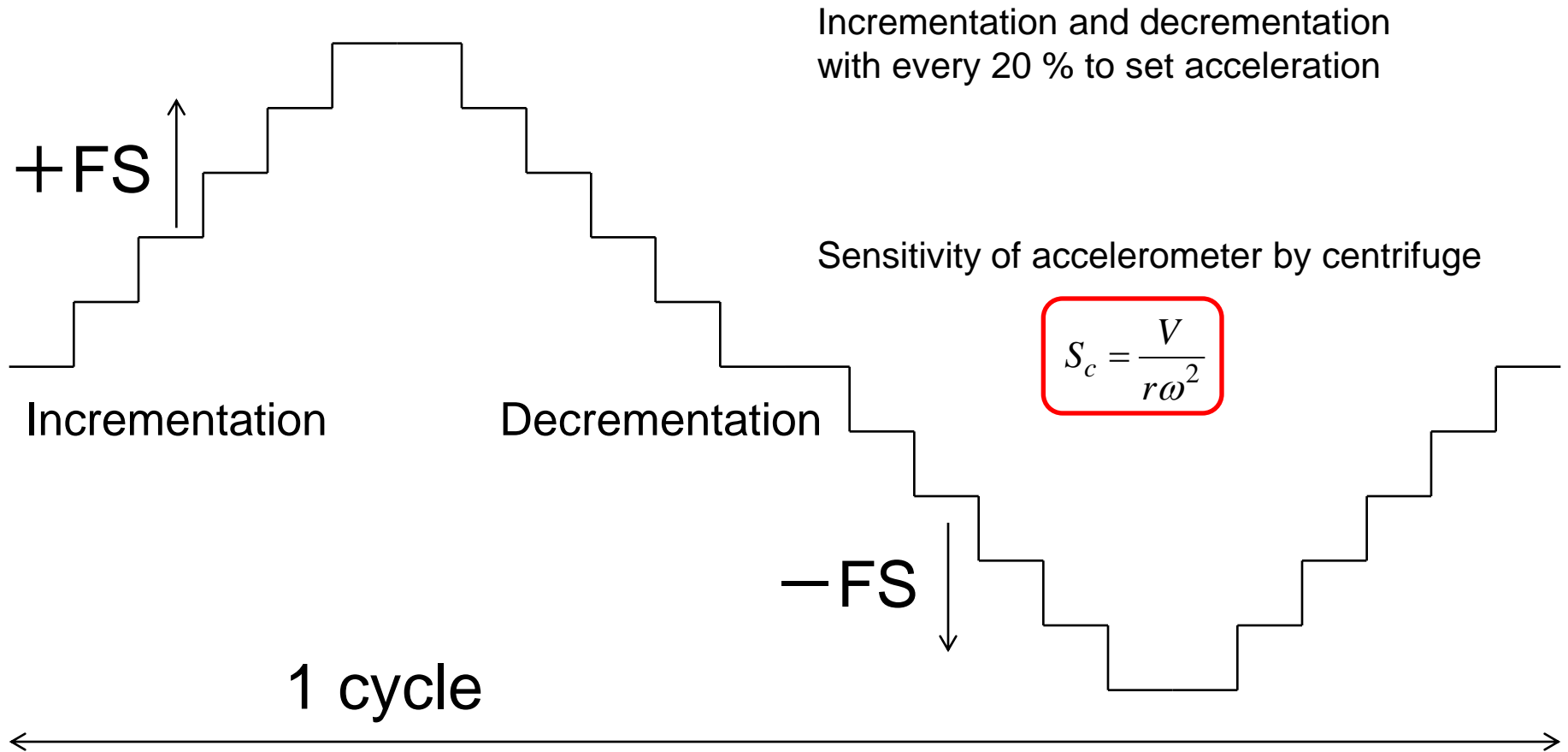
r : radius
 ω : angular velocity



Kyowa
TTDC (Toyota)
JARI
NICS (Nissan)



Operational procedure of centrifuge calibration

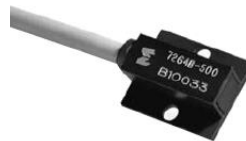


Devices under test and calibration quantity

Accelerometer		Signal conditioner			
Type	Serial number	Type	Gain	Bridge voltage	Low-pass filter
ASD-B-1KV	GF3760022	CDV-700A	1000-fold	10 V	100 kHz
ASD-B-1KV	GF4190169	CDV-700A	1000-fold	10 V	100 kHz
7264C-2000	P80928	CDV-700A	100-fold	10 V	100 kHz
7264C-2000	P80929	CDV-700A	100-fold	10 V	100 kHz

Device under test

Piezoelectric accelerometer



+

Signal conditioner



Calibration quantity

Voltage output per acceleration

$$\frac{V_{out}}{m/s^2}$$

Verification method of consistency between shock and centrifuge calibrations

Z score

$$Z = \frac{x - X}{\sigma}$$

x : calibration value of participants

X : reference value

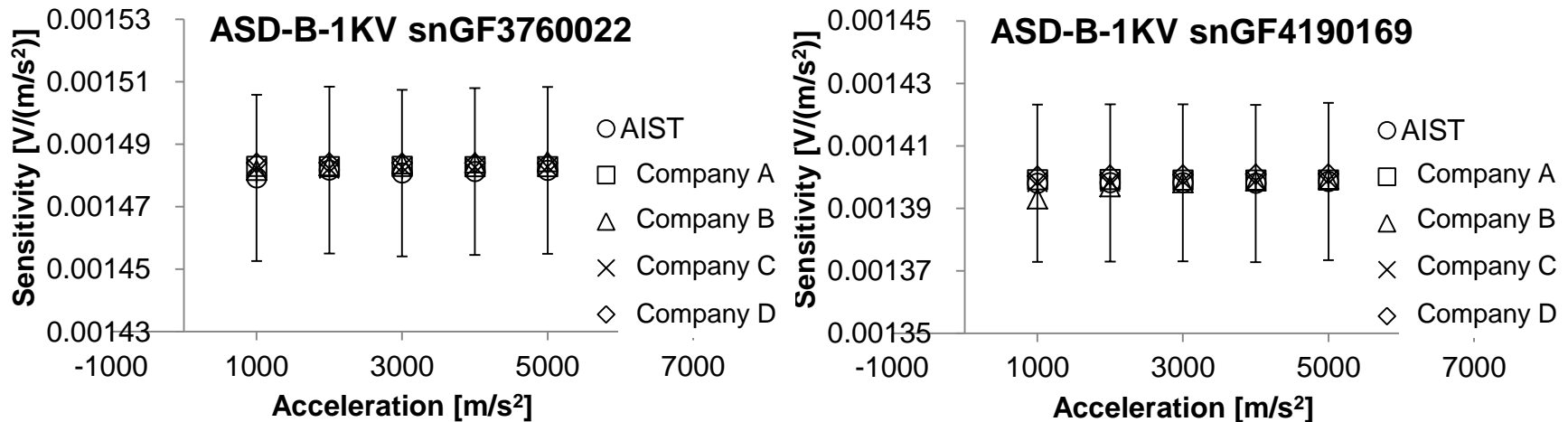
σ : standard deviation for this round robin test

The standard deviation is determined as **0.9 %** by ISO 6487.

Judgment by Z score is as follows.

$|Z| \leq 2$: satisfied、 $|Z| > 2$: doubtful、 $|Z| \geq 3$: unsatisfied

Calibration results of ASD-B-1KV

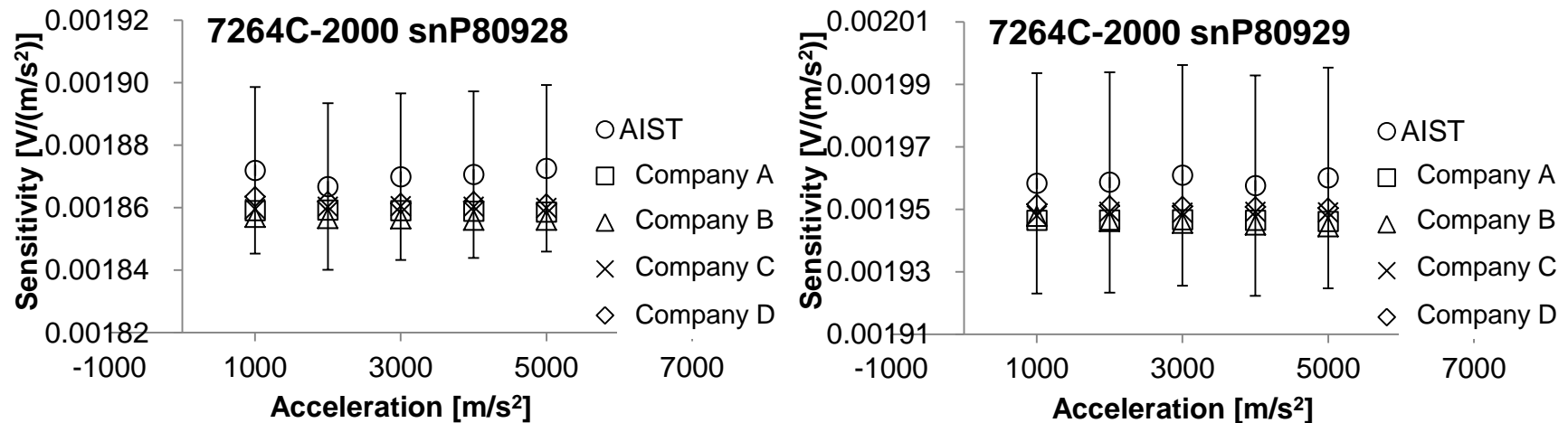


The calibration results of ASD-B-1KV are consistent among five participants.

The error bar means that Z score < 2 (satisfied).

[Ref] H. Nozato *et al.*, "A round robin test of piezoresistive accelerometers between shock and centrifuge calibrations"
Transactions of society of automotive engineers of Japan Vol 46, No. 2, p461-p466 (2015).

Calibration results of 7264C-2000



The calibration results of 7264C-2000 are consistent among five participants.

The error bar means that Z score < 2 (satisfied).

[Ref] H. Nozato *et al.*, "A round robin test of piezoresistive accelerometers between shock and centrifuge calibrations"
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Summary

- A round robin test of piezoresistive accelerometer was carried out among five participants.
- AIST implemented shock calibration, and other participants implemented centrifuge calibration.
- In regard to two kinds of piezoresistive accelerometer, the consistency of all calibration results between shock and centrifuge was confirmed using Z score.