“BIPM Workshop on Challenges in Metrology for Dynamic Measurement”
15-16 November, 2012, BIPM

Requested reliability of dynamic mechanical measurement in mobility, from automobile to service robot

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Japan Automobile Research Institute (JARI)

Japan Automobile Research Institute

➢JARI: Independent lab. for automotive research & test in Japan

- ✓Research and testing on automotive safety and environment
- ✓Expanding our research and testing field to safety of robotics in terms of interactions with human
- ✓In this presentation, dynamic measurement methods for collision of cars and robots will be reported and discussed.

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Contents

- Collision tests of personal care robots
- Car crush criteria
- Car crush dummy
- Calibration of sensors
- Required dynamic response (Examples of data)
- Dynamic measurement in our studies

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Collision tests of personal care robots

Project for practical applications of service robots
by New Energy and Industrial Technology Development Organization

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Collision tests of personal care robots

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Car crush criteria

Example 1: Rigid barrier / in-position / FMVSS 208

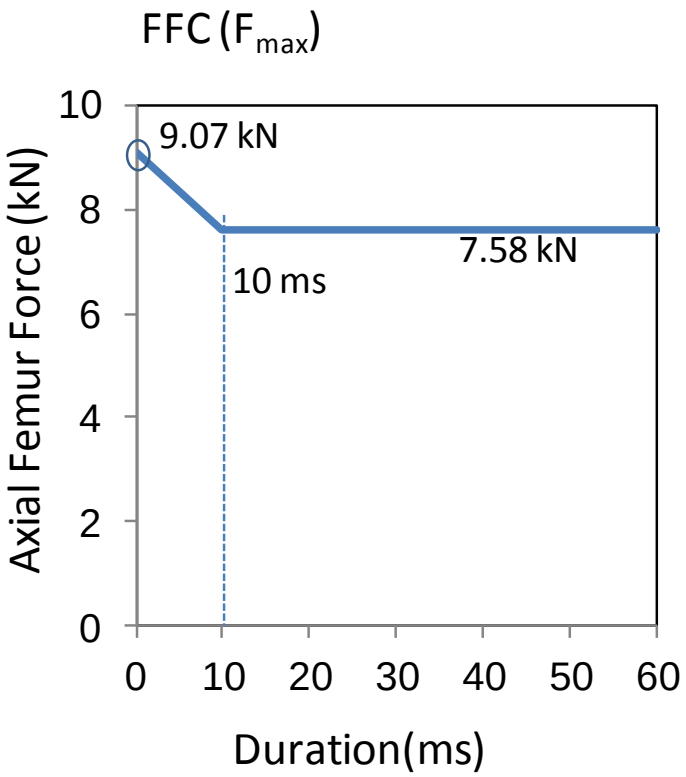
	50 % male	5% female
Head	HIC_{15} = 700	HIC_{15} = 700
Neck	Nij = 1.0 Tension: Fz_{max} = 4.17 kN Compression: Fz_{max} = 4.0 kN	Nij = 1.0 Tension: Fz_{max} = 2.62 kN Compression: Fz_{max} = 2.52 kN
Chest	a_{3ms} = 60 G s_{max} = 63 mm	a_{3ms} = 60 G s_{max} = 52 mm
Femur	F_{max} = 10 kN	F_{max} = 6.805 kN

$$HIC_{15} = \left[\frac{1}{t_2 - t_1} \int_{t_1}^{t_2} a(t)\,dt \right]^{2.5} (t_2 - t_1)$$

Car crush criteria

Example 2: Deformable barrier / in-position / EC

	50 % male
Head	HPC_{36} = 1000 a_{3ms} = 80 G
Neck	My = 57 Nm
Chest	VC = 1 m/s ThCC(s_{max}) = 50 mm
Femur	FFC (F_{max})
Knee	s_{max} = 15 mm
Tibia	TCFC(F_{max}) = 8.0 kN TI =1.3



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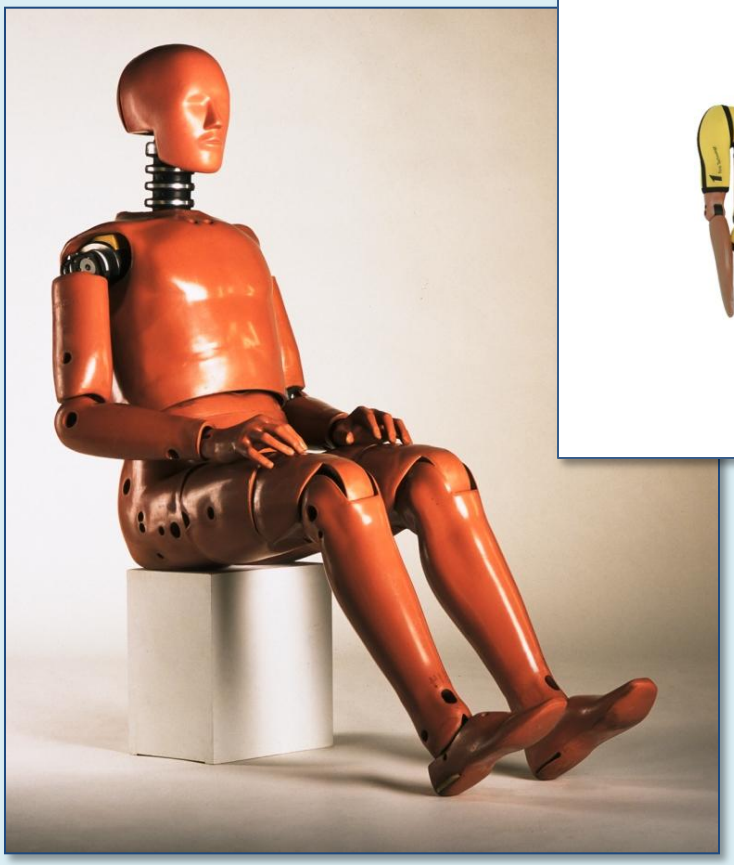
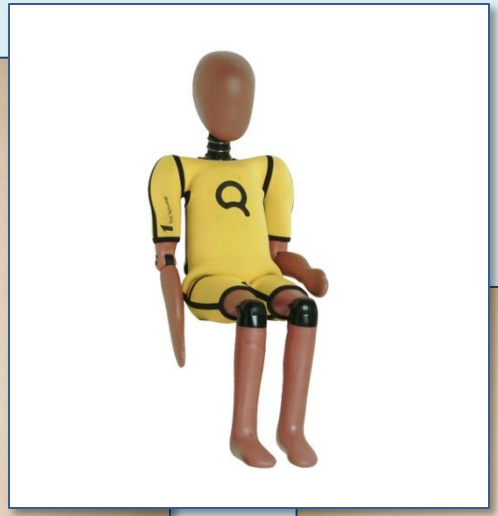
Car crush dummy





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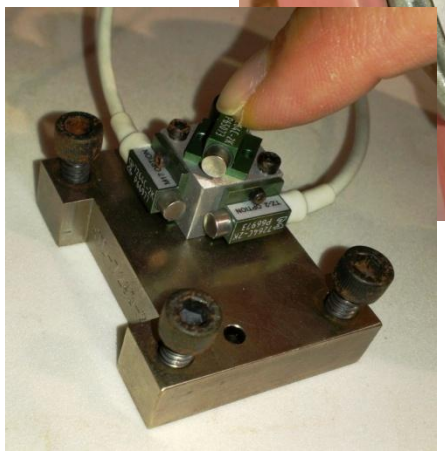
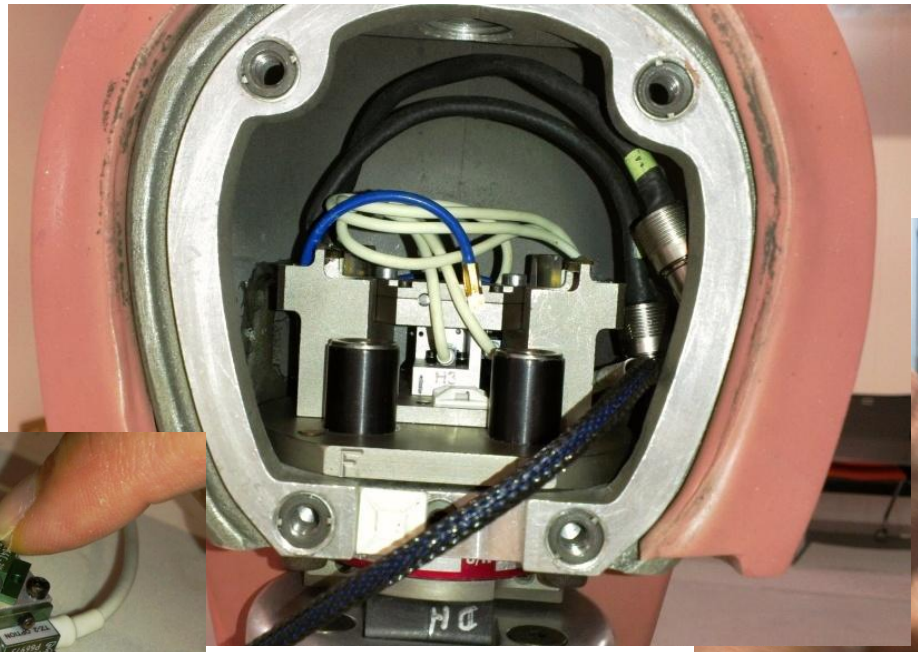
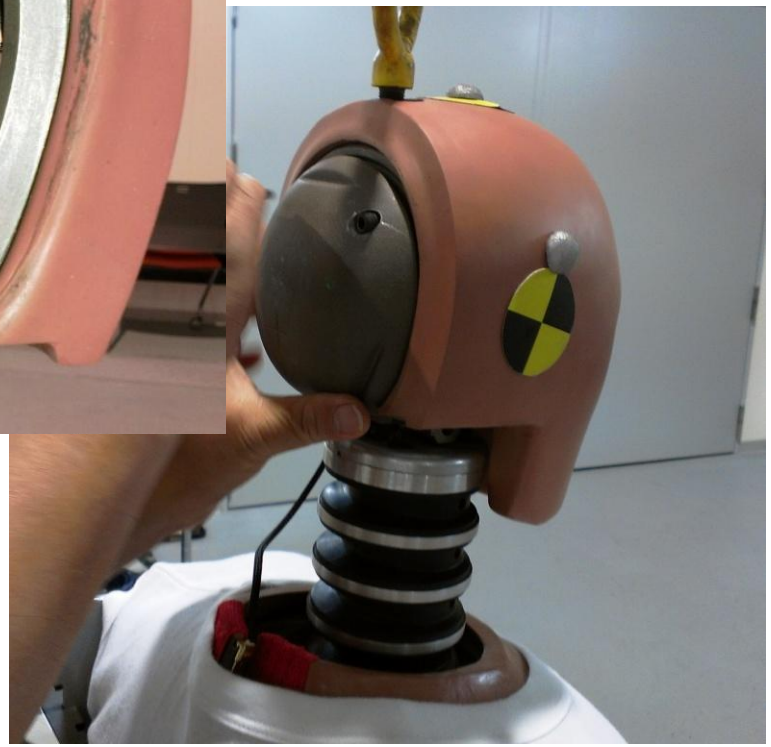
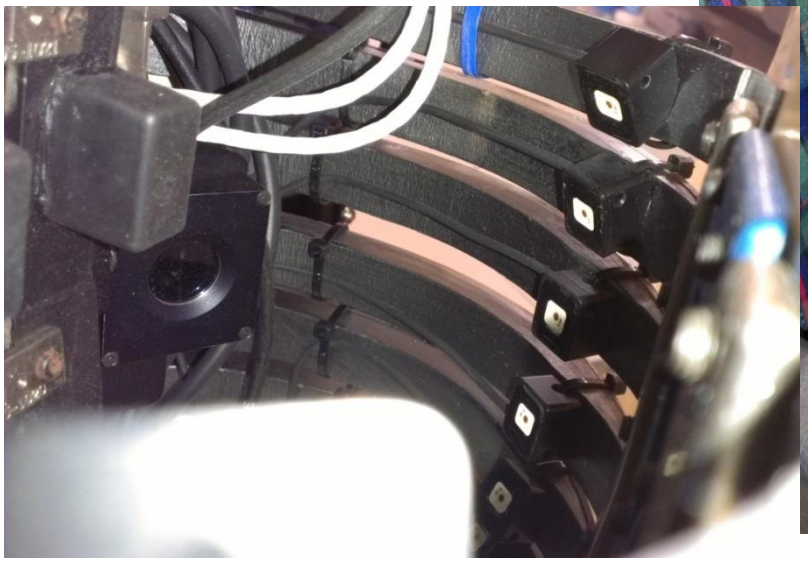
Car crush dummy

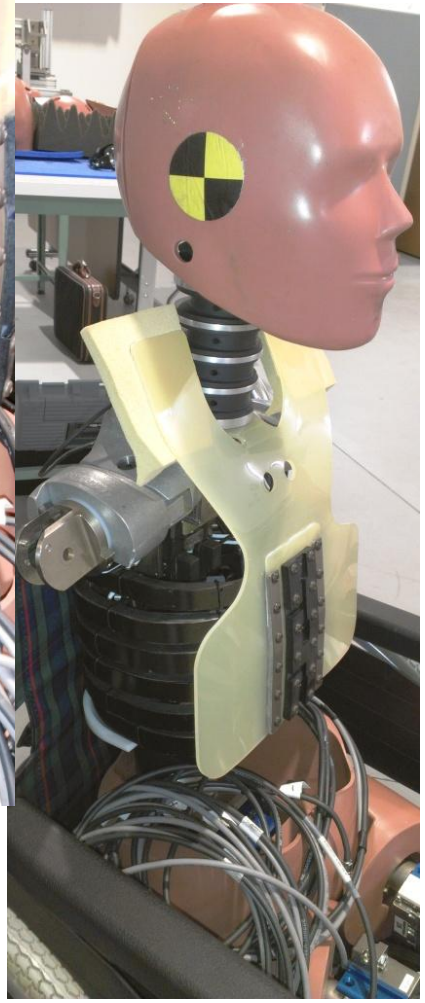






Car crush dummy





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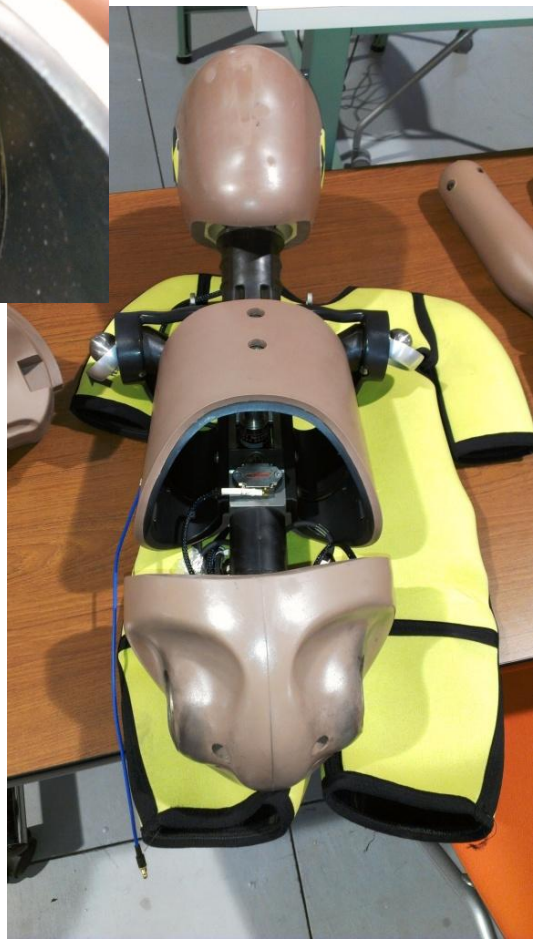
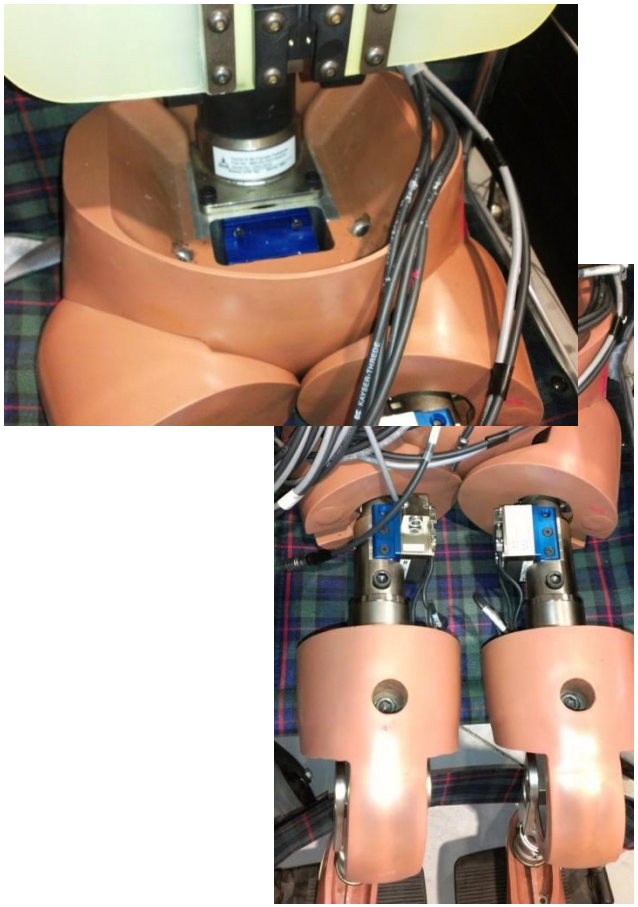
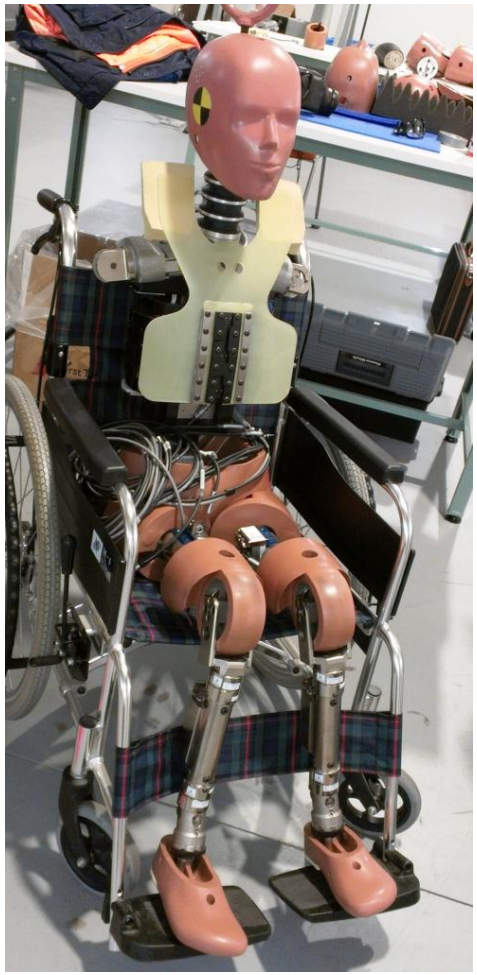
Car crush dummy



Car crush dummy





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Calibration of sensors

	Static Calibration of sensors	Dynamic Calibration of sensors	Response verification of dummy
Acceleration	✓	improving	✓
Displacement	✓	-	✓
Force	✓	-	✓
Torque	✓	-	✓

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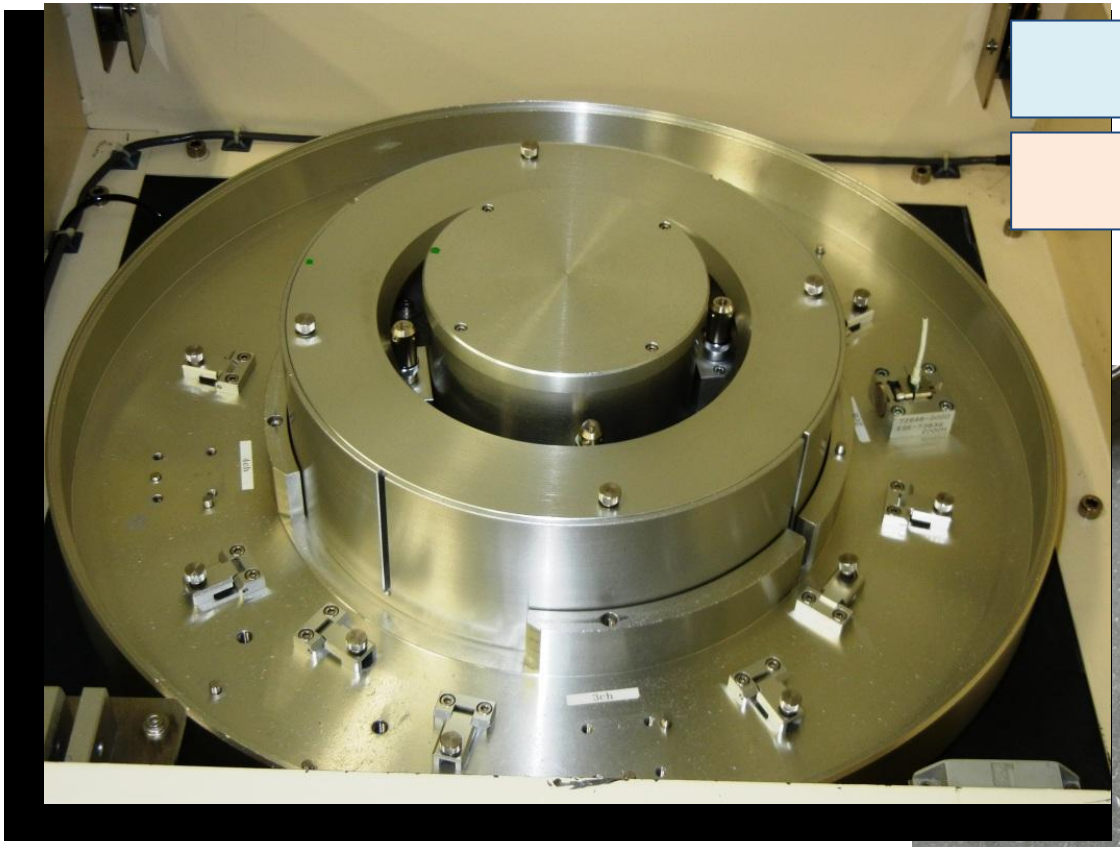
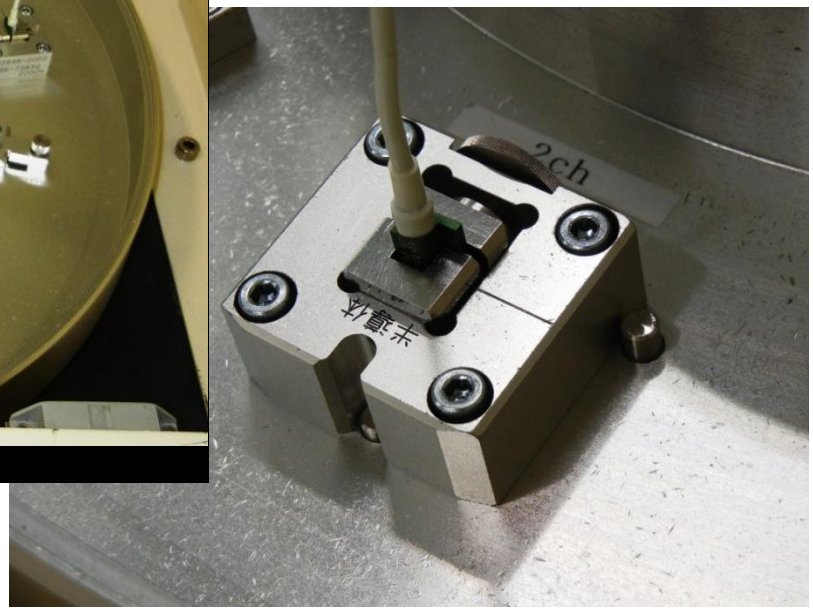
Calibration of accelerometer

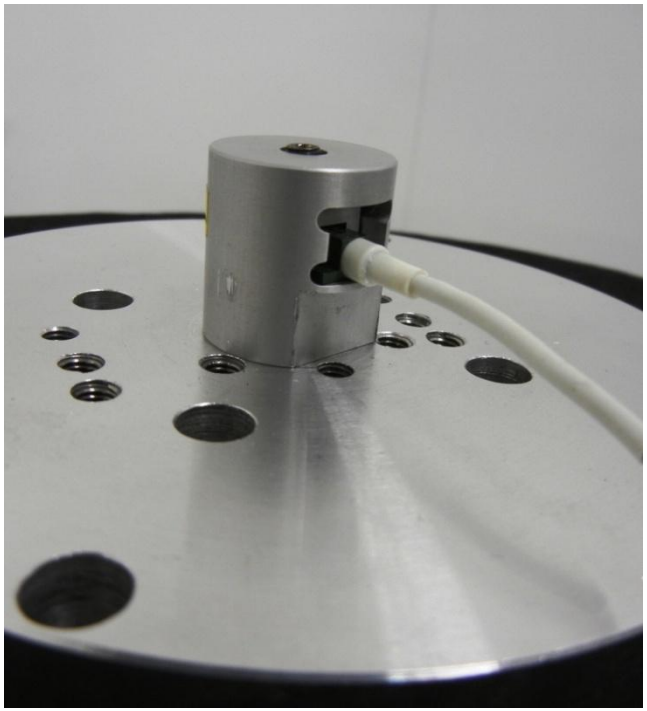


~ 1000 G

Static

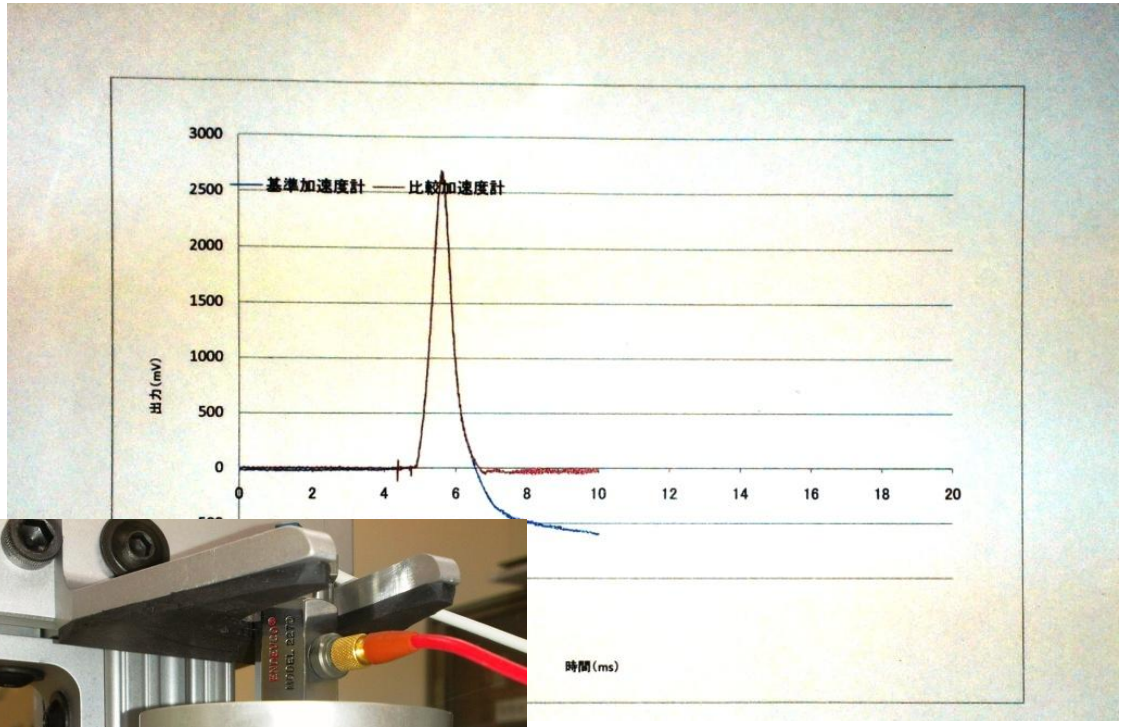


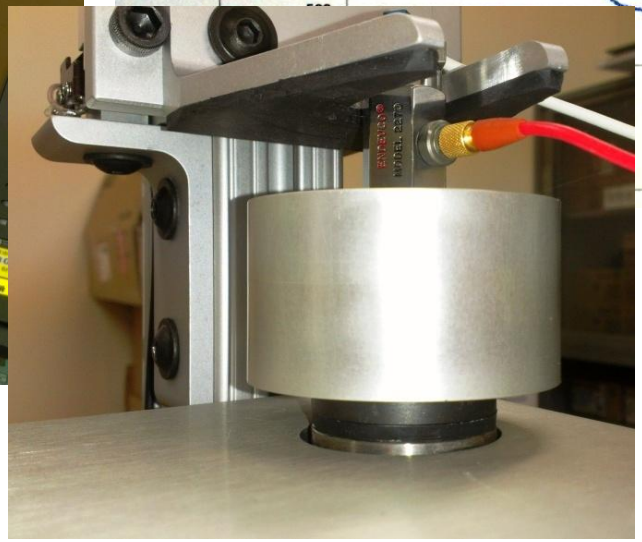
Calibration of accelerometer



Dynamic (up to 2000 Hz)
<10 G

Calibration of accelerometer





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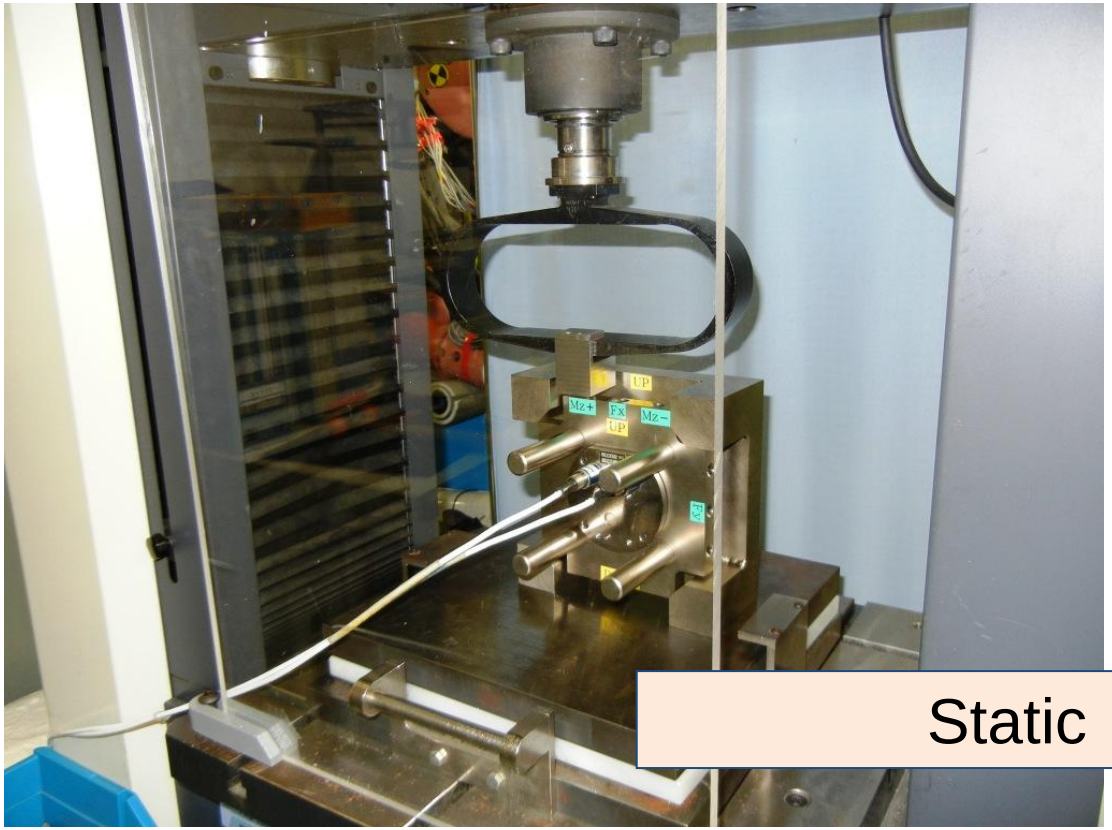
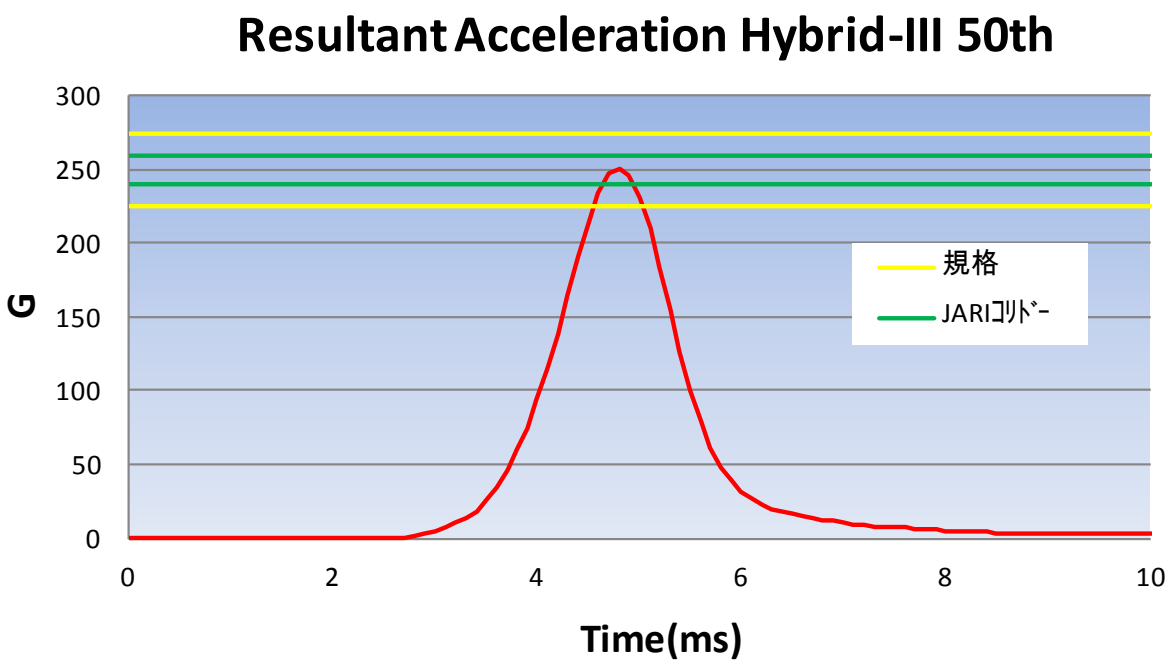
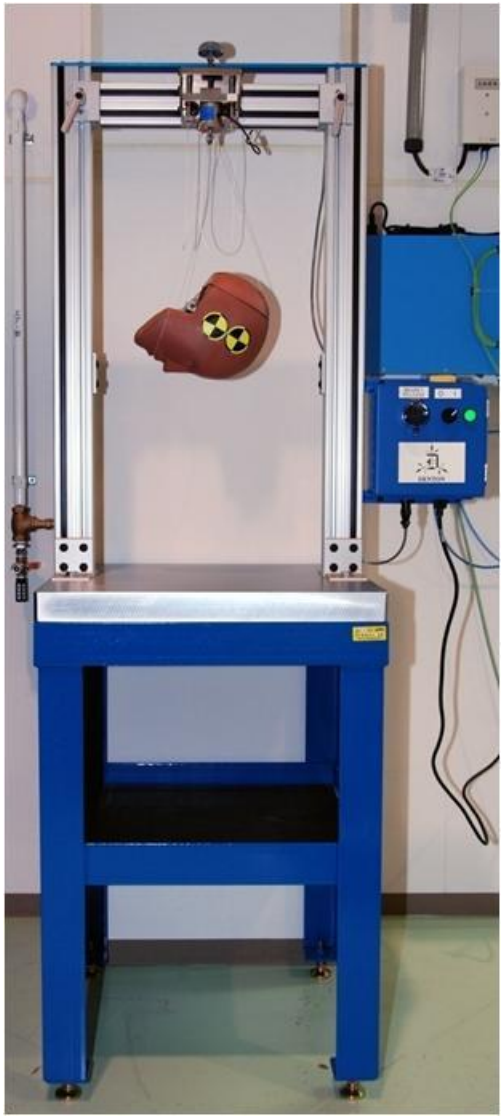
Calibration of force/torque transducer



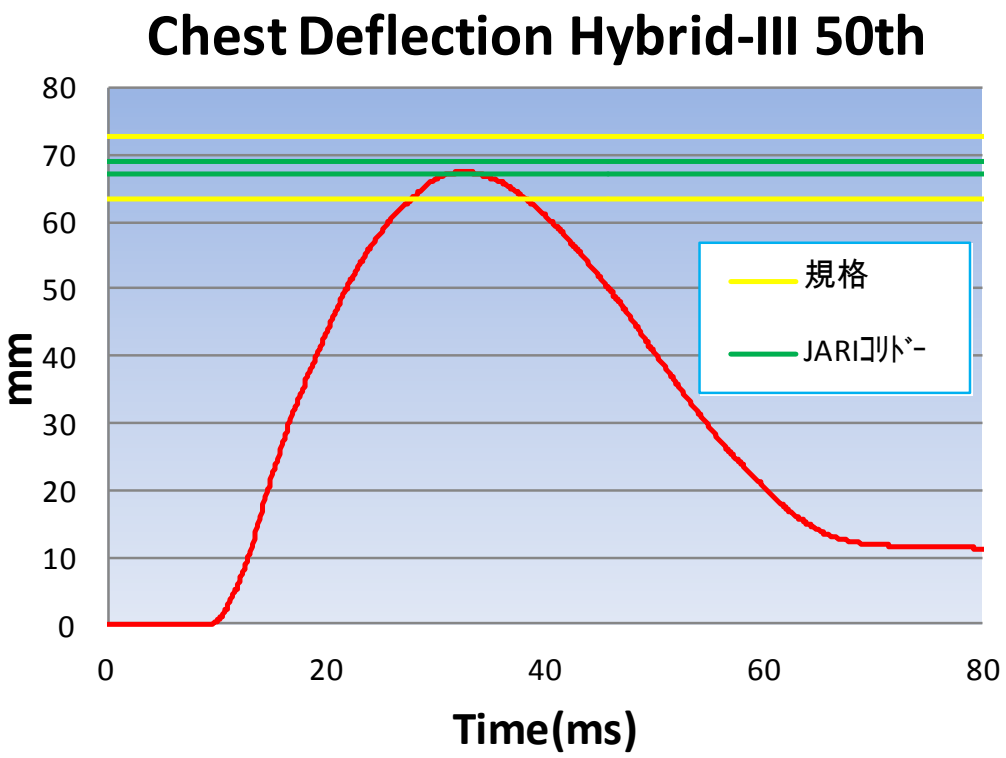
Static

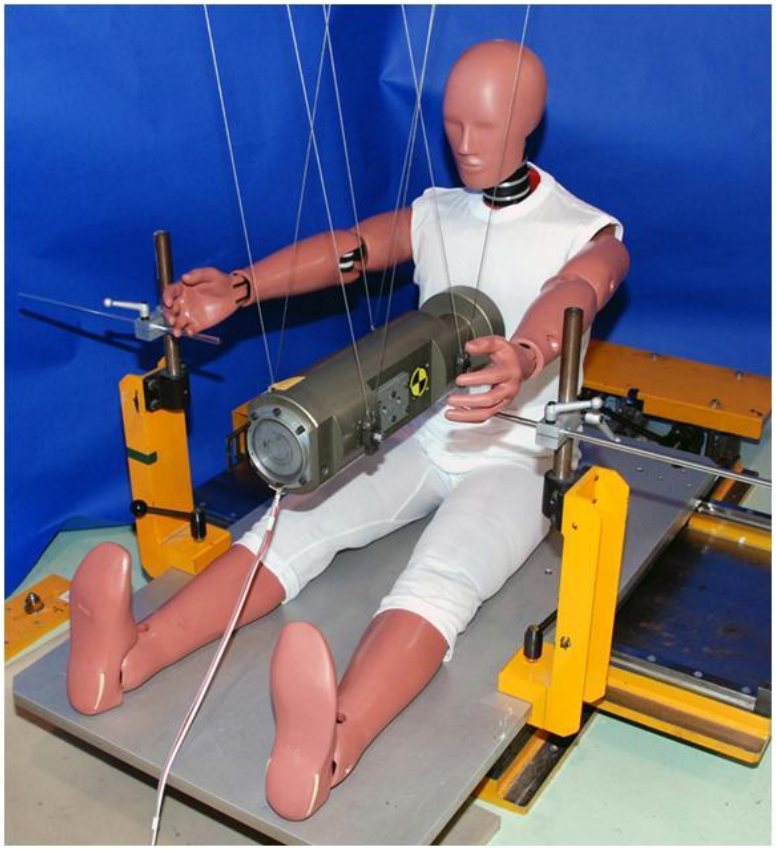
Verification of dummy head response



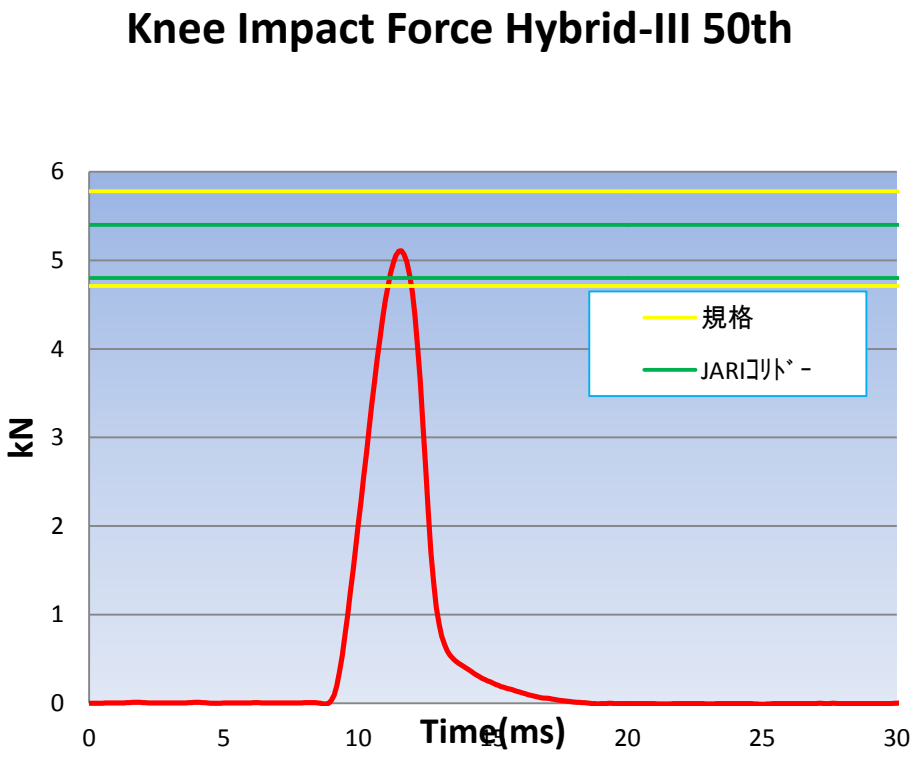


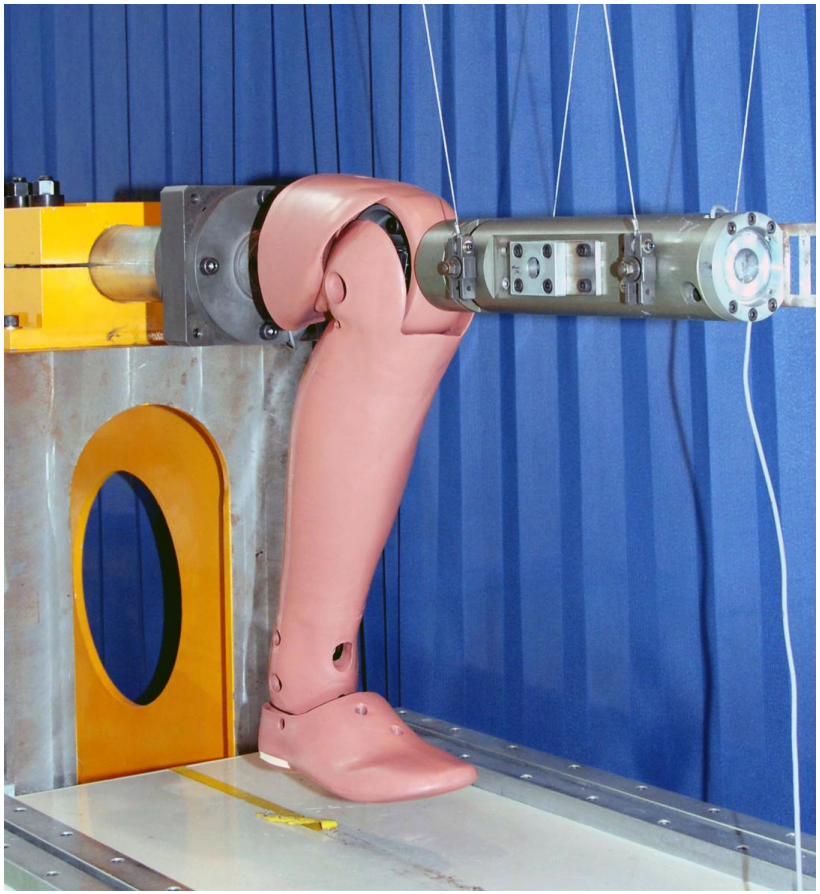
Verification of dummy chest response





Verification of dummy chest response





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Examples of car crash data

35mph Frontal Impact

$$HIC_{15} = \left[\frac{1}{t_2 - t_1} \int_{t_1}^{t_2} a(t)\,dt \right]^{2.5} (t_2 - t_1)$$

HIC_{15} = 518

NEW CAR ASSESSMENT PROGRAM FRONTAL BARRIER IMPACT TEST
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

Examples of car crash data

35mph Frontal Impact

NEW CAR ASSESSMENT PROGRAM FRONTAL BARRIER IMPACT TEST
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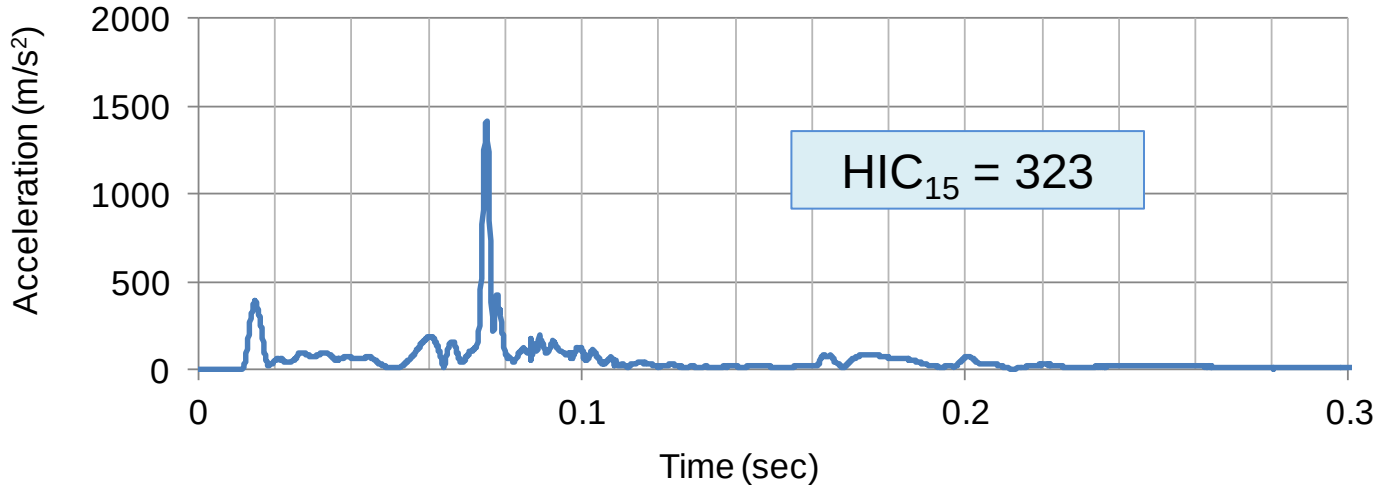
Examples of car crash data

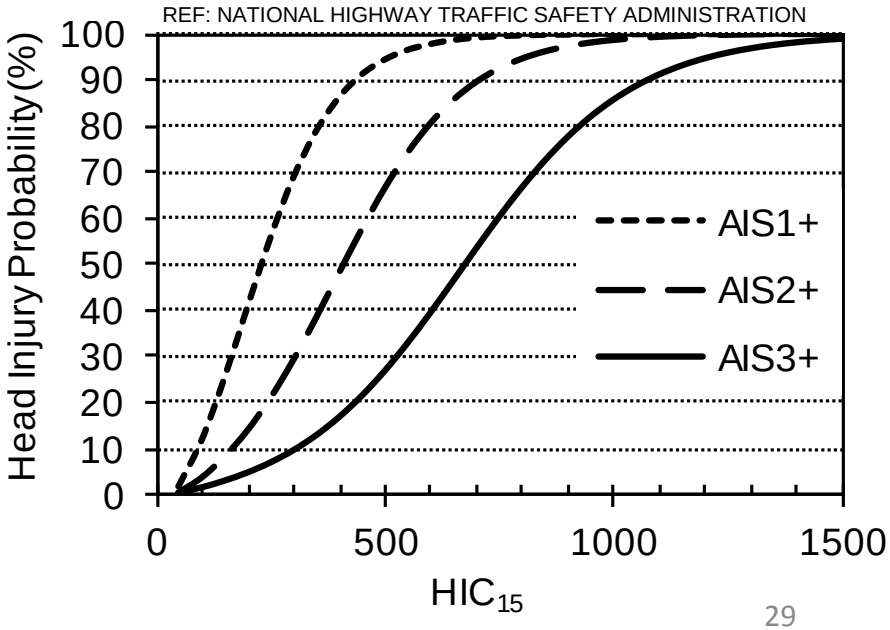
35mph Frontal Impact

NEW CAR ASSESSMENT PROGRAM FRONTAL BARRIER IMPACT TEST
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

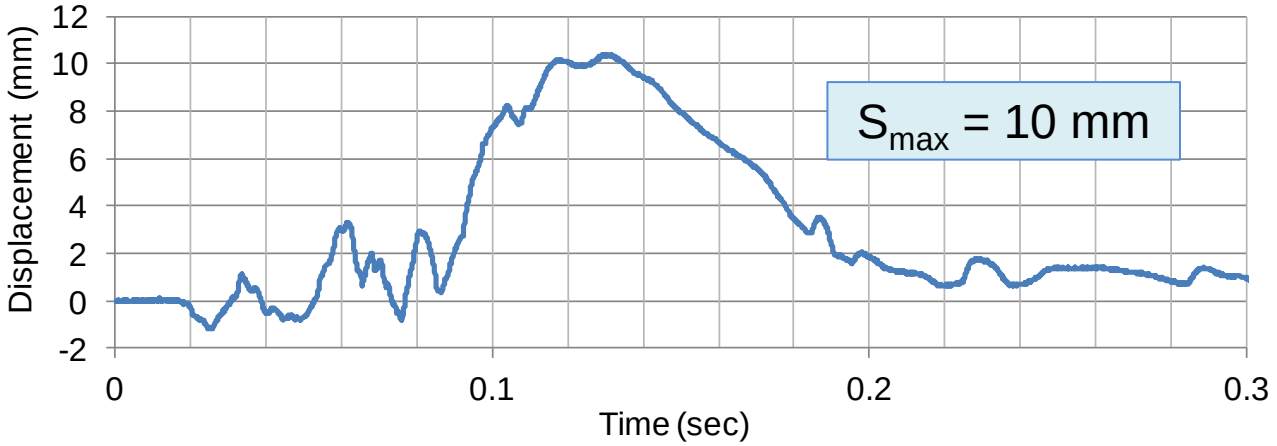
Example of robot crash data



Moving object :
200 kg
Steel Structure
6 km/h
Dummy: 6-Y-O
Standing
in front of wall



Example of robot crash data



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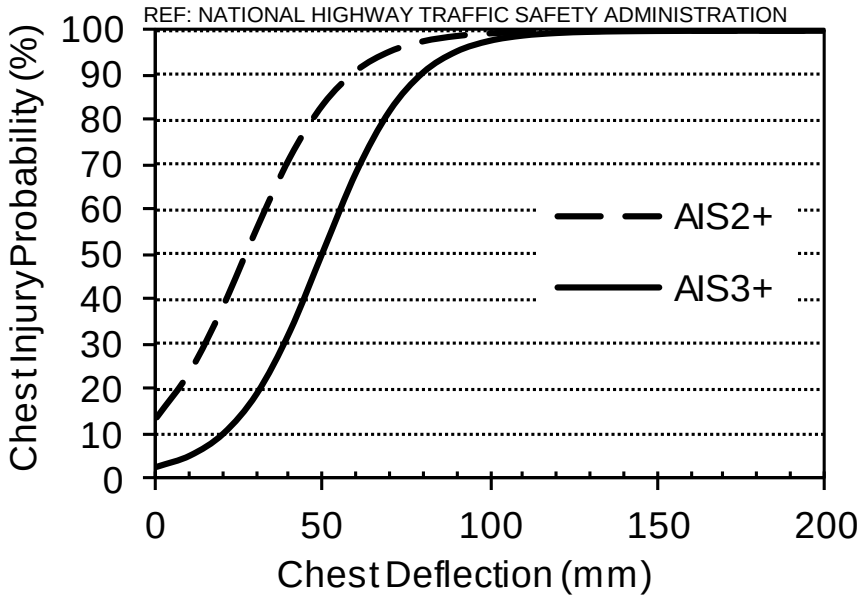
Steel Structure
6 km/h
Dummy: 6-Y-O
Standing
in front of wall



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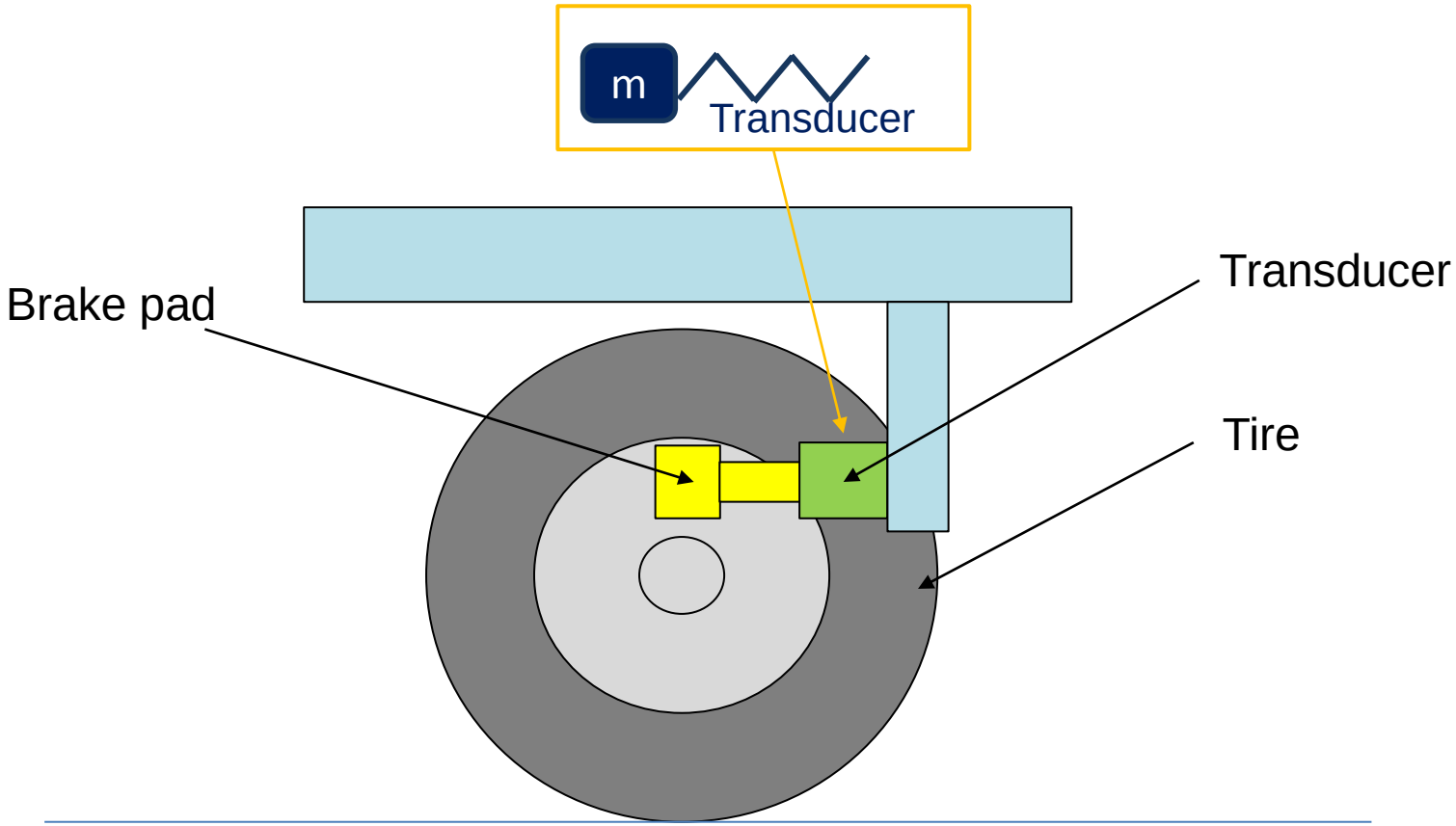
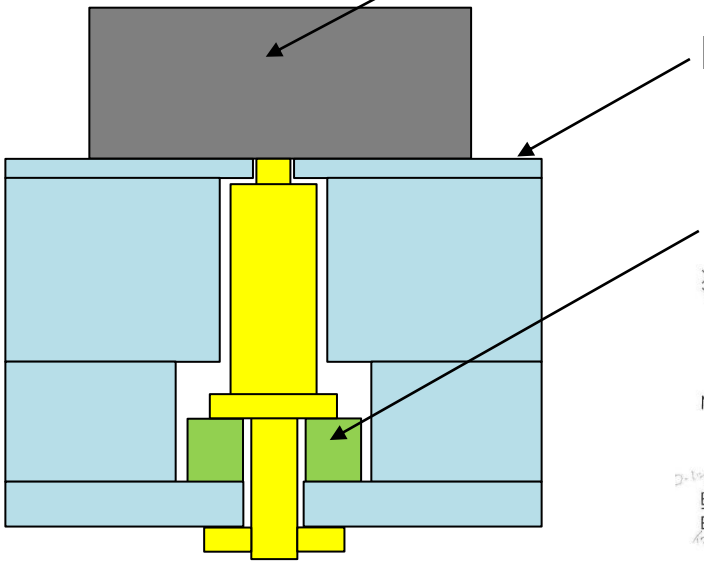
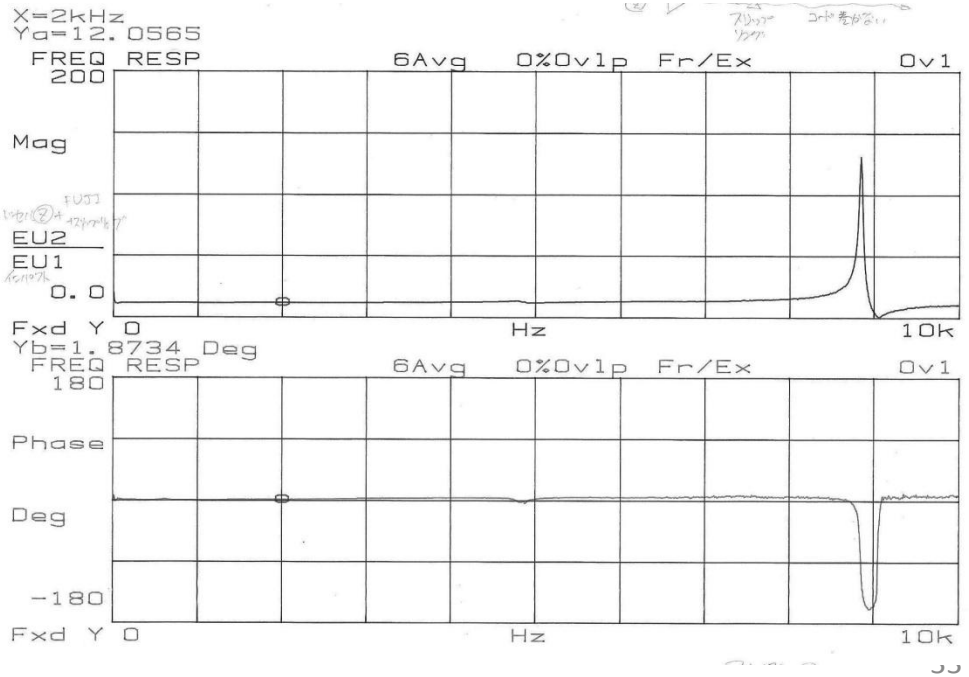
Dynamic measurement
Tire dynamic force /1987



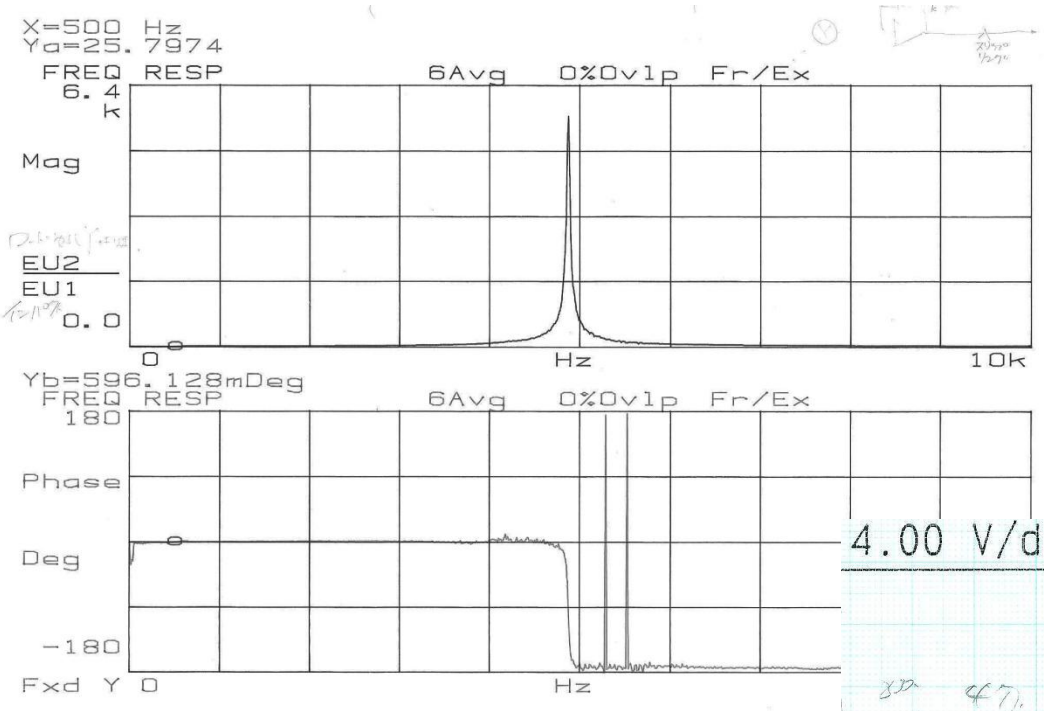
Dynamic measurement
Tire contact force /1989

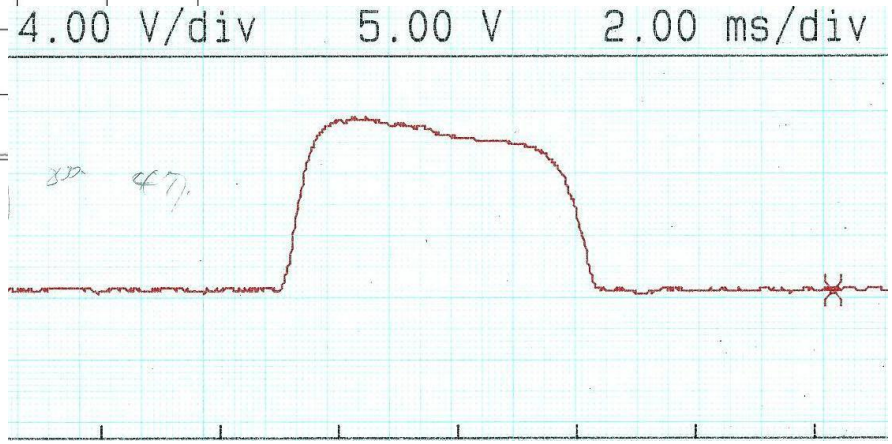




Dynamic measurement

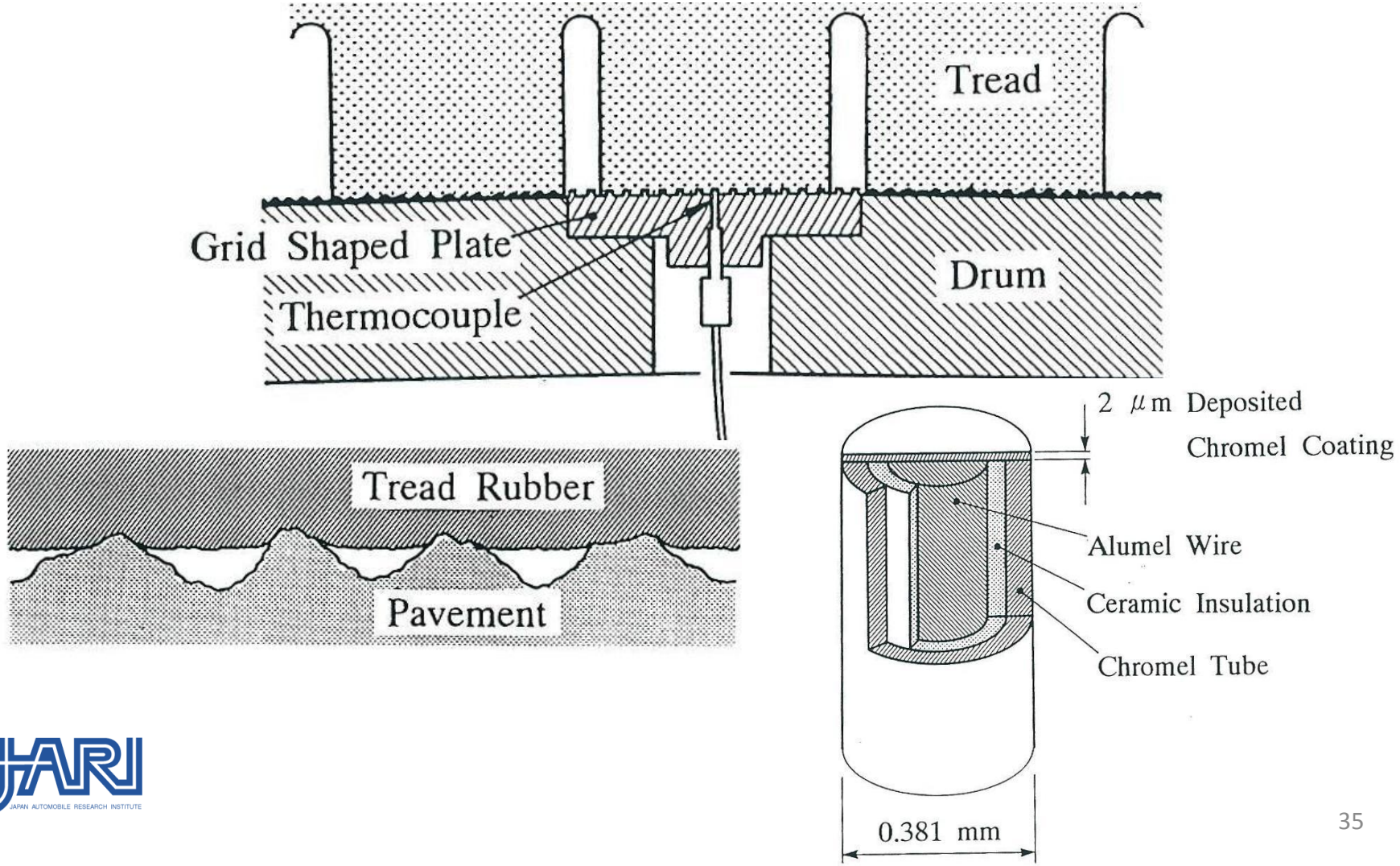
Tire contact force / 1989





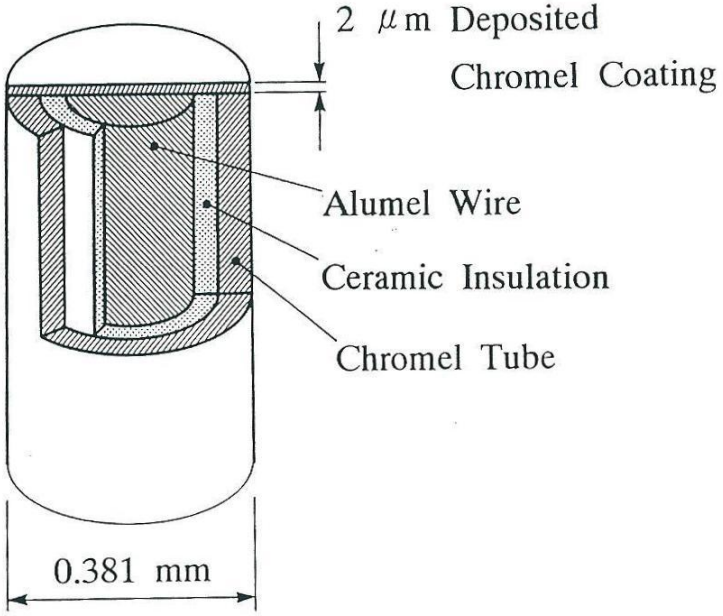
Dynamic measurement

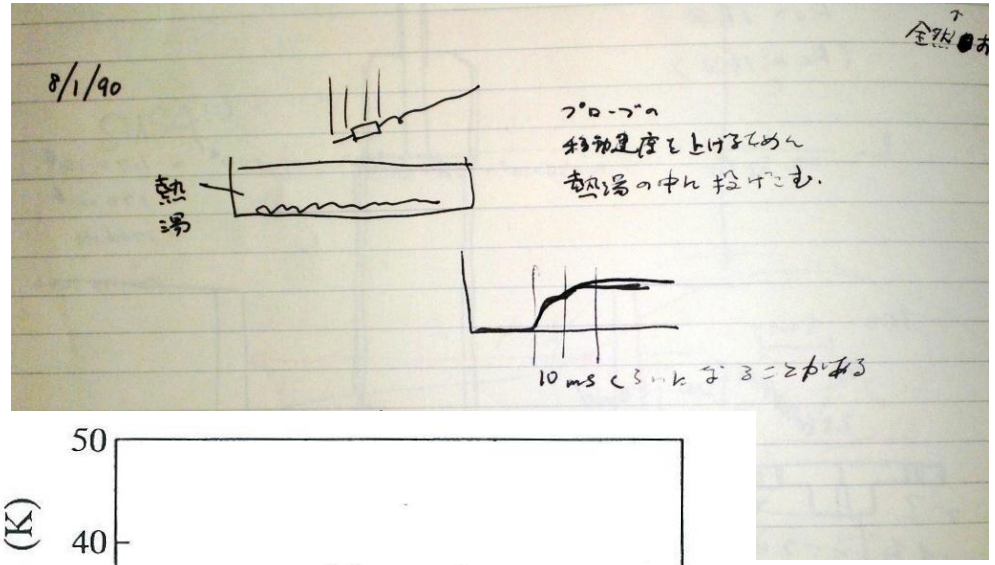
Tire temperature in actual contact area /1990

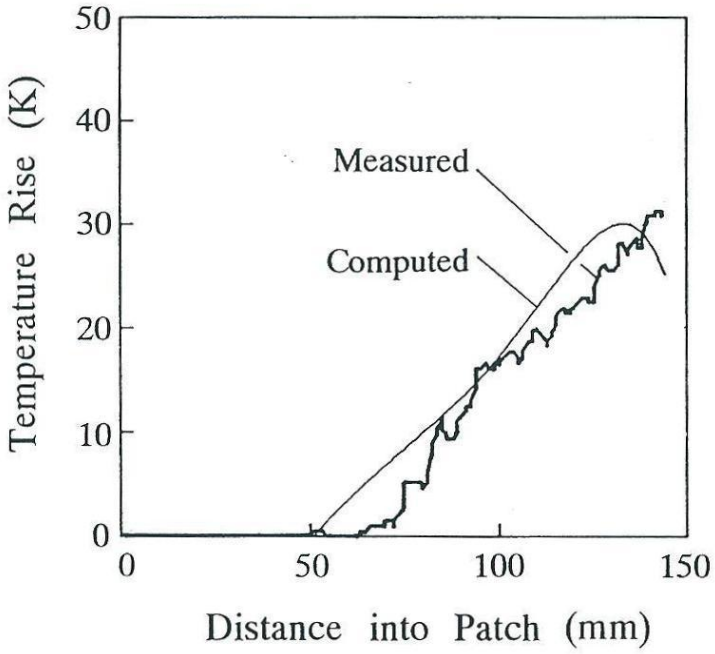


Dynamic measurement

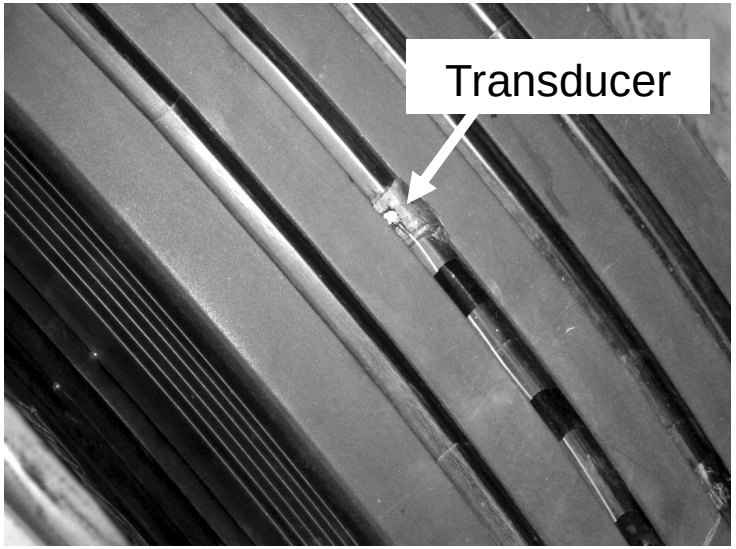
Tire temperature in actual contact area /1990

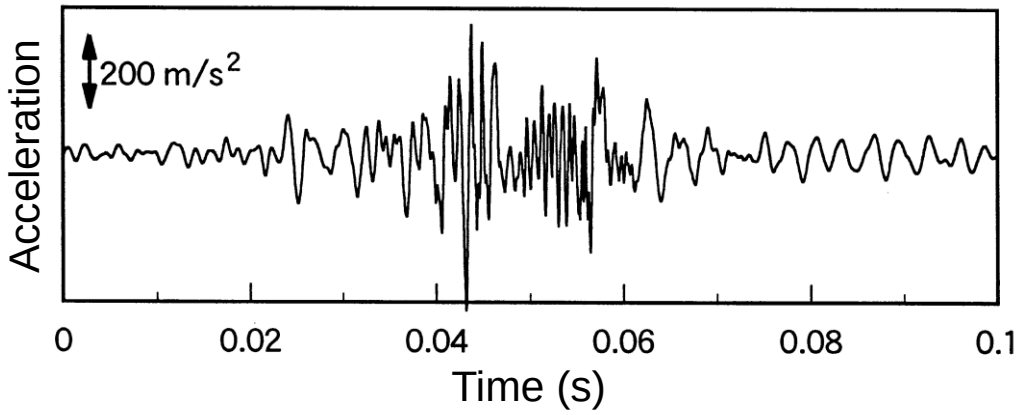


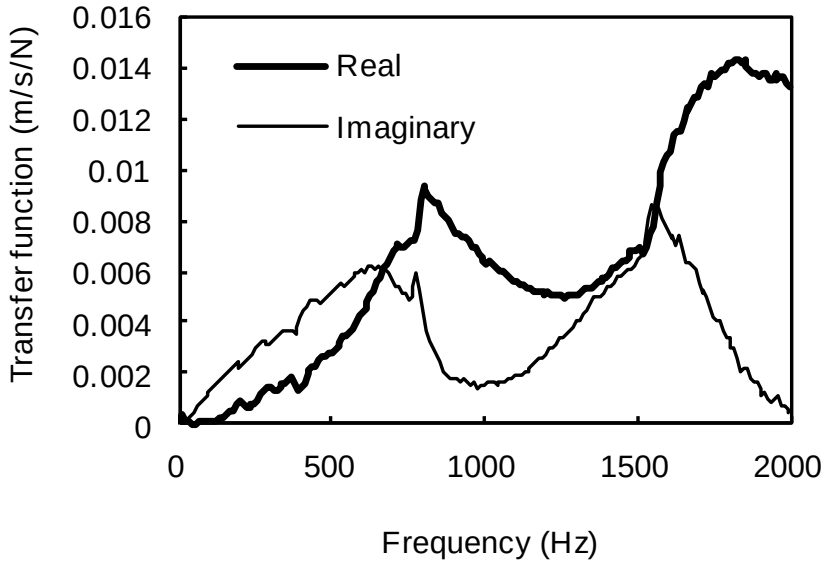




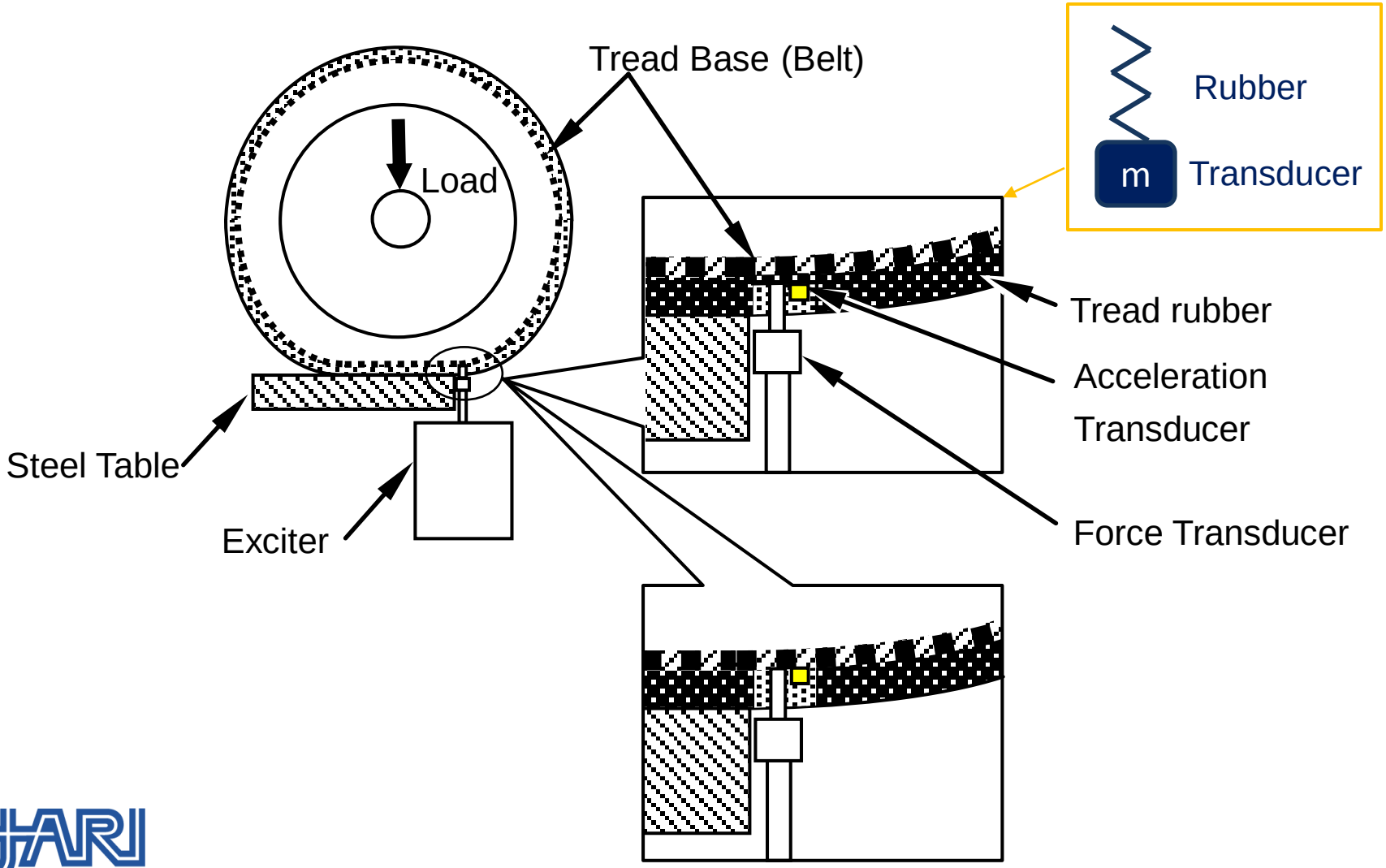
Dynamic measurement
Tire tread vibration /1999





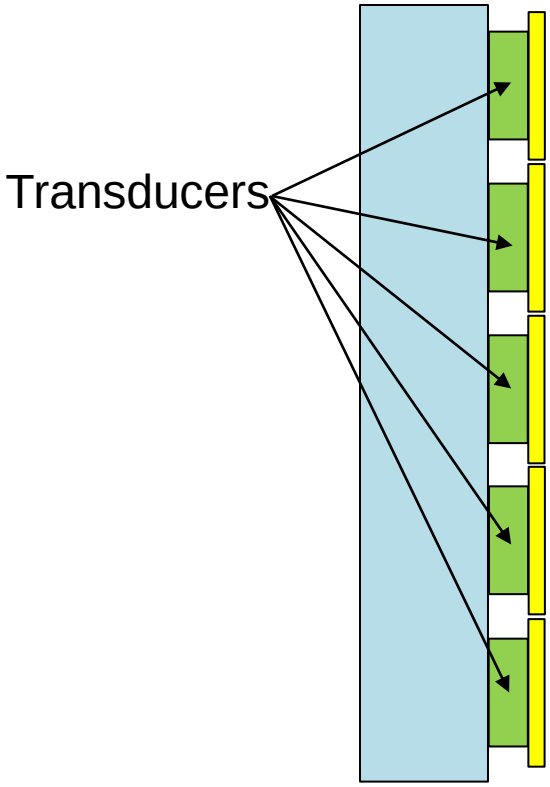


Dynamic measurement
Tire tread vibration /1999



Dynamic measurement

Crash barrier force / 20XX



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