



Expanding the scope of the national metrology system employing the revised SI

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JAPAN

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1. Introduction of NMIJ/AIST
2. Mission and Strategy of NMIJ
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Tsukuba Station



Mount Tsukuba



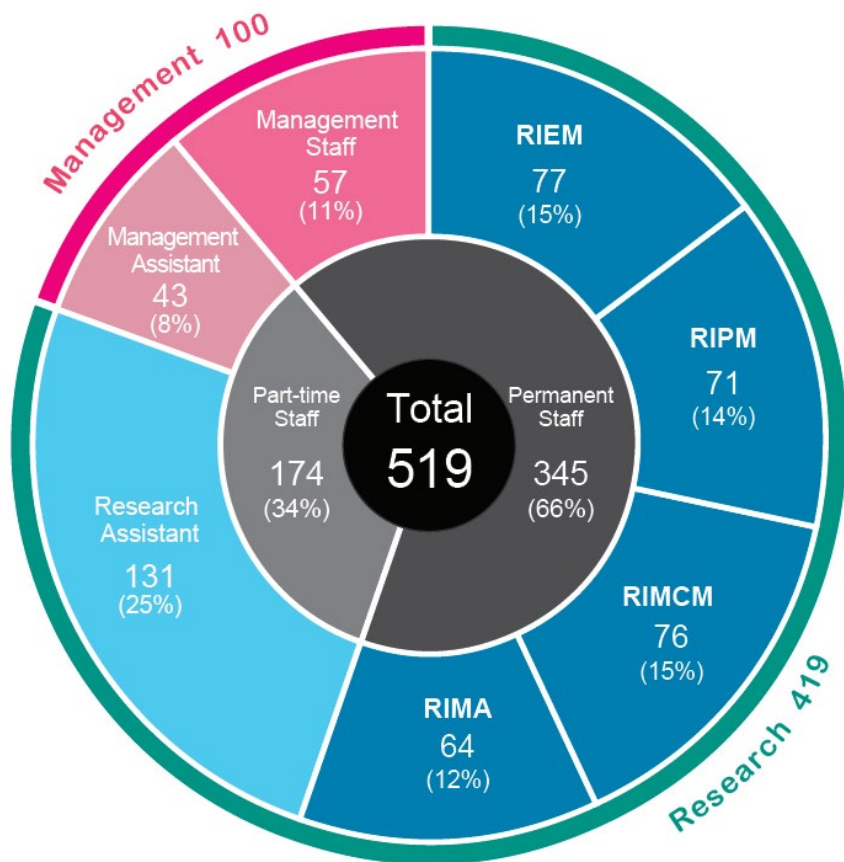
National Institute of Advanced Industrial Science and Technology (AIST)

Introduction of NMIJ/AIST

- **NMIJ** (National Metrology Institute of Japan) is a principal NMI in Japan
 - **NMIJ is a part of AIST** (National Institute of Advanced Industrial Science and Technology)
 - **AIST** is an independent administrative institute in its 4th 5-years mid-term plan, under **METI** (Ministry of Economy, Trade and Industry)
- ➔ **NMIJ** performs functions of NMI, but also contributes to industry as a part of AIST.

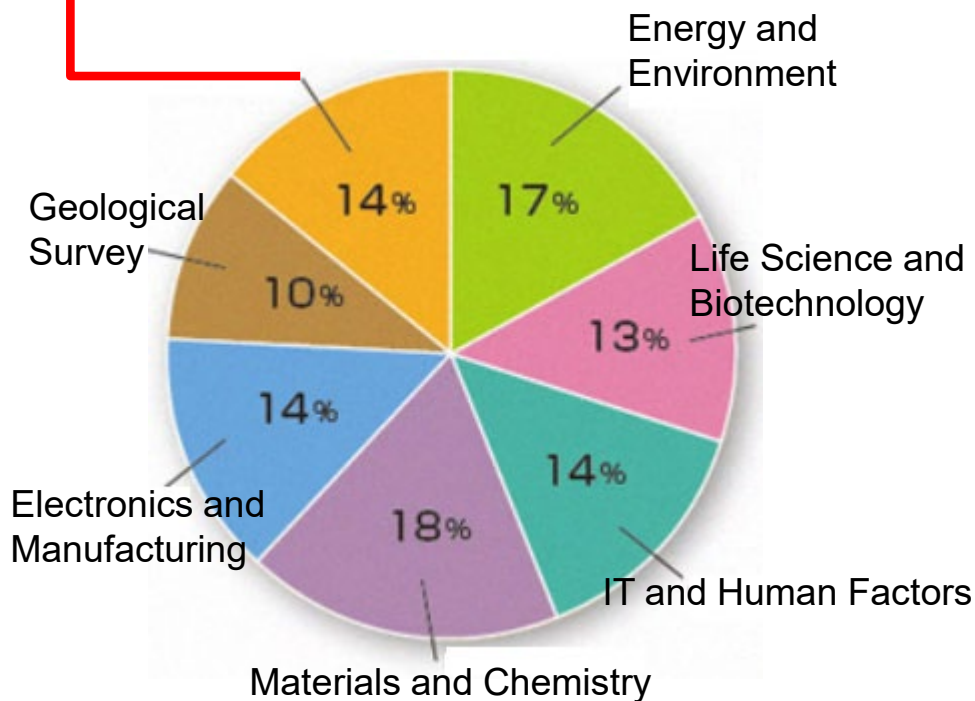
Personnel (as of 2019)

NMIJ

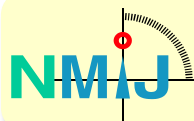


All AIST

Research	2,331
Management	699
Total Permanent staff	3,030
Part-time staff	1,549



Organization Structure of NMIJ



National Metrology Institute of Japan

- 4 research institutes
- 2 administrative units



Dr. Usuda



NMIJ Headquarter Building

Research Promotion Division of NMIJ

Research Planning Office

Research Institute for Engineering Measurement (RIEM)

Length, Mass, Pressure, ...
type approval, verification std.

Research Institute for Physical Measurement (RIPM)

Electricity, Time/Frequency,
Temperature, Photometry, ...

Research Institute for Material and Chemical Measurement (RIMCM)

Inorganic standards,
CRM, ...

Research Institute for Measurement and Analytical Instrumentation (RIMA)

Ionizing Radiation,
Ultrasonics, ...

Center for Quality Management of Metrology

Metrology Training Center,
International Cooperation, ...



Dr. Fujimoto



Mr. Fujima



Dr. Nonaka



Dr. Takatsuji



Dr. Takatsu



Dr. Kobata

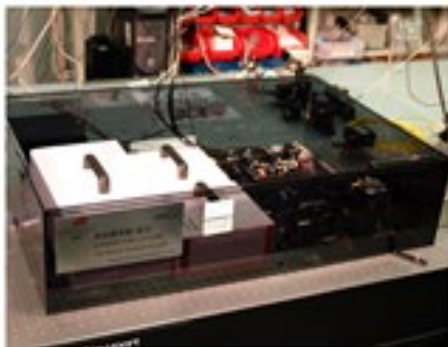
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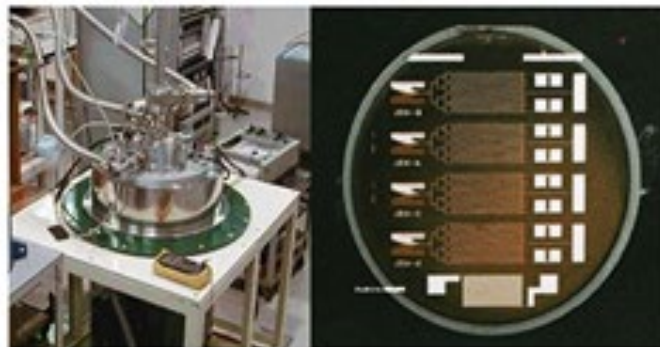
Establishment and Dissemination of National Metrology Standards

Length (m)



Optical frequency comb

Electric Current (A)



Quantum Hall Resistance system (R)

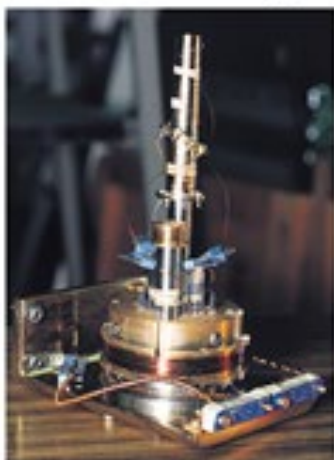
Josephson effect Voltage standards (V)

Amount of Substance (mol)



Certified Reference Materials

Luminous intensity (cd)



Receiver unit of Cryogenic electrical substitution radiometer

Mass (kg)



Kilogram prototype

Time (s)



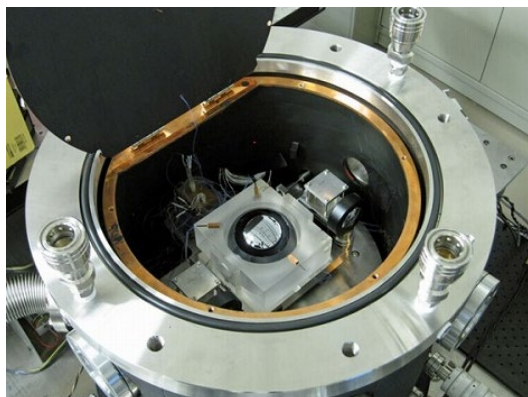
Cesium atomic fountain frequency Standard

Thermodynamic temperature (K)

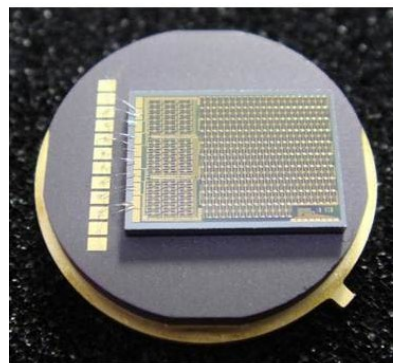


Water triple-point cell

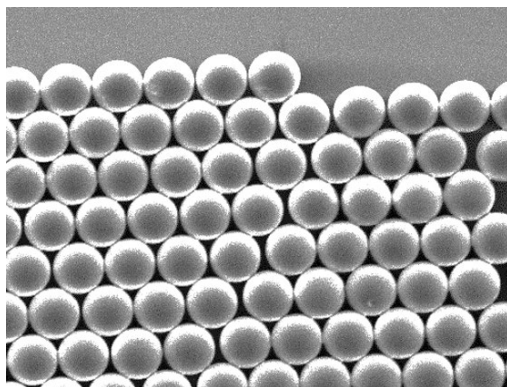
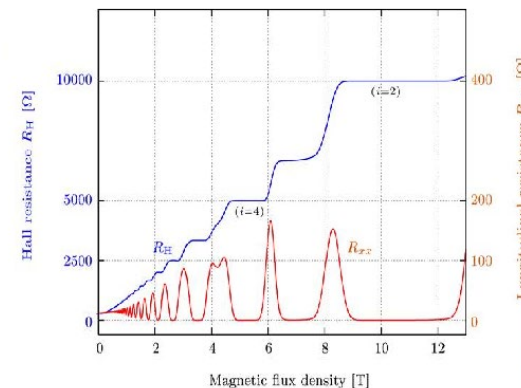
Scientific activities relating Metrology and Measurement



Redefine kg via Silicon sphere



Integrated quantum Hall effect device



Particle analysis and CRM



Microscopic analysis by positron beam

Changes of NMIJ main missions

The 1st and 2nd terms (2001-2009)

Developing the national primary measurement standards aiming for **a level equivalent to that of European countries and the U.S.**

The 3rd term (2010-2014)

Developing the national primary measurement standards, which are especially required **for environmental protection, energy, medical care, and healthcare.**

The 4th term (2015-2019)

Developing the national primary measurement standards **in accordance with user's request** and delivering the **measurement science and technology to enable businesses** across all industrial sectors.

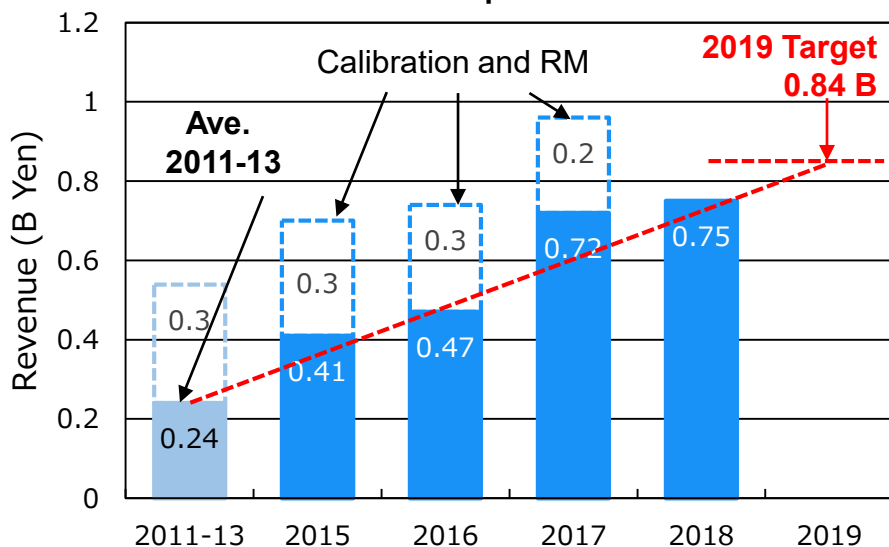
Quantity



Quality

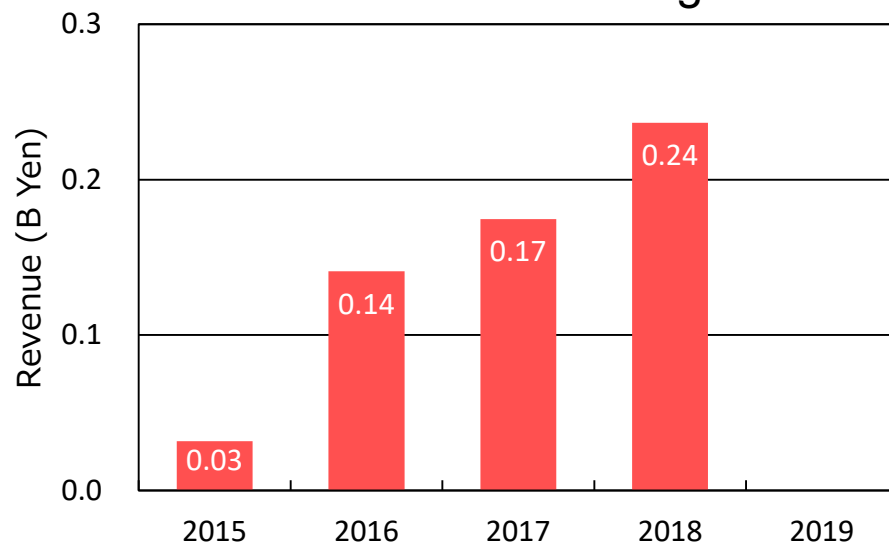
Revenue from the private sectors

Revenue from private sector



Target (B Yen)	0.36	0.48	0.60	0.72	0.84
Achievement	114%	98%	120%	104%	

Technical consulting



Year	2015	2016	2017	2018
The percentage of revenue from the private sectors	8%	30%	24%	31%

Target between 2015-18: **2.2 B Yen**
 Total revenue for 4 years: **2.4 B Yen (109%)**

The percentage of revenue from the private sectors for 4 years: **25%**

The technical consulting has continuously grown, reaching **31%** of the revenue from the private sectors at the end of 2018 FY.

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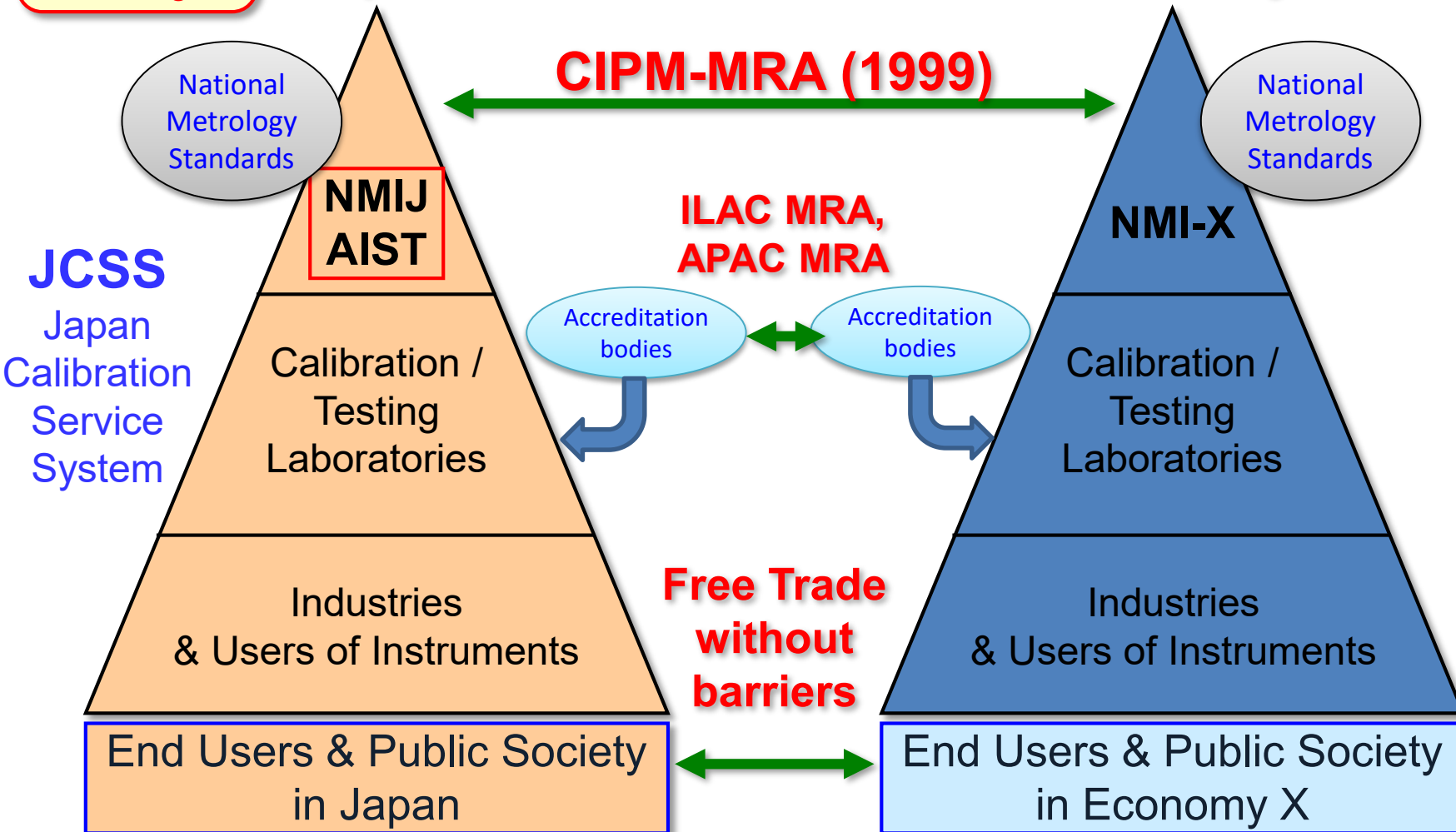


International Traceability System Based on the CIPM-MRA

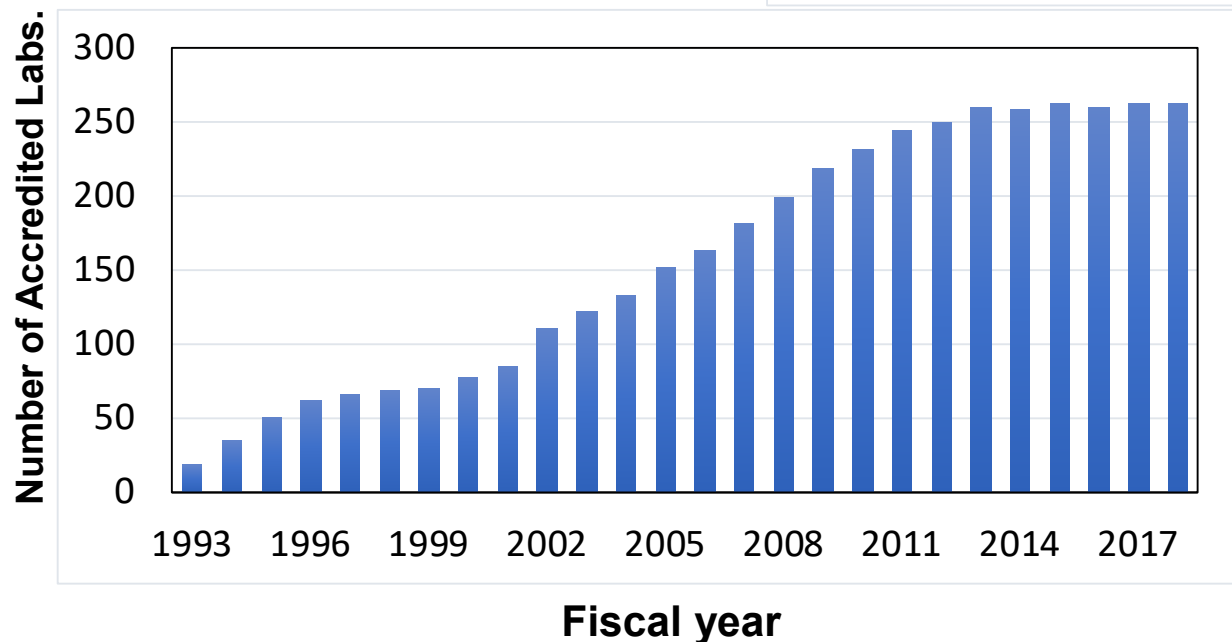
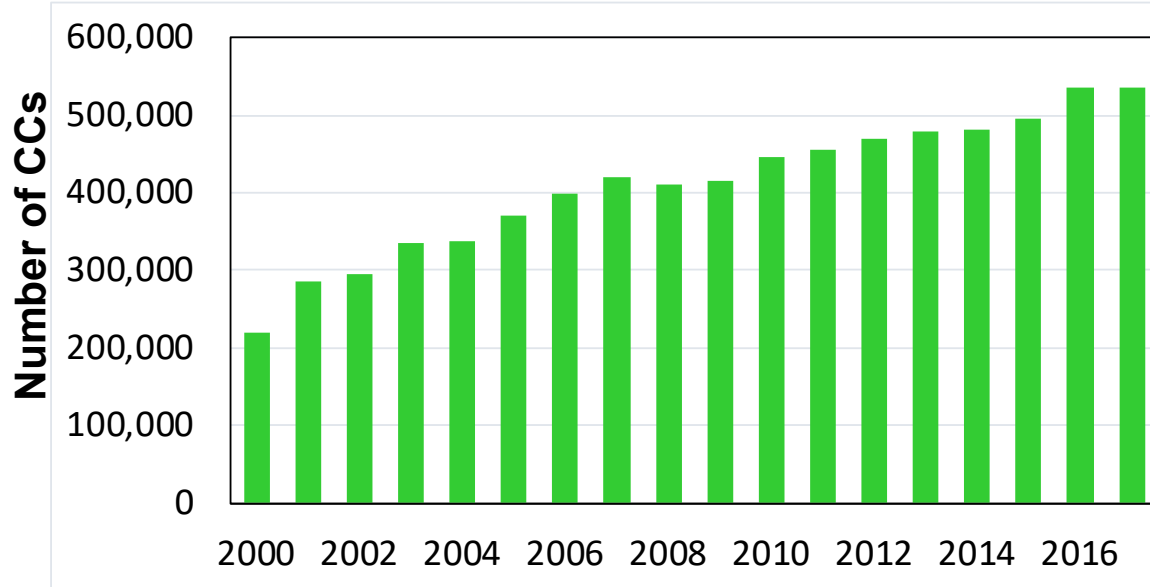
Realization of
ONE-STOP
testing

Japan

Economy X



Issued calibration certificates (CCs) and accredited laboratories under JCSS



Fiscal year

More than **500 000** calibration certificates (CCs) were issued a year, and more than **260** laboratories have been accredited in 2017 under JCSS!

Response to the revised SI

Information in NMIJ website (<https://unit.aist.go.jp/nmij/english/>)

[General information] - Web page updated (May 20, 2019)

A new age in base metrology units - Redefinition of the International System of Units (SI)

[Electricity] May 15, 2019

“Effects of the redefinition of the SI units on domestic electrical standards”

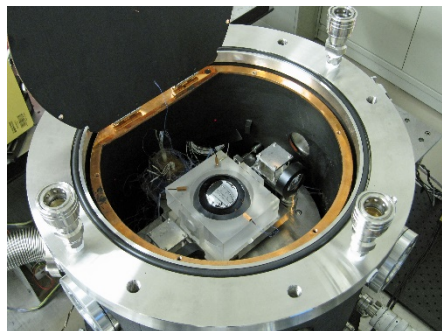
[Mass] May 20, 2019

“Re-assignment of the Specified Mass Standard”

[Temperature] July 4, 2019

Operation of the calibration certificate based on thermodynamic temperature for radiation thermometers (960 °C to 2800 °C)

Traceability chart of mass standard based on the new kg definition after the independent realization is validated



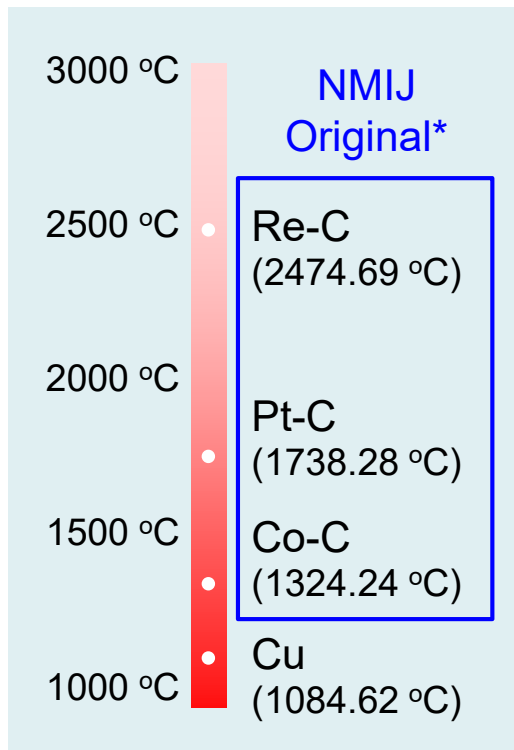
Laser interferometer and ^{28}Si sphere to realize the kilogram based on the Planck constant



Standard weights of NMIJ

The kelvin redefinition

- The new definition is no longer be linked to the triple point of water.
- No uncertainty propagation from TPW.
- Primary thermometry will increasingly supplant the defined temperature scales for realization and dissemination of the unit.
- At high temperatures, absolute or relative primary thermometry can already give similar or superior uncertainties to ITS-90.



Mise en pratique for the definition of the kelvin in the SI (*MeP-K-19*)

Relative primary radiometric thermometry

- Interpolation or extrapolation from three or more fixed points.
- Thermodynamic temperatures are assigned for high-temperature metal-carbon eutectic fixed points.

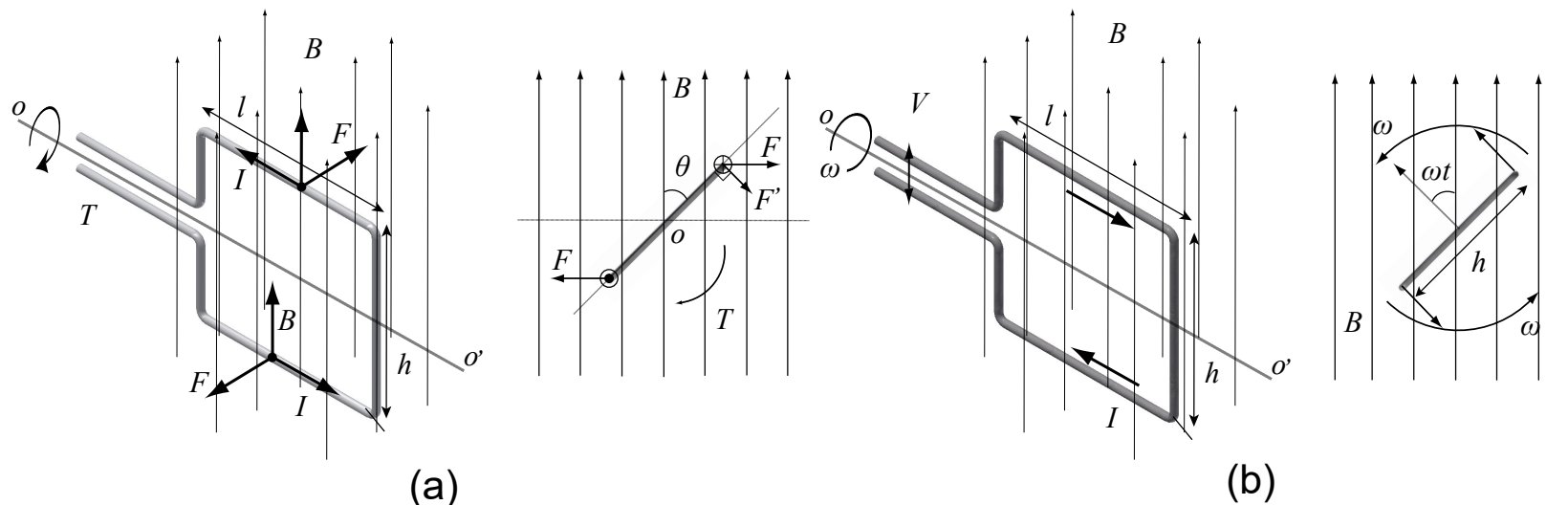


NMIJ has started dissemination of thermodynamic temperature above 960 °C by relative primary radiometric thermometry method.

* Yamada Y., *et al.*, *Metrologia*, 2001, **38**, 213-219

A New Torque Standard Machine based on a Torque Generation Method using Electromagnetic Force

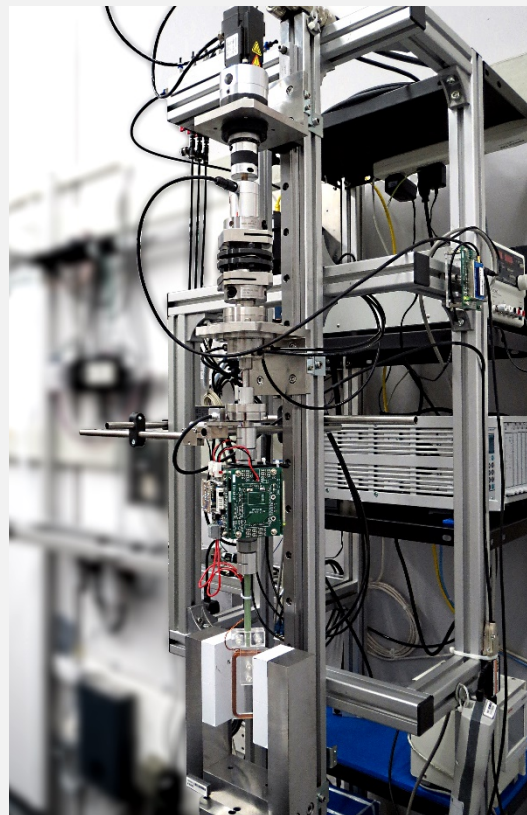
Principle of a torque, T , generation method: Kibble balance in a rotating coordinate system



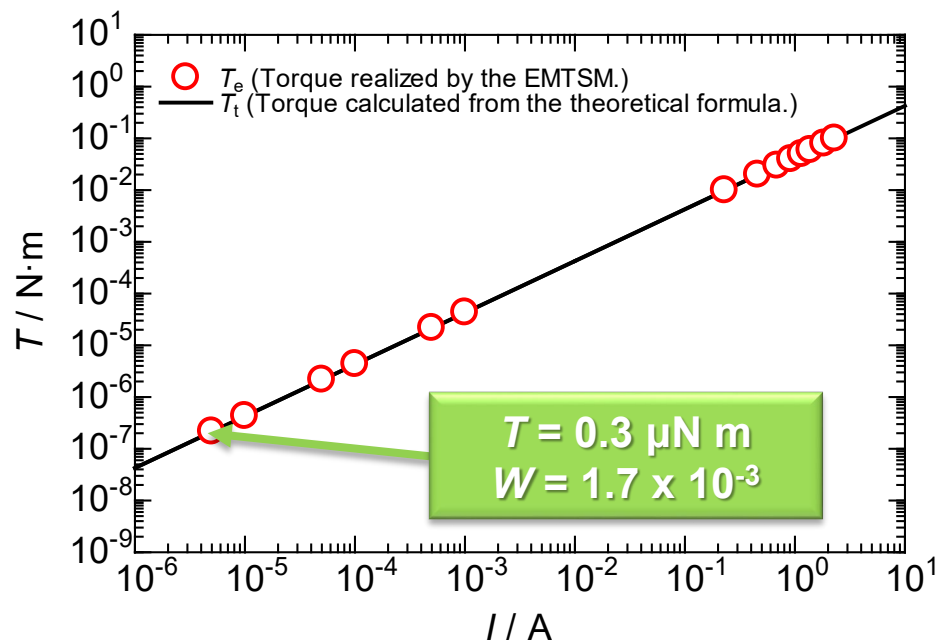
Schematic of the principle of the torque generating method using electromagnetic force, showing (a) Torque, T , generating mode, and (b) induced electromotive force, V , generating mode.

$$\underbrace{T\omega}_{\text{Mechanical power}} = \underbrace{VI}_{\text{Electrical power}}$$

A New Torque Standard Machine based on a Torque Generation Method using Electromagnetic Force



Electromagnetic force torque standard machine, EMTSM.



Relationship between the electric current I and the torque T .

SI-traceable microscopic torque was successfully realized for the first time using a method which does not rely on the gravitational force.

A. Nishino, *et al.*, *Meas. Sci. Technol.* **28** (2017) 025005 (11pp)

A. Nishino and K. Fujii, *Measurement* **147** (2019) 106821

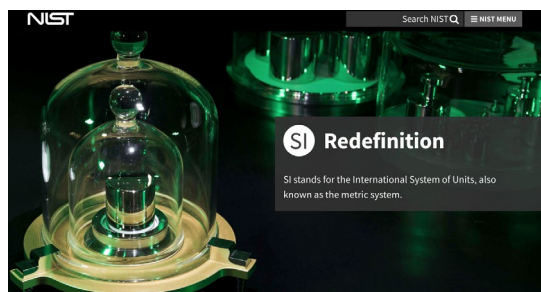
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NMI websites around the world

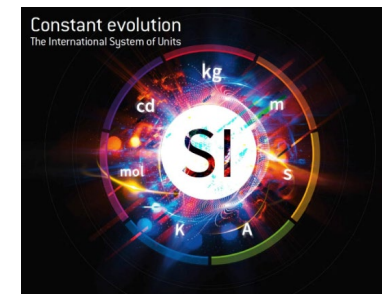
- Establish special websites for the redefinition, and publish news on the new definition.
- EURAMET appeals the contribution of EMPIR by its newsletter.



United States : NIST



Germany : PTB



Switzerland : METAS



UK : NPL



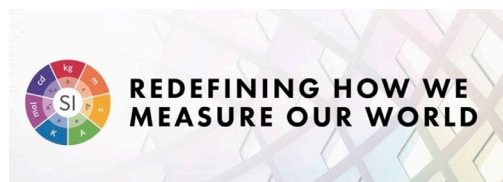
France: LNE



China : NIM



Italy : INRIM



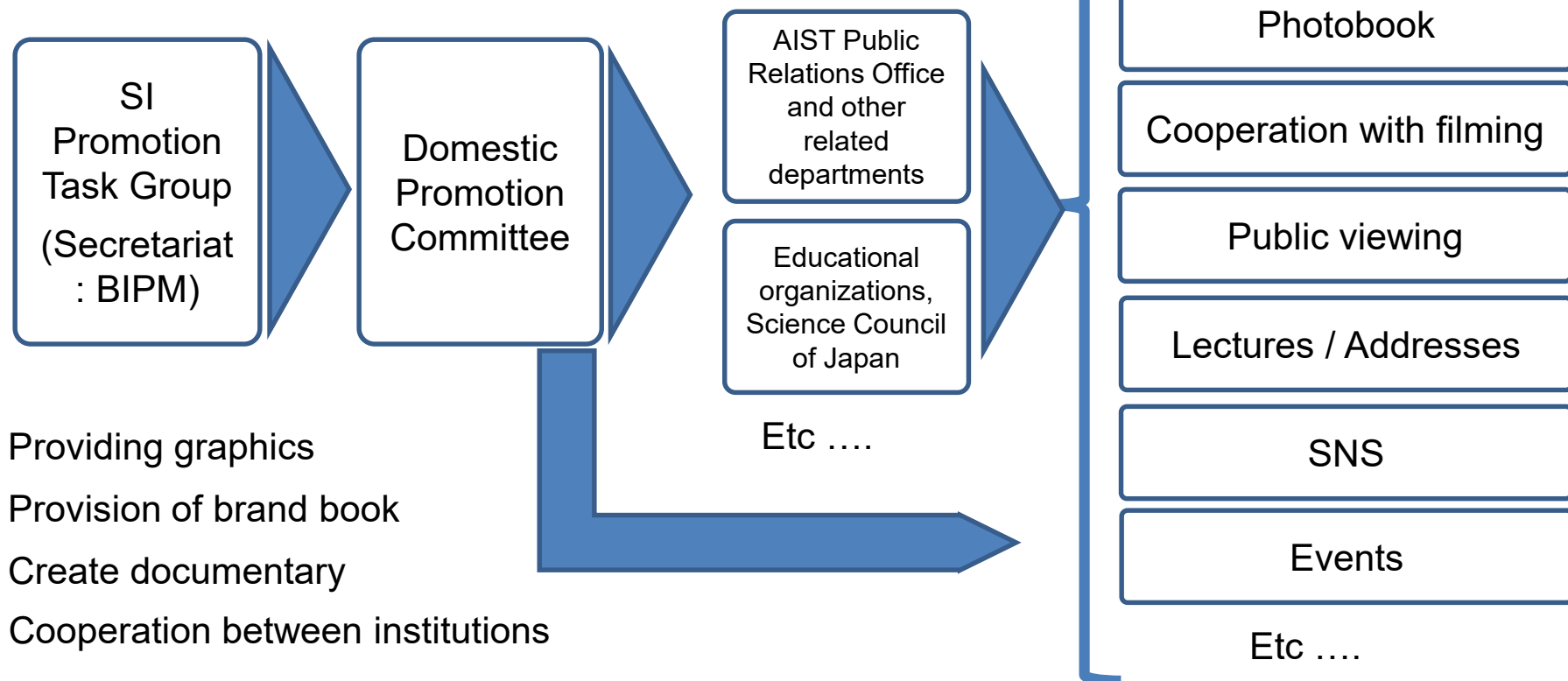
Australia : NMIA



New Zealand : MSL

Promotion activity for SI in Japan

- SI Promotion TG (Task Group) is established under the CIPM to provide common reference materials.
- The materials and information are shared with relevant parties through domestic promotion committee, to be reflected in the promotion activities.



Educational materials at NMIJ / AIST

- Translation of the information from BIPM into Japanese
- Publish the Photobook
- NMIJ special website



NMIJ special website



From the International Prototype Kilogram to a silicon sphere



表 7つの基本単位の現在の定義 (簡略化してあります)

量	単位	定義	採択年 ¹⁾
長さ	メートル (m)	ある一定の時間に光が真空中を伝わる行程の長さ	1983年
質量	キログラム (kg)	国際キログラム原器の質量	1889年
時間	秒 (s)	セシウム 133 原子が発する電磁波の固有の周期の 9 192 631 770 倍の時間	1967-1968年
電流	アンペア (A)	真空中に 1 メートルの間隔で平行に配置された無限に長く無限に長い二本の直線状導体が一定の力を及ぼし合う電流 (磁気定数を規定)	1948年
熱力学温度	ケルビン (K)	水の三重点の熱力学温度の 1/273.16	1967-1968年
物質	モル (mol)	0.012 キログラムの炭素 12 の中に存在する原子の数の等しい数の酸素原子を含む系の物質	1971年
光度	カンデラ (cd)	周波数 540 × 10 ¹² ヘルツの単色放射を放出し、所定の方向におけるその放射強度が 1/683 ワット毎ステラジアンである光源の、その方向における光度	1979年

¹⁾ 定義が採択された国際度量衡総会 (CGPM) の開催年



Proposed redefinition of the base SI units

Photobook: History of seven base units

Special AIST website on SI redefinition

Exhibition at National Museum of Science: For general public

150th anniversary of Meiji era: AIST cooperated with the Special Exhibition "1000 technologies that changed Japan".

AIST lent a replica of the Japanese Prototype of the Kilogram, the transport container (original), and a replica of the silicon sphere.



National Prototype of the Kilogram (replica)



Container for the Prototype (original)



Silicon sphere (replica)

Books etc. : For general public

Publishing books for general readers interested in science.
Spread to various promotion activities including Radio and TV programs.



2018.5
at a Bookstore

TV / Radio appearance
J-Wave:
FM-Yokohama:



TV variety programs
NHK:

Talk events, etc.
Bookstore,
Culture center,
and many other places



For general public, SNS, Twitter, etc.



AIST Instagram

https://www.instagram.com/aist_aris_teles/?hl=ja



AIST Official Twitter



https://www.1101.com/hayano_researcher_03/2018-12-07.html

SI rhyming game campaign



5/31まで募集中!

るくるくびの 無礼な まいご にダメだされて 父さんよんぱり

6.62 607 015 × 10⁻³⁴

For educational institutions and students

Exhibited at Science Plaza at the National Science Education Convention and introduced the new definition.

(Held in Gifu Prefecture in 2018 and Kochi Prefecture in 2019)



There were many teachers who intently listened how to explain the redefinition to their students.

For chemistry teachers, it was effective to explain by using the X-ray crystal density method, and for physics teachers, using the watt balance method.

For industry, academia and professionals

- Lectures held with cooperation of domestic metrology organizations.

2018/1/24 “A new age in base metrology units - impact of the redefinition of the SI - ”
Lectured by [Martin J. T. Milton, Director of BIPM](#).

2018/4/25 “A new age in base metrology units - Redefinition of ampere and future prospects - ”
Lectured by [Gert Rietveld, Chief Metrologist of VSL \(Netherland\)](#).

2018/9/27 “A new age in base metrology units - Redefinition of kelvin and future prospects - ”
Lectured by [Yuning Duan, Deputy Director of National Institute of Metrology, China \(NIM\)](#).

2019/1/16 “Redefinition of the base units of SI” The 123rd representative roundtable lecture,
Japan Measuring Instruments Industry Federation. Lectured by [Takashi Usuda, Director General of NMIJ](#).





Neck strap commemorating the historic redefinition of the SI base units

This year, NMIJ has produced a neck strap for [the anniversary of the Measurement Act of Japan](#), with the aim of promoting the SI in response to the recent redefinition of the SI base units.

[The day of 1st November](#), when the act was revised and implemented in 1993, was enacted as the anniversary in Japan.



Design concept: Feel the revised SI familiar

Designed with the SI logo, the seven SI base units, the seven physical constants defining the units, and the words that express the philosophy of the metric system.

"À tous les temps, à tous les peuples" (For all times, for all peoples)

Finished neck strap

- Loop clutch
- Band for a loophole of a mobile phone
- Safety release



We brought 100 straps to this meeting.
We present them to those who want it.
Please contact the attendees from NMIJ.

Produced 2, 000 pieces

- ✓ SI Logo
- ✓ Seven SI base units
- ✓ Seven physical constants defining the units
- ✓ Seven SI base units
- ✓ Words that express the philosophy of the metric system



Summary

- Mission and Strategy of NMIJ
 - To continue establishment and dissemination of national metrology standard.
 - More direct commitment to the industry, not only by disseminating metrology standards but also by providing solutions to their activities.
- Expanding Scope of National Metrology System
 - Employing the revised SI.
 - Promote the redefinition in various ways: from "knowing" phase to "using" phase.
 - Analyzing **economic impact** by national metrology system is continuously needed.

Upcoming event



XXIII World Congress of the
International Measurement
Confederation (IMEKO 2021)



Welcome to IMEKO 2021!



Chairman of International
Program Committee

Dr. Takashi USUDA
Director General,
National Metrology Institute
of Japan, National Institute of
Advanced Industrial Science
and Technology (NMIJ/AIST)





Thank you for your kind attention!



NMIJ Neck strap

Do not miss this opportunity!

National Metrology Institute of Japan (NMIJ)
National Institute of Advanced Industrial Science and Technology (AIST)
JAPAN