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

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JAPAN
Contents

1. Introduction of NMIJ/AIST
2. Mission and Strategy of NMIJ
3. National Metrology System in Japan
4. SI Promotion Activity in Japan
5. Summary
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

**NMIJ/AIST**

- Energy and Environment: 14%
- Life Science and Biotechnology: 17%
- IT and Human Factors: 18%
- Materials and Chemistry: 14%
- Electronics and Manufacturing: 14%
- Geological Survey: 10%
- RIMCM: 13%
- RIMA: 14%
- Permanent Staff: 71 (14%)
- RIEM: 77 (15%)
- Management Staff: 57 (11%)
- Management Assistant: 43 (8%)
- Part-time Staff: 174 (34%)
- Research Assistant: 131 (25%)
Organization Structure of NMIJ

- 4 research institutes
- 2 administrative units

Research Promotion Division of NMIJ

Research Institute for Engineering Measurement (RIEM)

Research Institute for Physical Measurement (RIPM)

Research Institute for Material and Chemical Measurement (RIMCM)

Research Institute for Measurement and Analytical Instrumentation (RIMA)

Center for Quality Management of Metrology

Research Planning Office

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

Electricity, Time/Frequency,
Temperature, Photometry, …

Inorganic standards,
CRM, …

Ionizing Radiation,
Ultrasonics, …

Metrology Training Center,
International Cooperation, …

NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)
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5. Summary
Establishment and Dissemination of National Metrology Standards

**NMIJ Mission**

- **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 1\textsuperscript{st} and 2\textsuperscript{nd} terms (2001-2009)

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

The 3\textsuperscript{rd} term (2010-2014)

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

The 4\textsuperscript{th} 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.
Expanding scope of NMIJ Mission

Revenue from the private sectors

Revenue from private sector

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<tbody>
<tr>
<td>Revenue (B Yen)</td>
<td>0.24</td>
<td>0.41</td>
<td>0.47</td>
<td>0.72</td>
<td>0.75</td>
<td>0.84</td>
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<td>Target (B Yen)</td>
<td>0.36</td>
<td>0.48</td>
<td>0.60</td>
<td>0.72</td>
<td>0.84</td>
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<tr>
<td>Achievement</td>
<td>114%</td>
<td>98%</td>
<td>120%</td>
<td>104%</td>
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Technical consulting

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<tr>
<th>Year</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
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<tbody>
<tr>
<td>Revenue (B Yen)</td>
<td>0.03</td>
<td>0.14</td>
<td>0.17</td>
<td>0.24</td>
<td></td>
</tr>
</tbody>
</table>

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

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%**
Contents

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4. SI Promotion Activity in Japan
5. Summary
International Traceability System Based on the CIPM-MRA

Japan

JCSS
Japan Calibration Service System

NMIJ
National Metrology Standards

AIST
Calibration / Testing Laboratories

Industries & Users of Instruments

End Users & Public Society in Japan

Economy X

NMI-X
National Metrology Standards

ILAC MRA, APAC MRA

Free Trade without barriers

Realization of ONE-STOP testing

Calibration / Testing Laboratories

Accreditation bodies

Accreditation bodies

CIPM-MRA (1999)

End Users & Public Society in Economy X

End Users & Public Society in Japan

ILAC MRA

JCSS

Japan Calibration Service System

NMIJ
National Metrology Standards

AIST
Calibration / Testing Laboratories

Industries & Users of Instruments

End Users & Public Society in Japan

Free Trade without barriers

Realization of ONE-STOP testing

CIPM-MRA (1999)

End Users & Public Society in Economy X

NMI-X
National Metrology Standards

ILAC MRA

JCSS

Japan Calibration Service System

NMIJ
National Metrology Standards

AIST
Calibration / Testing Laboratories

Industries & Users of Instruments

End Users & Public Society in Japan

Free Trade without barriers

Realization of ONE-STOP testing

CIPM-MRA (1999)

End Users & Public Society in Economy X

NMI-X
National Metrology Standards

ILAC MRA

JCSS

Japan Calibration Service System

NMIJ
National Metrology Standards

AIST
Calibration / Testing Laboratories

Industries & Users of Instruments

End Users & Public Society in Japan

Free Trade without barriers

Realization of ONE-STOP testing

CIPM-MRA (1999)

End Users & Public Society in Economy X

NMI-X
National Metrology Standards

ILAC MRA

JCSS

Japan Calibration Service System

NMIJ
National Metrology Standards

AIST
Calibration / Testing Laboratories

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Free Trade without barriers

Realization of ONE-STOP testing

CIPM-MRA (1999)
Issued calibration certificates (CCs) and accredited laboratories under JCSS

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/)

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 28Si sphere to realize the kilogram based on the Planck constant.

NMIJ

Planck constant

1st Key comparison on the realization of the new kg: End of 2019

28Si-enriched spheres

Standard weights
- Material: Pt-Ir, Stainless steel
- Mass: 1 mg ~ 20 kg

JCSS accredited laboratory

Standard weights (1 mg ~ 20 kg)

User

Standard weights of NMIJ

NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)
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.**


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.

$$T \omega = VI$$

Mechanical power = Electrical power

Electromagnetic force torque standard machine, EMTSM.

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

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

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4. SI Promotion Activity in Japan
5. Summary
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.
SI 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.

Providing graphics
Provision of brand book
Create documentary
Cooperation between institutions

NMIJ homepage
Japanese translation of the Joint Statement
Photobook
Cooperation with filming
Public viewing
Lectures / Addresses
SNS
Events
Etc ….
Educational materials at NMIJ / AIST

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

SI Promotion Activity

Photobook: History of seven base units

Proposed redefinition of the base SI units

From the International Prototype Kilogram to a silicon sphere

NMIJ special website

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.
Books etc. : For general public

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

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

- TV variety programs
  - NHK:

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

2018.5 at a Bookstore
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
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.
SI Promotion Activity

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)
SI Promotion Activity

Finished neck strap

Produced 2,000 pieces

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

✔ 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

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

Do not miss this opportunity!

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National Institute of Advanced Industrial Science and Technology (AIST)
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