Impact of Metrology on Industry: NMIJ's Experience in Japan

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

2017 May 3rd
For CMS-NML 30th Anniversary Celebration

Outline of the organization and the mission

AIST

Profile of the organization

AIST is a public research institute. Its origin is the Geological Survey of Japan, the Ministry of Agriculture and Commerce, established in 1882.

In 2001, fifteen research institutions of the Agency of Industrial Science and Technology, MITI, and Weights and Measures Training Institute were integrated into AIST.

Ministry of International Trade and Industry (MITI)

Agency of Industrial Science and Technology

- Hokkaido National Industrial Research Institute
- Tohoku National Industrial Research Institute
- National Institute for Advanced Interdisciplinary Research
- National Research Laboratory of Metrology
- Mechanical Engineering Laboratory
- National Institute of Materials and Chemical Research
- National Institute of Bioscience and Human-Technology
- Electrotechnical Laboratory
- Geological Survey of Japan
- National Institute for Resources and Environment
- National Industrial Research Institute of Nagoya
- Osaka National Research Institute
- Chugoku National Industrial Research Institute
- Shikoku National Industrial Research Institute
- Kyushu National Industrial Research Institute
- Weights and Measures Training Institute (MITI)

National Institute of Advanced Industrial Science and Technology (AIST)

AIST

Employees and Budget

Staffs:
2260 researchers
+**670** administrative
+**1700** assistants
+**5000** visitors

Annual budget:
800 million USD
(60% from gov.)

- Researchers (foreign nationals)……2,284(116)
  [Permanent] [1,925]
  [Fixed term] [359]
- Administrative employees (foreign nationals) ……686(1)

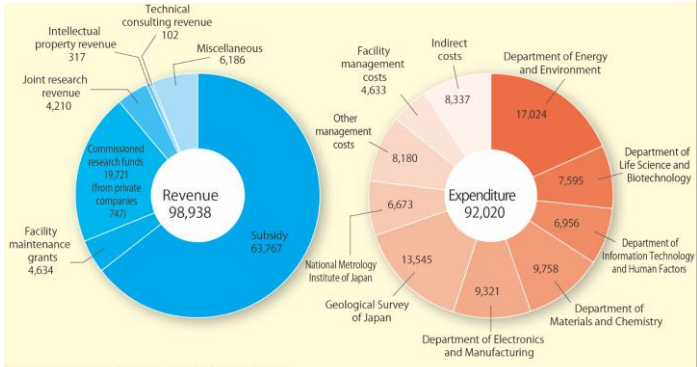
Total number of employees : 2,970(117)

- Executives (full time)……13
- Visiting researchers ……185
- Postdoctoral researchers ……190
- Technical staff ……1,487

(As of July 1, 2016)

Number of researchers accepted through industry/academia/government partnerships
- Companies ……1,856
- Universities ……1,924
- Other organizations ……936

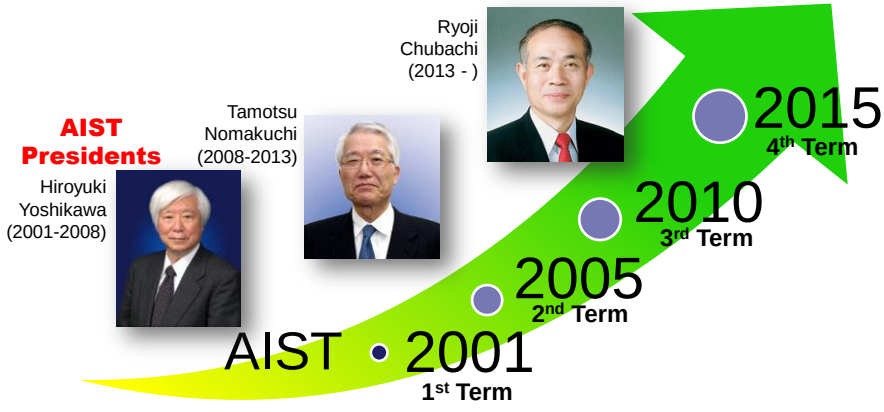
(foreign nationals : 456)
(Total number of researchers accepted in FY 2015)



Notes 1: Total may not become 100 % due to rounding off.
Notes 2: The amounts of revenue and expenditure are adapted from the "Financial Statement" prescribed in Article 38 of the Act on General Rules for Incorporated Administrative Agencies.

AIST

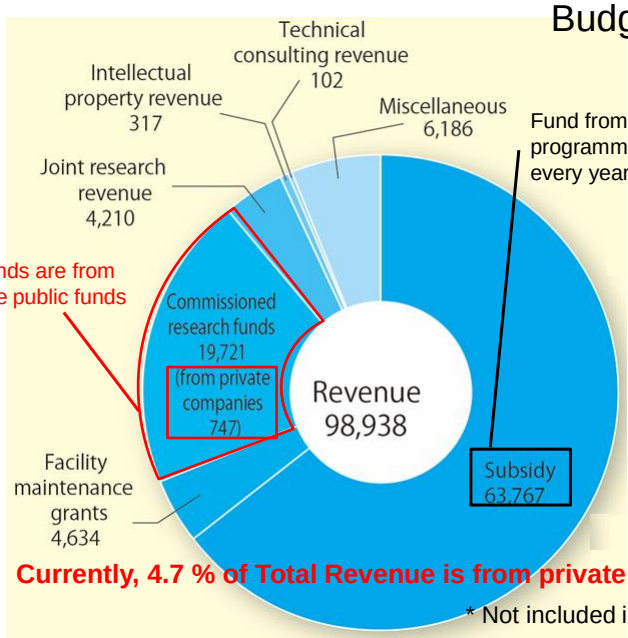
AIST, as an autonomous agency



Engage in a mid-term plan revised normally once every 5 years based on the contract with the government

AIST

Budget details



Fund from the government, programmed to reduce every year

60 % of funds are from competitive public funds

Currently, 4.7 % of Total Revenue is from private sector.

* Not included in your handout

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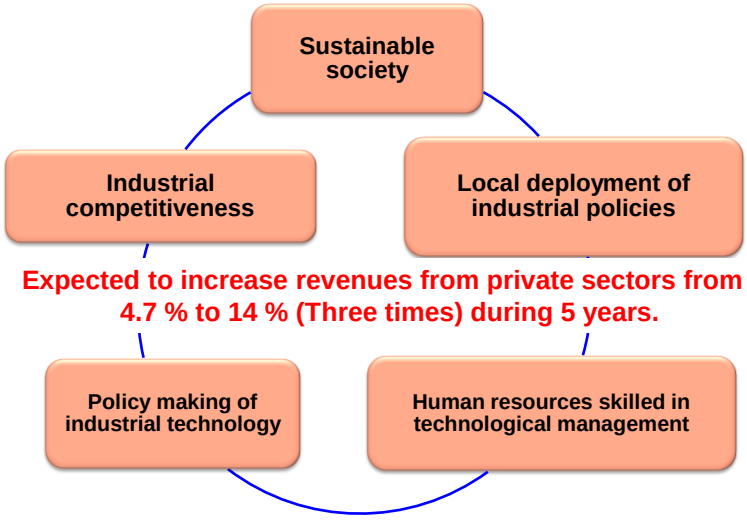
Main missions during the 4th mid-term plan



* Not included in your handout

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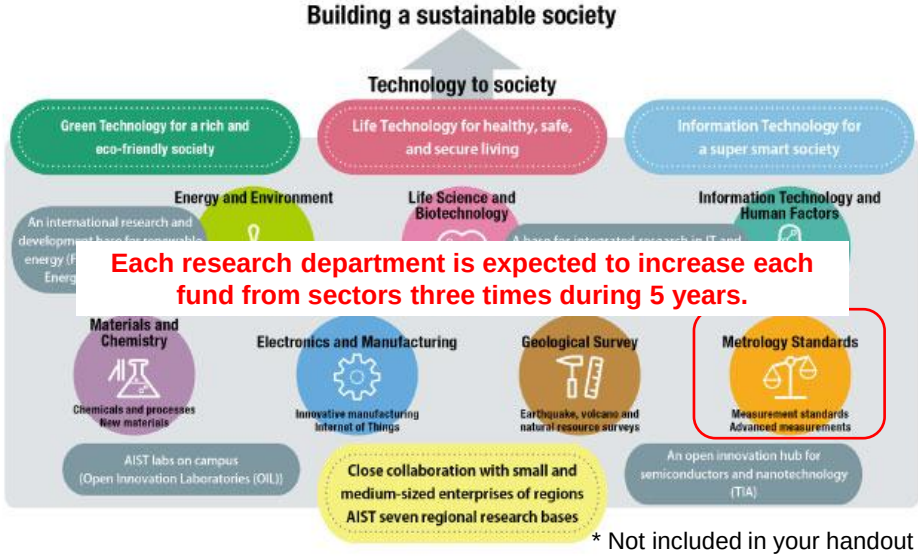
Main missions during the 4th mid-term plan



* Not included in your handout

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Achievements and contributions to industries at the AIST

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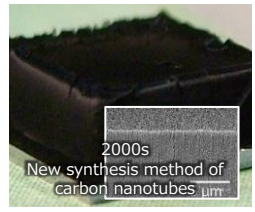
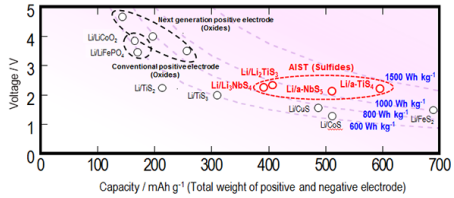
Achievements in the past to present



AIST is highly expected to create social and economic values

AIST

Development of next-generation batteries with high energy density that can be used for electric vehicle (EV) applications is highly desired. AIST has developed metal polysulfide materials which display unique electrochemical performance.



Voltage-capacity plots of conventional electrode materials (oxides) in comparison to the newly developed materials (sulfides)

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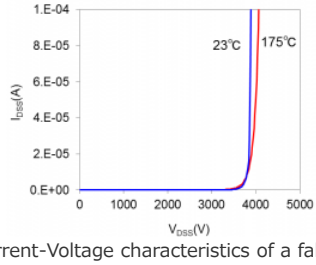
Aiming at further development of electric power converters used in home appliances, automobiles, and various types of industrial equipment, AIST has developed novel processes for SiC high-voltage switching transistors that meet practical reliability requirements.



Current-Voltage characteristics of a fabricated planar-type SiC 3.3 kV switching transistor

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Life Science and Biotechnology

ent of Life Science and Biotechnology

earch Highlights》

Industrial development of "Maholo", the biomedical experiment robot driven by industrial robot technology

Molecular Profiling Research Center for Drug Discovery

Together with Yasukawa Electric Corporation, AIST has developed the general-purpose humanoid robot "Maholo" with the aim of automating bench work in the biomedical field.

It performs certain tasks more accurately and reproducibly than experienced lab technicians.

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Information Technology and Human Factors

of Information Technology and Human Factors

rch Highlights》

Project for developing and evaluating efficacy and safety standards of lifestyle support robots

Robot Innovation Research Center

As expectations rise for the practical use of robots in daily life, AIST has established a safety evaluation standard (ISO13482), test methods, and certification schemes for robots, which have not been established until now. Furthermore, AIST has established the "Robot Safety Center" as the world's first base for conducting consultations, tests, and evaluations on the safety of robots.

AIST

Electronics and Manufacturing

Zeon Corporation has completed and started operating the world's first mass production plant for carbon nanotubes (CNTs) using the super-growth (SG) method developed by AIST.

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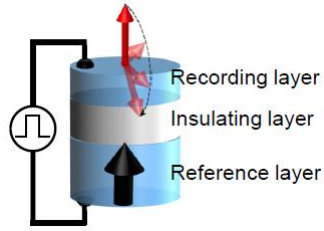
AIST has cleared the path for reduced write error rates required for practical applications of "voltage-induced writing," which is expected to be a low power consumption writing technology in magnetic tunnel junction devices.



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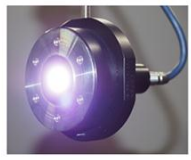
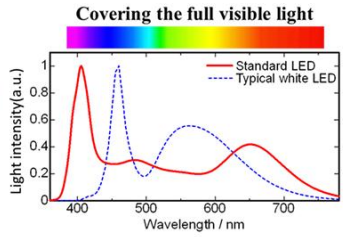
National Metrology Institute of Japan

AIST has developed standard LED with sufficient light intensity over almost all wavelengths of visible light, as standard light source suitable for accurate measurement of LED lighting.





The newly developed LED

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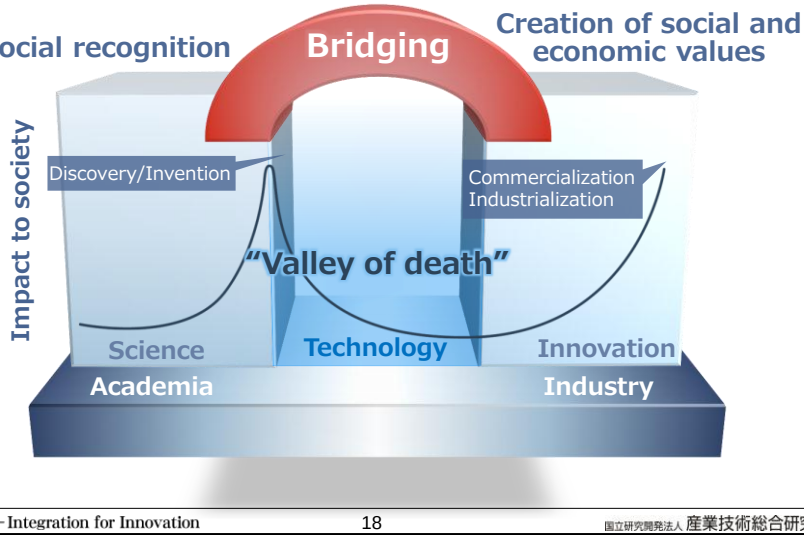
AIST basic approach to industry

AIST conducts continuous research from basic to commercialization to bring scientific findings to industry.



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Our products developed by our R&D


Fig.3 Lake sediment certified reference material for analysis of trace elements


Fig.4 Cylindrical graphite cavity ionization chambers (right: approx. Φ50 x 70 mm)

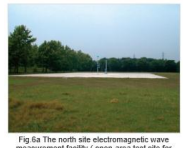
Fig.6a The north site electromagnetic wave measurement facility (open-area test site for outdoor measurement)

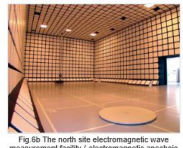
Fig.6b The north site electromagnetic wave measurement facility (electromagnetic anechoic chamber for indoor measurement)

are for our metrology standards.


Fig.12 Atomic fountain primary time and frequency standard

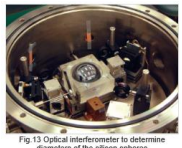
Fig.13 Optical interferometer to determine diameters of the silicon spheres

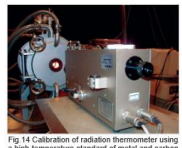
Fig.14 Calibration of radiation thermometer using a high-temperature standard of metal and carbon alloy

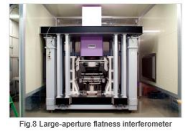
Fig.8 Large-aperture flatness interferometer

How can we transfer those products to industry?

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Organization Structure of NMIJ (since April 2015)

National Metrology Institute of Japan


【Director】
Takashi Usuda


NMIJ Headquarter

- **Research Promotion Division of NMIJ**
- **Research Institute for Engineering Measurement**
- **Research Institute for Physical Measurement**
- **Research Institute for Material and Chemical Measurement**
- **Research Institute for Measurement and Analytical Instrumentation**
- **Center for Quality Management of Metrology**

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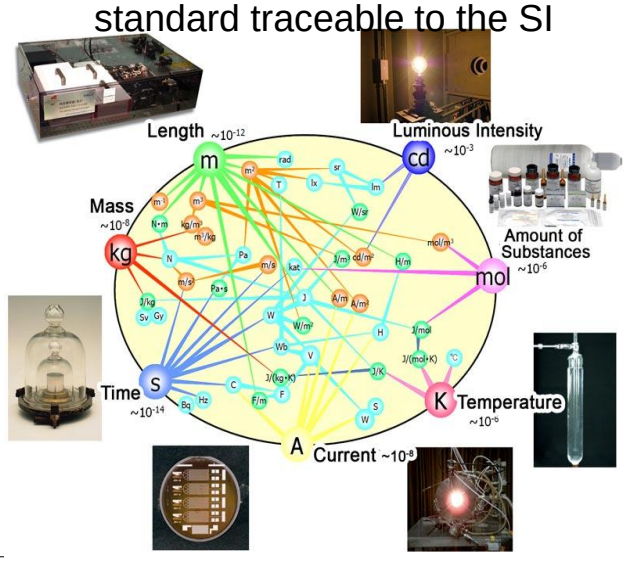
A primary role of NMIJ:

Realization and dissemination of National metrology standard traceable to the SI



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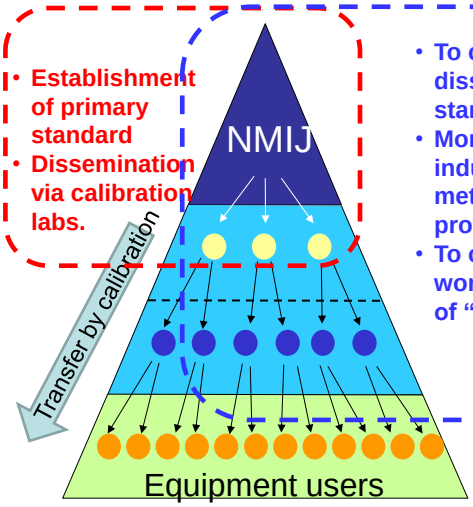
Our strategy in the 4th mid-term plan 1

Main activities until 3rd mid-term plan

- **Establishment of primary standard**
- **Dissemination via calibration labs.**

Main activities from 4th mid-term plan

- **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.**
- **To catch up with the new trend in world metrology standard in the era of "Post MRA".**



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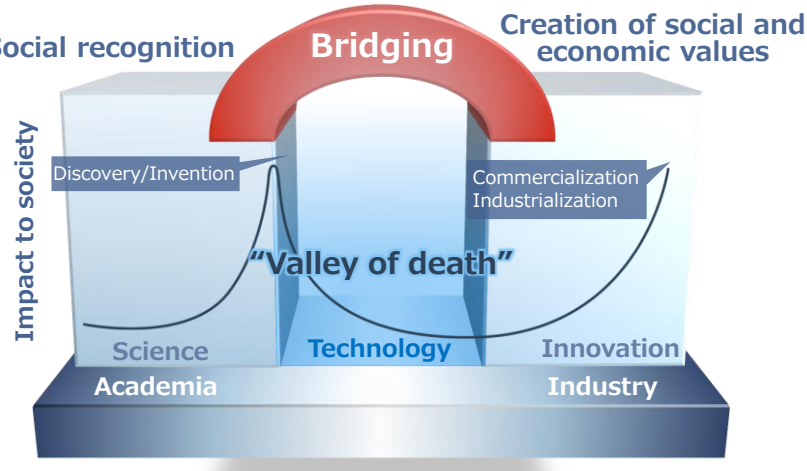

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Our strategy in the 4th mid-term plan 1

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- **Establishment of primary standard**
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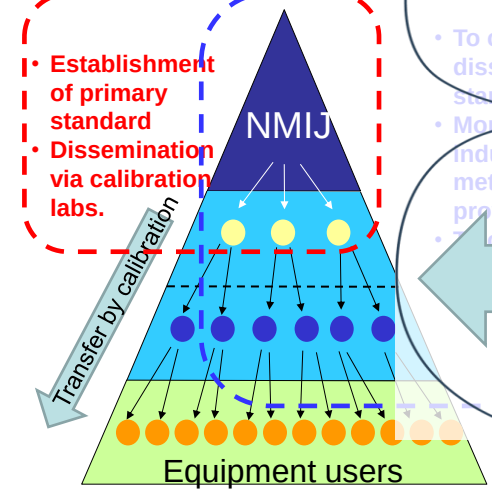
- **To catch up with the new trend in … in the era**



"Valley of death" for metrology institute

How we can vitalize the

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Our strategy in the 4th mid-term plan 2

- Technology transfer (Equipment and instrumentation).
- Measurement to provide solutions in industries.
- Knowledge transfer.
- Technical assessment for validation and standardization.

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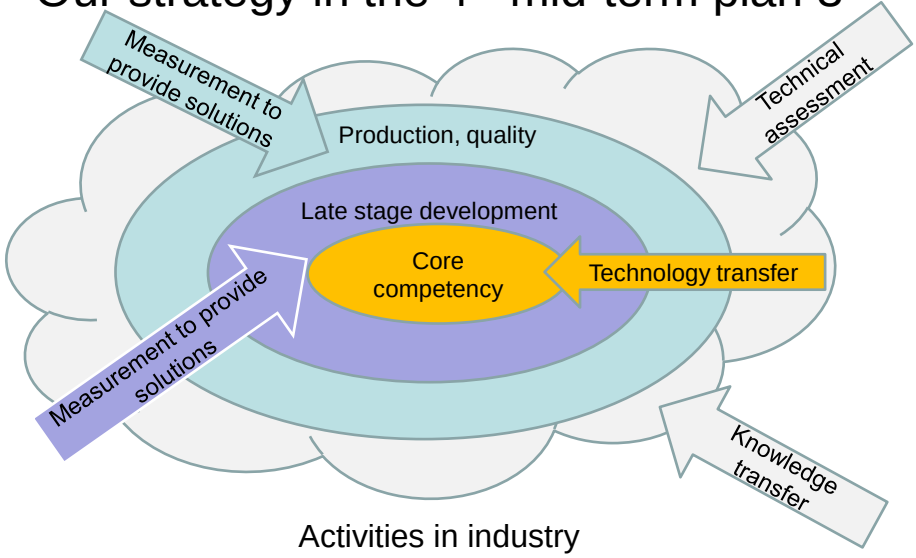
Our strategy in the 4th mid-term plan 3



Activities in industry
and contribution from NMIJ

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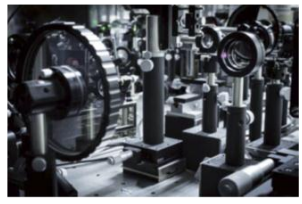
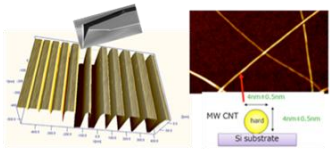
Core competency

Technology transfer





カーボンナノチューブのサイズ測定例

Laser interferometry, probe-microscopy, Positron beam measurement

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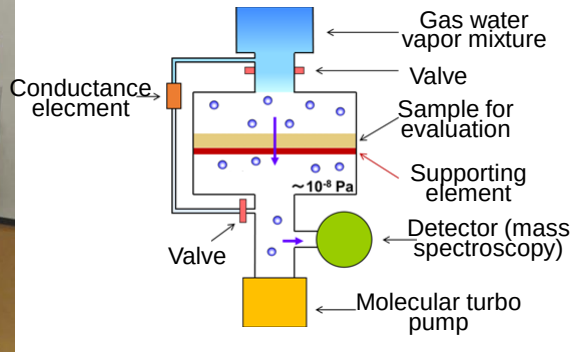
Measurement to provide solutions

Late stage development



Gas-water vapor transmittance evaluation system

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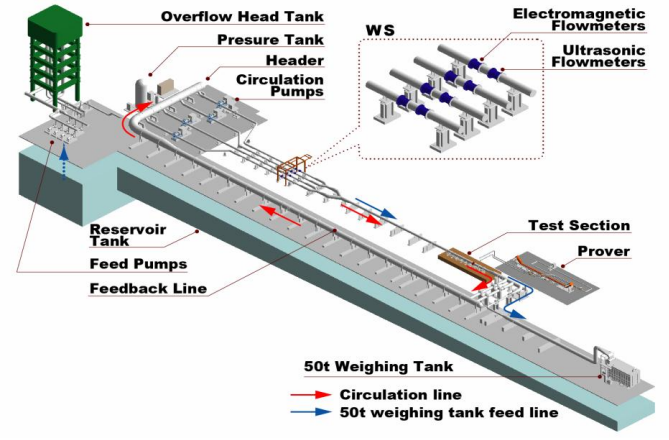
Measurement to provide solutions

Production, quality



Evaluation platform for flowmeters

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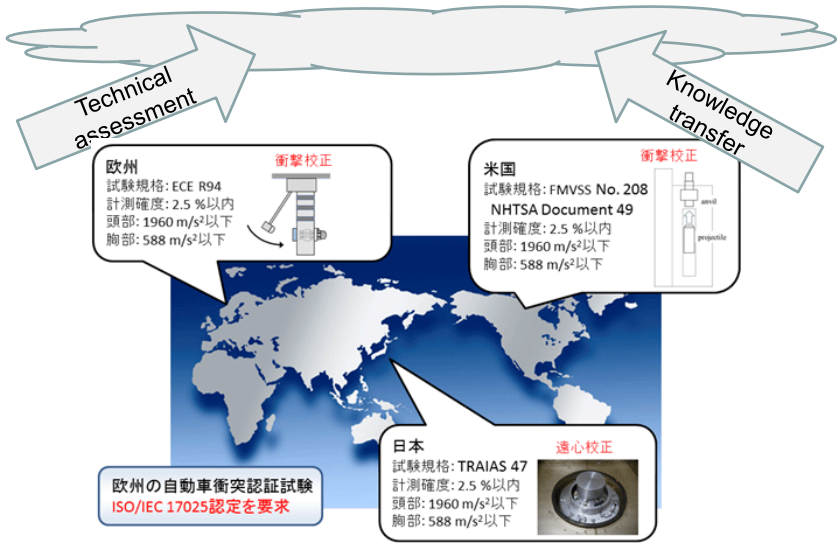

Validation and standardization of various evaluation methods in industries

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Possible scenario for contribution to FCV

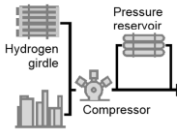
High pressure measurement, material evaluation for erosion, etc.

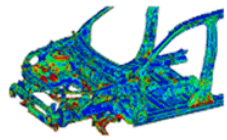
Component test, motor torque and power efficiency etc.

3D measurement, vibration testing, etc.

Validation of regal test, Dispenser type approval etc.

Research → Development → Production → Market in





* Not included in your handout

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NMIJ's Experience in 2015

Private sector's funds expansion of each division from 2014 to 2015

Energy and Environment	16.5B yen to 19.6B yen 120%	Electronics and Manufacturing	6.4B yen to 6.5B yen 102%
Life Science and Biotechnology	5.1B yen to 6.4B yen 125%	Geological Survey of Japan	1B yen to 0.8B yen 80%
Information Technology and Human Factors	4.9B yen to 5.7B yen 120%	National Metrology Institute of Japan	2.4B yen to 4.1B yen 170%
Materials and Chemistry	6.7B yen to 9.2B yen 140%		

* Not included in your handout

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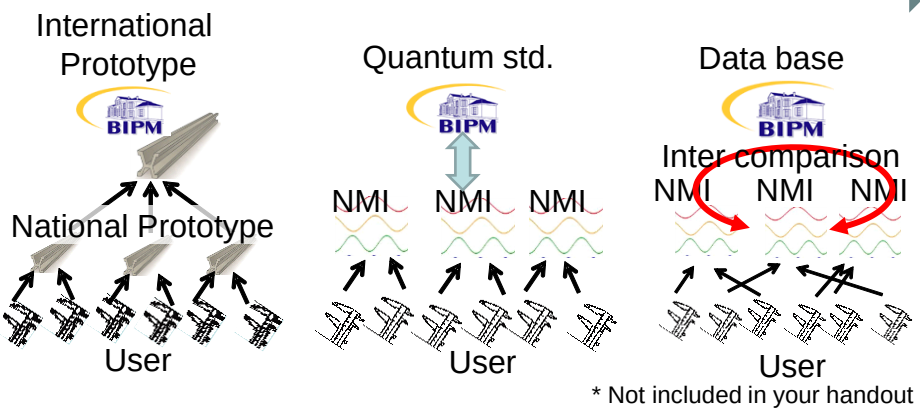
Metrology standards, past, present and future

1875 Mid 20th 1999~ CIPM-MRA



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International corporations

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International corporation

JICA Training Course in Legal Metrology

NMIJ, in cooperation with JICA, held a training course entitled "Social and Industrial Infrastructure in Legal Metrology in India" from 22nd February through 27th March, 2015.

Twelve officers from India in Legal metrology participated in the training.

*** Japan International Cooperation Agency**

AIST

International Cooperation

Metrology Arena in Tsukuba (MAT)

From Thailand (NIMT:4, BDN:1, TISTR:2, DSS:2), Indonesia, Viet Nam & Malaysia

[for Chemical metrology]


NMIJ AIST

Metrology Arena in Tsukuba (MAT) 2014

Organized by NMIJ/AIST

MAT2014 aims to promote expanding the chemical metrology communities in ASEAN countries through seminars, lab tours and discussions organized by NMIJ experts for young and mid-career metrologists who are willing to improve their skill and expected to be core researchers to carry out collaboration research projects with NMIJ/AIST.

Date : 17-21 February, 2014
9:30-12:00, 13:30-16:30

Venue: NMIJ/AIST in Tsukuba, Japan

Tentative Schedule

Date	Morning Session	Afternoon Session
17 mon	Opening remarks NMIJ quality system	CRM Production and Guide 34
18 tue	Uncertainty	Inorganic Analysis
19 wed	Organic Analysis (composits, etc.)	Gas Analysis
20 thu	Lab tour	
21 fri	Organic Analysis (purity etc.)	Report Closing remarks

◆Welcome reception hosted by NMIJ/AIST will be held in the evening of 17 Feb.

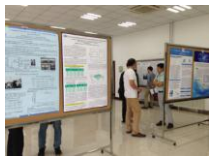
◆For more information and registration,
International Metrology Cooperation Office (IMCO), NMIJ
seminar-imco-mi@aist.go.jp

AIST

International corporation

Human resources

- Emerging Scientist Workshop



- Metrology summer school

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Conclusions

- During the 4th mid-term plan period (5 years), NMIJ is expected to perform their capability not only by providing measurement standards, but also by vitalizing industries.
- During the first 2 years of the period, NMIJ doubled private funds from industries.
- NMIJ is also requested to maintain national primary standards as a public institute.
- NMIJ should scrutinize their portfolio, long-term strategy, to perform both keeping national metrology standard and vitalizing industries consistently.
- NMIJ should consider metrology scheme for post MRA era.

AIST

Dr. Takashi Usuda, Deputy Director General of NMIJ, visited CMS/ITRI as a technical peer reviewer.

Dr. Takashi Usuda　Dr. Gwo-Sheng Peng

Site visit for peer review (September, 2008)

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Peer reviewers, invited by CMS/ITRI

2015FY				
2015/10/4-9	濕度標準 (Humidity standards)	Dr. Abe (阿部恒)	+Lecture	
2015/10/4-8	硬標準 (Hardness standard)	Dr. Hattori (服部浩一郎)		
2015/10/4-8	壓力真空標準 (Pressure vacuum standard)	Dr. Kobata (小畠時彦)		
2014FY				
2014/6/15-21	長度標準 (Length standard)	Dr. Takatsuji (高辻利之)		

Dr. Takatsuji

Dr. Kobata　Dr. Hattori　Dr. Abe

AIST

Peer reviewers from CMS/ITRI, invited by NMIJ/AIST

2014FY	Host: 堂前篤志 Domae Atsushi (Applied Electrical Standards Group)
2015/1/25-2/1	Dr. Chun-Ming HSU
2015/1/25-1/29	Dr. Hsiu-Ju TSAI
2015/1/25-1/29	Dr. Shih-Fang CHEN

Three reviewers from CMS/ITRI in the field of Electric standards (電標準).

Dr. Shih-Fang CHEN
Dr. Chun-Ming HSU Dr. Hsiu-Ju TSAI

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Researchers visiting to NMIJ/AIST

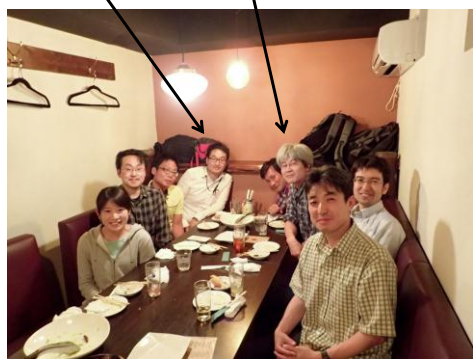
(1)	2016FY 2016/4/25-6/4 (42 days)	Dr. Yi-Cyun Yang	Researcher of Medical & Chemical Research Lab., CMS/ITRI "Research on formaldhyde standards gas mixtures"
		煤氣標準 (Gas standards)	Host: 下坂琢哉(Shimosaka Takuya)
(2)	2015FY 2015/11/1-12/4 (34 days)	Dr. I-Hsiang Hsu	Standards Medical & Chemistry Reserach Laboratory, CMS/ITRI "Research on the analytical method of metals in plastics by ICP-OES and ICP-MS"
		無機分析標準 (Inorganic analysis standards)	Host: 三浦勉(Miura Tsutomu)
(3)	2014FY 2014/8/24-10/17 (55 days)	Mr. Cheng-Han Lin	Associate Research fellow, CMS/ITRI "Study on generaion and measurement methods of trace moisture in gases"
		煤氣・濕度標準 (Gas & humidity standards)	Host: 阿部恒(Abe Hisashi)
(4)	2013FY 2013/5/4-10/31 (181 days)	Dr. Shih-Fang Cheng	Researcher, CMS/ITRI "Advance precision measurements of DC and AC Voltage with programmable Josephson voltage standard system "
		電標準 (Electric standards)	Host: 金子晋久(Kaneko Nobuhisa)

AIST

(1)

2016/4/25-6/4	Dr. Yi-Cyun Yang	Researcher of Medical & Chemical Research Lab., CMS/ITRI
(42 days)		"Research on formaldhyde standards gas mixtures"
	煤氣標準 (Gas standards)	Host：下坂琢哉(Shimosaka Takuya)

Gas standards (2016)
- Dr. Yi-Cyun Yang



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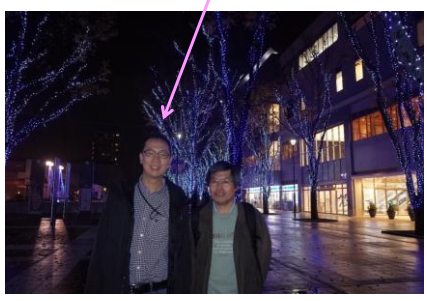
(2)

2015/11/1-12/4	Dr. I-Hsiang Hsu	Standards Medical & Chemistry Research Laboratory, CMS/ITRI
(34 days)		"Research on the analytical method of metals in plastics by ICP-OES and ICP-MS"
	無機分析標準 (Inorganic analysis standards)	Host：三浦勉(Miura Tsutomu)

Inorganic analysis standards (2015)
- Dr. I-Hsiang Hsu



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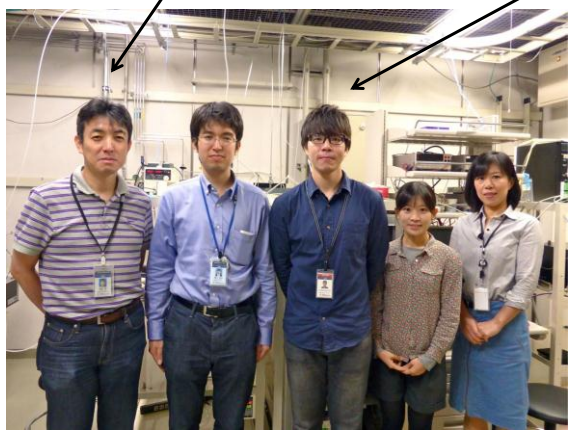
(3)

2014/8/24-10/17 (55 days)	Mr. Cheng-Han Lin	Associate Research fellow, CMS/ITRI "Study on generaion and measurement methods of trace moisture in gases"
	煤氣・濕度標準 (Gas & humidity standards)	Host：阿部恒(Abe Hisashi)

Gas & humidity standards (2014)
- Mr. Cheng-Han Lin



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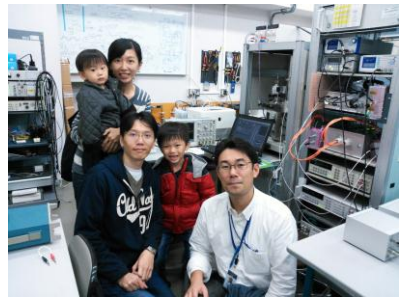
Researchers visiting to NMIJ/AIST <Electric standards>

(4)

2013/5/4-10/31 (181 days)	Dr. Shih-Fang Cheng	Researcher, CMS/ITRI "Advance precision measurements of DC and AC Voltage with programmable Josephson voltage standard system "
	電標準 (Electric standards)	Host：金子晋久(Kaneko Nobuhisa)



Comparison study APMP.EM.BIPM-K11.5 on programmable Josephson voltage standards (PJVS') was carried out and the CMS and NMIJ collaboratively analysed the data of quantum voltages generated by the NMIJ's PJVS that works with a cryogen-free cryocooler.

The CMS and NMIJ studied ac voltage generation by PJVS systems as well and published two scientific articles on peer-reviewed journals.

(1) Shih-Fang Chen, et al., IEEE TIM, Vol.64 No.12, 3308-3314 (2015)
(2) Michitaka Maruyama, et al., IEEE TIM, Vol.64, No.6, 1606-1612 (2015)

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Research collaborations between NMIJ and CMS/ITRI (in progress or under planning)

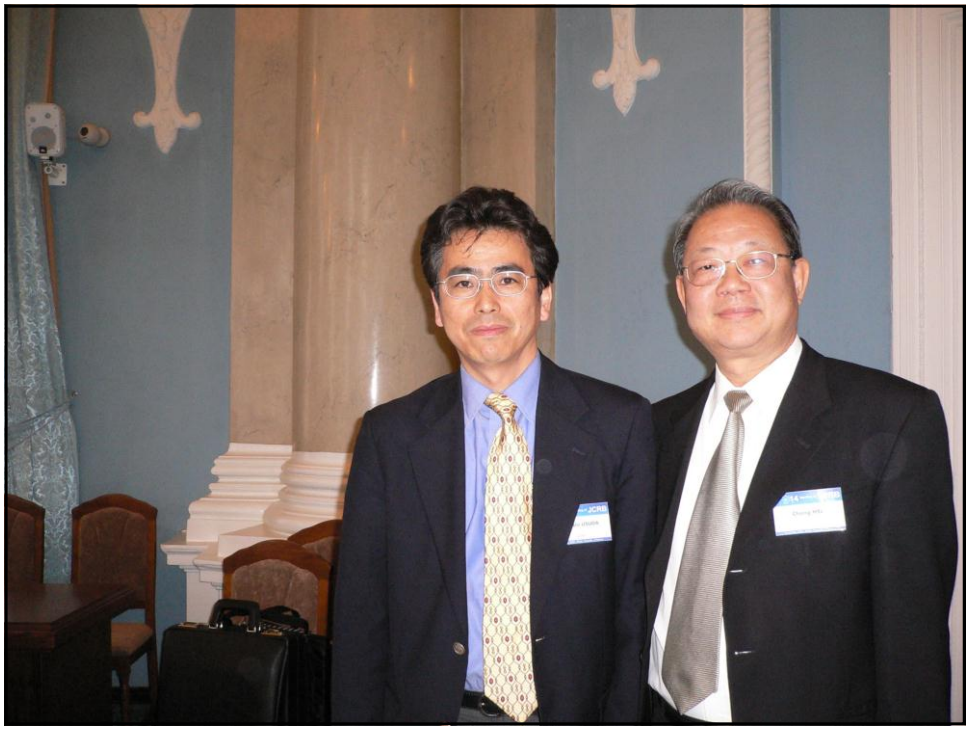
✔**B1.** “Comp. study APMP.EM.BIPM-K11.5 on programmable Josephson voltage standards (PJVS’) (Draft B)”
【Dr. Nobuhisa Kaneko (金子晋久) GL（Quantum Electrical Standards Group）】

✔**B2.** “Co-pilot lab. of internat. comp. APMP.L-S5 on nanoparticle size meas. (on-going)”
【高橋かより、高畑圭二、桜井博GL（Particle Measurement Research Group）】

✔**B3.** “Bilateral comparisons of force and torque standards (in the future)”
【Dr. Koji OGUSHI (大串浩司) GL（Force and Torque Standards Group）】

✔**B4.** “Internat. comparison on two-dimensional grid standard (in the future)”
【鍛島麻理子、阿部誠GL（Dimensional Standards Group）】

✔**B5.** “Potential transfer of NMIJ's generator-type particle number standard to ITRI”
【飯田健次郎、桜井博GL（Particle Measurement Research Group）】
＜counterpart of CMS/ITRI：陳國棟＞　A Japanese instrument will be introduced.



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Congratulations on your 30 year anniversary of the foundation.

謝謝 Thank you for your attention!