Metrology and the international stage

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BIPM

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Bureau International des Poids et Mesures

Content

- Importance of metrology
- National metrology infrastructure
- Quality infrastructure and the role of NMIs
- International aspects of metrology

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What is metrology?

Metrology is the science of measurement, embracing both experimental and theoretical determinations at any level of uncertainty in any field of science and technology.

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Metrology is essential for…

Metrology influences, drives and underpins much of what we do and experience in our everyday lives.

SCIENCE & INNOVATION

QUALITY of LIFE

INDUSTRY & TRADE

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…all rely on metrology

The role of Metrology

THE ROLE OF METROLOGY IN THE CONTEXT OF THE 2030
SUSTAINABLE DEVELOPMENT GOALS

- The brochure highlights the contribution of metrology to the implementation of the 2030 Agenda for Sustainable Development
- Jointly developed by the UNIDO, the BIPM and the OIML.
- The partnership enables these three international organizations to coordinate their activities in complementary and mutually supportive areas of operation, in order to enhance the impact of industrial development on economic growth.

UNIDO-BIPM-OIML joint publication

https://www.bipm.org/utils/common/liaisons/unido-bipm-oiml-brochure.pdf

Measurements and poverty reduction

Measurements for affordable and clean energy

Measurements for climate change

Measurements for health

Measurements for innovative new products

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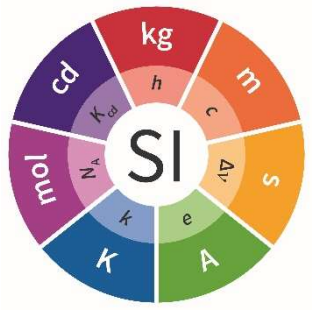
Metrology is the “science and application of measurements”

An effective metrology system is characterized by the ability to properly calibrate measuring instrument with measurement uncertainties that are fit for purpose, against an appropriate reference via national standards (or CRMs).



Essential factors for effective metrology systems are:

- traceability to SI, where possible or not yet possible, or internationally agreed reference materials or procedures
- regulated measurements and measuring instruments (in selected cases)
- confidence in testing and measurement results via certification, standardization, accreditation and calibration

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Fit for purpose - Measurement uncertainty

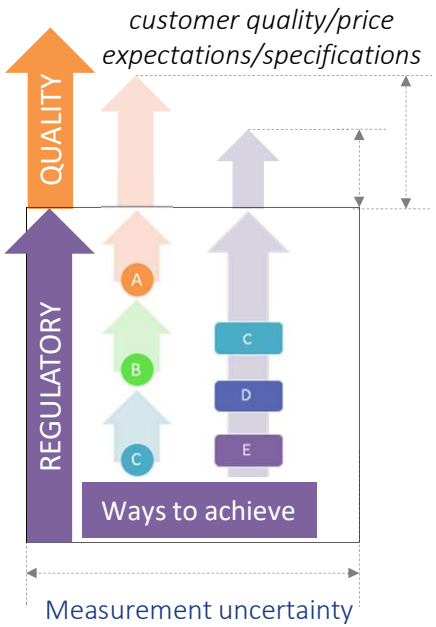
…ease of increasing innovation

LEGALLY CONTROLLED MEASUREMENT INSTRUMENTS

Dedicated measurement instruments for dedicated applications

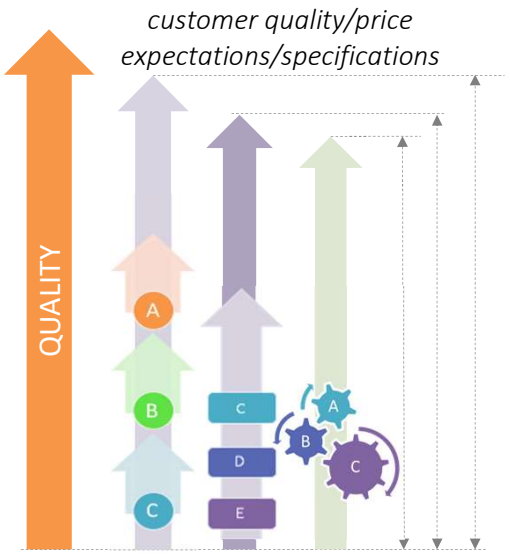
Knowledge of measurement uncertainty "built in"

REGULATED MEASUREMENTS



Measurement uncertainty 'Decision rules' must be consistent with regulatory requirements

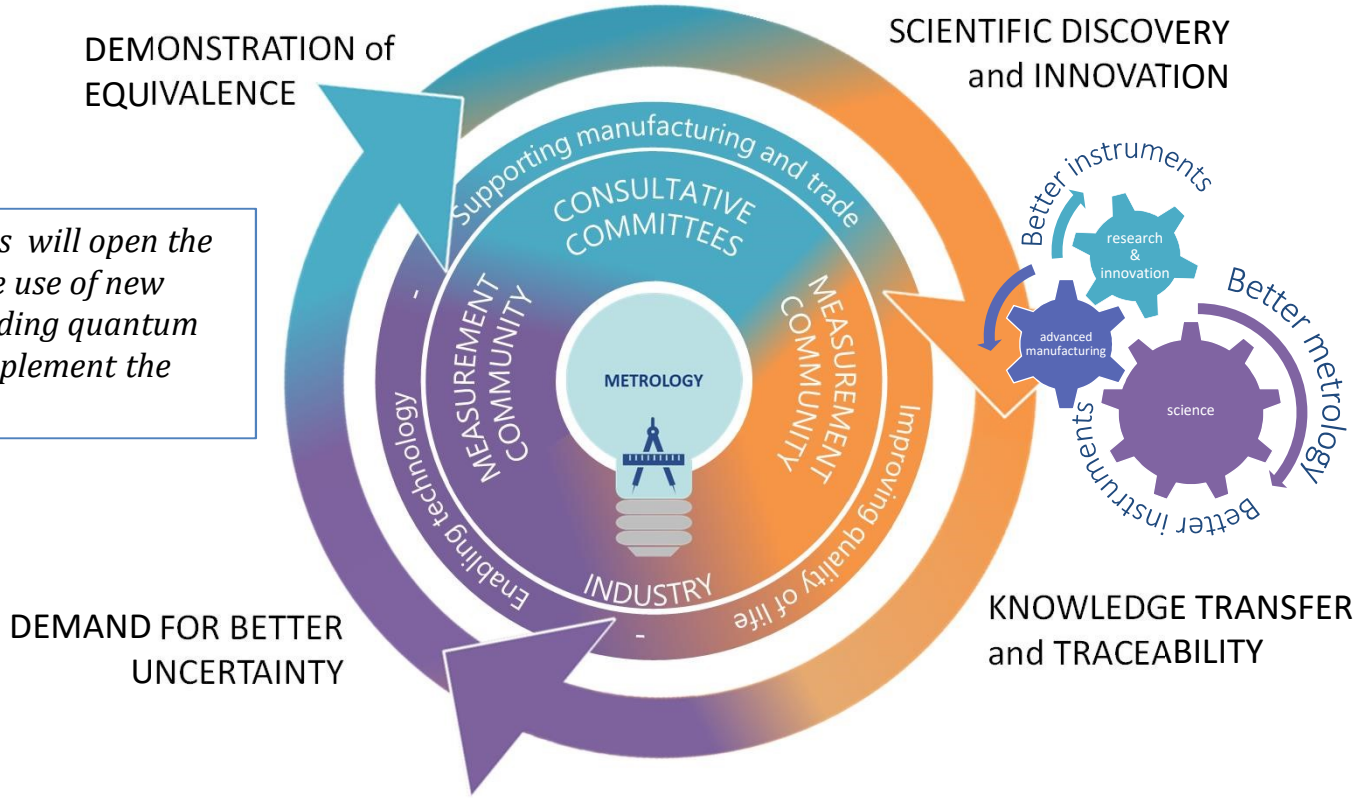
UNREGULATED MEASUREMENTS



Measurement uncertainty - "bespoke". 'Decision rules' are agreed in advance.

Metrology's positive feedback loop

The new definitions will open the opportunity for the use of new technologies, including quantum technologies, to implement the definitions.



Measurements must be…

Stable

- Long-term trends can be used for decision making

Comparable

- Results from different laboratories can be brought together

Coherent

- Results from different methods can be brought together

To meet the needs of the economy, society and citizens

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Metrology's three main fields

Applied or industrial metrology

- Applied or industrial metrology concerns the application of measurement science to manufacturing and other processes and their use in society, ensuring the suitability of measurement instruments, their calibration and quality control of measurements.

Science
Innovation
Advanced manufacturing & process industries
Complex service industries

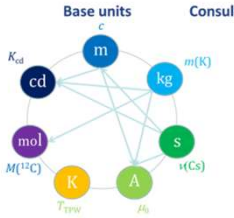
Quality and Competition

Trade
Economic well being

National well being

Scientific or fundamental metrology

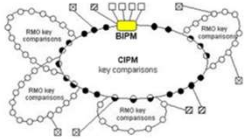
- Scientific or fundamental metrology concerns the establishment of measurement units, unit systems, the development of new measurement methods, realization of measurement units and the transfer of traceability from these standards to users in society.



Consultative Committees

CCAUV
CCEM
CCL
CCM
CCPR
CCQM
CCRI
CCT
CCTF

Comparisons



There are also many derived units!
See the SI brochure for recommended units.

Calibration & Measurement Capabilities in the KCDB

Legal metrology

- Legal metrology concerns regulatory requirements of measurements and measuring instruments for the protection of health, public safety, the environment, enabling taxation, protection of consumers and fair trade.

Science
Health
Safety
Environment

Legislation and Regulation

Security
Social well being

National well being

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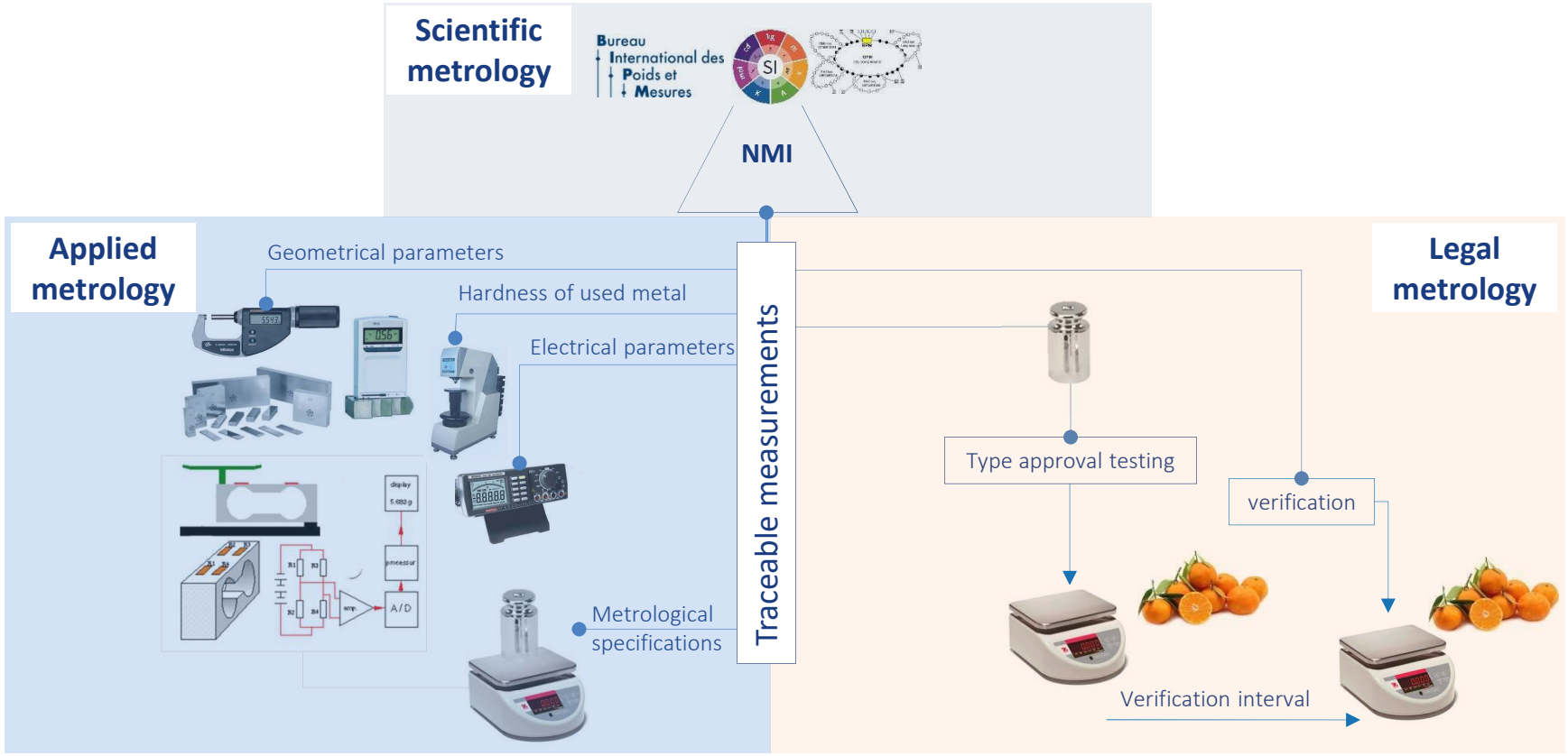
In practice…


Scientific metrology
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SI
NMI
Applied metrology
Geometrical parameters
Hardness of used metal
Electrical parameters
Metrological specifications
Traceable measurements
Legal metrology
Type approval testing
verification
Verification interval

BIPM and OIML
'Single metrology' concept
Under development

V6

National metrology infrastructure

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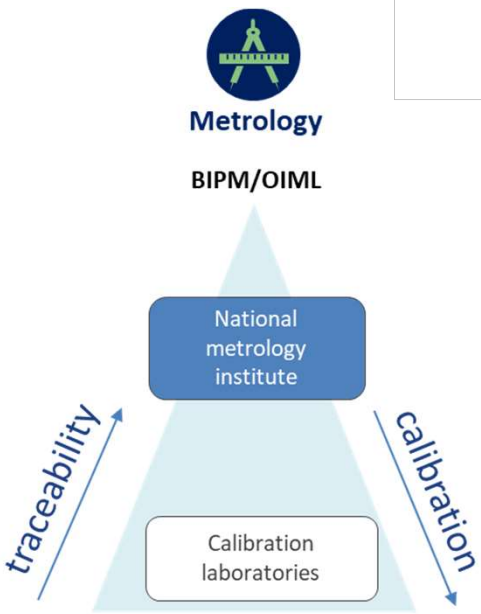
Building of measurement capability



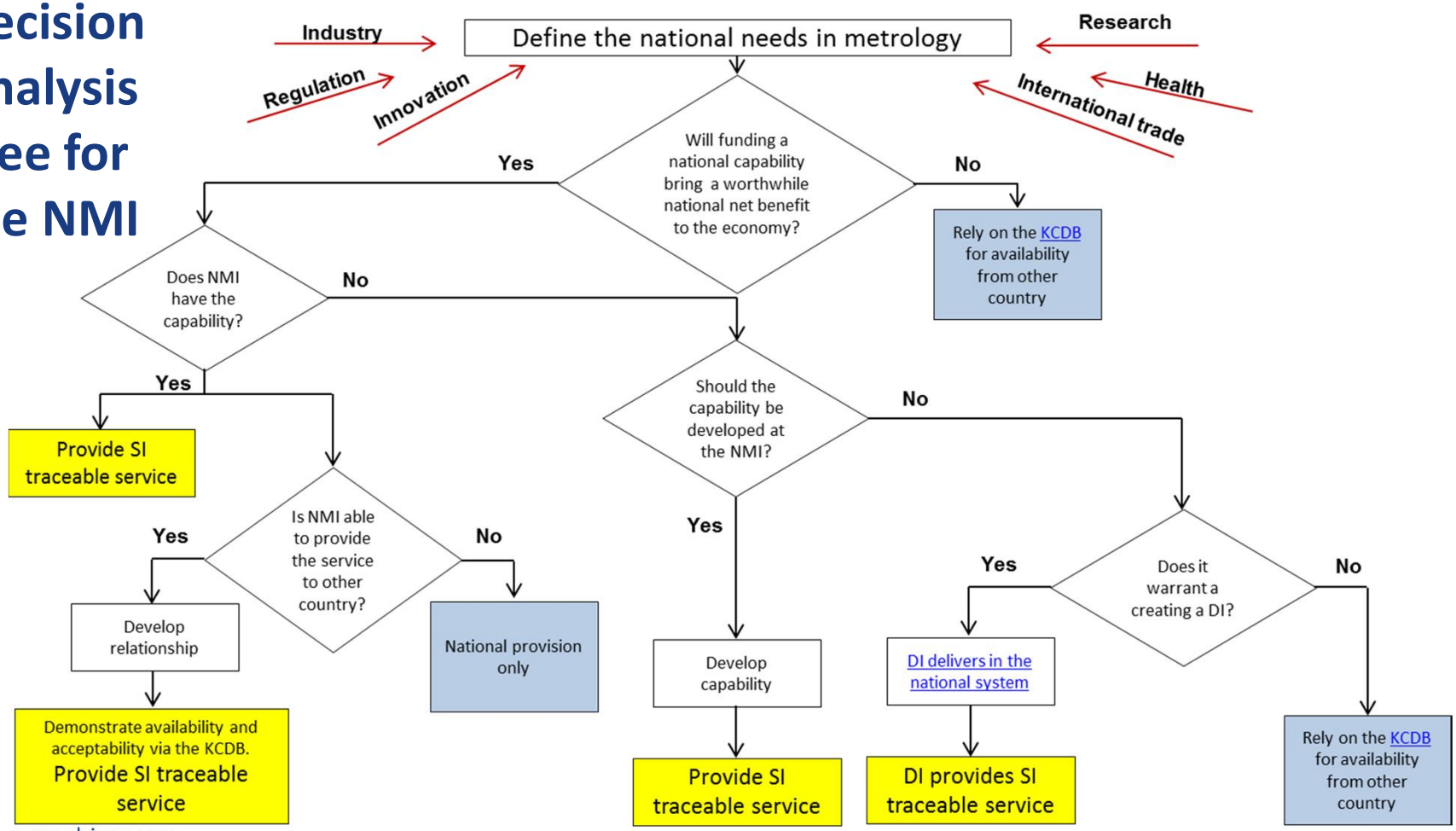
An NMI capabilities should meet the national needs in metrology

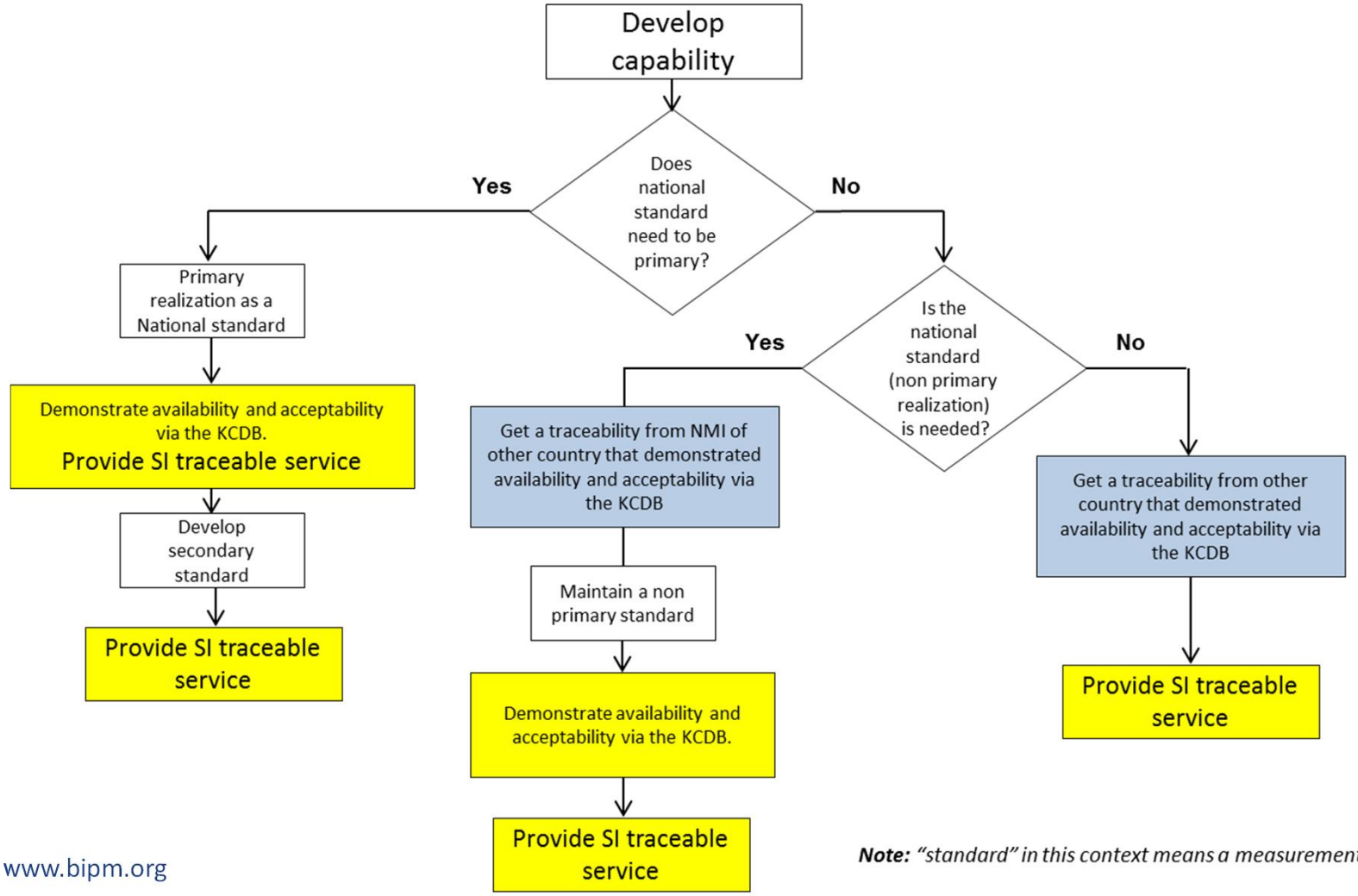
In the development of NMI capabilities, at least two dimensions need to be considered:

- identification of the area of need *(AUV, Mass, Length, Electricity, etc…)*
- identification of the degree of need that is involved (*research, supporting innovation, regulation, etc…)*

Understanding the needs allows important decisions to be made, for example: *Do national measurement standards need to be primary realizations or will a national standards traceable to another NMI suffice?*

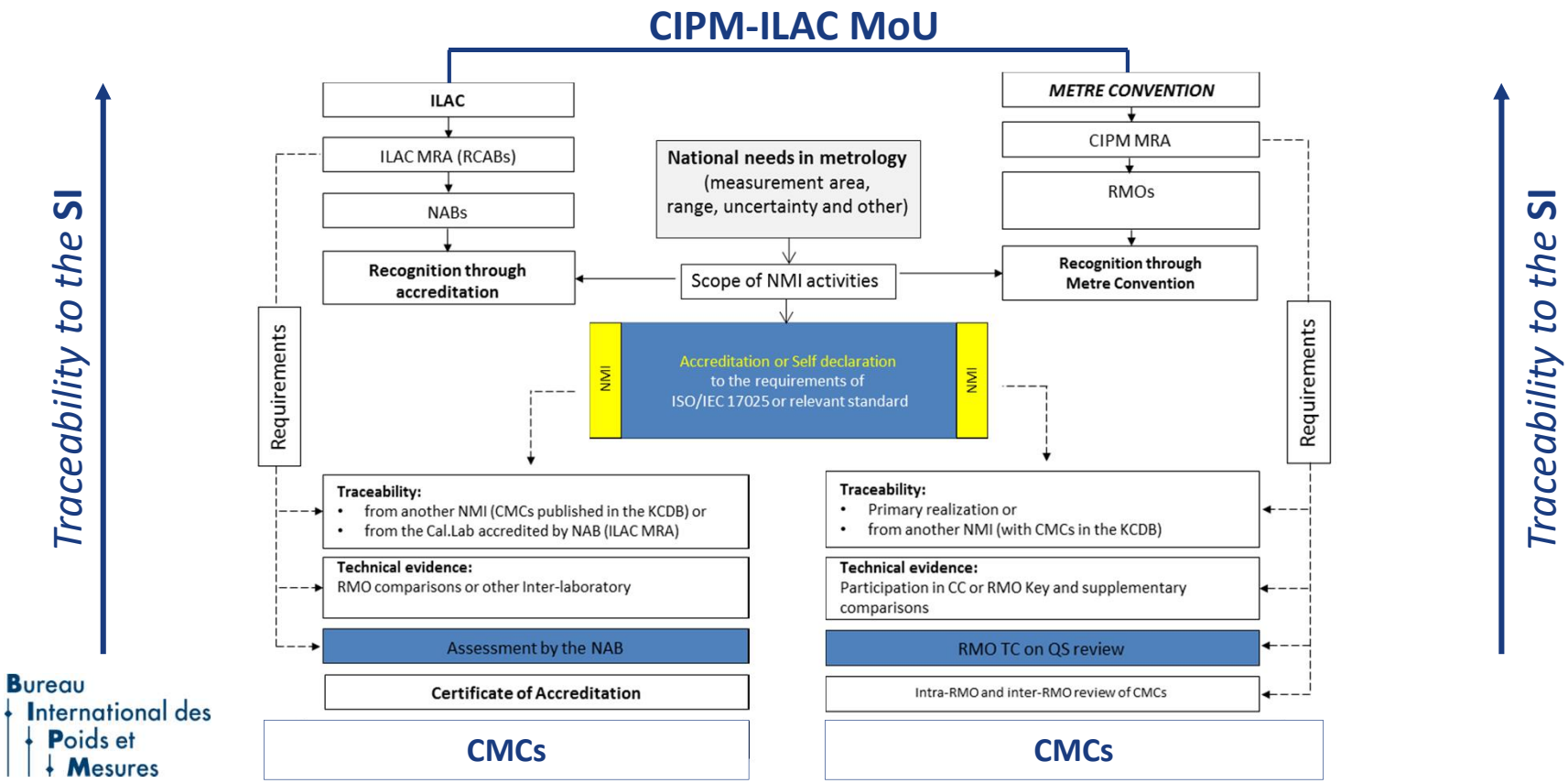
Decision Analysis Tree for the NMI





Note: *"standard" in this context means a measurement standard*

Options for NMIs providing traceable services



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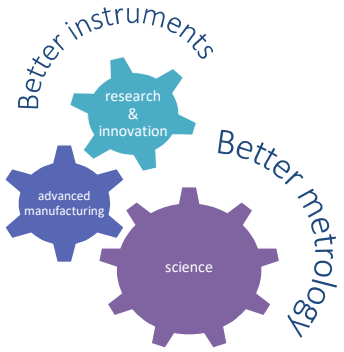
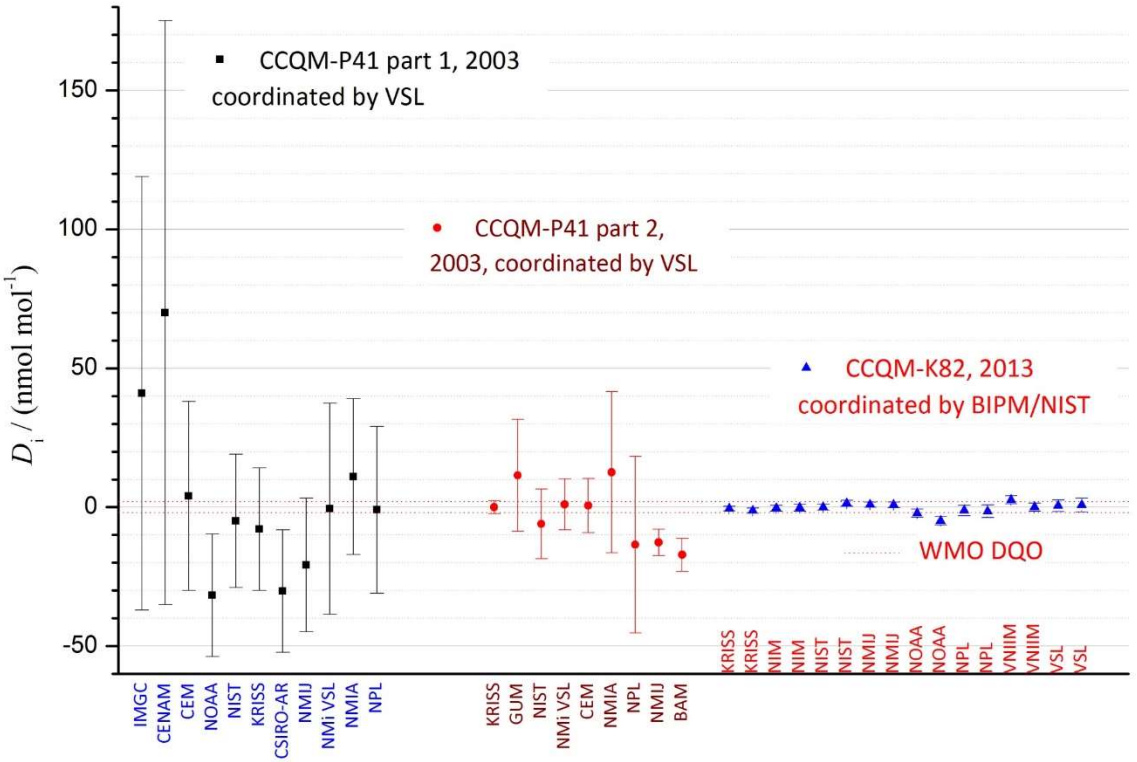
CCQM Comparisons





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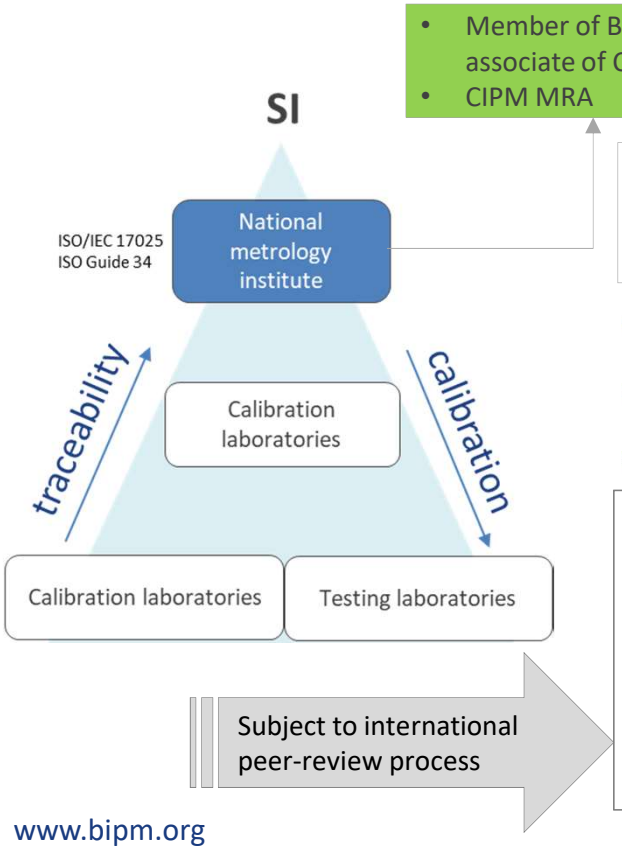
International recognition of NMI's measurement capabilities



- Member of BIPM or associate of CGPM
- CIPM MRA

Demonstration of measurement capabilities through the instruments defined by the *Metre Convention*

- Participate in the activities of the Regional Metrology Organization (RMO)
- Become a Member State of the BIPM or Associate of the CGPM
- **Participate in the CIPM MRA**
  - Demonstrate measurement capabilities through participation in the CIPM and RMO Key or Supplementary comparisons
  - Operate an appropriate quality management system and demonstrate through the RMO
  - Demonstrate metrological traceability
  - Declare calibration and measurement capabilities (CMCs) in the KCDB

Quality infrastructure and the role of NMIs

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Quality infrastructure *–definition*

"The system ..

comprising the organizations (public and private) together with the policies, relevant legal and regulatory framework, and practices

needed to support and enhance the quality, safety and environmental soundness of goods, services and processes.

it relies on

- ***metrology***
- *standardization*
- *accreditation*
- *conformity assessment, and*
- *market surveillance" (in regulated areas)"*

INet QI

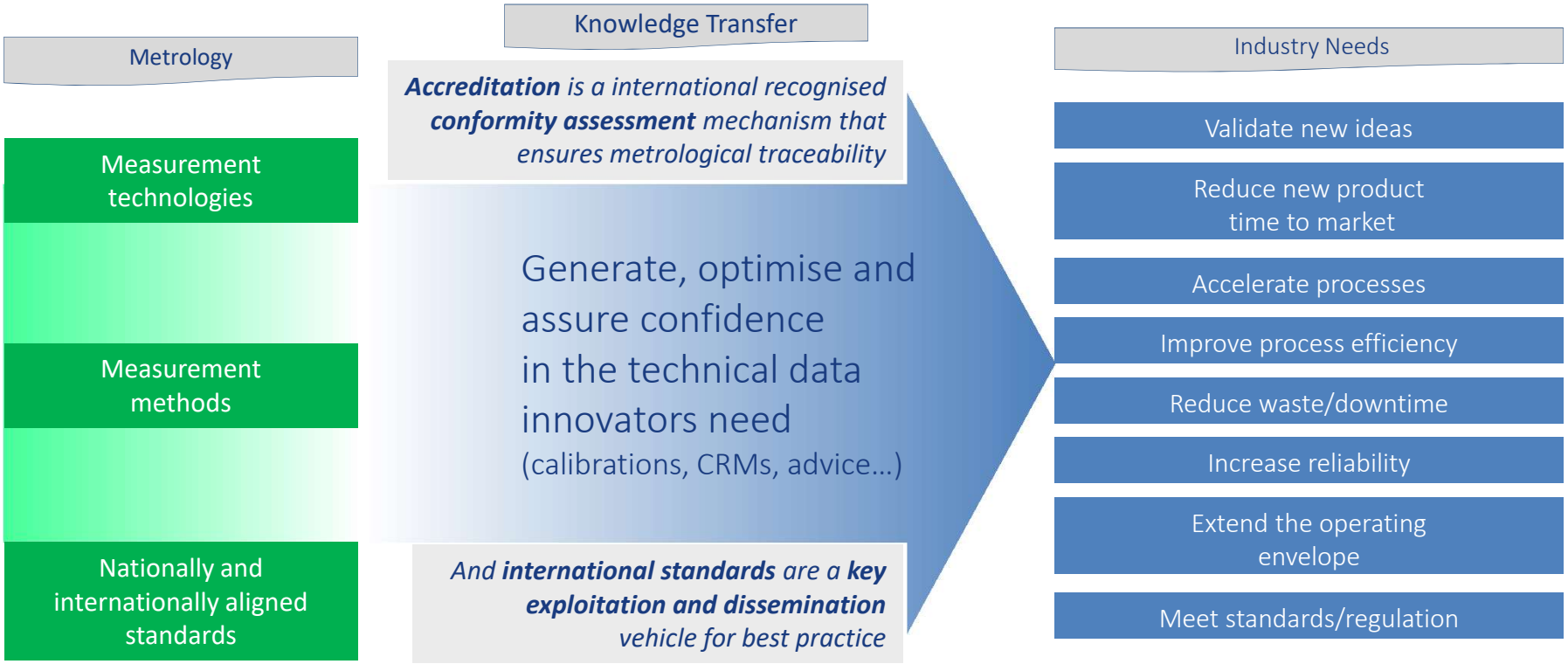
International Network on Quality Infrastructure

"The quality infrastructure is required for the effective operation of domestic markets, and its international recognition is important to enable access to foreign markets.

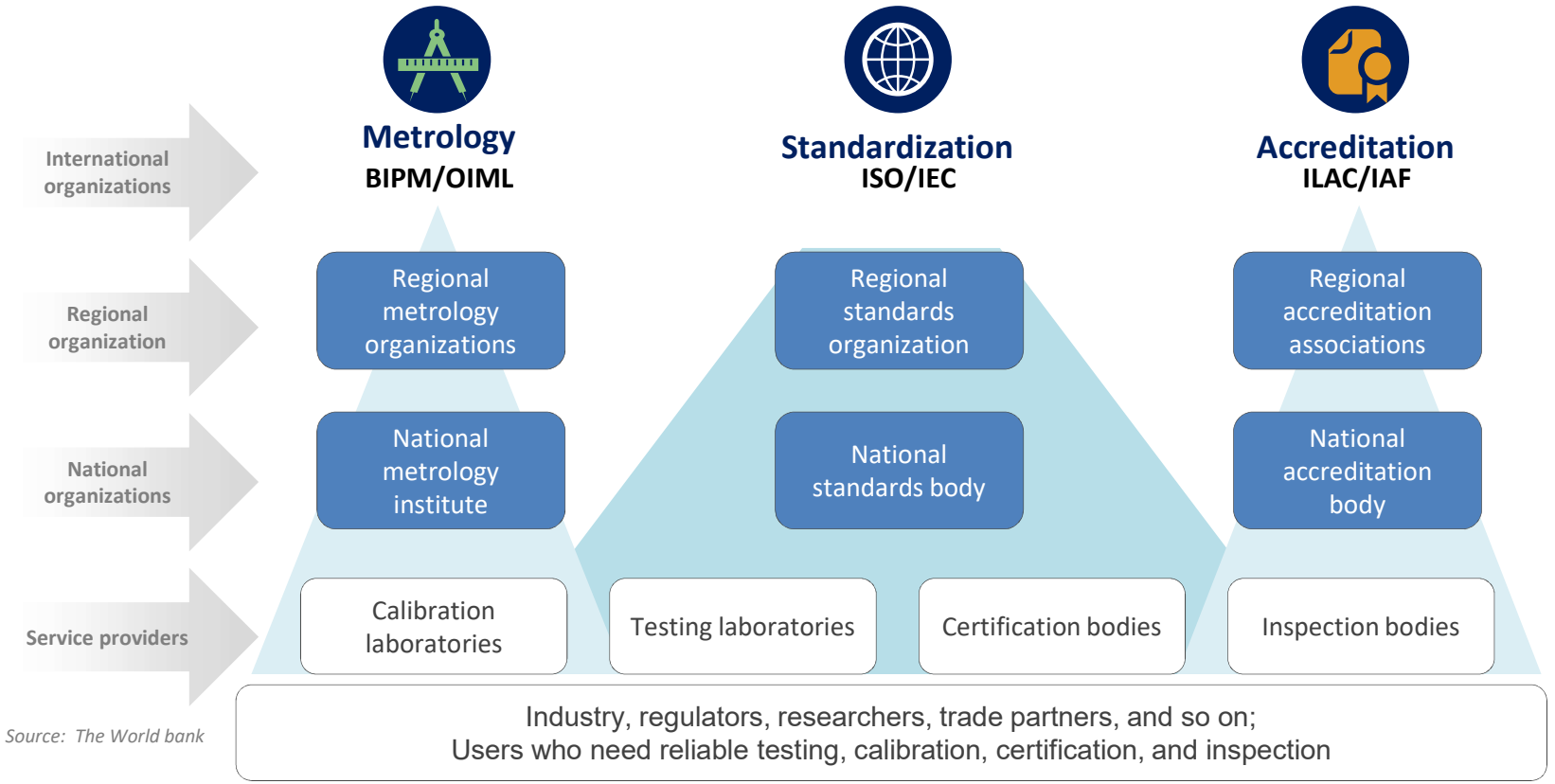
It is a critical element in promoting and sustaining economic development, as well as environmental and social wellbeing."

adopted in June 2017 by the DCMAS Network
BIPM, *IAF, IEC, ILAC, ISO, ITC, ITU, OIML, UNECE and UNIDO + the World Bank.*

Accreditation ensures metrological traceability

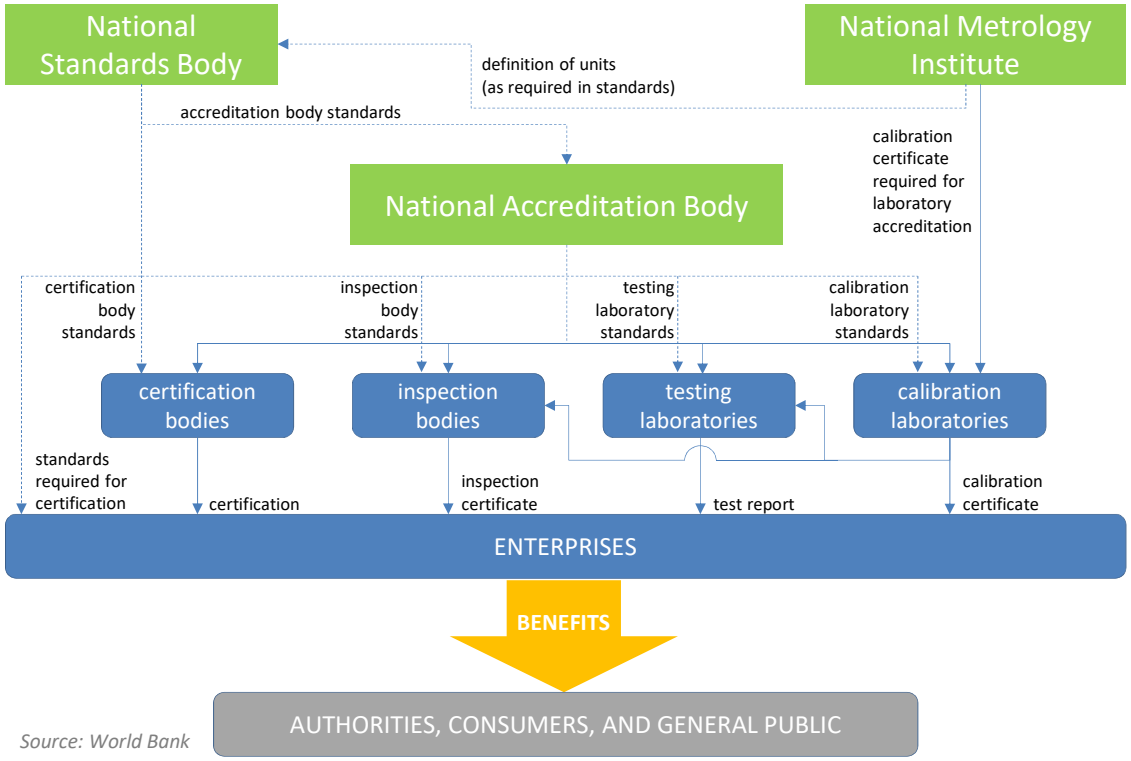


Key players at international, regional and national level



Source: The World bank

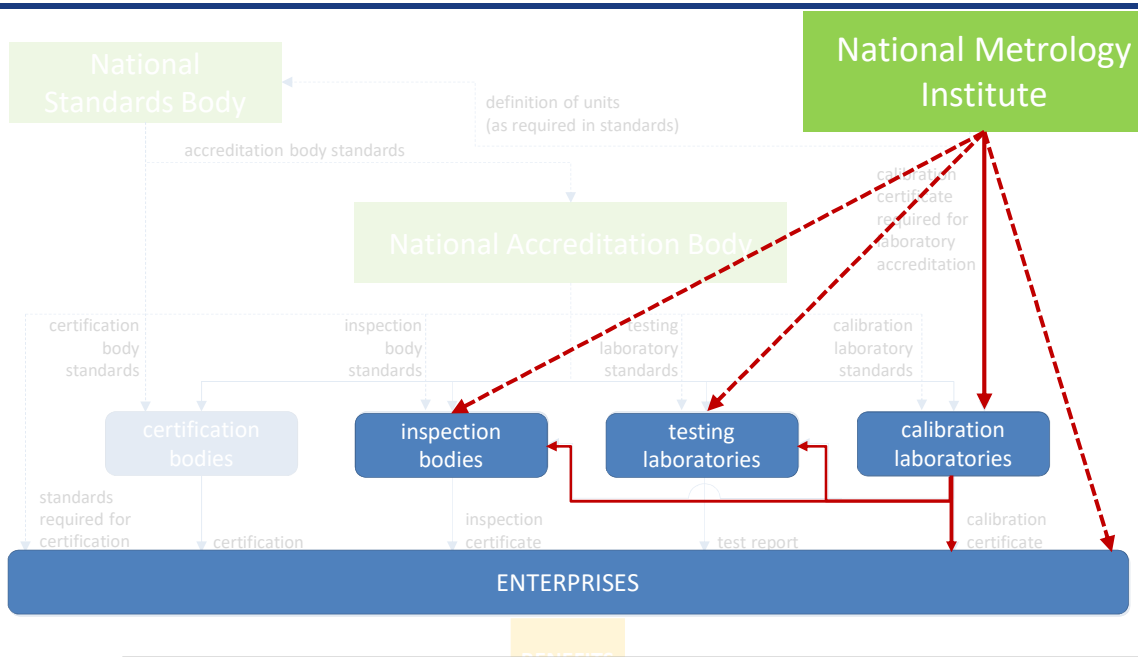
Metrology is a key pillar of the QI



Source: World Bank

- Enhanced product quality and compatibility
- Enhanced safety and health
- Decreased environmental impact
- Increased trade opportunities
- Facilitating innovations to the market place

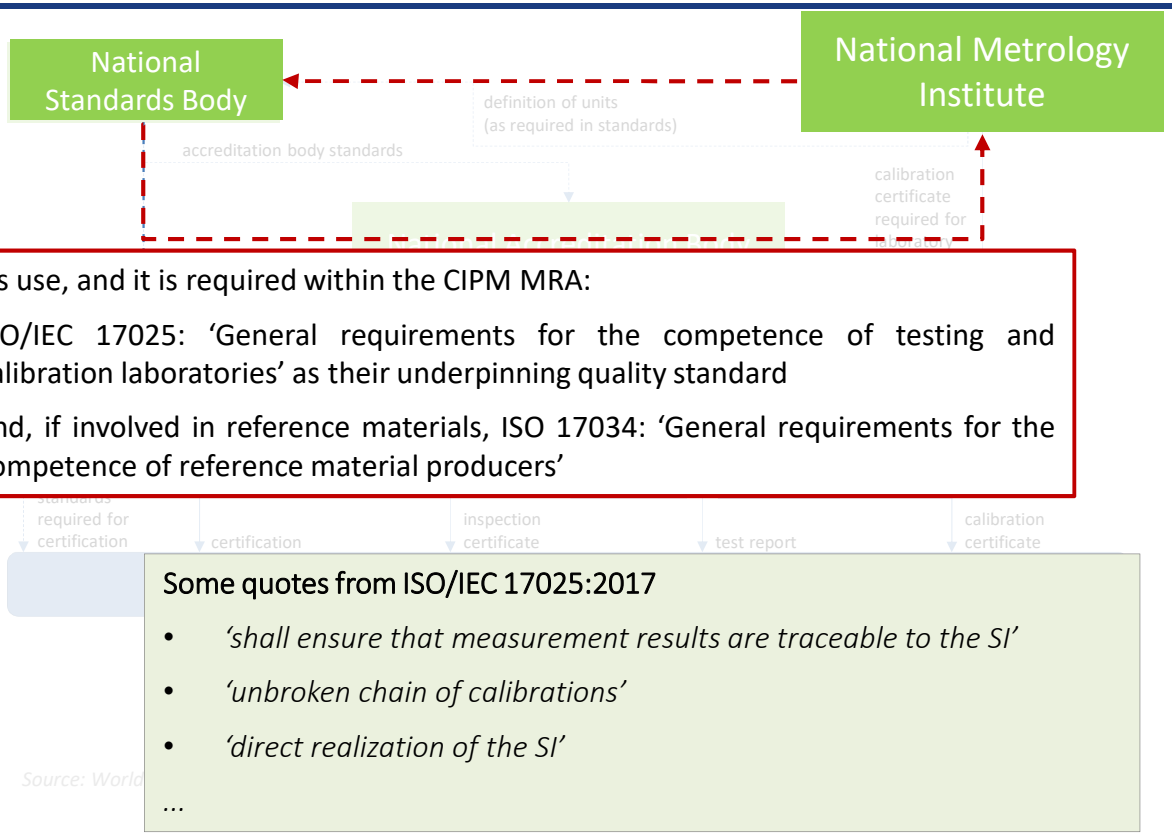
Role of NMI



- Disseminates metrological traceability via the national standards through:
  - Calibration
  - Certified Reference Materials
- Provides advice to stakeholders/ customers on:
  - measurement challenges
  - where to obtain internationally accepted traceable services when not provided by the NMI

National regulatory bodies and other agencies utilise effectively the pool of technical knowledge that is generated within an NMI.

Role of NMI



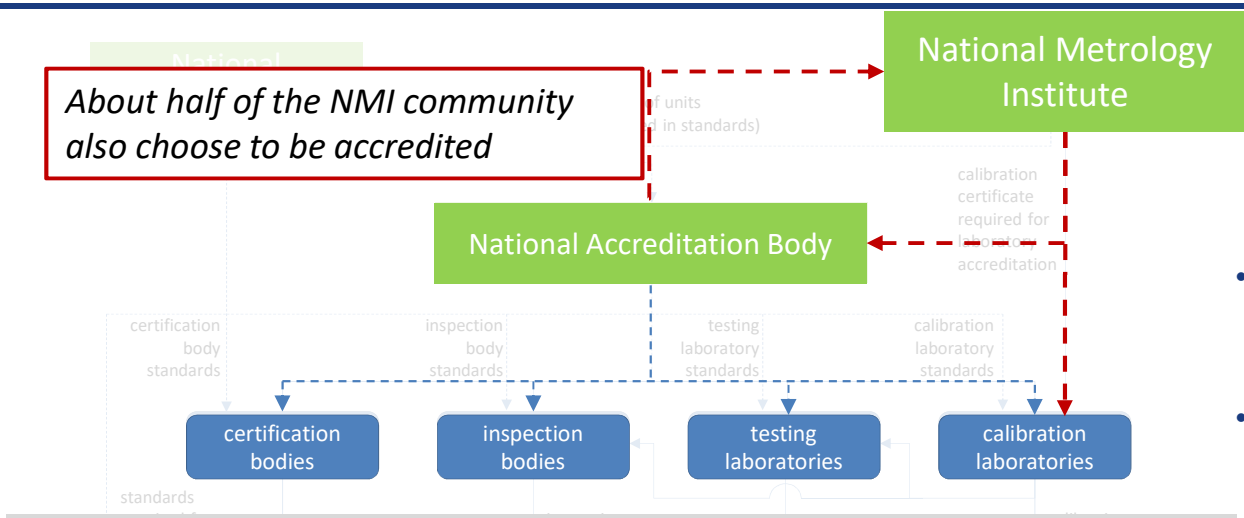
- NMIs provide experts:
  - to national standards body
  - to regional and ISO technical committees and WGs
  - national mirror committees

To ensure documentary standards embody best measurement practice (including SI traceability)

ISO/IEC Documentary standards

- Embody metrological traceability including poromoting the use SI
- Require testing and calibration laboratories to be competent
- …and thus measurement uncertainty
  - Use of the VIM
  - Use of the GUM

Role of NMI



More than 76 500 accredited calibration and test laboratories… *accreditation is excellent tool for ensuring the metrological traceability chain!*

- Disseminate traceability via the national standards through:
  - Calibration
  - Reference materials

- NMIs provide technical experts to the accreditation bodies to help review top level calibration labs and other NMIs.
- NMIs provide capacity building and knowledge transfer activities. NMI comparison protocols can form the basis of the measurement methods.

BENEFITS

NMI participation in the CIPM MRA; CMC claims and comparison exercises declared on the KCDB database are value for accredited laboratories and accreditors.

International aspects of metrology

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The objectives of the BIPM

To **represent** the worldwide measurement community aiming to maximise its uptake and impact

To be a **centre for scientific and technical** collaboration between Member States providing capabilities for international measurement comparisons on a shared-cost basis.

To be the **coordinator** of the worldwide measurement system ensuring it gives comparable and internationally-accepted measurement results

Fulfilling our mission and objectives is underpinned by our work in:

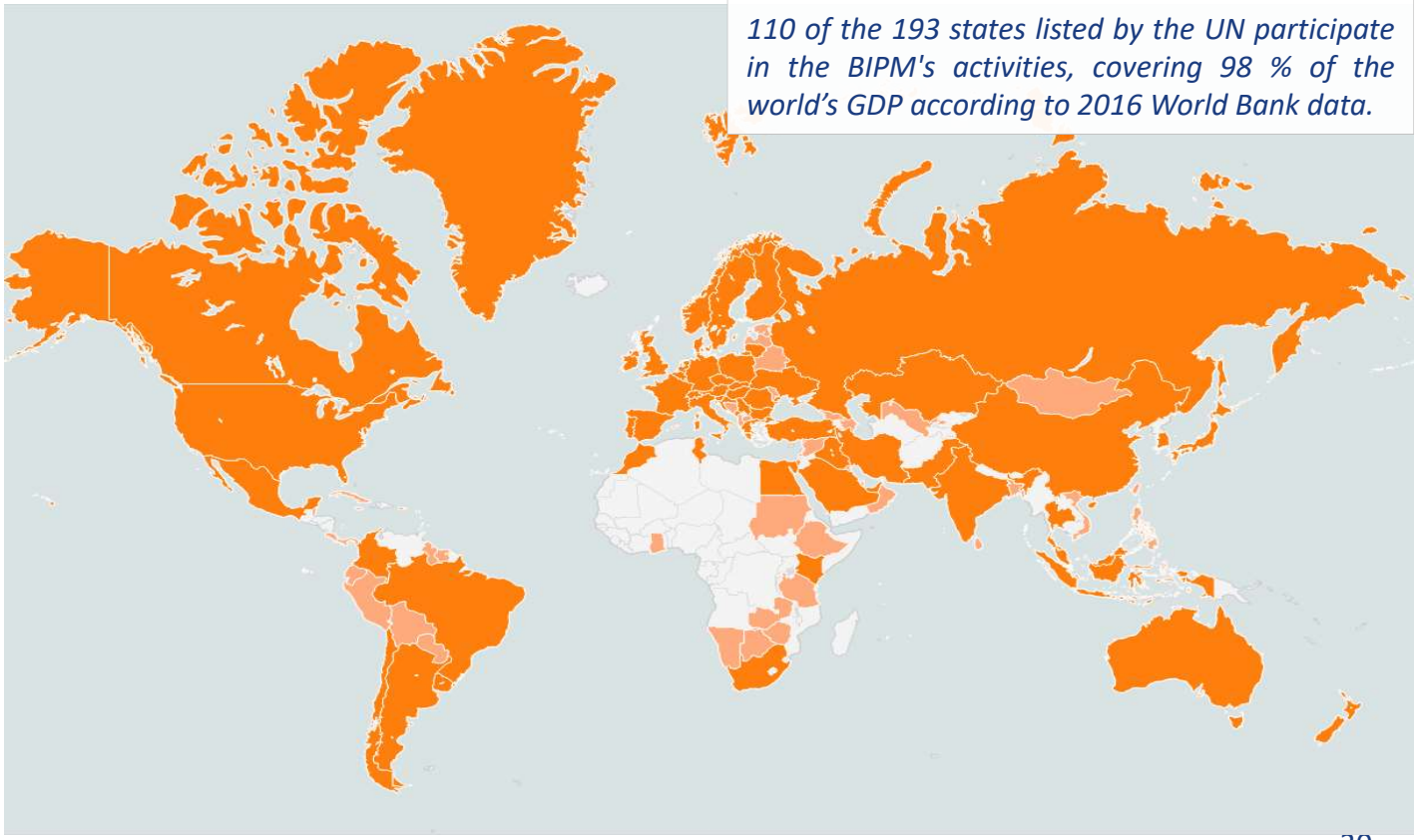
- ***capacity building**, which aims to achieve a global balance between the metrology capabilities in Member States.*
- ***knowledge transfer,** which ensures that our work has the greatest impact.*

Member States and Associates

As of 24 May 2019, there are:

- 60 Member States
- 42 Associates of the CGPM (States and Economies)

** The official term is "State Parties to the Metre Convention"; the term "Member States" is its synonym and used for easy reference.*



110 of the 193 states listed by the UN participate in the BIPM's activities, covering 98 % of the world's GDP according to 2016 World Bank data.

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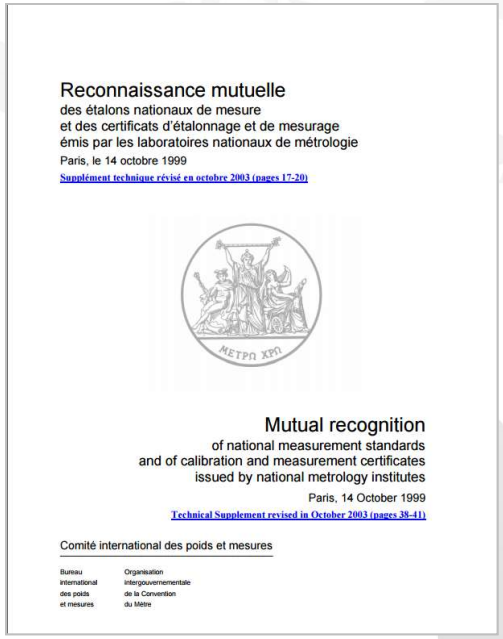
CIPM MRA - a secure technical foundation for wider agreements



Reconnaissance mutuelle
des étalons nationaux de mesure
et des certificats d'étalonnage et de mesurage
émis par les laboratoires nationaux de métrologie
Paris, le 14 octobre 1999
Supplément technique révisé en octobre 2003 (pages 17-20)

Mutual recognition
of national measurement standards
and of calibration and measurement certificates
issued by national metrology institutes
Paris, 14 October 1999
Technical Supplement revised in October 2003 (pages 38-41)

Comité international des poids et mesures

Bureau international des poids et mesures
Organisation intergouvernementale de la Convention du Mètre

The CIPM Mutual Recognition Arrangement (CIPM MRA) is the framework through which **NMIs demonstrate**

- the international equivalence of their measurement standards and
- the calibration and measurement certificates they issue.

The work of the CIPM MRA now goes far beyond matters of trade to cover climate change, healthcare etc.

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CIPM MRA participation today

Participation

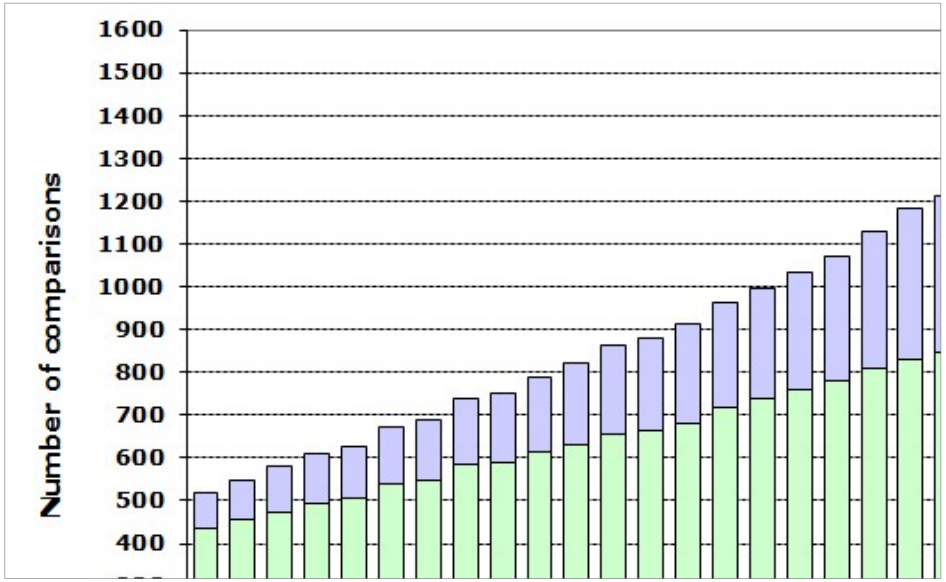
- **101 National Metrology Institutes**
  - *59 Member States*
  - *42 Associates*
- **4 International organizations** *(ESA, IAEA, JRC, WMO)*
- **plus 154 Designated Institutes**

Total: 259 Institutes

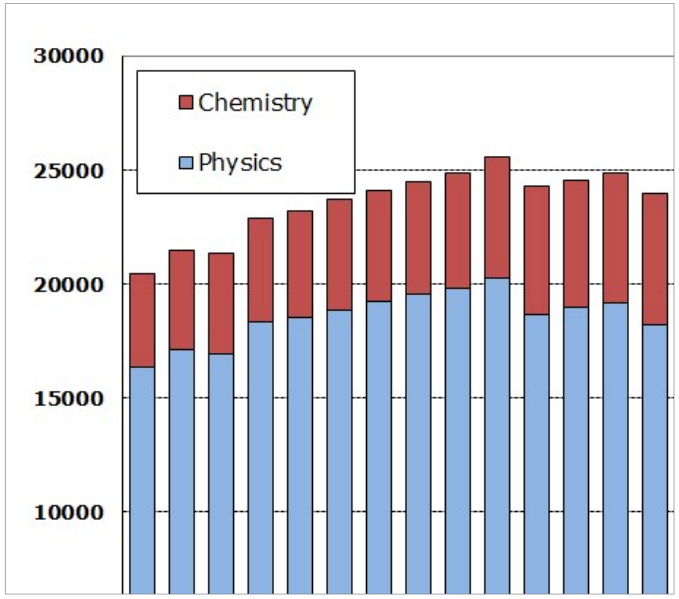
KCDB figures *(March 2019)*

1588 comparisons :

1022 key, 566 supplementary comparisons

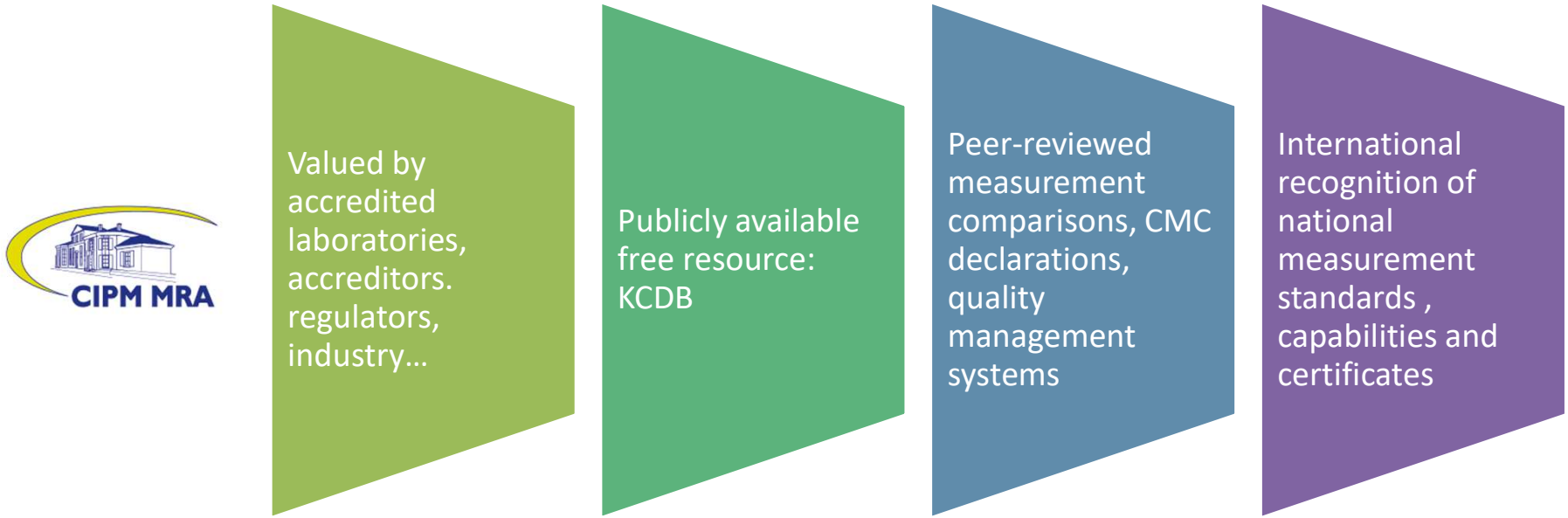


Total: 25 268 CMCs



CIPM MRA is…

Cornerstone of the Quality Infrastructure



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BIPM and the international QI

- BIPM promotes the interests of its Member states within the scope of the Metre Convention
  - Scientific coordination
  - International liaison

  And the BIPM and its NMI community have extensive QI links

  …. Lets take a look

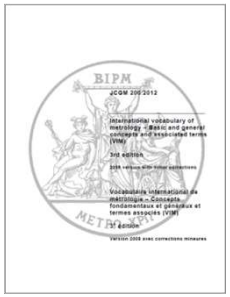
JCGM: Joint Committee for Guides in Metrology (VIM & GUM)

GUM

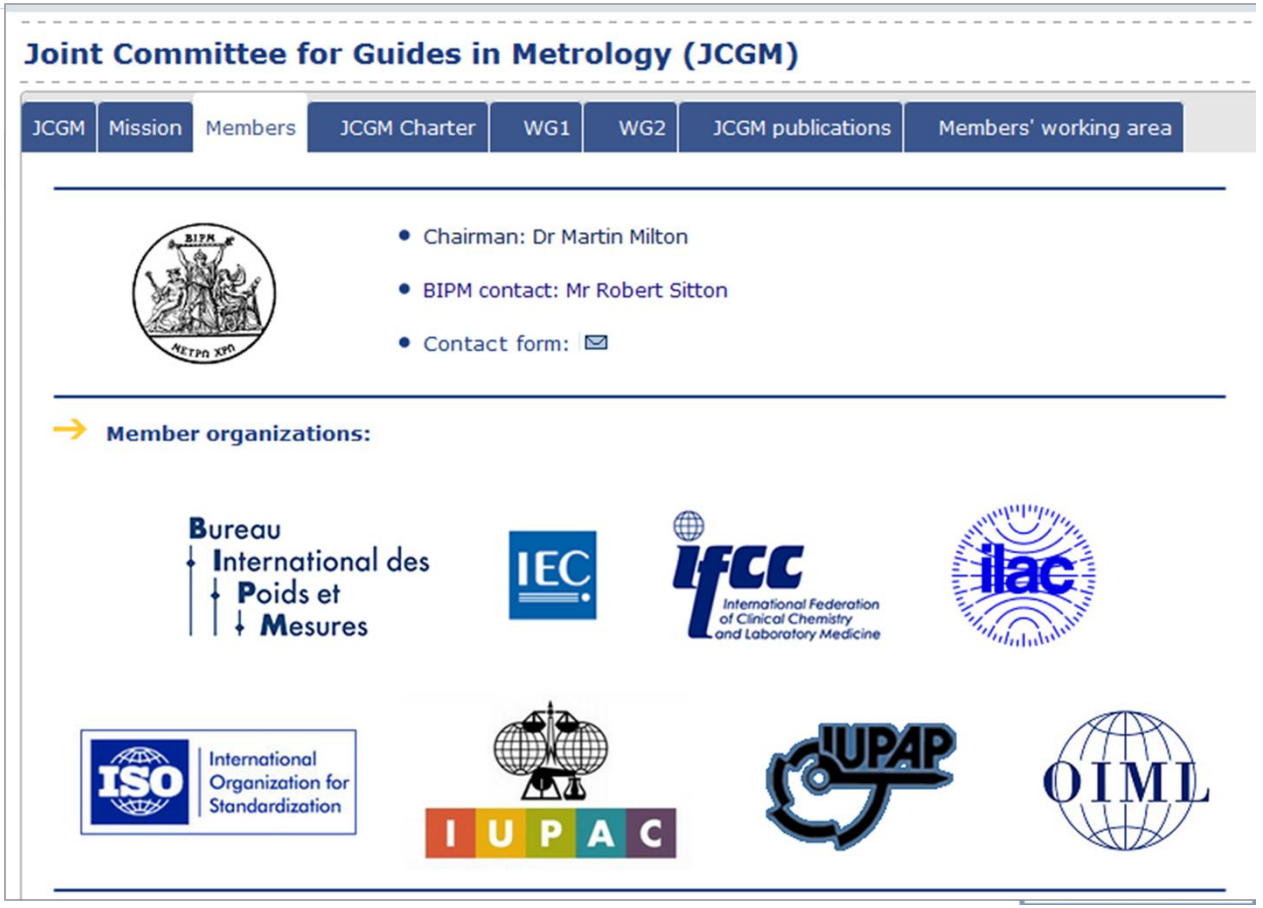
Guide to the Expression of Uncertainty in Measurement

VIM

International Vocabulary of Metrology

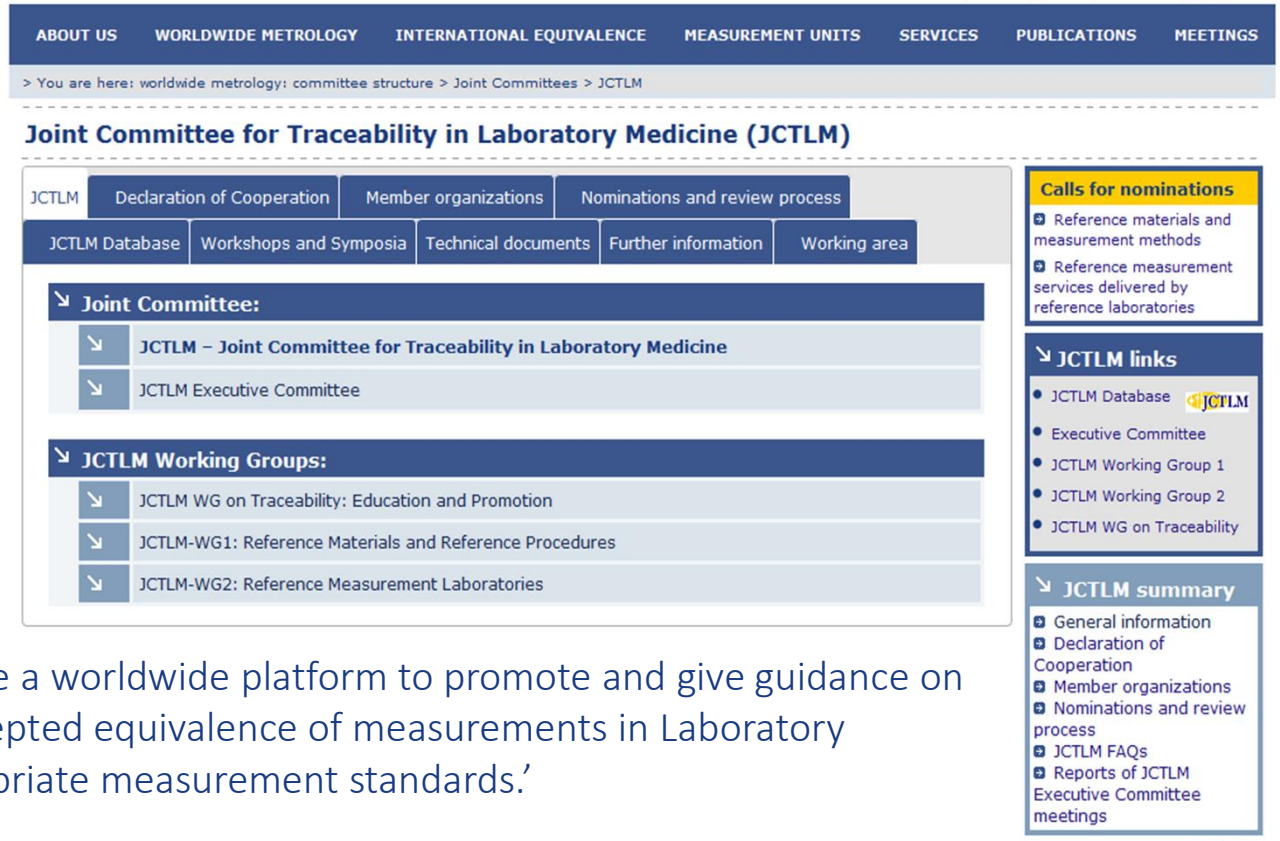


www.bipm.org



Joint Committee for Traceability in Laboratory Medicine (JCTLM)

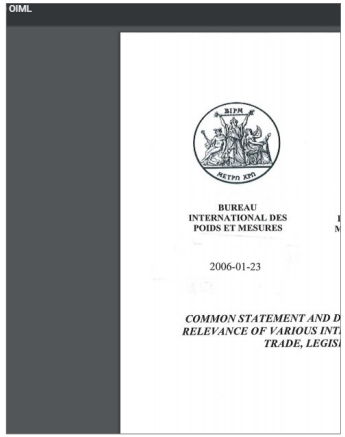
BIPM
IFCC
ILAC
…….agree to cooperate to establish a Joint Committee for Traceability in Laboratory Medicine, with the acronym JCTLM.

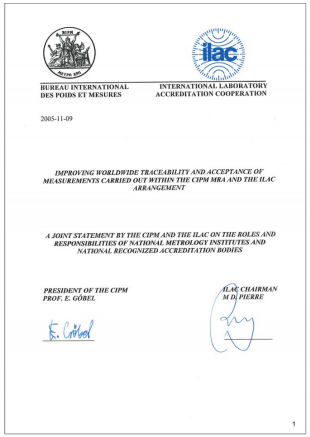


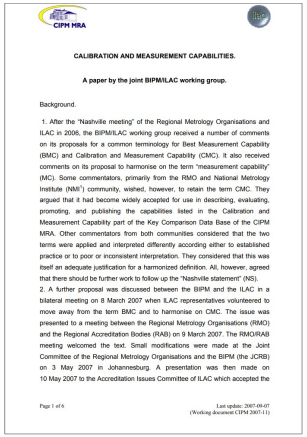
'The goal of the JCTLM is to provide a worldwide platform to promote and give guidance on internationally recognized and accepted equivalence of measurements in Laboratory Medicine and traceability to appropriate measurement standards.'

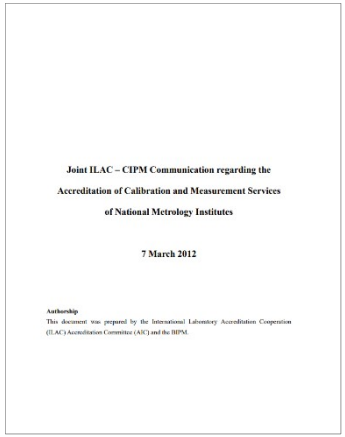
BIPM, OIML, ILAC and ISO

There are five collaborative documents









BIPM, OIML, ILAC and ISO meet annually at senior level in a ‘Quadripartite’

Joint BIPM and OIML initiative - ***World Metrology Day***

The international metrology community *which works to ensure that accurate measurements can be made across the world* ***endeavors to raise awareness each World Metrology Day through a poster campaign and web site****.*

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World Metrology Day

Bureau International des Poids et Mesures

http://www.worldmetrologyday.org/

World Metrology Day 2019

The theme of World Metrology Day in 2019 is ***"The International System of Units - Fundamentally better"***

Information on national WMD activities is posted on the website:
http://www.worldmetrologyday.org

The 2019 poster was designed by the Standards and Calibration Laboratory, Hong Kong, China.

創新科技署
Innovation and Technology Commission

Standards and Calibration Laboratory, Hong Kong, China

Conclusions

- The value of metrology isn't easy for the everyday person to understand…..
- The metrology community needs mechanisms that help embed its principles and practices such that they are adopted (even if that adoption is often invisible)
- The international and national quality infrastructure plays a major role in ensuring good metrological practice is carried from the laboratory to the application
- At national level the relationship between the QI players is important
- The national and international quality infrastructure cooperates intensively
- Metrology is a major winner from the QI association

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Reflections

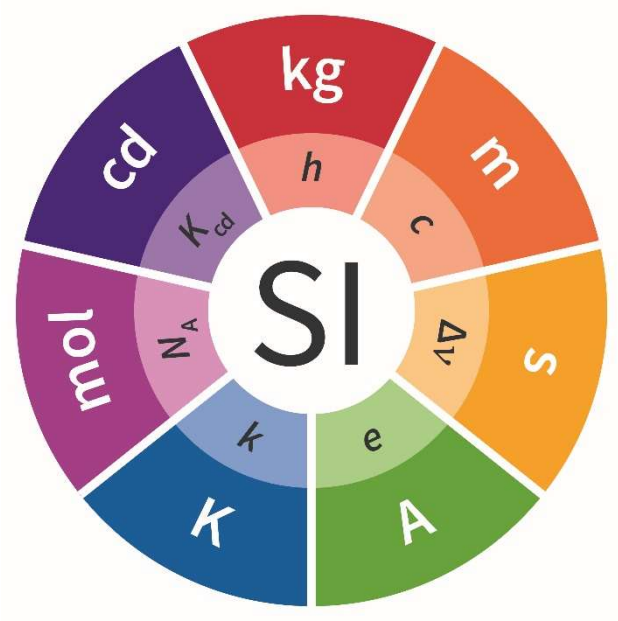
- Future challenges?
  - Standards on-a Chip… ‘intrinsic quantum standards’
    - Embedded sensors – will they require calibration/comparison?
    - ...calibrated *in situ*/remotely?
  - The data revolution:
    - Algorithms
    - AI
    - Large amounts of data from low cost sensors
    - Crowd sourced measurements
    - Quality of data (or data set) *vis a vis* quality of a measurement?
    - Reproducibility of scientific results in research
  - ??? …. what else do YOU think might be on the horizon?

  We can’t ignore…
  We should be ready to respond to the need of innovation

Bureau International des Poids et Mesures

Thank you.

andy.henson@bipm.org



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