



CIPM Task Group on the Digital SI

Joachim Ullrich, CIPM TG-DSI Chair

November 2022

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Working together to
promote and advance
the global comparability
of measurements



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27^e réunion de la
Conférence générale
des poids et mesures

Quality Infrastructure of the Future

by 2050 about 50 % to 80 % of the population live in cities

What will cities look like?

How will the **supply** work?

What **measurements** and **metrology** will be needed?

What **Quality Infrastructure** will be needed:

→ How can we guarantee high-quality and reliability in complex interlinked digital systems?

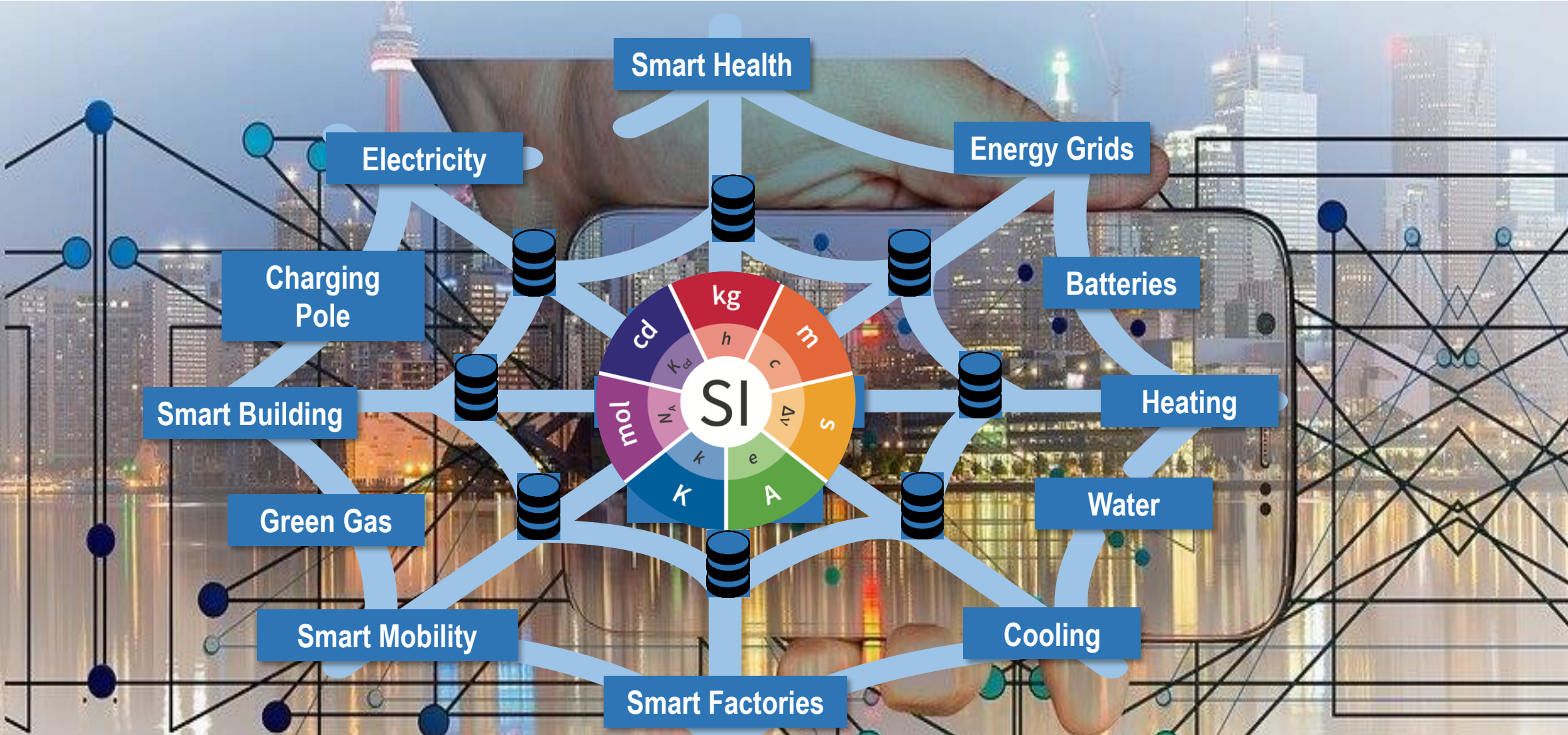
Smart Health

Smart Building

Smart Mobility

Smart Factories

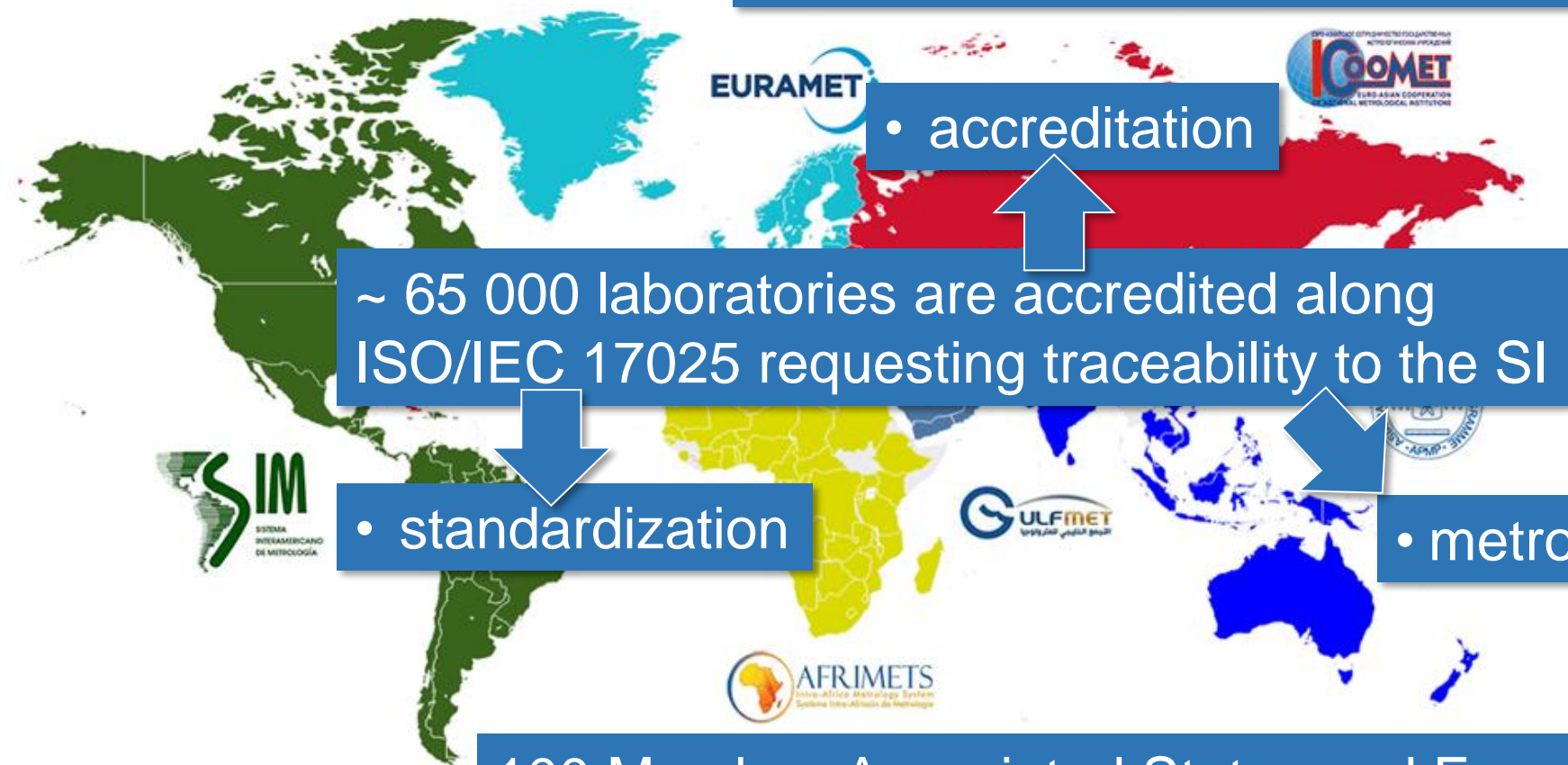
Quality Infrastructure of the Future



Usually expressed in units of the SI!

The Metre Convention and the SI

Diplomatic Treaty signed in 1875



• accreditation

~ 65 000 laboratories are accredited along ISO/IEC 17025 requesting traceability to the SI

• standardization

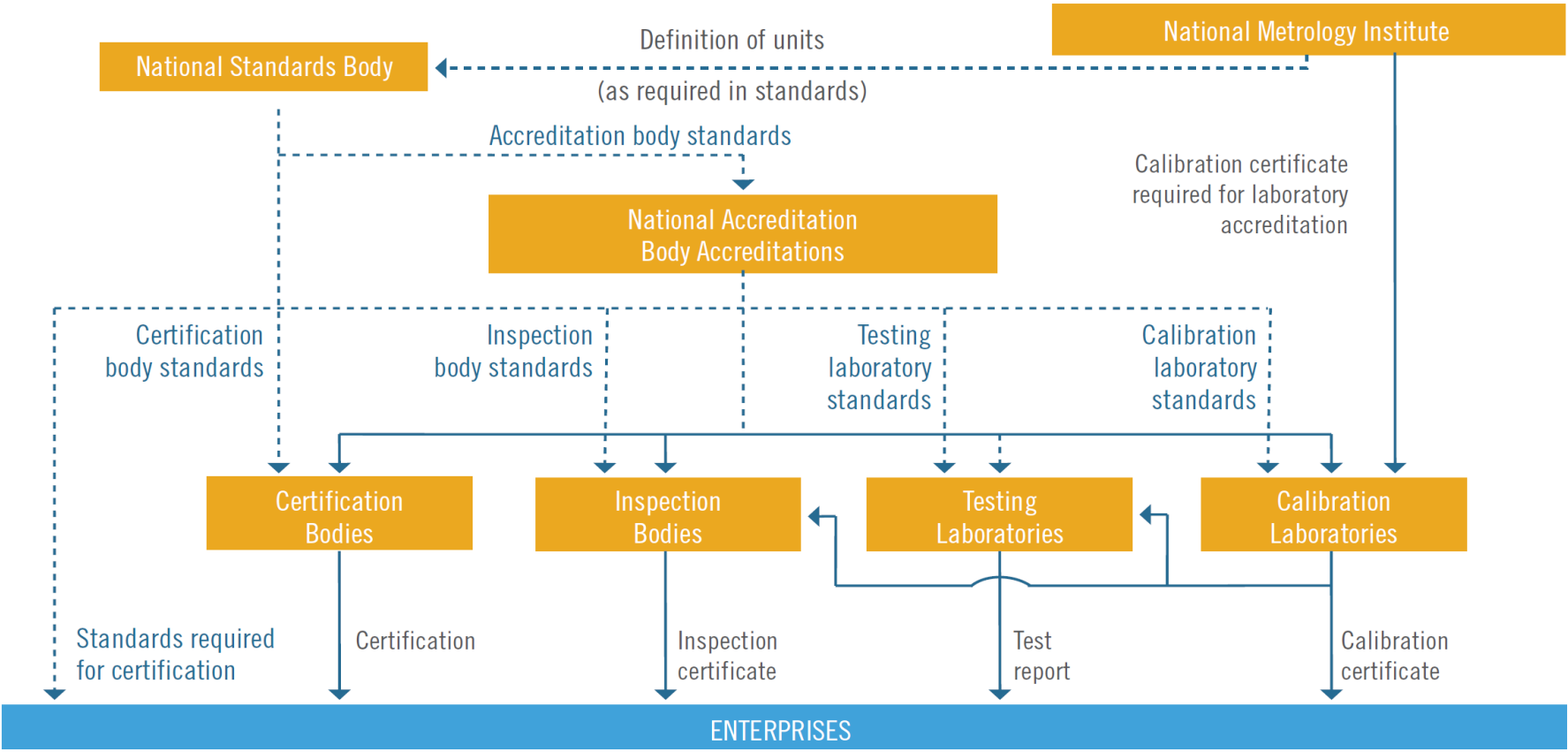
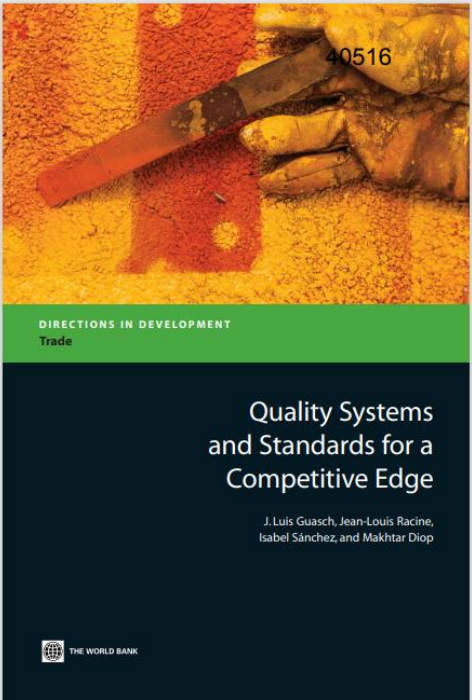
• metrology

100 Member, Associated States and Economies

- 97.6 % of the World's GDP participate
- Scientific basis for Quality Infrastructure



Worldwide Quality Infrastructure



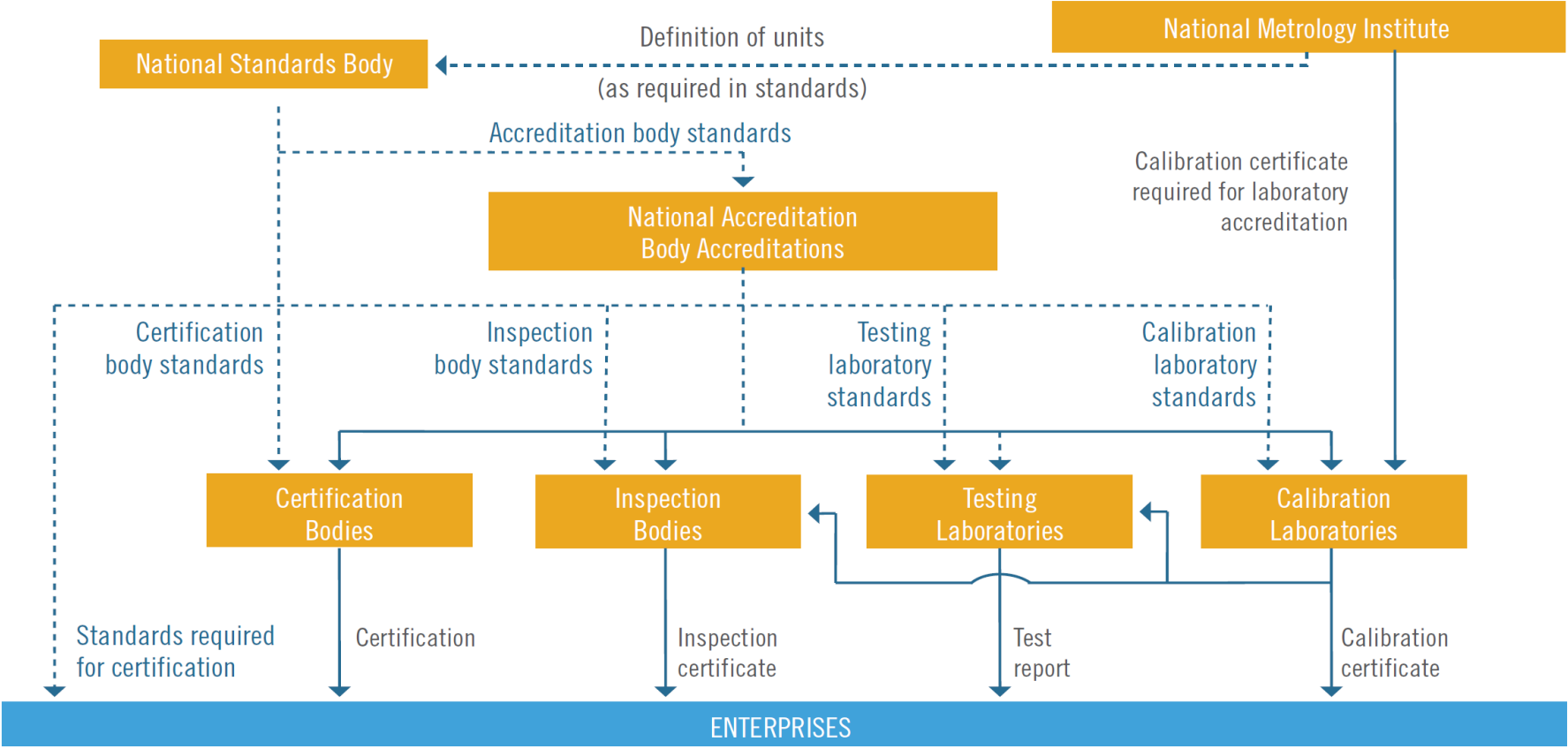
Source: World Bank, 2007, Quality Systems and Standards for a Competitive Edge, Washington D.C. Standards

Worldwide Quality Infrastructure

complex processes:
→ Fully digitalized



... a worldwide agreed metadata format for all measurement data



Source: World Bank, 2007, Quality Systems and Standards for a Competitive Edge, Washington D.C. Standards

Worldwide Quality Infrastructure

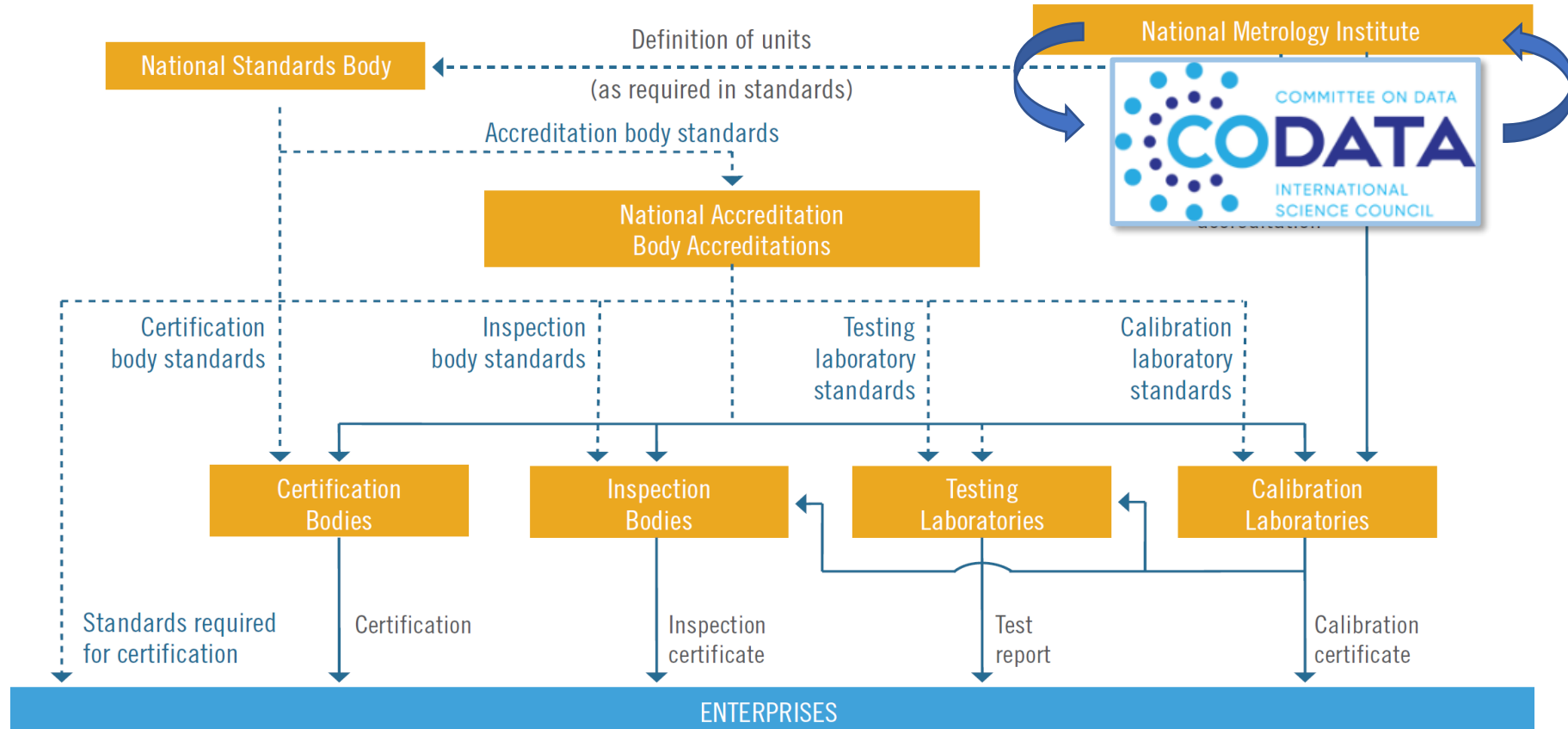
complex processes:
→ Fully digitalized



... a worldwide agreed metadata format for all measurement data



- Quality Infrastructure
- Industry & Health
- Science



Source: World Bank, 2007, Quality Systems and Standards for a Competitive Edge, Washington D.C. Standards

Grand Vision: SI Digital Framework

The International System of Units (SI), provided by the BIPM SI Brochure, provides a coherent foundation for the representation and exchange of measurement data, enabling interoperability and reproducibility in all scientific and technological domains. *The long-term aim of the TG “Digital SI” initiative is to establish a framework that meets FAIR principles (respecting business and privacy constraints) and allows all aspects of the international measurement system – measurement results, uncertainties, traceability and provenance – to be accessed and interpreted digitally, enabling **machine-to-machine communication and analysis**.* With this respect the SI, existing for more than one century – might be considered as an exemplar of interoperability principles for data. The envisioned framework encompasses foundational (core) models for SI based data representation, digital services and tools, and data stewardship and management activities, providing SI data and information that is transparent to (authorized) users and machines.



The Grand Vision: SI Digital Framework

machine-to-machine communication

From level 3 on all digital formats will need interoperable unit and quantity representations

<https://www.din.de/resource/blob/801106/0251eb1280a9a97e53285d42d3bf1fea/whitepaper-idis-en-data.pdf>

5 degrees of digitalization for **Smart Standards** (ISO/IEC)



Level 1

Digital document

Digital representation



Level 2

Machine-readable document

Structured document format
Software processing with high manual workload



Level 3

Machine-readable and -executable content

Content completely (semantically) discovered
Semantic search and selective access on content level



Level 4

Machine-interpretable content

Information models describing and explaining the content and the relationships between items of information
Self-learning analysis together with automatic validation and optimization
Value-adding services possible e.g. conformity check, question answering,



Level 5

Machine-controllable content

The content of a standard is amended automatically and adopted by automated decision-making processes.
Digital standards are based on a system of artificial general intelligence with cognitive capabilities.
Digital standards adapt constantly to the current state of the art of technical and regulatory framework conditions.

SI Digital Framework
(machine-actionable)

The Grand Vision: SI Digital Framework

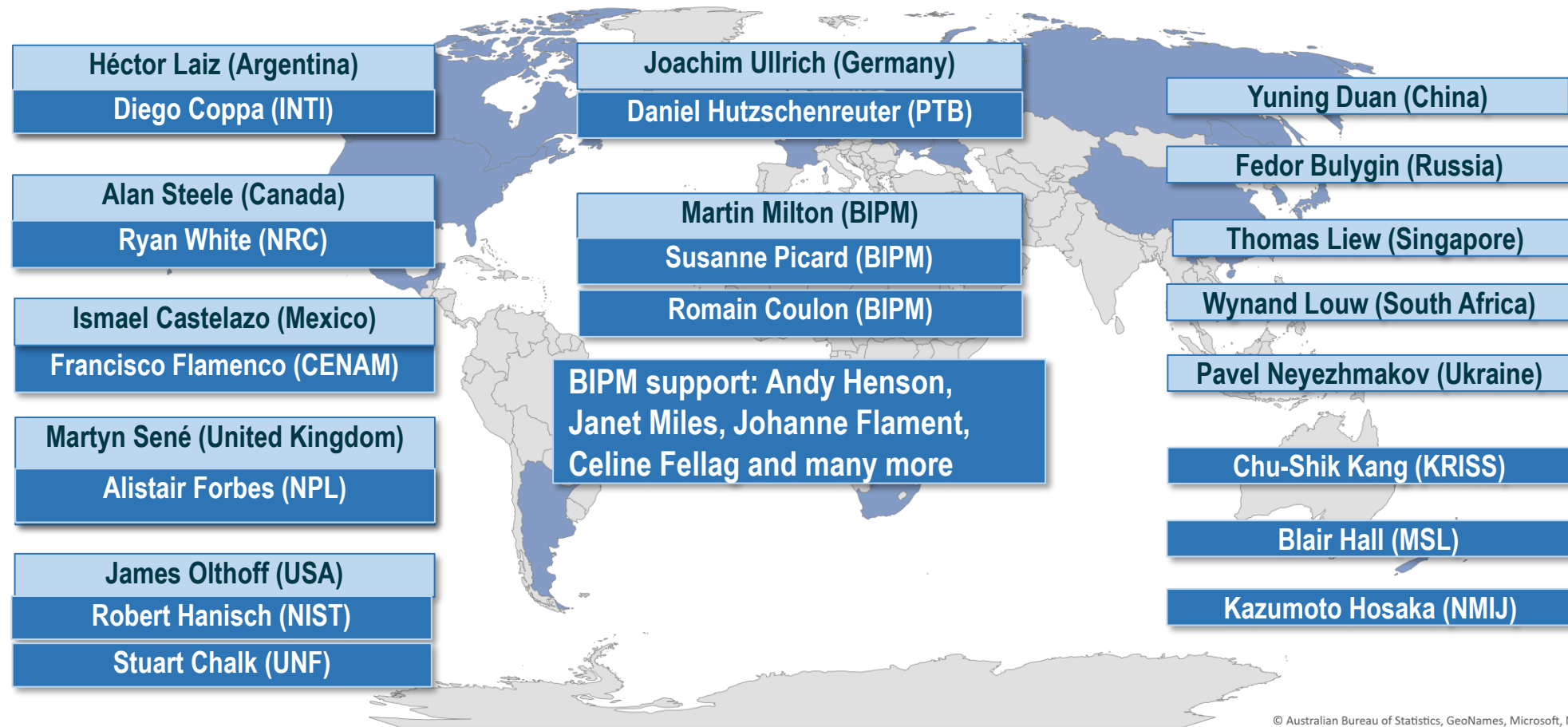
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Established in the
108th meeting of
the CIPM

- International **Task Group “Digital-SI”** of the CIPM: November 2019
- International **Expert Group** for technical support and expertise



The Grand Vision: SI Digital Framework



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CIPM Task Group members

Expert Group members

The Grand Vision: SI Digital Framework



Long-term goal
World-wide agreed, uniform, unambiguous, authoritative and dependable data exchange framework based on the International System of Units (SI)
Coordination with all international QI and science stakeholders

First international workshop on the SI Digital Framework in 2021



- ◆ 785 Participants,
- ◆ 1287 Registrations
- ◆ 33 Talks
- ◆ Representative from
 - International QI
 - Science and industry
 - NMIs and RMOs

The International System of Units (SI) in FAIR digital data.

Prof. Dr. Joachim Ullrich
CIPM Vice President
CCU and TG "Digital SI" Chair
22 February 2021



The Grand Vision: SI Digital Framework



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World-wide agreed, uniform, unambiguous, authoritative and dependable data exchange framework based on the International System of Units (SI)

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Joint Statement of Intent with international organizations of the quality infrastructure 2022



30 March 2022

Joint Statement of Intent

On the digital transformation in the international scientific and quality infrastructure

Recognising that

- governments, industry, academia, and civil society have been working toward comprehensive digital transformation for many years, and, in so doing, are increasingly
 - establishing systems to collect, aggregate, analyse and interpret digital data;
 - introducing networked sensor systems for diverse scientific and industrial applications;
 - sharing data at local, national, regional, and international scales;
- the scientific community has made significant progress in establishing reliable foundations for digital data interchange and management, including the FAIR principles for data management and stewardship;
- the organisations of the international quality infrastructure (metrology, accreditation, standardization, and conformity assessment) have a critical role working together to ensure sustainable economic development;
- the International System of Units (SI) plays a particular role in the international quality infrastructure providing confidence in the accuracy and global comparability of measurements needed for international trade, manufacturing, human health and safety, protection of the environment, global climate studies, and scientific research;
- maintaining this confidence in the accuracy and global comparability of measurements will require the creation and adoption of a full digital representation of the SI, including robust, unambiguous, and machine-actionable digital representations of units of measurement and of measurement results and uncertainties;
- progress on global challenges such as this requires the participation of, and critical thinking from, diverse communities;
- successfully effecting such a comprehensive digital transformation for metrology and ensuring its benefits are fully realised will require the active participation of a wide range of stakeholders; particularly other members of the International Quality System;

We the undersigned undertake to support in a way appropriate to each organisation the development, implementation, and promotion of the SI Digital Framework as part of a wider digital transformation of the international scientific and quality infrastructure.

The Grand Vision: SI Digital Framework



ISO



CIPM



ISC



CODATA



CIE



IEC



ILAC



IMEKO



OIML

We the undersigned undertake to support in a way appropriate to each organisation the development, implementation, and promotion of the **SI Digital Framework** as part of a wider digital transformation of the international scientific and quality infrastructure

<https://www.bipm.org/en/-/2022-03-30-digital-statement>

The Grand Vision: SI Digital Framework



ISO



CIPM



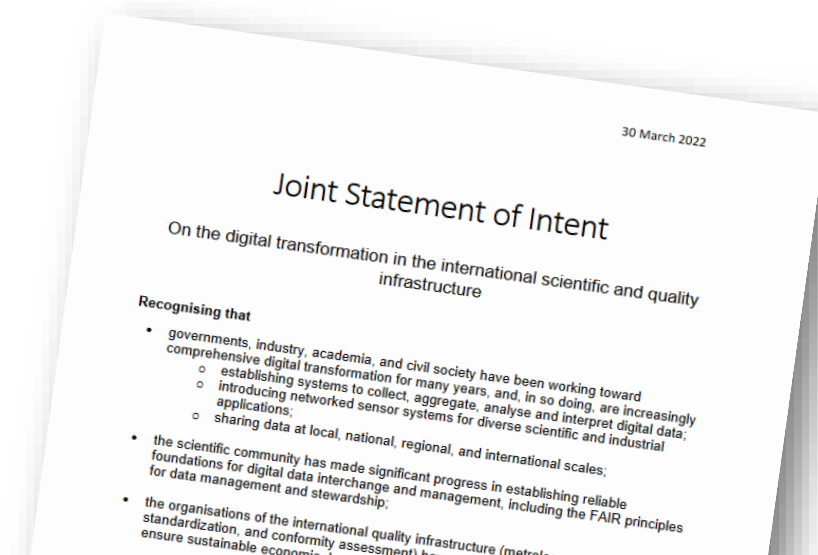
ISC



CODATA



CIE



IEC



ILAC



IMEKO



OIML

A first platform for exchange
with all signatories of the
Joint Statement
in February 2023

<https://www.bipm.org/en/-/2022-03-30-digital-statement>

The Grand Vision: SI Digital Framework



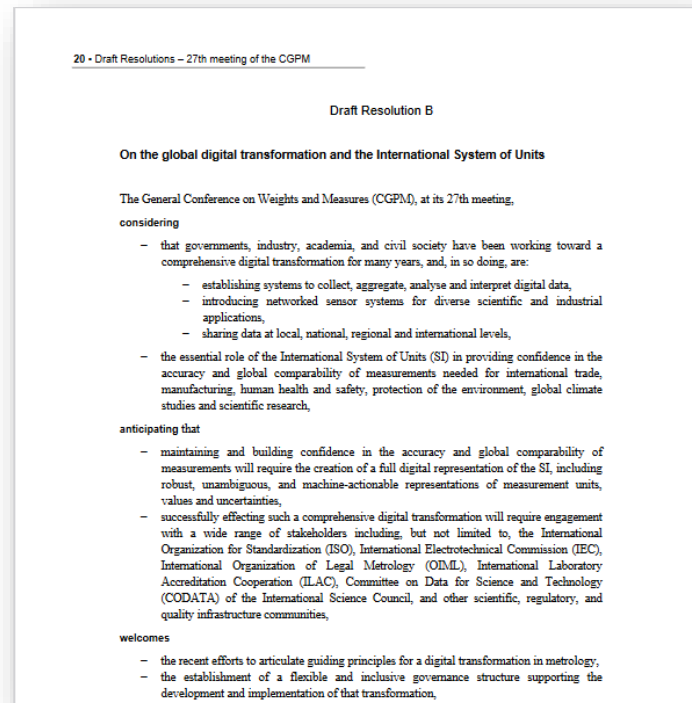
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Metre Convention Resolution for governmental support 2022

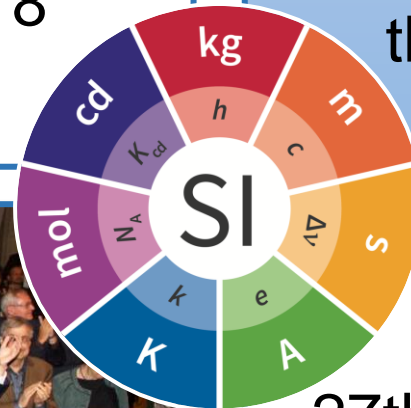


Metre Convention Resolution B

26th General Conference on Weights and Measures November 2018

Draft Resolution B

On the global digital transformation and the International System of Units



27th General Conference on Weights and Measures November 2022



Revised definition of the SI

On the global digital transformation and the International System of Units

The General Conference on Weights and Measures (CGPM), at its 27th meeting,

considering

- that governments, industry, academia, and civil society have been working toward a comprehensive digital transformation for many years, and, in so doing, are:
 - establishing systems to collect, aggregate, analyse and interpret digital data,
 - introducing networked sensor systems for diverse scientific and industrial applications,
 - sharing data at local, national, regional and international levels,
- the essential role of the International System of Units (SI) in providing confidence in the accuracy and global comparability of measurements needed for international trade, manufacturing, human health and safety, protection of the environment, global climate studies and scientific research,

anticipating that

- maintaining and building confidence in the accuracy and global comparability of measurements will require the creation of a full digital representation of the SI, including robust, unambiguous, and machine-actionable representations of measurement units, values and uncertainties,
- successfully effecting such a comprehensive digital transformation will require engagement with a wide range of stakeholders including, but not limited to, the International Organization for Standardization (ISO), International Electrotechnical Commission (IEC), International Organization of Legal Metrology (OIML), International Laboratory Accreditation Cooperation (ILAC), Committee on Data for Science and Technology (CODATA) of the International Science Council, and other scientific, regulatory, and quality infrastructure communities,

welcomes

- the recent efforts to articulate guiding principles for a digital transformation in metrology,
- the establishment of a flexible and inclusive governance structure supporting the development and implementation of that transformation,

**Meeting in
February
2023**



encourages

- the CIPM to continue its outreach and engagement initiatives to ensure that the Metre Convention naturally extends its role as the globally accepted anchor of trust for metrology into the digital era,
- the CIPM to undertake the development and promotion of an SI Digital Framework, that will include the following features:
 - a globally accepted digital representation of the SI, compatible with, and useable within, digital data exchange standards and protocols, whilst maintaining compatibility with existing non-digital solutions,
 - facilitating use of digital certificates in the existing robust infrastructure for the world-wide recognition and acceptance of calibration and measurement
 - the adoption of the FAIR principles (Findable, Accessible, Interoperable, and Reusable) for digital metrological data and metadata, ensuring that other communities recognize the critical importance of metrological traceability for measurement data, the latter being an established requisite for building trust,

invites

- National Metrology Institutes, Regional Metrology Organizations and other stakeholders to maintain and, where possible, increase their existing level of commitment and collaboration with the CIPM to continue the development, promotion and implementation of the SI Digital Framework,
- all organizations with an interest in, or activities related to, the quality infrastructure – that relies on metrology, standardization, accreditation, conformity assessment, and market surveillance – to consider joining the collaborative venture of the digital transformation to ensure that the SI Digital Framework meets the needs of all stakeholders.

Please pass Draft Resolution B

“Stop squandering data: make units of measurement machine-readable”

- Comment in Nature, May 10 2022
- Highlighted in Nature News Feed on May 11

Co-organization of Conferences and Webinars

- CODATA SciDataCon conference – 22 June 2022
- Webinar with ILAC – 30 June 2022
- IMEKO TC6 conf. – CIPM session September 2022



The Grand Vision: SI Digital Framework

Let the **SI** be the mother of **FAIR**: for humans and machines

Let's overcome the **Babylonian confusion** in the digital world

26th CGPM: International System of Units (SI) with 7 fundamental constants & base units

“Babylonian confusion of languages”:
thousands of different measurement standards
... and digital representations

27th CGPM: Resolution B On the global digital transformation and the International System of Units

Metre Convention
Human interoperable and comprehensible measurement data

Metre Convention
Machine interoperable and comprehensible measurement data



The Grand Vision: SI Digital Framework

CIPM
Digital SI

Let's shape the **Quality Infrastructure** for the Digital Future

Please pass Draft Resolution B

Smart Health

Smart Factories

Smart Mobility


Smart Building



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Working together to
promote and advance
the global comparability
of measurements

END

Next steps: Towards the Forum

- **Until April 2023**

Outline of an axiomatic terminology system by the CCU-WG-CMT for “Core Metrological Terms”

→ To support levels 3 to 5 of digitalization (whitepaper IDIS)

- **14 March 2023**

Meeting with all signatories of the Joint statement: management and expert levels

→ Exchange and outline the general structure of the



- **21 to 24 March: Meeting of the CIPM**

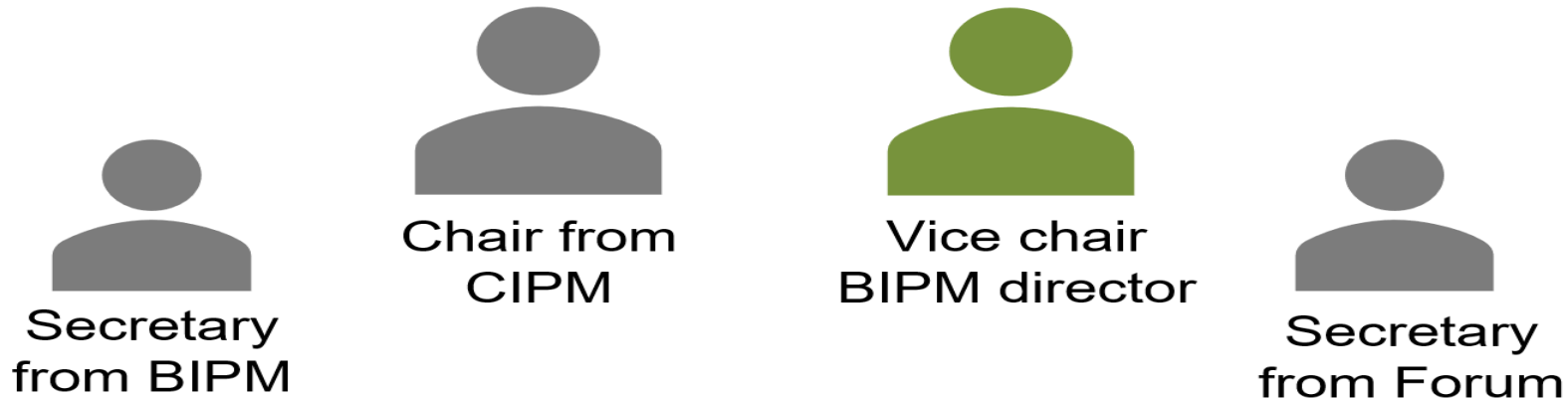
→ Discuss and pass Draft Mission

→ Discuss and pass envisaged Members and Liaisons of the Forum

Horizontal Forum on Metrology and Quality Infrastructure in the Digital World

- **WG on the SI Digital Framework for the harmonization of metadata formats**
- **WG on harmonization work between CCS, RMOs, and the BIPM**
- **WG on Digital Calibration Certificates (DCC)**
- **WG on reliable data in metrology**
- **WG on industrial needs**
- **WG on scientific needs**
- **...**

Horizontal Forum on Metrology and Quality Infrastructure in the Digital World



**Data without correct
metadata is useless**

**Measurement data without
units is dangerous**



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CIPM
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