

# The SI Reference Point and other BIPM digital services

**B**ureau  
International des  
**P**oids et  
**M**esures

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**BIPM**

# Overview

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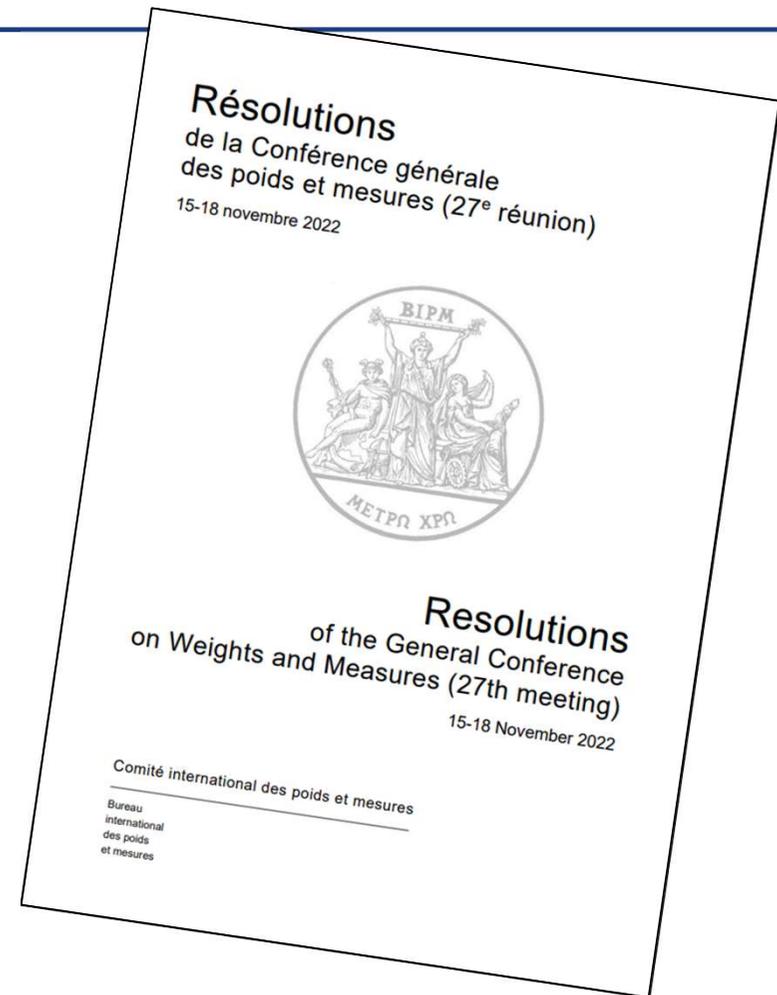
1. What does Digital Transformation mean for metrology?
2. Three types of digital identifiers you can implement today
3. Coming very soon: The SI Reference Point
4. Other new services on their way
5. Engagement opportunities

# Mandate from the 27th CGPM

## Resolution 2

On the global digital transformation  
and the International System of Units

See: <https://www.bipm.org/en/cgpm-2022/resolution-2>



# Mandate from the 27th CGPM

## 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 capabilities,
  - 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,

# Digital Transformation

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## One of many definitions:

Digital transformation is the **process** that an organization applies to integrate digital technology in all areas of a business, fundamentally changing how it delivers value to customers. <sup>[1]</sup>

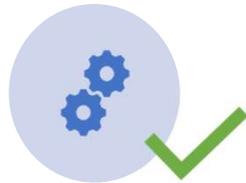
[1]. <https://aws.amazon.com/what-is/digital-transformation/>

# Digital Transformation

## One of many definitions:

Digital transformation is the **process** that an organization applies to integrate digital technology in all areas of a business, fundamentally changing how it delivers value to customers.

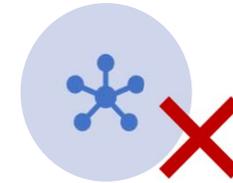
In this talk:



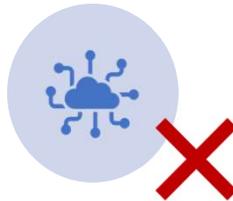
Interaction  
machine-machine



Digital Calibration  
Certificates



Sensor  
networks



Blockchain



Big Data



Artificial  
intelligence

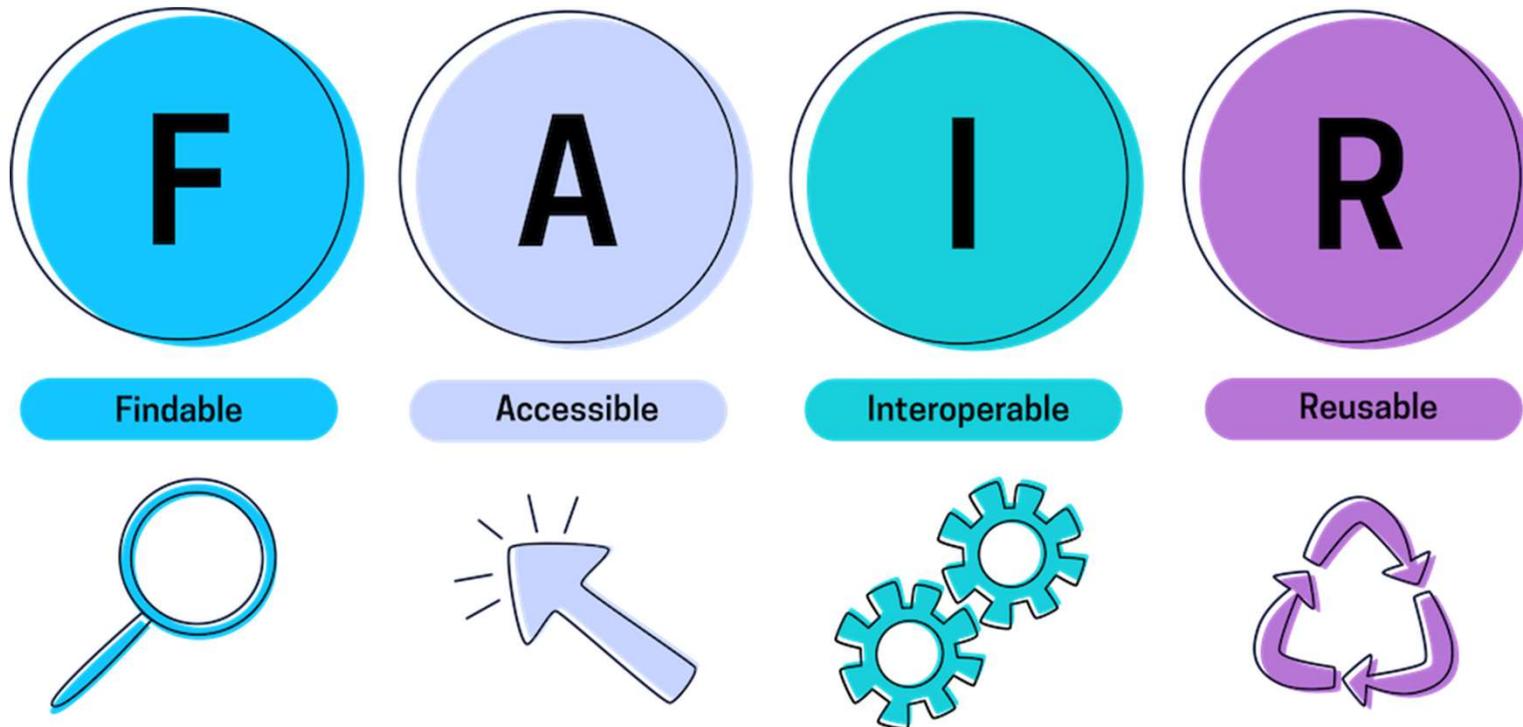
# Digital Transformation

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## Applications in the measurement community

- Facilitating measurement processes and the communication of results
- Provision of digital services to customers
- Increasing the “FAIRness” of data

# The FAIR principles



# The FAIR principles

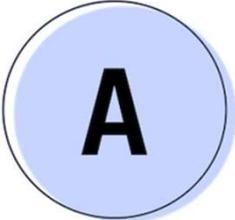
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**F**

Data are **Findable** when they are

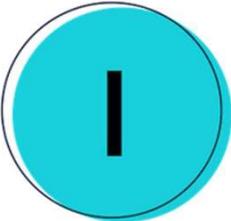
- described by sufficiently rich metadata and registered or indexed in a searchable resource.



**A**

**Accessible** data objects can be obtained

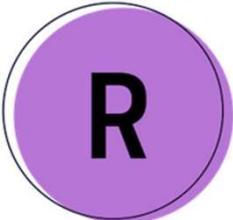
- through a well-defined and universally implementable protocol.
- ‘The ‘A’ in FAIR does not necessarily mean ‘Open’ or ‘Free’.



**I**

**Interoperable** data and metadata are those that

- use a formal, accessible, shared, and broadly-applicable language.



**R**

For data to be **Reusable**, they need

- rich metadata and documentation that meet relevant community standards.

# The Data Plane: Findable and Accessible



User-driven applications



NMI applications



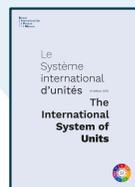
BIPM registry and portal services



BIPM digital references



BIPM core references

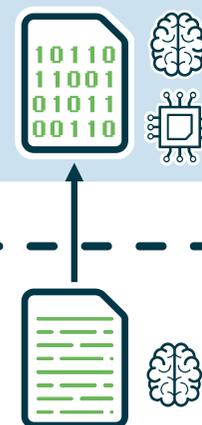


SI brochure + Agreed realization protocols

Fundamental constants data



Encoding line



# In practice: What to do first?

Start introducing Digital Identifiers whenever they're available!

Examples of Digital Identifiers:



Three Digital IDs you can introduce today (whether or not you have a digital programme in place):

1. For your institute (see the BIPM website!)
2. For your institute's service categories
3. For your CMCs

# What are the advantages?

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- Improve the FAIRness of your output
- Identify your institute/services in a machine-friendly way: certificates, data, publications
- Be ready for the machine-readable version of the KCDB

# Digital Identifiers for your Institute

The image displays three overlapping panels, each representing a different country's digital identifier information. The panels are arranged from left to right, with the Kenya panel being the most prominent.

- Ethiopia Panel:**
  - Header: Ethiopia
  - Section: Signatory
  - Content: National → NMIE, Addis Ababa
  - Footer: Participating, Signed by: A
- Ghana Panel:**
  - Header: Ghana
  - Section: Signatory
  - Content: Ghana → GS, Accra
  - Footer: Participating, Signed by: \* now C
- Kenya Panel:**
  - Header: Kenya
  - Section: Signatory/NMI
  - Content: Kenya Bureau of Standards ROR  → KEBS, Nairobi
  - Footer: Participating in the CIPM MRA since: 21 November 2002, Signed by: J. KIOKO (for the Managing Director, KEBS)

**Bureau International des Poids et Mesures**

# Digital Identifiers for your Service Categories

- **M/Mass-1.1.1**      Mass standard
- **M/Density-2.1.2**      Volume of a solid
  
- **EM-2.1.1**      DC resistance below or equal to 1  $\Omega$
- **EM-8.1.3**      High DC voltage ratio
  
- **RAD-2.3.1**      Activity of a radionuclide
  
- **T-3.4.1**      Liquid-in-glass thermometers



# Digital Identifiers for your CMCs



Morocco, LPEE-LNM (Laboratoire National de Métrologie du Laboratoire Public d'Essais et d'Études)

Fluid flow , Volume of liquid : **10  $\mu$ L to 1.00E4  $\mu$ L**

Pipettes

Relative expanded uncertainty : **1.0E-2 % to 0.25 %**

[Uncertainty table](#)

Gravimetric

EURAMET Cg19, ISO 8655-6

Approved on 02 February 2022

**Help on the KCDB**

**Quick starts**

**| CMC Unique Identifiers (PIDs)**

# In printed calibration certificates...

This measurement is in the Service Category **M/Mass-1.1.1**.



This certificate is underpinned by **AFRIMETS-M-ZA-00000A3W-1**.



**To be published soon!**

</api/kcdb-cmc/AFRIMETS-M-ZA-00000A3W-1>

# In your calibration certificates...

Link result for humans:

**KCDB-CMC Identifier: AFRIMETS-M-ZA-00000A3W-1**

**Published in the KCDB**

Approved on 07 May 2015  
KCDB Service Category: M/Mass-1.1.1

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**South Africa, NMISA (National Metrology Institute of South Africa)**  

Institute service identifier : NMISA/MV-1 1.1-1

Mass , Mass : **1.00E-3 g to 0.02 g**  
Mass standard  
Absolute expanded uncertainty : **2.0E-3 mg**  
Comparison in air

# In your calibration certificates...

Link result for humans:

KCDB-CMC Identifier: AFRIMETS-M-ZA-00000A3W-1

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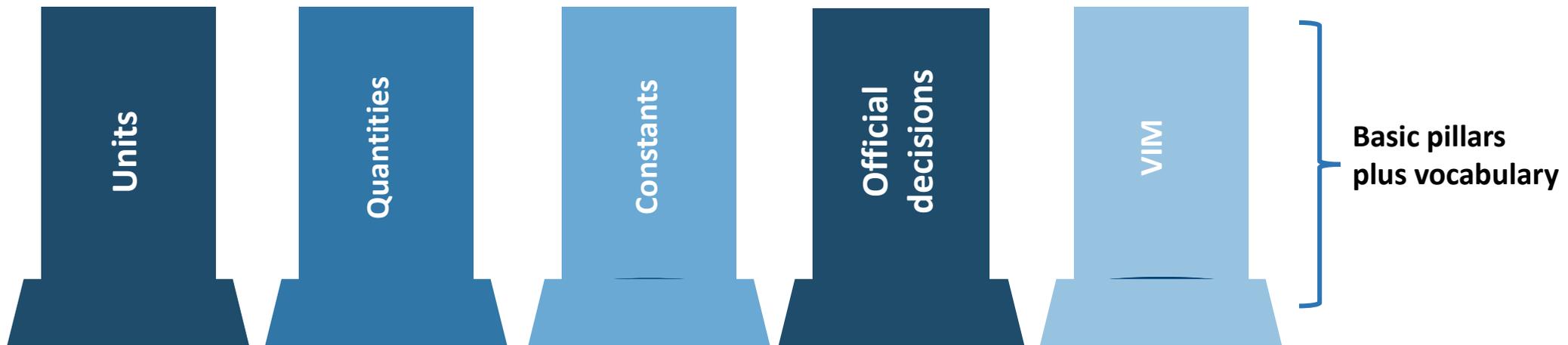
# Digital calibration certificates...

Link result for machines:

```
{
  "versionApiKcdb": "1.0.7",
  "pageNumber": 0,
  "pageSize": 20,
  "numberOfElements": 1,
  "totalElements": 1,
  "totalPages": 1,
  "data": [
    {
      "id": 13100,
      "status": "Published",
      "statusDate": "2019-10-17",
      "kcdbCode": "AFRIMETS-M-ZA-00000A3W-1",
      "domainCode": "PHYSICS",
      "metrologyAreaLabel": "M",
      "rmo": "AFRIMETS",
      "countryValue": "South Africa",
      "nmiCode": "NMISA",
      "nmiName": "National Metrology Institute of South Africa",
      "nmiServiceCode": "NMISA/MV-1 1.1-1",
      "nmiServiceLink": null,
      "quantityValue": "Mass",
      "cmc": {
        "lowerLimit": 0.001,
        "upperLimit": 0.02,
        "unit": "g"
      },
      "cmcUncertainty": {
```

# The SI Reference Point

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Web interface for humans - API for programmers - SPARQL endpoint for machines



# SI Reference Point

Web – for humans

API – for programmers

SPARQL – for machines

Janet Miles, Gregor Dudle

## Units and prefixes (SI Brochure)

```
http://si-digital-framework.org/SI#second1967
second1967 rdf:type owl:NamedIndividual ,
              SI:Definition ;
              SI:hasDefiningAuthority <http://si-digital-framework.org/SI#13th
              SI:hasDefiningText "La seconde est la durée de 9 192 631 770 péri
              SI:hasEndValidity "2019-05-19"^^xsd:date ;
              SI:hasStartValidity "1967-05-20"^^xsd:date .

tp://si-digital-framework.org/SI#second2018
second2018 rdf:type owl:NamedIndividual ,
              SI:Definition ;
              SI:hasDefiningAuthority <http://si-digital-framework.org/SI#26th_CGP
              SI:hasDefiningText "La seconde, symbole s, est l'unité de temps du S
```



## SI Reference Point

Web – for humans

API – for programmers

SPARQL – for machines

Quantities – those covered by SCs

◆◆↓ KCDB

↑↑↓ CCAUV    ↑↑↓ CCEM    ↑↑↓ CCL

↑↑↓ CCM    ↑↑↓ CCPR    ↑↑↓ CCQM

↑↑↓ CCRI    ↑↑↓ CCT    ↑↑↓ CCTF



## SI Reference Point

Quantities

We are mapping the CC Service Categories to external digital identifiers for quantities, such as those available from the following domain-specific, openly available references:



International Electrotechnical Vocabulary



IUPAC Gold Book (machine-readable)



International Lighting Vocabulary

# Projects with the CCs

UTC data – API available for beta-testing



Mises en pratique:

Frequency standards – API available for beta-testing



CCT: Data collated ready for programming of APIs



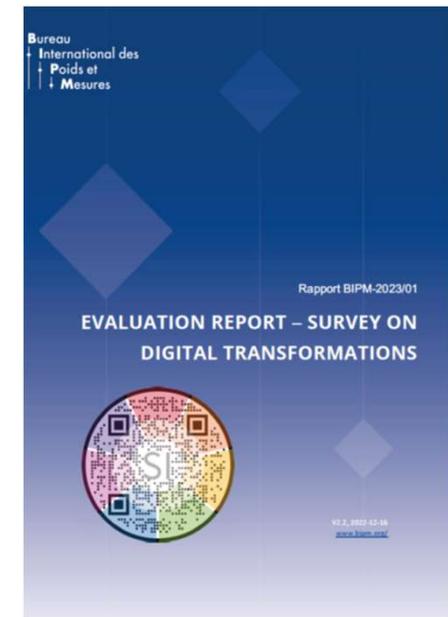
# Other projects



Digital IDs for:  
BIPM's publications  
CGPM Resolutions  
Metrological data



Digital IDs for people  
Possibility for individuals to enter ORCID iDs  
through their BIPM website accounts/  
registrations for meetings



Survey of user needs

<https://doi.org/10.59161/Rapport202301>

# BIPM Staff involved

## SI Reference Point; digital portal services

### ILC Department

- Janet Miles
- Gregor Dudle (seconded, METAS)
- Stéphanie Maniguet
- Olav Werhahn (seconded, PTB)

### Meetings Office

- Johanne Flament
- Aurélie Barthouil

### Physical Metrology Department

- Michael Stock

## Collaborations with CC digital WGs

### Ionizing Radiation Department

- Romain Coulon

### Time Department

- Gianna Panfilo
- Frédéric Meynadier
- Aurélie Harmegnies

### Chemistry Department

- Joële Viallon

# Secondments – All welcome!

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## Secondees:

- Stuart Chalk (Univ. N. Florida) – Demonstration model of the SI Reference Point
- Gregor Dudle (METAS) – Development of the semantic version of the SI Reference Point
- Bob Hanisch (NIST) – Foundations for the IMRRv2
- Jean-Laurent Hippolyte (NPL) – Ontological model for the CIPM MRA Service Categories
- Maximilian Gruber (PTB) – Ontological model for the Time Department services

Contact:  
[jmiles@bipm.org](mailto:jmiles@bipm.org)



# Forum for Metrology and Digitalization

Kickoff Meeting: 23 November 2023

Invitations to workshop and call for  
membership to be published soon

