

# Metrology and Digitalization under the SI

Groundbreaking Developments in Weighing Metrology

CECIP 74th General Assembly, Prague

6. June 2024

Frank Härtig



# Outline

- Developing the SI Digital Framework  
International Committee for Weights and Measures (CIPM)
- CIPM Forum on Metrology and Digitalization
- Machine actionable Digital Certificates **D***i* (ISO 17000 Series)
- Digital Metrological Experts (**D**-ME)
- IMEKO World Congress 2024

# CIPM - Developing the SI Digital Framework as the anchor of trust for metrology in the digital era

## Resolution 2 of the 27th CGPM (2022)

- digital representation of the SI
- digital certificates in the existing robust infrastructure for the worldwide acceptance of calibration and measurement capabilities
- FAIR principles  
(Findable, Accessible, Interoperable, and Reusable)



# CIPM - Forum on Metrology and Digitalization

## Forum<sup>1</sup>

Chair: Prof. Denz, PTB, Germany

Vice Chairs: Dr. Laiz, INTI, Argentina, Ms Macdonald NRC, Canada

 Consultative Committees (CCs) will have a major influence on the developments

 Establishment of:

- 6 Task Groups (TG)
- 2 working groups (WG)

 Organization of

- 2 workshops

<sup>1</sup><https://www.bipm.org/en/committees/fo/forum-md/members>

# CIPM - Forum on Metrology and Digitalization

Task group on SI Digital Framework (A. Cypionka, BIPM)

Task group on Harmonizing **DCC** and DRMC (M. Koval, CMI)

Task group on FAIR for Metrology (R. Harnisch, NIST)

Task group on Metrological Semantics (R. White, NRC)

Task group on Data quality in Metrology (M. Ballico, NMIA)

Task group on Secure and Trustworthy AI (L. Wright, NPL)

Working Group on Coordination between CCs (P. Blattner (METAS)

Working Group on coordination between RMOs (N. Zviagin, VNIIM)

Workshop Complex Sensor Networks (S. Cui NMC)

Workshop Traceability IMEKO WC2024 (F. Härtig. PTB)



BIPM: Forum-MD Report on the 1st meeting, 2024

# ISO 17 000 series

- development of machine actionable digital documents  
machine to machine interoperable
- ISO 17 000 must be seen as directive document  
normative basis for:
  - ISO 17025 test and calibration laboratories
  - ISO 17065 Conformity assessment
  - ...
- Harmonization strategy  
development of a directive guideline



# DCC and DKD

- DCCs are developed by worldwide consortium coordinated by PTB
- German Calibration Service (DKD) defines pre-normative documents
  - 13 Technical Committees
  - most advanced
  - DKD TC 7 Mass and Weighing Instruments



<https://www.ptb.de/cms/metrologische-dienstleistungen/dkd/publikationen.html>

# DCC video (free download)



The paper era

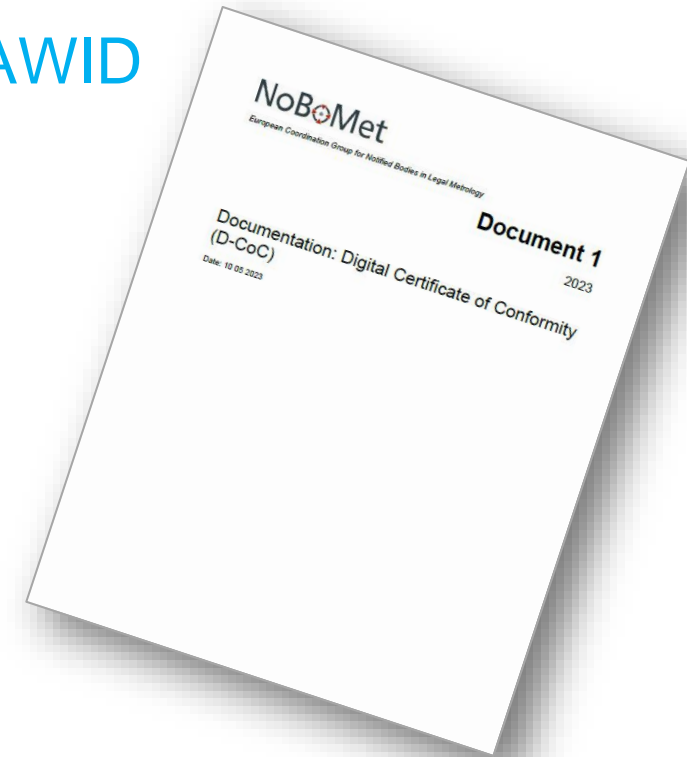
*has come to an end.*

<https://www.youtube.com/watch?v=xEE7Mv5s0es>



# D-CoC

- **D-CoCs** machine interoperable Certificates for MID and NAWID  
Module B, D und F
- Project group established by NoBoMet in 2021  
NoBoMet<sup>1</sup> Chair: Dr. Harry Stolz, PTB  
Project Group: Digital Certificates in Metrology (**D-CoC M**)  
Chair: Dr. Gisa Foyer, PTB  
Participants: PTB (DE), NMI Certin (NL), LNE (FR),  
METAS (CH), SIQ (SI), KIWA CERTMET (IT),  
CAMERA DI COMMERCIO DI ASTI (IT)



<sup>1</sup>NoBoMet is the European Coordination Group of Bodies notified by the European Commission (act. 1010) established in 2010 by the European Commission

Documentation: Digital Certificate of Conformity, Document 1, 2023

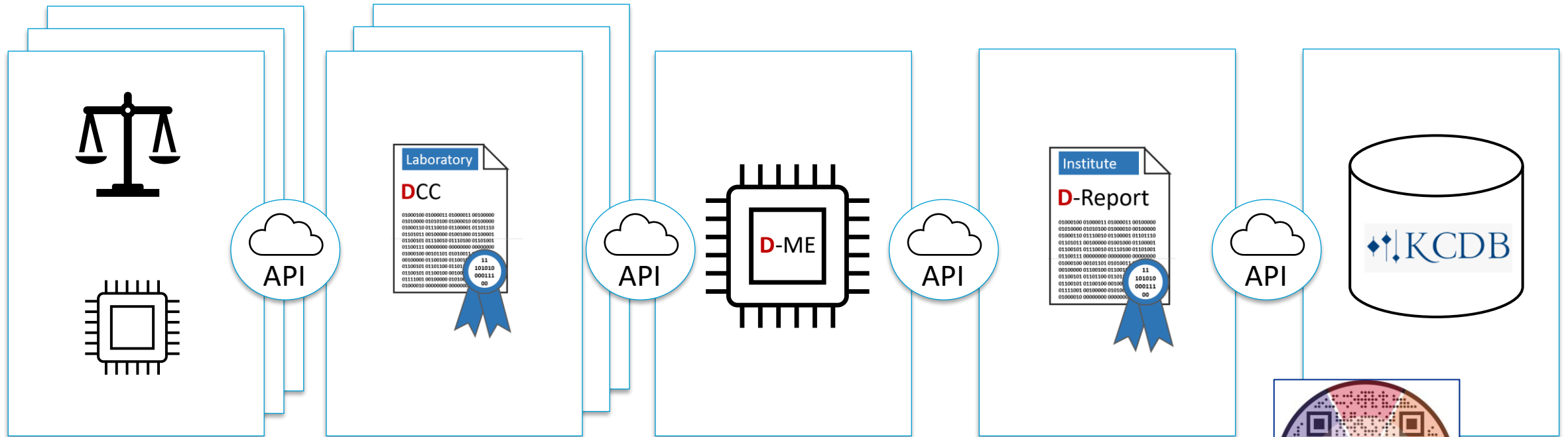
# Actionable Intercomparisons

Digital

NMIs

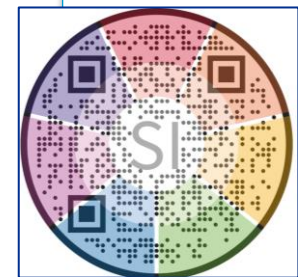
Metrological Expert (D-ME)

BIPM

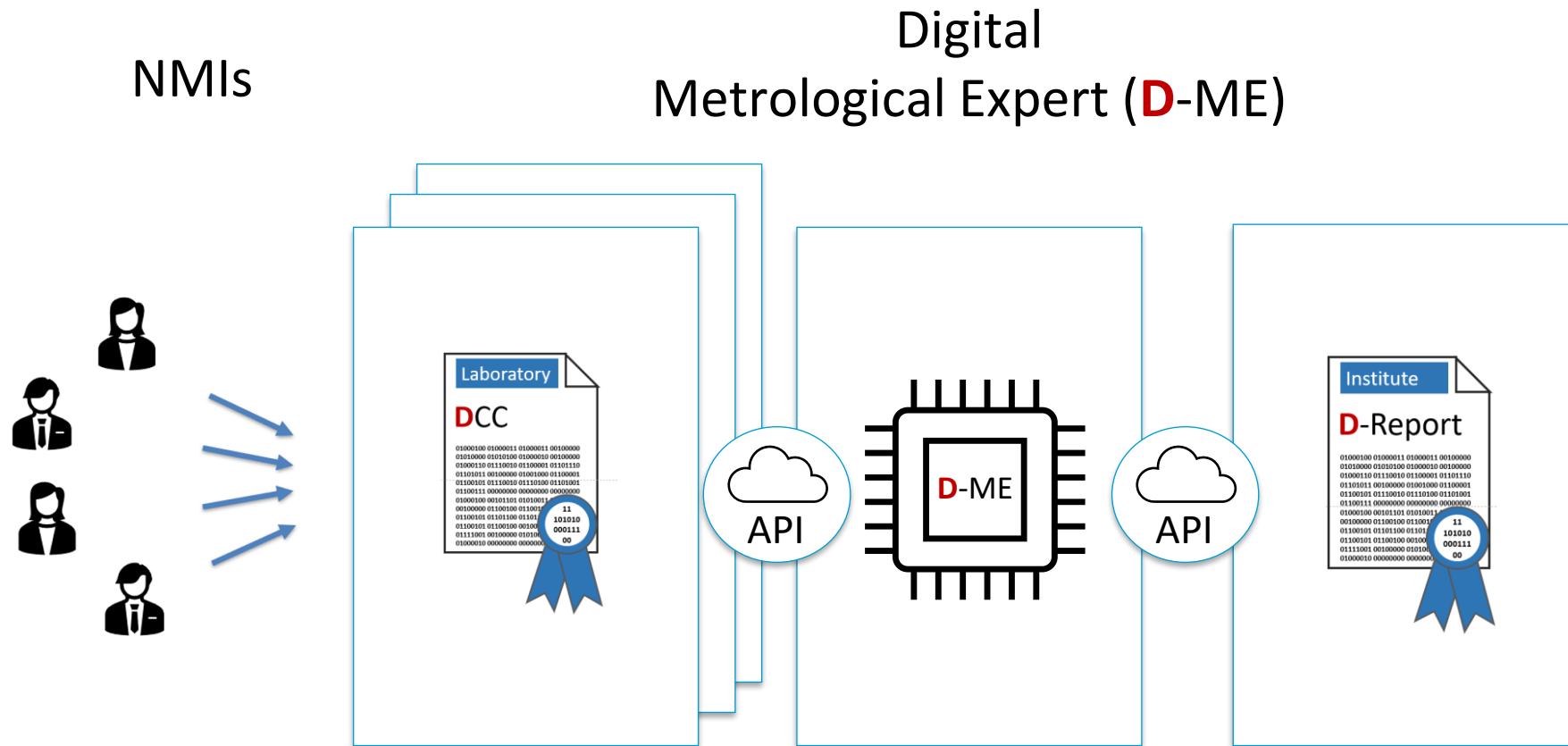


13 DKD

expert committees



# Actionable Intercomparisons



Expert Report  
DKD-E 7-2

Instructions on how to use the DCC  
schema to create a digital calibration  
certificate for weights



# Intercomparison in Mass Metrology

- Worldwide first machine actionable intercomparison
- Basis are **DCCs** defined in the DKD-Expert report
- Fully machine actionable
- Participants  
Pilot PTB, Dr. Beatrice Rodiek  
10 Participants: PTB, NPL, MSL, UME, NMIJ, KRISS, NIM, INRIM, NRC, CENAM
- Development presented at the IMEKO WC 2024



B. Rodiek et al; PROJECT ON A FULLY AUTOMATED EVALUATION OF A VIRTUAL MASS COMPARISON USING THE DIGITAL CALIBRATION CERTIFICATE (DCC) SCHEMA; soon published IMEKO WC 2024

# Intercomparison in Mass Metrology

<https://www.gemimeg.ptb.de/gemimeg-tool>

Value \* 1.000000287

Unit \* \kilogram

Date/ Time 2024-02-02T11:25:38

**Expanded Uncertainty** ⓘ

Uncertainty \* 0.000000046

Coverage Factor \* 2

Coverage Probability \* 0.95

Distribution normal

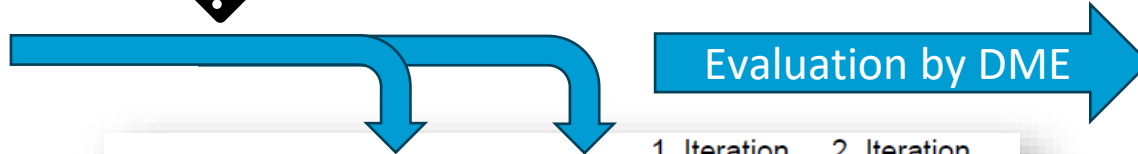
Web tool to fill data into the DCC template

Participant	$x_i$ /kg	$U_i$ /kg
PTB	1.000000287	4.6E-08
KRISS	1.000000259	4.5E-08
NPL	1.000000283	4.6E-08
MSL	1.000000230	5.7E-08
NRC	1.000000249	5.7E-08
UME	1.000000271	1.0E-07
CENAM	1.000000232	5.0E-08
NMIJ	1.000000270	6,8E-08
NIM	1.000000254	5.0E-08

**Expert Report DKD-E 7-2** Instructions on how to use the DCC schema to create a digital calibration certificate for weights

# Intercomparison in Mass Metrology

**Base value**  
1.000000264 kg



**Reference value: weighted mean**

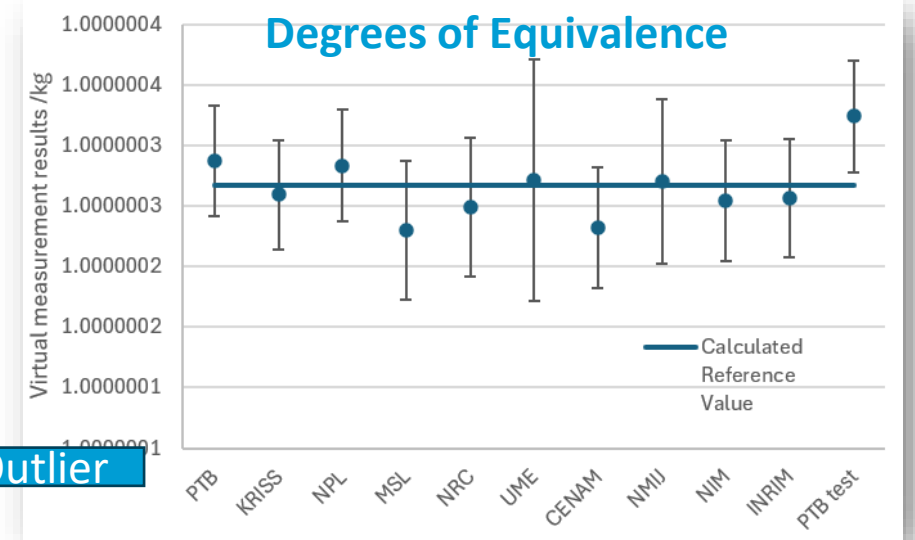
$x_{\text{ref}} = 1.0000002596 \text{ kg}$   
 $U_{\text{ref}} = 1.670E-8 \text{ kg}$

**Outlier filter**

$$|E_n| = |x_i - x_{\text{ref}}| / U(x_i - x_{\text{ref}}) > 1$$

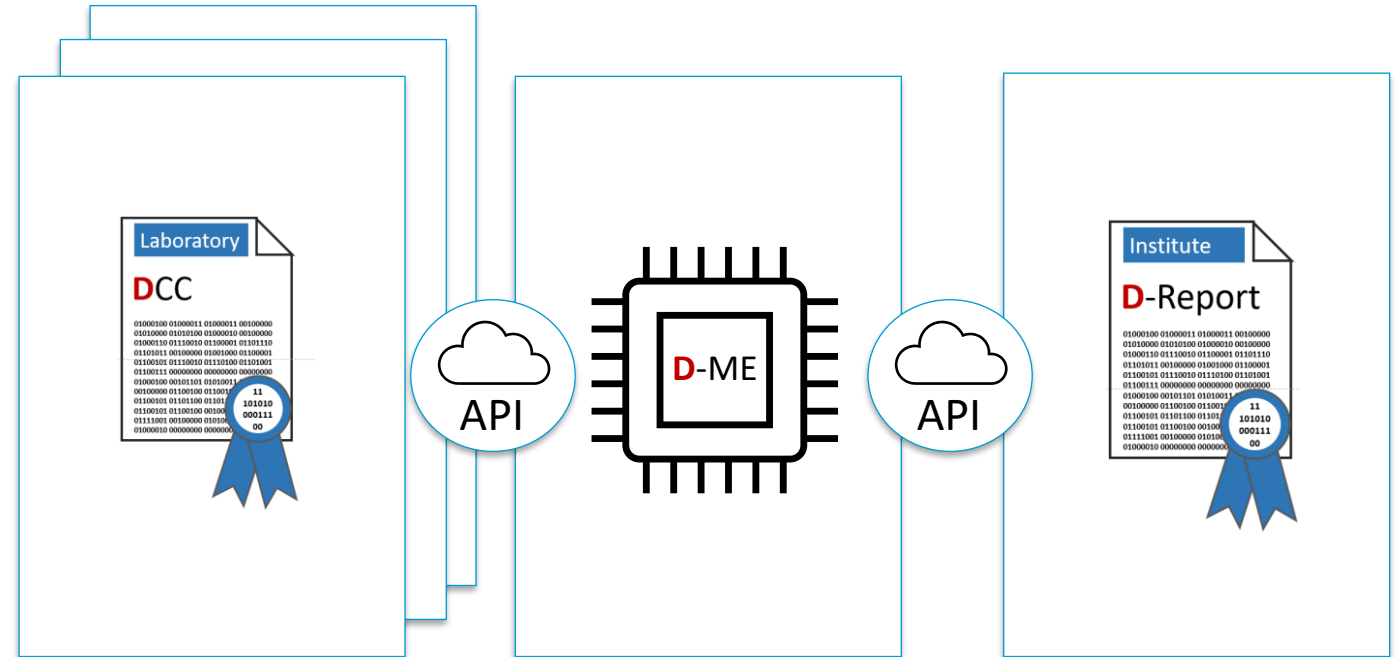
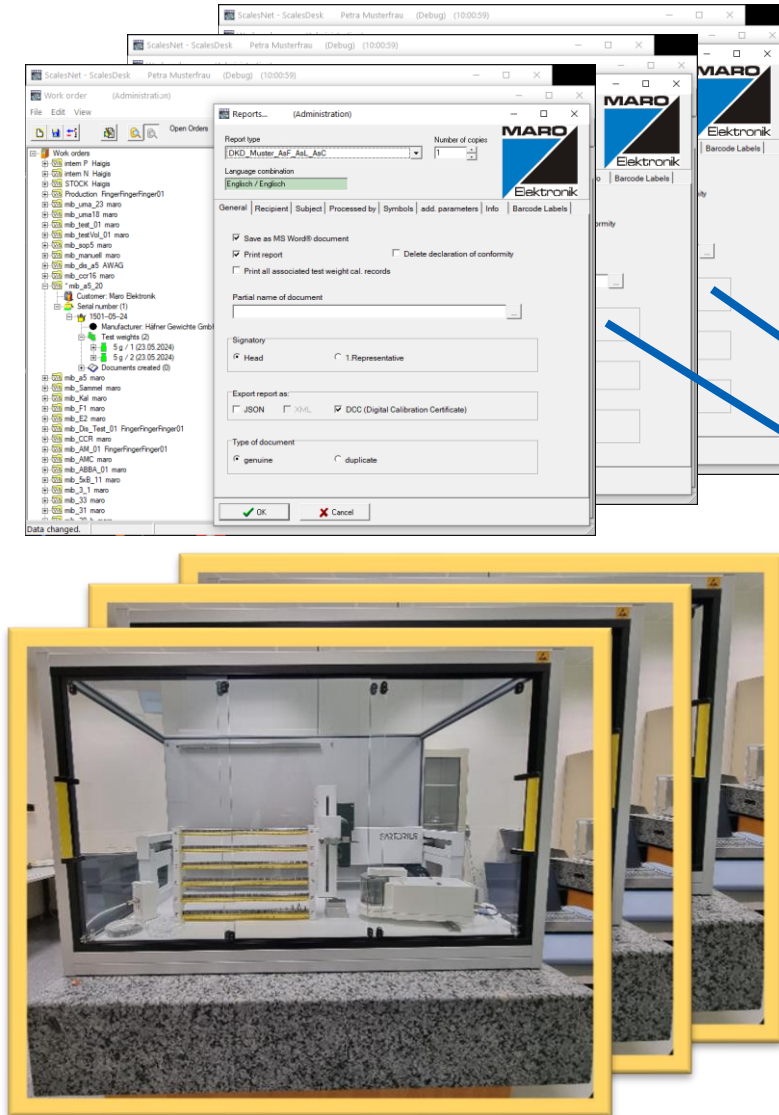
Participant	$x_i / \text{kg}$	$U_i / \text{kg}$	1. Iteration	2. Iteration
			$ E_n $	$ E_n $
PTB	1.000000287	4.6E-08	0.461	0.640
KRISS	1.000000259	4.5E-08	0.192	0.014
NPL	1.000000283	4.6E-08	0.368	0.546
MSL	1.000000230	5.7E-08	0.677	0.543
NRC	1.000000249	5.7E-08	0.330	0.194
UME	1.000000271	1.0E-07	0.040	0.116
CENAM	1.000000232	5.0E-08	0.739	0.585
NMIJ	1.000000270	6,8E-08	0.044	0.158
NIM	1.000000254	5.0E-08	0.276	0.119
INRIM	1.000000256	4.9E-08	0.239	0.078
PTB test	1.000000324	4.6E-08	1.316	1.316

**Outlier**



# Fully actionable (robotic) mass metrology

Digital  
Metrological Expert (**D**-ME)



Worldwide first product will be presented at the IMEKO WC 2024

# IMEKO World Congress

26-29 August 2024  
Hamburg, Germany



[www.imeko2024.org](http://www.imeko2024.org)



Special information provided on:

- **D**-SI
- unit converter
- ontology database
- **D**CCs pre-normative documents
- **D**CCs in industrial applications
- **D**CCs used by intercomparisons
- **D**CCs in QI-Digital
- **D**CoCs
- electronic product passport
- ...
- workshops & exhibition





Accurate

Objective

Passionate

Physikalisch-Technische Bundesanstalt  
Das nationale Metrologieinstitut

Dr.-Ing. Prof. h. c. Frank Härtig

