The Digital Metrological Expert

A software tool helping to automate key comparison data analysis

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Including parts of the presentation given by Stuart Davidson at the 2nd annual meeting of CIPM FORUM-MD, February 2025

Digital transformation*

Digitize

paper → image, PDF file,…

Digitization

analogue process → digital form

Digitalization

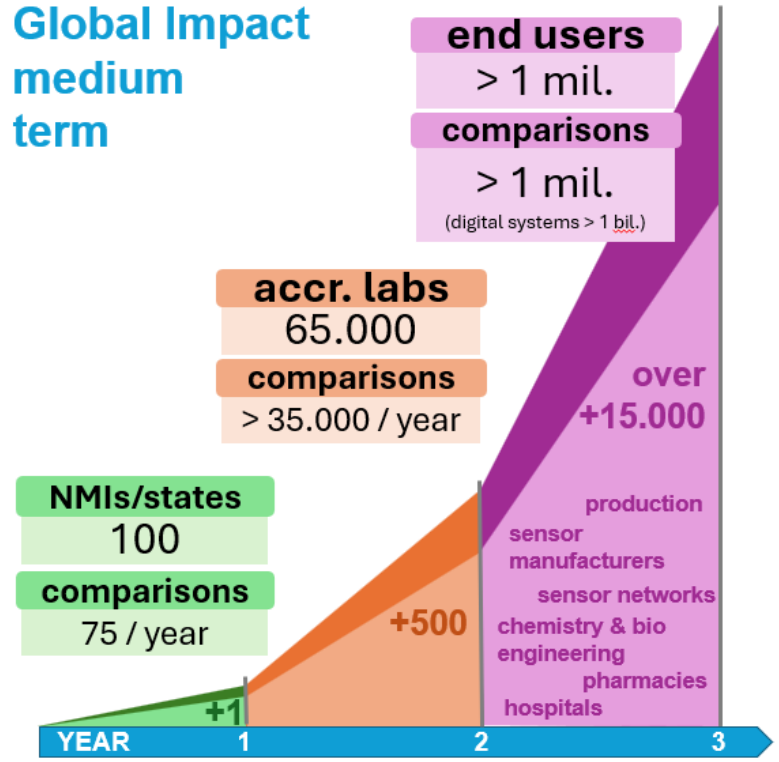
digital technologies → change business models, new revenue

Vison for Key-Comparison Services (along with Digital-SI)

* Terms from Gartner IT Glossar

Motivation

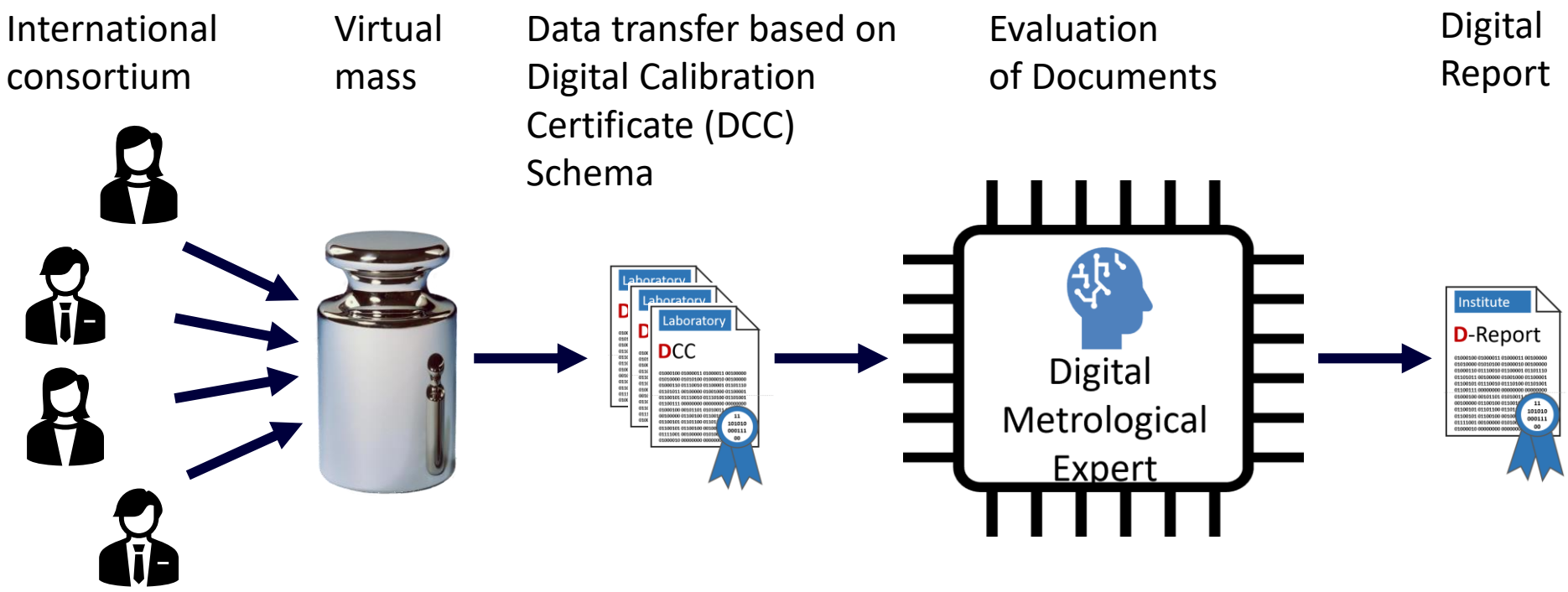
- ❑ Improving consistency and integrity of outcomes
- ❑ Supporting suitable measurements and reporting
- ❑ Saving time for creation of reports
- ❑ Enabling non-IT experts to use emerging digital tools
- ❑ Emerging interdisciplinary use of comparison methods



Numbers estimated for participants under CIPM MRA and their customers

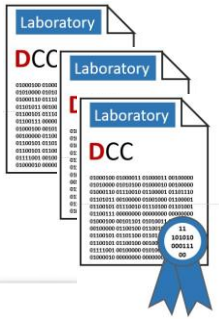
Proof of principle

Virtual Mass Comparison



B. Rodiek, S. Davidson, S. Schönhals, et al., 2024, Project on a fully automated evaluation of a virtual comparison of mass using the Digital Calibration Certificate (DCC) schema, DOI: 10.1016/j.measen.2024.101361

Data exchange – DCC schema



CCM

- **Secure and flexible Data exchange**
- **Machine-interpretable**

Expert Report DKD-E 7-2

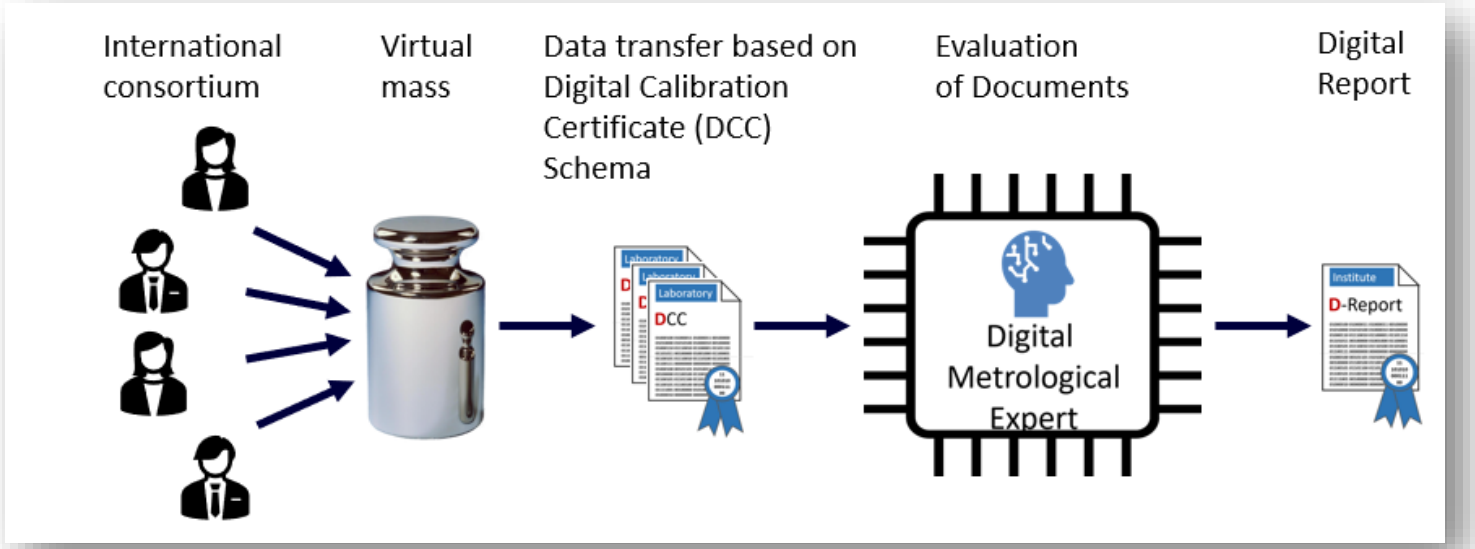
Instructions on how to use the DCC schema to create a digital calibration certificate for weights

→ DCC (Digital Calibration Certificate)

- well structured in XML
- complies with many standards (GUM, ISO 17025, VIM, ...)
- complies with FAIR Principles
- developed by institutes with and for industry
- documentation available https://www.ptb.de/dcc/

Comparison is no calibration, thus use simplified data structure

Data processing



Measured values

x_1 = 1.000000287 kg
U_1 = 4.6E-8 kg
…
x_n = 1.000000324 kg
U_n = 4.5E-8 kg

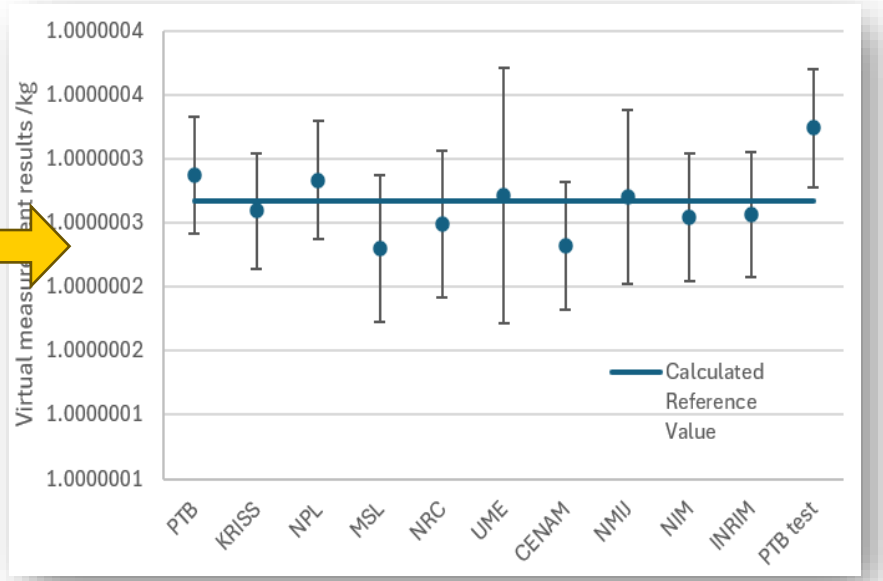
Reference value: weighted mean

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

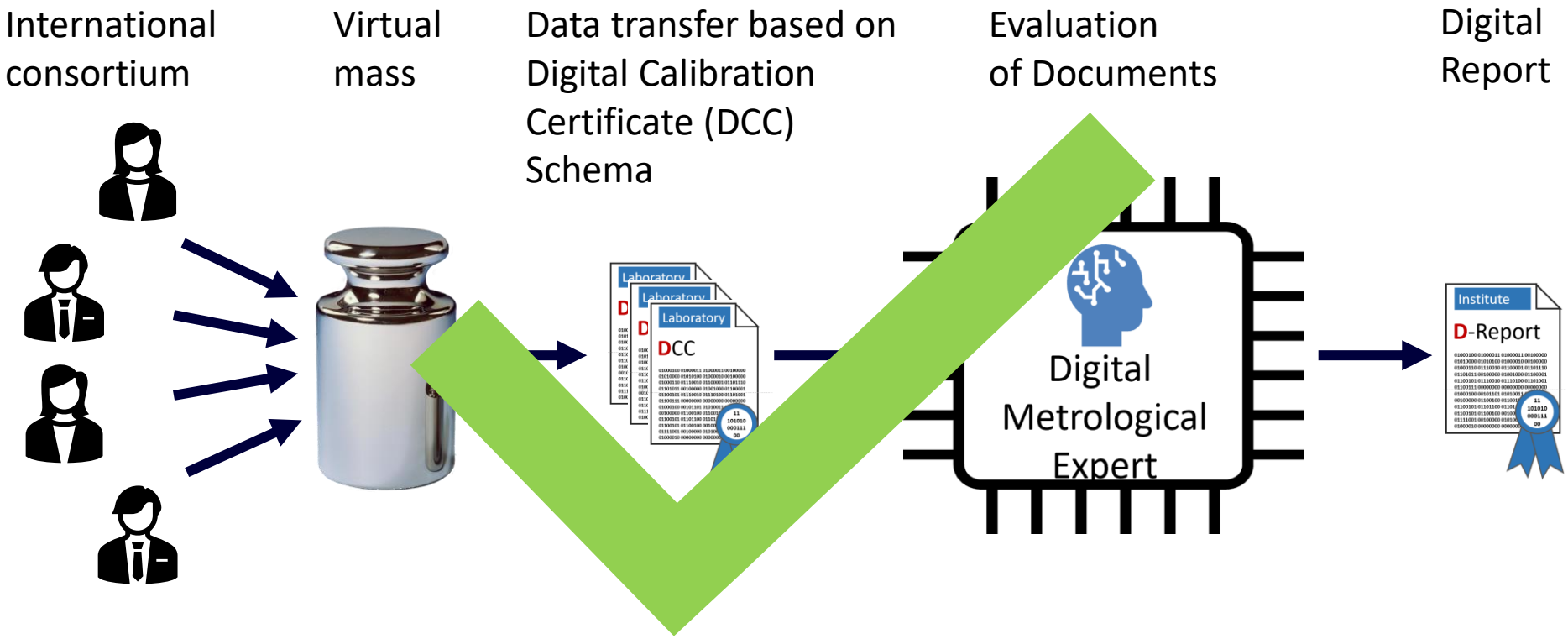
Outlier filter

$|En| = |x_i - x_{ref}| / U(x_i - x_{ref}) > 1$

Degrees of Equivalence

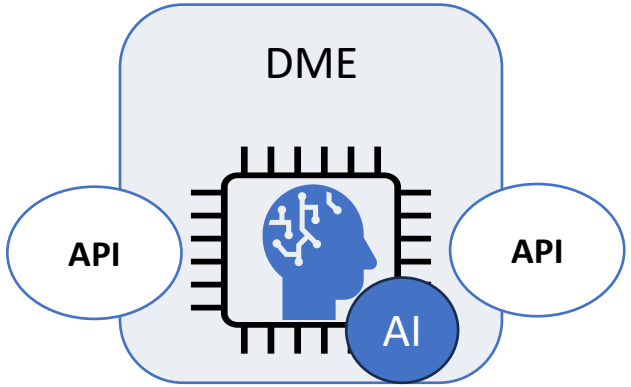


Proof of principle



Digital Metrological Expert concept

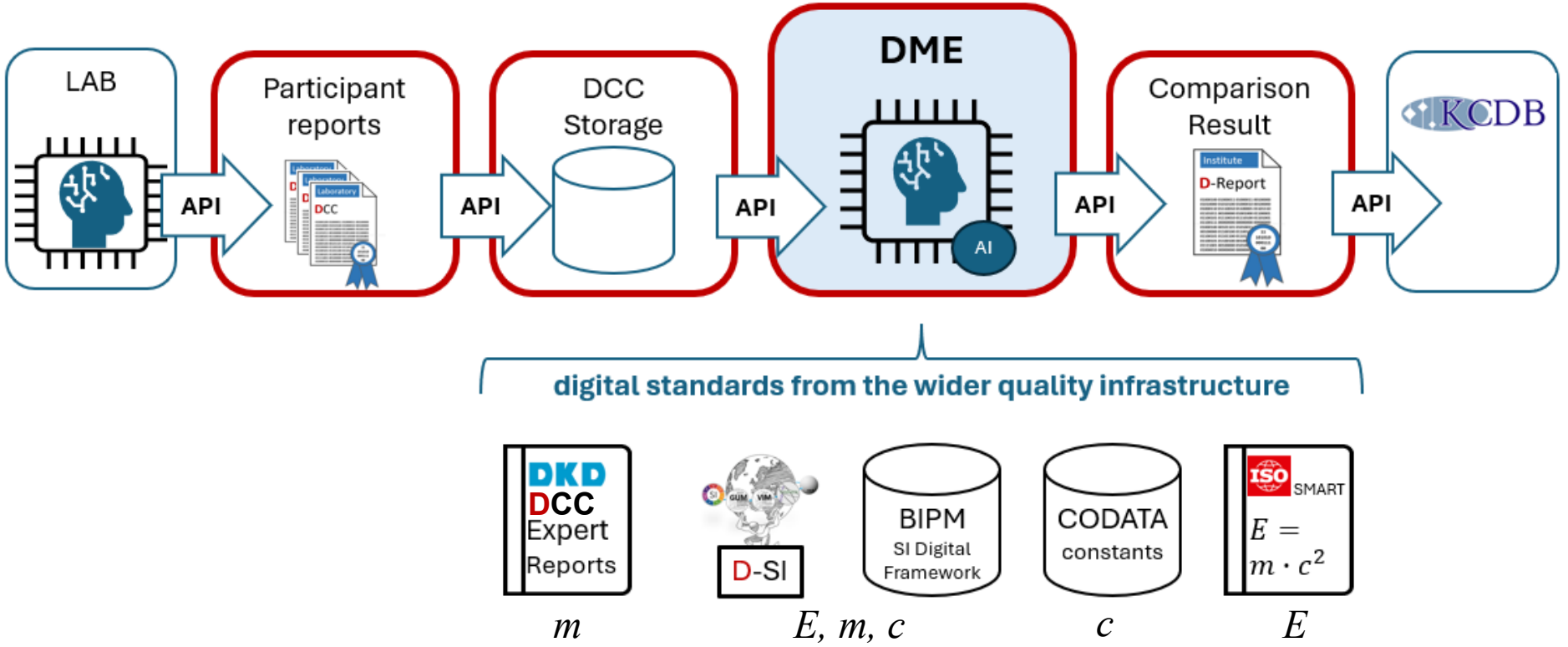
- For standard work, e.g., evaluation of comparison, calculation of measurands, etc. (taking over tedious human work)
- Exchange information in environment of quality infrastructure (QI) through SI-based data and FAIR services
- Assess data and propose ways of processing including verification, filter, uncertainty propagation, use of AI, etc.
- Results as machine-actionable reports disclosing (metrological) traceability of outputs to inputs (utilizing PIDs)
- Itself digital standard in QI when operated and maintained by authoritative organizations



Digital end-to-end workflows

round robin, star, petal, running KCRV →

draft A, B, final →



Lessons learned and progress

- Comparison protocols needs to be machine-interpretable
- DCC-based schema and GEMIMEG tool were fit for purpose
- On-boarding is essential

- The underlying software framework of the Digital Metrological Expert (DME) has gone through an update facilitating the integration of new comparisons with multiple measurands
- Work with CCT K11 EURAMET loop and CCQM K186 comparisons are about to be completed
- Integration of creation and export of plots for DoEs and KCRVs

More information

You can check the results

https://d-si.ptb.de/#/d-comparison

As well as check out informations about the DCC and the GEMIMEG Tool

https://www.ptb.de/dcc/

https://www.gemimeg.ptb.de/gemimeg-tool/#/

M4D CONF BENEVENTO2025

3-5 September 2025

CCM

Special Session 6: Calibration and Comparison in a Digital Era

Session chairs
Shanna Schönhals
Daniel Hutzschenreuter

- Latest DCC developments and digital calibration chains along NMIs/DIs, accredited laboratories, and end-users
- Digital tools supporting comparison workflows and data analysis, including AI and interoperable QI
- Machine-actionable calibration and comparison data brought to life
- Featuring 10 presentations

https://www.m4dconf.org/

Thank you.

And thanks to all who are helping to shape the future of digital tools for comparison and the SI!