Metrolojinin Dijitalleşmesi
Digitalization of Metrology

TURKLAB Uygunluk Değerlendirme Konferansı

3. Sürdürülebilirlik: Yeşil Dönüşüm ve Dijitalleşme

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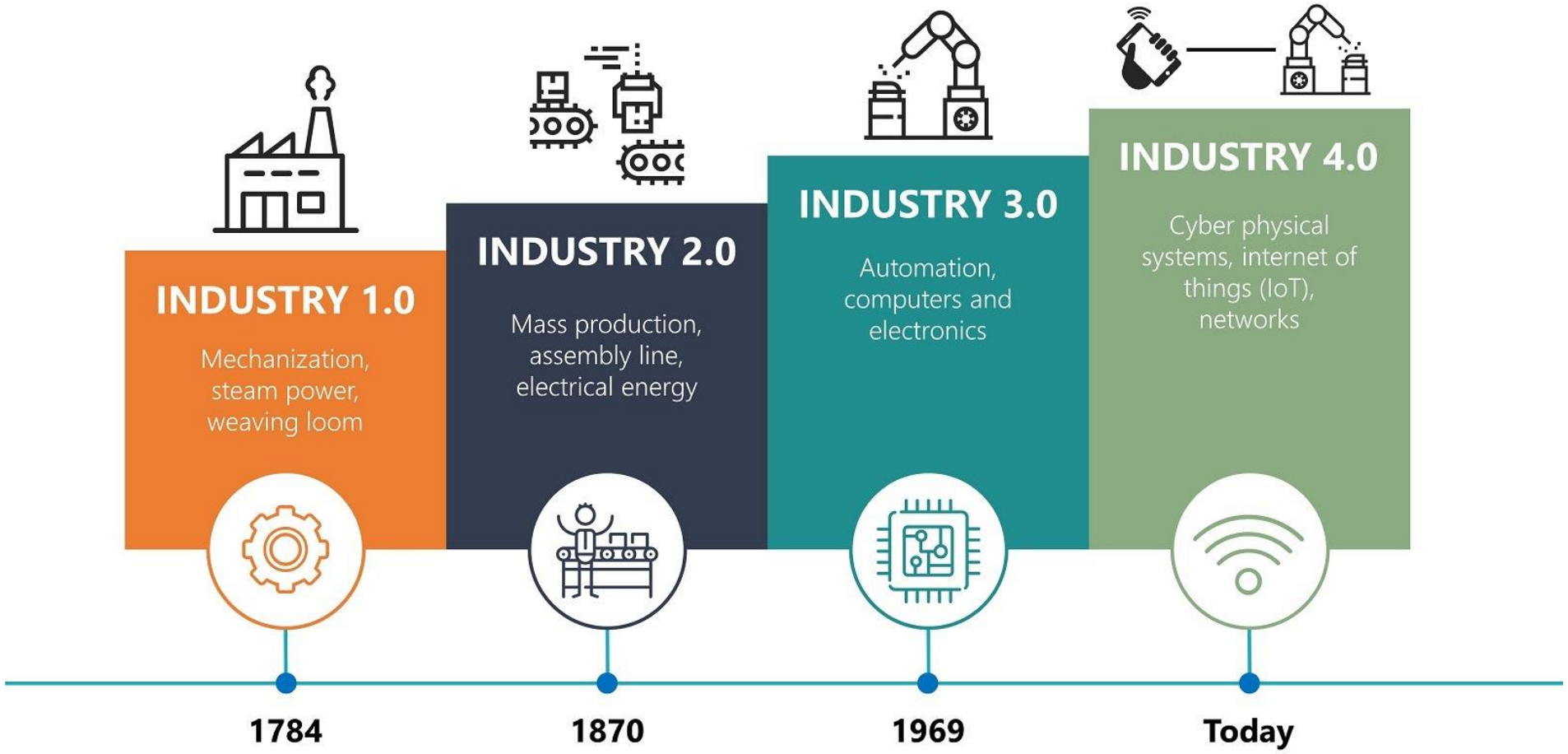
Content

- Concept of Digitalization
- Digital Transformation in Metrology
- BIPM CIPM Digitalization Actions
- EURAMET Digitalization Actions
- Scientific Activities on Digitalization
- TUBITAK UME Digitalization Working Group
- Digital Calibration Certificate

Metrology in the Digital Age



Digital Transformation Need in All Sectors

- **Changing World and Needs**
  - Time abbreviation
  - Cost reduction
  - Increasing Production / Productivity
  - Advantage of increased amount of data (?)
  - Automatic data processing / resource management possible

TIME=MONEY

Digital Transformation in Metrology

- **Digital Transformation** is necessary in metrology as in every field.

- In Industry – Metrology cooperation, it is necessary to be a guide, pioneer and determinant of the **digital transforming** world.

Digitization, Digitalization and Digital Transformation

- **Digitization:** In short, it is the process of converting the information in physical documents from analog to digital.

  Scanning the document on paper, converting it to PDF and transferring it to electronic media

- **Digitalization:** It is the process of using digitized or digitally produced information to work more simply and efficiently.

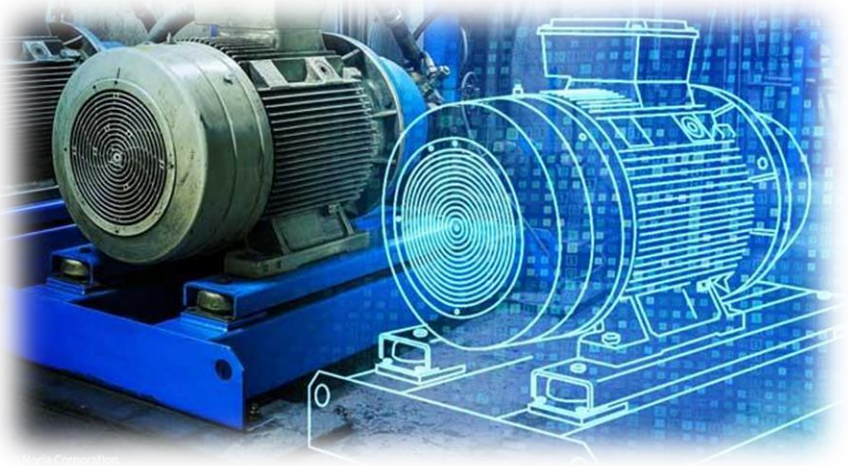
  Automatic issuance of certificate using measurement results in digital media

- **Digital transformation:** It is the adoption of digital technology, changing the way business is run. Increasing efficiency and value and applying innovation to the business model.

  Starting from the automatic measurement, creating a certificate by performing the entire calibration process in digital environment, delivering it in electronic environment, and even adapting the certificate (DCC) to its own processes by processing the certificate in electronic environment

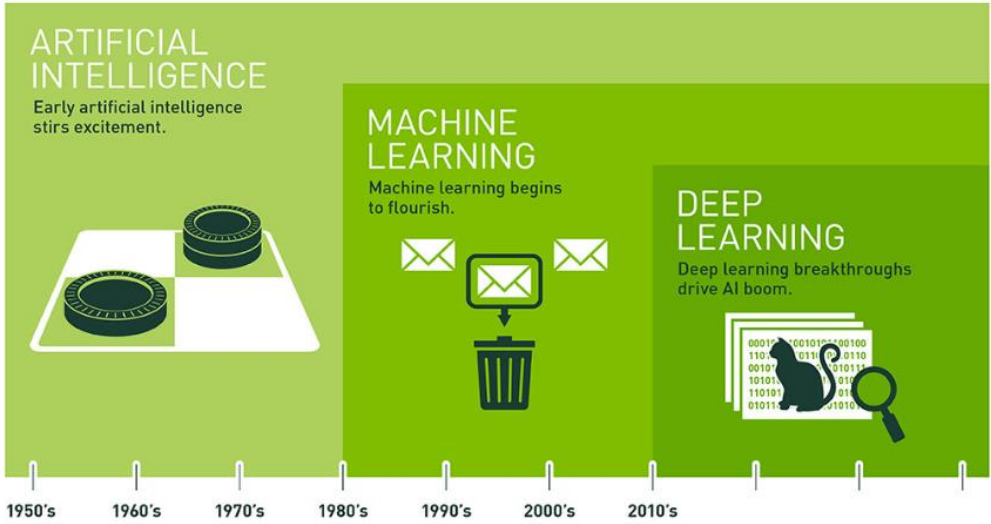
Digital Twins

- **Digital Twins,** is a virtual model of a product, process, or service. It means creating a virtual twin, the exact equivalent of a physical object.
  - The virtual copy can be a car, a machine, a train or even a jet engine
  - Virtual twins are used for simulation purposes before producing real devices
  - Digital twins are not only used in manufacturing, but also influence the development of technologies such as the internet of things (IOT), artificial intelligence (AI) and data analytics

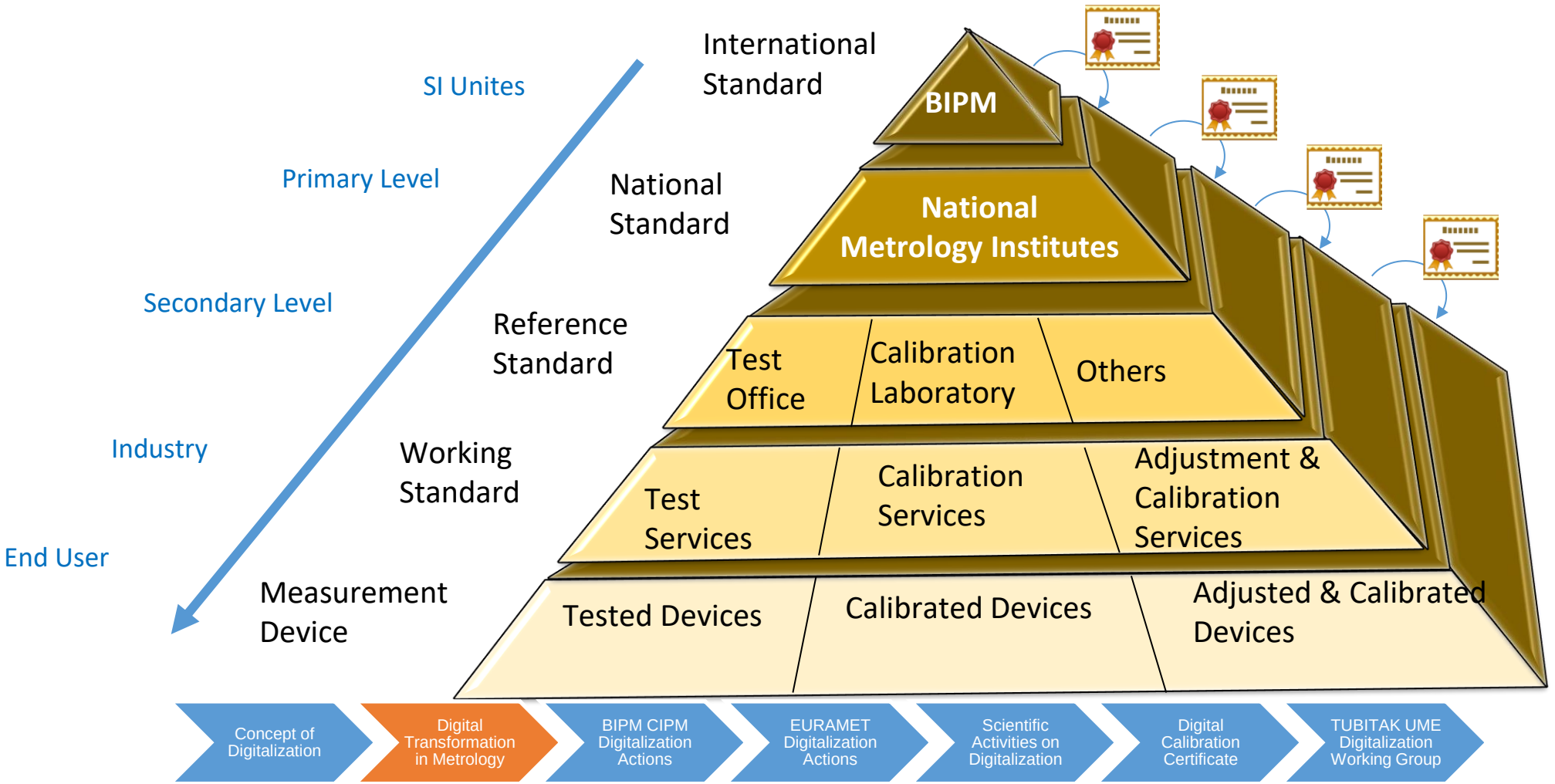


Artificial Intelligence, Machine and Deep Learning

- **AI** is the ability of a computer or computer-controlled device/robot to perform various activities similar to intelligent creatures.
- **Machine Learning**, refers to a machine learning to use large datasets instead of coded rules.
  - **Supervised Learning**, involves using labeled datasets with inputs and expected outputs.
  - **Unsupervised Learning**, It is the task of machine learning that uses datasets that do not have a specific structure.
- **Deep Learning**, It allows us to train artificial intelligence to predict outputs with a given dataset. Both supervised and unsupervised learning can be used to train artificial intelligence.



Industry Trends and Challenges in Metrology in the Digital Transformation Process



Concept of Digitalization → Digital Transformation in Metrology → BIPM CIPM Digitalization Actions → EURAMET Digitalization Actions → Scientific Activities on Digitalization → Digital Calibration Certificate → TUBITAK UME Digitalization Working Group

Industry Trends and Challenges in Metrology in the Digital Transformation Process

- Current Industrial Trend Numerous sensors become available
  - Computing capacity increased
  - ML (Machine Learning - Artificial Intelligence) algorithm has become more widely applicable
  - There are concerns about the reliability of the sensor data and algorithm output
- Some metrology challenges for the Factory of the Future
  - Data collection and cleaning
  - Data Merge
  - Network synchronization and scheduling
  - Rrepetitive measurements
  - Network design for sensors with different quality (resolution/uncertainty) output

Digital Technologies in Industrial Measurements (Examples)

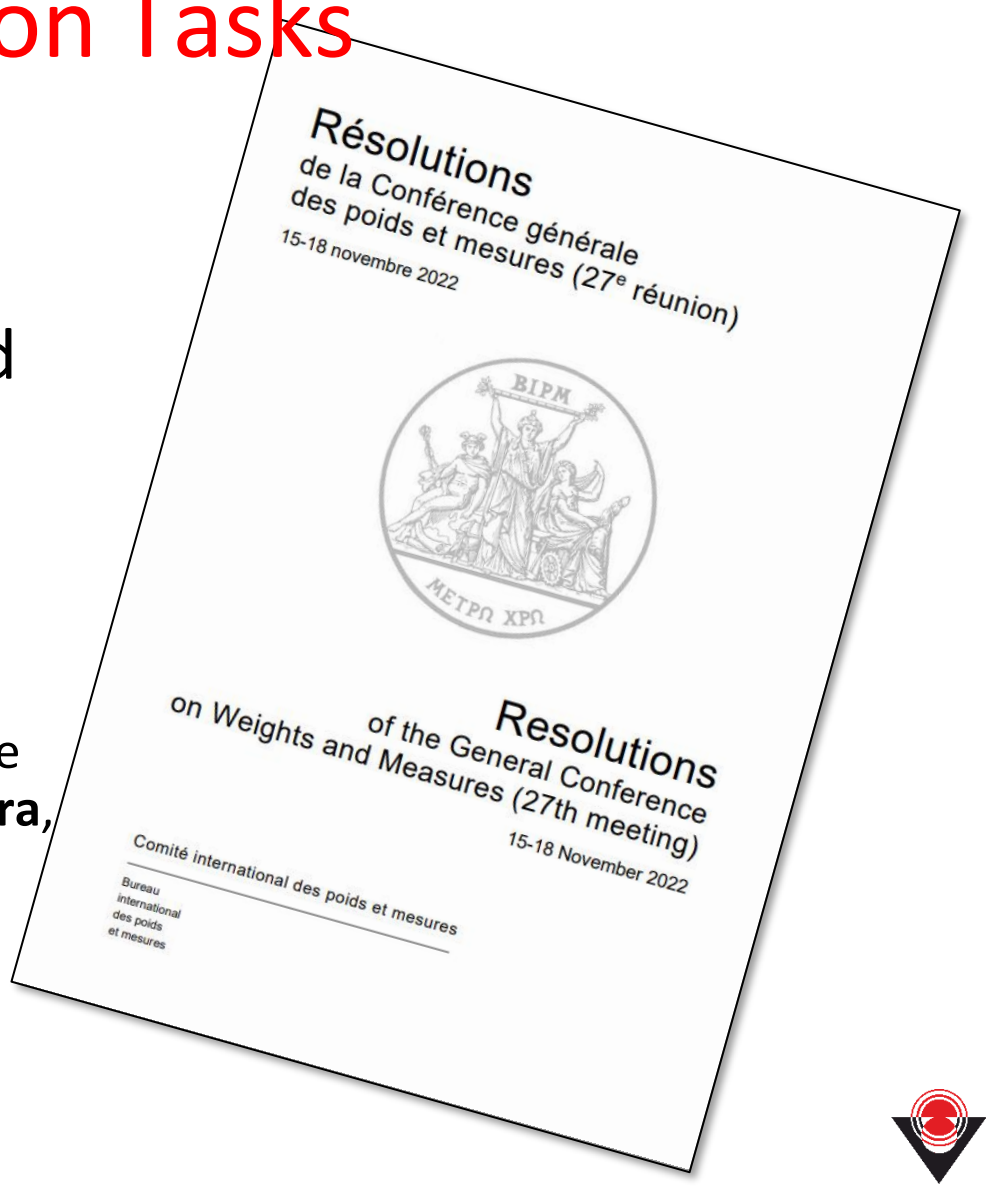
- One click MEMS temperature sensor calibration (SPEA, Italia)
- Dynamic calibration of MEMS accelerometers (PTB, Germany)
- Machine Learning and Data Analysis at ZeMA Mechatronics and Automation Technology Center (ZeMA, Germany)
- Container Weighing System (DCC) (Aalto University, Finland)

BIPM CIPM Digitalization Tasks

- Mandate by the 27th CGPM

  Resolution 2

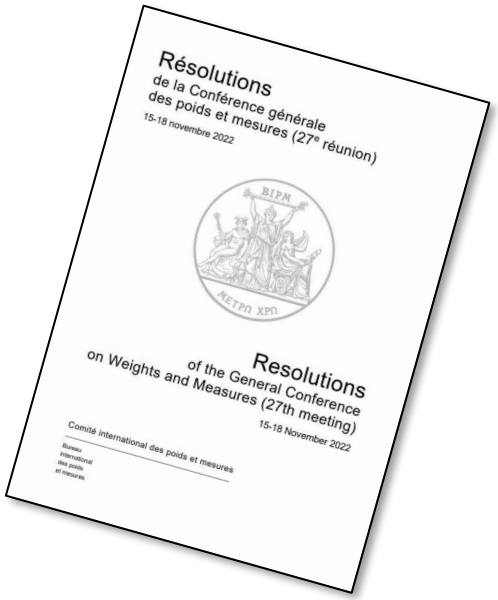
  “On the global digital transformation and the International System of Units”



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**, …

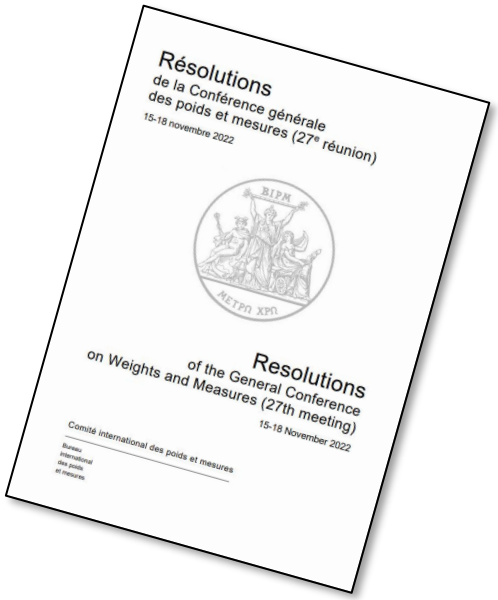
BIPM 27th CGPM Resolution 2



The 27th CGPM Summary

- BIPM is working on several building blocks to establish a **SI Digital Framework**
- Prototype of **machine readable SI Brochure** is being tested with other modules
- Next steps include **references for Quantities** Interaction with experts of the specific field required

BIPM Activities on Digitalization



BIPM | ABOUT US | COORDINATION | LIAISON | TECHNICAL/SCIENTIFIC | PUBLICATIONS & EVENTS

Information for Developers

Information on available APIs is available through the links below, along with documentation and the terms of reference for each.

CIPM MRA - REFERENCE DATA

Machine-readable data for CMCs

KCDB API

READ MORE

TECHNICAL SERVICE - REFERENCE DATA

Machine-readable data for standard frequencies

Time Department API

TAI(A)BIPM.ORG READ MORE

TECHNICAL SERVICE - REFERENCE DATA

Machine-readable data for time scales

Time Department API

TAI(A)BIPM.ORG READ MORE

Other digital services

KCDB - PIDS FOR CMCS

Permanent link for a given CMC: https://si-digital-framework.org/kcdb-cmc/[CMC identier]

BIPM KCDB QUICK START

KCDB - PIDS FOR SERVICE CATEGORIES

Machine-readable reference for Service Categories (AUV, EM, L, M, PR, T, and TF) https://si-digital-framework.org/kcdb-sc/

BIPM

for

C (and each
required, for
e link to the

binar on Digital References
ology

by the BIPM in conjunction with SciDataCon 2023, took place on October 12. As
nars, this event was dedicated to the new digital services developed by the BIPM,
ative Committees for Photometry and Radiometry (CCPR) and Ionizing Radiation
available on the BIPM YouTube channel.

ebinars will be organized to present and discuss the progress of digital
d within the Consultative Committees for Length (CCL) and Time and Frequency
ork envisaged to develop a machine-readable version of the VIM.

/watch?v=NAKKMTs4_YA

Bureau International des Poids et Mesures

Concept of Digitalization | Digital Transformation in Metrology | BIPM CIPM Digitalization Actions | EURAMET Digitalization Actions | Scientific Activities on Digitalization | Digital Calibration Certificate | TUBITAK UME Digitalization Working Group

EURAMET Digitalization Tasks

European Partnership on Metrology Work Programme
Call Scope: Metrology support for Digital Transformation (2022-4 M€), 2024-13 M €)

…The Targeted Programme on Metrology for Digital Transformation (TP DIT) complements other planned TP's targeting at metrology challenges in the areas of **Green Deal, Health, Industrial Innovation, Fundamental Metrology, Integrated European Metrology, and Standardization/Regulation**. It addresses specific digital topics that have a generic or cross-disciplinary character….

EPM (*European Partnership on Metrology*) project call as digital transformation in 2022 and 2024 (https://www.euramet.org/research-innovation/metrology-partnership)

EURAMET Digitalization Tasks

Trustworthy virtual experiments and digital twins

Short Name: ViDiT, Project Number: 22DIT01

A dashboard of augmented virtual reality

COORDINATOR
Sonja Schmelter (PTB)

Supporting Europe's digital transformation

Simulation models, that can mimic or replicate physical systems, are used in a wide range of industries to design, test and develop products. As well as drastically reducing production time and cost per part, they can reduce energy usage and material wastage, helping reduce

PARTICIPATING EURAMET NMIS AND DIS

GUM (Poland)
LCOE (Spain)
LNE (France)
MIKES (Finland)
PTB (Germany)
UME (Türkiye)
VSL (Netherlands)

OTHER PARTICIPANTS

Dutch United Instruments B.V. (Netherlands)
Ecole Normale Supérieure Paris-Saclay (France)
FLEXIM Flexible Industriemeßtechnik GmbH (Germany)
Fundacion Tekniker (Spain)
GEOMNIA (France)
Ideko S.Coop (Spain)
Instituto Nacional de Tecnología Industrial (Argentina)
KROHNE Messtechnik GmbH (Germany)
Mahr GmbH (Germany)
Politechnika Krakowska (Poland)
Politecnico di Torino (Italy)
SICK Engineering GmbH (Germany)
Universidad Poltécnica de Madrid (Spain)

INFORMATION

PROGRAMME
Metrology Partnership

FIELD
Digital Transformation

CALL
2022

DURATION
2023-2026

TOTAL EU CONTRIBUTION (IN M €)
2,047

- TUBITAK UME Joint Project of EPM 2022 call
  - 22DIT01 ViDiT, Trustworthy virtual experiments and digital twins

https://www.euramet.org/research-innovation/search-research-projects/details/project/trustworthy-virtual-experiments-and-digital-twins

EURAMET Digitalization Tasks

- TC-IM (Interdisciplinary Metrology Technical Committee)
  - Metrology for Digitizing (M4D)
  - Projects on Digitalization

Code	Start Date	Name	Coordinator	Status	Type
1551	2022-05-22	Challenges and opportunities in sensor network metrology	METAS	in progress	Research
1449	2018-06-01	Research data management in European metrology (Formerly including the European Open Science Cloud)	PTB	in progress	Research
1448	2018-06-01	Development of digital calibration certificates	PTB	in progress	Research

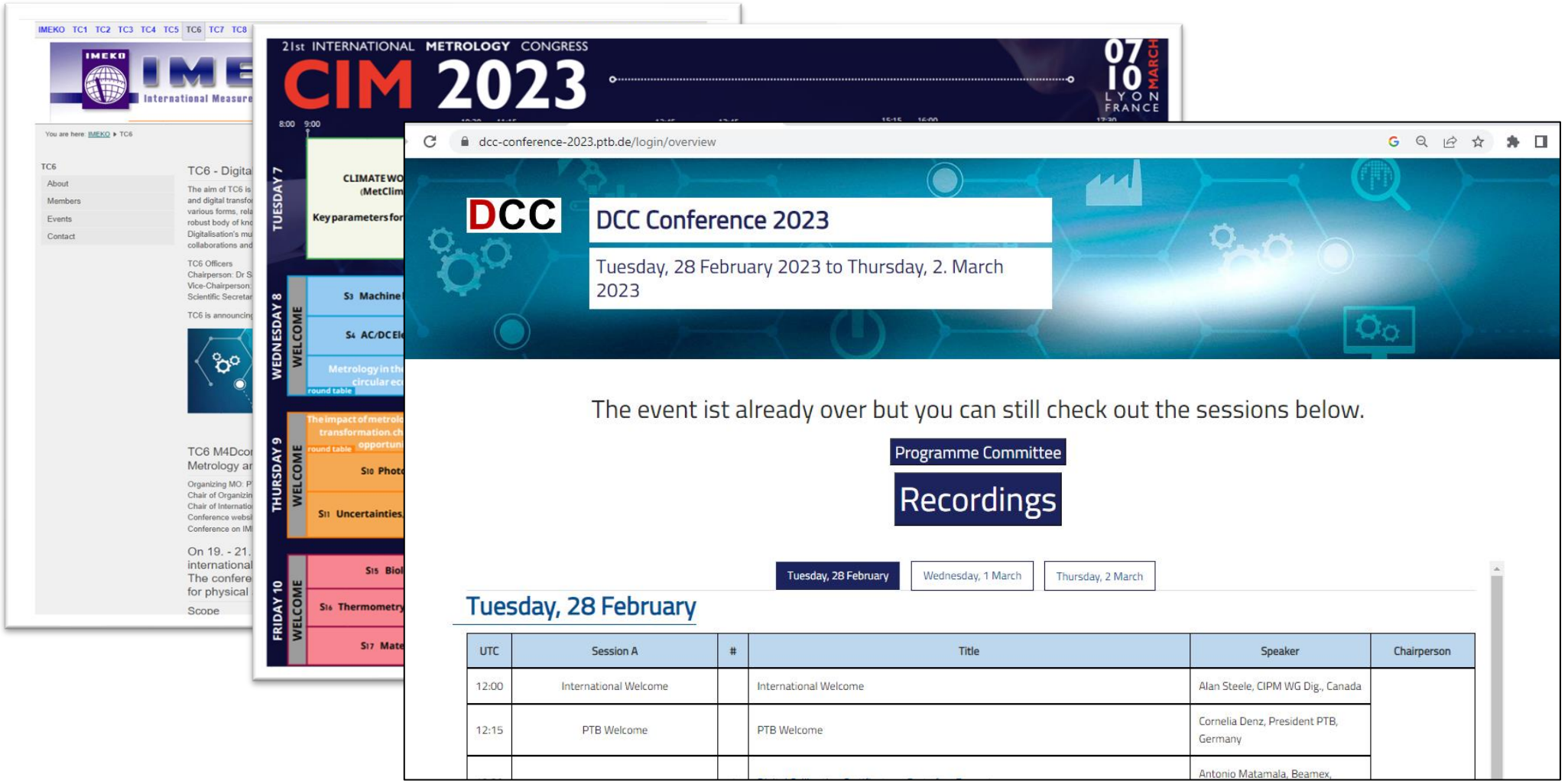
WORKING GROUP ON METROLOGY FOR DIGITAL TRANSFORMATION

The EURAMET TC-IM working group 'Metrology for Digital Transformation' (WG M4D) is bringing together the expertise of EURAMET Members specialised in data management, digital certificates and processes, Internet of Things and sensor networks.

In 2020, the European Commission (EC) published the strategy 'Shaping Europe's digital future', alongside its European industry strategy, data strategy and the White Paper on Artificial Intelligence.
The EC's digital future objectives are centered around developing a technology that works to support a fair and competitive economy, as well as an open, democratic and sustainable society. According to the EC's vision, this can only be achieved through a digital transformation of existing and established processes, in addition to securing and strengthening European digital leadership.

The working group M4D aims to support EURAMET in its mission to implement a strategic digital transformation that is aligned both with the aims of the European Commission, as well as the relevant needs of EURAMET members.

Scientific Activities



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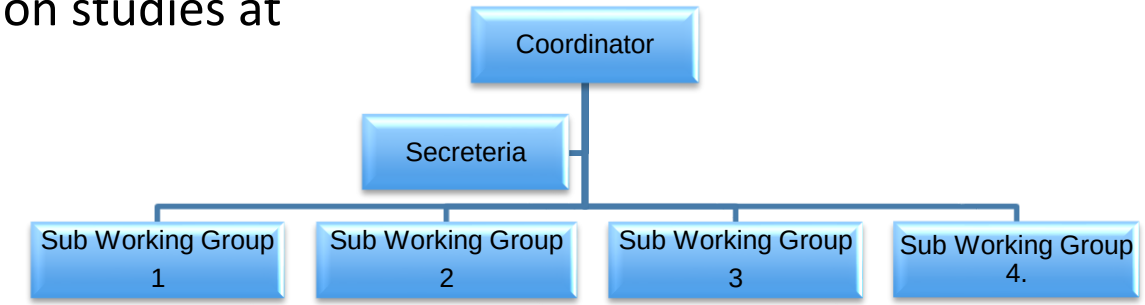
TUBITAK UME Digitlization Working Group

- On 08.09.2023, the “TÜBİTAK UME Digitalization Working Group” (DÇG) was established to coordinate the digitalization studies at TÜBİTAK UME.

Contact:

ume.dcg@tubitak.gov.tr



10 Researchers
2 Technicians
2 Intern students

TÜBİTAK UME Digitalization Working Group

TÜBİTAK UME Digital Metrology Pilot Project and Dissemination at Turkiye for 5 years (between 2024 and 2028)

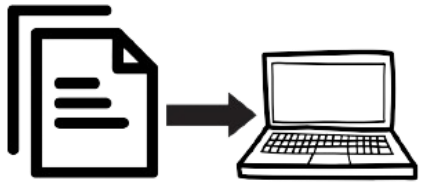
The TÜBİTAK UME **Digital Metrology Pilot Project** marks a transformative step towards enhancing the efficiency and precision of metrology practices in Turkiye.

The objectives of the TÜBİTAK UME digitalization pilot project :

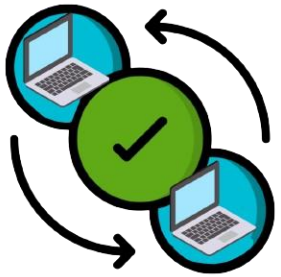
- **Obj1.** Transferring Metrological Scientific Outputs to Digital Media
- **Obj2.** Creating the Digital Calibration Certificate (DCC) and Digital Test Reports (DTR) and Sharing them an a digital platform
- **Obj3.** Creating smart Calibration Systems with Digital Measurement Device Twins

O1. Transferring Metrological Outputs to Digital Media

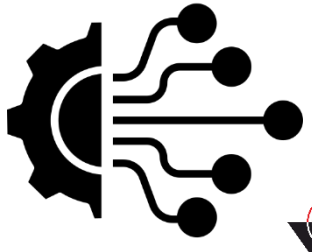
The sub-task steps planned within the scope of the Transferring Metrological Scientific Outputs to Digital Media objective are determined as follows.



1.1. **Transferring the publications** produced by institutions and organizations interested in Scientific and Industrial Metrology and for the benefit of institutions and organizations carrying out metrological activities in our country **into digital media**. (2025)



1.2. **Making the demand and offer systems** of calibration and experiment services offered by TÜBİTAK UME, which is interested in Scientific Metrology in our country, **accessible digitally**. (2026)



1.3. **Establishing a mechanism** to share the digital forms of **Calibration Certificates (DCC)** and **Test Reports (DTR)** with the relevant parties (2027)

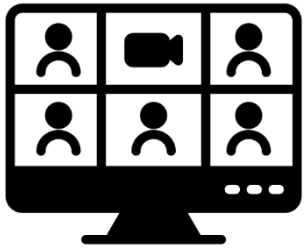
O2. Creating the DCC and DTR

The sub-task steps planned within the scope of the Creating the Digital Calibration Certificate (DCC) and digital Test Reports (DTR) objective are determined as follows.

2.1. **Creating and publishing the taxonomies** of the quantities measured **in our country** according to the international measurement system (2025)

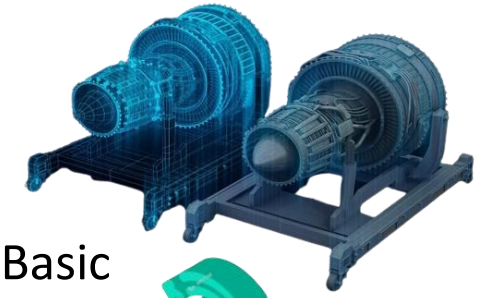
2.2. **Creation of machine-readable format** of Calibration Certificate and Test reports (DCC / DTR) (2027)

2.3. **Dissemination of digital formats of Calibration Certificates and Test Reports** within the country (2028)



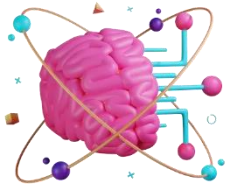
O3. Creating Smart Calibration Systems with Digital Measurement Device Twins

The sub-task steps planned within the scope of the Creating smart Calibration Systems with Digital Measurement Device Twins objective are determined as follows.



3.1. **Creating digital twins of devices** (2028)

3.2. **Establishing Remote and Automatic Calibration Systems** for Basic Measurement Quantities (2028)



3.3. **Application of machine and deep learning methods** to automatic calibration and experiment systems (2028)

3.4. **Developing open-source software** and device drivers for automatic **calibration and uncertainty calculations** (2028)

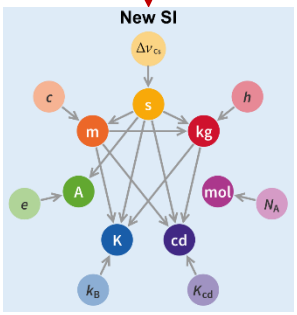
Outputs of Digital Metrology Pilot Project

2024
-Business Development

-Networking

2025
-Digital Transformation of Current Documentations

-Taxonomy studies



2026
-Interactive Service Management System

2027
-DCC creating

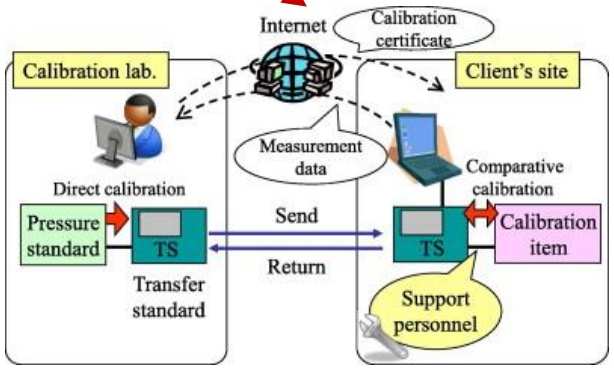
-DCC sharing Platform

2028
-Knowledge Sharing on DCC in Turkiye

-Automatic Calibration Systems

-Machine Learning, Deep Learning application on metrology

-Cloud Computing



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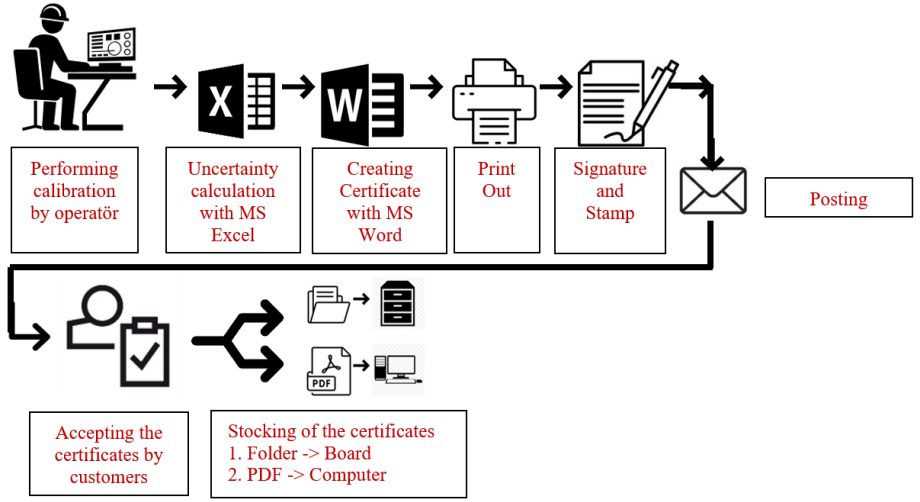
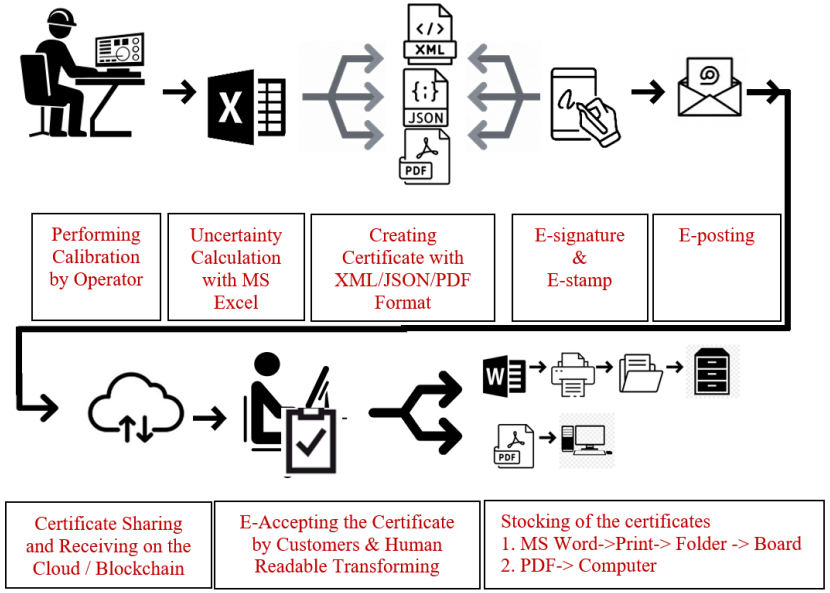
Digital Calibration Certificate (DCC)

- Current workflow in calibration certificate creation:



  - Error prone
  - Time consuming because of manual processing
  - Lacks the extra functional gains to come when using DCC

- How DCC works:



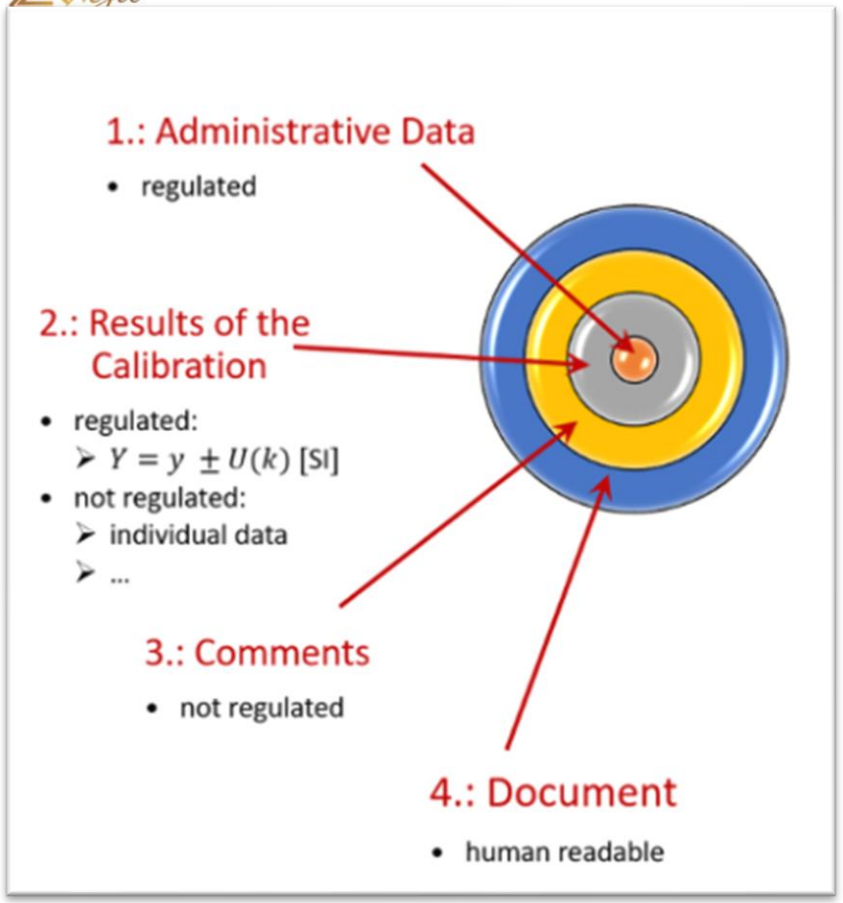
  - It is possible for the corrected values to be used directly by SCADA systems
  - Overall time required is shorter due to automation
  - Integration is possible

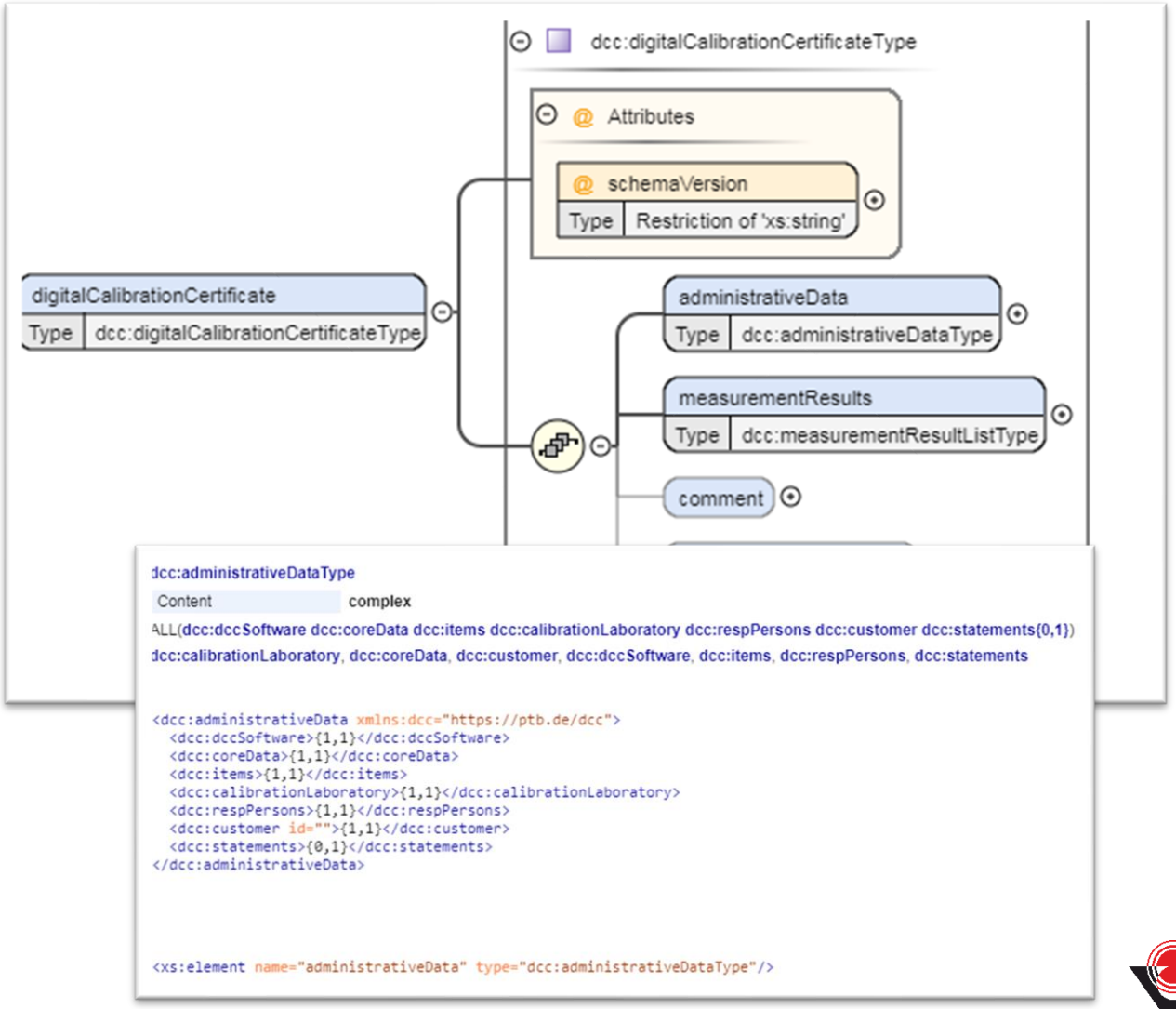
Digital Calibration Certificate (DCC)

What is DCC?

DCC is in electronic form (in XML, JSON- and even PDF etc. formats), which contains all the information contained in the current calibration certificates, plus all information including the measurement results (kept digitally), and can contain the certificate in the form of pdf, etc. and is electronically signed digital file that can be processed by machine and used in digital workflows, whose integrity and immutability are well guaranteed.

Structure of DCC





Signing and distribution of DCC

DCC must include cryptographic signatures for integrity, authenticity and, where necessary, confidentiality and ensure security

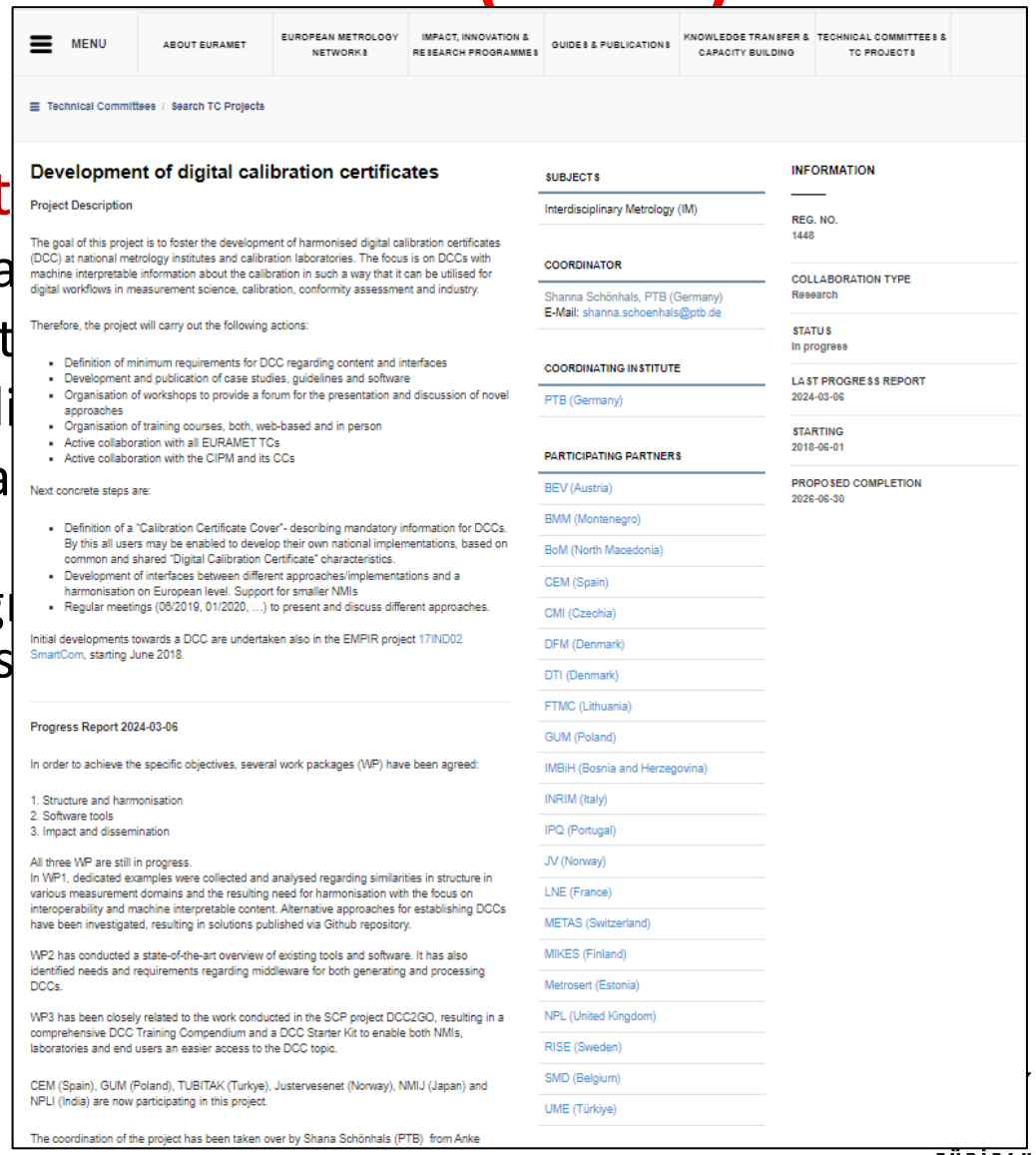
Digital Calibration Certificate (DCC)

- Current status in DCC:
  - TC-IM Project 1448 development of Digital Calibration Certificates
  - Part of Digital Transformation in Metrology
  - The draft structure has been formed, but we have a long way to go for a common structure.
  - There are some institutes currently working

Digital Calibration Certificate (DCC)

- TC-IM 1448 DCC common requirement
  - Must be machine readable (without huma
  - It must be directly or indirectly traceable t
  - Must have proof of metrological traceabili
  - It must contain additional information (da numerical calibration information, etc.)
  - Include cryptographic signatures for integ necessary, confidentiality and guarantee s

TÜBİTAK UME is participant of this project



MENU | ABOUT EURAMET | EUROPEAN METROLOGY NETWORKS | IMPACT, INNOVATION & RESEARCH PROGRAMMES | GUIDES & PUBLICATIONS | KNOWLEDGE TRANSFER & CAPACITY BUILDING | TECHNICAL COMMITTEES & TC PROJECTS

Technical Committees / Search TC Projects

Development of digital calibration certificates

Project Description

The goal of this project is to foster the development of harmonised digital calibration certificates (DCC) at national metrology institutes and calibration laboratories. The focus is on DCCs with machine interpretable information about the calibration in such a way that it can be utilised for digital workflows in measurement science, calibration, conformity assessment and industry.

Therefore, the project will carry out the following actions:

- Definition of minimum requirements for DCC regarding content and interfaces
- Development and publication of case studies, guidelines and software
- Organisation of workshops to provide a forum for the presentation and discussion of novel approaches
- Organisation of training courses, both, web-based and in person
- Active collaboration with all EURAMET TCs
- Active collaboration with the CIPM and its CCs

Next concrete steps are:

- Definition of a "Calibration Certificate Cover"- describing mandatory information for DCCs. By this all users may be enabled to develop their own national implementations, based on common and shared "Digital Calibration Certificate" characteristics.
- Development of interfaces between different approaches/implementations and a harmonisation on European level. Support for smaller NMIs
- Regular meetings (06/2019, 01/2020, ...) to present and discuss different approaches.

Initial developments towards a DCC are undertaken also in the EMPIR project 17IND02 SmartCom, starting June 2018.

Progress Report 2024-03-06

In order to achieve the specific objectives, several work packages (WP) have been agreed:

1. Structure and harmonisation
2. Software tools
3. Impact and dissemination

All three WP are still in progress.
In WP1, dedicated examples were collected and analysed regarding similarities in structure in various measurement domains and the resulting need for harmonisation with the focus on interoperability and machine interpretable content. Alternative approaches for establishing DCCs have been investigated, resulting in solutions published via Github repository.

WP2 has conducted a state-of-the-art overview of existing tools and software. It has also identified needs and requirements regarding middleware for both generating and processing DCCs.

WP3 has been closely related to the work conducted in the SCP project DCC2GO, resulting in a comprehensive DCC Training Compendium and a DCC Starter Kit to enable both NMIs, laboratories and end users an easier access to the DCC topic.

CEM (Spain), GUM (Poland), TUBITAK (Turkye), Justervesenet (Norway), NMIJ (Japan) and NPLI (India) are now participating in this project.

The coordination of the project has been taken over by Shana Schönhals (PTB) from Anke

SUBJECTS
Interdisciplinary Metrology (IM)

COORDINATOR
Shanna Schönhals, PTB (Germany)
E-Mail: shanna.schoenhals@ptb.de

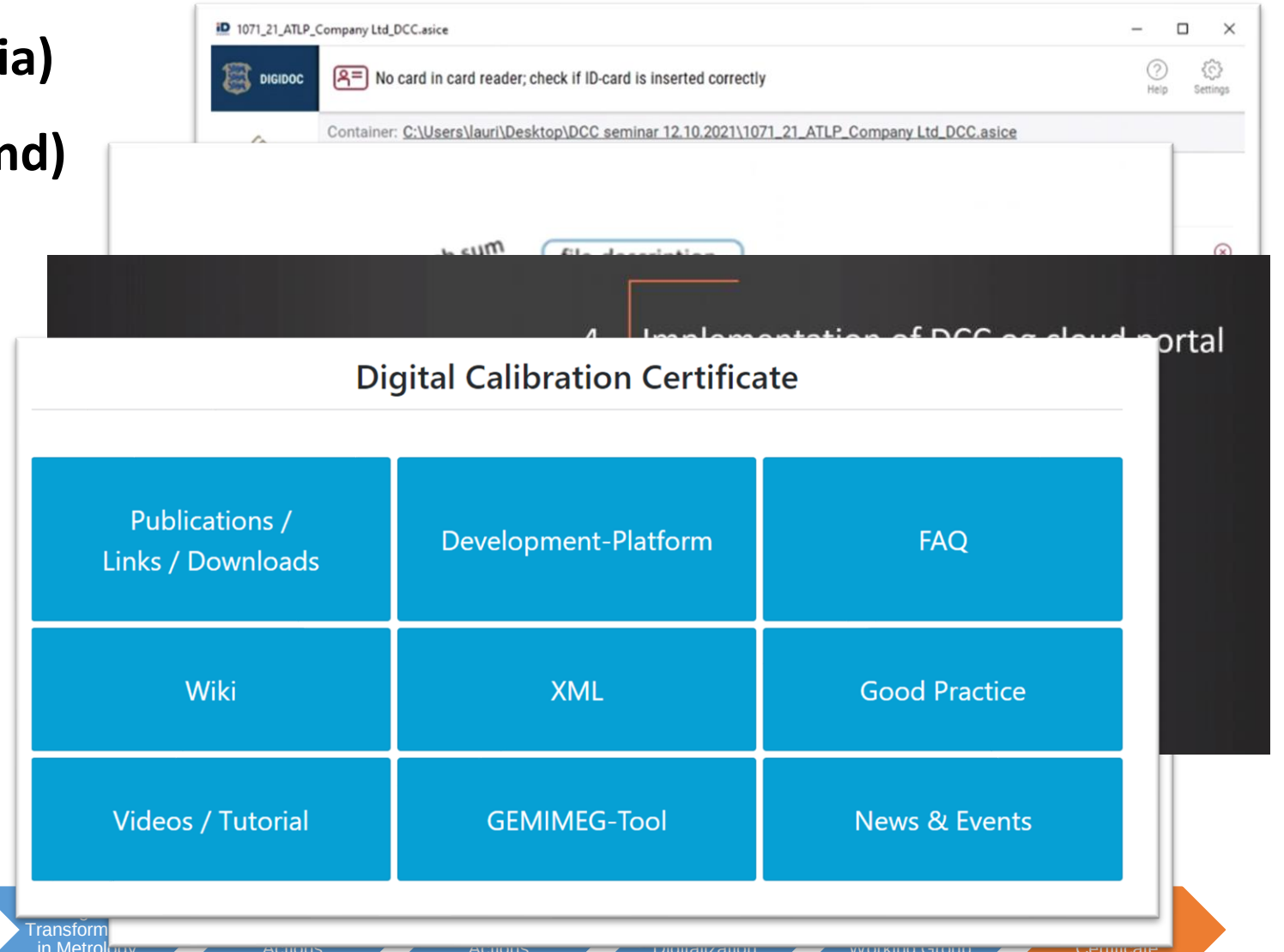
COORDINATING INSTITUTE
PTB (Germany)

PARTICIPATING PARTNERS
BEV (Austria)
BMM (Montenegro)
BoM (North Macedonia)
CEM (Spain)
CMI (Czechia)
DFM (Denmark)
DTI (Denmark)
FTMC (Lithuania)
GUM (Poland)
IMBiH (Bosnia and Herzegovina)
INRIM (Italy)
IPQ (Portugal)
JV (Norway)
LNE (France)
METAS (Switzerland)
MIKES (Finland)
Metrosert (Estonia)
NPL (United Kingdom)
RISE (Sweden)
SMD (Belgium)
UME (Türkiye)

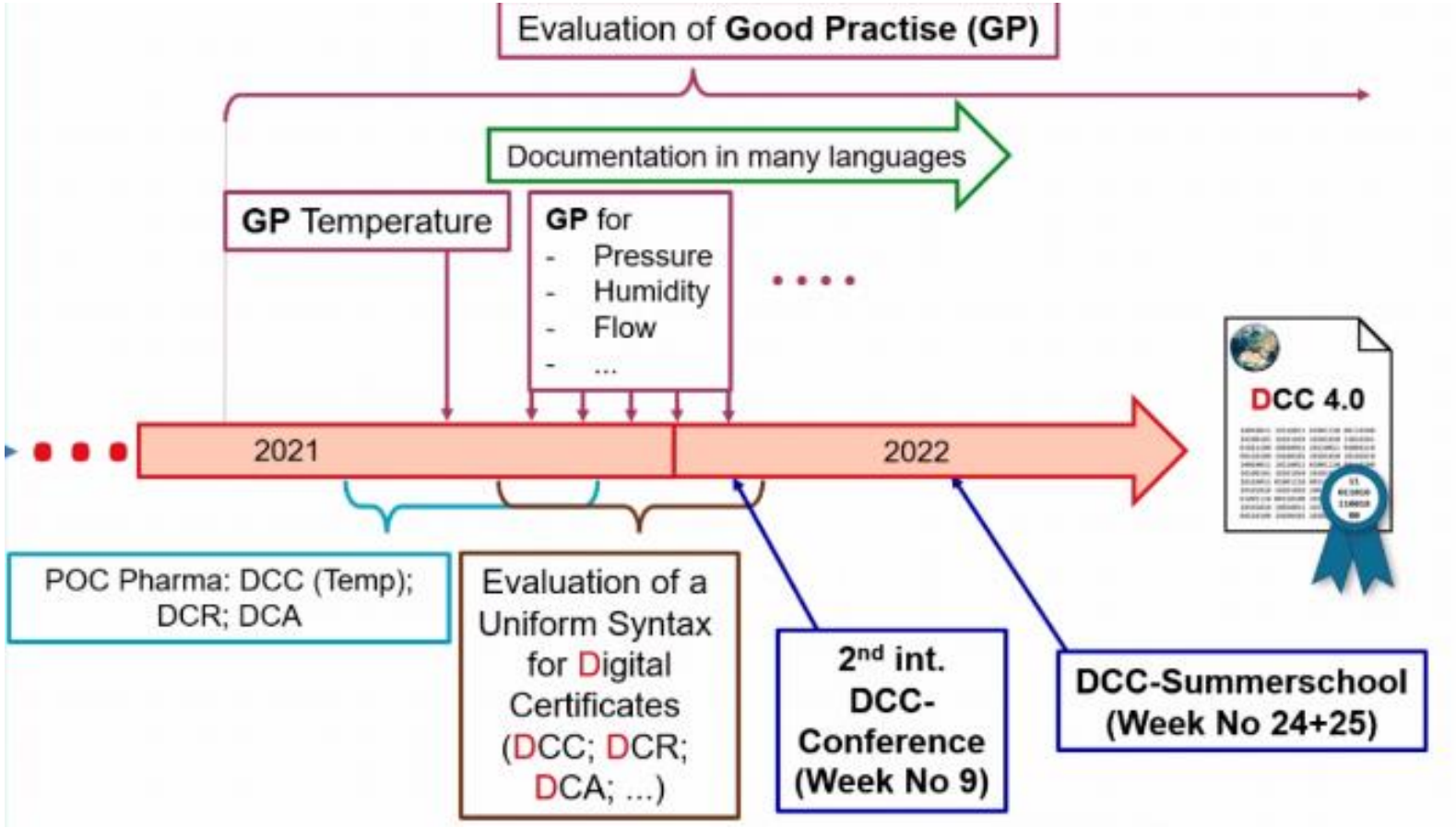
INFORMATION
REG. NO.
1448
COLLABORATION TYPE
Research
STATUS
In progress
LAST PROGRESS REPORT
2024-03-06
STARTING
2018-06-01
PROPOSED COMPLETION
2026-06-30

DCC related work

- **Metrosert (Estonia)**
- **Metas (Switzerland)**
- **DFM (Denmark)**
- **PTB (Germany)**



DCC Road Map

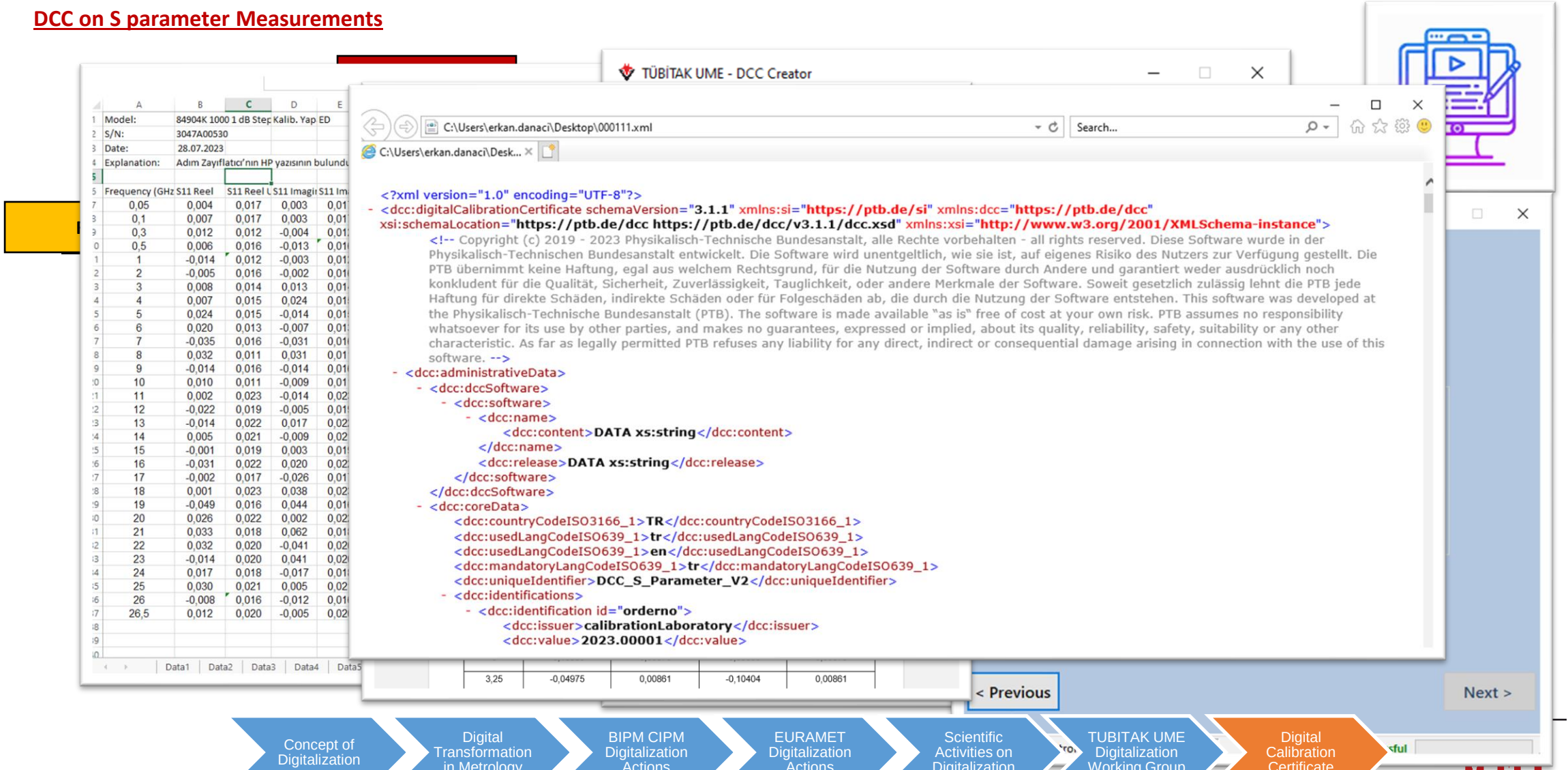

Evaluation of Good Practise (GP)
Documentation in many languages
GP Temperature
GP for
- Pressure
- Humidity
- Flow
- ...
2021
2022
DCC 4.0
POC Pharma: DCC (Temp); DCR; DCA
Evaluation of a Uniform Syntax for Digital Certificates (DCC; DCR; DCA; ...)
2nd int. DCC-Conference (Week No 9)
DCC-Summerschool (Week No 24+25)

XML Based First DCC at TUBITAK UME

- DCC Process

XML Based First DCC at TUBITAK UME

- **DCC on S parameter Measurements**



Concept of Digitalization | Digital Transformation in Metrology | BIPM CIPM Digitalization Actions | EURAMET Digitalization Actions | Scientific Activities on Digitalization | TUBITAK UME Digitalization Working Group | Digital Calibration Certificate

The future metrology network with digitalization

Creating Digital Twins of Measurement Devices

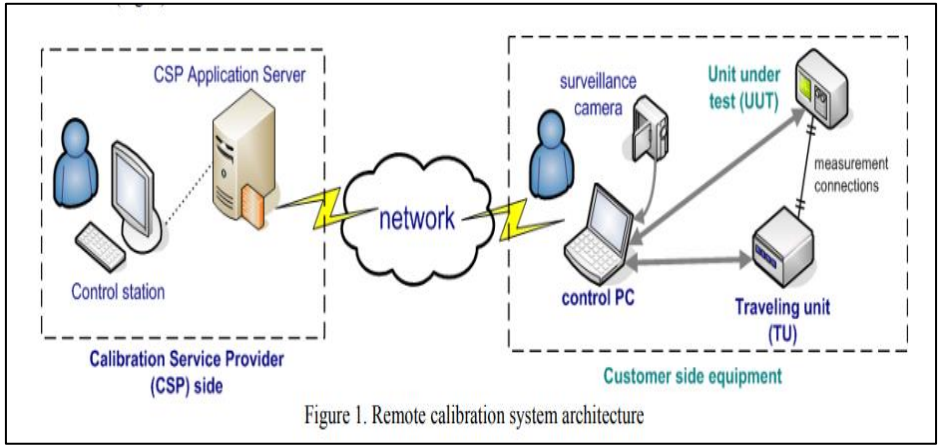
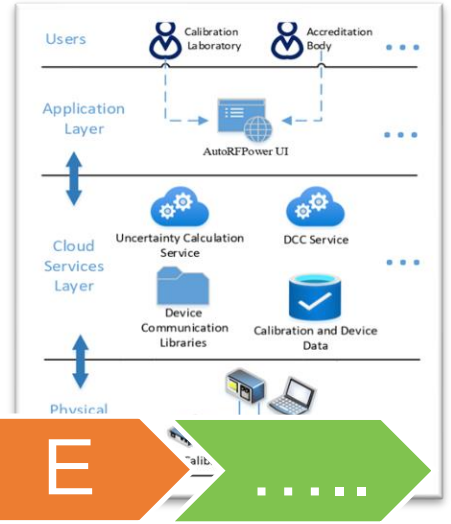


Figure 1. Remote calibration system architecture

Jurcevic, Marko & Hegedus, Hrvoje & Malarić, Roman & Zeba, Hrvoje. (2008). Generic Environment for internet-enabled calibration services.

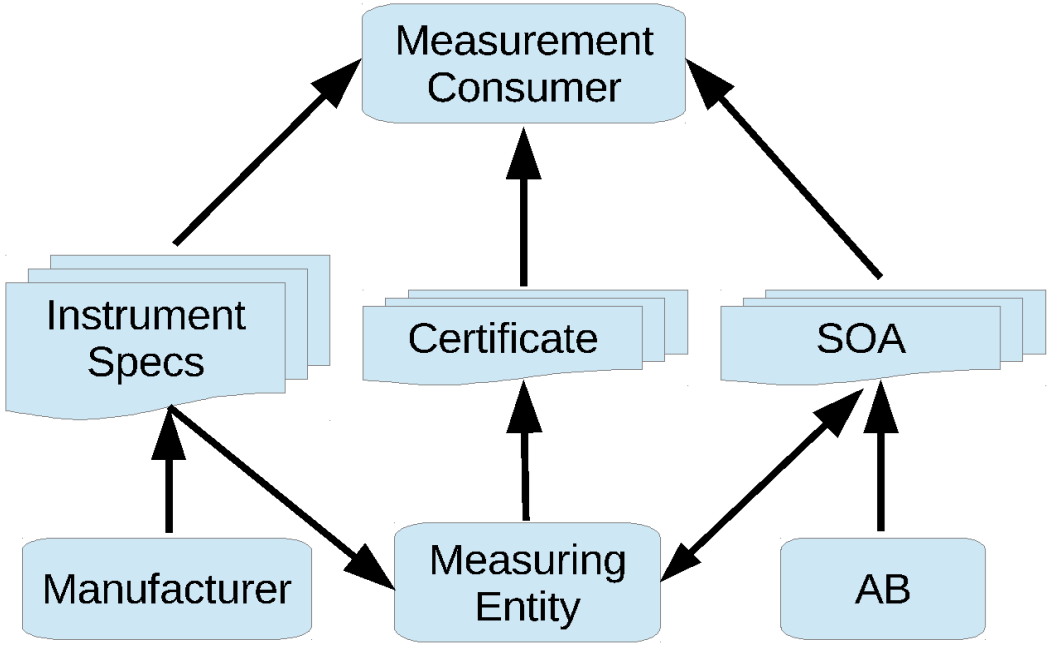
Providing the calibration and test as Remote



Uncertainty calculation on metrology clouds

F U T U R E .....

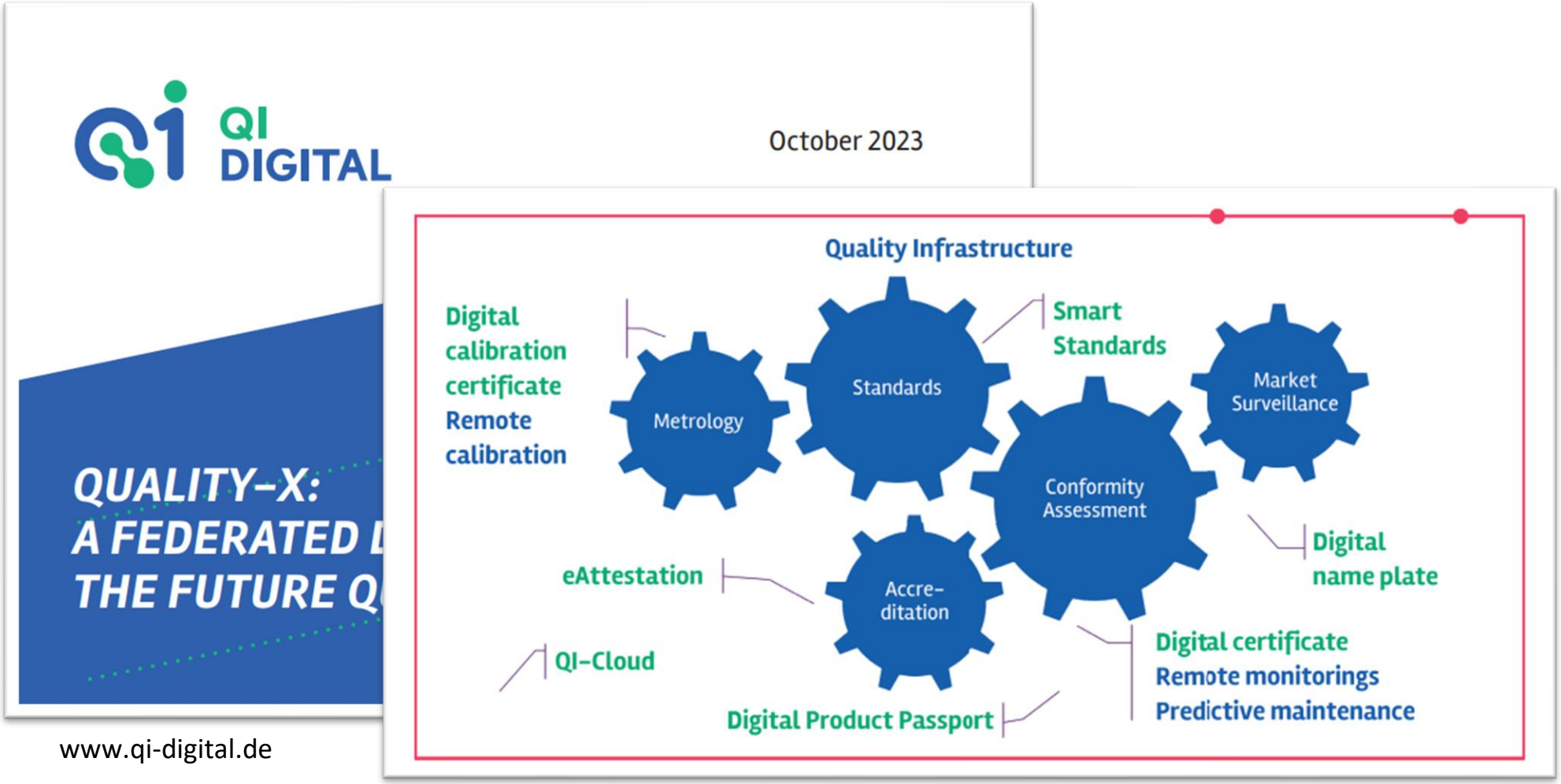
The future metrology network with digitalization



- BIPM's KCDB, M-Layer
- European Metrology Cloud
- NMI's Digitization Strategy
- MSL, APMP, others

F U T U R E .....

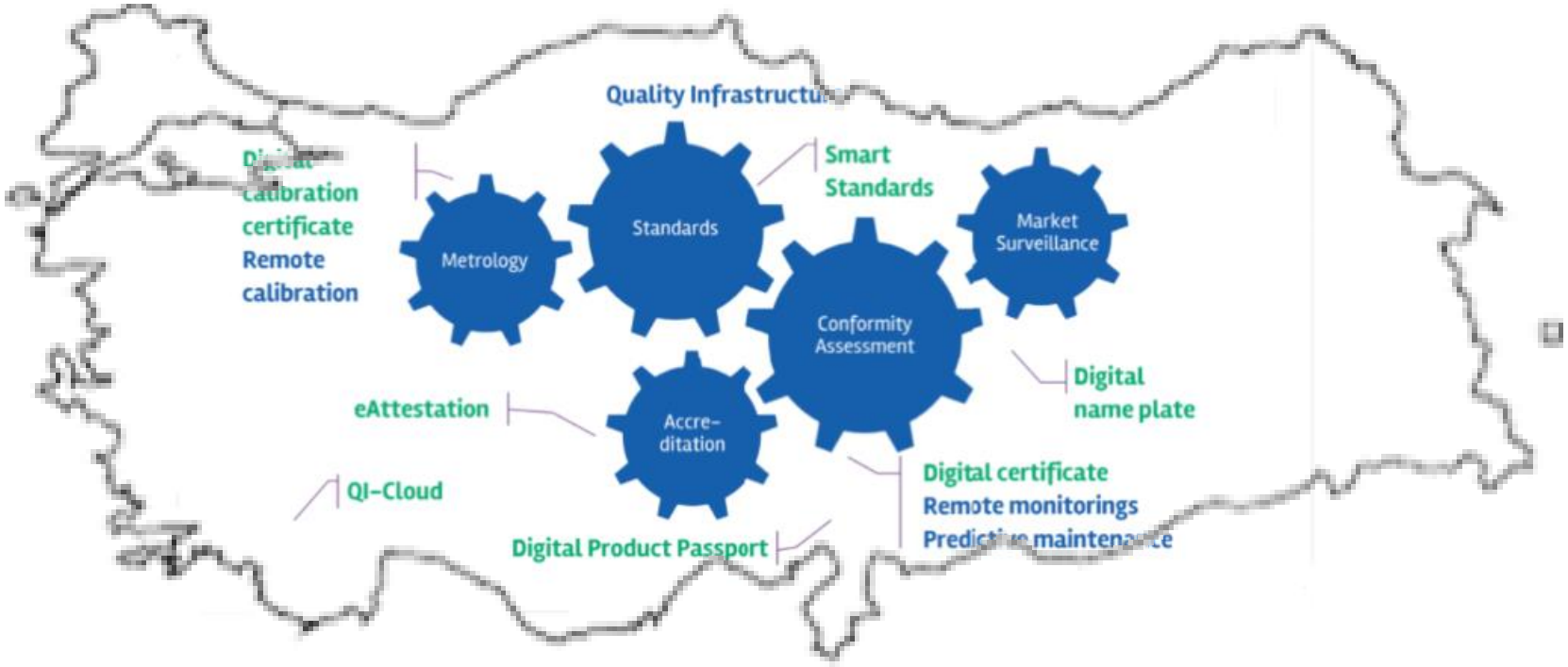
The future metrology network with digitalization



www.qi-digital.de

F U T U R E .....

The future metrology network with digitalization



F U T U R E .....

turklab
Kalibrasyon ve Deney Laboratuvarları Derneği 20.yıl

TÜBİTAK NATIONAL METROLOGY INSTITUTE

2024

sustainable life via metrology

TRUE MEASUREMENT EXCELLENCE

Thank you for your attention

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