Physikalisch-Technische Bundesanstalt
National Metrology Institute

3rd International DCC-Conference

2023-02-28 to 2023-03-02

Proceedings

DOI: https://doi.org/10.7795/810.20230331

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Programme Committee

- Blair Hall, MSL - Measurement Standards Laboratory; New Zealand
- Brett Hyland, NATA - National Association of Testing Authorities; Australia
- Carlos Galvan-Hernandez, CENAM - Centro Nacional de Metrología; Mexico
- David Balslev-Harder, DFM - Danish National Metrology Institute; Denmark
- Girija Moona, CSIR-NPL India - Council of Scientific and Industrial Research - National Physical Laboratory India
- Kim Nguyen, D-Trust GmbH; Germany
- Mark Kuster, Independent Researcher; USA
- Peter Carter, GS1 Australia; Australia
- Robert Hanisch, NIST - National Institute of Standards and Technology; USA
- Siegfried Hackel, PTB - Physikalisch-Technische Bundesanstalt; Germany
- Wee Hoe Ng, National Metrology Centre; Singapur

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Agenda and Chairpersons

2023-02-28 (Tuesday)

2023-02-28 (Tuesday)					
UTC	**Session A**	**#**	**Title**	**Speaker**	**Chairperson**
12:00	International Welcome		International Welcome	Alan Steele, CIPM WG Dig., Canada	Siegfried Hackel
12:15	PTB Welcome		PTB Welcome	Cornelia Denz, President PTB, Germany	
12:30	The International Perspective of DCC	1	Digital Calibration Certificate as Part of an Ecosystem	Antonio Matamala, Beamex, Finland	
12:45		2	Calibration, Certification, Testing – Is Compatible Digitalisation Possible?	Brett Hyland, NATA, Australia	
13:00		3	Towards Digital SI Traceability Statements in Calibration Certificates Issued by NMIs and DIs	Olav Werhahn, BIPM	
13:15		4	Recent Advances in Digital Representation of Measurement Data by the D-SI Metadata Model	Daniel Hutzschenreuter, PTB, Germany	
13:30	**Break**				
13:45					
UTC	**Session B**	**#**	**Title**	**Speaker**	**Chairperson**
14:00	DCC and Accreditation	5	Bringing the Digital Accreditation Symbol and the Digital Calibration Report (DCC) into Practice	Susanne Kuch, German Accreditation Body (DAkkS), Germany	Robert J. Hanisch
14:15		6	The General DCC Rulebook and the Rules under the Aspects of Accreditation	Siegfried Hackel, PTB, Germany	
14:30	Digital Signatures	7	Qualified Electronic Seals - The Peace of Westphalia in the Laboratory Sector	Robert Hilgers, Bundesdruckerei / D-Trust, Germany	
14:45		8	How to Apply Digital Signatures on a Digital Calibration Certificate	Robin Fay, Deutsche Telekom Security GmbH, Germany	
15:00	Semantics / Persistent Identification	9	The Semantics of Measured Quantities	Mark Kuster, Independent Researcher, USA	
15:15		10	Persistent Identification of Instruments and the Digital Calibration Certificate	Markus Stocker, TIB – Leibniz Information Centre for Science and Technology, Germany	

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2023-03-01 (Wednesday)

2023-03-01 (Wednesday)					
UTC	**Session C**	**#**	**Title**	**Speaker**	**Chairperson**
12:00	Different DCC Approaches	11	DCC and Digitisation versus Digitalisation and Digital Transformation	Siegfried Hackel, PTB, Germany	Brett Hyland
12:15		12	Development of PDF based Digital Calibration Certificates at NMIJ, AIST	Kazuaki Yamazawa, NMIJ, Japan	
12:30		13	Software for the Creation of Machine-Readable and Human-Friendly Reports	Diego Nahuel Coppa, INTI, Argentina	
12:45	DCC and Machines	14	Machine Readability – Automating the Extraction of Data from DCC's	David Balslev-Harder, DFM, Denmark	
13:00	DCC-News	15	What's New in the DCC Schema Version 3.2.0?	Benjamin Gloger, PTB, Germany	
13:15		16	Validation Methods in the Preparation of DCCs: The Schematron Validation Tool	Gamze Söylev Öktem, PTB, Germany	
13:30	**Break**				
13:45					
UTC	**Parallel Session 1**	**#**	**Title**	**Speaker**	**Chairperson**
14:00	DCC-Tools	23	The GEMIMEG Tool – A Software for Creating Digital Calibration Certificates (DCCs)	Moritz Jordan, PTB, Germany	David Balslev-Harder
14:15		24	Python Tools Examples for the Transition to DCC	Claudio Francese, INRIM, Italy	
14:30		25	Generation of Digital Calibration Certificates for Temperature Sensor Calibrations using Python and Excel	Ian Smith, National Physical Laboratory, UK	
14:45		26	Dynamic Web Tool for Generating DCC	Itzel Domínguez-Mendoza,CENAM, Mexico	
15:00		27	The Use of (Anonymised) Timestamps in the DCC	Gamze Söylev Öktem, PTB, Germany	

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2023-03-01 (Wednesday) cont.

UTC	Parallel Session 2	#	Title	Speaker	Chairperson
14:00	DCC and Machines	28	Pilot Comparison Project in Terms of Air Kerma in Radiation Protection between Digital Twin Laboratories	Eric Matos Macedo, Labprosaud/IFBA, Brazil	Kim Nguyen
14:15		29	Data Analysis and Business Intelligence - Digital Metrology	Talaat Abdulkadder Al-Rahali, NMCC, Saudi Arabia	
14:30	Good Practice (GP)	30	Calibration 4.0: A DCC Implementation in Electrical Metrology for the Calibration of Digital Multimeters	Juan Carlos Suárez Barón, INTI, Argentina	
14:45		31	DCCs for Non-Automatic Weighing Instruments (NAWIs) – Current Status of a Respective Working Group Elaborating "Good Practice" Conventions	Julian Haller, Sartorius Lab Instruments GmbH & Co. KG, Germany	
15:00		32	Digital Calibration Certificates for Weights and Mass Standards: Rules and Applications	Gisa Foyer, PTB, Germany and Martin Häfner, Häfner Gewichte GmbH, Germany	
15:15		33	DCC Good Practice Examples for Air Humidity and Air Pressure – Current Status of Respective Working Groups	Christian Rohrig, PTB, Germany	
UTC	**Parallel Session 3**	**#**	**Title**	**Speaker**	**Chairperson**
14:00	In Development	34	The DCC in its Role as Networked Data Source	Benjamin Gloger, PTB, Germany	Robert J. Hanisch
14:15		35	The Digital SchemaX (DX)	Justin Jagieniak, PTB, Germany	
14:30	DCC and Industry	36	Pharmaceutical Test Case of a DCR- and DCC Implementation in an Accredited Calibration Laboratory	Jakob Fester, Danish Technological Institute, Denmark	
14:45		37	A Universal Measurement Model	Michael Brown, Fluke, USA	
15:00		38	The Quality of Sensing, of Data or of Information	Thomas Engel, Siemens AG, Germany	
15:15		39	Two Implementations of Digital Calibration Certificates in Industrial and Metrological Services	Marcos E. Bierzychudek, INTI, Argentina	

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2023-03-02 (Thursday)

2023-03-02 (Thursday)					
UTC	**Session D**	**#**	**Title**	**Speaker**	**Chairperson**
12:00	Community-Feedback for Further Developments of the DCC	17	The Digital NIST: Pilot Project for the Digital Transformation of NIST's Measurement Services	Catherine C. Cooksey and Dinis Camara, NIST, USA	Siegfried Hackel
12:15		18	On the Construction and the Dissemination of Digital Metrology Datasets for Research and Development Purposes	Mohammed S. Gadelrab, NIS, Egypt	
12:30		19	Analyzing the Conformance of DCC Prototype Architecture to Calibration Laboratory Expectations Report	Praiya Thongluang, NIMT, Thailand	
12:45		20	A Proof of Concept for a Digital Calibration Environment for Digital Multimeters	Marcos E. Bierzychudek, INTI, Argentina	
13:00		21	DKDs Contribution to DCC Harmonisation and Coordinated Development	Thomas Krah, PTB, Germany	
13:15		22	GEMIMEG-II – Status and Progress Report	Thomas Engel, Siemens AG, Germany	
13:30	**Break**				
13:45					
UTC	**Parallel Session 4**	**#**	**Title**	**Speaker**	**Chairperson**
14:00	Human Readable DCC	40	Human Readable Digital Calibration Certificate for Piston-Operated Volumetric Apparatus	Thilini Pathiragoda, Industrial Technology Institute, Sri Lanka	Ng Wee Hoe
14:15		41	Generating DCC and Human-Friendly Readable Using Auto-Generated XML Schema	Praiya Thongluang, NIMT, Thailand	
14:30		42	A Human Readable Form for the DCC	Muhammed-Ali Demir, PTB, Germany	
14:45	DCC Tools	43	Using a Spreadsheet to generate XML Based on XSD Schema	José Armando Lopez-Celis, CENAM, Mexico	
15:00		44	XML Tree Editor	Justin Jagieniak, PTB, Germany	

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2023-03-02 (Thursday) cont.

UTC	Parallel Session 5	#	Title	Speaker	Chairperson
14:00	Adoption of DCC at NMI's	45	Digital Transformation of NMI: Practical Experience on DCC and Beyond @ NIS-Egypt	Ahmed Hussein, NIS, Egypt	Radu Teodor Bolocan
14:30		47	Equipment Management and Tracking System - Cloud Service for Calibration Certificate Management	Sunantiya Parana, NIMT, Thailand	
14:45		48	Mapping of Processes and Risks in the Digital Transformation in Metrology of Ionizing Radiation - A Case Study in X-Ray Air Kerma Calibration	Igor Fernando Modesto Garcia, Labprosaud/IFBA, Brazil	
15:00		49	Processes and Conventions for the DCC – Results of PTB's 100-Day Programmes in 2022	Shanna Schönhals, PTB, Germany	
15:15	RMO Activities around DCC	50	DCC2GO - Supporting the Implementation of Digital Calibration Certificates in the European Metrology Community	Anke Keidel, PTB, Germany	
UTC	**Parallel Session 6**	**#**	**Title**	**Speaker**	**Chairperson**
14:00	Community-Feedback for Further Developments of the DCC	51	How does a Machine Distinguish the Different Types of DCCs?	Siegfried Hackel, PTB, Germany	David Balslev-Harder
14:15	Traceability	52	Traceability	Abdullah Al Mamun, Bangladesh Standards and Testing Institution (BSTI), Bangladesh	
14:30	Commercial Approaches to DCC	53	DCC Middleware - Obstacles and Approaches	Hans Koch, da+d, Germany	
14:45		54	Digital Calibration Certificate with MetricodeHUB, a Real Implementation Case	Damiano Pietri, Metricode s.r.l., Italy	
15:00		55	Automatic Generation of Digital Calibration Certificates with AnyDCC	Maik Stotz, STOTZ-Software, Germany	
15:15		56	DCC via iPhone (or iPad)	Hans Koch, da+d, Germany	
UTC	**Session E**	**#**	**Title**	**Speaker**	
15:30	End of Conference		Summary of the 3rd international DCC-Conference	Siegfried Hackel, PTB, Germany	

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Welcome

International Welcome

Alan Steele, CIPM WG Dig., Canada

CIPM Digital SI

CIPM View of the Digital SI

3rd International DCC Conference

Online Event Hosted by PTB

28 February 2023

Alan Steele PhD, FRSC
CIPM Member and CODATA Liaison
NRC Canada (Ret'd)

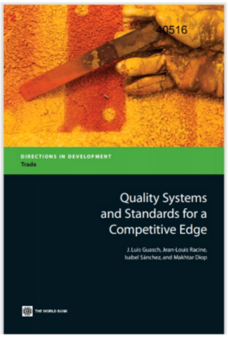
The Metre Convention and the SI

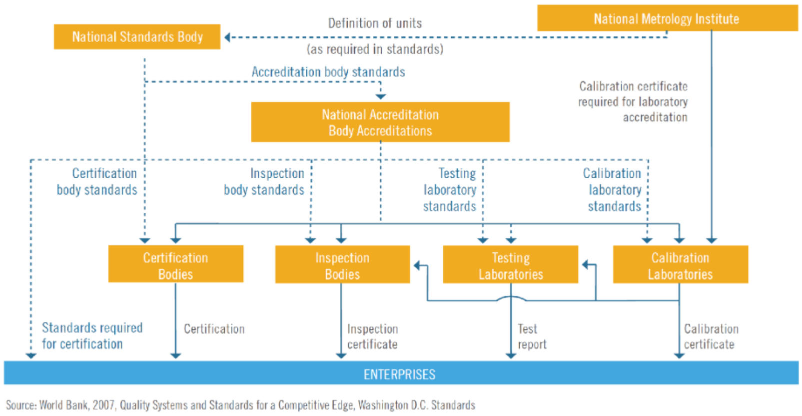
CIPM Digital SI

- Diplomatic Treaty signed in 1875: still going strong!
  - 100 Member States (64) and Associates (36)
  - 97.6 % of the World's GDP participate
- Creates the International System of Units
  - metrology for measurement, research, industry
- Scientific basis for Quality Infrastructure
  - approximately 65 000 laboratories are accredited to ISO/IEC 17025 requesting traceability to the SI

Worldwide Quality Infrastructure

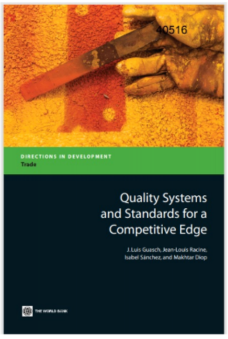
CIPM Digital SI

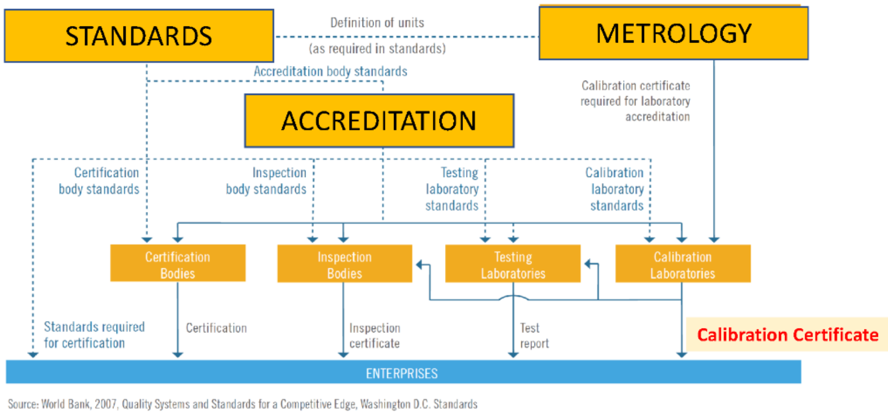




Worldwide Quality Infrastructure

CIPM Digital SI





The Grand Vision: SI Digital Framework

CIPM Digital SI

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.

International Conference for Weights and Measures | CIPM Task Group on the Digital SI

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CIPM Task Group & Expert Group "Digital SI"

CIPM Digital SI

Héctor Laiz (Argentina)
Diego Coppa (INTI)

Alan Steele (Canada)
Ryan White (NRC)

Ismael Castelazo (Mexico)
Francisco Flamenco (CENAM)

Martyn Sené (United Kingdom)
Alistair Forbes (NPL)

James Olthoff (USA)
Robert Hanisch (NIST)
Stuart Chalk (UNF)

Joachim Ullrich (Germany)
Daniel Hutzschenreuter (PTB)

Martin Milton (BIPM)
Janet Miles (BIPM)
Romain Coulon (BIPM)

Yuning Duan (China)
Fedor Bulygin (Russia)
Thomas Liew (Singapore)
Wynand Louw (South Africa)
Pavel Neyezhmakov (Ukraine)
Chu-Shik Kang (KRISS)
Blair Hall (MSL)
Kazumoto Hosaka (NMIJ)

CIPM Task Group members & CIPM support

CIPM Expert Group members

BIPM support: Andy Henson, Suzanne Picard, Johanne Flament, Celine Fellag and many more

International Conference for Weights and Measures | CIPM Task Group on the Digital SI

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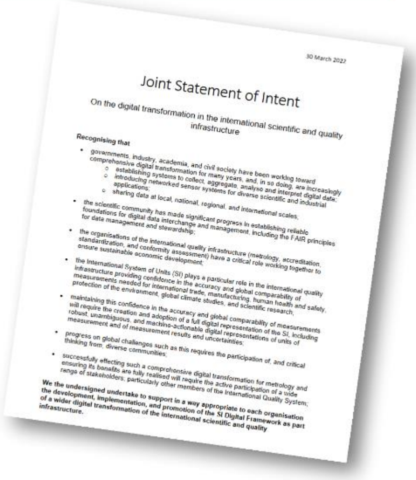
Joint Statement of Intent

CIPM
Digital SI


30 March 2022

Joint Statement of Intent

On the digital transformation in the international scientific and quality infrastructure

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

International Conference for Weights and Measures

CIPM Task Group on the Digital SI

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Joint Statement of Intent

CIPM
Digital SI

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

International Conference for Weights and Measures

CIPM Task Group on the Digital SI

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Ongoing Joint Efforts: Outreach

CIPM Digital SI

Stop squandering data: make units of measurement machine-readable

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

Spreading the word and encouraging others to join the effort is important to the mission!

Liaison with CODATA DRUM

Ongoing Joint Efforts: Outreach

CIPM Digital SI

IMEKO TC6: M4D Conference

- Digital representation and use of metrological information
- Machine-readable certificates for metrological services
- Cloud infrastructures, remote and digital service in the quality infrastructure
- Metrology for industry 4.0


IMEKO TC6 M4Dconf

19. – 21. September 2022

Hybrid with physical attendance in Berlin, Germany

IMEKO TC6: First International Conference on Metrology and Digital Transformation

M4Dconf 2022

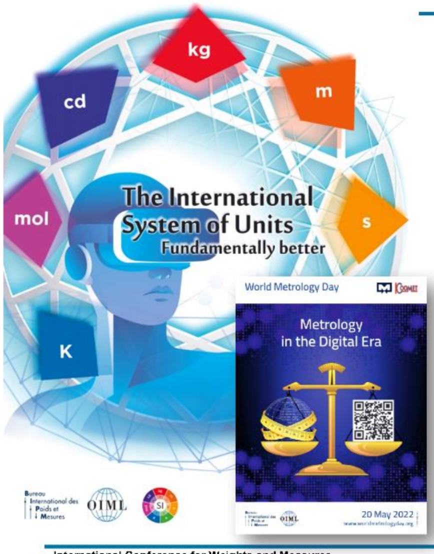
On **19. - 21. September 2022** the IMEKO TC6 "Digitalization" organises the first international conference on metrology and digital transformation - the **M4Dconf 2022**. The Conference will be organized as hybrid event - with limited number of places for physical attendance in Berlin.

All sessions will provide video conferencing rooms for virtual attendees. Recordings of the presentations and sessions will also be available for participants to review until the end of December 2022.

Liaison with IMEKO TC6

CIPM Task Group & Expert Group "Digital SI"

CIPM Digital SI



Long-term goal

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

Management Coordination

- First **international workshop** on the SI Digital Framework in 2021
- **Statement of collaboration** with international organizations of the quality infrastructure (in 2022)
- **Metre Convention Resolution** for governmental support (in 2022)

Technical developments

- **SI Digital Framework** concept for **machine-actionable** and **FAIR** data, services & tools (2020)
- Evaluation of **Existing Ontologies**
- Unique **SI Reference Point**
- Digital **dissemination** of units from CCL and CCTF
- **API for KCDB** access and analysis

International Conference for Weights and Measures — CIPM Task Group on the Digital SI

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CGPM 2022: Resolution 2 "Digital SI"

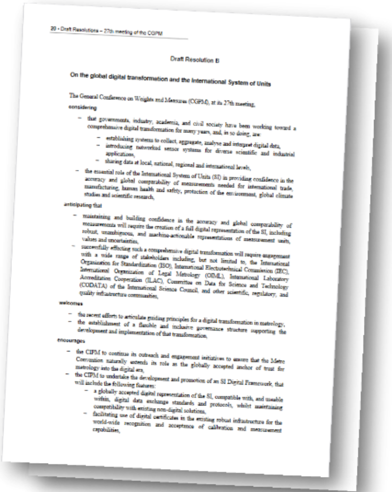
CIPM Digital SI

On the global digital transformation and the International System of Units

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

[…]

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,



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

International Conference for Weights and Measures — CIPM Task Group on the Digital SI

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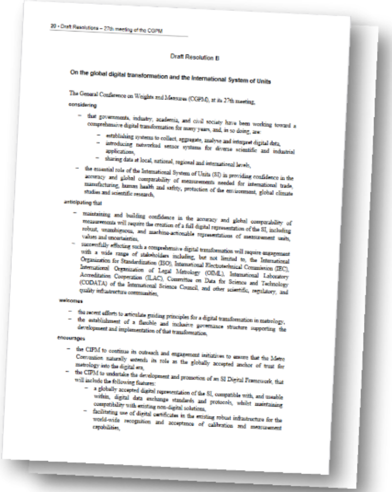
CGPM 2022: Resolution 2 “Digital SI”

CIPM Digital SI

[…]

encourages
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,


Draft Resolution B

On the global digital transformation and the International System of Units

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

International Conference for Weights and Measures

CIPM Task Group on the Digital SI

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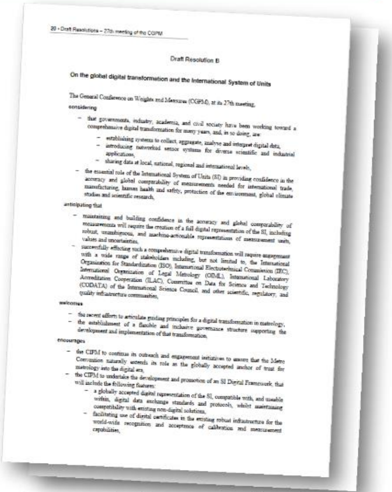
CGPM 2022: Resolution 2 “Digital SI”

CIPM Digital SI

[…]

invites

- 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.


Draft Resolution B

On the global digital transformation and the International System of Units

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

International Conference for Weights and Measures

CIPM Task Group on the Digital SI

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PTB Welcome

Cornelia Denz, President PTB, Germany

Welcome address of the president of PTB, Prof. Dr. Cornelia Denz,
on the occasion of the 3rd International DCC Conference, February 28, 2023, virtual conference

Dear representative of the National Metrology Institutions,
dear Ladies and Gentlemen,

it is a huge pleasure for me to welcome you at the digital site of Physikalisch-Technische Bundesanstalt (PTB) – The German Metrology Institute, to the 3rd International DCC Conference.

I would first like to thank **Dr. Alan Steele**. We are especially happy that he is today present as a **member the CIPM Task Group on the Digital SI** (CIPM-TG-DSI), and has given us already a warm welcome. **Thank you, Alan for the great words.**

I also like to welcome **Dr. Olav Werhahn**, **Executive Secretary of the Joint Committee of the Regional Metrology Organizations and the BIPM**.

A German saying is **Aller guten Dinge sind Drei**. On the one hand, it can be translated as an **encouraging word to try more often than once to succeed: Third time lucky.** On the other hand, it also means: **The best things come in threes**, emphasizing **that there are always three things that are great.**

Today, the **number three** can be seen **in many respects as the red thread of the conference**. Foremost, **there are three challenges with respect to Digital Calibration Certificates that govern also the conference**.

First, the **world is becoming more and more digital**, and thus, **the same is required for the world of metrology and its SI. Is the SI already as digital as it need to be for a successful implementation and spreading of digital calibration certificates, also on an international level?**

Second, we are **aiming to create a seamless environment** starting from ideal **digital certificates as a metrology service** all the way to **real-world applications where analog and digital certificates still coexist**. **Is this already sufficiently achieved?**

Third, **digital calibration certificates success** depends on **being readable by humans as well as various machines**. **Do we already have the right formats and structure to achieve this goal?**

In the **traditional analogue metrology world**, the **answer to these three challenges would be easy.** It is the **public and private institutional framework** to implement **standardization, accreditation and conformity assessment services including inspection, testing, laboratory and product certification**. In short, it is **the quality infrastructure** – or **QI,** which – by **creating confidence in measured values** - is **an essential guarantor for economic success.**

Especially in Germany, the **QI is a tremendous success story. Due to the QI, German products have an excellent reputation that is due to a complex system for quality assurance and consumer protection**.

This quality promise is named "Made in Germany" and is **as old as PTB itself – it stems from 1887.** It was **introduced in Britain** by the **Merchandise Marks Act** to **mark inferior goods especially from Germany that were at this time entering the British high-quality market.**

However, the **attempt to shield the British market** from the **aggressive and ambitious uprising Germany economy** was **not successful. Soon, "Made in Germany" became a synonym for quality** that **also indicated the change in the market policy in Germany – quality instead of cheap products.**

I am **sure that many countries have similar success stories** that have **their original at metrology** and **include the whole value chain of QI from product certification and quality monitoring.**

To **ensure** that **this quality promise also applies in a digitalized world**, the PTB, **together with other research partners and companies**, has **on the one hand established QI Digital,** a **project that unities the German value chain of QI in defining a digital workaround for the quality infrastructure of tomorrow**.

This project as well as an **internationally headed lighthouse project, GENIMEG II, are funded by the Federal Ministry for Economic Affairs and Climate Action (BMWK).**

With **the idea to create secure and robust calibrated measurement systems for the digital transformation**, GENIMEG II unites **13 partners throughout Germany** that **develop standards** to **ensure reliable communication of digital data**, **create**

trustworthy digital twins and **certificates that help to transform QI into the industrial digital world and thus strengthen the Germany economy.**

In **the spirit of a lighthouse**, this **project is seen from far, being of high significance and is guiding digital development.**

With these projects, **the future of calibration certificates in quickly going digital.** Therefore, **conventional calibration certificates could soon be an outdated document of the past. In present, PTB is issuing itself around 5,500 calibrations a year – still at paper - and is complemented by millions of calibrations per year in the German industry. Thus, conventional calibration certificates are also an issue of sustainability.**

Thus, **digital calibration certificates – coined as DCC's** also **giving the name to this conference** – **have highest priority in the metrology community and are the future of calibration certification** in **many respects.**

Moreover an by the wa: **DCC's abbreviation is another example of the magic number three for a good reason**.

This conference cl**early proves that the DCC is more than just the transformation of contents of the analogue certificate into a digital format.** Instead, it is **an impressive act of thinking calibration certification in a completely new, integrated way.**

And this brings me back to the three questions from the beginning which are central to realize versatile DCC's and are addressed in this conference.

With respect to the last of the three challenges, the **DCC is today not only readable by humans, but in particular also readable and interpretable by machines**. This is realized **by storing the data in a clearly defined format**, **allowing much more information to be transported with the calibration certificate than before.**

For that reason, **over the past several years, PTB has elaborated a machine-readable format for DCCs together with industry and international partners**. This format **is based on XML, a well-established markup language, furthermore suitable for worldwide use**

In **close cooperation with DAkkS, the German Accreditation body**, the **integration**

and application of a digital accreditation symbol as a machine-readable national emblem is now being implemented.

This **allows accredited bodies issuing all relevant information in a machine-readable manner without having to change between different media. Uniform semantics and interoperability**, which at the same time **meet the requirements of the ISO/IEC 17025 standard for laboratories is key to open this technique for international uses.**

For **the second question on the smooth integration of needs of industry**, let me **quote the Japanese engineer Ohno Taiichi**: **"Without standards, there can be no improvement."** Ohno Taiichi is **considered the father of the Toyota Production System.**

The **Toyota Production System** – or short TPS with three letters – **is a process for series production** in which t**he productivity of mass production is combined with the high-quality standards of workshop production.** At the same time, **employees are enabled to optimize quality by constantly improving processes** and **by avoiding waste of natural, human, and corporate resources**.

The aim of the TPS is to **design production in such a way that it is exactly in synchrony with the customer and that all resources are wasted as little as possible during the production process.** It **encourages responsibles to "go and see", suggesting that in order to truly understand a situation one needs to observe what is happening at the site where work actually takes place.**

This "GENCHI GENBUTSU" principle means **go to the source. Collect data and information to make the right decision, build consensus and achieve the goals at the best possible speed while considering sustainability and the needs of people.**

In this respect, The Toyota Production System **is on the one hand an impressive exam-ple of Industry 5.0. Following industry 4.0, and also known as the fifth industrial revolution, it is a new and emerging phase of industrialization in which humans collaborate with advanced technology and robots controlled by artificial intelligence (AI) to improve workflows.** This is **accompanied by a greater focus on people, as well as increased resilience and an improved focus on sustainability.**

On the other hand, **GENCHI GENBUTSU also fits very well to the core values of the DCC. In my opinion, the Toyota way is particularly apt for the DCC in the context of "going to the source" and of continuous improvement.**

In this spirit, **DCC's are tracing back to the source, the full digital calibration system**: A DCC contains **the entire information of a calibration in a format that is comprehensible to computers.** This **information can be read out directly from digital systems** and **can be used further on in an automated way.** It can **be easily combined with the concept of circular economy to consider products from a life-cycle perspective.**

As such, in my opinion, the **strength of DCC's within this stance of continuous improvement is that it is well prepared and equipped to include future requirements of the European green deal and UNESCO's sustainable development goals among others.**

The Digital Product Passport (DPP) is an actual instrument that includes exactly this perspective by making all relevant information on a product available in a secure, trans-parent, and trustworthy manner.

By **taking the next step via digital and standardized information**, it **supports the full value chain of circular economy.** As such, **it enables, for example, manufacturers, users, and disposal companies to ensure a uniform exchange of data throughout the entire product life cycle, from raw materials to recycling, from cradle to cradle**. According **to the EU's market goals, the DPP is to be made mandatory for almost all products. Some companies already offer prototypes and demonstrators for a DPP. Siemens, for example, offers a QR code-based DPP which can be used by mobile end device as smartphones.**

As institutions within the quality infrastructure, we **have now the unique chance to integrate these different approaches into a unifying framework**.

I have the vision of an administrative ecosystem in form of a digital warehouse with different administrative shelfs. **Machine-readable digital calibration certificates, digital product passes or digital conformity certificates will then be the building blocks of a versatile overall structure that is at hand to all stakeholders**

easily.

At last, let's come **to the first of our three challenges. Not only nationally, but also internationally, the digital transformation in metrology is extremely topical, and the digital SI is an important step.**

At the **27th General Conference on Weights and Measures (CGPM), which took place last November in Versailles,** the **digital transformation was one of the main topics.**

With **Resolution B of the General Conference**, it was **decided that a digital infrastructure should be established based on DCCs.**

Thus, the **CGPM clearly encourages the development and promotion of an SI Digital Framework.** This **includes features like** a) **a globally accepted digital representation of the S**I, but also b) **facilitating the use of digital certificates in the existing robust infrastructure for the world-wide recognition and acceptance of calibration and measurement capabilities.** And last but not least as c) **the adoption of the FAIR principles being Findable, Accessible, Interoperable, and Reusable, for digital metrological data and metadata.**

The **practical implementation rules are developed by the Consultative Committees (CC) that will also establish appropriate task forces to support the work.**

And – no surprise – **we see again three aspects underpinning the critical importance of metrological traceability for measurement data, being an established requisite for building trust.**

In its more than 135 years, PTB has not only successfully mastered mechanization and electrification transformation, mass production, automation, computers and networks, but has also shaped these transformations with new and harmonized standards, including the first and second quantum revolution.

Since our founding, our mission has been to combine cutting-edge scientific research with industrial services. Indeed, **this was precisely the aspiration of our founding fathers, Werner von Siemens and Hermann von Helmholtz**.

They **strived to consider newest scientific research methods of precision**

metrology as the sure ground of technical progress, allowing industry to preserve leading positions due to the access to the scientific progress in metrology.

This tradition of playing a decisive role in shaping science, society and the economy is what drives us to this day.

That **holds for the digital future of metrology**, and thus, **within the international metrology community, we are aiming at actively promoting digital transformation.**

This is the **motivation for us to organize this International DCC Conference**, which **have been held as fully digital events since 2020.** The aim is to **create an international framework to bring together stakeholders of the calibration community with those of digital certifications. In doing so, we follow the aspiration of paving the way for a future of secure and robust metrology within a digital world.**

In the beginning, I was referring to the magic number three and that all good things come in threes. This is also true for this DCC conference which holds now its third edition. This makes it **the third great and remarkable opportunity to bring together the international DCC community representing the state of the art and current advances in DCCs around the world, including all continents, but also all stakeholders, from NMIs over academia to the different accreditation bodies and industry representatives.**

This year's conference will - and here we close the circle – focus on transferring the DCC into practice – and further address the most important challenges of today I mentioned in the beginning – from machine readability over international harmonization and industry compatibility.

I would like to **take this opportunity to express my sincere gratitude to the hosts and coordinator of today's conference Sigfried Hackel**, and **the International Program Committee.** You have faced the challenge to organize a conference for more than 800 people – this has been achieved in a tremendously attractive and successful way. Thank you so much for your commitment.

I wish you a great conference with inspiring talks, many intensive discussions, and – also within this digital format – a huge number of opportunities for personal interactions. Thank you very much.

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Session A: The International Perspective of DCC

Presentations that would also fit into this session:

- 11 DCC and Digitisation versus Digitalisation and Digital Transformation
- 17 The Digital NIST: Pilot Project for the Digital Transformation of NIST's Measurement Services
- 21 DKD's Contribution to DCC Harmonisation and Coordinated Development
- 22 GEMIMEG-II – Status and Progress Report
- 31 DCCs for Non-Automatic Weighing Instruments (NAWIs) – Current Status of a Respective Working Group Elaborating "Good Practice" Conventions

01 Digital Calibration Certificate as part of an Ecosystem

Presenting author: Antonio Matamala, Beamex, Finland

E-mail address: antonio.matamala@beamex.com

Additional authors: Jan-Henrik Svensson, Sami Koskinen

Abstract

Digital calibration certificates are an important part of the calibration ecosystem, providing a way to store and transmit calibration information electronically between organizations.

In this presentation, we will explore the role of digital calibration certificates in the broader context of the calibration ecosystem, including the various stakeholders, systems, and processes involved. We will discuss the benefits of using digital calibration certificates, such as improved efficiency and accuracy, and we will examine the standards and guidelines that may be relevant to their use. We will also look at some of the challenges and considerations involved in implementing digital calibration certificates, including challenges related to security, interoperability, and regulatory compliance. We will highlight the complex IT situation in the pharmaceutical industry, which can benefit from an ecosystem approach due to regulations that place a very high priority on data integrity. Finally, we will also highlight economic factors that may be of great interest to industrial companies striving for operational excellence and improvement of calibration processes.

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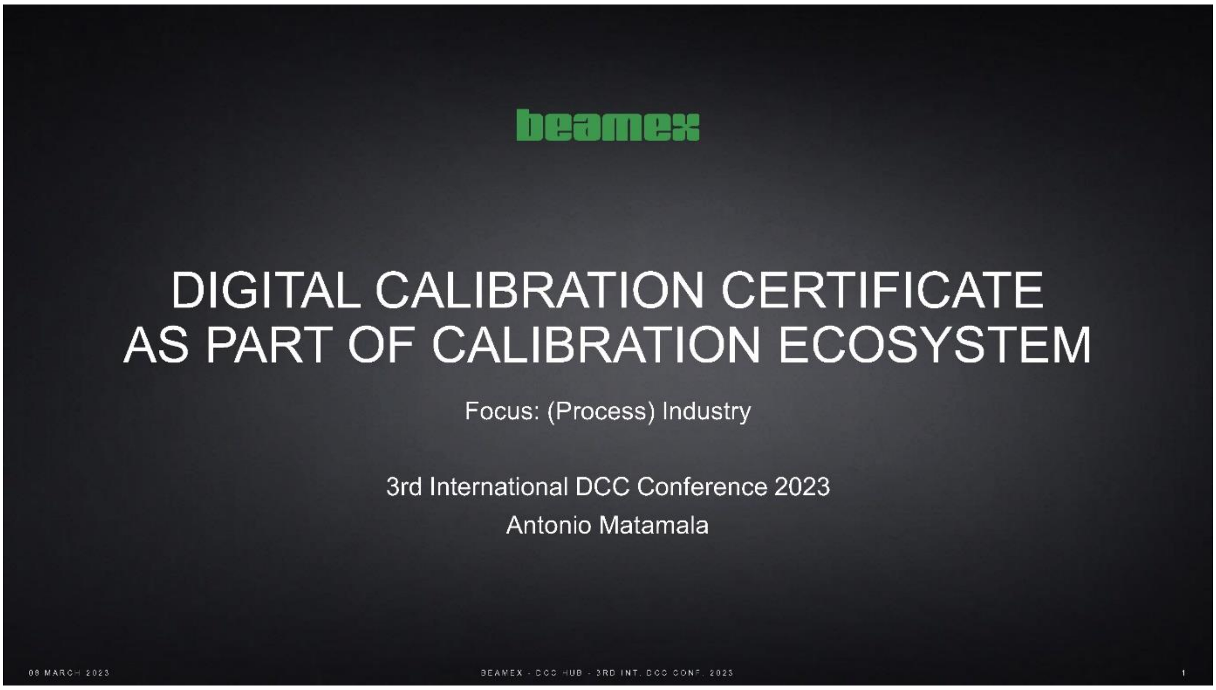
beamex
DIGITAL CALIBRATION CERTIFICATE
AS PART OF CALIBRATION ECOSYSTEM
Focus: (Process) Industry
3rd International DCC Conference 2023
Antonio Matamala
08 MARCH 2023
BEAMEX - DCC HUB - 3RD INT. DCC CONF. 2023
1


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TESTED
CERTIFIED
GUARANTEED


beamex
TESTED
CERTIFIED
GUARANTEED

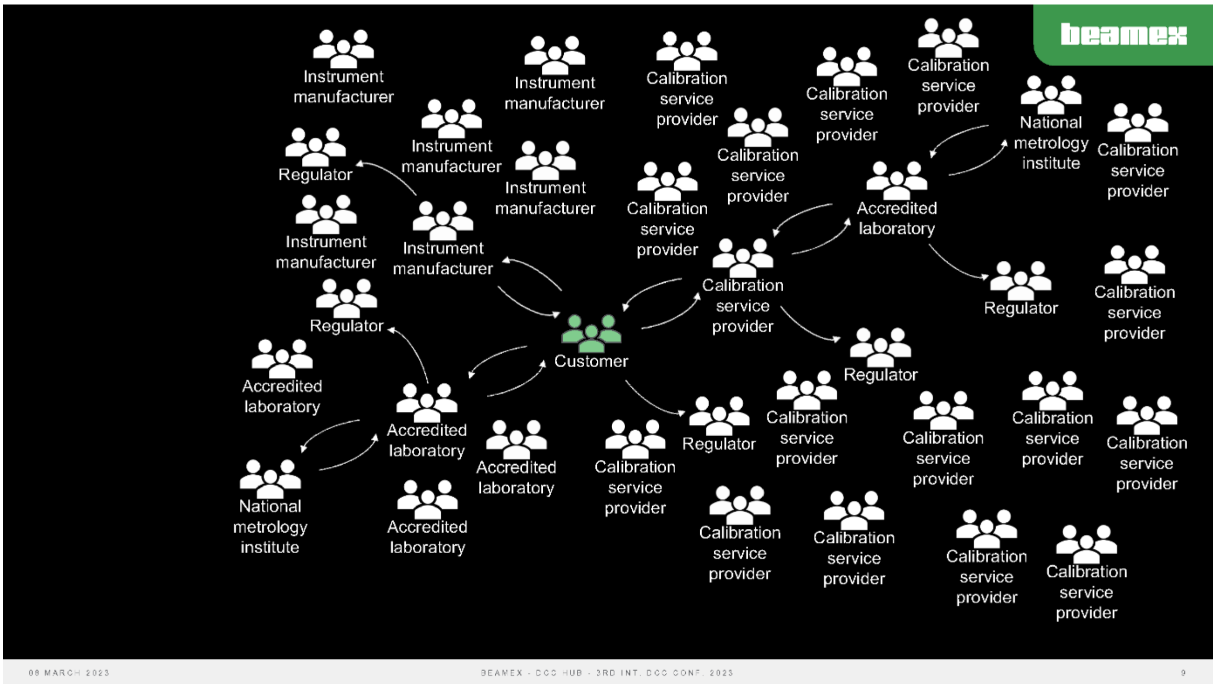

beamex
H2
HYDROGEN
ENERGY STORAGE
TESTED
CERTIFIED
GUARANTEED


beamex
INDUSTRIAL ENVIRONMENT


beamex
ACCREDITED ENVIRONMENT
beamex
A BETTER WAY TO CALIBRATE


beamex
1. Process Instrument
2.Reference Standard
CALIBRATION CERTIFICATE
Certificate of Calibration No


beamex
Calibration
Service
Provider
Accredited
Laboratory
Instrument
Manufacturer
Customer


beamex
Instrument manufacturer
Instrument manufacturer
Calibration service provider
Calibration service provider
Calibration service provider
Regulator
Instrument manufacturer
Calibration service provider
National metrology institute
Calibration service provider
Instrument manufacturer
Calibration service provider
Calibration service provider
Accredited laboratory
Instrument manufacturer
Instrument manufacturer
Calibration service provider
Regulator
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Customer
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Accredited laboratory
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Regulator
National metrology institute
Accredited laboratory
Calibration service provider
Calibration service provider
Calibration service provider
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How many 1-1 relationships did you count?
BTW: Beamex has 14k customers, globally
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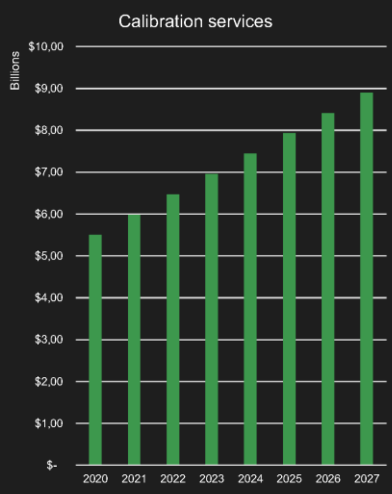
GLOBAL MARKET FOR CALIBRATION SERVICES

- Global market for Calibration Services: **US$8.9 Billion** by 2027 *
- Service Providers: **>59M** calibration certificates per year ($150/certificate)
- Assumption: service providers account ~50% of all calibrations delivered => ca. **120M** calibration certificates each year
- Are these ALL calibration certificates generated?



* Source: Global Industry Analysts Inc.

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CALIBRATION CERTIFICATE EFFORTS AND COSTS IN NUMBERS

- A4 paper 0.1 millimeters thick, height of 120 million sheets:
  - 120,000,000 sheets x 0.1 mm/sheet = 12,000,000 millimeters
  - 12,000,000 mm / 1,000 = **12,000 meters**
- Amount of paper per tree: 8,333 sheets of A4
  - Number of trees required: 120 million A4 sheets of paper / 8,333 sheets of A4 paper per tree = **14,401 trees**
- Total cost of sending calibration certificates via normal mail: $1.25 x 120 million = **$150 million**
  - Not to mention other costs, like CO2 emissions, etc.
- Total time required to process and send paper certificate: 5 minutes x 120 million = 600 million minutes = 10 million hours = 416,667 days = ca. 1442 years manual work per year
- Storage costs: "What you see above the ground, we have underneath the ground … paper archives"

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CALIBRATION CERTIFICATE EFFORTS AND COSTS IN NUMBERS

DCC

- Electronic transmission of calibration certificates:
  - faster,
  - more cost-effective, and
  - environmentally friendly
- More secure and reliable, less risk of certificates
  - lost,
  - damaged,
  - delayed when sent
- simplify record-keeping and tracking

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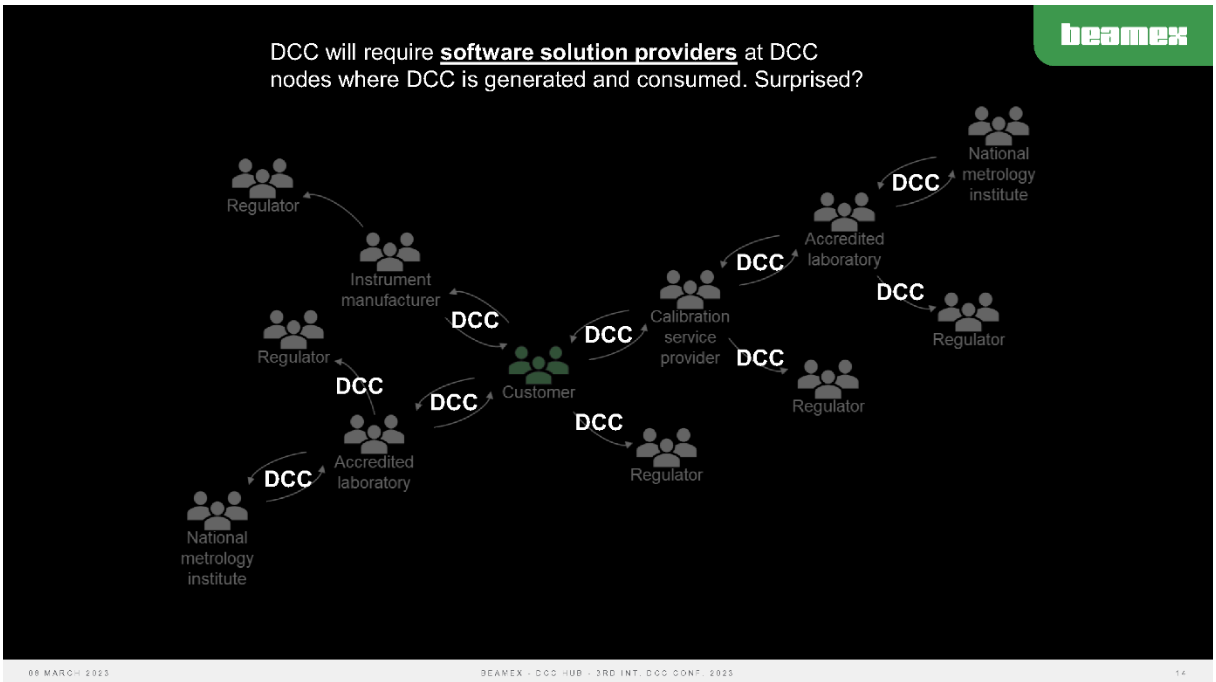

DCC INDUSTRIAL PROOF OF CONCEPT PROJECTS

PARTNERS WORKING TOGETHER

PTB
Perschmann Calibration
LAHTI PRECISION
SIEMENS
Boehringer Ingelheim
BAYER
ORION
VTT
beamex
VAISALA
testo
Aalto University

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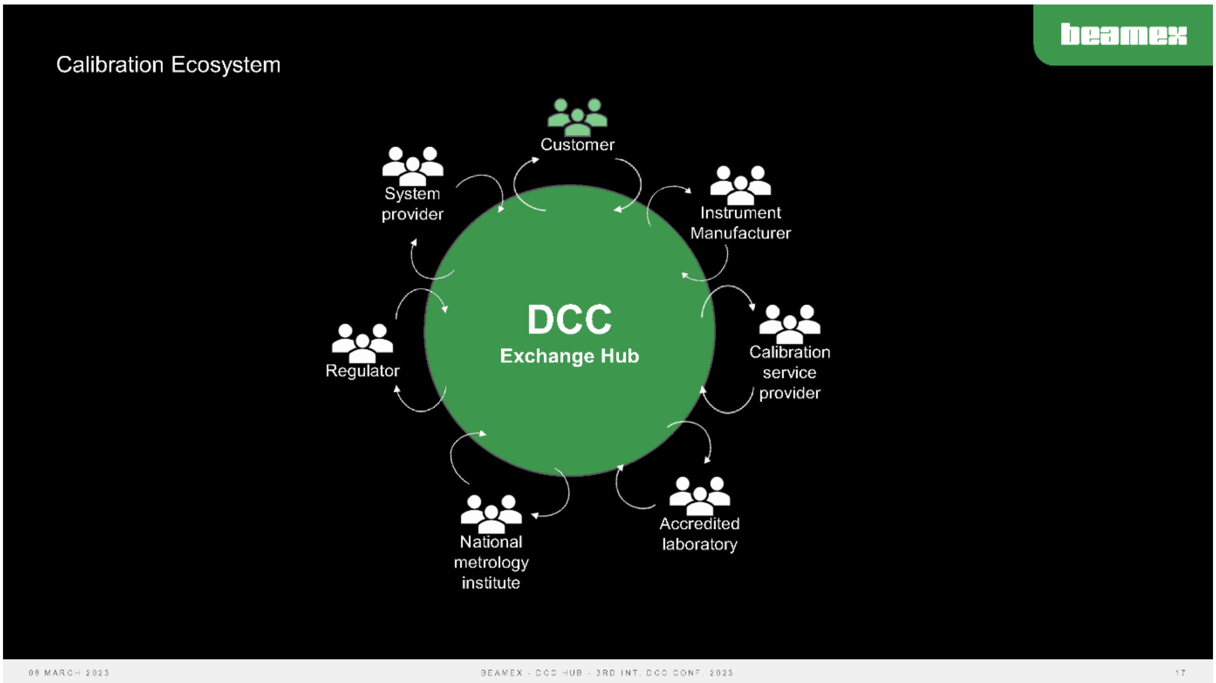
beamex
Calibration Ecosystem
Customer
System provider
Instrument Manufacturer
DCC
Exchange Hub
Regulator
Calibration service provider
National metrology institute
Accredited laboratory
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HIGH-LEVEL OVERVIEW DCC HUB
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gemimeg compatible
Powered by
beamex
testo Be sure.
Industrial Customer
ERP / Asset Mngt. (SAP, COMOS, …)
Calibration Management
Industrial Customer
ERP / Asset Mngt. (SAP, COMOS, …)
Calibration Management
trendic hub
Perschmann Calibration
Cloud Exchange & Integration Hub
Netilion
Industrial Customer
ERP / Asset Mngt. (SAP, COMOS, …)
Calibration Management
Industrial Customer
ERP / Asset Mngt. (SAP, COMOS, …)
Calibration Management
esz
calibration & metrology
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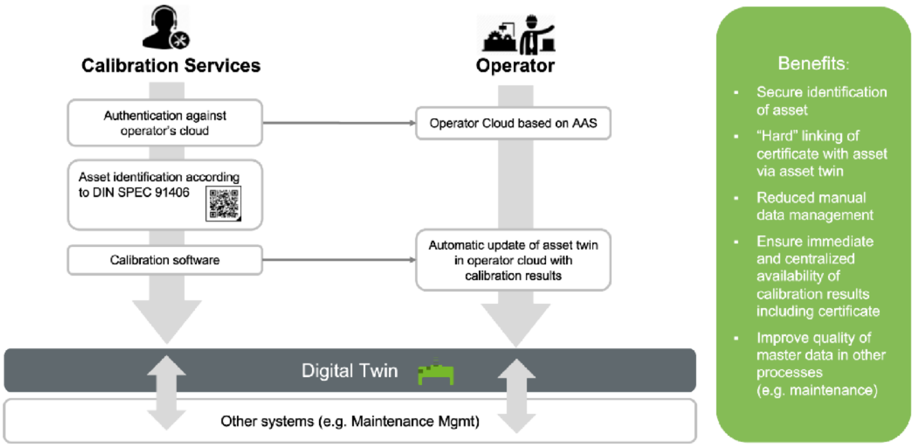
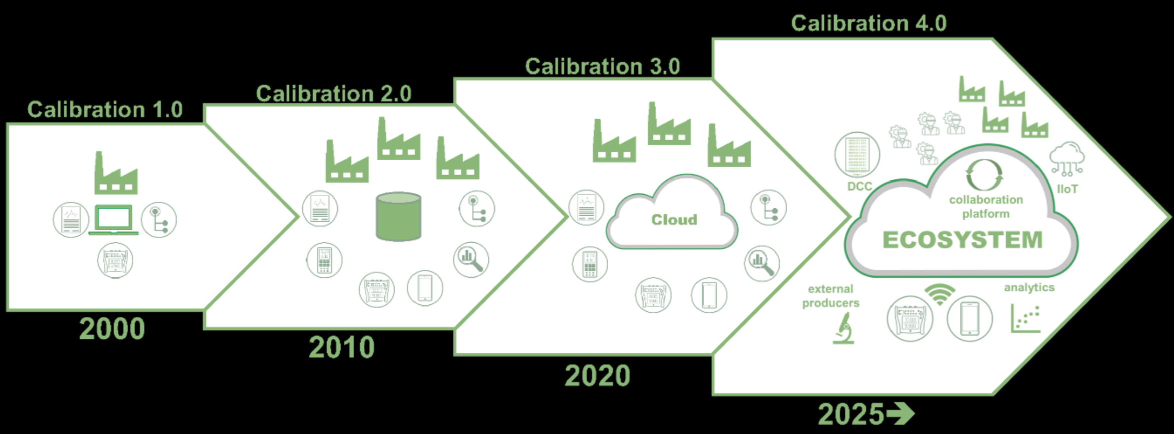
Updating of master data through on-site calibration at the customer's premises



DCC = Machine readable, exchangeable format, Industry 4.0 ready!

Where are we today?
Where are we heading to?




beamex
FOR A SAFER AND LESS UNCERTAIN WORLD
Join us on the DCC journey
Get in touch, we look forward to talking to you
Antonio Matamala
antonio.matamala@beamex.com

02 Calibration, Certification, Testing – Is Compatible Cigitalisation Possible?

Presenting author: Brett Hyland, NATA Australia

E-mail address: Brett.Hyland@nata.com.au

Abstract
There have been impressive digitalisation advances at an international level relating to the calibration and conformity assessment of instruments and equipment. While not as globally coherent, there has been effort directed towards digital assurance over traded goods. There are fundamental differences in the handling of such conformity data, compared with equipment assurance data, yet there are potential payoffs if a degree of harmonisation could be achieved given that the national accreditation bodies (ABs) and, in some cases the conformity assessment bodies (CABs), are the same. The digitalisation of accreditation data elements will be considered in terms of reconciling elements which are tightly defined, such as the Digital SI system, with more loosely structured data elements applicable to testing and certification. The challenge of validating accreditation status of CAB certificates will also be considered, with the premise that individual ABs have responsibility for deciding how an accreditation 'match' is determined. In principle, whenever data sets are agreed, it should be possible to bring these into a broader framework without compromising established data validation systems. Some insights will be reported from an Australian collaboration exploring these matters. The work will be placed within the context of a Draft White Paper from the United Nations Trade Facilitation and E-business group, dealing with digital exchange of conformity certificates and which builds on the emerging practice of barcoded URLs in certificates for authentication. It is hoped that drawing attention to these developments may facilitate discussion regarding engagement on digitalisation matters between the scientific and trade measurement community and the wider conformity community.

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Calibration, Certification and Testing – is compatible digitalization possible?

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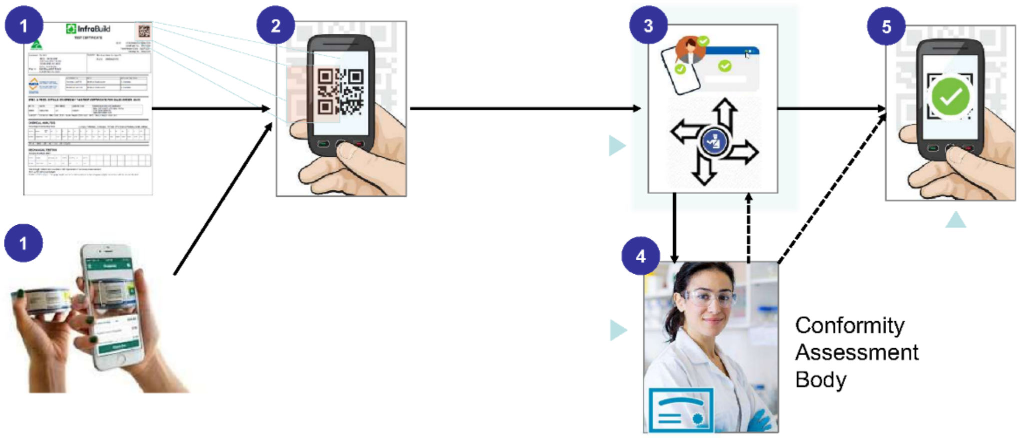
Can this product-related concept be generalised?



NATA

Different emphasis in calibration

- Testing/certification involves parties unknown to the CAB seeking access to conformity data
- Tested/certified goods are dispersed (calibrated items are normally held by a single party)
- There are differences in the degree of commercial sensitivity of information
- Calibration accreditation uniquely involves Calibration & Measurement Capability statements
- Stark difference in progress towards digitalizing content of reports/certificates

NATA

Yet …there is also common ground

- Need for **unique identification** of certificates/reports
- Need to **link data with physical objects** (item under test, traded goods)
- Need for **defined access** to certificates/reports
- Certificates/reports are **subject to revision** by the issuing CAB
- A **common accreditation structure** exists (ILAC MRA coverage)
- Accreditation coverage depends on **parameter combinations** (product type, measurand, standards)

NATA

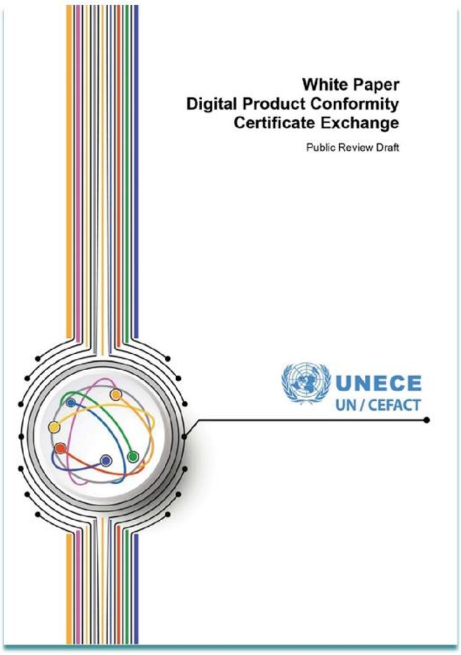
Is there a driver for cooperation across sectors?

- Many CABs are involved in both testing and calibration activities
- Most Accreditation Bodies (AB) accredit both testing and calibration (often certification as well)
- Compatible processes may improve the chances of successful implementation for all sectors

United Nations - Centre for Trade Facilitation and Electronic Business (CEFACT)

Introducing UN/CEFACT

- **Facilitates national and international transactions**, through simplification/harmonization of processes and information flows.
- Delivering **internationally agreed** recommendations, e-business standards, common libraries, directories and code lists.
- A logical home for discussion regarding conformity data exchange/access



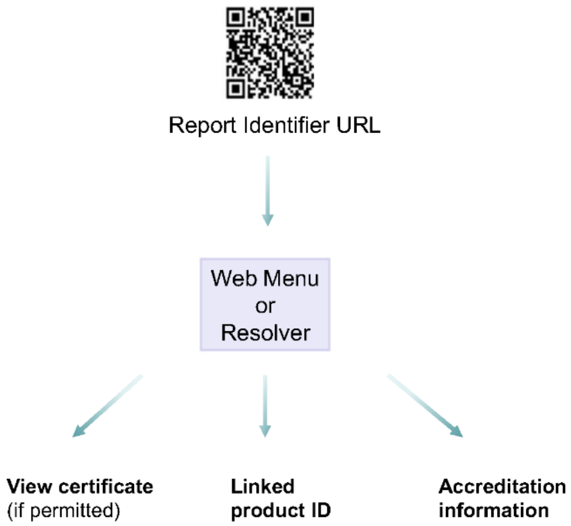
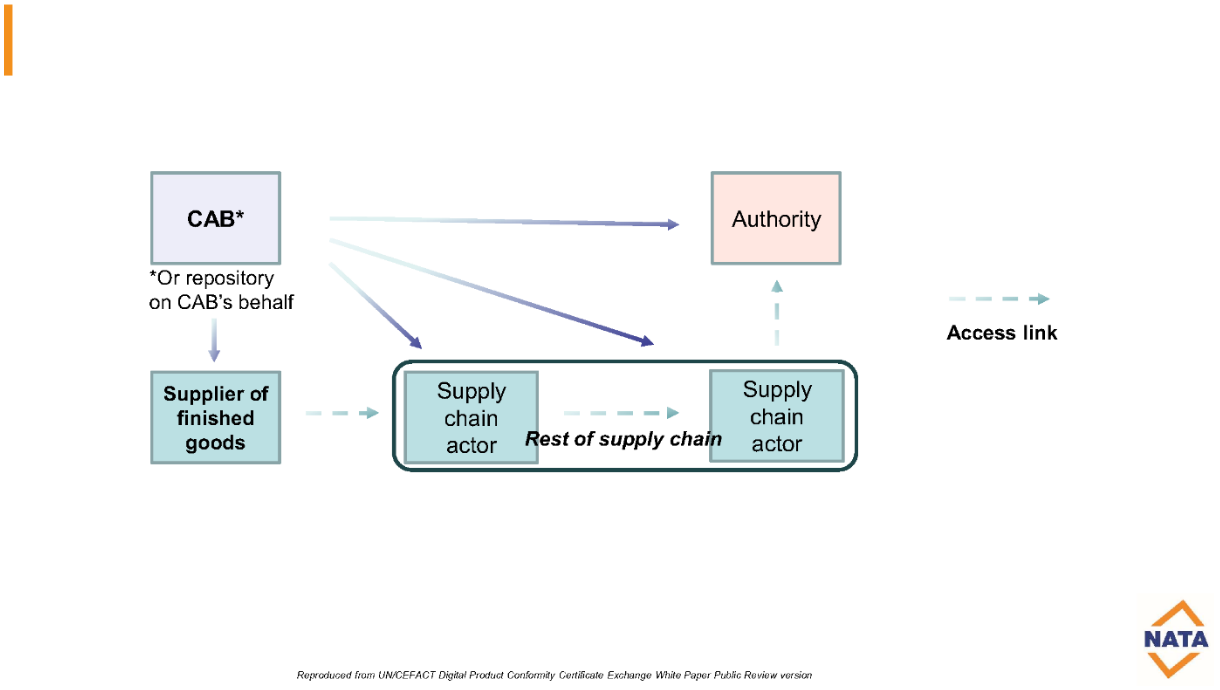
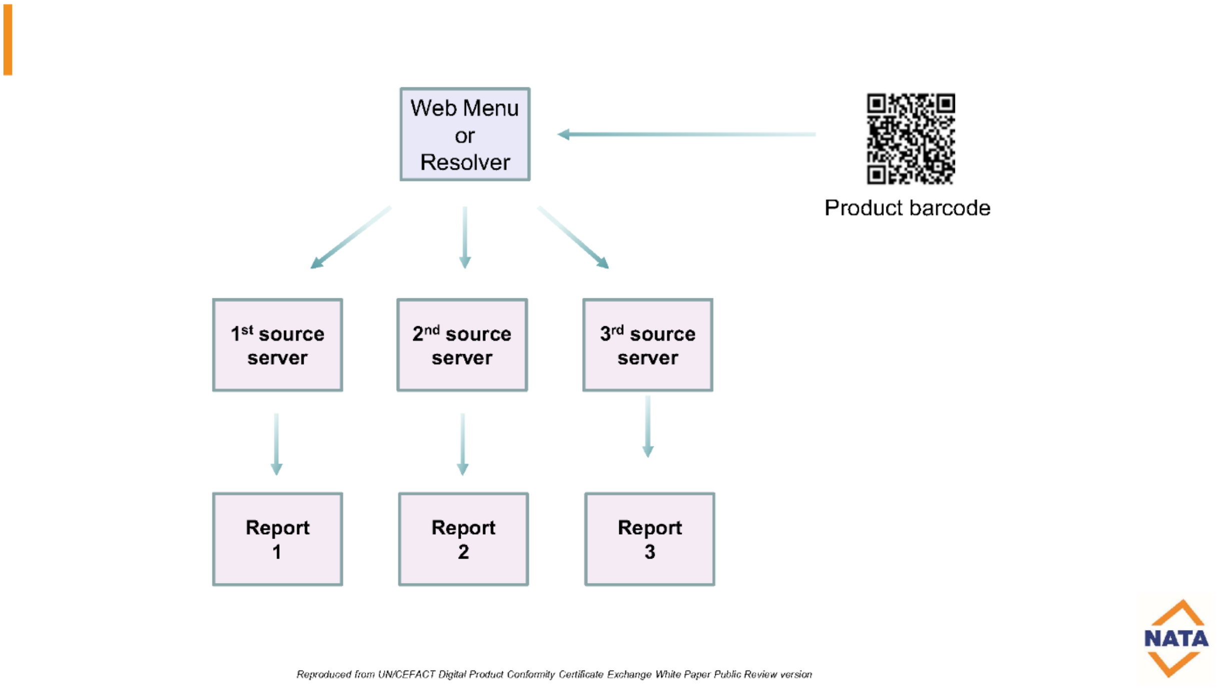


Image adapted from diagram from UN/CEFACT Digital Product Conformity Certificate Exchange White Paper Public Review version


CAB*
*Or repository on CAB's behalf
Authority
Access link
Supplier of finished goods
Supply chain actor
Rest of supply chain
Supply chain actor
Reproduced from UN/CEFACT Digital Product Conformity Certificate Exchange White Paper Public Review version
NATA


Web Menu or Resolver
Product barcode
1st source server
2nd source server
3rd source server
Report 1
Report 2
Report 3
Reproduced from UN/CEFACT Digital Product Conformity Certificate Exchange White Paper Public Review version
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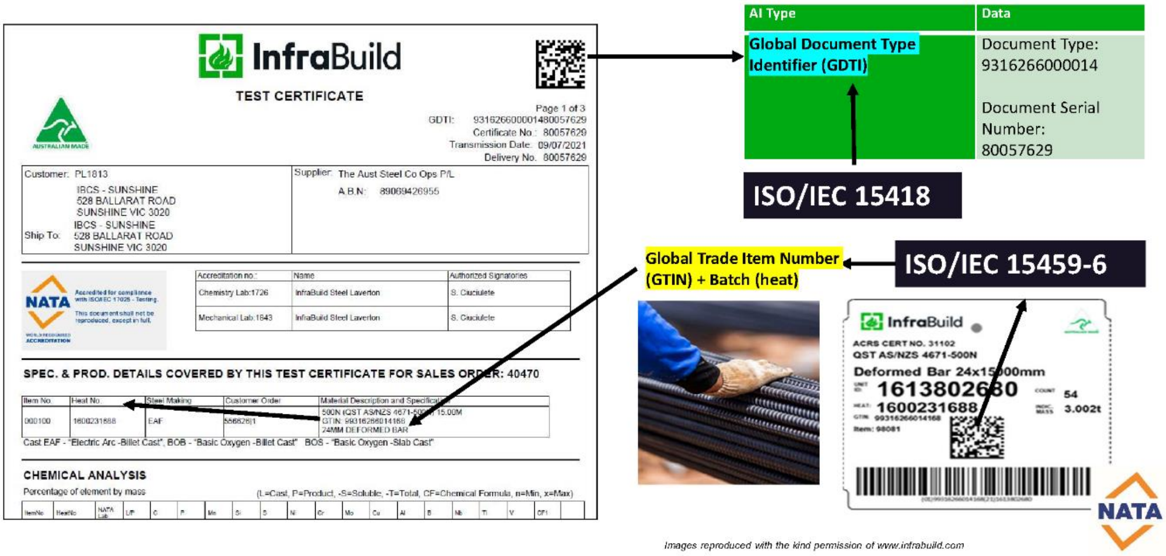
Standard identifiers



An accreditation perspective

Will we ever achieve **digital matching** from certificates to accreditation scopes?

Universal Code Lists remain out of reach for testing parameters (product type, procedure/standards, measurands/determinations, etc). Consider the following taken from a real accreditation scope *(AS = Australian Standard):*

- AS 3996 Appendices D4.3 and D4.4 for bicycle tyre penetration resistance
- AS 1012.14 Clause 6.4 d) i) only for concrete specimen conditioning
- AS 1012.14 excluding Clause 6.2 for concrete compressive strength

Product Certification is arguably even worse off! Conformity activity in this area is globally splintered into hundreds of Schemes, each operated by an individual Scheme Owner (SO) and carrying its 'home grown' set of language for the AB to adopt.

Defining accreditation elements

However, code lists do exist at one level – that is, the idiosyncratic data sets issued by individual ABs or SOs. This may seem chaotic, but at least it is already in place!

Might it also point to a flexible framework that could be adopted across calibration, testing and certification?

Imagine an AB could make available to each CAB a **selectable menu of time-stamped combinations of accredited parameters**, reflecting the CAB's evolving accreditation coverage over time.

Defining accreditation elements

Any instance of a new combination of parameters added by the AB would be time-stamped ('Granted') and, at the time of any scope update, any obsolete entries would be time-stamped ('Ended'). A key finding is that the **parameters could be completely free text** (as indeed is the case for many ABs) and still operate as intended, since they need only apply to the listed CAB.

An example of an accreditation line entry for a specific testing laboratory might be:

Granted ***xx/yy/zz*** for *17025 - testing* of *Bicycle tyres* to *AS 3996 Appendices D4.3 and D4.4*
Ended on ***Nil (remains current)***

An analogous example for a certification body:

Granted ***xx/yy/zz*** for *Product Certification under the CodeMark (Australia) scheme* for *Ceiling insulation products* to *National Construction Code 2018 Vol 1 – J1.2(a)*
Ended on ***Nil (remains current)***

Defining accreditation elements

When a CAB issues a report, they could select any/all of the valid parameter combinations relevant to their reported result and then they could irrevocably (via register, digital stamping etc) **associate those data points to the issued report**. Any obsolete parameter combination (showing an ‘End date’) would not be selectable by the CAB.

If an AB at any point wants to change their code lists (or decides to adopt a newly-agreed universal code list), any historically issued reports/certificates would not be not affected, since the time-stamped entries based on the earlier code list would **remain valid and searchable**.

On this basis, the international community could progressively absorb internationally agreed code lists, **without having to rewrite global trade systems** every time an AB wants to amend their code lists.

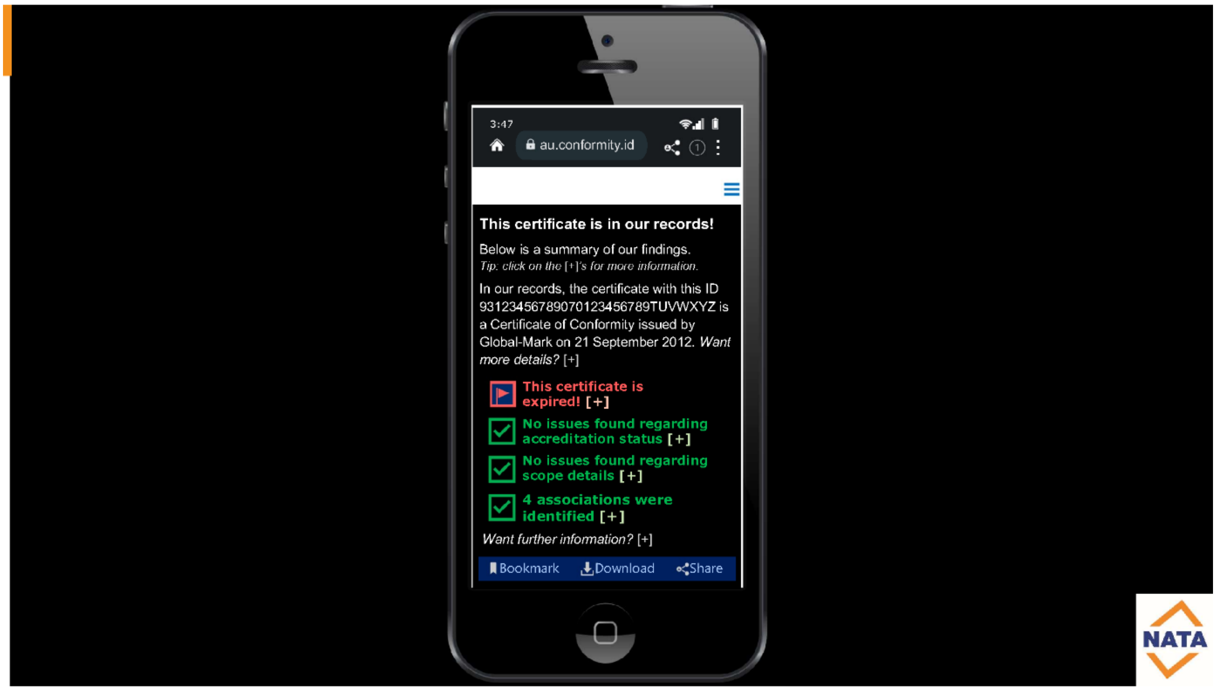
Back to physical test items

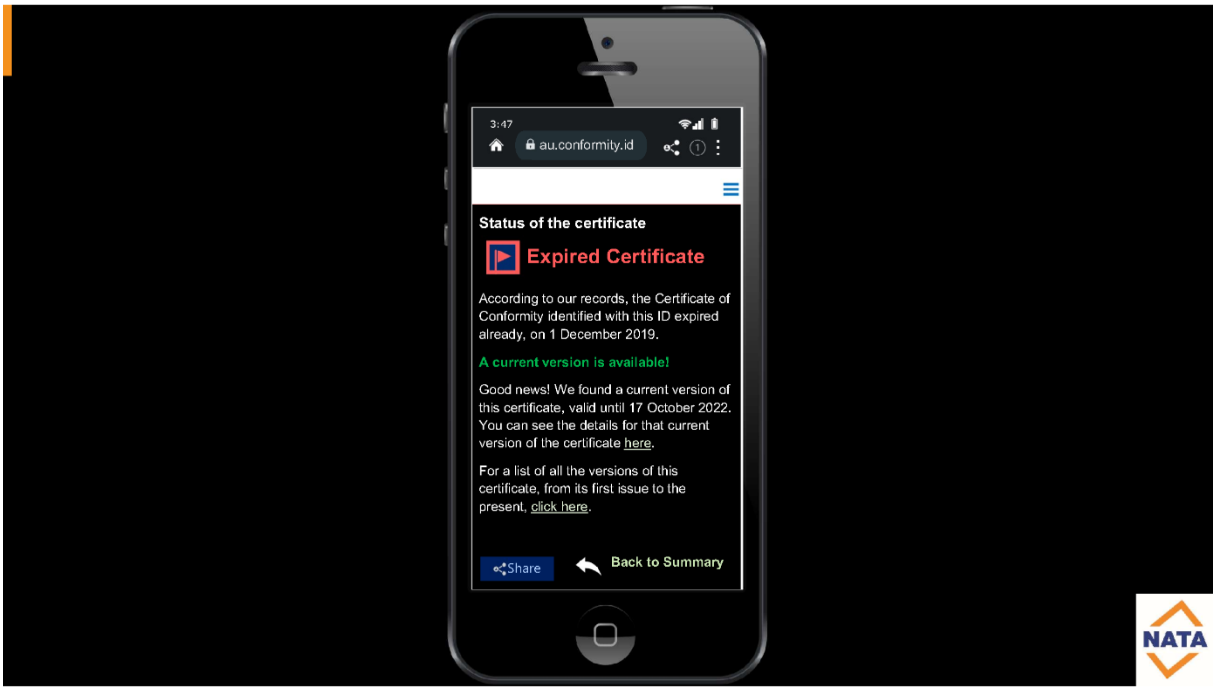
To bring us back to the original premise - linking reports to physical products - what if the CAB **scans the product barcode for the item under test** – and then irrevocably associate that identity with the issued report?

Could we achieve a **globally interoperable** framework for product conformity validation? To find out, NATA, JAS-ANZ and GS1 in Australia are undertaking some non-commercial validation of the concept.

Example of non-commercial conceptual work underway

NATA/JAS-ANZ/GS1 collaboration funded by Australian Department of Industry Science and Resources




3:47
au.conformity.id
Status of the certificate
Expired Certificate
According to our records, the Certificate of Conformity identified with this ID expired already, on 1 December 2019.
A current version is available!
Good news! We found a current version of this certificate, valid until 17 October 2022. You can see the details for that current version of the certificate here.
For a list of all the versions of this certificate, from its first issue to the present, click here.
Share
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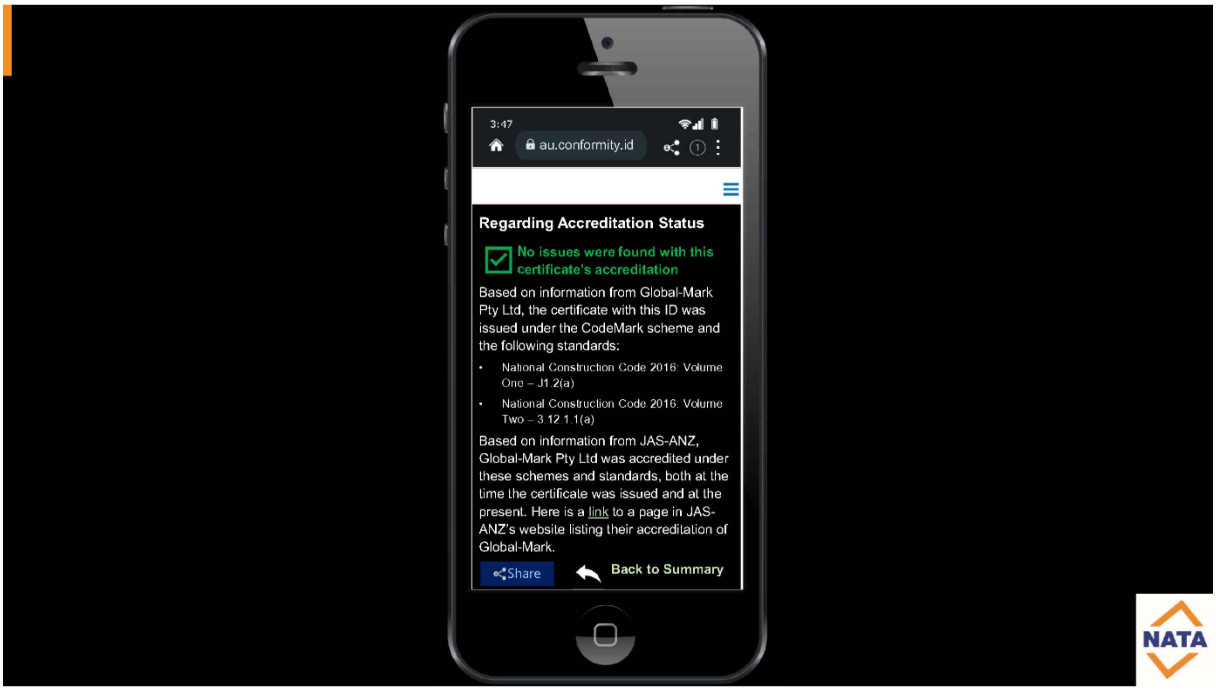
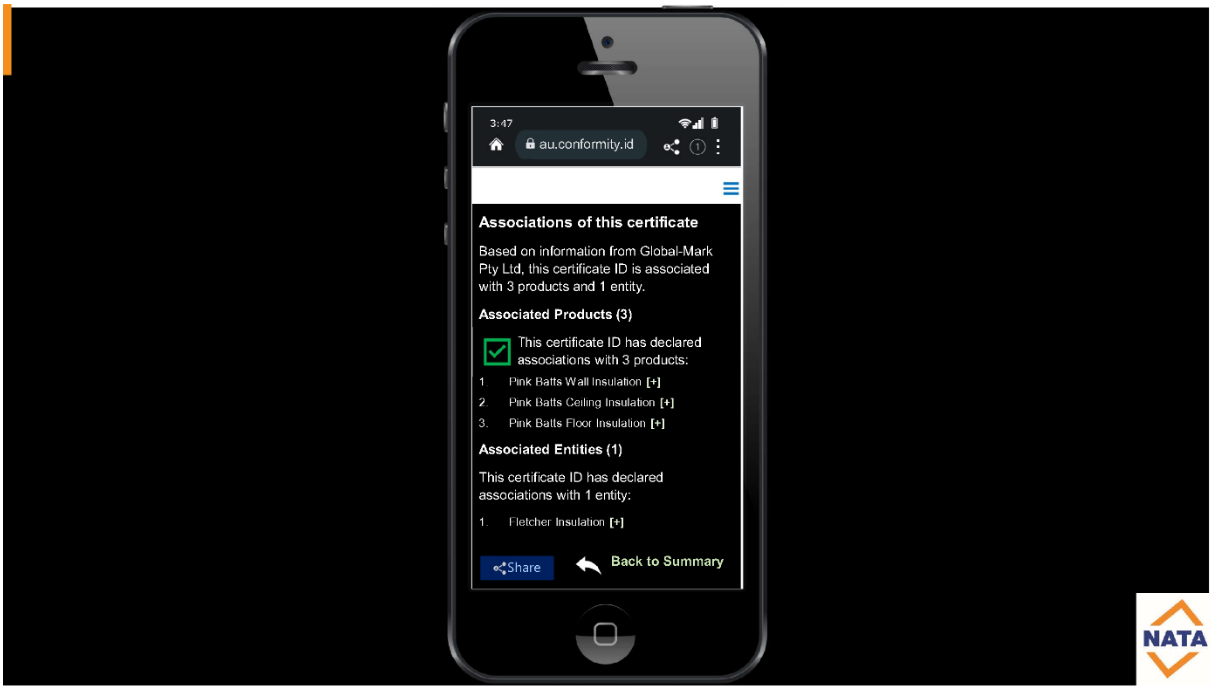

3:47
au.conformity.id
Regarding Accreditation Status
No issues were found with this certificate's accreditation
Based on information from Global-Mark Pty Ltd, the certificate with this ID was issued under the CodeMark scheme and the following standards:
National Construction Code 2016: Volume One – J1.2(a)
National Construction Code 2016: Volume Two – 3.12.1.1(a)
Based on information from JAS-ANZ, Global-Mark Pty Ltd was accredited under these schemes and standards, both at the time the certificate was issued and at the present. Here is a link to a page in JAS-ANZ's website listing their accreditation of Global-Mark.
Share
Back to Summary
NATA



Is there any potential benefit for the CAB community?

CABs retaining flow-on value of connections made from conformity data to the physical world ('data is the new oil')

CABs seen as the custodians of their own data in a purely digital environment, and not forced to upload their data to platforms in vendor-stipulated formats

CAB outputs driving (rather than limiting) global innovation, using feasible models for **data aggregation** across different economies and supply routes

Machine validation of **accreditation** coverage

Closing thoughts

The calibration sector is clearly the frontrunner in the digitalisation space. Still, exchanging ideas with other sectors may unlock additional benefit for all areas of conformity assessment.

Relevant fora for dialogue include:

- ILAC & regional bodies
- DCC/DCoC/DTC project groups
- National Laboratory Associations
- UN/CEFACT project groups

Possible topics for cross-sector exchange:

- Use of standardised identifier protocols?
- Distribution of certificates via weblink to the CAB (or nominated host) repository?
- Common approach for validating accreditation coverage?

Would you like to begin this conversation?

Thank you!

For further information please contact
Brett.Hyland@nata.com.au

03 Towards Digital SI Traceability Statements in Calibration Certificates Issued by NMIs and DIs

Presenting author: Olav Werhahn, Bureau International des Poids et Mesures (BIPM)

E-mail address: olav.werhahn@bipm.org

Additional authors: Gregor Dudle, Stéphanie Maniguet, Chingis Kuanbayev, Janet Miles

Abstract

In line with Resolution 2 of the 27th CGPM [1], we propose a simple first step on the route towards digital SI traceability. We demonstrate how a calibration certificate covered by the CIPM Mutual Recognition Arrangement (CIPM MRA) can be directly linked to the issuing laboratory's internationally agreed and published calibration and measurement capability (CMC).

The concept of metrological traceability is the backbone of modern international acceptance and reliability of measurement data. The CIPM MRA provides the fundamental framework for international recognition of the national measurement standards of participating NMIs and DIs and the certificates they issue [2]. One of the outcomes of the CIPM MRA are the peer-reviewed CMCs published in the BIPM key comparison database (KCDB) [3], which are generally underpinned by the results of international comparisons [4]. When calibration certificates are issued to customers by NMIs/DIs, the CIPM MRA logo and a statement referring to CMCs published in the KCDB can be used. The use of the sentence and the logo is copyright-protected and granted by the BIPM as laid down in the policy document CIPM MRA-P 11 [5].

A recent survey on digital transformations carried out amongst members of the CIPM's Consultative Committees (CCs) [6] showed that there is significant interest in the development of digital calibration certificates (DCCs), but currently little awareness as to how metrological traceability to the SI might be digitally addressed. In this presentation, we propose and discuss the concept of including of an explicit link to the underpinning CMC; this can be introduced into calibration certificates with immediate effect, and easily translated into DCCs. The concept is effectively a digital extension of the use of the CIPM MRA logo and corresponding statement and is compatible with the digital requirements and FAIR principles of DCCs.

[1] CGPM, On the global digital transformation and the International System of Units, 27th CGPM Resolution 2, 2022, URL: https://www.bipm.org/web/guest/committees/cg/cgpm/27-2022/resolution-2

[2] CIPM, Mutual recognition of national measurement standards and of calibration and measurement certificates issued by national metrology institutes, CIPM MRA, 1999, URL: www.bipm.org/documents/20126/43742162/CIPM-MRA-2003.pdf

[3] BIPM key comparison database (KCDB), www.bipm.org/kcdb

[4] CIPM, CMCs in the context of the CIPM MRA: Guidelines for their review, acceptance and maintenance, CIPM MRA-G 13, 2022, URL: www.bipm.org/documents/20126/43742162/CIPM-MRA-G-13.pdf

[5] CIPM, Overview and implementation of the CIPM MRA, CIPM MRA-P 11, 2021, URL: www.bipm.org/documents/20126/43742162/CIPM-MRA-P-11.pdf

[6] BIPM, Evaluation Report of the survey on digital transformations, 2022, URL: www.bipm.org/documents/20126/77500070/Evaluation-Report-CC-Survey.pdf

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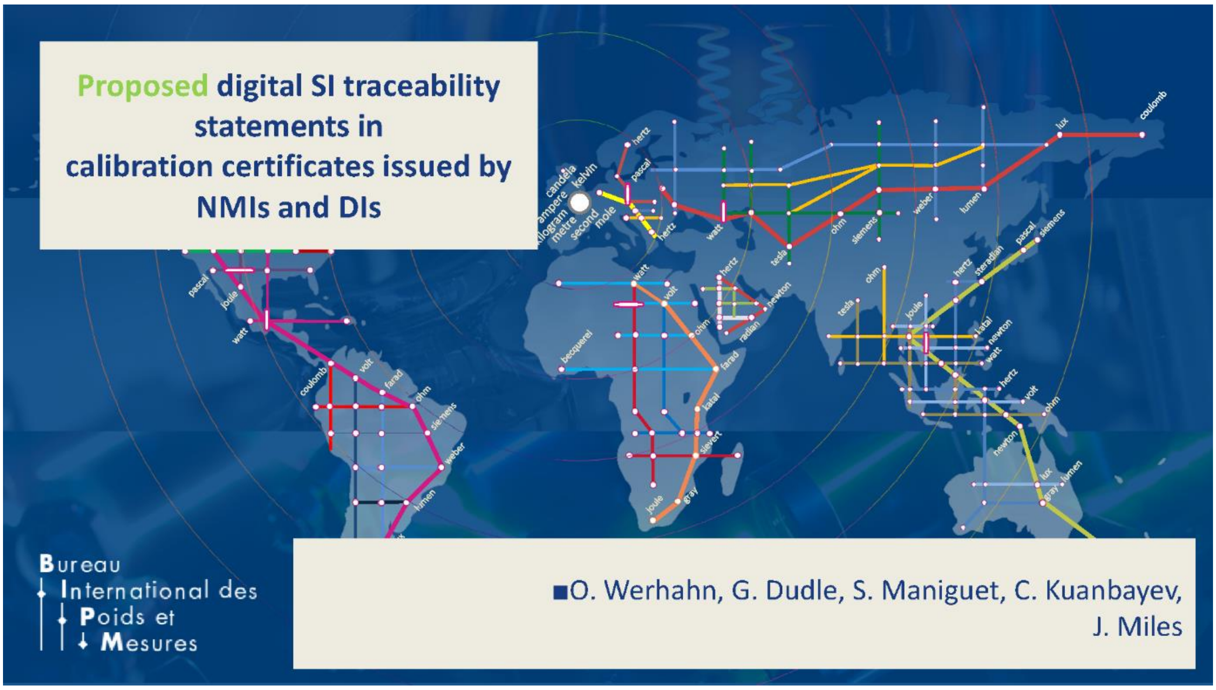

Calibration Certificates

- ISO/IEC 17025-2017: … section 7.8.4.1, clause c) “a statement identifying how the measurements are metrologically traceable” – two routes explicitly mentioned, i.e. the CIPM MRA and ILAC MRA;
- issued by NMIs/DIs documenting a certain calibration service;
- in the context of the CIPM MRA calibration services of NMIs/DIs can be backed up by calibration and measurement capabilities published in the KCDB.

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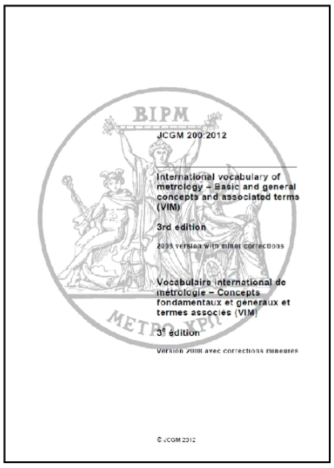
Metrological Traceability

- The International Vocabulary of Metrology (JCGM 200:2012, VIM) provides the definition of the concept/term of "metrological traceability"

  property of a measurement result whereby the result can be related to a reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty.



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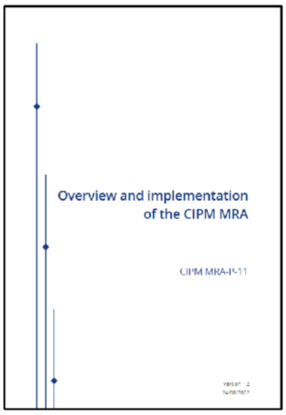
CIPM MRA and its governing processes

- The CIPM MRA participating laboratories' activities provide technical evidences on their calibration and measurement capabilities (CMCs).
- CMCs are the outcome of the CIPM MRA defining
  - the measurement range,
  - the measurement uncertainty, and the statement
  - of the metrological traceability

  for a calibration or measurement performed at the NMI/DI
- Calibration certificates issued of NMIs/DIs on services provided to customers can relate to CMCs published in the KCDB.



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in analogue world

Use of the CIPM MRA logo

Description of the logo. The logo for the CIPM MRA is:

CIPM MRA

This logo, designated as "CIPM MRA Logo", is the exclusive property of the BIPM.

The following "CIPM MRA statement" shall also be included on the calibration certificates together with the logo.

> *This certificate is consistent with the capabilities that are included in Appendix C of the CIPM MRA drawn up by the CIPM. Under the CIPM MRA, all participating institutes recognize the validity of each other's calibration and measurement certificates for the quantities, ranges and measurement uncertainties specified in the KCDB (for details see https://www.bipm.org/kcdb/).*

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in the digital era

- **The concept of how to provide a statement of metrological traceability in DCCs is not yet clear.**
  - Of the CC members expressing an interest in DCCs, **only 15 %** were able to **articulate** how **metrological traceability** to the SI could be addressed **in a DCC**.

https://www.bipm.org/documents/20126/77500070/Evaluation-Report-CC-Survey.pdf/f087e5a9-eaee-6d59-36c3-d64f751f7999

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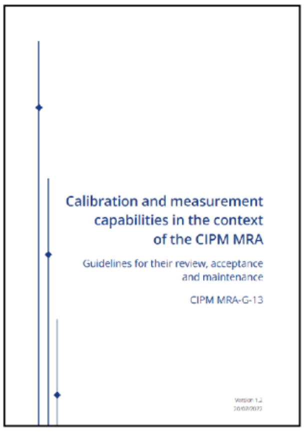
CMCs and the CIPM KCDB

- CMCs published in the KCDB in the context of the CIPM MRA
- do have a PID:

RMO-Area-A2-ID-V

with

RMO	organization claiming the CMC file
Area	corresponding acronym of the metrology area
A2	ISO 3166-1 Alpha-2 country code (or the abbreviation of an international organization)
ID	unique CMC identifier, eight symbols length
V	alphanumerical version value from 1 to Z.



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CMC identifiers and the API KCDB

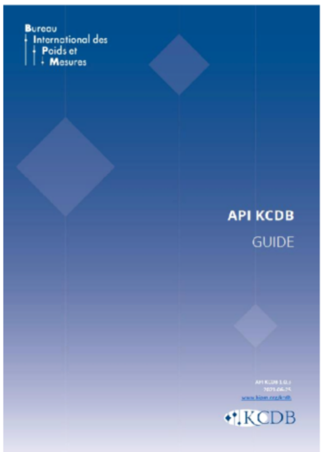
The Key Comparison Database - KCDB - supports the Mutual Recognition Arrangement of the International Committee for Weights and Measures (CIPM MRA), implemented in 1999. It contains data on Calibration and Measurement Capabilities (CMCs) and comparison results of measurements in physics, chemistry and biology, and ionizing radiation. The KCDB is an evidence-based database: all data included have been reviewed by international groups of experts and approved for mutual recognition.

The KCDB website www.bipm.org/kcdb gives access to the following open access services:

- Search published CMCs in the KCDB
- Search published comparison reports and results
- Information on statistics and recent news on issues linked to CMCs and comparisons
- A set of guidance documents and video demonstrations

In 2021 the BIPM made available an Application Programming Interface - API - for search of CMCs on the KCDB.

The API KCDB provides the data as a response of search queries on CMCs. Although it may provide the basis for digital CMCs on a longer term, this API is presently only intended for search on CMCs.



[Link]

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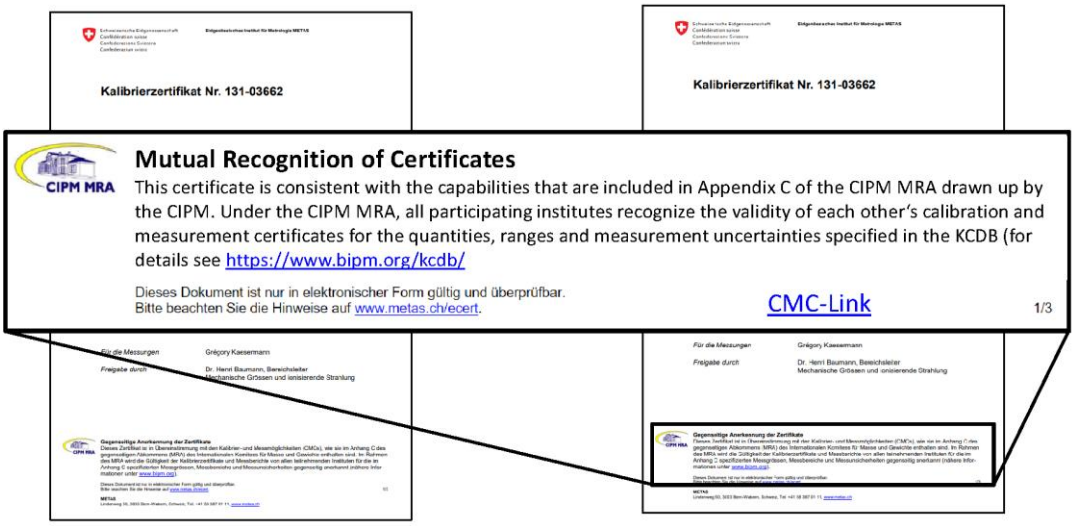
CMC identifiers and the API KCDB

- CMCs are searchable in the KCDB by their PID;
- The API KCDB provides a means for machine-initiated retrievals and feeds back search results on published CMCs;
- Example: [EURAMET-T-FR-00000L89-1]

idea: automatic check of metrological traceability chain by a machine

Current situation
(paper or PDF)

Future
(PDF and machine readible)



Conclusions

- CMCs as outcome of the CIPM MRA are one internationally accepted demonstration of metrological traceability to the international system of units (SI).
- Analogue calibration certificates can provide a statement pointing on CMCs published in the CIPM MRA database (KCDB).
- Digital calibration certificates (in analogy to the analogue world) could make use of the CMCs' PID, uniquely identifying a specific CMC on what the calibration has been done at the NMI/DI.
- CMC PIDs enable a machine readable/executable digital metrological traceability statement to the SI in digital calibration certificates.

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04 Recent Advances in Digital Representation of Measurement Data by the D-SI Metadata Model

Presenting author: Daniel Hutzschenreuter, PTB, Germany

E-mail address: daniel.hutzschenreuter@ptb.de

Additional authors: Wafa El Jaoua, PTB

Abstract

Establishing machine-useable and machine-interoperable measurement data based on the International System of Units (SI) is a fundamental perquisite to foster an integration of digital metrological data into highly automated processes. Today, the international Digital Calibration Certificate (DCC) format is implementing this requirement by using the D-SI metadata model for the representation of values of all physical quantities. The steadily growing maturity of the DCC format, the increasing expertise from DCC users, and developments towards a digital provision of the SI by the International Committee for Weights and Measures (CIPM) and its bureau in Paris (BIPM) has raised promising ideas for further advancements of the D-SI. An update of the metadata model to adopt to these ideas is currently being discussed and will be presented. One highlight is the outline of approaches for future interoperation with the new BIPM Unique SI Reference Point which will be providing authoritative definitions of the SI for digital data.

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Braunschweig and Berlin
National Metrology Institute

D-SI Metadata Model

Recent advancements in digital representation of measurement data

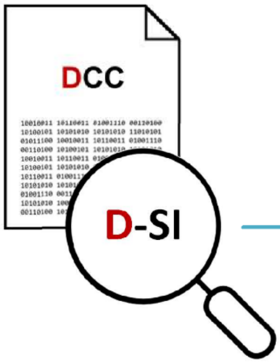
Wafa El Jaoua, Daniel Hutzschenreuter
Department 9.4, Metrology for the Digital Transformation

Credits

- DCC developers, users and DKD members
- CIPM Task and Expert Group on the Digital-SI
- BIPM 'SIDR' support (Janet Miles & Stuart Chalk)
- PTB colleagues (Wafa El Jaoua, Maximilian Gruber, Frank Härtig and many more)

D-SI Metadata Model

Exchange of metrological core data suitable for machines in IoT and Industry 4.0



Easy to use
Unambiguous
Universal
Safe
SI, VIM, GUM

Used since 2019 (outcome SmartCom EMPIR project)

Minimum Requirement
Value + (SI) unit

Further needs emerging
- CIPM Digital-SI
- user applications (DCC, D-CoC, …)
- Smart Standards

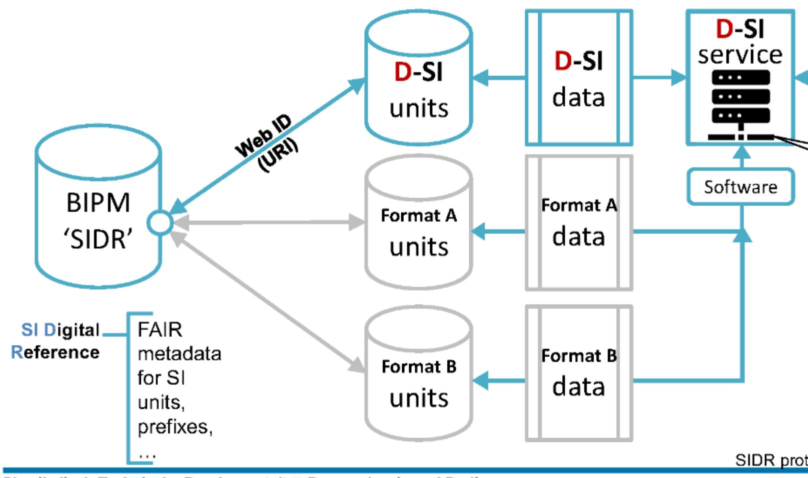
CIPM SI Digital Framework

Fostering worldwide interoperability across existing digital units representation systems and metrological data based on

- Definitions for International System of Units in digital world (**BIPM 'SIDR'**)
- **Translations/mappings** between representations
- Disambiguation by **kinds of quantities**
- **FAIR** (Findable, Accessible, Interoperable, Reusable data)
- CIPM trustworthy anchor within Quality Infrastructure

BIPM digital reference for SI 'SIDR'

Machine and human actionable interoperation & linking across unit formats



- Transition across unit representations
- FAIR, open access & open source
- Online and/or offline
- Enable linking 'SIDR' and future QI services

SIDR prototype: https://siunits.stuchalk.domains.unf.edu/

Example D-SI linking units

```
<si:real xmlns:si=https://ptb.de/si>
  <si:value>6.62607015e-34</si:value>
  <si:unit>/joule/second</si:unit>
</si:real>
```

D-SI service interface
https://ptb.de/si/unit/api message: "/joule/second"

```
si:unit:        "/joule/second"
sidr:unit:      "https://siunits.stuchalk.domains.unf.edu/api/unit/joule_second"
formatA:unit:   "http://formatA.org/..."
formatB:unit:   "https://formatB.com/..."
```

```
apiurl:            "https://siunits.stuchalk_du/api/unit/joule_second"
name:              "joule second"
numeratorunits:
  ▾ 0:
    ▾ unit:
      ▾ weburl:    "https://siunits.stuchalk.domains.unf.edu/si/definition/unit/joule"
      ▾ apiurl:    "https://siunits.stuchalk.domains.unf.edu/api/unit/joule"
```

Attention
SIDR & D-SI service under development, thus content of example & URIs not final

Types of quantities

Improving interoperability through a sound “Metrology Layer” [1]

```
Temperature calibration

Thermodynamic temperature point
68°F  =>  20 °C  =>  293.15 K

Thermodynamic temperature difference
1 °F  =>  1 °C   =>  1 K
```

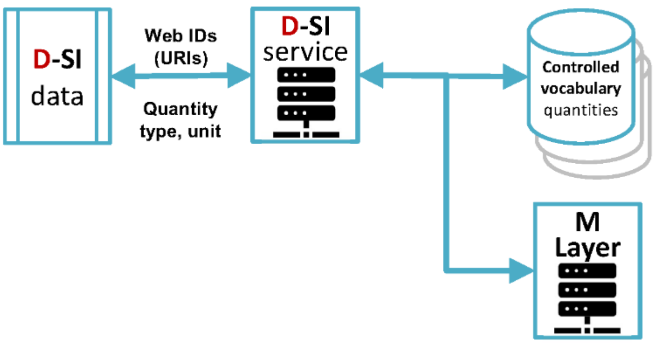
D-SI easy to use:

- quantity type minimum requirement
- link to scale of unit by quantity type

aspect / quantity type	value	unit	unit scale
temperature point	20	°C	interval scale 273.15 K

[1]: Hall, B. Representing and Expressing Measurement Data in Digital Systems. *SN COMPUT. SCI.* **4**, 120 (2023). https://doi.org/10.1007/s42979-022-01534-x

Service layer for types of quantities



- Interoperating controlled vocabularies for quantities
- Interoperating registries for Metrology Layer (M-Layer)
- Establishing context between units, quantities and scales → **foster automatic conversion and validation**

D-SI metadata model advancements

Extensions planned for the metadata model (D-SI beta version 2.2.0 in 2023)

- Quantity type
- Standard uncertainty
- Better uncertainty semantics
- Allowing 'NaN' or similar
- Number significant digits
- Additional units: percent, bit, ronna, …
- XML list complex values

D-SI & DCC already used in industry → no breaking changes guaranteed

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National Metrology Institute
D-SI Advancements

Summary

D-SI Metadata Model advancements

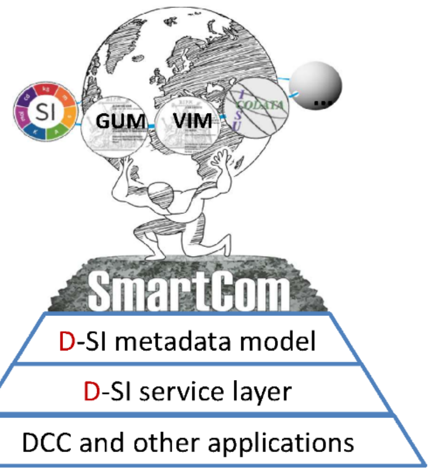
- Service layer for FAIR units and quantities
- Additional useful metadata

D-SI information

https://gitlab1.ptb.de/d-ptb/d-si/xsd-d-si

CIPM & BIPM information

https://www.bipm.org/en/digital-transformation



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National Metrology Institute
D-SI Advancements

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www.ptb.de

Stand: 02/23

Session B: DCC and Accreditation

Presentations that would also fit into this session:

- 09 The Semantics of Measured Quantities
- 21 DKD's Contribution to DCC Harmonisation and Coordinated Development

05 Bringing the Digital Accreditation Symbol and the Digital Calibration Report (DCC) into Practice

Presenting author: Susanne Kuch, German Accreditation Body (DAkkS), Germany

E-mail address: susanne.kuch@dakks.de

Additional authors: Dr.-Ing. Kerstin Rost, German Accreditation Body (DAkkS), Germany

Abstract

As national accreditation body, DAkkS supports the implementation of the DCC as digital version of a result report in the specific form of a calibration certificate.

In this contribution, DAkkS will present the status quo regarding the implementation of a digital accreditation symbol for accredited bodies. This will be realized within a project which will also include the launch of DCCs in accredited calibration laboratories. This digital accreditation symbol enhances the opportunity of fully machine readable test or calibration reports but also further kinds of attestations. This allows the integration of digital test reports in fully automated processes.

This contribution will further address the necessary requirements for CABs regarding accreditation procedures as well as the necessity of general guidelines from experts regarding the correct implementation of normative requirements for a certain measurand in the DCC XML scheme.

The project is integrated within a broader initiative of the central players in German quality infrastructure (QI) - DIN, DKE, DAkkS, PTB, and BAM. The joint initiative “QI-Digital” develops digital and interlinked processes and solutions for a modern quality infrastructure that serves the analogue as well as the digital product world.

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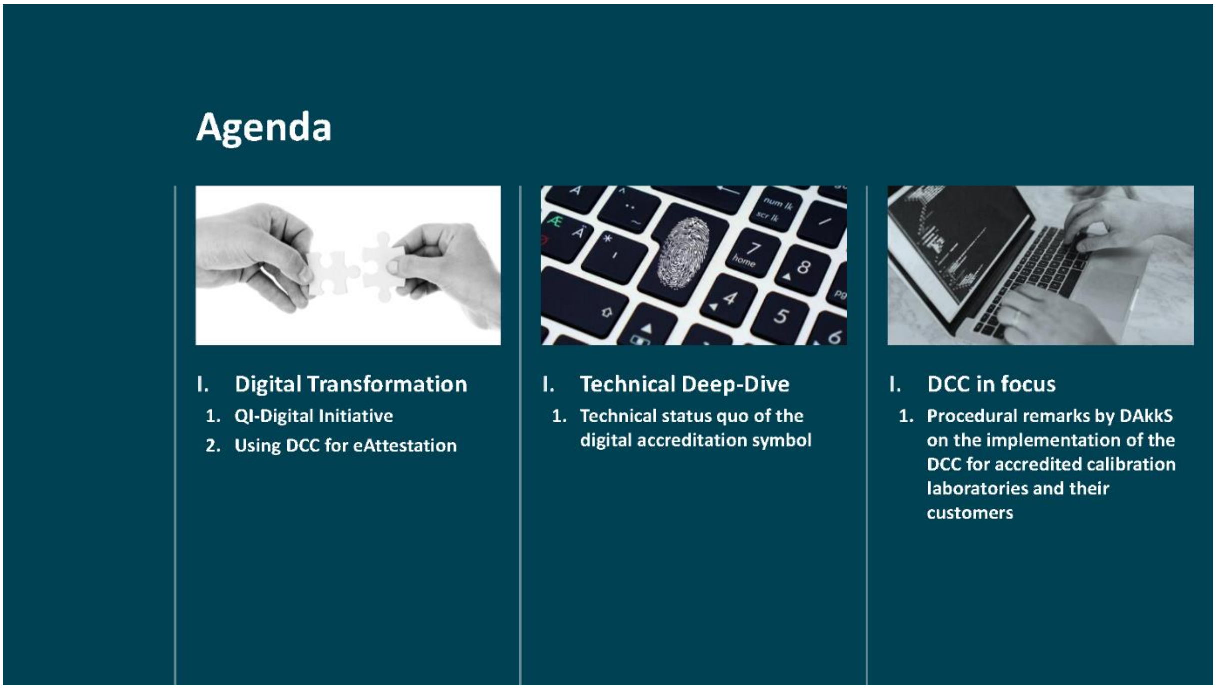
3rd International DCC Conference
Bringing the digital accreditation symbol and the DCC into practice
SUSANNE KUCH | DIGITAL POLICY FOR QUALITY INFRASTRUCTURE OFFICER
GERMAN ACCREDITATION BODY (DAKKS)
DAkkS
Deutsche Akkreditierungsstelle

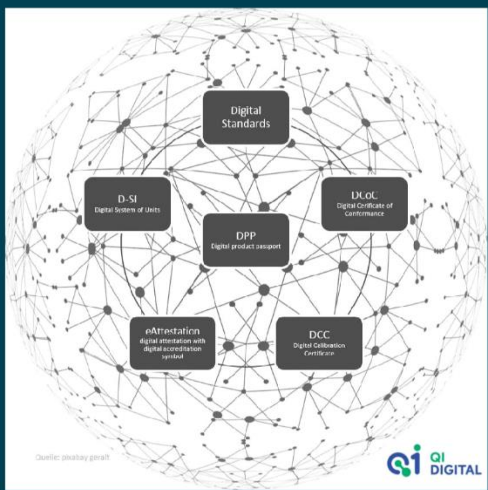

Agenda
I. Digital Transformation
1. QI-Digital Initiative
2. Using DCC for eAttestation
I. Technical Deep-Dive
1. Technical status quo of the digital accreditation symbol
I. DCC in focus
1. Procedural remarks by DAkkS on the implementation of the DCC for accredited calibration laboratories and their customers

Digital Transformation

DIGITAL TRANSFORMATION

The QI-Digital Initiative

- **Mission: Keep up with digital transformation**
- **Aims**:
  - Capability of **addressing new / innovative products or processes** (e.g. AI)
  - Enable a **smooth, interlinked** quality assurance and conformity assessment **process**
- **Methods**:
  - Develop **interoperable digital tools** for a modern QI
  - **Integrate** currently existing **approaches**



DIGITAL TRANSFORMATION

Using DCC for eAttestation

- **Enable eAttestation** for accredited CABs by combining the DCC with the digital accreditation symbol
- Need for digital accreditation symbol due to digital transformation: **authenticity** of the content and the **identity of an accredited CAB** has to be ensured
- Automatized **real-time verification** of integrity and authenticity for machines or by „a single click“ for any person

→ **Strengthens confidence** for market participants **in accreditation** and thus **in quality and safety**

Technical Deep-Dive

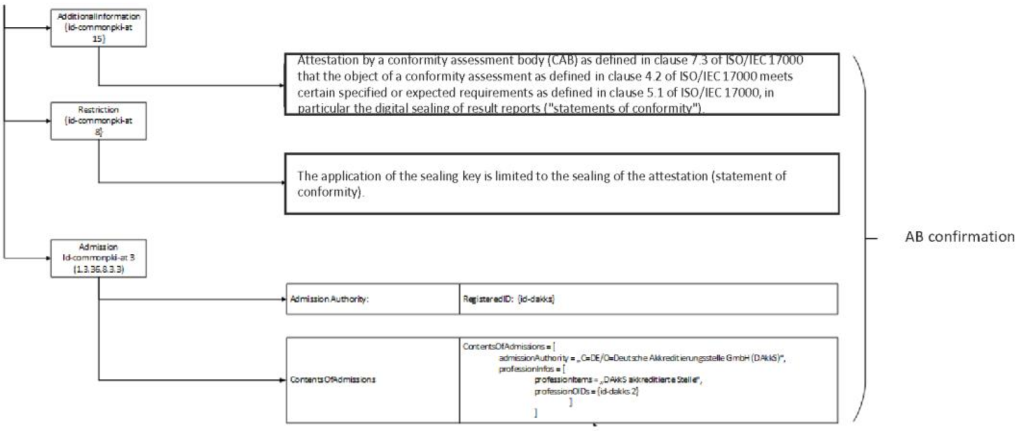
DIGITAL ACCREDITATION SYMBOL

Technical status quo

- **Implementation** of digital accreditation symbol is **based on** a **Public-Key-Infrastructure (PKI)**
- **Specification** of a standard seal product based on a **advanced seal with a qualified certificate** (no hardware needed)
- **Restricted to** the use by **legal entities**
- **Accreditation Body confirms** the **attribute** „accredited CAB“ within the **PKI** for a specific evaluation activity
- **Machine readability** is ensured via the **definition of an OID** that carries the information of the accreditation status of the legal entity

DAkkS

Technical structure of the digital accreditation symbol



DAkkS

DCC in focus

DCC IN FOCUS

Procedural remarks

- The calibration laboratory shall **demonstrate compliance** with the **requirements** of **ISO/IEC 17025:2018**
- It shall also be **compliant with** the **legal requirements** as well as potential **further technical specifications** regarding the measurand and its documentation within a DCC
- Calibration laboratory need to **ensure interoperability** of DCC in order to meet the needs of its customers
- **No changes** to the application or the status of the **accreditation** are required for the implementation of the DCC
- **Proof of traceability** via digital accreditation symbol possible (due to cryptographic method securing accreditation symbol)

Questions?

Imprint and Contact

National Accreditation Body
Deutsche Akkreditierungsstelle GmbH (DAkkS)
Spittelmarkt 10
10117 Berlin

Susanne Kuch M.A.
Digital policy for quality infrastructure officer
Accreditation governance, Research and Innovation Department
German National Accreditation Body – DAkkS
susanne.kuch@dakks.de

Images

- Digitized laboratory: Image by DCStudio on Freepik.com
- Digital identity and status check: Image by Freepik on Freepik.com
- Digital twin of delivery bag: Image by graystudiopro1 on Freepik.com

06 The General DCC Rulebook and the Rules under the Aspects of Accreditation

Presenting author: Siegfried Hackel, Physikalisch-Technische Bundesanstalt (PTB), Germany

E-mail address: siegfried.hackel@ptb.de

Additional authors: Muhammed Ali Demir, Lutz Doering, Benjamin Gloger, Justin Jagieniak, Moritz Jordan, Christian Keilholz, Jan Loewe, Kai Mienert, Shanna Schönhals, Gamze Söylev Öktem (in alphabetical order, all PTB)

Abstract

Machines are still far from being intelligent. In the digital transformation towards Industry 4.0, this must also be considered. The Good Practice (GP) approach to DCCs reflects this. GP developments have shown that a general set of rules for the creation of DCCs can be derived from them. In the first part of the presentation, the resulting draft of a set of rules will be presented.

DCCs prepared by an accredited calibration laboratory have to comply with ISO/ICE 17025 in its current version. In addition to the fulfilment of a DCC schema-compliant XML data set, further criteria must be met for this. Some of these criteria can be checked by means of the Schematron test. For example, it can be checked whether the environmental conditions have been included in the measurements.

In the second part of the presentation, the author shows a draft of a rulebook, which consequences result from the requirements of section 7.8 of ISO/ICE 17025 for the creation of a DCC. A procedure is shown how these points can be fulfilled. The aim is to create an internationally agreed and accepted set of rules in cooperation with the accreditation bodies.

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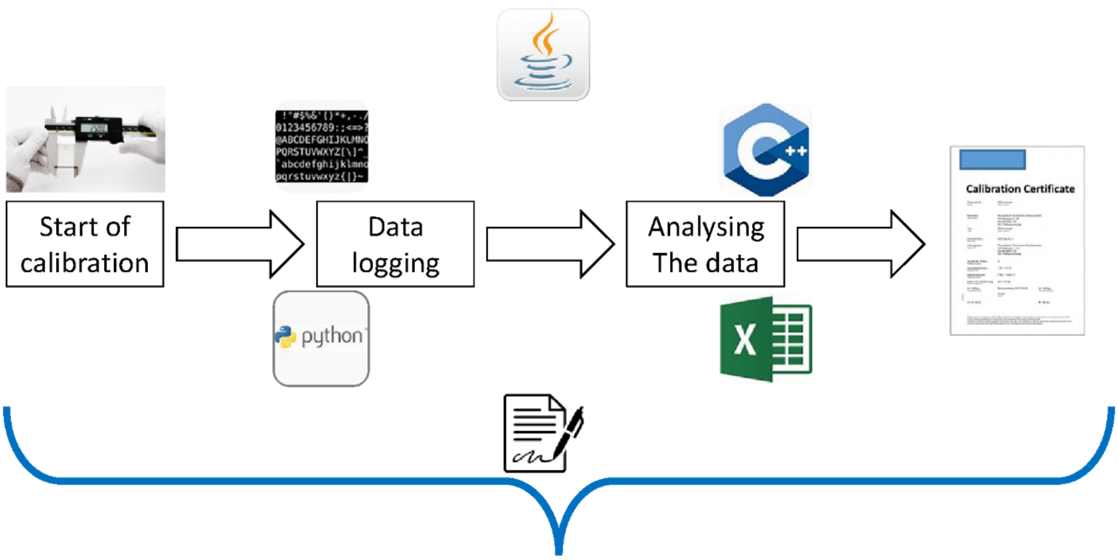
The General DCC Rulebook and the Rules under the Aspects of Accreditation

Siegfried Hackel

02

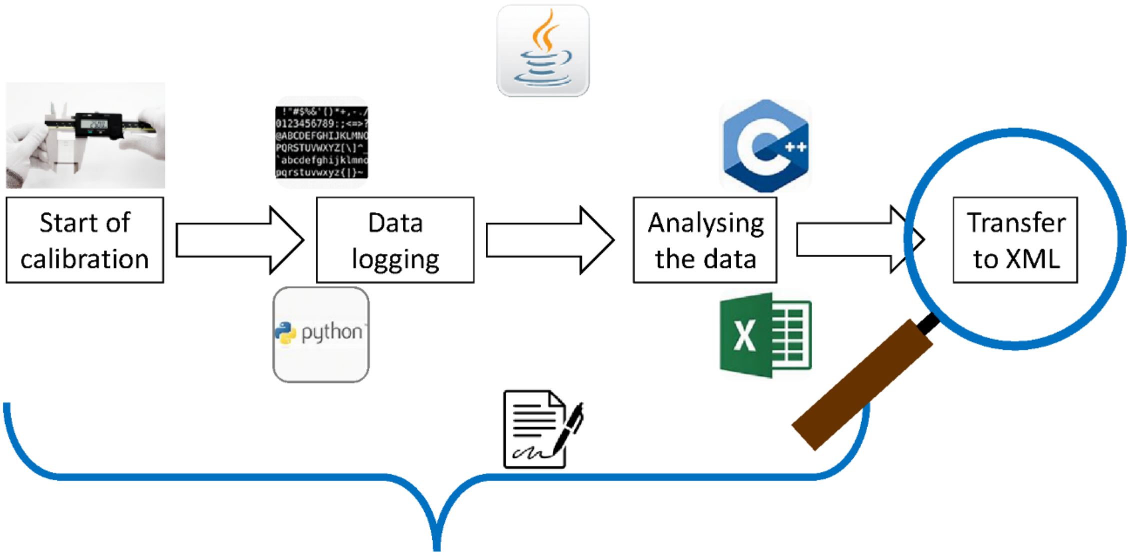
Workflow



Proceed as previously done

02

Workflow



Proceed as previously done

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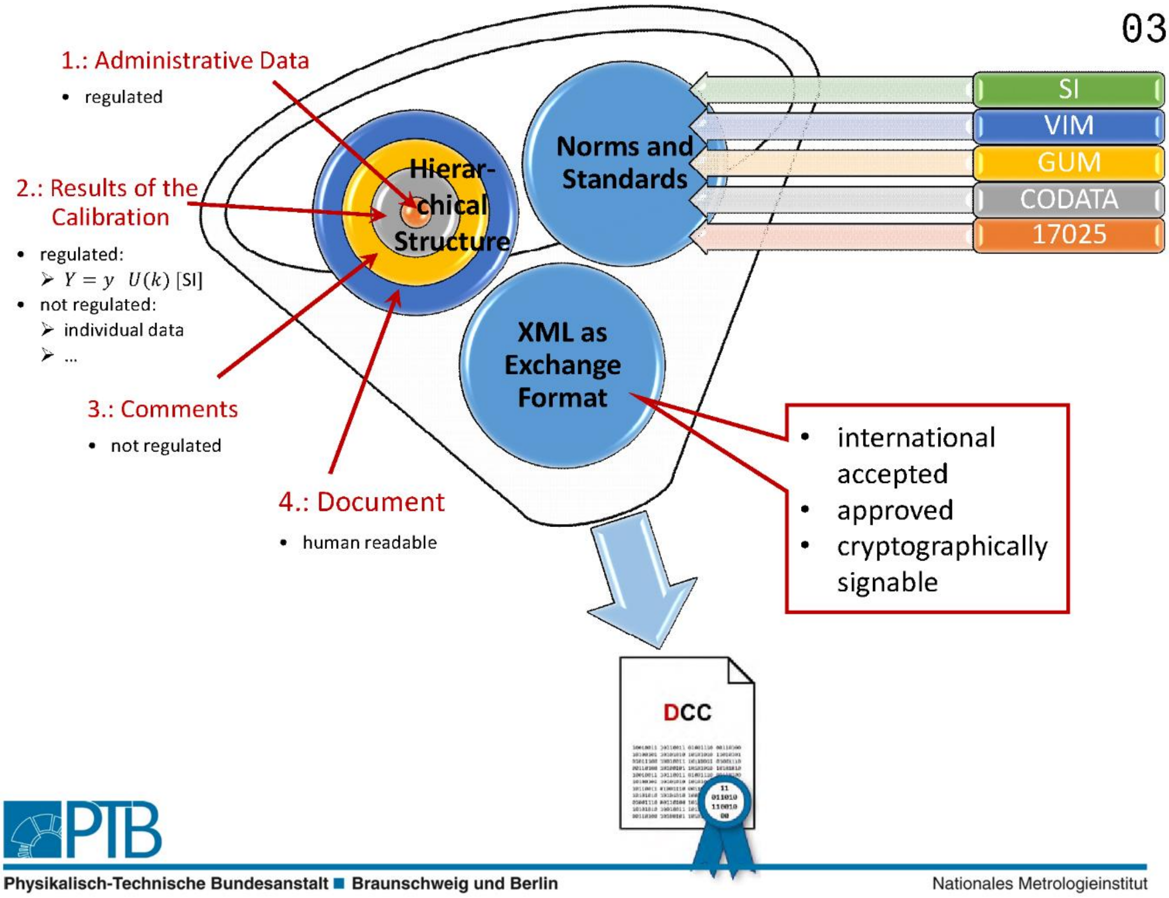
Nationales Metrologieinstitut

03



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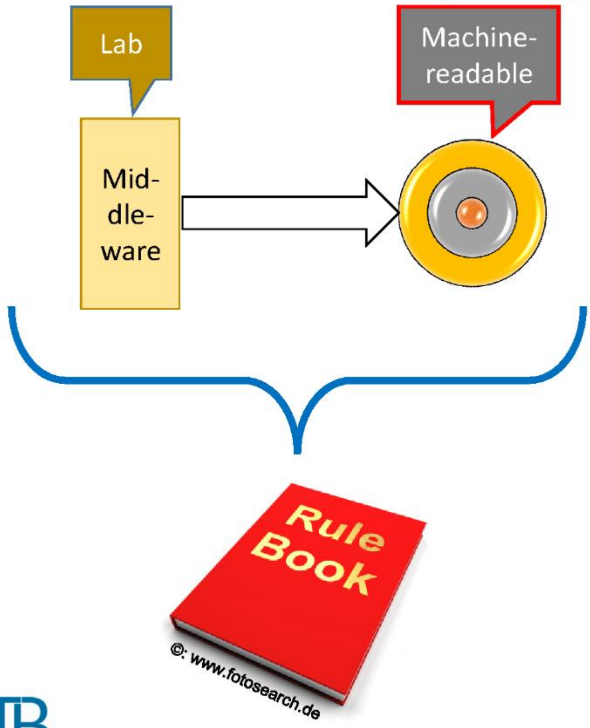
Nationales Metrologieinstitut

04

Transfer to XML observing the general DCC Rulebook



05

The General DCC Rulebook

Basic principles:

- Principle of data minimisation
  - ✓ One basic principle of IT

06a

The General DCC Rulebook

Principle of data minimisation

Place the data as close as possible to the root element

- ➢ Example: Environmental conditions

e. g. 100 measurements

Many conceivable variants and possibilities:

a) All measurements have the same conditions — 1 set of conditions
- Measurements in a climate chamber

b) 10 measurement series with the same conditions in each case for the 10 measurements — 10 sets of conditions
- Measurement campaign over several days

c) Each measurement has different conditions — 100 sets of conditions
- One measurement per day for 100 days

➢ Mixtures of a) to c) — ??? sets of conditions

06*

The General DCC Rulebook

Principle of data minimisation

Place the data as close as possible to the root element

- ➢ Example: Environmental conditions
  - Input possible at any level
  - From global to individual
- ➢ Problem:
  - Principle of data minimization
- ➢ Solution:
  - Case a)
    - ✓ Use the dcc:measurementResult child:

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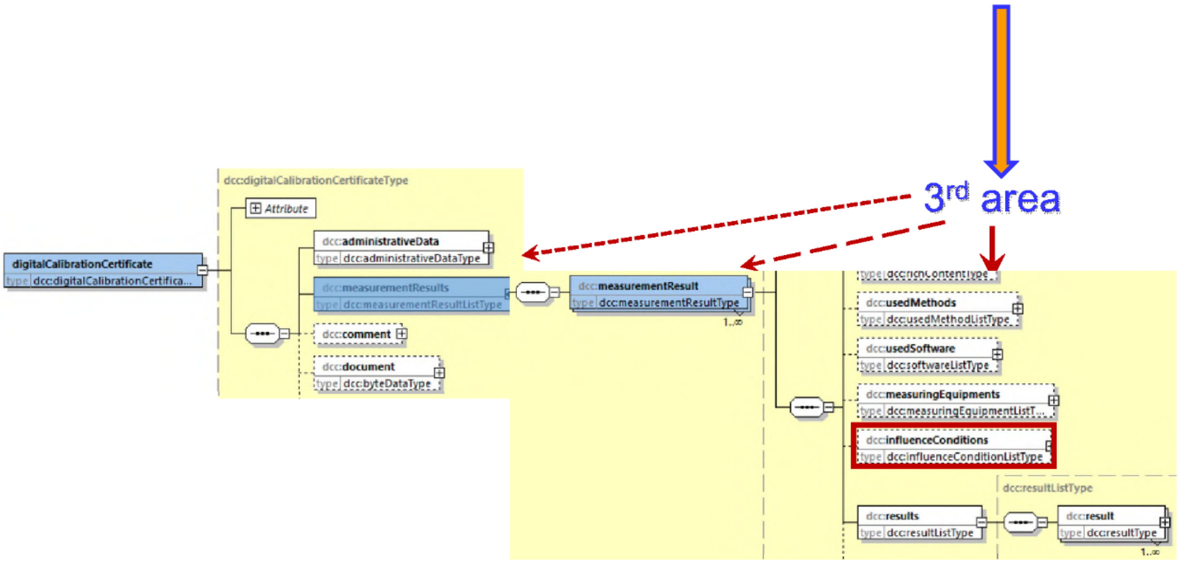
06b

The General DCC Rulebook

Principle of data minimisation



06*

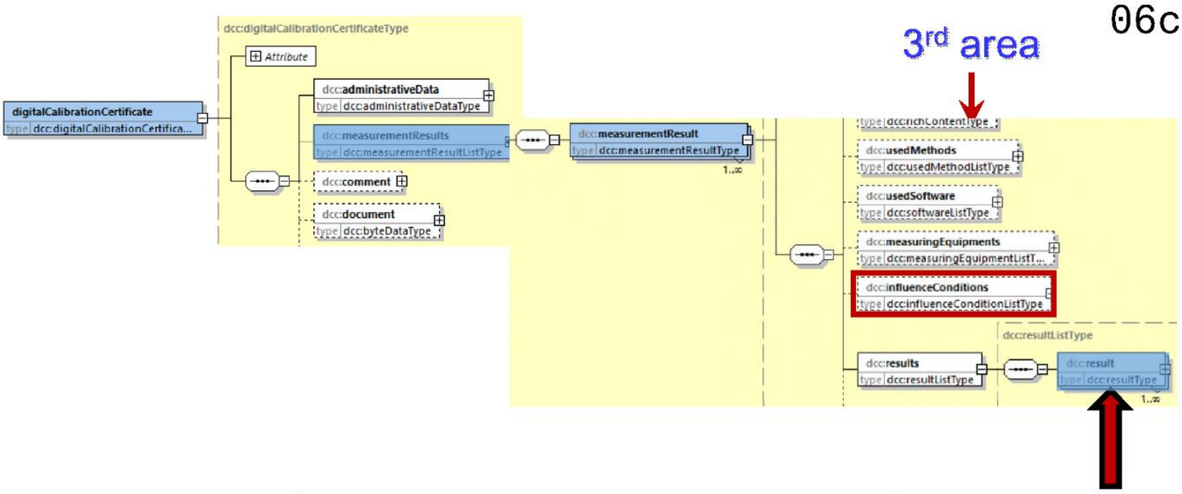
The General DCC Rulebook

Principle of data minimisation

Place the data as close as possible to the root element

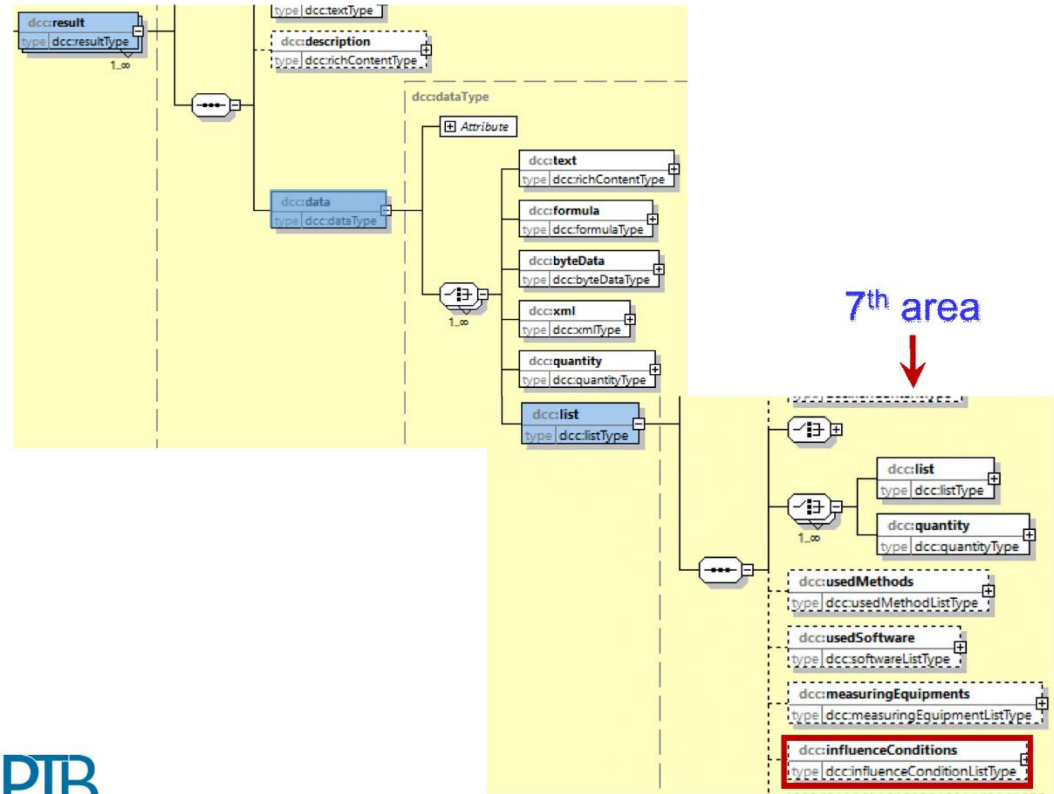
- Example: Environmental conditions
  - Input possible at any level
  - From global to individual
- Problem:
  - Principle of data minimization
- Solution:
  - Case a) 3rd area
    - ✓ Use the dcc:measurementResult child:
  - Case b)
    - ✓ Use the dcc:list child:

06c



This figure is shown two slides before

06d



06*

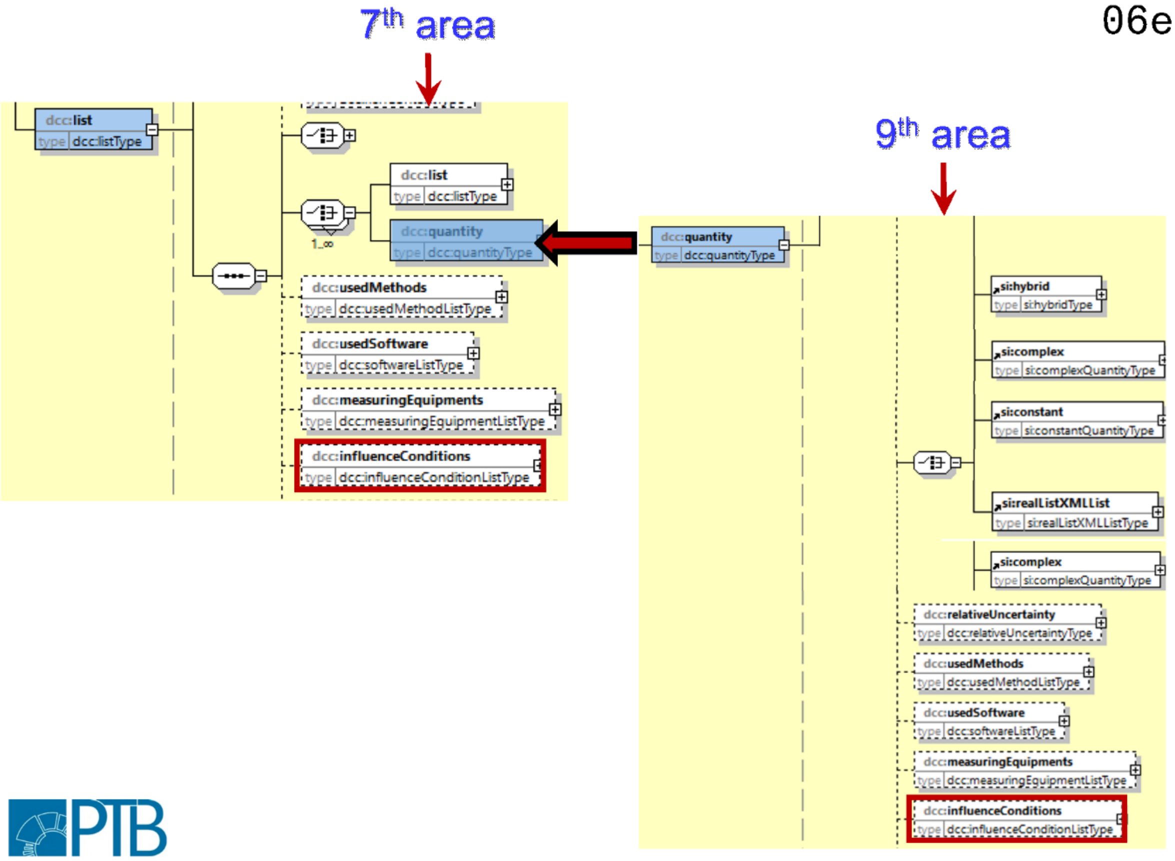
The General DCC Rulebook

Principle of data minimisation

Place the data as close as possible to the root element

- Example: Environmental conditions
  - Input possible at any level
  - From global to individual
- Problem:
  - Principle of data minimization
- Solution:
  - Case a) 3rd area
    - ✓ Use the dcc:measurementResult child:
  - Case b) 7th area
    - ✓ Use the dcc:list child:
  - Case c)
    - ✓ Use the dcc:quantity child:

06e



06f

The General DCC Rulebook

Principle of data minimisation

Place the data as close as possible to the root element

- Example: Environmental conditions
  - Input possible at any level
  - From global to individual
- Problem:
  - Principle of data minimization
- Solution:
  - Case a) 3rd area
    - ✓ Use the dcc:measurementResult child:
  - Case b) 7th area
    - ✓ Use the dcc:list child:
  - Case c) 9th area
    - ✓ Use the dcc:quantity child:

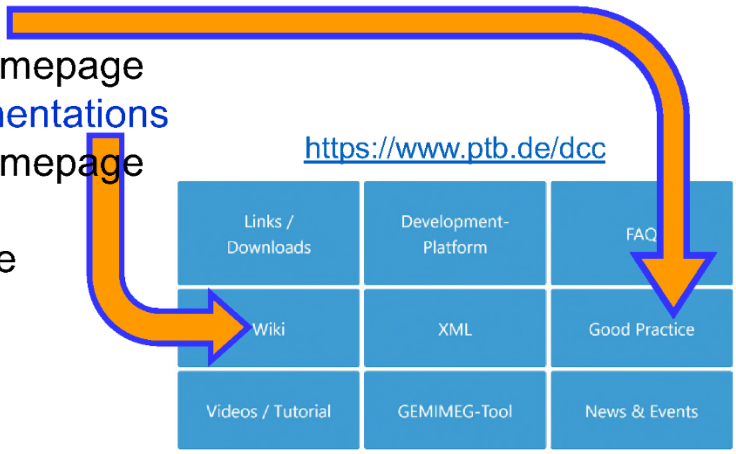
07

The General DCC Rulebook

Basic principles:

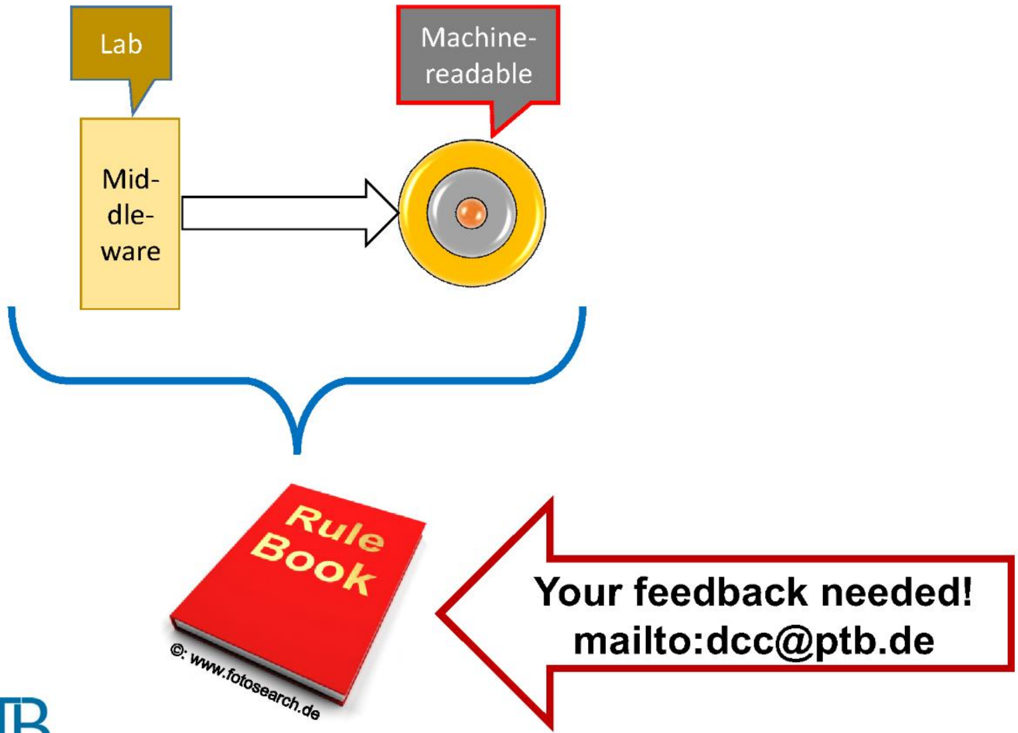
- Principle of data minimisation
  - ✓ One basic principle of IT
- Good Practice
  - ✓ See DCC-Homepage
- Check the documentations
  - ✓ See DCC-Homepage
- Modularity
  - ✓ Keep it simple
  - ✓ Less is more

https://www.ptb.de/dcc



08

Transfer to XML



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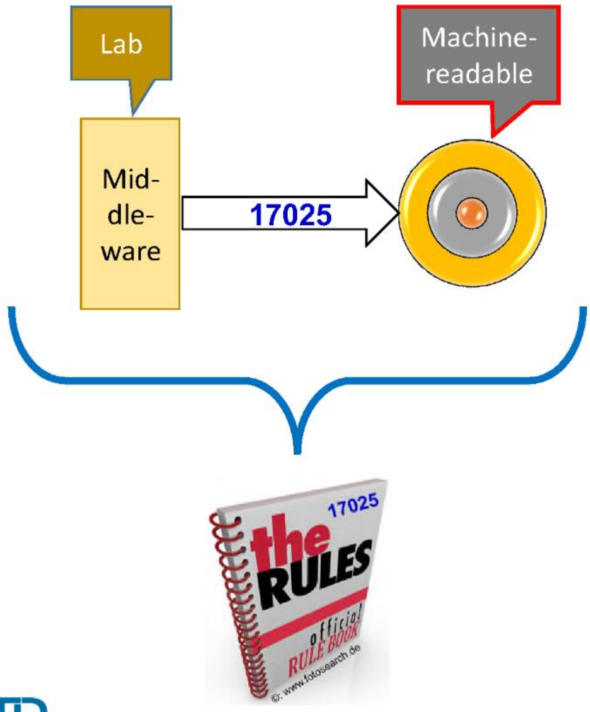
09

ISO/IEC 17025 Transfer to XML



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10

The 17025 DCC Rulebook

Basic principles:

- ISO/IEC 17025 checked
  - ✓ Especially section 7.8
- Feedback very much desired
  - ✓ Especially from the accreditation bodies
  - ✓ From the auditors
  - ✓ From all of you
- How are the requirements fulfilled?
  - ✓ See examples on the following slides
- What would be helpful?
  - ✓ Citation of parts of the norm as it was realized
  - ✓ for auditors

11a

The 17025 DCC Rulebook
Examples

Conditions fulfilled immediately, for example
- Chapter 7.8.2.1 a)

On the following slides, quotations from ISO/IEC 17025 are shown in green letters.

It would be very helpful if these citations could be used in the Rulebook.

Who can help here?

The 17025 DCC Rulebook
Examples

Conditions fulfilled immediately, for example

- Chapter 7.8.2.1 a)
  - *"a title (e. g. "Test Report", "Calibration Certificate" or "Report of Sampling")"*
    - ✓ `dcc:digitalCalibrationCertificate`
- Chapter 7.8.2.1 d
  - *"unique identification that all its components are recognized as a portion of a complete report and a clear identification of the end;"*
    - ✓ `/dcc:digitalCalibrationCertificate`

The 17025 DCC Rulebook
Examples

Mandatory criteria ("shall"), for example

- Chapter 7.8.2.1 b)
  - *"the name and address of the laboratory;"*
    - ✓ Name and address of the calibration laboratory shall be entered in the mandatory element `dcc:calibrationLaboratory`

Overlap with the general DCC Rulebook:

- What is to be entered into which element? https://www.ptb.de/dcc
  - Check the documentations
    - ✓ See DCC-Homepage

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The 17025 DCC Rulebook
Examples

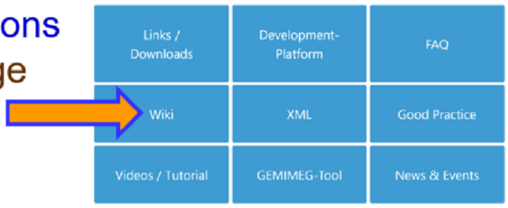
Optional criteria (“should / can”), for example

- Chapter 7.8.3.1 a)
  - *“information on specific test conditions, such as environmental conditions;”*
    - ✓ The information for this has to be entered in the element `dcc:influenceConditions`

Overlap with the general DCC Rulebook:

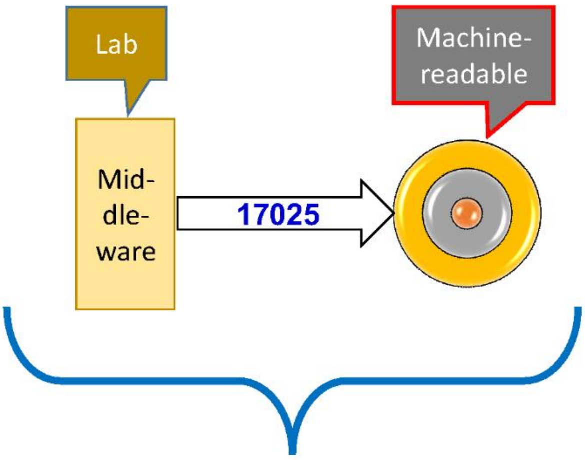
- What is to be entered into which element?
  - Check the documentations
    - ✓ See DCC-Homepage

https://www.ptb.de/dcc



14

ISO/IEC 17025 Transfer to XML



Your feedback needed!
mailto:dcc@ptb.de

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2023-02-28

Session B: Digital Signatures

Presentations that would also fit into this session:

- 01 Digital Calibration Certificate as part of an Ecosystem
- 05 Bringing the Digital Accreditation Symbol and the Digital Calibration Report (DCC) into Practice
- 53 DCC Middleware – Obstacles and Approaches
- 56 DCC via iPhone (or iPad)

07 Qualified Electronic Seals - The Peace of Westphalia in the Laboratory Sector

Presenting author: Robert Hilgers, Bundesdruckerei / D-Trust, Germany

E-mail address: Robert.Hilgers@bdr.de

Additional authors: Andrew Freund, Andrew.Freund@d-trust.net

Abstract

We all recognize seals from history lessons. Princes, kings and bishops used coloured wax, heated it and stamped their coat of arms into it. This was used to confirm the authenticity of a document. A contract, a passport or an escort bill with a seal was considered genuine, and breaking a seal was punishable by severe penalties.

In legal transactions, the seal has been out of fashion for a very long time, but the last traces of it can still be found on the registered letters of the German postal service or the rubber stamps of the tax office on the annual income tax assessment notice.

The EU's eIDas regulation is now bringing the government and corporate seal increasingly into the focus of public institutions and companies.

It makes sense to look for application scenarios for seals, because signatures usually cost more time and money, while seals are suitable for mass use.

In the future, incoming mail from a health insurance company, for example, will probably only be processed with a qualified electronic seal. Paper and fax documents can be destroyed and a legally valid digital workflow can be established. With several million incoming documents every day, this is a step that is hard to avoid.

We all know there are mass transactions in the laboratory sector, such as the sampling of water on the basis of the Drinking Water Ordinance, or of soil samples by farmers on the basis of the Fertilizer Ordinance.

Our presentation will use practical examples to illustrate the benefits of a qualified electronic seals: saving paper and an increased operational efficiency through digitalisation. The technical solutions for such scenarios are ready. A TÜV-approved eIDAS qualified electronic seal from the Bundesdruckerei | D-Trust is easy to integrate into existing laboratory software architectures and can therefore be quickly and successfully implemented.

Customers and recipient institutions of laboratory reports can check them digitally for authenticity and forward them to other recipients if necessary. In a time when time and trust are high commodities, digitization is a must.

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d-trust.

Qualified Electronic Seals: From dripping wax to secure PKI - an unexpected success story

D Trust GmbH Sales and Consulting & Marketing
Product and Business Development

03.03.2023
Berlin
R. Hilgers & A. Freund

First a Bit of History . . .

d-trust.

From dripping wax to secure PKI

- We all recognize the velum pages full of wax blobs and ribbons from our history lessons. Princes, kings and bishops used coloured wax, heated it and then stamped their coat of arms into it. This seal was used to confirm the authenticity of a document. A contract, a passport or an escort bill with a wax seal was recognized as genuine.
- In legal transactions, this kind of document sealing has been out of fashion for a very long time.
  - The last traces of it can still be found on registered letters that you receive through the German postal service or in the rubber stamps of the tax office on annual income tax assessment notices.
- The EU's eIDAS (electronic IDentification, Authentication and trust Services) regulation has brought government and corporate seals back into focus.

Teil der Bundesdruckerei-Gruppe

Electronic Seals

d-trust.

Electronic Seals

The digital stamp for legal entities

- ✗ Substitute for a personal statement of will
- ✓ Confirmation of origin
- ✓ Confirmation of integrity
- ✓ Security against forgery
- ✓ Can be verified over the longterm

Customers and institutions receiving laboratory reports with eIDAS qualified electronic seals can digitally authenticate these documents and confidently forward them to further recipients.

Are There Use Cases for Laboratories?

d-trust.

The Smart Solution?

- It makes sense to look for application scenarios for digital seals in the laboratory sector
- An individual signature costs time and therefore money. A digital seal happens in an instant.
- Digital seals are suitable for mass use, where a large number of documents need to be processed in a short time.

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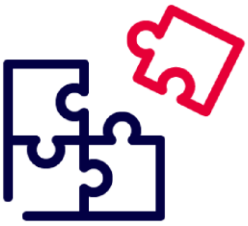
Use Cases for Laboratories

d-trust.

The Smart Solution

- In the laboratory sector there is great potential for mass sealing
  - the sampling of water to adhere to the Drinking Water Ordinance
    - For example a single Waterworks Company in a large German city automatically takes around 12,000 samples a day
  - the taking of soil samples by farmers to adhere to the Fertilizer Ordinance.
  - In contrast to the medical sector, laboratory reports do not usually require the handwritten or digital eHBA signature of the laboratory physician so a digital seal issued to the laboratory could secure and authenticate a number of reports at once.
  - Calibration certificates in the laboratories themselves could also be digitally sealed and could then be electronically stored, easily accessible and always verifiable.
- Integrating an eIDAS qualified electronic seal into one's LIMS application is a fairly simple and straightforward process.



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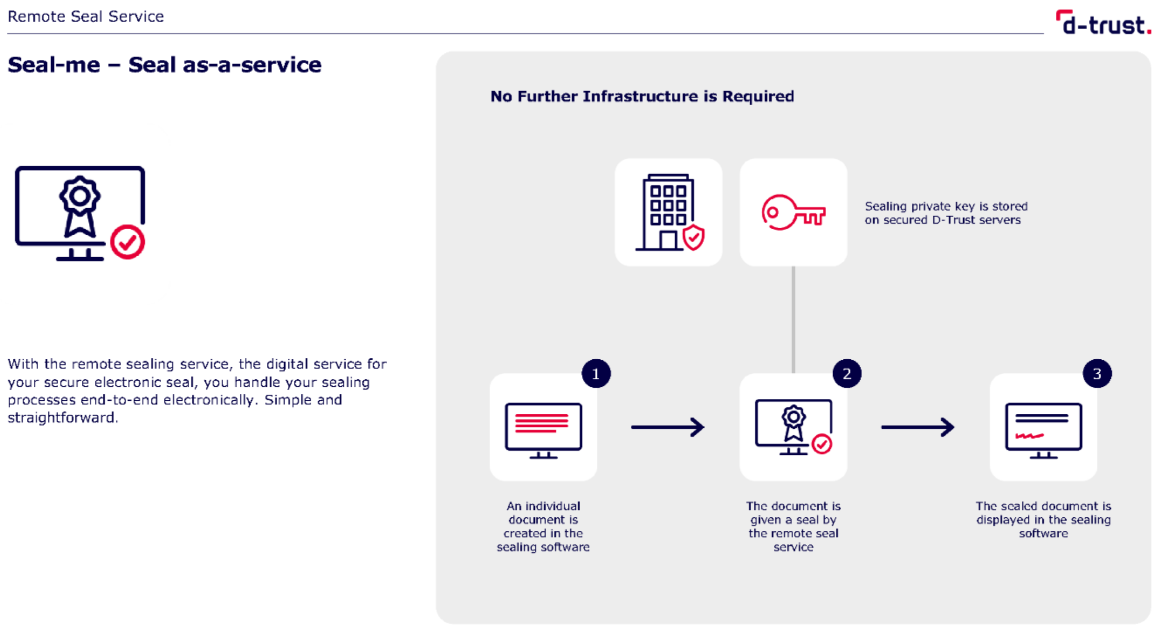
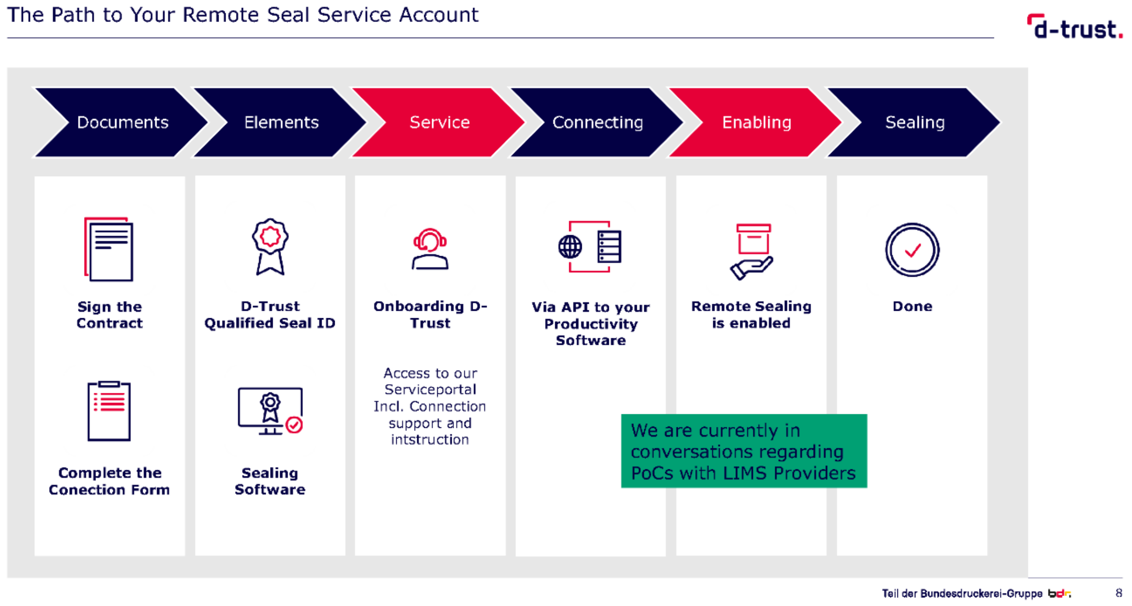
d-trust.

Our Solution – The Remote Seal Service „seal-me“

Teil der Bundesdruckerei-Gruppe



Remote Seal Service
d-trust.
Seal-me – Seal as-a-service
With the remote sealing service, the digital service for your secure electronic seal, you handle your sealing processes end-to-end electronically. Simple and straightforward.
No Further Infrastructure is Required
Sealing private key is stored on secured D-Trust servers
1
An individual document is created in the sealing software
2
The document is given a seal by the remote seal service
3
The sealed document is displayed in the sealing software



The Path to Your Remote Seal Service Account
d-trust.
Documents
Elements
Service
Connecting
Enabling
Sealing
Sign the Contract
Complete the Conection Form
D-Trust Qualified Seal ID
Sealing Software
Onboarding D-Trust
Access to our Serviceportal Incl. Connection support and intstruction
Via API to your Productivity Software
Remote Sealing is enabled
Done
We are currently in conversations regarding PoCs with LIMS Providers
Teil der Bundesdruckerei-Gruppe
8

Thank you.

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08 How to Apply Digital Signatures on a Digital Calibration Certificate

Presenting author: Robin Fay – Deutsche Telekom Security GmbH, Germany

E-mail address: robin.fay@telekom.de

Additional authors: Caroline Bender - Deutsche Telekom Security GmbH

Abstract

Digital calibration certificates (DCCs) should be digitally signed to protect the content against undetected manipulation and to achieve authenticity. Digital signatures can be applied in various ways using different specifications, encodings and file formats. Clearly, this is a nightmare for interoperability when DCCs are created by many organizations around the world.

Therefore, we have analyzed technical and operational requirements for digital signatures applied to the machine readable DCC with the goal to find a flexible signature format that allows broad interoperability for many use cases.

Based on our analysis, we show in our presentation that the enveloped XML Advanced Electronic Signature (XAdES) specification outperforms other methods. Moreover, we demonstrate how this signature format can be used in practice together with a Public Key Infrastructure (PKI) as Trust Framework. A private key associated with a qualified digital certificate can be used to create a qualified signature compliant to the eIDAS Regulation, which yields a digital version of a handwritten signature in the European Union. XAdES is not limited to qualified signatures inside the European Union. The specification allows parallel signatures, and we show how this can be used to apply digital signatures that are compliant to different international regulations.

Our results foster a wide international adaptation of digital signatures for the DCC, since a common signature format is the foundation for all secure applications of the DCC.

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How to apply digital signatures on a digital calibration certificate

Dr. Robin Fay & Caroline Bender
Deutsche Telekom Security GmbH
Third International DCC Conference 2023

This research is supported by the German Federal Ministry of Economic Affairs and Climate Action (BMWK) through the GEMIMEG-II project.

1. Motivation
2. Different approaches for a digital signature format
3. XML Signature types & XAdES
4. Trust services and signature validation

Motivation

- Digital Calibration Certificates (DCCs) should be digitally signed to protect the content against undetected manipulation and to achieve authenticity
- Various standards, formats and encodings exist for digital signatures
- Without a standard or best practice, this is a nightmare for interoperability.

Which signature format should be used for the machine readable DCC?

```xml
<dcc:administrativeData>
    ...
    <dcc:coreData>
        ...
        <dcc:uniqueIdentifier>unsignedDCCExample-2023-28-02
        </dcc:uniqueIdentifier>
        <dcc:identifications>
            <dcc:identification>
                <dcc:issuer>calibrationLaboratory</dcc:issuer>
                <dcc:value>string-calibrationLaboratory-coreData</dcc:value>
                ...
            </dcc:identification>
        </dcc:identifications>
        ...
    </dcc:coreData>
    <dcc:items>
        <dcc:item>
            <dcc:name>
                <dcc:content lang="en">Temperature sensor
                </dcc:content>
            </dcc:name>
            ...
        </dcc:item>
    </dcc:items>
</dcc:administrativeData>
```


Different approaches & signature formats

Cryptographic Message Syntax (CMS or PKCS#7)

- Container format for digital signatures
- Encapsulation of the content inside a CMS package (signed-data)
- Applications must parse the CMS in order to find the content of the digital calibration certificate even if they cannot process the CMS
- Signing certificate (i.e., public key certificate) is not required as signedData, which makes key management more complex

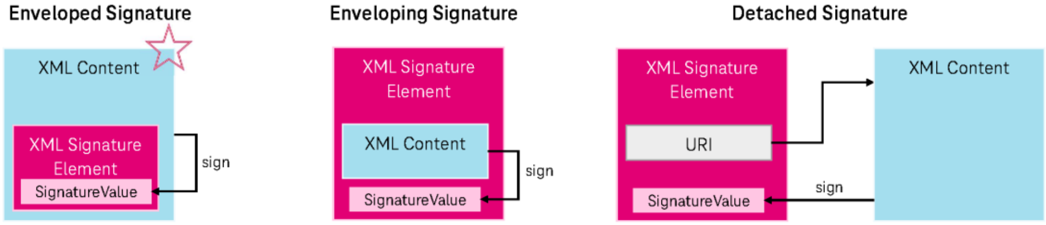
PDF based Signatures

- Well established standards
- Supported by a wide range of applications
- Applications must parse the content of the PDF in order to find necessary information
- Additional layer on top of the existing XML

XML based signatures

- Can be applied in different ways (enveloped, enveloping, detached)
- W3C recommendations for XML-DSig published and stable
- Signed XML with enveloped signature is still a valid XML, hence applications that cannot verify digital signatures can treat the signed DCC as any other DCC
- ETSI standards enhance the XML-DSig recommendations for digital signatures that should be valid for a long time

Enveloped, Enveloping and Detached Signatures



Enveloped Signature

- Signature Element is included in the XML Content
- Can be ignored if it is not understood
- Parallel- and counter-signatures are possible

Enveloping Signature

- Signature Element surrounds the DCC element
- Signature must be parsed before the content can be parsed by applications
- Complex with multiple independent signatures

Detached Signature

- Document and signature are not bundled
- Complex document management

The XAdES signature format

- XML Signatures based on the W3C recommendations (XML-DSig) are defined by a signature element

```
Schema Definition:

<element name="Signature" type="ds:SignatureType"/>

<complexType name="SignatureType">
  <sequence>
    <element ref="ds:SignedInfo"/>
    <element ref="ds:SignatureValue"/>
    <element ref="ds:KeyInfo" minOccurs="0"/>
    <element ref="ds:Object" minOccurs="0" maxOccurs="unbounded"/>
  </sequence>
  <attribute name="Id" type="ID" use="optional"/>
</complexType>
```

hash function + signature algorithm + canonicalization method + reference to the signed data

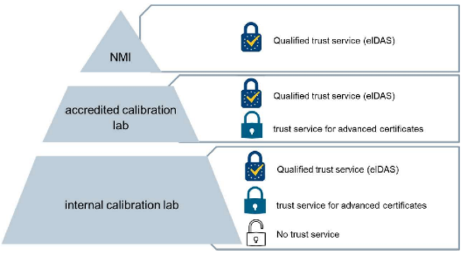
the digital signature

optional: public key or public key certificate for signature validation

- XML Advanced digital Electronic Signatures (XAdES) enhances XML-DSig with additional elements
  - signed properties: contains the **SigningTime, SigningCertificate,** SignerRole, ...
    - the SigningTime is required for long-term signature validation
    - The SigningCertificate is necessary for simple signature validation when well established Public Key Infrastructures are used
  - unsigned properties: CounterSignature
  - XAdES can be enhanced with TimeStamps from trusted third parties if required
  - Standardized by ETSI (EN 319 132-1) and W3C

Relation to trust services

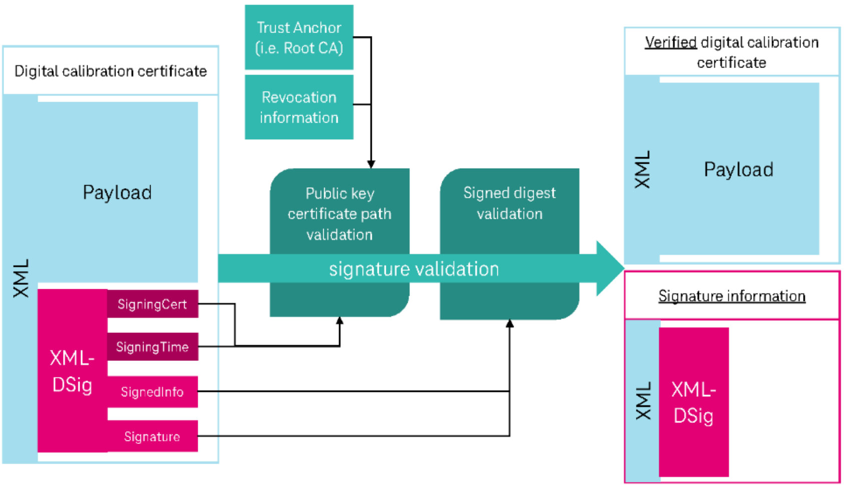
- The SigningCertificate allows the signer to include the public key certificates that are required for signature validation
- The signer can obtain his/her Public Key Certificate from *different* trust services depending on customer requirements or external regulations



Example: Trust Services on the calibration pyramid

- *Parallel signatures* can be used to bridge the gap between different trust zones simply by applying multiple digital signatures with public key certificates from different trust services (e.g. a qualified signatures following eIDAS and another signature trusted outside of the EU)

Signature validation



Conclusion

- XML Signatures are the most natural way to sign a machine readable DCC, which allows applications to parse the DCC even if they cannot validate digital signatures
- The XAdES specification allows to create digital signatures that are valid for a long time period
- Since the SigningTime and the SigningCertificate are required in XAdES, most of the necessary information for signature validation are included in a signed DCC
  - Trust Anchors should be established out of band
- The approach is not bound to a single trust framework and different entities on the calibration pyramid can use different trust services
- Parallel signatures can be used to sign DCCs with different public key certificates


```xml
<dcc:administrativeData>
    ...
    <dcc:coreData>
        ...
        <dcc:uniqueIdentifier>unsignedDCCExample-2023-28-02
        </dcc:uniqueIdentifier>
        <dcc:identifications>
            <dcc:identification>
                <dcc:issuer>calibrationLaboratory</dcc:issuer>
                <dcc:value>string-calibrationLaboratory-coreData</dcc:value>
                ...
            </dcc:identification>
        </dcc:identifications>
```

```xml
<ds:SignatureValue Id="...">
mQMqeZgbqYAjd2FfUrkkJI3rjmpUc5R/...
</ds:SignatureValue>
<ds:KeyInfo>
    <ds:X509Data>
        <ds:X509Certificate>...</ds:X509Certificate>
    </ds:X509Data>
</ds:KeyInfo>
<ds:Object>
    <xades:QualifyingProperties xmlns:xades="http://uri.etsi.org/01903/v1.3.2
        <xades:SignedProperties Id="...">
            <xades:SignedSignatureProperties>
                <xades:SigningTime>2023-02-28T07:47:21Z</xades:SigningTime>
                <xades:SigningCertificateV2>
                    <xades:Cert>
                        <xades:CertDigest>
                            <ds:DigestMethod Algorithm="http://www.w3.org/200
                            <ds:DigestValue>DrTx5hgV...</ds:DigestValue>
                        </xades:CertDigest>
                        <xades:IssuerSerialV2>MGcwW6RZMFcxCzAJBgNVBAYTAkRFMR4
                    </xades:Cert>
                </xades:SigningCertificateV2>
```

```xml
            </xades:SignedProperties>
        </xades:QualifyingProperties>
    </ds:Object>
</ds:Signature>
</dcc:digitalCalibrationCertificate>
```


Thank you for your attention

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Trust Center & ID Security
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Session B: Semantics / Persistent Identification

Presentations that would also fit into this session:

09 The Semantics of Measured Quantities

Presenting author: Mark Kuster, Independent Researcher, USA

E-mail address: mjk@ieee.org

Additional authors: Blair Hall, MSL, New Zealand

Abstract

There are two distinct notions of quantity involved when reporting measurement results: the kind of quantity associated with units of measurement and the quantity intended for measurement---the measurand. While practitioners should precisely specify measurands, kinds of quantity remain general. Digital representations of measurement data should address these different notions of quantity and the relationships between them. We require unique identification of kinds of quantity, as well as a flexible system of classification for measured quantities. The latter should somehow accommodate the variety of information about measurement capabilities currently published in 'calibration and measurement capabilities' and 'scopes of accreditation' and likewise identify measurement results in DCCs. A simple taxonomy of quantities, built up from a general parent class---the kind of quantity, would satisfy the simultaneous demand for a specific and a general classification. More complicated and expressive hierarchical structures for quantities may have uses but will require ontologies.

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The Semantics of Measured Quantities

Blair Hall, blair.hall@measurement.govt.nz
Mark Kuster, mjk@ieee.org

NCSL International 141 MII and Automation Committee

Measurement-Information Infrastructure

Section 1

Introduction

Today's Topics

1. Introduction

Introduction

Today's Topics

1. Introduction
2. Quantity Kinds and the M-Layer

Today's Topics

Introduction

Today's Topics

NCSLI 141 (MII) DCC 2023 Tuesday, February 28, 2023 3 / 23

Today's Topics

Acronyms

- SoA—scope of accreditation
- DCC—digital calibration certificate (PTB)
- CMC—calibration and measurement capability
- KCDB—key comparison database
- NCSLI—NCSL International
- FAIR—findable, accessible, interoperable, reusable
- M-Layer—metrology information layer to support measurement systems

Definition

MII (measurement information infrastructure)
—set of normative standards that unambiguously define data structures, taxonomies, service protocols and security for locating, communicating and sharing measurement information

Incremental Progress toward an Ideal DCC

DCC development strategy advantages:

- Target an easy transition—increases adoption rate
- Quick results and incremental progress—no inordinate delays for the "perfect" DCC
- Pareto coverage—widest applicability in the shortest time

Some (future) ideal DCC elements:

- Unique equipment class IDs, e.g.
- A universal measurement-results model
- Rich, detailed traceability
- Machine-actionable measurement results

Toward Machine-Actionable Measurement Results

Distinct quantity concepts and representation levels

1. Quantity kind: most general, associated with measurement units, e.g. length
   - Applies to all quantity values, including uncertainties
   - Unique quantity IDs for unambiguous quantities
   - Unambiguous scales & units to handle any measurement arena
2. Measurand: most specific, the desired measured quantity, e.g., inner diameter
   - Metadata for measurement results in DCCs, functions in instrument specs, CMCs in accreditation statements and the KCDB
   - Unique measurand IDs
3. Semantically qualified: ontologically augmented quantities
   - Applies to machine-actionable operations
   - Smart calculations, unguided derivations

Section 2

Quantity Kinds and the M-Layer

Quantity Kinds

- Associated with quantity values and measurement units: $L = 1\,\mathrm{m}$
- Group references and expression conversions: $1\,\mathrm{m} = 100\,\mathrm{cm}$
- Explicitly or implicitly used in all sciences and applications
- Problems for machines:
  - Units do not always capture the quantity kind ($10°$: optical incidence or phase angle? Dimensionless quantities? $12\,\mathrm{N\,m}$: torque or energy? ...).
  - Free-form text descriptions do not suffice.
  - Scales not explicitly distinguished ($5\,°\mathrm{C}$: absolute temperature or temperature interval?)
  - Uncontrolled scale operations ($2\,°\mathrm{C} + 1\,°\mathrm{C} = ?$)

M-Layer Proposal for Quantity Kinds & Units

Remove all ambiguity and generalize to all measurement scenarios.

- Explicitly augment the usual quanity value $q\ [Q]$ with the quantity kind (aspect) $q\ [Q]\ \langle Q \rangle$.
- Handle all scales: ratio, interval, cyclic, logarithmic, ordinal, nominal, ...
- Handle any unit system.
- Uniquely identify aspects, scales and units in FAIR registries.

Section 3

Measurands and the MII Taxonomy

Measurands

- The quantity intended for measurement (radius or diameter?)
- Laboratories require accreditation for competency in specific measurement classes.
- The measurement classes should have unambiguous meaning and correspond to instrument functions (calibration requirements) and calibration results.
- Problems for machines:
  - The KCDB and accreditation statements present CMCs in a variety of ad hoc and unharmonized classification schemes.
  - Free-form text descriptions do not suffice.
  - Current descriptions correlate neither between document types nor organizations.

Example: Flow-Rate Descriptions in Use

Names from recognized bodies:

- KCDB: “fluid flow” (with “gas flow” or “liquid flow” and species)
- *ISO-IEC 80000*: “mass flow rate” and “volume flow rate”
- NVLAP: “[20/M05] Flow Rate”, plus “liquid flow” and “gas flow”
- DAkkS: ‘Gas flow rate”, “Volume of flowing gases”, and “Mass of flowing gases”

Neither names nor quantities consistent!

Example: Flow-Rate Descriptions in Use

Looking at approved SoAs from various ABs and Laboratories, we additionally find

> *"Mass Flow", "Liquid Flow", "Gas Flow", "Flow - Air", "Flow - Gas", "Flow - Liquid", "Flow - Gas (Air)", "Air/Nitrogen Flow", "Flow Rate by Volume", "Air Volume Flow", "Flow Hydraulic", "Fuel Flow", "Flow Rate by Volume for Compressible Gas", "Volumetric Flow Rate (Water)", "Liquid Flow Rate Inline", "Liquid Flow Rate Non-Intrusive", "Gas Flow - Leak", "Gas Leak", "Gas Flow Rate Into Vacuum", "mole-flow-rate", "Flow Meter Factor", "Flow Calibration Factor", "Flow Meter", "Determination of Flow Meter" (by gas or liquid species), "Electrical Output of Flow & Pressure Devices",*

and many other categorizations by flow instrumentation.
Further confusion: melt-flow index, flow velocity, air velocity, evaporation, load rate. Wow!

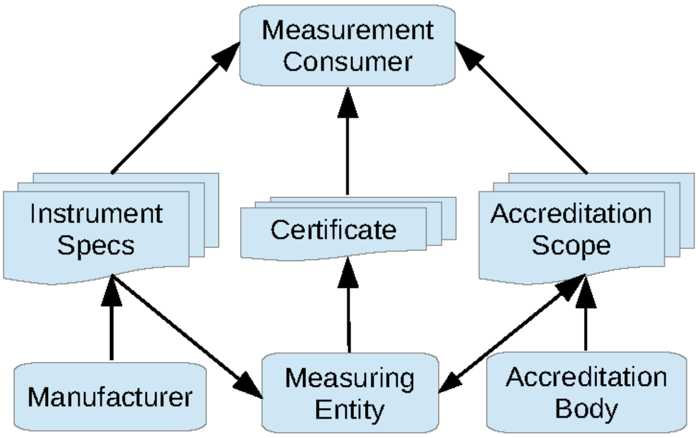
MII Proposal for Measurands

1. Standardize a taxonomy of measurands.
2. Link taxons to KCDB entry IDs and NMI service codes.
3. Tag digital document data with the taxons as metadata.

Spec: `Source.Voltage.DC`

SoA: `Measure.Voltage.DC`

Cert: `Source.Voltage.DC`



The MII Taxonomy and the M-Layer

Taxons associate to the aspect ID that governs the quantity values.

Quantity Value	Aspect ID	Taxon
		`Length.Circumference`
		`Length.Diameter`
		`Length.Form.Flatness`
1 ft		`Length.Form.Parallelism`
12 in		`Length.Form.Perpendicularity`
0.3048 m	⇔ ⟨length⟩ ⇔	`Length.Form.Roughness`
30.48 cm		`Length.Form.Roundness`
304.8 mm		`Length.Form.Sphericity`
		`Length.Form.Straightness.Axis`
		`Length.Form.Straightness.Surface`
		`Length.Radius`

Draft Taxons

Capacitance
Conductance
Conductivity
Current.AC
Current.AC.Noise.RMS
Current.AC.Sinewave
Current.AC.Sinewave.2Phase
Current.AC.Sinewave.3Phase
Current.AC.Squarewave
Current.AC.Trianglewave
Current.DC
Current.DC.Delta.Current.LoadEffect
Current.DC.Delta.Current.SourceEffect
Current.DC.OutputAndReadback
Density.Mass.Gas
Density.Mass.Liquid
Density.Mass.Solid
Energy.AC.Sinewave
Energy.AC.Sinewave.Simulated
Energy.AC.Sinewave.Simulated.2Phase
Energy.AC.Sinewave.Simulated.3Phase
Energy.DC
Energy.DC.Simulated
Force
Frequency
Frequency.AmplitudeModulation.Rate
Frequency.FrequencyModulation.Deviation
Frequency.FrequencyModulation.Rate
Frequency.PhaseModulation.Rate
Humidity.Absolute
Impedance
Inductance
Length
Length.Circumference
Length.Diameter
Length.Form.Flatness
Length.Form.Parallelism
Length.Form.Perpendicularity
Length.Form.Roughness
Length.Form.Roundness
Length.Form.Sphericity
Length.Form.Straightness.Axis
Length.Form.Straightness.Surface
Length.Radius
Mass.Apparent
Mass.Conventional
Mass.True
Phase.PhaseModulation
Phase.ReflectionFactor.RF
Phase.TransmissionFactor
PhaseNoise.SideBand
Power.AC.Sinewave
Power.AC.Sinewave.Simulated
Power.AC.Sinewave.Simulated.2Phase
Power.AC.Sinewave.Simulated.3Phase
Power.DC
Power.DC.Simulated
Power.RF.Sinewave
Pressure.Hydraulic.Static
Pressure.Pneumatic.Absolute.Static
Pressure.Pneumatic.Differential.Static
Pressure.Pneumatic.Gage.Static
Ratio.AmplitudeModulation
Ratio.AmplitudeModulation.Delta.Rate
Ratio.Density.Mass
Ratio.Distortion
Ratio.Distortion.AmplitudeModulation
Ratio.Distortion.FrequencyModulation
Ratio.Distortion.PhaseModulation
Ratio.DutyCycle
Ratio.FrequencyModulation.Delta.Rate
Ratio.Humidity.Relative
Ratio.Humidity.Specific
Ratio.PhaseModulation.Delta.Rate
Ratio.Power.ReflectionFactor.RF
Ratio.Power.RF.Sinewave.Delta.Frequency
Ratio.Power.RF.Sinewave.Delta.Power
Ratio.Power.RF.Sinewave.Harmonic
Ratio.Power.RF.Sinewave.Spur
Ratio.Power.TransmissionFactor
Ratio.PulseModulation.CWtoPulsedPower
Ratio.PulseModulation.OnOffPower
Ratio.Torque
Ratio.Voltage.AC.Ripple.OnDC

Draft Taxons

Ratio.Voltage.AC.Sinewave.Delta.Frequency
Ratio.Voltage.AC.Sinewave.Delta.Voltage
Resistance
Resistance.Insulation
Temperature
Temperature.Radiometric
Temperature.Simulated.PRT
Temperature.Simulated.RTD
Temperature.Simulated.Thermocouple
Time.Interval

Time.Period
Time.PulseWidth
Time.Transient
Time.Transition
Time.Transition.PulsedRF
Time.UTC
Torque
Torque.HydraulicPressure
Voltage.AC
Voltage.AC.NoisePeakToPeak
Voltage.AC.Ripple.OnDC

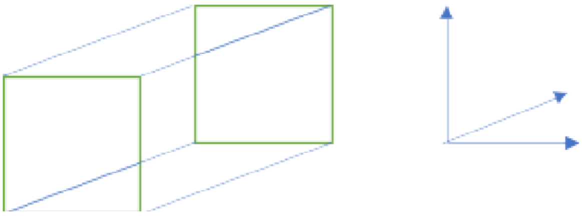
Voltage.AC.Sinewave
Voltage.AC.Sinewave.2Phase
Voltage.AC.Sinewave.3Phase
Voltage.AC.Squarewave
Voltage.AC.Trianglewave
Voltage.DC
Voltage.DC.Delta.Voltage.LoadEffect
Voltage.DC.Delta.Voltage.SourceEffect
Voltage.DC.OutputAndReadback
Voltage.DC.Segemented.Delta
Voltage.PeakToPeak

Section 4

More Advanced Semantics

Semantically Qualified Quantities

- Applies to machine-actionable operations
- May involve a more thorough quantity hierarchy
- Problems for machines:
  - No knowledge of quantity relations ($F = ma$)
  - No semantic knowledge (Which mass and acceleration?)
  - Consider a rectangular solid:
    - How do we define a perimeter, e.g., as a legal calculation?
    - Lengths on different axes (L_x, L_y, L_z) do not add linearly.
    - Falling back to the abstract length drops the perimeter ID. (Which face?)

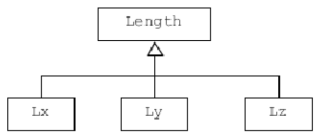


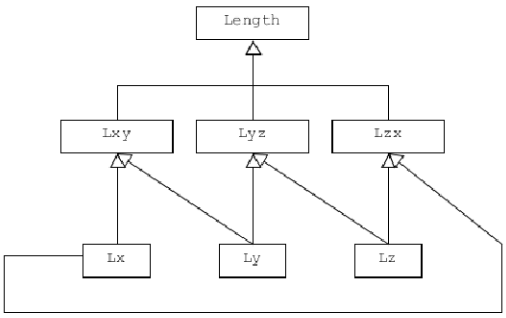
Extension Possibilities for Semantic Augmentation

Establish a hierarchical ontology of quantities to control calculations?

- `Length.Lxy.Lx`
- `Length.Lxy.Perimeter`
- Ontologies to distinguish shapes?

The NCSL International 141 MII and Automation Committee does not expect to build these; we merely offer ideas for thought.





Section 5

Conclusion

Incremental Steps toward Ideal Representations

1. M-Layer
   - Applies to all quantity values, including uncertainties
   - Unambiguous quantities to support any measurement software
   - Generalized scales & units for any measurement scenario
2. MII Measurand Taxonomy
   - Unique measurand IDs with unlimited human-readable aliases
   - Fully qualifies measurands for interoperable digital documents
   - (DCCs, instrument specs-DCRs, SoAs)
3. Semantic representations
   - Augmented representations for machine-actionable data
   - Future smart calculations, derivations

Conclusion

Collaboration

- Current information
  - Informal taxonomy at https://www.metrology.net/home/metrology-taxonomy/
  - Open-source taxonomy and SoA editors: https://github.com/CalLabSolutions/Metrology.NET_Public
  - Further info: http://miiknowledge.wikidot.com/
- Going forward
  - GitHub for configuration management: collaboration, submissions, approvals
  - M-Layer and MII Taxonomy specification and governance documents
  - https://github.com/NCSLI-MII opening for public participation soon
  - Prototype M-Layer registry and API now up and running

Conclusion

Acknowledgments

Please see the literature for further details.

Many thanks go to

- PTB and the DCC conference organizers for the kind invitation
- NCSL International for its MII support
- NCSL International Committee members for their MII development work
- Cherine-Marie Kuster

And Thank You for your time!

Collaboration opportunities? Please bring your expertise!

Questions?

10 Persistent Identification of Instruments and the Digital Calibration Certificate

Presenting author: Markus Stocker, TIB – Leibniz Information Centre for Science and Technology, Germany

E-mail address: markus.stocker@tib.eu

Additional authors: Rolf Krahl (Helmholtz-Zentrum Berlin, Germany), Robert Huber (MARUM, Univ. of Bremen, Germany)

Abstract

Instruments play an important role in producing research data, but they are mostly only identified with free text in research assets (e.g., dataset metadata or scientific literature). Through the use of persistent identifiers (PIDs), it is now common practice to establish traceable links between research assets. This webinar introduces the work by the RDA PIDINST WG [1] on persistent identification of instruments. Of particular focus are the PIDINST Metadata Schema [2] and the proposed solutions for publishing PIDs for instruments with DataCite and ePIC as established PID providers. Furthermore, we will sketch a proposal for how to interlink the PIDINST Metadata Schema with the Digital Calibration Certificate Schema.

[1] Research Data Alliance Persistent Identification of Instruments Working Group, https://www.rd-alliance.org/groups/persistent-identification-instruments-wg

[2] Krahl, R, Darroch, L, Huber, R, Devaraju, A, Klump, J, Habermann, T, Stocker, M, & RDA PIDINST WG Members. (2022). Metadata Schema for the Persistent Identification of Instruments (1.0). https://doi.org/10.15497/RDA00070

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Motivation

- Instruments play an essential role in creating research data
- Instrument metadata is required to assess data quality and reuse

  Borgman (*): “To interpret a digital dataset, much must be known about the hardware used to generate the data, whether sensor networks or laboratory machines.”

- Persistent linking of research data and instruments
- Cite instruments in scientific literature
- Inventory, funding, etc.

(*) Borgman, CL. 2015. Big Data, Little Data, No Data. MIT Press. https://doi.org/10.7551/mitpress/9963.001.0001

Origins

- PIDapalooza, November 2016
  - First presentation of Persistent Identification of Instruments
  - Yay! … http://yapid.org/
- Research Data Alliance, since 2017
  - RDA PIDINST WG endorsement and kick-off, March 2018
  - DSJ Article as RDA Supporting Outputs, July 2020
  - PIDINST metadata schema as RDA Recommendation, March 2022
  - https://pidinst.org

(*) https://doi.org/10.6084/m9.figshare.4246100.v1

Approach

- Persistent identifier for instrument instances used in research
- Use case driven metadata schema development
- Catalyse schema implementation by *existing* PID infrastructures, DataCite and ePIC
- Prototype adoption by existing institutional instrument providers
- Schema revisions to account for community feedback

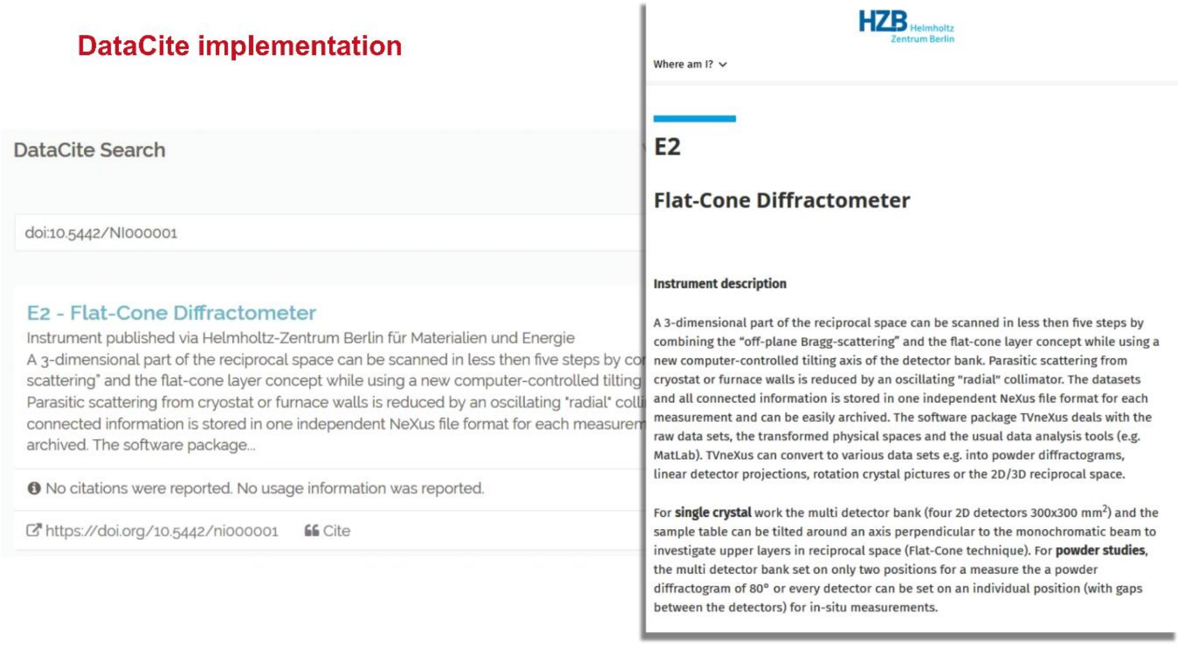
Schema

Name	Name by which the instrument instance is known
Owner	Institution(s) responsible for the management of the instrument
Manufacturer	The instrument's manufacturer(s) or developer
Model	Name of the model or type of device as attributed by the manufacturer
Description	Technical description of the device and its capabilities
InstrumentType	Classification of the type of the instrument
MeasuredVariable	The variable(s) that this instrument measures or observes
Date	Dates relevant to the instrument
RelatedIdentifier	Identifiers of related resources
AlternateIdentifier	Other identifiers pertaining to the same instrument instance

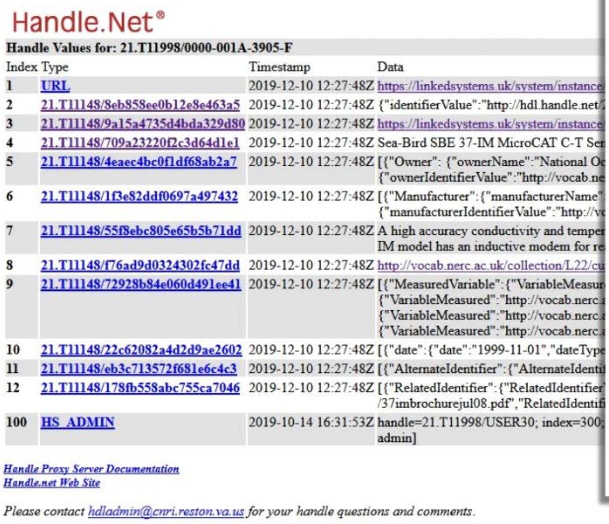
Schema implementations

- DataCite
  - Based on a PIDINST-DataCite Schema partial mapping
  - Missing attributes, e.g. measured variables, model name
  - Not applicable attributes, e.g. publisher, publication year
  - Bending semantics, e.g. creator for manufacturer
  - With version 4.5 new resource type “Instrument” (release planned for Q2/2023)
  - Global PID provider
- ePIC
  - Full PIDINST schema implementation
  - European-centric PID provider

DataCite implementation



ePIC implementation



Handle.Net®

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4	21.T11148/709a23220f2c3d64d1e1	2019-12-10 12:27:48Z	Sea-Bird SBE 37-IM MicroCAT C-T Ser
5	21.T11148/4eaec4bc0f1df68ab2a7	2019-12-10 12:27:48Z	[{"Owner": {"ownerName":"National Oc {"ownerIdentifierValue":"http://vocab.ne
6	21.T11148/1f3e82ddf0697a497432	2019-12-10 12:27:48Z	[{"Manufacturer":{"manufacturerName" {"manufacturerIdentifierValue":"http://vo
7	21.T11148/55f8ebc805e65b5b71dd	2019-12-10 12:27:48Z	A high accuracy conductivity and temper IM model has an inductive modem for re
8	21.T11148/f76ad9d0324302fc47dd	2019-12-10 12:27:48Z	http://vocab.nerc.ac.uk/collection/L22/cu
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Handle Proxy Server Documentation
Handle.net Web Site

Please contact hdladmin@cnri.reston.va.us for your handle questions and comments.


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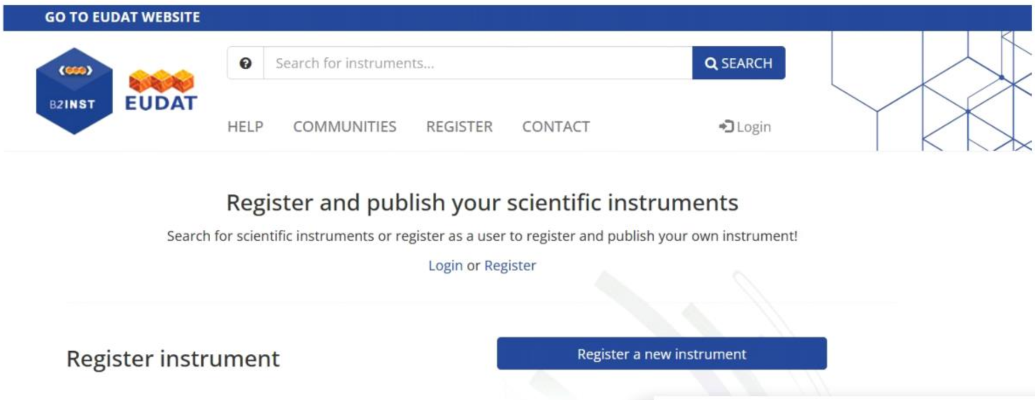
B2INST



https://b2inst.gwdg.de/

Outputs

TIB

Metadata Schema for the Persistent Identification of Instruments

RDA Recommendation

RDA RESEARCH DATA ALLIANCE

DOI: 10.15497/RDA00070

Authors: Rolf Krahl, Louise Darroch, Robert Huber, Anusuriya Devaraju, Jens Klump, Ted Habermann, Markus Stocker, RDA PIDINST WG members

Published: 30 March 2022

Version: 1.0

Abstract: Instruments play an essential role in creating research data but they are often only identified in scientific literature using free text. Through the use of globally unique, persistent identifiers (PIDs) such as the Digital Object Identifier (DOI), it is now common practice to establish traceable links between scientific literature and the data that generated it. Such cross-linking has received considerable attention in the community in recent years and has been generalized to other entities, including people, organizations, funders, etc. Given the importance of instruments and associated metadata to the assessment of data quality and data reuse, globally unique, persistent and resolvable identification of instruments is also crucial. The Research Data Alliance Persistent Identification of Instruments Working Group (PIDINST WG) developed and demonstrated a solution for publishing persistent identifiers for instruments at established PID providers. This solution comprises a metadata schema for the persistent identification of instruments (PIDINST Schema).

Schema is the recommended schema for the persistent identification of
ons or bodies using or managing instruments. The Schema is PID provider
een tested with ePIC and DataCite by numerous institutions including
lin für Materialien und Energie GmbH, British Oceanographic Data Centre,

https://doi.org/10.15497/RDA00070

RDA webpage: https://www.rd-alliance.org/group/persistent-identification-instruments-wg/outcomes/metadata-schema-persistent-identification

Citation and Download: Krahl, R., Darroch, L., Huber, R., Devaraju, A., Klump, J., Habermann, T., Stocker, M., & The Research Data Alliance Persistent Identification of Instruments Working Group members. (2021). Metadata Schema for the Persistent Identification of Instruments. *Research Data Alliance*. https://doi.org/10.15497/RDA00070

Outputs

TIB

PIDINST
latest
Search docs

PIDINST White Paper
ePIC Cookbook

Docs » Persistent Identification of Instruments   Edit on GitHub

Persistent Identification of Instruments

The Persistent Identification of Instruments WG (PIDINST) seeks to explore a community-driven solution for globally unique identification of measuring instruments operated in the sciences.

Measuring instruments, such as sensors used in environmental science, DNA sequencers used in life sciences or laboratory engines used for medical domains, are widespread in most fields of applied sciences. The ability to link an active instrument (instance) with an instrument type and with the broader context in which the instrument operates, including generated data, other instruments and platforms, people and manufacturers, etc., is critical, especially for automated processing of such contextual information and for the interpretation of generated data.

PIDINST is a working group in the Research Data Alliance (RDA). It aims to establish a cross-discipline, operational solution for the unique and lasting identification of measuring instruments actively operated in the sciences.

The group produced the following outputs:

- L, Krahl, R, Habermann, T, Devaraju, A, Schwardmann, U, D'Onofrio, C and
  Persistent Identification of Instruments. Data Science Journal, 19: 18, pp.
  oi.org/10.5334/dsj-2020-018
  an overview of the work of PIDINST.
- vides recommendations for the use of instrument PIDs and gives technical
  d the overview provided in the Data Science Journal paper. It is expected
  user requirements and working group activities.
- ePIC Cookbook
  Detailed instructions on how to create instrument PIDs using the ePIC infrastructure.

https://rda-pidinst.readthedocs.io/

Next

Outputs


DATA SCIENCE JOURNAL

Reading: Persistent Identification of Instruments   Share:

Special Collection: Research Data Alliance Results

Research Papers

Persistent Identification of Instruments

Authors: Markus Stocker, Louise Darroch, Rolf Krahl, Ted Habermann, Anusuriya Devaraju, Ulrich Schwardmann, Claudio D'Onofrio, Ingemar Häggström

Abstract

Instruments play an essential role in creating research data. Given the importance of instruments and associated metadata to the assessment of data quality and data reuse, globally unique, persistent and resolvable identification of instruments is … Working Group Persistent Identification of … a community-driven solution for persistent … h we present and discuss in this paper. Based on an … eveloped a metadata schema and prototyped … Cite and ePIC as representative persistent identifier infrastructures and with HZB (Helmholtz-Zentrum Berlin für Materialien und Energie) and BODC (British Oceanographic Data Centre) as representative institutional instrument providers. These implementations demonstrate the viability of the proposed solution in practice. Moving forward, PIDINST will further catalyse adoption and consolidate the schema by addressing new stakeholder requirements.

Keywords: Persistent Identification, Instruments, Metadata, DOI, Handle

https://doi.org/10.5334/dsj-2020-018

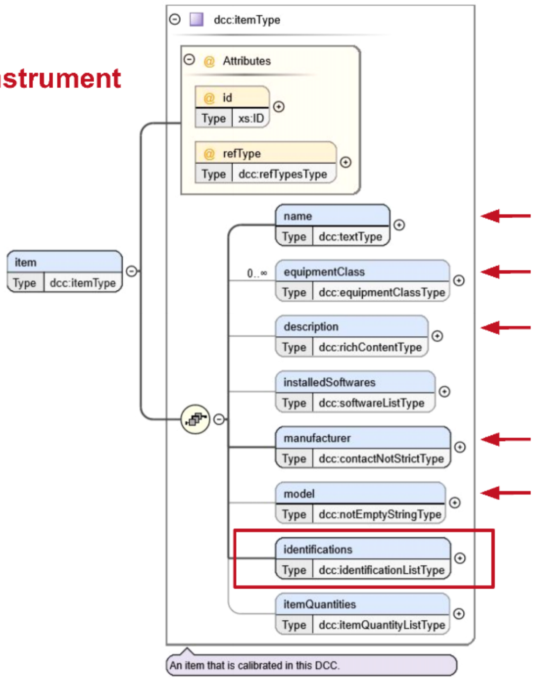
Adoption

Linking DCC and PIDINST: The calibrated instrument

digitalCalibrationCertificate

→ administrativeData

→ items



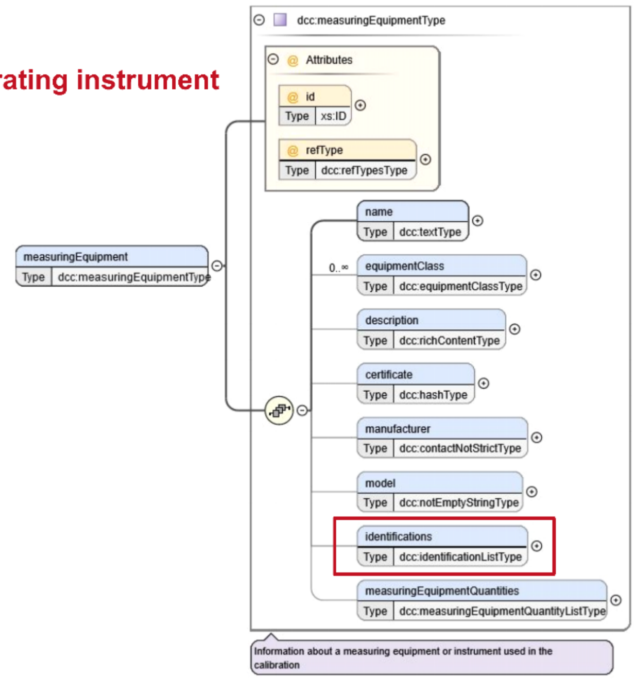
Linking DCC and PIDINST: The calibrating instrument

digitalCalibrationCertificate

→ measurementResults

→ measurementResult

→ measuringEquipments



Linking PIDINST and DCC

Attribute	Value	Comment
RelatedIdentifier	https://dccwiki.ptb.de/goodpractice/temperature/dcc_gp_temperature_simplified_v12.xml	Not really, but you get the point
relatedIdentifierType	DOI, URL, Handle, etc.	
relationType	HasMetadata	Or a more specialized one, which we could add
relatedIdentifierName	Digital Calibration Certificate	Or similar

Takeaways

- Foundations for persistent identification of instruments are in place
- Approaches have been tested and validated
- Time to scale adoption
- Potential of integrating DCC and PIDINST, in industry and in science (ESFRIs)
- Develop some concrete examples showcasing the integration

Session C: Different DCC Approaches

Presentations that would also fit into this session:

- 09 The Semantics of Measured Quantities
- 17 The Digital NIST: Pilot Project for the Digital Transformation of NIST's Measurement Services
- 24 Python Tools Examples for the Transition to DCC

11 DCC and Digitisation versus Digitalisation and Digital Transformation

Presenting author: Siegfried Hackel, PTB, Germany

E-mail address: siegfried.hackel@ptb.de

Additional authors: Muhammed Ali Demir, Lutz Doering, Benjamin Gloger, Justin Jagieniak, Moritz Jordan, Christian Keilholz, Jan Loewe, Kai Mienert, Shanna Schönhals, Gamze Söylev Öktem (in alphabetical order, all PTB)

Abstract

The utility model [1] is a description of the scope to which data formats are suitable for use in the Industry 4.0 or IIoT environment. The levels assigned range from level 0 (paper) to level 5 (machine-controllable content). PDF is seen at level 1 (digital document). XML without an XML schema referenced to it reaches Level 2 (machine-readable document). Since a DCC XML file is a file validated according to the DCC XML schema, the elements and attributes used in the DCC are defined. Therefore, a DCC XML file reaches level 3 (machine-readable with executable content).

Based on this model and the comparison between the previous methods and procedures, it is analysed to what extent the different approaches known to the author meet the requirements of a digital transformation. As a result, the question is discussed to what extent the individual methods differ from each other and to what extent the methods can be merged.

[1] https://www.dke.de/resource/blob/2272802/facc9bde1806e2194a3d26a60c79bf77/idis-whitepaper-1-en---download-data.pdf

Link to the video with subtitles: https://www.youtube.com/watch?v=zJ8bhhYILvw

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Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin
Nationales Metrologieinstitut

DCC and Digitisation versus Digitalisation & Digital Transformation

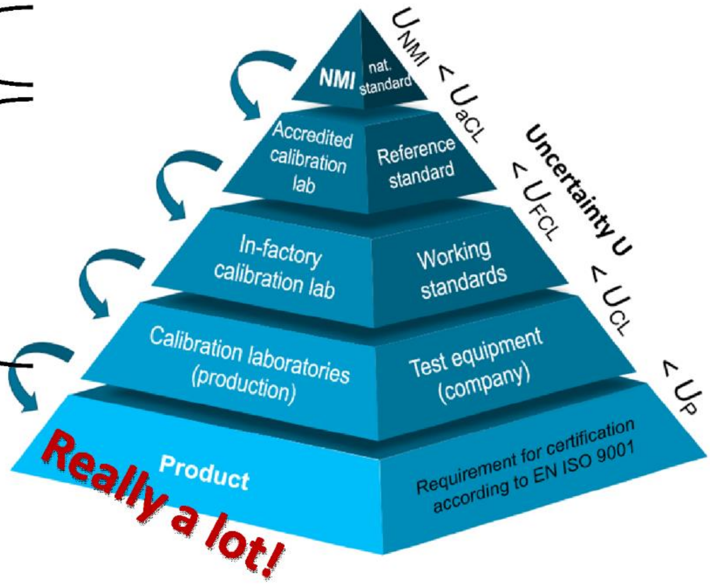
Siegfried Hackel

02

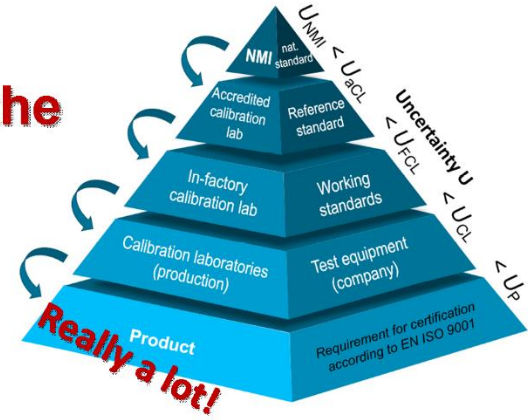
The Calibration Pyramid

PTB:
≈ 5 500
calibrations per year

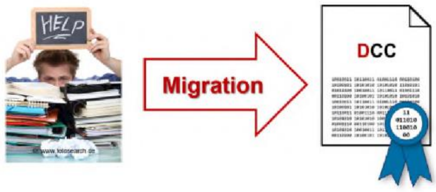
German industry:
millions of
calibrations per year



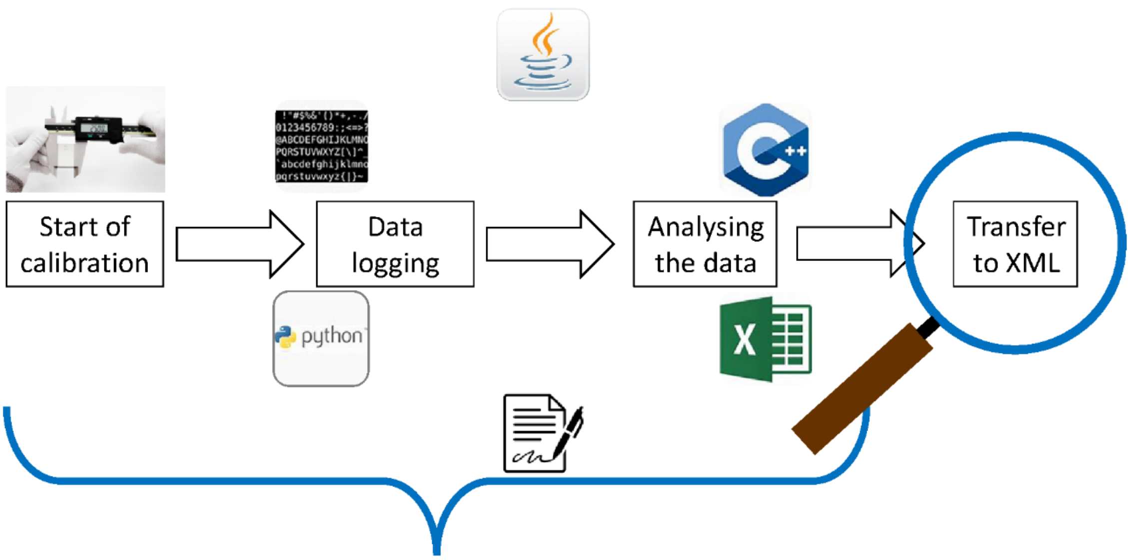
What are the essential goals for everyone in the pyramid?



- Free of media discontinuity
- Safety and security
- Industry
  - ✓ Process efficiency
  - ✓ Important for Industry 4.0
    - ✓ Administration shell
- Unambiguousness
  - ✓ Clear and error-free data
  - ✓ Clearly defined globally
  - ✓ Strong quality increase

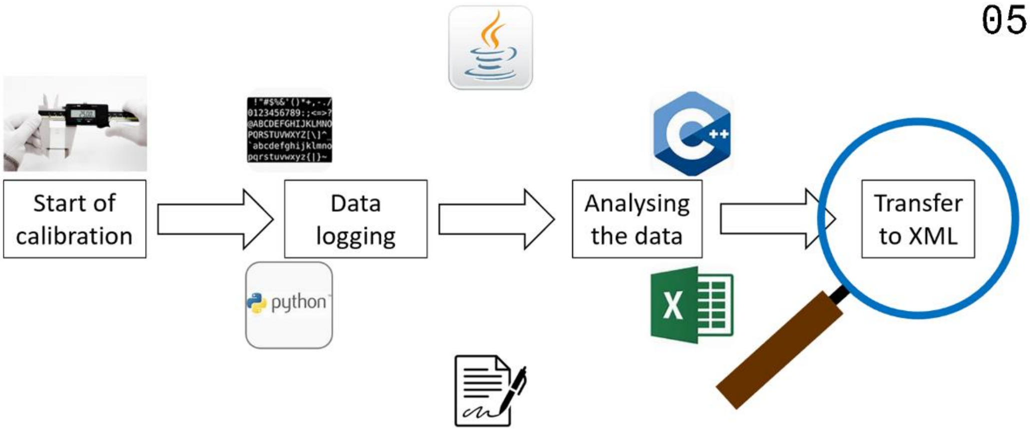


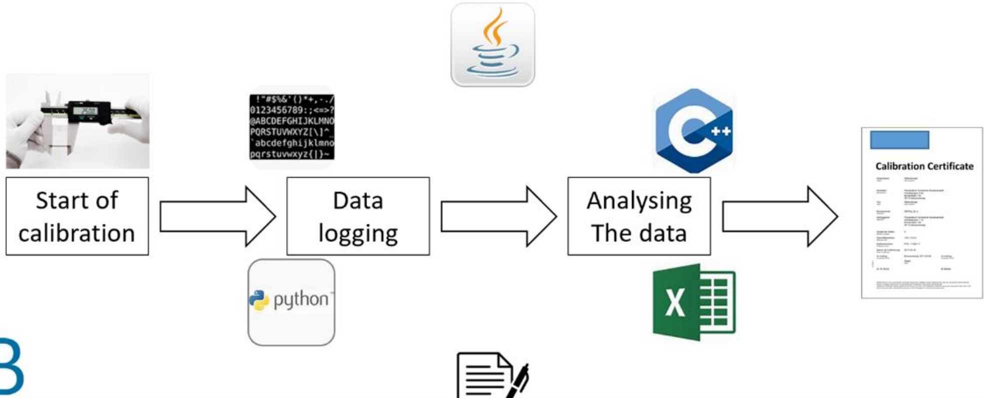
Workflow



Proceed as previously done

05





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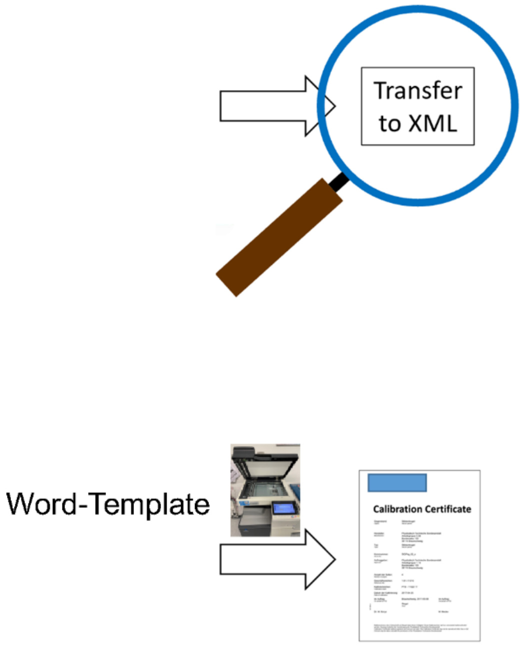
05



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06

The Utility-Model

DIGITALIZATION

Level 5: Machine controllable Contents — AI Dig. Twin

Level 4: Machine readable and interpretable content — GP DCC

Level 3: Machine readable and executable content — DCC

Level 2: Machine readable document — XML

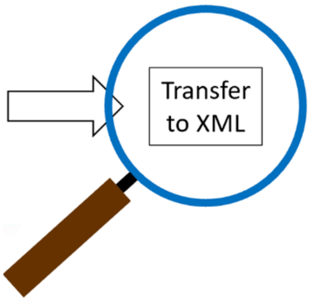
Level 1: Digital document — PDF

Level 0: Paper

From: „IDiS – Initiative Digitale Standards“. [Online].
see: https://www.dke.de/resource/blob/2076816/facc9bde1806e2194a3d26a60c79bf77/idis-whitepaper-1-en---download-data.pdf

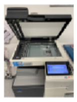
07

Digitalization and Digital Transformation



Digitisation

Word-Template
Word-Template → PDF
PDF-Template
LaTeX-Template → PDF



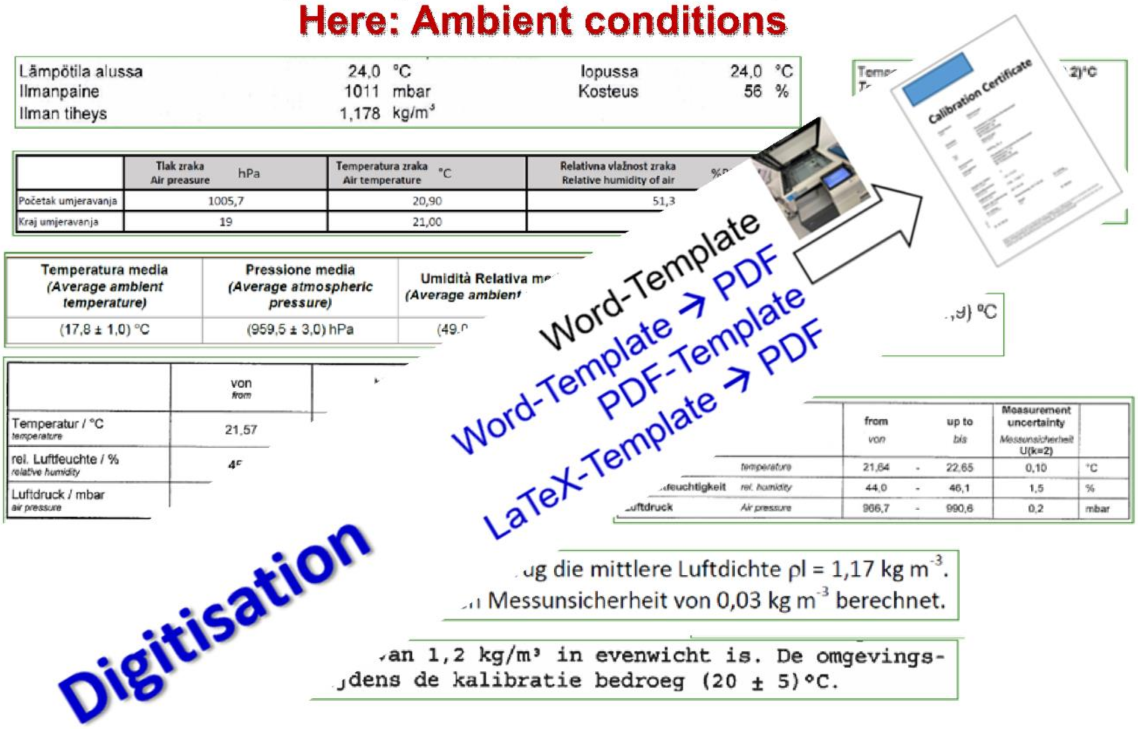
08a

Why Digitalisation and Digital Transformation and not only Digitisation?

- Machines are stupid
  - ✓ Example:
    - ❖ Ring comparison for a mass piece

Ring comparison for a mass piece
Here: Ambient conditions

08b



Snapshots taken from the presentation of Julian Haller (Sartorius), held on the 42th AWA-PTB-Talk, 2022-05-09

08c

Why Digitalisation and Digital Transformation and not only Digitisation?

- Machines are stupid
  - ✓ Example: Ring comparison for a mass piece
- Machines need unambiguously interpretable data
  - ✓ Clear and error-free data
  - ✓ Globally unique and clear
- No limitation when transmitting a lot of data
- Error protection through XML schema and Schematron
- Compliance with the requirements (if needed)
  - ✓ ISO/IEC 17025
  - ✓ More objective auditing
  - ✓ ...
- See industry related presentations at this conference
  - ✓ (next Slide)

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09a

Links to presentations at this conference

- Industry related presentations (1)

Presentations that would also fit into this session:

- 01 Digital Calibration Certificate as part of an Ecosystem
- 05 Bringing the Digital Accreditation Symbol and the Digital Calibration Report (DCC) into Practice
- 09 The Semantics of Measured Quantities
- 11 DCC and Digitisation versus Digitalisation and Digital Transformation
- 21 DKD's Contribution to DCC Harmonisation and Coordinated Development
- 22 GEMIMEG-II – Status and Progress Report
- 31 DCCs for Non-Automatic Weighing Instruments (NAWIs) – Current Status of a Respective Working Group Elaborating "Good Practice" Conventions
- 32 Digital Calibration Certificates for Weights and Mass Standards: Rules and Applications

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09b

Links to presentations at this conference

➢ Industry related presentations (2)

Presentations that would also fit into this session:

- ➢ Session C: DCC and Machines
- ➢ 01 Digital Calibration Certificate as part of an Ecosystem
- ➢ 06 The General DCC Rulebook and the Rules under the Aspects of Accreditation
- ➢ 10 Persistent Identification of Instruments and the Digital Calibration Certificate
- ➢ 11 DCC and Digitisation versus Digitalisation and Digital Transformation
- ➢ 22 GEMIMEG-II – Status and Progress Report
- ➢ 38 The Quality of Sensing, of Data or of Information
- ➢ 51 How does a Machine Distinguish the Different Types of DCCs?

10

And what's about human readability?

- ➢ There are a variety of tools for XML
  - ✓ XML Notepad (Microsoft; p. d.), ...
  - ✓ But also:
    - ❖ Altova, Oxygen, ...
- ➢ Auditors
  - ✓ A standardized output is presented to the auditors
  - ✓ Contributes to objectification
  - ✓ With tools XML can be checked directly
  - ✓ Of course: Check also possible via human readable
- ➢ See human readable presentations at this conference
  - ✓ (next Slide)

11a

Links to presentations at this conference

➢ Human readable related presentations (1)

Presentations that would also fit into this session:

- 01 Digital Calibration Certificate as part of an Ecosystem
- 12 Development of PDF based Digital Calibration Certificates at NMIJ, AIST
- 53 DCC Middleware – Obstacles and Approaches
- 56 DCC via iPhone (or iPad)

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11b

Links to presentations at this conference

➢ Human readable related presentations (2)

Presentations that would also fit into this session:

- 07 Qualified Electronic Seals - The Peace of Westphalia in the Laboratory Sector
- 19 Analyzing the Conformance of DCC Prototype Architecture to Calibration Laboratory Expectations Report

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11c

Links to presentations at this conference

➢ Human readable related presentations (3)

Presentations that would also fit into this session:

➢ 01 Digital Calibration Certificate as part of an Ecosystem

12a

Pros and cons (1)

Pro XML		Pro PDF/A3
XML is internationally standardised and is very well suited for long-term storage.	Pro1	PDF/A3 is internationally standardised and is very suitable for long-term storage.
If the end user works with XML straight away (which he does not notice because of the tools), he will be spared another migration step later (away from PDF/A3 to XML).	Pro2	Everyone knows PDF and it is easy to understand. It is often used in public authorities and administrative offices.
Tried and tested, in widespread use for more than 20 years, and already human-readable in this form for skilled users.	Pro3	Does not require much training time or has been in use for a long time and is therefore familiar.

12b

Pros and cons (2)

Pro XML		Pro PDF/A3
Human readable are supported in several formats. Stakeholders have the choice between different formats. For example, PDF, HTML5, DOCX...	Pro4	
Use of modern viewers such as HTML is possible. Advantages (not complete): 1. Especially for larger calibration results, a much better possibility of viewing is enabled (keyword: no page breaks and no size limitations). 2. Further active HTML5 elements can be integrated (e.g., sorting of tables).	Pro5	
Free choice of signature and encryption algorithms.	Pro6	

12c

Pros and cons (3)

Pro XML		Pro PDF/A3
Allows pure data exchange without the 4th ring. This avoids the danger of data being provided with errors when it is output twice due to the HR. According to ISO 17025, the inner rings would be completely sufficient.	Pro7	
The DCC is complete.	Pro8	
Transfer to other formats is guaranteed without loss of information	Pro9	
Utility model: Level 3-4 (PDF A/3: Level 1)	Pro10	

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12d

Pros and cons (4)

Contra XML		Contra PDF/A3
The enclosed Human Readable must first be extracted from the XML and converted to view it (task of the calibration lab). Solved.	Contra 1	If the end user works with XML straight away (which he does not notice because of the tools), he will be spared another migration step later (away from PDF/A3 to XML).
Seems more complicated than signing and encrypting via PDF.	Contra 2	A special viewer is always needed (XML does only need a text editor).
Easy-to-understand software to validate the DCC via XML signature must be developed separately. Solved.	Contra 3	ALWAYS requires human readable document. This would make an analogue document a mandatory field.

12e

Pros and cons (5)

Contra XML		Contra PDF/A3
	Contra 4	The use of the DCC scheme can be completely undermined as all files are taken over without checking.
	Contra 5	It is not clear whether the DCC is complete.
	Contra 6	The XML file must be extracted beforehand. This means an additional step in the process chain.
	Contra 7	Utility Model Level 1 (XML: Level 3-4)
	Contra 8	It is not a given that PDF/A3 is supported by all PDF viewers

12f

Pros and cons (6)

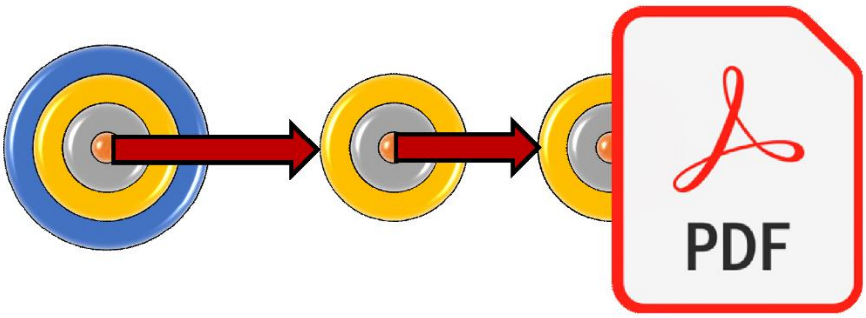
Contra XML		Contra PDF/A3
	Contra 9	Adobe would have a monopoly on the signature and encryption algorithms supported by PDF, as well as valid certificate authorities, even though PDF/A3 is standardised.

What's about the FAIR principle?

Findable, Accessible, Interoperable, Reusable

13

Finally:
And what's about PDF/A3 with validated XML on board?



13

Finally: And what's about PDF/A3 with validated XML on board?

See Slide 10 ...

- There are a variety of tools for XML
  - ✓ XML Notepad (Microsoft; p. d.)
  - ✓ But also:
    - ❖ Altova, Oxygen, ...
- Auditors
  - ✓ With tools XML can be checked directly
  - ✓ A standardized output is presented to the auditors
  - ✓ ...

But: **Fixation on one PDF**
No other formats
Additional step: XML extraction

14

The Co-Authors

alphabetical sequence

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2023-03-01

12 Development of PDF based Digital Calibration Certificates at NMIJ, AIST

Presenting author: Kazuaki Yamazawa, NMIJ, Japan

E-mail address: kazuaki-yamazawa@aist.go.jp

Additional authors: Michitaka Ameya, Naoyuki Taketoshi

Abstract

Digital Transformation in metrology has grown to be a worldwide interest since the publication of the Joint Statement of Intent on the digital transformation in the international scientific and quality infrastructure in March 2022 [1]. During the year 2022, NMIJ, AIST has carefully made interactions with domestic stakeholders upon their demands. Through such communication, we have identified that many of our stakeholders prefer to experience a moderate transition to digitalization.

Having the leading examples such as the PTB's XML approach [2] and the PDF approach proposed by METAS [3] and some further investigations upon the ISO Standards related to PDF, we have selected the PDF approach to implement our first Digital Calibration Certificate (DCC) to be issued under our governing domestic law. The PDF file has an appearance very similar to our existing calibration certificates issued on paper, however, it also includes digital data embedded, such as the metadata of the calibration as well as calibration results in CSV format as a courtesy to our customers [4]. Since November 2022, we have officially initiated our service to issue DCCs for service items that are prepared for issuing DCCs to those customers anticipating them. Among approximately 600 service items that we provide, we have given priority to those service items that contain a large amount of data (eg. calibration certificates in radio frequency) and the number of DCC issued has just exceeded 10. In our presentation, we will explain the domestic background, the considerations we have made until we finally decided to initiate the official service to issue DCCs to our customers along with the technical details of our DCC format utilizing the various features of the PDF.

[1] https://www.bipm.org/en/liaison/digital-transformation
[2] https://dccwiki.ptb.de/en/home
[3] https://www.sciencedirect.com/science/article/pii/S2665917421002452
[4] Presentation at the APMP DXFG webinar, 28 November 2022.
https://apmp-dxfg.org/dxfg-eoy-webinar-2022.html

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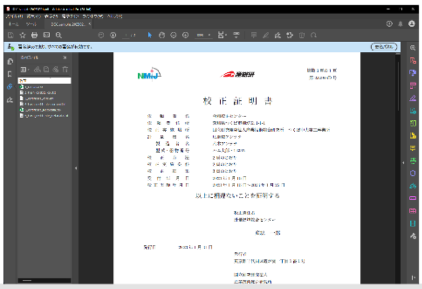
Session C: Different DCC Approaches
Presentation 12
3rd DCC Conference, March 2023

Development of PDF based Digital Calibration Certificates at NMIJ, AIST



Kazuaki Yamazawa
Michitaka Ameya
Naoyuki Taketoshi
NMIJ, AIST Japan

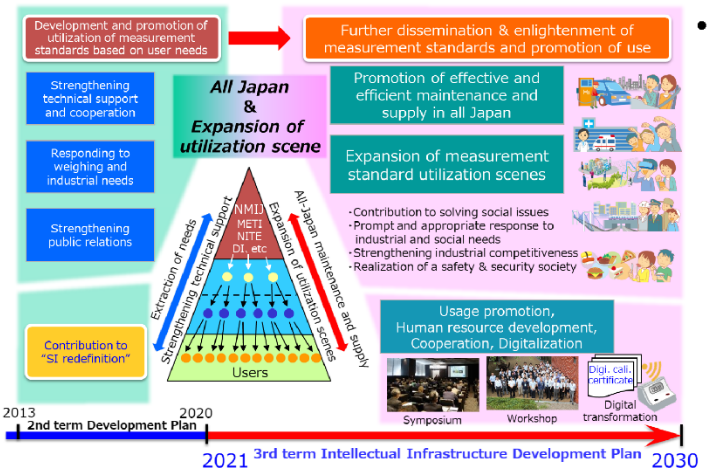
Contents

- Domestic background
- Considerations upon the development of our DCCs
- Our current DCC
- Conclusion

Domestic background

Necessity on talking with our stakeholders

The National Roadmap includes DCCs



- National road map, 3rd term (2021 to 2030)
  - DCC is included as one of the key elements
  - Implementation is discussed among the stakeholders
    - NMI/DIs
    - Accreditation bodies
    - Utilizers of calibration certificates
  - (In Japanese) https://www.meti.go.jp/press/2021/05/20210531004/20210531004.html

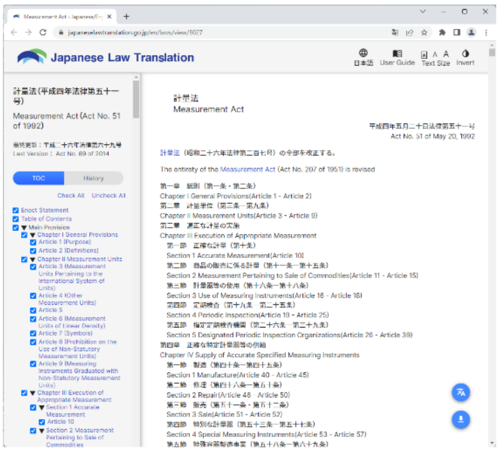
Of course, in progress!

NMIJ

AIST

Domestic background: Measurement Act

https://www.japaneselawtranslation.go.jp/en/laws/view/3027



JCSS as a system for dissemination of standards through calibration is established under the domestic law “Measurement Act”

JCSS =Japan Calibration Service System

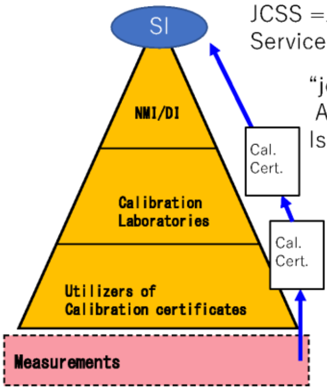
第八章　計量器の校正等
Chapter VIII Calibration of Measuring Instruments
第一節　特定標準器による校正等（第百三十四条―第百四十二条）
Section 1 Calibration using Specified Standard Instruments(Article 134 - Article 142)
第二節　特定標準器以外の計量器による校正等（第百四十三条―第百四十六条）
Section 2 Calibration using Measuring Instruments other than Specified Standard

NMIJ

AIST

Calibration Certificates are one of our interfaces between NMI/DIs and customers

- NMIs/DIs implement the National Standard
  - Realization of the SI
- Calibration certificates issued employing the National Standard will be one of the evidences to demonstrate metrological traceability for the customer’s point of view
- Stakeholders
  - METI: the Ministry
  - IAJapan, NITE; Accreditation body
  - DIs: Designated Institutes
  - Calibration Laboratories
    - Approximately 260 labs nationwide



JCSS =Japan Calibration Service System

“jcss” certificates
Article 136
Issued by NMIJ

“JCSS” certificates
Article 144
Issued by Calibration Labs

Calibration certificates can be also interpreted as one of the communication paths for NMIs/DIs with our society

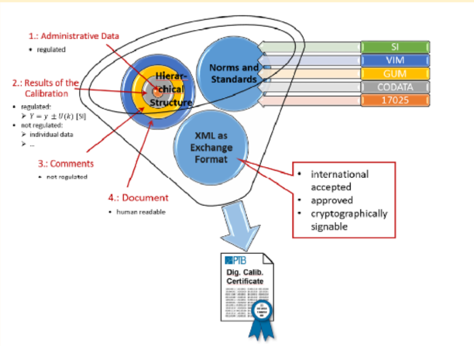
Considerations upon the development of our DCCs

Considerations on the DCC Format and its production method

Consideration on the format of our DCCs

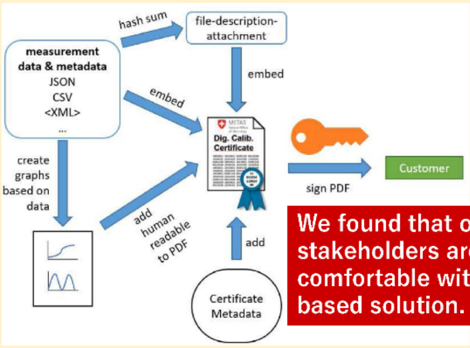
Learning from the experience of the leading institutes

PTB's XML format



https://dccwiki.ptb.de/flyer/dcc_english.pdf

METAS's PDF/A



We found that our stakeholders are more comfortable with the PDF based solution.

https://doi.org/10.1016/j.measen.2021.100282

Consideration on the DCC production method

- Survey within NMIJ with their tools through internal audits
  - Data analysis
    - MS-Excel
      - Many using macros
    - Automated programs
      - LabVIEW
      - Python
      - MATLAB
      - C or C++
      - Visual Basic
      - FORTRAN
  - Printing the paper calibration certificates
    - MS-Excel
    - MS-Word
    - TeX

We indeed have a variety of tools, and an extreme difficulty is foreseen when attempting to unifying the production method.

Our current DCC

NMIJ

AIST

NMIJ's DCC

- **PDF file with attachment of digital data**
  - Friendliness to our existing customers
  - Having a governing domestic law, adopting PDF files needed less effort to change the regulations
- **Security**
  - Electronic signature
  - Unique identification by certificate number distinguishing digital format
- **Software**
  - Since we foresee that it is difficult to unify the production method, we adopt various options for the DCC production.
    - Producing PDF files and embedding digital files can be accomplished using off the shelf software.
    - Necessity of special care so that the data appearing upon the PDF pages and that embedded to the PDF file. (e.g. number of digits of the data)

Adopt various options to ease participation to DCC

NMIJ

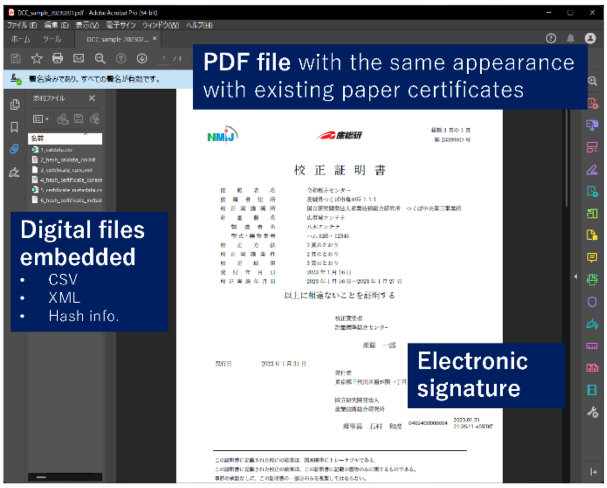
AIST

NMIJ's DCC

- **PDF file**
- **Electronic signature**
- **Embedded files**
  - **Considering the consistency with our paper certificates, the embedded digital data is provided as a courtesy.**

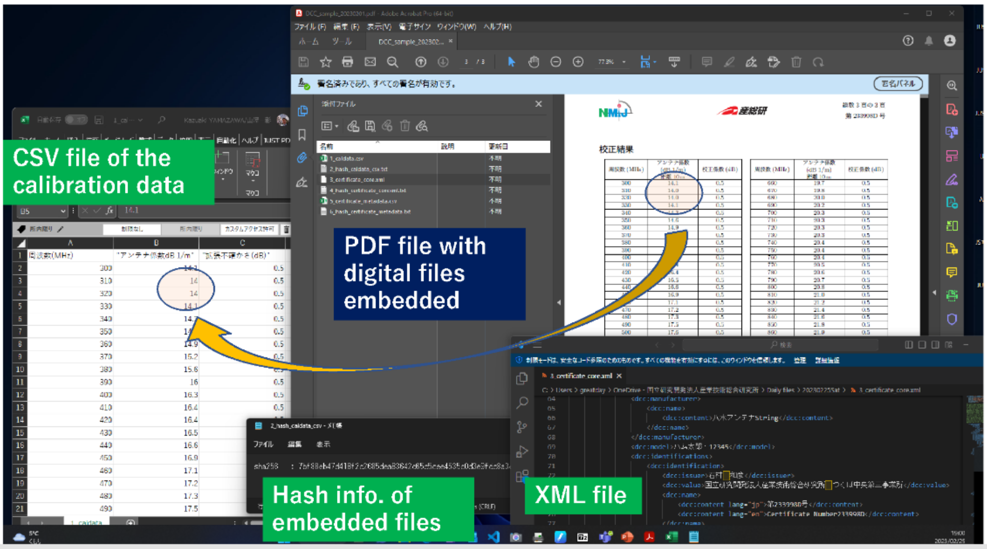
We have just reached the "Starting-line" of the marathon race!

- Our institution regulation is now revised to enable issuing DCCs (effective 1st Nov. 2022)
- The first DCC issued Nov. 2022
- We will release services from those items that we get prepared (about 600 service items to go)



NMIJ's DCC

Calibration certificate for antenna factor 300 MHz to 1 GHz (71 frequency points)



Conclusion

Conclusion

- For the DCCs, NMIJ has selected PDF files with attachments of digital data upon talking with our stakeholders
  - We have officially initiated our service to issue DCCs for service items that are prepared for issuing DCCs to those customers anticipating them.
  - First DCC issued November 2022.
  - Among approximately 600 service items that we provide, we have given priority to those service items that contain a large amount of data (eg. calibration certificates in radio frequency).
- Talking with the stakeholders is very important to change systems
- Implication of further difficulties between the generalization and software independence of the DCC data format

Development of PDF based Digital Calibration Certificates at NMIJ, AIST

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Quality Manager, NMIJ, AIST
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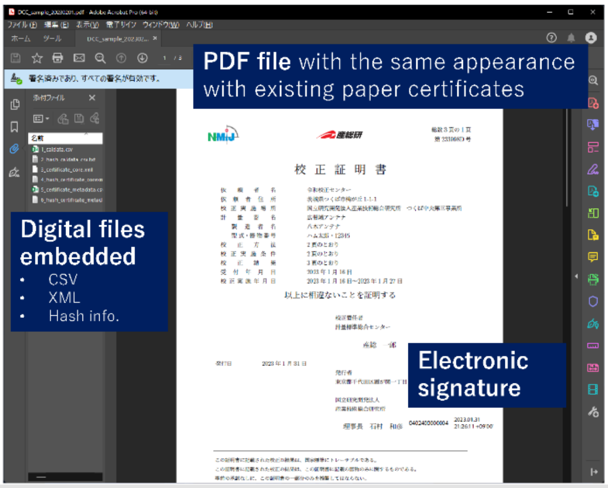
Session C: Different DCC Approaches
Presentation **12**
3rd DCC Conference, March 2023



13 Software for the Creation of Machine-Readable and Human-Friendly Reports

Presenting author: Diego Nahuel Coppa, Instituto Nacional de Tecnología Industrial, Argentina

E-mail address: dcoppa@inti.gob.ar

Additional authors: Federico Grasso Toro, Diego Calero, Santiago Mercado, Marcos Bierzychudek

Abstract

Towards the fourth industrial revolution, the metrology community will be required to report metrological information in digitalized structured forms. Beyond the discussion of which structures will be harmonized in reporting types and formats, it is imperative to start developing software, good practices and examples that help metrologists to report digitally structured information.

Mapping seems to be the most important issue to address when generating digital reports. Hence, this paper refers to mapping as the link from the information source to the final report, providing traceability and provenance when required.

This paper also shows a practical way of approaching mapping for metrologists to engage in the generation of data and metadata models, an XML for a given XSD, as well as to harmonize the generation of digitalized reports by PDF-A.

This paper bases its example in the data structure (XSD) of the DCC XML schema hosted by PTB.

To simplify the approach of generating results as an XML and a PDF-A, this example makes its foundation in simplifying the mapping to scripts written in Python and XSLT. The usage of a subscriber file, a JSON data structure, allows the approach to articulate between the different scripts. The software that manages them is also written in Python.

Finally, the paper takes as a source a spreadsheet, used as a simple data collector. The mapping to other types of sources, such as relational and non-relational databases, can be also addressed. XML generation is handled by generateDS, a python library that generates methods from the XSD to be used in the scripts, as well as for validation and parsing. An XSLT script is the link to transform the XML in the PDF-A.

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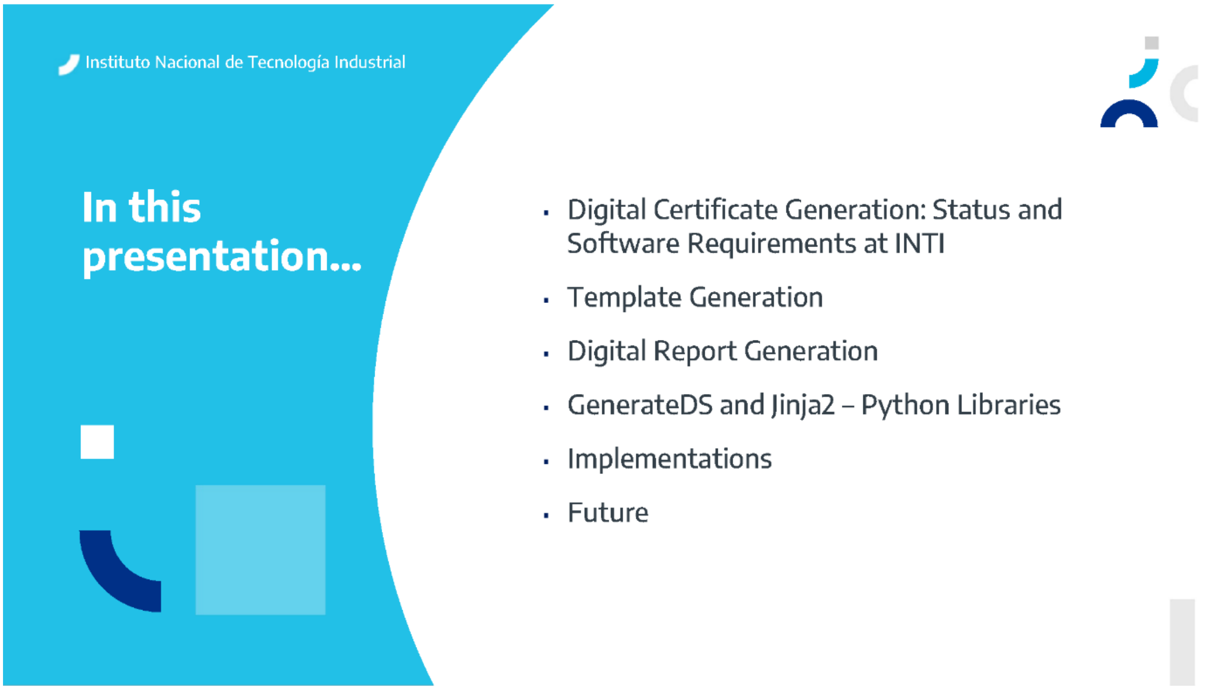
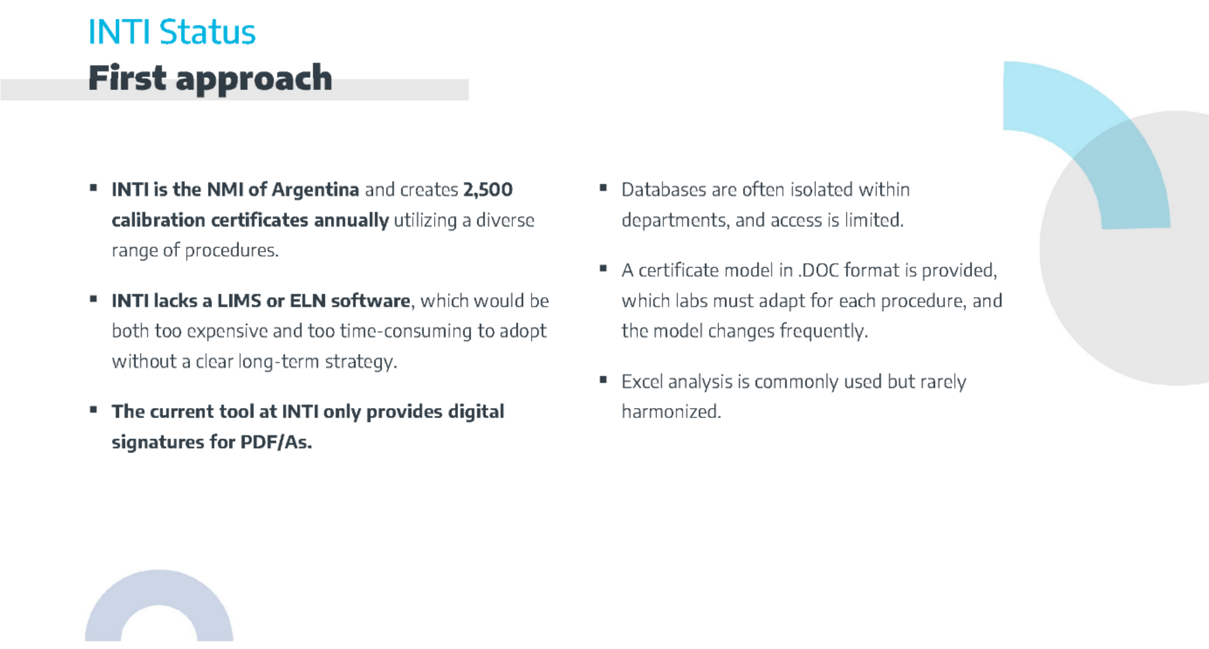
DR-INTI Software
Software for the Creation of Machine and Human Readable Reports
Online | March | 2023 - Diego Nahuel Coppa, Federico Grasso Toro, Diego Calero, Santiago Mercado, Marcos Bierzychudek
Instituto Nacional de Tecnología Industrial
INTI
Ministerio de Economía Argentina
Secretaría de Industria y Desarrollo Productivo

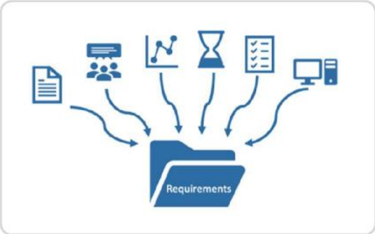

Instituto Nacional de Tecnología Industrial
In this presentation...
Digital Certificate Generation: Status and Software Requirements at INTI
Template Generation
Digital Report Generation
GenerateDS and Jinja2 – Python Libraries
Implementations
Future


Instituto Nacional
de Tecnología Industrial
INTI
Digital Certificate Generation:
Status and Software
Requirements at INTI


INTI Status
First approach
INTI is the NMI of Argentina and creates 2,500 calibration certificates annually utilizing a diverse range of procedures.
INTI lacks a LIMS or ELN software, which would be both too expensive and too time-consuming to adopt without a clear long-term strategy.
The current tool at INTI only provides digital signatures for PDF/As.
Databases are often isolated within departments, and access is limited.
A certificate model in .DOC format is provided, which labs must adapt for each procedure, and the model changes frequently.
Excel analysis is commonly used but rarely harmonized.

Software Requirements
Ideal Objectives

- **Modular and scalable.**
- **Cost-effective to develop, implement and maintain (supported by the community).**
- **Workload Distribute Among Metrologists who do not program on daily basis.**
- **Intuitive software management. Transparent for the final user.**
- **FAIR data focused** (machine to machine, M2M, oriented).
- Improve report generation.
- Availability to be adopted by Secondary Labs



DR-INTI Software
Development Highlights

DR-INTI is a tool created by INTI with two functionalities:

- **Template generation** in XLSX format and
- **Digital Reports generation,** XMLs and PDF/As files

Three Modules or Layers:

- The Interface Module: Web interface and an optional XLSX interface
- The Management Module is written in Python and jinja2*LATEX*.
  - Source/XLSX -> XML -> PDF/A.
  - All packages has MIT licenses or similar.
  - No database involved
- Subscription Module: **Mapping of the information.**
  - generateDS software support.
  - 'dictionary' based interaction to generate LATEX files.

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de Tecnología Industrial
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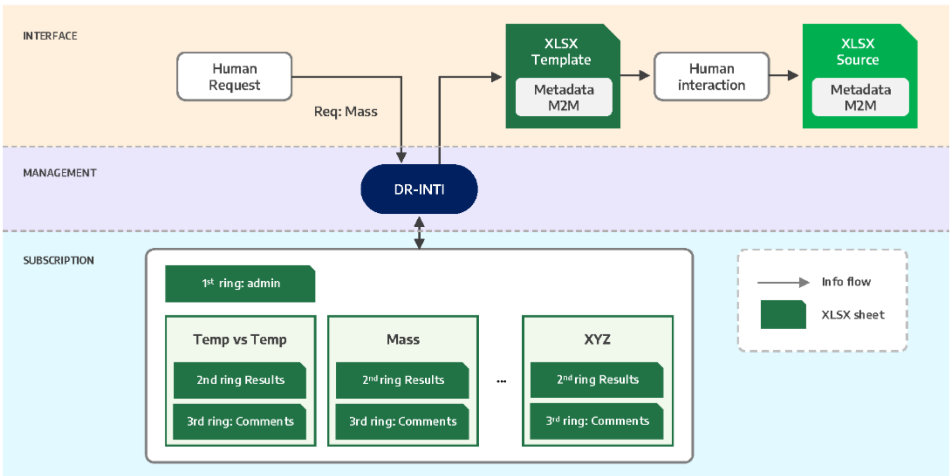
Template Generation

Template Generation
Information Flow: DR-INTI



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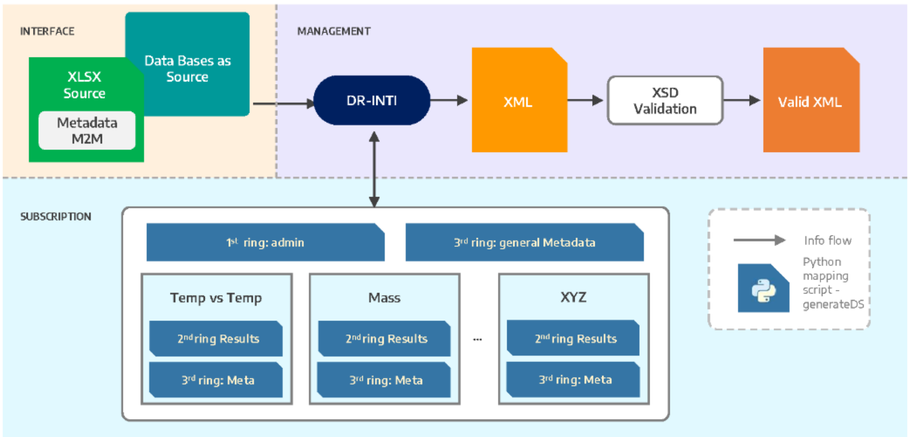
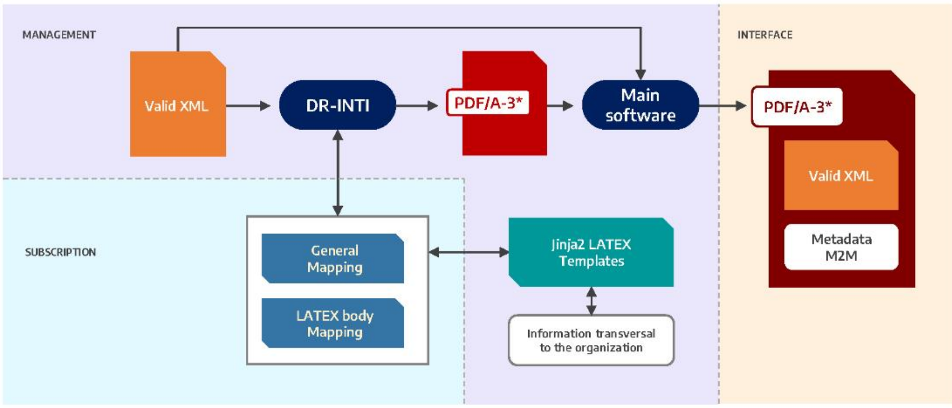
INTI

Digital Report Generation

Digital Report Generation: XML
Information Flow: DR-INTI

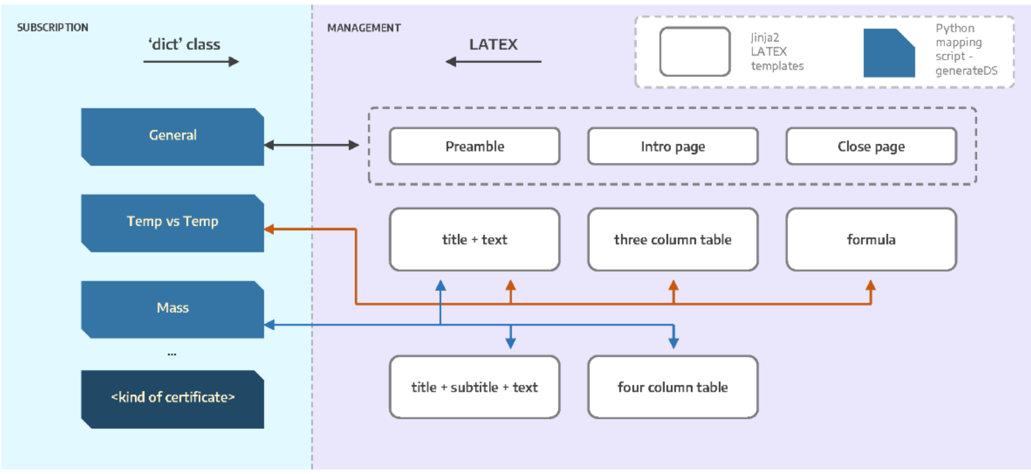


Digital Report Generation: PDF/A-3
Information Flow: DR-INTI



*Boschung, Gregor & Wollensack, Michael & Zeier, Markus & Blaser, Cédric & Hof, Christian & Stathis, Manuel & Blattner, Peter & Stuker, Florian & Basic, Nina & Grasso Toro, Federico. (2021). PDF/A-3 solution for digital calibration certificates. Measurement: Sensors. 18. 100282. 10.1016/j.measen.2021.100282.

Digital Report Generation: LATEX
Information Flow: DR-INTI



Information Clarification: PDF, PDF/A, PDF/A-3
Not the same format, not the same functionality

Advantages of PDF/A

1. ISO standard 32000-1:2008 – embed and long-term archiving
2. XMP as metadata of the PDF/A
3. Free programs/Python exist for displaying and editing PDF/A files.
4. The multi-part PDF/A standard offers great flexibility to users.
5. PDF/A files can be used on any platform.

ISO 32000-1:2008. Document management — Portable document format — Part 1: PDF 1.7. International Organization for Standardization.
https://www.youtube.com/watch?v=g-tJRSsZHyc

XML

```
<?xml version='1.0' encoding='UTF-8'?>
<dcc:digitalCalibrationCertificate xmlns:dcc="https://ptb.de/dcc" xmlns:xsi="http:/
  <dcc:administrativeData>
    <dcc:dccSoftware>
      <dcc:software>
        <dcc:name>
          <dcc:content lang="en">RamiroDCC7</dcc:content>
        </dcc:name>
        <dcc:release>5.3.2</dcc:release>
```

PDF/A-3

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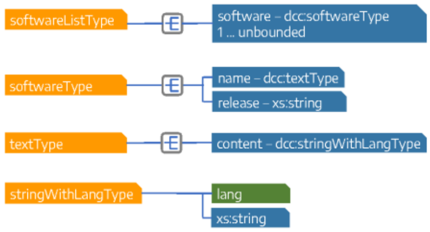
GenerateDS and Jinja2 Python libraries

GenerateDS Python library
Attributes and Example

- Serves from an XSD to generate **methods in Python**.
- **XML Validation. XML Parsing. MIT licensed.**

Graphical View of the XSD (extract)



For a properly understanding of the code, a full graphical view of the XSD of the DCC PTB is recommended

XML example extracted from PTB DCC:

XML

```xml
<dcc:software>
<dcc:name>
<dcc:content lang="en">FakeSoftName</dcc:content>
</dcc:name>
<dcc:release>1548</dcc:release>
</dcc:software>
```

generateDs example (extract):

XSD Python Methods generated through generateDs

```python
import dcc
…
softwares = dcc.softwareListType()
usedSoftware,ver = “FakeSoftName”,1548
soft_name = dcc.textType()
soft_name.add_content(
  dcc.stringWithLangType(
  lang="en",
  valueOf_=usedSoftware
   )
)
software_ = dcc.softwareType(name=soft_name,\
                 release=ver)
softwares.add_software(software_)
```

XML and PDF generation
GenerateDS and Jinja2 Python tool

GenerateDS

In favor

- **Simplifies the code compared to lxml and others**
- **Doesn't alienate XML concepts,** making it easy for beginners to learn and use – Creating/using methods is easy.
- **XML Validation. XML Parsing. MIT licensed.**
- Maintained by an active community of developers
- Custom methods can be easily owned and managed for more efficient XML processing

Against

- **It is not widely spread library as lxml.**
- It offers a similar level of abstraction as XPATH.
- If the XSD changes, new methods must be generated.

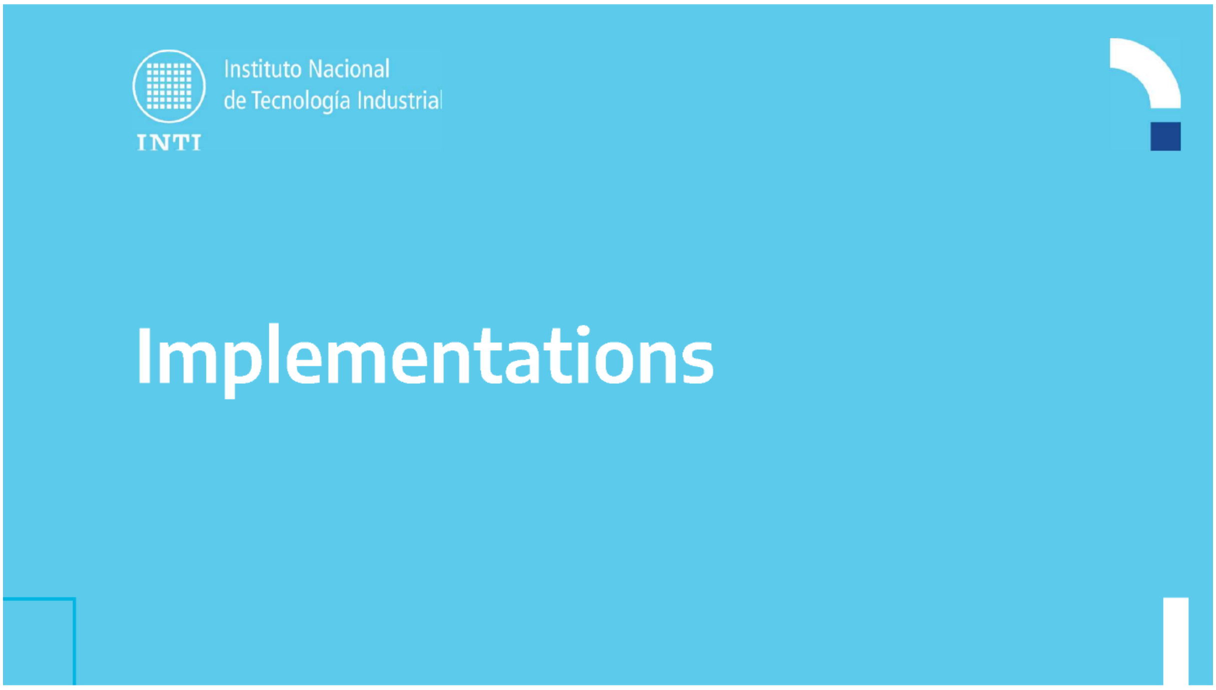
Jinja2

In favor

- **PDF/A-3 compatible**
- **Reusable section templates with great level of abstraction.**
- Latex based - very simple programming
- Python based library.
- Report subscription will not deal with Latex.

Against

- **PDF/A is not mandatory in PTB DCC.**
- **Not graphic interface yet.**
- **The PDF/A must be generated every time (automatization possible)**


Instituto Nacional
de Tecnología Industrial
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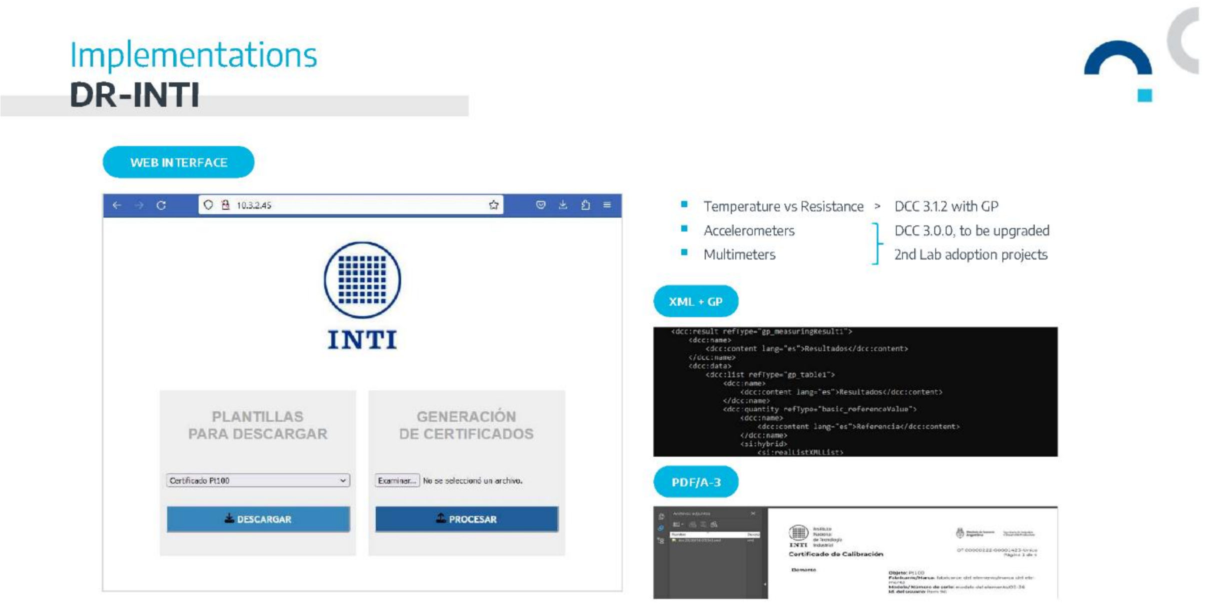
Implementations


Implementations
DR-INTI
WEB INTERFACE
10.3.2.45
INTI
PLANTILLAS PARA DESCARGAR
Certificado Pt100
DESCARGAR
GENERACIÓN DE CERTIFICADOS
Examinar... No se seleccionó un archivo.
PROCESAR
Temperature vs Resistance > DCC 3.1.2 with GP
Accelerometers
Multimeters
DCC 3.0.0, to be upgraded
2nd Lab adoption projects
XML + GP
<dcc:result refType="gp_measuringResult1">
<dcc:name>
<dcc:content lang="es">Resultados</dcc:content>
</dcc:name>
<dcc:data>
<dcc:list refType="gp_table1">
<dcc:name>
<dcc:content lang="es">Resultados</dcc:content>
</dcc:name>
<dcc:quantity refType="basic_referenceValue">
<dcc:name>
<dcc:content lang="es">Referencia</dcc:content>
</dcc:name>
<si:hybrid>
<si:realListXMLList>
PDF/A-3
INTI
Certificado de Calibración

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Future

Future
DR-INTI

- **Provide a high-level abstraction report subscription based on good practices.**
- **Make this software maintained by the community**

More functionalities:

- Web history display
- Data traceability: Hash
- Usage as a generic methods management.
- Optional Graphical method to map the XLSX to the XML
- Provide XSD/ XSD-CTID web verification
- DB as source and for traceability
- Upgrade to 3.2.0 and then 4.0.0
- Full Best practices implementation
- Blockchain implementation
- Software validation
- Enormous file management (compression / json conversion)
- Quality and error management


Thanks!
Diego Coppa
dcoppa@inti.gob.ar
INTIArg
@INTIargentina
INTI
@intiargentina
canalinti
Instituto Nacional
de Tecnología Industrial
INTI
Ministerio de Economía
Argentina
Secretaría de Industria
y Desarrollo Productivo

Session C: DCC and Machines

Presentations that would also fit into this session:

14 Machine Readability – Automating the Extraction of Data from DCC's

Presenting author: David Balslev-Harder, DFM, Denmark

E-mail address: dbh@dfm.dk

Additional authors: Søren Kynde

Abstract

For DCC's to be practically machine readable where data can be extracted in a consistent automated way, data needs to be stored in an algorithmically consistent form with consistent and harmonized wording.

Starting from the best practice guide for temperature and DCC schema 3.1.2 we have created and implemented algorithms to extract data. In this process it was necessary to make additional assumptions and rules to ensure consistent extraction. We are exploiting how these extra constraints can be communicated through the use of well described ref_type tags in the DCC. The implemented software will be presented along with our conclusion on necessary steps to ensure consistent machine readability. Methods of standardization and communication of sub-sets of rules for machine readable DCCs constrained for specific purposes will be discussed, along with consideration addressed within the TC-IM 1448 WP1 working group on "Harmonising DCC structure for machine readability".

DFM's work is supported by funds from The Danish Agency for Institutions and Educational Grants.

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Machine Readability
– Automating the Extraction of Data from DCC’s

By Søren R. Kynde and David Balslev-Harder

3rd international DCC Conference 2023
March 1st 2023

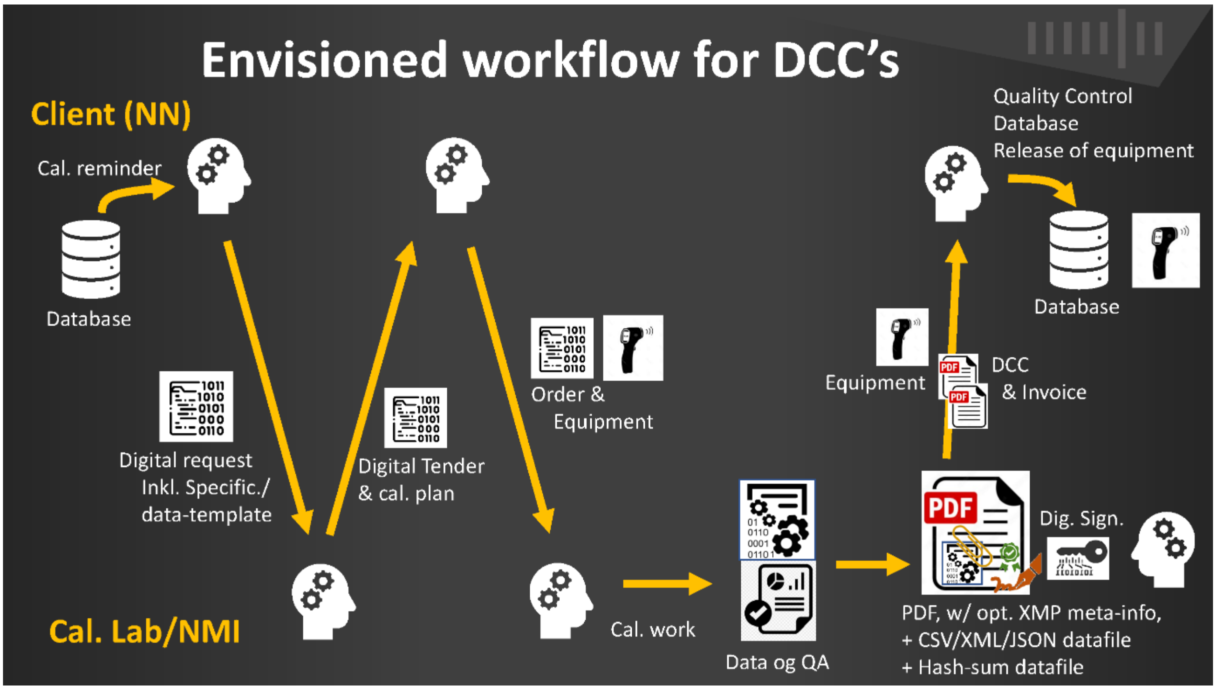
DFM receives funding by:
Danish Agency for Institutions and Educational Grants

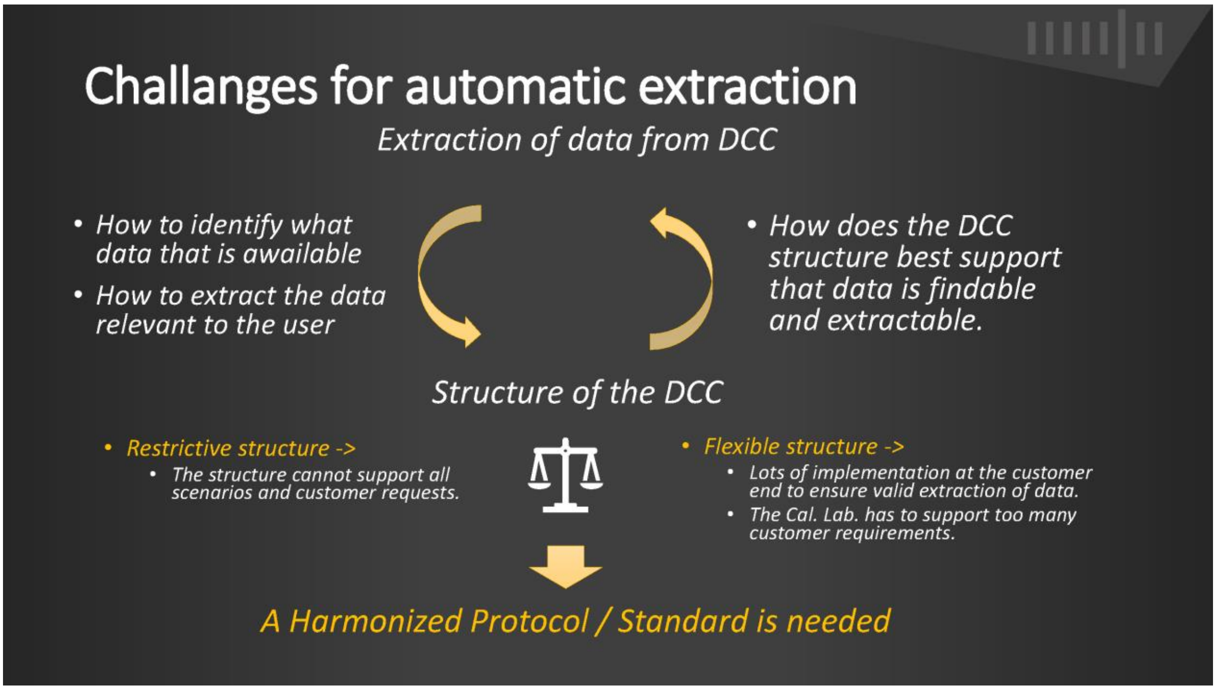
DFM
Danish National Metrology Institute

Machine readable Calibration Certificates

DFM’s mission: **To support implementation of DCC’s that are globally recognized, in order to support efficiency and quality in production companies through automation.**

- Value creation for the customers
  - Easier transfer/integration to databases
  - Easier control and adjustment of measurement equipment
  - Improved dataintegrity/safety (reduction of manual errors)
  - Efficiency
- Primarily relevant to
  - Areas with large numbers of calibrations: Temperature, Pressure, IoT sensors
  - Certificates with large amounts of data: CMM, BRDF, acoustics, …


Envisioned workflow for DCC's
Client (NN)
Cal. reminder
Database
Digital request
Inkl. Specific./
data-template
Digital Tender
& cal. plan
Order &
Equipment
Equipment
DCC
& Invoice
Quality Control
Database
Release of equipment
Database
Cal. Lab/NMI
Cal. work
Data og QA
Dig. Sign.
PDF, w/ opt. XMP meta-info,
+ CSV/XML/JSON datafile
+ Hash-sum datafile

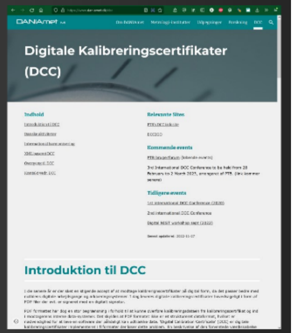

Challanges for automatic extraction
Extraction of data from DCC
How to identify what data that is awailable
How to extract the data relevant to the user
How does the DCC structure best support that data is findable and extractable.
Structure of the DCC
Restrictive structure ->
The structure cannot support all scenarios and customer requests.
Flexible structure ->
Lots of implementation at the customer end to ensure valid extraction of data.
The Cal. Lab. has to support too many customer requirements.
A Harmonized Protocol / Standard is needed

Collaborations

DANIAmet
Organisation for dansk metrologi
DFM Danmarks Nationale Metrologiinstitut
TEKNOLOGISK INSTITUT
FORCE TECHNOLOGY

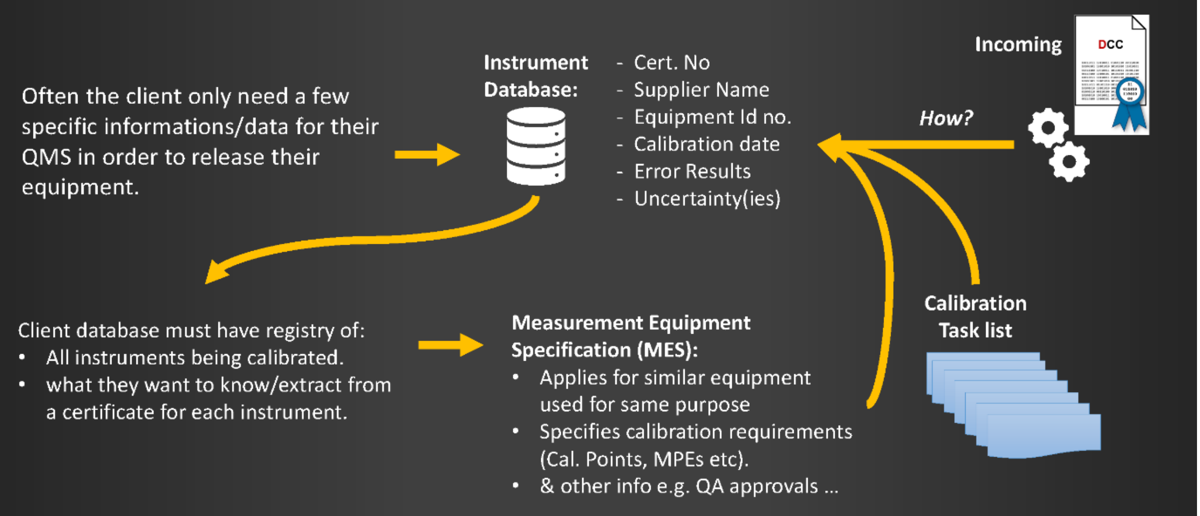
EURAMET Project TC-IM 1448
- WP1: Harmonisation
- WP2: Software tools for DCC handling
- WP3: Impact and dissemination.
- github.com/TC-IM-1448 & gitlab.com/TC-IM-1448

National level:
- Collaborations between DFM, FORCE and DTI and with Danish pharma-industry (Novo Nordisk) and accredited labs e.g. Eupry and Dandiag (pipettes).
- Danish webpage to coordinate and disseminate information about DCC to Danish stakeholders.



www.daniamet.dk/dcc

Client aspect of extracting data from DCC



First attempt for automatic extraction

- *Using the GP-guide for temperature and DCC schema 3.1.2 we implemented Python routines to extract data from the XML.*
- *The routines were then used to extract the data based on referencing to*
  - *'basic_referenceValue',*
  - *'basic_measuredValue', and*
  - *'basic_measurementError'.*
- *then the children of these elements were parsing to extract the data.*
- *Code will be available on* github.com/TC-IM-1448 next week.

First Findings

We need a general algorithm to extract the data.

We need an easy way to validate that the DCC supports automatic extraction GP-guides are not machine readable.

Conceptually it is advantageous to consider:

- *XML-Element for certificate content both human readable and machine readable.*
- *Attributes of elements primarily for machine interoperation*

```python
############ Begin: help functions to locate specific elelments #################

def find_child(parent,child_type, search_key, search_value):

def get_root(xml):

def get_results(root,refType):

def get_item(root,ID, issuer='customer'):
```

```python
########## Get labeled results for a specific item ########################

### step 1: find the value of the id attribute of the desired item.
### given the id issued by the customer
item=DCCf.get_item(root, ID='NN66', issuer='customer')

### step 2: get all results of a specific refType
results=DCCf.get_results(root, refType=example_refType)

for result in results:
    if ( item.attrib['id'] in result.attrib['refId'] ) :
        data=result.find(DCC+'data')
        table=data.find(DCC+'list')
        ref=DCCf.find_child(table,DCC+'quantity','refType','basic_referenceValue')
        val=DCCf.find_child(table,DCC+'quantity','refType','basic_measuredValue')
        err=DCCf.find_child(table,DCC+'quantity','refType','basic_measurementError')
        # column() from DCCf is a function to read a quantity into a column
        ref_col=DCCf.column(ref)
        val_col=DCCf.column(val)
        err_col=DCCf.column(err)


def make_dictionary(labels,values):
    dic={}
    for i , lab in enumerate(labels):
        dic[lab]=values[i]
    return dic

ref_dict=make_dictionary(ref_col.label,ref_col.certValue)
val_dict=make_dictionary(val_col.label,val_col.certValue)
err_dict=make_dictionary(err_col.label,err_col.certValue)
unc_dict=make_dictionary(err_col.label,err_col.certUncertainty)
```

Algorithm for extraction of calibration data

0. Validates authenticity of the certificate (valid provider, …)
1. List all items calibrated in the provided certificate
2. Customer looks in their own database to match calibrated items
3. List all results for a given item and associated reference results in DCC
4. Link data from DCC to entries in customer database

1. List all items calibrated in the provided DCC

Assumptions:

✓ DCC.xsd defines an <dcc:items> sections where all <dcc:item>’s are declared.

✓ Each item can be assigned a unique ‘id’ which can be referenced to using the ‘refId’ attributes.

NB - *For machine readability and validation:* we recommend that the item ‘id’ is mandatory for all items. In this way it can be ensured that data results relating to the item can be identified later steps of the algorithm.

3. List all results for a given item and associated reference results in the DCC

Assumptions:

✓ DCC.xsd defines the <dcc:measurementResult> sections where all <results>’s are reported.

✓ Each <dcc:result> can be assigned a ‘refId’ attribute referring to an item.
As described by Siegfried’s presentation on Rule-Book this should be assigned at the highest level possible.

NB - *For machine readability and validation:*

- All data in a result is related to all the specified items.
- It would be advantageous to introduce a ‘dutId’ in that way it can be made mandatory at the <dcc:measruementResult> level, that there is a reference to the specific <item> being calibrated.

Suggestion to split the refType attribute

refType has many purposes. Consider splitting this up into:

- measurandType
  - Defines what kind of physical property is measured
- structureType
  - Defines the datastructure: list, table, array, # of columns, # of rows, etc. enabling integrity check.
- resultType
  - Defines restricted types: reference_value, measured_value, displayed_value, deviation, correction, correction_factor, nominal_value, error, Index, etc.

This suggested splitting will enable clear definition of these attributes and their allowed values in the schema.

Integration of measurands in the Schema.

Car-industry:

Q-DAS : ASCII codes are pre-defined for relevant measurands.

https://help.hexagonmi.com/bundle/q-das/page/aqdef.html

8.2.9Measured quantity K2009

Value	Description	
0	Undefined	
100	straightness	
101	Flatness	
102	roundness	
103	cylindricity	
104	profile of a line	
105	profile of a surface	
106	angularity	
107	perpendicularity	
108	parallelism	
220	Spring rate	
230	width	Since V11/150515
231	squareness	Since V11/150515
232	Diameter maximum	Since V11/150515
233	Diameter minimum	Since V11/150515
234	Diameter average	Since V11/150515
250	temperature [°C]	
251	temperature [F]	
255	pressure [bar]	
260	coating thickness	
270	volume	
280	mass	
282	force	
285	hardness	
290	viscosity	
300	unbalance	
301	torque	
302	Tightening torque	
303	Additional torque	

Healthcare sector:

Relevant medical conditions as well as measurement units are predefined in XML-schemas.

HL7FHIR
http://hl7.org/fhir/

AQIHQ
http://www.aqihq.org/qcdrDataSample/prodFiles/2018%20Files/AQISchDoc/default.html

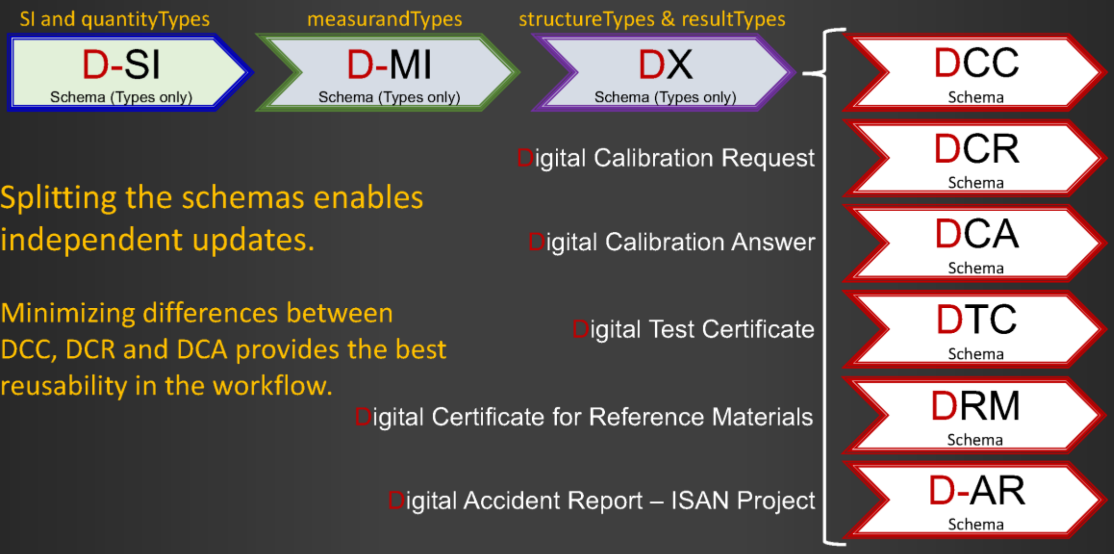
```
<xs:simpleType name="LabDataCategoryCodeType">
  <xs:restriction base="xs:string">
    <xs:enumeration value="Blood bank"/>
    <xs:enumeration value="Chemistry"/>
    <xs:enumeration value="Cytology"/>
    <xs:enumeration value="Genetics"/>
    <xs:enumeration value="Hematology"/>
    <xs:enumeration value="Histology"/>
    <xs:enumeration value="Immunology"/>
    <xs:enumeration value="Microbiology"/>
    <xs:enumeration value="Other"/>
    <xs:enumeration value="Unknown"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="CommonUnit">
  <xs:union memberTypes="CommonUnitExample AnyString"/>
</xs:simpleType>
<xs:simpleType name="CommonUnitExample"<!-- THE FOLLOWING

        It is impossible to provide a comprehensive list
        unit values used in medicine. The following is a
        values provided from several groups. -->>
  <xs:restriction base="xs:string">
    <xs:enumeration value="%"/>
    <xs:enumeration value="CM"/>
    <xs:enumeration value="DROP"/>
    <xs:enumeration value="EQ/HR"/>
    <xs:enumeration value="EQ/MIN"/>
```

HL7 FHIR

Anesthesia Quality Institute®
American Society of Anesthesiologists®

Modularizing XML schema, enables other uses



Splitting the schemas enables independent updates.

Minimizing differences between DCC, DCR and DCA provides the best reusability in the workflow.

Conclusions and outlook

- We recommend
  - using attributes to enable machine interoperability and elements for certificate content.
  - Extending ‘id’ and ‘refType’ to distinguish different uses.
  - Define as much as possible in the schema’s in order to keep validation of DCC machine readability as simple as possible.

Outlook

- We want to test implementation of the suggested updates to the XML schemas.
- Collaborate NCLSI MII WG and to integrate this into XML schema.


Thank You
To PTB for organizing the conference and their contributions to DCC.
To Danish collaborators, TI, FORCE, Novo Nordisk etc.
To International collaborators in TC-IM 1448, DCC2GO and other fora.
To audience for listening.
Contact: David Balslev-Harder (dbh@dfm.dk)

Session C: DCC-News

Presentations that would also fit into this session:

➢ 06 The General DCC Rulebook and the Rules under the Aspects of Accreditation

15 What's New in the DCC Schema Version 3.2.0?

Presenting author: Benjamin Gloger, Physikalisch-Technische Bundesanstalt (PTB), Germany

E-mail address: Benjamin.Gloger@ptb.de

Additional authors: Siegfried Hackel, Gamze Söylev Öktem, Shanna Schönhals, Justin Jagieniak, Lutz Doering, Jan Loewe, Muhammed Ali Demir, Moritz Jordan, Kai Mienert, Christian Keilholz (all PTB)

Abstract

Version 3.2.0 of the XML schema is scheduled for release in February 2023. Backwards compatibility with version 3.0.0 is guaranteed, as these are additions.

Over the last year, a lot of experience has been gained with the DCC. There was feedback from all areas of the calibration pyramid. From the National Metrology Institutes (NMIs), organised in Regional (partly continental wide) Metrology Organisations (RMO) to the accredited laboratories to the industry. The valuable feedback from the participants of the DCC Summer School in June 2022 was also implemented. There was also feedback from the accreditation bodies. The result has been implemented in the new version 3.2.0. A selection of the changes is listed in this presentation and the release protocol is provided.

Links and a list will be added to the summary after the release is published.

Release log: https://gitlab.com/ptb/dcc/xsd-dcc/-/releases

Direct link: https://www.ptb.de/dcc/dcc.xsd

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Physikalisch-Technische Bundesanstalt
Braunschweig and Berlin
National Metrology Institute

What's new in the DCC Schema Version 3.2.0?

Benjamin Gloger, AG 1.24

Version 3.2.0

DCC
Version 3.2.0

Release Date:	2023-02-08
Release Log:	https://gitlab.com/ptb/dcc/xsd-dcc/-/releases
Current Scheme:	https://ptb.de/dcc/dcc.xsd

Bugfix

DCC
Version 3.2.0

```
<xs:choice maxOccurs="unbounded">
    <xs:element name="list" type="dcc:listType" maxOccurs="unbounded"/>
    <xs:element name="quantity" type="dcc:quantityType" maxOccurs="unbounded"/>
</xs:choice>
```

- dcc:list can contain a combination of dcc:quantity and dcc:list.
- dcc:comment can now be used without specifying a schema.
- Empty elements are prevented with a regular expression.

Improvements

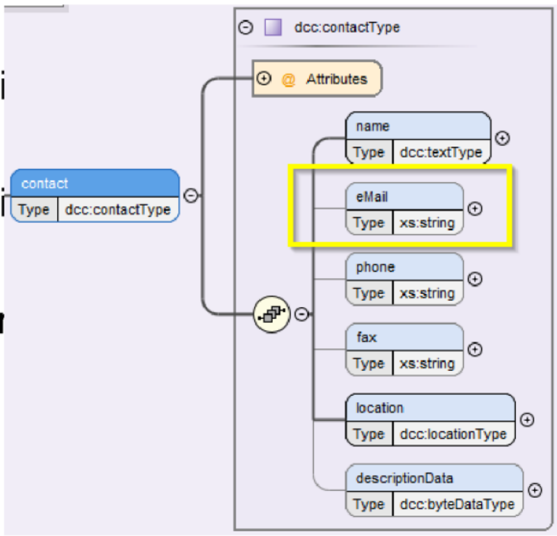
DCC
Version 3.2.0

- **Email is no longer mandatory in the DCC**
- Introduction of the element dcc:issueDate
- Introduction of XML signatures in the DCC schema
- Extension to dcc:calibrationLaboratory

Improvements

DCC
Version 3.2.0

- **Email is no longer mandatory in the DCC**
- Introducti … te
- Introducti … C schema
- Extensior

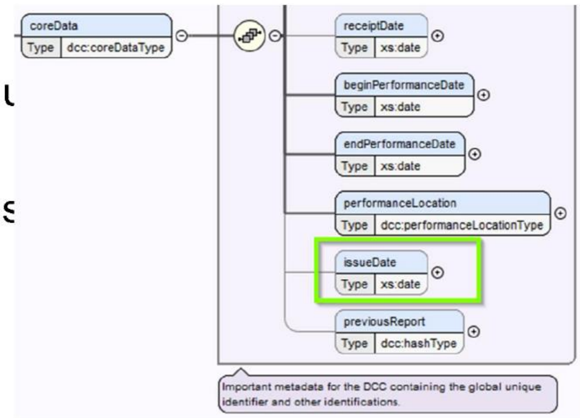


2023-02-26 5 Benjamin Gloger

Improvements

DCC
Version 3.2.0

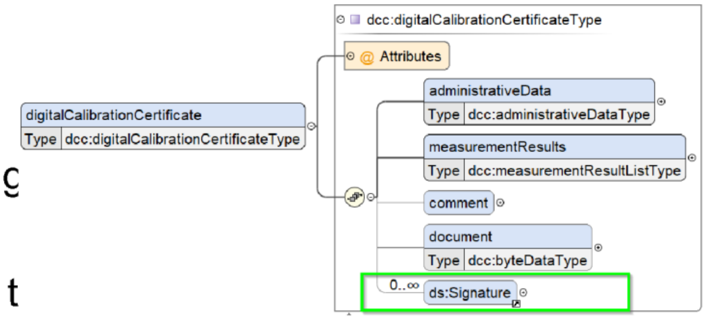
- Email is no longer mandatory in the DCC
- **Introduction of the element dcc:issueDate**
- Introdu … DCC schema
- Extens



2023-02-26 6 Benjamin Gloger

Improvements

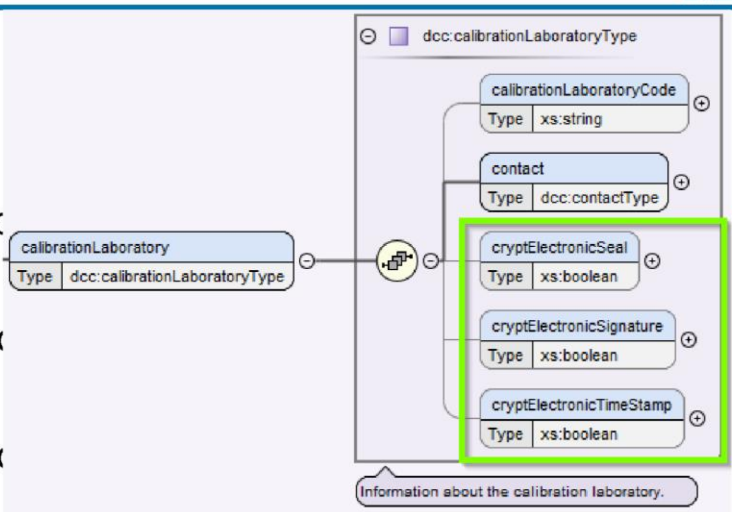
DCC
Version 3.2.0



- Email is no long
- Introduction of t
- **Introduction of XML signatures in the DCC schema**
- Extension to dcc:calibrationLaboratory

Improvements

DCC
Version 3.2.0



- Email is no lo
- Introduction o
- Introduction o
- **Extension to dcc:calibrationLaboratory**

Improvements

DCC
Version 3.2.0

- **Introduction of dcc:validXMLList and dcc:charsXMLList**
- Introduction of the element dcc:refTypeDefinitions in dcc:administrativeData.
- dcc:name and dcc:description in dcc:statementMetaDataType

Improvements

DCC
Version 3.2.0

- Introduction of dcc:validXMLList and dcc:charsXMLList
- **Introduction of the element dcc:refTypeDefinitions in dcc:administrativeData.**
- dcc:name and dcc:description in dcc:statementMetaDataType

Improvements

DCC
Version 3.2.0

- Introduction of dcc:validXMLList and dcc:charsXMLList
- Introduction of the element dcc:refTypeDefinitions in dcc:administrativeData.
- **dcc:name and dcc:description in dcc:statementMetaDataType**

Team

DCC
Version 3.2.0

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Stand: 02/23

16 Validation Methods in the Preparation of DCCs: The Schematron Validation Tool

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Additional authors: Siegfried Hackel, Benjamin Gloger, Shanna Schönhals, Justin Jagieniak, Lutz Doering, Jan Loewe, Muhammed Ali Demir, Moritz Jordan (all PTB)

Abstract

In this lecture, we will show which types of errors can be found automatically during the creation process of a Digital Calibration Certificate (DCC). First of all, schema validation will be used. This includes unfilled mandatory elements or incorrectly arranged XML elements. This form of validation of the structure of the XML file against an XML schema is offered by almost every advanced editor. Still, there is also the possibility of validation with Schematron. Schematron is a schema language which is used to write logical rules for XML files. Therefore, with Schematron, an XML file like the DCC can be checked for logical errors. For this, individual rules are created which can either throw a hint, a warning, or an error. In DCC development, Schematron is used, among other things, for the implementation of the rulebook. This is a very elegant way to check the XML. Every DCC creator is free to write additional Schematron rules for his own use case and to check his XML with them. For a better presentation, a Schematron validation tool has been created by the DCC team by using open-source tools. The aim of this presentation is to show which errors can be found through schema validation and which errors can be found through Schematron validation.

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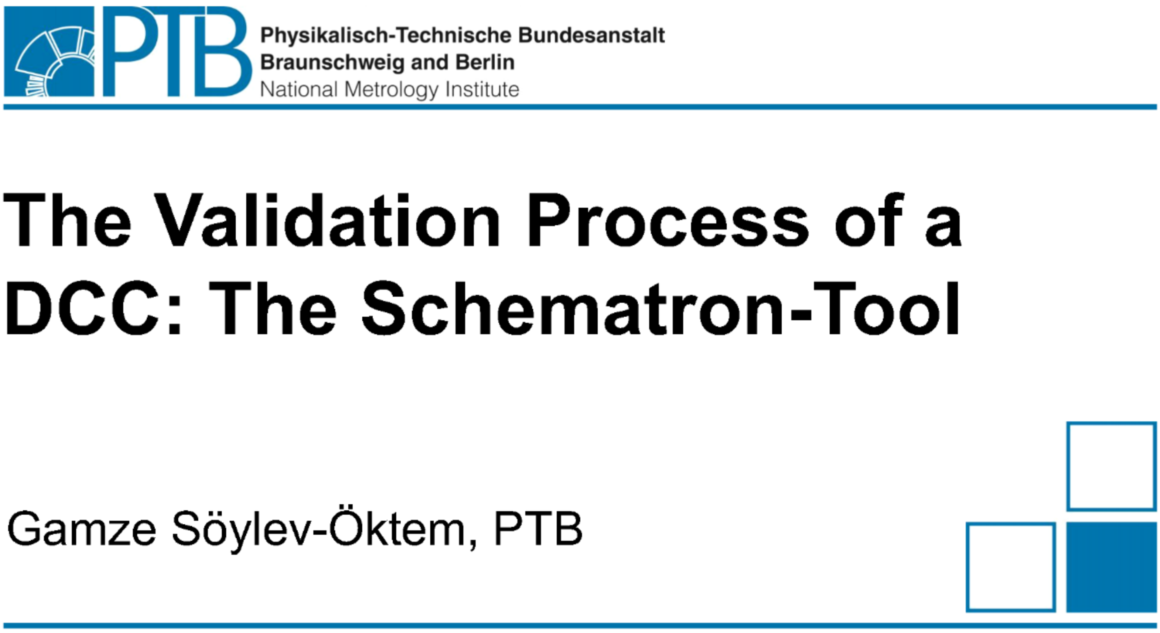


Overview

- DCC Validation Process
  - Which errors can be caught with the schema validation?
  - Which errors cannot be caught with the schema validation?
    - Schematron validation

XML Schema

- An XML Schema defines the structure of an XML File.
- There are several schema languages. DCC schema uses XML schema definition (XSD).
- It allows to enforce constraints for the XML files.

XML Schema Validation

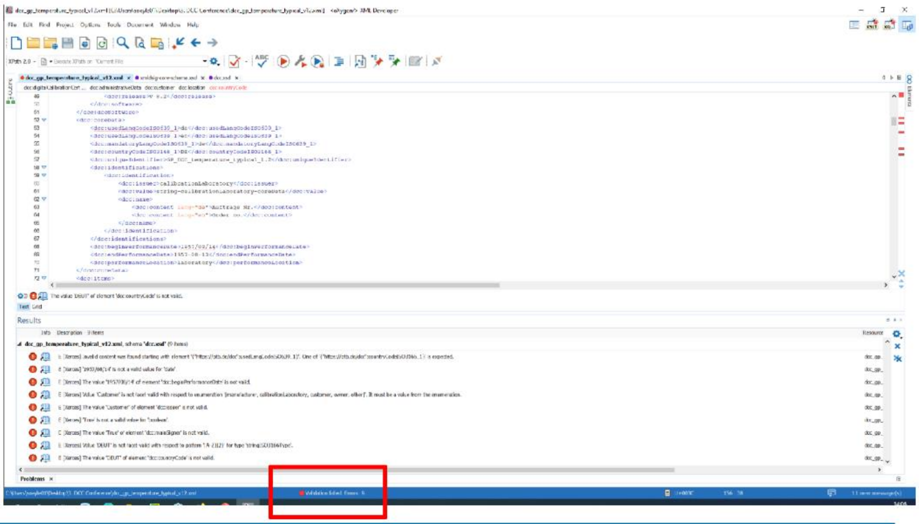
- An XML file is ‘well-formed’, if its syntax is correct.
- A well-formed XML file can be validated against a schema.

What can be validated by using a schema?

- Root name, element names
- The order of the child elements
- Maximum and minimum counts for elements to occur
- Some data types
  - xs:string, xs:date, xs:datetime, xs:boolean, …
- Patterns with regular expressions
- Enumerations
- …

Schema Validation

- Demo using oxygen



Schematron

- Schematron is a simple and powerful **Structural Schema Language** for making assertions about patterns found in XML documents
- With Schematron, it is possible to create specific rules and constraints for a specific XML document
- Designed to be used in conjunction with other validation languages

What can be validated by using Schematron?

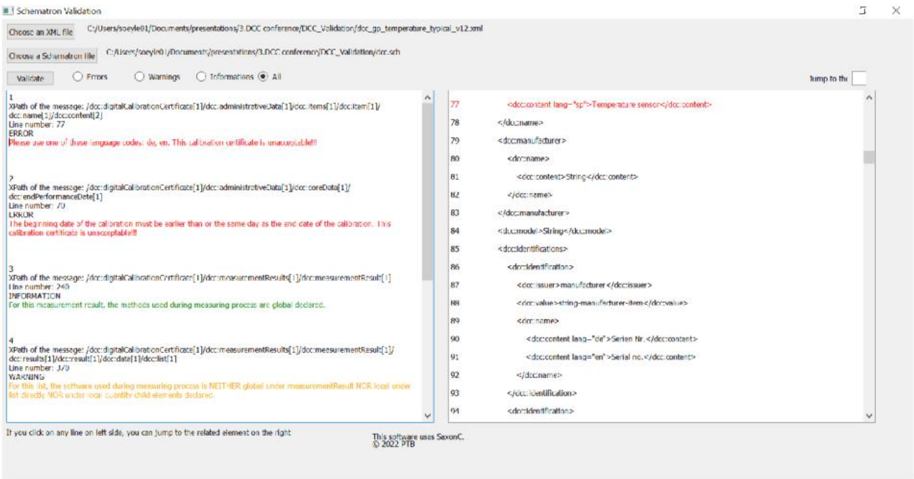
- General logic rules:
  - Begin Performance Date must be same day or earlier than End Performance Date.
  - Number of data in si:valueXMLList must be equal to the number of data in si:dateTimeXMLList.
  - If an optional element exists in a specific place.
  - If the language attributes are declared correctly.
  - …

What can be validated by using Schematron?

- DCC specific rules:
  - Company name.
  - The length of the data.
  - Number of digits that come after the dot in measurement data.
  - …

Schematron Validation Tool

- Demo using PTB's Schematron Tool



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Session D: Community-Feedback for Further Developments of the DCC

Presentations that would also fit into this session:

17 The Digital NIST: Pilot Project for the Digital Transformation of NIST's Measurement Services

Presenting author: Catherine C. Cooksey, NIST, USA , Dinis Camara, NIST, USA

E-mail address: catherine.cooksey@nist.gov, william.camara@nist.gov

Abstract

At the beginning of 2022, NIST embarked on a pilot project to produce a few examples digital calibration reports and certificates of analysis for the purpose of assessing the scope and challenges of digital transformation in these measurement services.

The aims for the NIST pilot project are

1) to generate a digital calibration report (DCR) from calibration data, customer metadata, and other data and metadata as needed;

2) to generate a digital reference material certificate (DCRM) from certification data, descriptive information about the material, and other data and metadata as needed;

3) to generate a human readable report from both DCR and DCRM;

4) and to hold a workshop to gather stakeholder feedback.

At the completion of the pilot project, it was determined that the PTB supported digital calibration certificate (DCC) schema is an excellent start towards creating DCR; however, it will need to be customized to address NIST specific needs. In contrast, DCRM will require a new schema, which NIST has begun to develop.

Through the stakeholder workshop, we confirmed a high level of interest in the community for fully digital delivery of calibration reports and reference material certificates.

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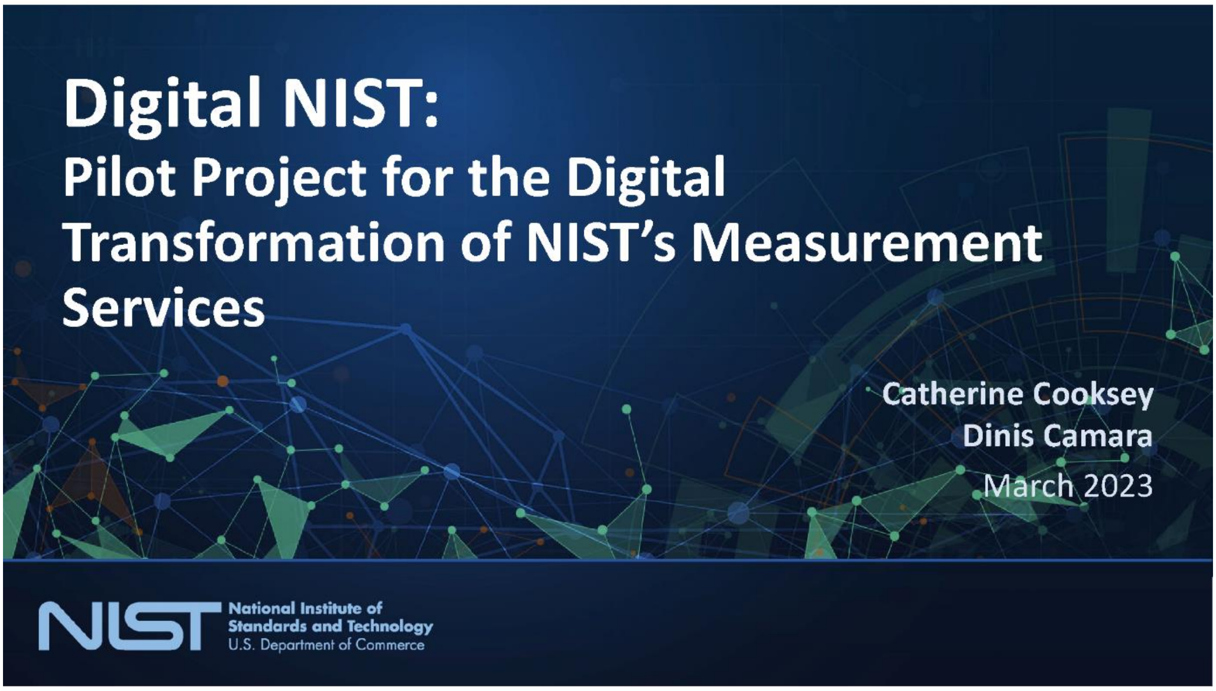
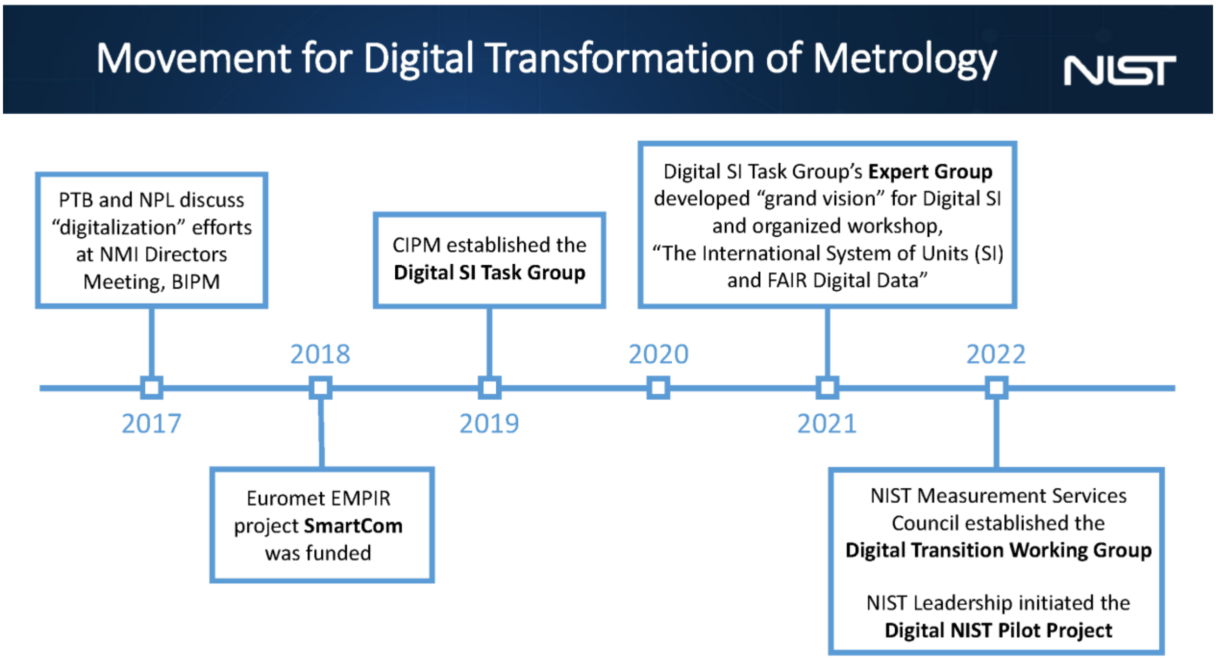
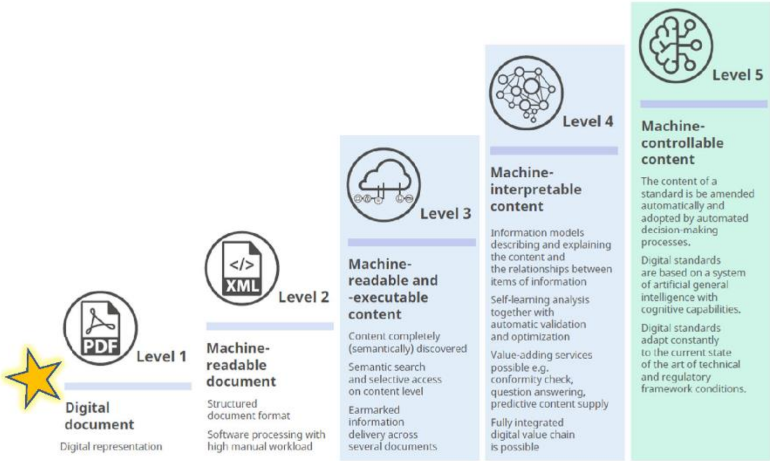

Digital NIST:
Pilot Project for the Digital Transformation of NIST's Measurement Services
Catherine Cooksey
Dinis Camara
March 2023
NIST National Institute of Standards and Technology
U.S. Department of Commerce


Movement for Digital Transformation of Metrology
NIST
PTB and NPL discuss "digitalization" efforts at NMI Directors Meeting, BIPM
CIPM established the Digital SI Task Group
Digital SI Task Group's Expert Group developed "grand vision" for Digital SI and organized workshop, "The International System of Units (SI) and FAIR Digital Data"
2017
2018
2019
2020
2021
2022
Euromet EMPIR project SmartCom was funded
NIST Measurement Services Council established the Digital Transition Working Group
NIST Leadership initiated the Digital NIST Pilot Project

Where are we?

NIST



IDIS Whitepaper, "SCENARIOS FOR DIGITIZING STANDARDIZATION AND STANDARDS", 2021

5

Digital NIST Pilot Project

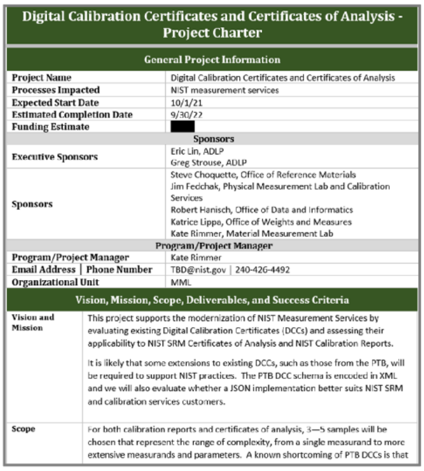
NIST

Objectives:

- Evaluate existing DCC schema and its applicability to NIST Calibration Reports and Certificates of Analysis for Standard Reference Materials® (SRMs)
- Assess resources required to deliver digital data for NIST measurement services

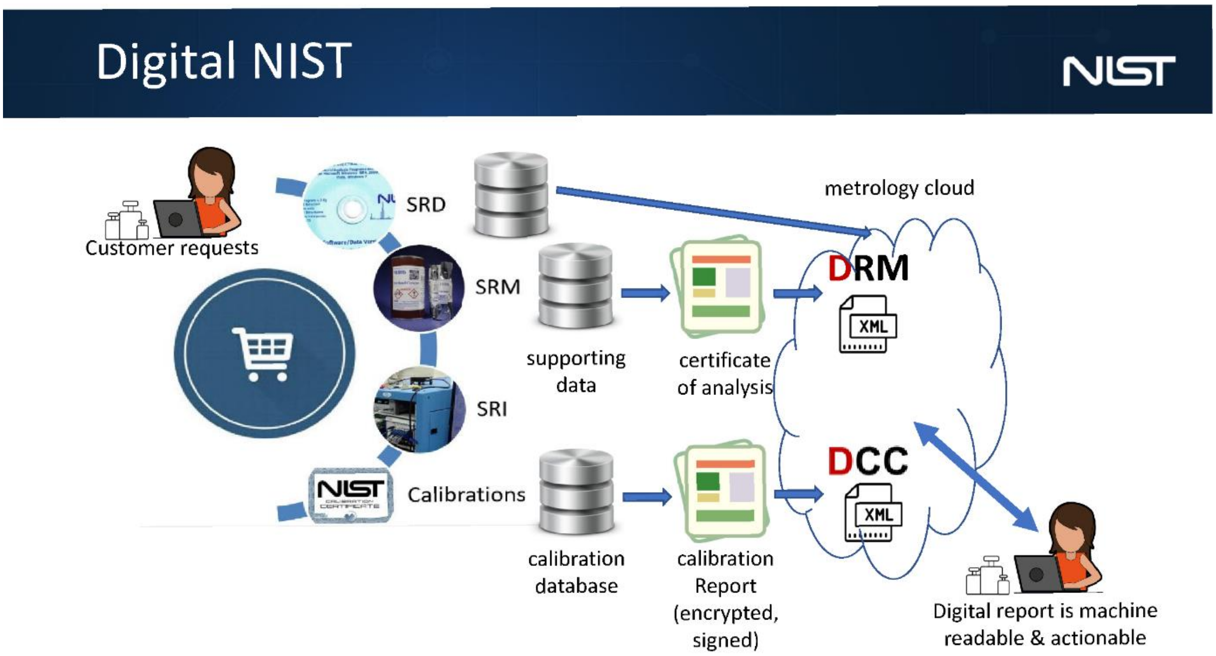
Deliverables:

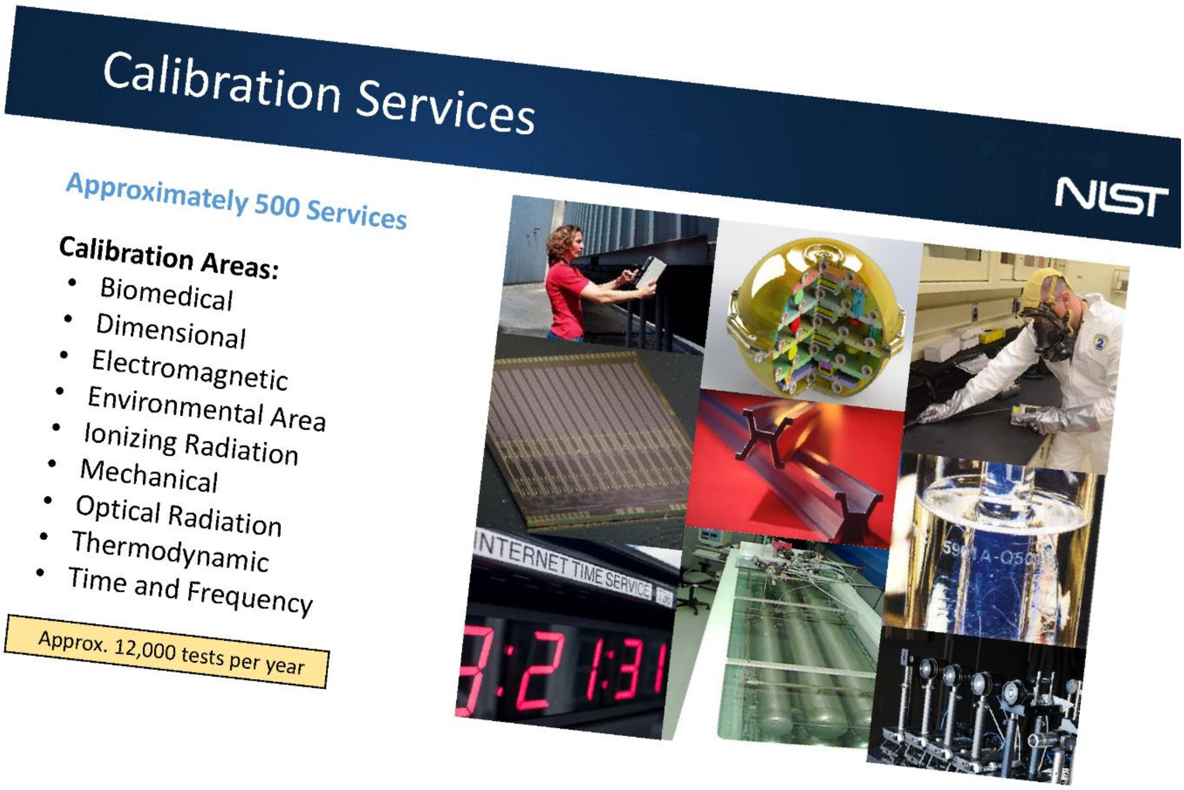
- Fully digital NIST calibration report and certificate of analysis
- Human-readable versions produced from the digital report and certificate



Digital Calibration Certificates and Certificates of Analysis - Project Charter

General Project Information	
Project Name	Digital Calibration Certificates and Certificates of Analysis
Processes Impacted	NIST measurement services
Expected Start Date	10/1/21
Estimated Completion Date	9/30/22
Funding Estimate	[redacted]
Sponsors	
Executive Sponsors	Eric Lin, ADLP Greg Strouse, ADLP
Sponsors	Steve Choquette, Office of Reference Materials Jim Fedchak, Physical Measurement Lab and Calibration Services Robert Hanisch, Office of Data and Informatics Katrice Lippa, Office of Weights and Measures Kate Rimmer, Material Measurement Lab
Program/Project Manager	
Program/Project Manager	Kate Rimmer
Email Address | Phone Number	TBD@nist.gov | 240-426-4492
Organizational Unit	MML
Vision, Mission, Scope, Deliverables, and Success Criteria	
Vision and Mission	This project supports the modernization of NIST Measurement Services by evaluating existing Digital Calibration Certificates (DCCs) and assessing their applicability to NIST SRM Certificates of Analysis and NIST Calibration Reports. It is likely that some extensions to existing DCCs, such as those from the PTB, will be required to support NIST practices. The PTB DCC schema is encoded in XML and we will also evaluate whether a JSON implementation better suits NIST SRM and calibration services customers.
Scope	For both calibration reports and certificates of analysis, 3—5 samples will be chosen that represent the range of complexity, from a single measurand to more extensive measurands and parameters. A known shortcoming of PTB DCCs is that


Digital NIST
NIST
Customer requests
SRD
SRM
SRI
Calibrations
metrology cloud
supporting data
certificate of analysis
DRM
XML
DCC
XML
calibration database
calibration Report (encrypted, signed)
Digital report is machine readable & actionable


Calibration Services
NIST
Approximately 500 Services
Calibration Areas:
• Biomedical
• Dimensional
• Electromagnetic
• Environmental Area
• Ionizing Radiation
• Mechanical
• Optical Radiation
• Thermodynamic
• Time and Frequency
Approx. 12,000 tests per year
INTERNET TIME SERVICE

Tasks & challenges for NDCRs

NIST digital calibration reports (NDCRs):

1. Identify and understand the elements within DCC schema

What we did:
- Used PTB's wiki and the GEMIMEG tool
- Imported DCC schema into Configurable Data Curation System (CDCS)
- Developed a prototype tool for generating XML documents using DCC schema

What we learned:
- DCC schema is a good starting point for NDCRs, but modifications will be needed
- Need tool(s) for converting report content to XML document

Tasks & challenges for NDCRs

NIST digital calibration reports (NDCRs):

2. Identify the elements within NIST calibration reports and mapping them to the DCC schema

What we did:
- Reviewed a sampling of NIST calibration reports
- Used GEMIMEG tool for comparisons
- Developed a prototype template for calibration reports with mapping to DCC schema

What we learned:
- Wide variety of report content will be challenging to accommodate by a single template
- Some report content is not easily/obviously mapped to DCC schema
- Need uniform approach for generating calibration reports to facilitate digital transformation

Tasks & challenges for NDCRs

NIST digital calibration reports (NDCRs):

3. Identify the sources of data and metadata and developing solutions for populating digital reports

What we did:
- Worked on developing API to extract customer metadata from existing E-commerce platform
- Worked with 2 calibration services on developing programs to automatically format data

What we learned:
- Need tool(s) for importing data and metadata
- Wide variety of data formats and storage methods
- Need a way to check, correct, and validate metadata before finalizing report

Tasks & challenges for NDCRs

NIST digital calibration reports (NDCRs):

4. Identify a repository and potential formats for data and final digital report

What we did:
- Considered some potential solutions, but largely postponed for future phases

What we learned:
- Solution that accommodates the wide variety of data and report generation will be challenging

Tasks & challenges for NDCRs

NIST

NIST digital calibration reports (NDCRs):

5. Identify solutions for displaying NDCRs in human-readable format

What we did:
- Identified elements that are primarily intended for human reader
- Demonstrated feasibility of generating human-readable report directly from NDCR using CDCS

What we learned:
- Figures, photos, and plots can be included as images with NDCR
- Lengthy descriptions can be included explicitly in NDCR or as links to separate documents, web resources, or publications
- Need tool(s) to view human-readable versions of NDCRs

Standard Reference Materials

NIST

>1100 SRM Products

- Ferrous Metals
- Nonferrous Metals
- Microanalysis
- High Purity Materials
- Health and Industrial Hygiene
- Inorganics
- Primary Gas Mixtures
- Fossil and Alternative Fuels
- Organics
- Food and Agriculture
- Geological Materials and Ores
- Ceramics and Glasses
- Cement
- Engine Wear Materials
- Forensics
- Ion Activity
- Polymeric Properties
- Thermodynamic Properties
- Optical Properties
- Radioactivity
- Electrical Properties
- Metrology, Liquids and Glasses
- X-Ray Diffraction
- Sizing
- Surface Finish
- Fire Research
- Nanomaterials
- Miscellaneous Performance Engineering Materials

Different from Calibrations

NIST

Standard Reference Materials:
ISO 17034

ISO Guide 31

NIST Quality Manual

NIST Policy

Customer and Stakeholder Input

Calibrations and the DCC are based on ISO/IEC 17025 and requires different information.

A new schema for Reference Materials must be researched and developed.

6

Challenges

NIST

Digital Reference Material Certificates (DRMC):

- Differences in homogeneity
- Types of Values (e.g., Value and Uncertainty vs. DNA sequences)
- Certified v. non-certified values
- Digital representation of SI units and non-SI units
- Revisions to certificates
- Security for public and individual availability
- Extracting data points from text

What Goes in a DRMC

NIST

Current Draft of Schema
- Organization Identification
- Reference Material Identification
- Material Information
  - Unit Description
  - Usage Information
  - Measurement Information
  - Additional Information
- Context
- Provenance
- References

Based On:
ISO 17034
ISO Guide 31
NIST Quality Manual
NIST Policy
Customer & Stakeholder Input

Next Steps

NIST

- **Continue to work on model for NIST and expand to learn and incorporate others.**
- **Convert existing "paper based" data to be digital**

Digital NIST Stakeholder Workshop

NIST

Goal: To hear from our stakeholders about what they want and need for digital transformation

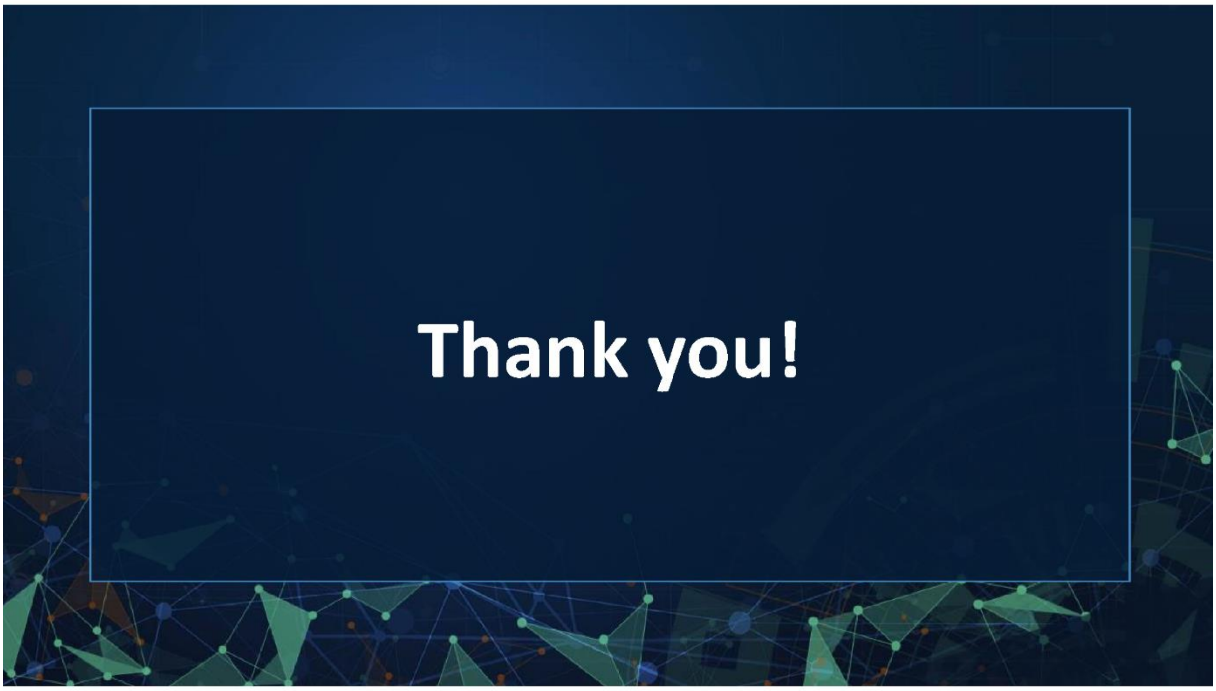
Takeaways:
- Interest in digital transformation, but are in the early stages.
- Full implementation not initially needed, but we need to be prepared.
- Looking to NIST for leadership and guidance on creating data models, norms, and technology

https://www.nist.gov/news-events/events/2022/09/digital-nist-workshop

Acknowledgements

NIST

- **Pilot study participants:** Robert Hansich, James Fedchak, Steven Choquette, Catherine Rimmer, Dinis Camara, Catherine Cooksey, Katya Delak, Benjamin Long, Raymond Plante, Melissa Phillips, Jared Ragland, John Quintavalle, Manmohan Moondra, Gregory Cala, Damian Lauria, Jay Hendricks, *et al*.
- **PTB colleagues**
- **NIST Associate Director for Laboratory Programs**


Thank you!

18 On the Construction and the Dissemination of Digital Metrology Datasets for Research and Development Purposes

Presenting author: Mohammed S. Gadelrab, National Institute of Standards, Egypt

E-mail address: masgad@ieee.org, mohammed.gadelrab@nis.sci.eg

Abstract

While the metrology field is progressively transforming digitally, new forms, procedures, techniques, artifacts and tools are continuously emerging. The Digital Calibration Certificate (DCC), the Digital Test Certificates (DTC), the Digital Certificates for Reference Materials (DRM), and the D-SI are few examples of the most prominent formats in “digital” metrology. Plenty of systems and applications are expected to be built upon these important artifacts that, from one hand, will replace existing traditional counterparts and on the other hand will open the door widely for novel applications. Fortunately, there is a considerable effort on the design of such artifacts with a plethora of ideas. However, unfortunately they most likely remain conceptual and prototypical, yet untested. Therefore, they are faraway from being mature for production and operational deployments in real environments. One reason of this problem could be the lack of sufficient datasets of these new metrology forms and formats.

To foster the advancement of Met4DT, we discuss in this presentation several issues related to the creation and the dissemination of DCC datasets that can be used in researching and developing new metrology systems and applications. Then, we propose a new framework that enables and encourages creating, comparing and sharing such datasets. First, we explain the need and the benefits to have such a repository of DCC Datasets. Accordingly, we identify what we need exactly and how that can be achieved. Moreover, we discuss the main components that are necessary for the implementation of the suggested framework.

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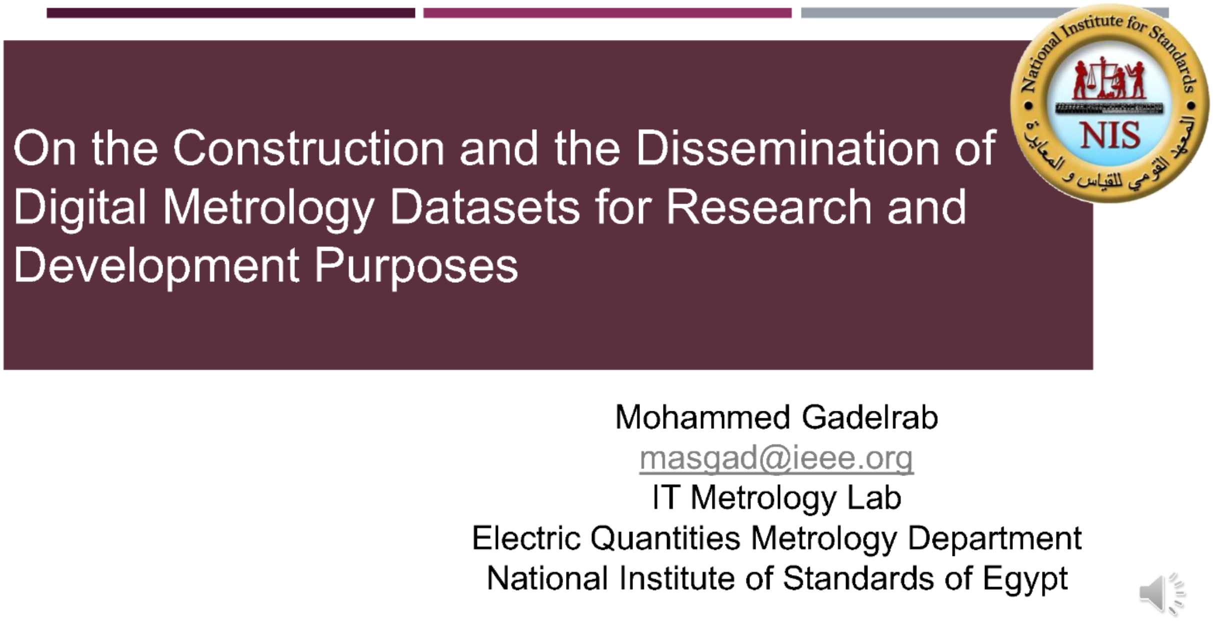


OVERVIEW

- Dataset Sources in Metrology
- Dataset Life-Cycle
- Benefits of having a Repository for Metrology Datasets
- Challenges
- Framework for Metrology Dataset Sharing

2

DATASET SOURCES IN METROLOGY

- Operational Measurement Data
- Digital Calibration Certificates (DCC)
- Digital Test Certificates (DTC)
- Digital Certificates for Reference Materials (DRM)
- Examples:

▪ Templates for DCC: single DCC certificate and its accompanying Scheme (e.g., XSD PTB scheme) from different sources and in different metrological fields. Those can be used to learn about the DCC and can be adapted or adopted by NMIs or Calibration labs.

▪ Reference Standard Datasets: a collection of DCCs as a standard test suit for systems and applications bench-marking.

▪ Datasets for ML/DL and Data analytics: large number of DCC datasets to be used in machine-learning, deep-learning based applications and data analytics.

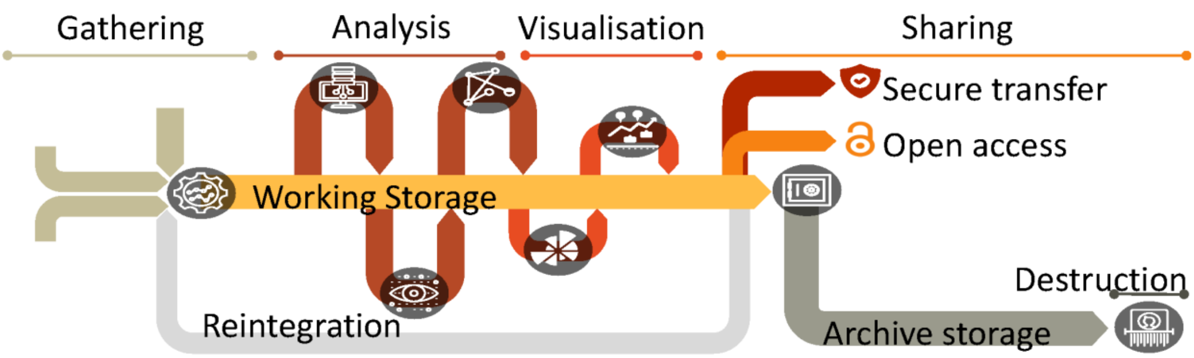
3

DATASET LIFE-CYCLE

- Generic Data Life-Cycle
- Calibration Certificate Life-Cycle
- New DCC Life-Cycle

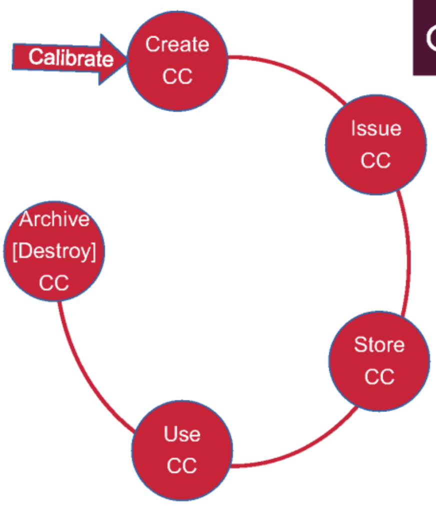
4

Generic Data Life-Cycle



CC BY Thomas Shafee: commons.wikimedia.org/wiki/Data lifecycle.svg,

5

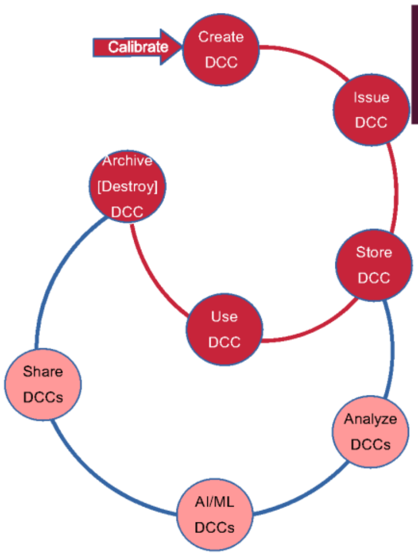


CALIBRATION CERTIFICATE LIFE-CYCLE

Create & Issue => Store => Use (Measure|Audit) => Archive

- Normally 2-3 years lifetime (Until the expiration date)
- Mostly used for direct in-field or in-lab measurements
- Only used by [or on behave of] device owner (e.g., Technician, Inventory Manager, Auditors)

6



NEW DCC LIFE-CYCLE

- Life-time extended beyond the expiration date > 3 years
- New usages and new use cases (Industry4.0 & IIoT: Collective analysis, Monitoring/prediction, Modeling, automation, Smart/autonomous devices, etc.)
- More users/stakeholders (+ researchers, SW developers, AI/ML and data scientists, etc.)

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- Learn about and compare various DCC samples coming from different sources.
- Allow dataset reuse and thus increase convergence and synergy between separate research efforts.
- Test compatibility, inter-operability and performance of systems and applications from different NMIs, Calibration Labs and industry.
- Test new ideas and new features of the new versions of the DCC itself.
- Test the implementation of new systems or applications.
- Apply machine learning and deep learning techniques.

BENEFITS OF HAVING A REPOSITORY FOR METROLOGY DATASETS (DCC AS AN EXAMPLE)

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Challenges

- Lack of shareable digital metrology datasets.
- Dataset producers are most likely reluctant to sharing their datasets due to legal, regulative issues or internal policies.
- Lack of public tools and platforms that enable and facilitate dataset sharing.
- The question is:
  - How to encourage DCC owners or issuers to share datasets? while:
    - Preserving privacy
    - Protecting their rights and
    - Not violating laws or regulations (e.g. European GDPR).
  - How to maintain data privacy without compromising accuracy and utility of data?

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- Sensitive data are data that can be used to ***identify*** an individual, species, object, or location that ***introduces a risk of discrimination, harm, or unwanted attention***."
  - How identifiable is your data?
  - What are the ethical and legal responsibilities?
  - What grant/contract conditions and mandates do you have to comply with?
  - Who has ownership or rights over the data?
  - What consent is there for future use?

DATA SENSITIVITY

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DATASET ANONYMIZATION

"A Process by which personal data is altered in such a way that a data subject can no longer be identified directly or indirectly, either by the data controller alone or in collaboration with any other party." [**]

- It aims to remove direct identifiers (e.g., names) from datasets and to enforce further constraints on indirect identifiers.
- Indirect identifiers (or quasi-identifiers, or keys) are attributes that do not directly identify a data subject but may together with other indirect identifiers form an identifier that can be used for information correlation.

[**] Raghunathan, Balaji (June 2013). The Complete Book of Data Anonymization: From Planning to Implementation. CRC Press. ISBN 9781482218565.

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ANONYMIZATION OF DCC ADMINISTRATIVE DATA

- **Device identifiers:**
  - Device serial numbers and device proprietary names that may reveal its owner. Device model or device name given by the manufacturer can be maintained.
- **Client identifiers:**
  - Client name or address (physical or electronic such as Url, emails, telephones, etc.)
- **NMI or Calibration Lab Identifiers:**
  - Institution name and telephone numbers: (sometimes this does not represent sensitive information)
  - Location, physical address or postcode information (sometimes this does not represent sensitive information)
  - Names of respondents or responsible persons (Technicians, metrologists, Lab head, etc.)
  - Electronic addresses: emails, website, url, and IP, etc.

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ANONYMIZATION TECHNIQUES

- **Pseudonymization:** data de-identification by replacing private identifiers with pseudonyms or false identifiers.
- **Data masking:** allowing access to a modified version of sensitive data. It can be applied by encryption, or dictionary substitution.
- **Data perturbation:** changes the initial dataset slightly by using rounding methods and random noise.
- **Data swapping**, also called shuffling or data permutation, rearranges dataset attribute values so that they don't match the initial information.
- **Generalization requires** excluding certain data to make it less identifiable.
- **Synthetic data** is algorithmically produced data with no connection to any real case. The data is used to create artificial datasets rather than utilizing or modifying the original dataset and compromising protection and privacy.

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Main Components of Metrology Dataset Sharing Platform

- Dataset storage + search engine (data & metadata)
- Dataset management back-end (Dataset Owner/provider tools and Dataset user/consumer tools)
- Dataset Version Management
- Dataset evaluation and review
- A set of dataset manipulation and processing tools, such as:
  - Source code and libraries for dataset processing
  - Data Extraction and display tools
  - DCC scheme checker
  - Conversion Tools (from XML to other formats such as pdf or json for example)
  - Anonymization tools
- APIs and DB connectors
- Documentation, Wikipedia, Guidelines and best practices

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Conclusion

- Availability of data and datasets is critical for Digital Transformation in Metrology.
- New digital formats in Metrology have a strong impact on the processes (life-cycles) and use-cases.
- Sharing metrology dataset has both technical, legal and organizational aspects.
- Urgent need for rules, mechanisms and platforms to enable metrology dataset publishing and sharing.
- Collaboration is the key.

15

Thanks!

Any Question | Suggestion | Feedback is welcome

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16

19 Analyzing the Conformance of DCC Prototype Architecture to Calibration Laboratory Expectations Report

Presenting author: Praiya Thongluang, NIMT, Thailand

E-mail address: ms.praiya@gmail.com

Additional authors: Narin Chantawong, Jariya Buajarern, and Sunantiya Parana

Abstract

This work aims to survey a calibration laboratory opinion in Thailand about changing the calibration format to digital. We hold two meetings in the dimension field and the electrical field to present a DCC prototype. For the DCC prototype, we digitalize the data in the Certificate of Calibration, which was previously issued by Microsoft Excel. We explore the utilization of an Extensible Markup Language (XML) map which adapts from the DCC guideline to automatically generate the DCC from XLSX files. Thus, the XML file is then displayed on a web browser for human readability. The questionnaire has 9 questions and we found some participant has a problem using the certificate in paper form and almost all of the participants agree to change the certificate format to the DCC. The participants also agree with the DCC can rise their service capability. In addition, they have a suggestion about adding calibration due date and decision rule. The second survey is divided into two parts which are compared between the type of organization and between job positions. From the survey, most participants agree with changing the calibration format to digital. However, they still have concerns. Their apprehension depends on the type of organization and job position. For the type of organization, the private sector has biggest concerned about changing organizational culture but the government sector has most concerned about the staff's lack of the new knowledge to support the DCC system. For the job position, the laboratory head and staff are concerned about the operation process while the department head focuses on budget and costs.

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Analyzing the conformance of DCC prototype architecture to calibration laboratory expectations report

Ms.Praiya Thongluang

National Institute of Metrology (Thailand)

สถาบันมาตรวิทยาแห่งชาติ
National Institute of Metrology (Thailand)

Overview

- Introduction
- DCC prototype, NIMT
- Objective
- Surveys meeting
  - First meeting
  - Second meeting
- Conclusion

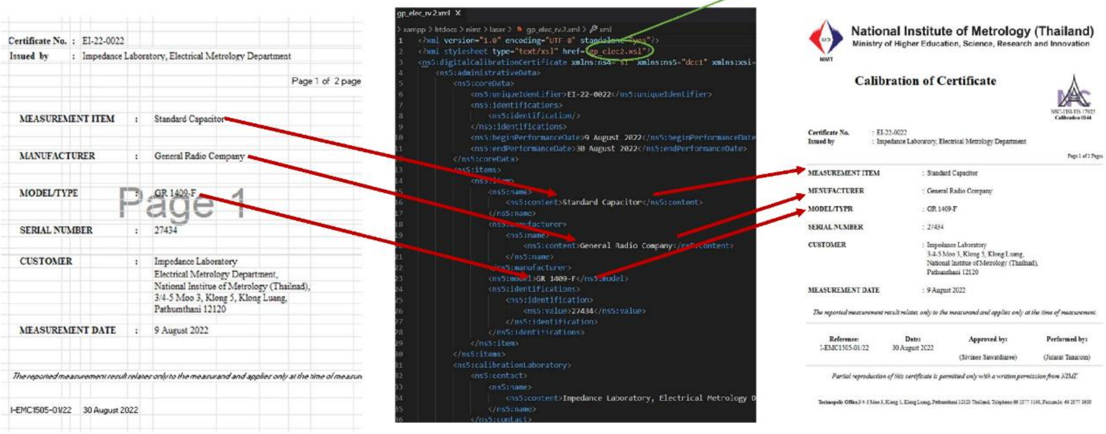
NIMT 2

Introduction

- Digital transformation in metrology has been started with Digital Calibration Certificates (DCC) by PTB
- In NIMT, we digitalize the data in the Certificate of Calibration
- We explore the utilization of an Extensible Markup Language (XML) map which adapts from the DCC guideline to automatically generate the DCC from XLSX files.
- The XML file is then displayed on a web browser for human readability.

DCC

.xsl file: To preview in human readable form



Excel XML PDF Preview

DCC

Administrative Data

National Institute of Metrology (Thailand)
Ministry of Higher Education, Science, Research and Innovation

NIMT

Calibration of Certificate

NSC-TISI-TIS 17025
Calibration 0144

Certificate No. : EI-22-0022
Issued by : Impedance Laboratory, Electrical Metrology Department

Page 1 of 2 Pages

MEASUREMENT ITEM	: Standard Capacitor
MENUFACTURER	: General Radio Company
MODEL/TYPR	: GR 1409-F
SERIAL NUMBER	: 27434
CUSTOMER	: Impedance Laboratory 3/4-5 Moo 3, Klong 5, Klong Luang, National Institue of Metrology (Thailnad), Pathumthani 12120
MEASUREMENT DATE	: 9 August 2022

The reported measurement result relates only to the measurand and applies only at the time of measurement.

Reference:	Date:	Approved by:	Performed by:
I-EMC1505-01/22	30 August 2022	(Sivinee Sawatdiaree)	(Jutarat Tanarom)

Partial reproduction of this certificate is permitted only with a written permission from NIMT.

Technopolis Office,3/4-5 Moo 3, Klong 5, Klong Luang, Pathumthani 12120 Thailand, Telephone:66 2577 5100, Facsimile: 66 2577 3659

Measurement Results

Page 2 of 2 Pages

Continuation of Certificate of Calibration Number EI-22-0022

ENVIRONMENTAL CONDITION

The measurement was carried out in an ambient temperature of (23.0 ± 1.0) °C and relative humidity of (50 ± 15) %.

MEASUREMENT METHOD

Capacitance of the standard capacitor was directly measured by an ultra-precision capacitance bridge at requested frequencies. The value of three-terminal capacitance was measured with the GND terminal unconnected to the LO terminal.

UNCERTAINTIES OF MEASUREMENT

The stated measurement uncertainties are the expanded measurement uncertainties obtained from the combined standard measurement uncertainties multiplied by the coverage factor k. The coverage factors $k = 2$ are implied in all cases except where different values of k are explicitly stated. They are determined in accordance with JCGM 100: 2008 "Evaluation of measurement data - Guide to the expression of uncertainty in measurement". The values of the measurand lie within the assigned range of values with a probability of approximately 95 %.

TRACEABILITY

This certificate provides traceability of measurement to recognized national standards, and to the realization of the International System of Units (SI).

MEASUREMENT RESULTS

3-terminal measurement

Freauency:	Measured Value	Uncertainty	k
100 Hz	990.796 pF	16 µF/F	2.15
120 Hz	990.766 pF	12 µF/F	2.00
200 Hz	990.710 pF	10 µF/F	2.01
400 Hz	990.642 pF	9 µF/F	2.00
500 Hz	990.621 pF	9 µF/F	2.00
1000 Hz	990.567 pF	9 µF/F	2.18
2000 Hz	990.507 pF	9 µF/F	2.11
5000 Hz	990.434 pF	10 µF/F	2.05
10000 Hz	990.381 pF	16 µF/F	2.01

End of Certificate of Calibration

NIMT 5

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National Institute of Metrology (Thailand)

Objective

- In this work, we hold two meetings to present the DCC prototype for calibration laboratories and then survey their opinion.
  - The first meeting participants are calibration laboratories in the dimension field from 23 companies (53 people).
  - The second meeting participants are calibration laboratories in the electrical field from 14 companies (28 people).

NIMT 6

The first meeting

- The questionnaire has 9 questions, and we use **Chi-square** to analyze the survey results.
- We found **some participant has a problem** using the certificate in paper form and **almost all of the participants agree (95%)** to change the certificate format to the DCC.
- The participants also agree with the DCC can rise their service capability. They have a suggestion about adding calibration due date and decision rule.

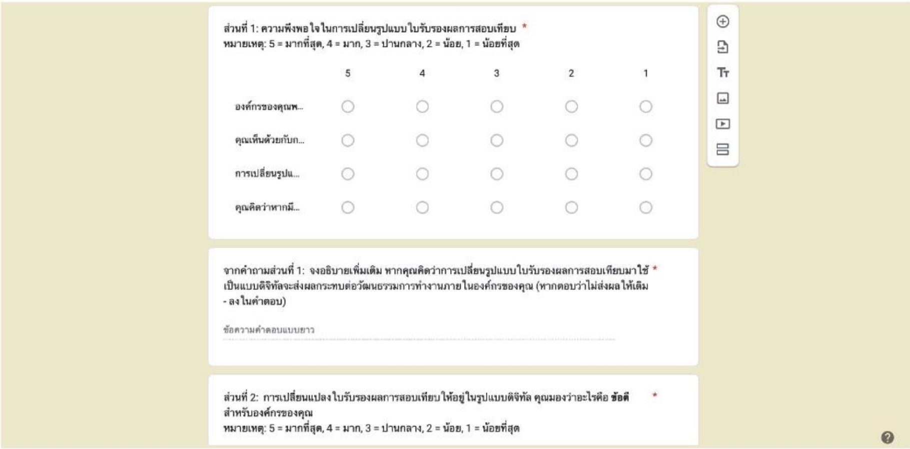
NIMT 7

Pros & Cons

Pros	Cons
❑ Save paper and reduce costs ❑ Convenience to information transfer ❑ Reduce the cost of document delivery ❑ Long term preservation ❑ Reduce the certificate issuing time ❑ Able to direct traceability	❑ Employees lack knowledge of XML, software, and hardware for supporting the DCC ❑ Changing the organizational culture in their company ❑ Signature and data forgery ❑ Loss of data via sending by e-mail ❑ Budget for supporting the DCC systems ❑ Increase of operation process

NIMT 8

The questionnaire (2nd meeting)



NIMT 9

The second meeting

Analyzation of the survey results is divided into 2 parts:

1. Comparison between **private and government sectors**, and we analyze by using T- test with 95% confidence.
2. Comparison between **position jobs**, we use Analysis of Variance (ANOVA) and Fisher's Least Significant Difference (LSD) with 95% confidence to analyze the surveys.

NIMT 10

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Comparison between private and government sectors

The questionnaire is divided into 3 parts and the survey results are shown in the following:

Part 1: Satisfaction with changing the format of the calibration certificate to DCC

Part 2: Advantages of the DCC

Part 3: Disadvantages of the DCC

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National Institute of Metrology (Thailand)

Results

Part 1	Part 2	Part 3
❑ Private and government sector satisfaction with changing the format.	❑ Private and government sector agree with changing the DCC format. ❑ The advantages of the DCC in their opinion are similar to the calibration laboratory in the dimension field.	❑ Private **sectors concern more** about ❑ **changing organizational culture,** ❑ **data missing via sending by e-mail,** ❑ **data use being unclear,** ❑ **data storage.**

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Comparison between the department head, laboratory head, and laboratory staff

The questionnaire is divided into 3 parts and the survey results are shown in the following:

Part 1: Satisfaction with changing the format of the calibration certificate to DCC

Part 2: Advantages of the DCC

Part 3: Disadvantages of the DCC

NIMT 13

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Results: Part 1

SUMMARY

Groups	*Count*	*Sum*	*Average*
Department head	4	15.25	3.8125
Laboratory head	4	17.33333	4.333333
Laboratory staff	4	15.35	3.8375

- Department head, laboratory head, and laboratory staff have satisfied with changing the certificate format.

NIMT 14

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Results: Part 2 (Advantages)

- Lab head and staff have the same opinion on the benefits of the DCC
  - Long-term storage
- Department head think the benefits of the DCC are
  - Convenience of information transfer
  - Saving paper
  - Reducing costs.

Job position	Average	Difference mean	Compared with LSD
Department head & laboratory haed	4.82 & 4.48	0.35	More
Laboratory head & laboratory staff	4.48 & 4.58	0.10	Less
Department head & laboratory staff	4.82 & 4.58	0.24	More

NIMT 15

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Results: Part 3 (Disadvantages)

- Laboratory head and staff have the same opinion on disadvantages of the DCC.
  - The most anxiety in their opinion is the privacy and security of the DCC
  - The last anxiety is the increase of the operation process.
- Department head position interested in
  - Budgeting and equipment for supporting the DCC system
  - Accuracy of data
  - Privacy and security
  - Data storage

Job position	Average	Difference mean	Compared with LSD
Department head & laboratory haed	4.27 & 3.58	0.70	More
Laboratory head & laboratory staff	3.58 & 3.59	0.02	Less
Department head & laboratory staff	4.27 & 3.59	0.68	More

NIMT 16

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Summary

- Most participants agree with changing the calibration format to digital.
- Their apprehension depends on the type of organization and job position.
  - For the type of organization
    - The private sector has biggest concerned about changing organizational culture
    - The government sector has most concerned about the staff's lack of the new knowledge to support the DCC system.
  - For the job position
    - The laboratory head and staff are concerned about the operation process.
    - The department head focuses on budget and costs.

20 A Proof of Concept for a Digital Calibration Environment for Digital Multimeters

Presenting author: Marcos E. Bierzychudek, INTI, Argentina

E-mail address: mbierzychudek@inti.gob.ar

Additional authors: D. Coppa and A. Toran

Abstract

This abstract presents a proof of concept for a digital calibration environment for digital multimeters (DMM). The calibration of DMM is a critical process that ensures the accuracy and reliability of measurements taken with this instrument, which is broadly used in industry. The approach proposed in this work utilizes digital structured information, like DCCs, and relational databases to manage the calibration process, improving its efficiency and effectiveness.

The DMM calibration laboratory of the Instituto Nacional de Tecnología Industrial has developed the software for data acquisition of calibration measurements. Then, the measured data is analyzed using a spreadsheet to calculate errors, tolerances, and uncertainties. From these results, the calibration report is generated with a word template. This process is adapted for each multimeter model, which includes particular spreadsheets and templates.

This work aims to create a unified environment for data acquisition, processing, and report generation for the calibration of digital multimeters. The environment utilizes digital metrology data from digital calibration certificates, a middleware, and a database system. The final output is a digital calibration certificate in XML and PDF format for the calibrated DMM.

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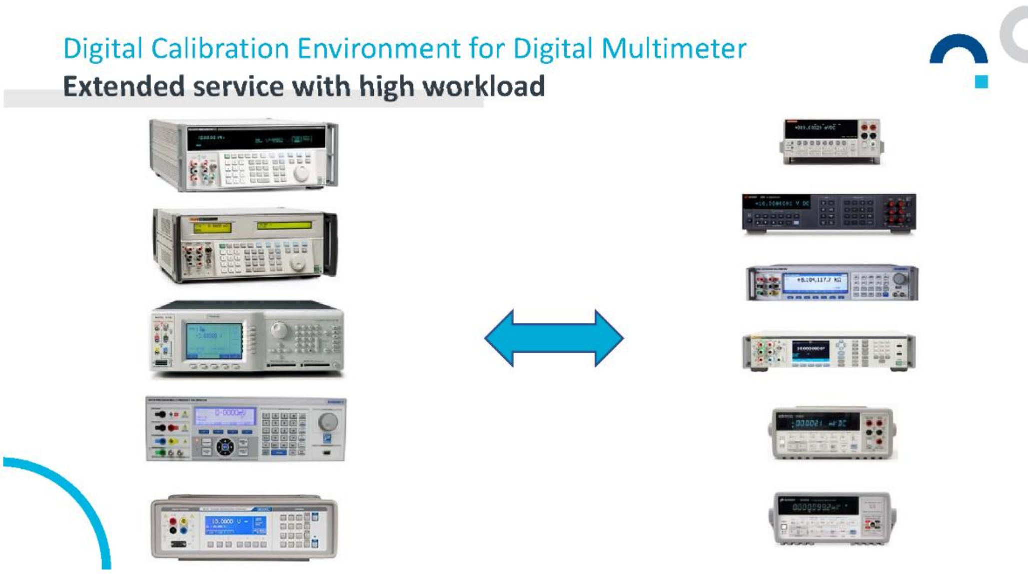
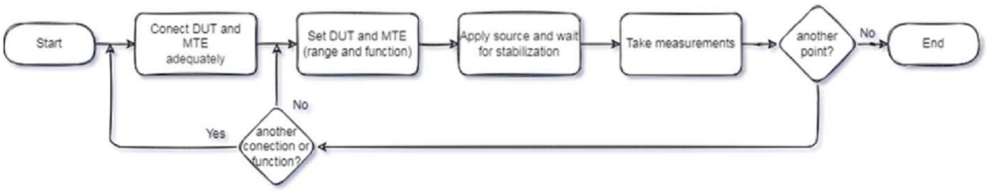
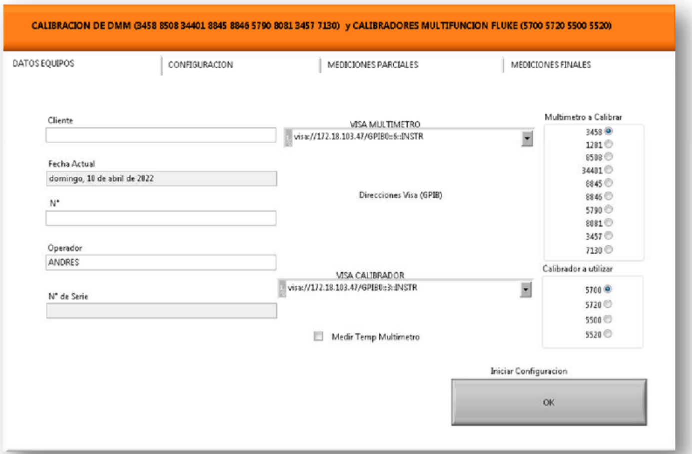
3rd International DCC Conference
A Proof of Concept for a Digital Calibration Environment for Digital Multimeters
March | 2023 | A. Toran, M. E. Bierzychudek and D. Coppa
Instituto Nacional de Tecnología Industrial
INTI
Ministerio de Economía Argentina
Secretaría de Industria y Desarrollo Productivo


Digital Calibration Environment for Digital Multimeter
Extended service with high workload

Digital Calibration Environment for Digital Multimeter
Flow diagram of measurement

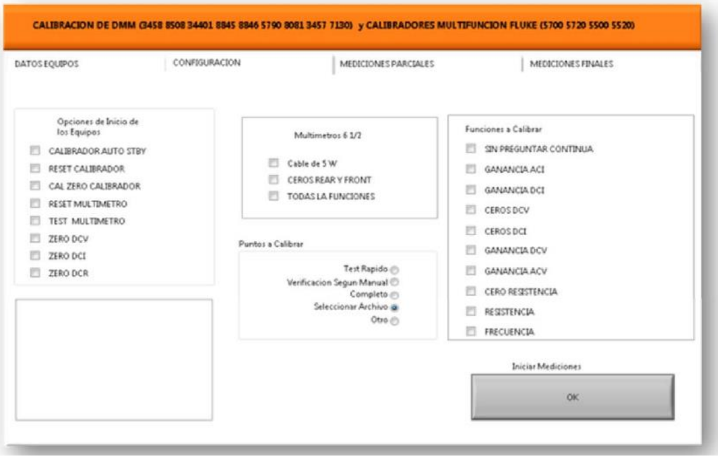


Digital Calibration Environment for Digital Multimeter
Software



Digital Calibration Environment for Digital Multimeter

Software



Digital Calibration Environment for Digital Multimeter

Software: configuration file

	A	B	C	D	E	F	G	H	I
1	FUNCION	M_RANGO	M_TERMINALES	M_CONFIG	ESTIMULO		C_CONFIG	NºMEDICIONES	ESPERA (SEG)
2	CORTO DCV	0,2	FRONT	DCV .1,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD INT;TRG_SRCE INT	CORTO DCV	0	STBY;RANGECLK OFF;OUT 0 V, 0 HZ	10	30
3	CORTO DCV	2	FRONT	DCV 1,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD INT;TRG_SRCE INT	CORTO DCV	0	STBY;RANGECLK OFF;OUT 0 V, 0 HZ	10	30
4	CORTO DCV	20	FRONT	DCV 10,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD INT;TRG_SRCE INT	CORTO DCV	0	STBY;RANGECLK OFF;OUT 0 V, 0 HZ	10	30
5	CORTO DCV	200	FRONT	DCV 100,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD INT;TRG_SRCE INT	CORTO DCV	0	STBY;RANGECLK OFF;OUT 0 V, 0 HZ	10	30
6	CORTO DCV	1000	FRONT	DCV 500,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD INT;TRG_SRCE INT	CORTO DCV	0	STBY;RANGECLK OFF;OUT 0 V, 0 HZ	10	30
7	DCV	0,2	FRONT	DCV 0.1,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE INT	CALIBRADOR	-0,01	STBY;RANGECLK OFF;OUT -0.01 V, 0 HZ	10	30
8	DCV	0,2	FRONT	DCV 0.1,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE INT	CALIBRADOR	0,01	OUT 0.01 V, 0 HZ	10	15
9	DCV	0,2	FRONT	DCV 0.1,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE INT	CALIBRADOR	0,02	OUT 0.02 V, 0 HZ	10	15
10	DCV	0,2	FRONT	DCV 0.1,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE INT	CALIBRADOR	-0,02	OUT -0.02 V, 0 HZ	10	15
11	DCV	0,2	FRONT	DCV 0.1,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE INT	CALIBRADOR	-0,05	OUT -0.05 V, 0 HZ	10	15
12	DCV	0,2	FRONT	DCV 0.1,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE INT	CALIBRADOR	0,05	OUT 0.05 V, 0 HZ	10	15
13	DCV	0,2	FRONT	DCV 0.1,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE INT	CALIBRADOR	0,1	OUT 0.1 V, 0 HZ	10	15
14	DCV	0,2	FRONT	DCV 0.1,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE INT	CALIBRADOR	-0,1	OUT -0.1 V, 0 HZ	10	15
15	DCV	0,2	FRONT	DCV 0.1,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE INT	CALIBRADOR	-0,1999	OUT -0.1999 V, 0 HZ	10	15
16	DCV	0,2	FRONT	DCV 0.1,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE INT	CALIBRADOR	0,1999	OUT 0.1999 V, 0 HZ	10	15
17	DCV	2	FRONT	DCV 1,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE INT	CALIBRADOR	0,1999	OUT 0.1999 V, 0 HZ	10	30
18	DCV	2	FRONT	DCV 1,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE INT	CALIBRADOR	-0,1999	OUT -0.1999 V, 0 HZ	10	15
19	DCV	2	FRONT	DCV 1,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE INT	CALIBRADOR	-0,5	OUT -0.5 V, 0 HZ	10	15
20	DCV	2	FRONT	DCV 1,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE INT	CALIBRADOR	0,5	OUT 0.5 V, 0 HZ	10	15
21	DCV	2	FRONT	DCV 1,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE INT	CALIBRADOR	1	OUT 1 V, 0 HZ	10	15
22	DCV	2	FRONT	DCV 1,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE INT	CALIBRADOR	-1	OUT -1 V, 0 HZ	10	15
23	DCV	2	FRONT	DCV 1,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE INT	CALIBRADOR	-1,999	OUT -1.999 V, 0 HZ	10	15
24	DCV	2	FRONT	DCV 1,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE INT	CALIBRADOR	1,999	OUT 1.999 V, 0 HZ	10	15
25	DCV	20	FRONT	DCV 10,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE INT	CALIBRADOR	1,999	OUT 1.999 V, 0 HZ	10	30
26	DCV	20	FRONT	DCV 10,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE INT	CALIBRADOR	-1,999	OUT -1.999 V, 0 HZ	10	15
27	DCV	20	FRONT	DCV 10,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE INT	CALIBRADOR	2	OUT 2 V, 0 HZ	10	15
28	DCV	20	FRONT	DCV 10,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE INT	CALIBRADOR	4	OUT 4 V, 0 HZ	10	15
29	DCV	20	FRONT	DCV 10,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE INT	CALIBRADOR	6	OUT 6 V, 0 HZ	10	15
30	DCV	20	FRONT	DCV 10,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE INT	CALIBRADOR	8	OUT 8 V, 0 HZ	10	15
31	DCV	20	FRONT	DCV 10,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE INT	CALIBRADOR	10	OUT 10 V, 0 HZ	10	15
32	DCV	20	FRONT	DCV 10,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE INT	CALIBRADOR	12	OUT 12 V, 0 HZ	10	15
33	DCV	20	FRONT	DCV 10,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE INT	CALIBRADOR	14	OUT 14 V, 0 HZ	10	15
34	DCV	20	FRONT	DCV 10,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE INT	CALIBRADOR	16	OUT 16 V, 0 HZ	10	15
35	DCV	20	FRONT	DCV 10,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE INT	CALIBRADOR	18	OUT 18 V, 0 HZ	10	15

DCV 500,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD INT;TRG_SRCE	CORTO DCV	0	STBY;RANGECLK OFF;OUT
DCV 0.1,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE	CALIBRADOR	-0,01	STBY;RANGECLK OFF;OUT
DCV 0.1,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE	CALIBRADOR	0,01	OUT 0.01 V, 0 HZ
DCV 0.1,FILT_ON,RESL8,FAST_OFF,TWO_WR;INPUT FRONT;GUARD EXT;TRG_SRCE	CALIBRADOR	0,02	OUT 0.02 V, 0 HZ

Digital Calibration Environment for Digital Multimeter
Software: results in txt file

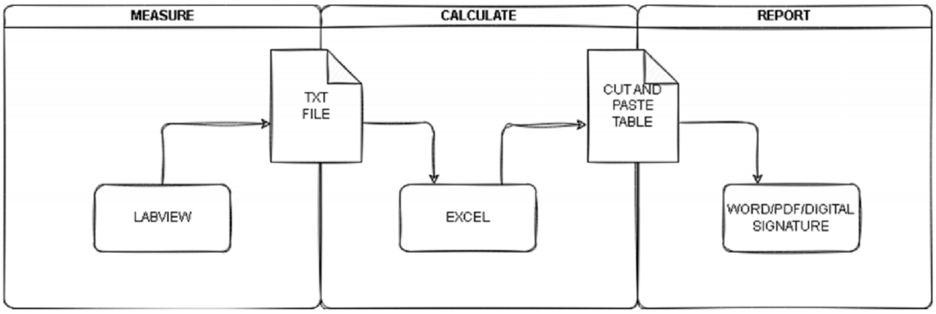
L	M	N	O	P	Q	R	S	T	U	V	W
Hora Fin	C_Funcion	C_Rango	C_ValorNom	C_Freq	M_Funcion	M_Bornera	M_Rango	M_N°Medici	M_Promedio	M_Desvstd	M_Max-Min
09:56:45	CORTO DCV	DC220MV	0,00E+00	0,00E+00	DCV	FRONT	1,00E-01	10	4,64965834E-07	3,44E-08	1,19E-07
09:58:06	CORTO DCV	DC220MV	0,00E+00	0,00E+00	DCV	FRONT	1,00E+00	10	4,26256956E-07	1,95E-08	5,82E-08
09:59:27	CORTO DCV	DC220MV	0,00E+00	0,00E+00	DCV	FRONT	1,00E+01	10	5,63884370E-07	1,41E-07	4,03E-07
10:00:50	CORTO DCV	DC220MV	0,00E+00	0,00E+00	DCV	FRONT	1,00E+02	10	1,89441594E-06	4,94E-06	1,39E-05
10:02:13	CORTO DCV	DC220MV	0,00E+00	0,00E+00	DCV	FRONT	1,00E+03	10	4,92350702E-06	1,05E-05	3,43E-05
10:11:24	DCV	DC220MV	1,00E-02	0,00E+00		FRONT	1,00E-01	10	9,99937901E-03	1,84E-08	5,25E-08
10:12:29	DCV	DC220MV	0,00E+00	0,00E+00	DCV	FRONT	1,00E-01	10	-5,40455527E-07	4,08E-08	1,45E-07
10:13:34	DCV	DC220MV	-1,00E-02	0,00E+00	DCV	FRONT	1,00E-01	10	-1,00004894E-02	2,15E-08	5,95E-08
10:14:39	DCV	DC220MV	-5,00E-02	0,00E+00	DCV	FRONT	1,00E-01	10	-5,00004486E-02	2,61E-08	8,47E-08
10:15:44	DCV	DC220MV	5,00E-02	0,00E+00	DCV	FRONT	1,00E-01	10	4,99996092E-02	2,32E-08	7,23E-08
10:16:49	DCV	DC220MV	1,00E-01	0,00E+00	DCV	FRONT	1,00E-01	10	9,99996411E-02	1,88E-08	5,11E-08
10:17:54	DCV	DC220MV	0,00E+00	0,00E+00	DCV	FRONT	1,00E-01	10	-2,92092201E-07	4,32E-08	1,50E-07
10:18:59	DCV	DC220MV	-1,00E-01	0,00E+00	DCV	FRONT	1,00E-01	10	-1,00000303E-01	3,24E-08	1,15E-07
10:20:20	DCV	DC220MV	-1,00E-01	0,00E+00	DCV	FRONT	1,00E+00	10	-1,00000330E-01	3,03E-08	9,39E-08
10:21:25	DCV	DC220MV	0,00E+00	0,00E+00	DCV	FRONT	1,00E+00	10	-2,49669050E-07	2,15E-08	5,82E-08
10:22:29	DCV	DC220MV	1,00E-01	0,00E+00	DCV	FRONT	1,00E+00	10	9,99997188E-02	3,55E-08	1,16E-07
10:23:34	DCV	DC2_2V	5,00E-01	0,00E+00	DCV	FRONT	1,00E+00	10	4,99999185E-01	3,20E-08	1,04E-07
10:24:39	DCV	DC2_2V	-5,00E-01	0,00E+00	DCV	FRONT	1,00E+00	10	-4,99999177E-01	3,35E-08	9,85E-08
10:25:44	DCV	DC2_2V	-1,00E+00	0,00E+00	DCV	FRONT	1,00E+00	10	-9,99998318E-01	4,92E-08	1,55E-07
10:26:49	DCV	DC2_2V	-1,02E+00	0,00E+00	DCV	FRONT	1,00E+00	10	-1,01799831E+00	4,60E-08	1,31E-07
10:27:54	DCV	DC2_2V	0,00E+00	0,00E+00	DCV	FRONT	1,00E+00	10	1,88668667E-07	1,98E-08	5,97E-08
10:28:59	DCV	DC2_2V	1,00E+00	0,00E+00	DCV	FRONT	1,00E+00	10	9,99998180E-01	4,69E-08	1,30E-07

Digital Calibration Environment for Digital Multimeter
Data processing by spreadsheet

FUNCION DCV								PASA / NO PASA			
UUT MULTIMETRO, VALORES Y RANGOS											
	C_ValorNominal	C_Freq	M_Rango	M_resolucion	M_Carga/I	M_MEDIDO	M_X-NOM	PNP S/U	PNP C/U	PNP C/U	%ESPEC
	0	0			Ohms/A		ppm	ERROR<1AÑO	ERROR+Ua<1año	ERROR+Uinf<1AÑO	
DCV	1	0	10	1,0E-06		0,999995817	-4,2	P	P	P	49,7
DCV	1,018	0	10	1,0E-06		1,017995963	-4,0				
DCV	2	0	10	1,0E-06		1,999992648	-3,7	P	P	P	47,6
DCV	3	0	10	1,0E-06		2,999989483	-3,5	P	P	P	53,5
DCV	4	0	10	1,0E-06		3,999985119	-3,7	P	P	P	49,2
DCV	5	0	10	1,0E-06		4,999982266	-3,5	P	P	P	53,5
DCV	6	0	10	1,0E-06		5,999977826	-3,7	P	P	P	49,5
DCV	7	0	10	1,0E-06		6,999973538	-3,8	P	P	P	48,9
DCV	8	0	10	1,0E-06		7,999969538	-3,8	P	P	P	47,8
DCV	9	0	10	1,0E-06		8,999966601	-3,7	P	P	P	47,7
DCV	10	0	10	1,0E-06		9,999962218	-3,8	P	P	P	46,7
DCV	-1	0	10	1,0E-06		-0,99999646	-3,5	P	P	P	64,2
DCV	-1,018	0	10	1,0E-06		-1,017996707	-3,2				
DCV	-2	0	10	1,0E-06		-1,999993531	-3,2	P	P	P	48,6
DCV	-3	0	10	1,0E-06		-2,999990421	-3,2	P	P	P	53,0
DCV	-4	0	10	1,0E-06		-3,999986193	-3,5	P	P	P	49,7
DCV	-5	0	10	1,0E-06		-4,999982713	-3,5	P	P	P	49,8
DCV	-6	0	10	1,0E-06		-5,999978712	-3,5	P	P	P	50,3
DCV	-7	0	10	1,0E-06		-6,999975151	-3,5	P	P	P	50,4
DCV	-8	0	10	1,0E-06		-7,999971201	-3,6	P	P	P	48,9
DCV	-9	0	10	1,0E-06		-8,999967924	-3,6	P	P	P	49,9
DCV	-10	0	10	1,0E-06		-9,999963682	-3,6	P	P	P	49,8
DCV	-10	0	100	1,0E-05		-9,999930494	-7,0	P	P	P	-14,5
DCV	10	0	100	1,0E-05		[illegible]	[illegible]	P	P	P	[illegible]

Digital Calibration Environment for Digital Multimeter

DCC application with former software



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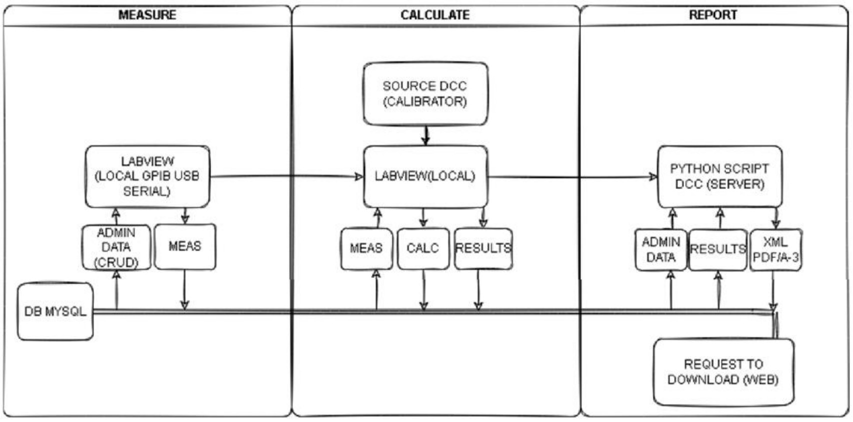
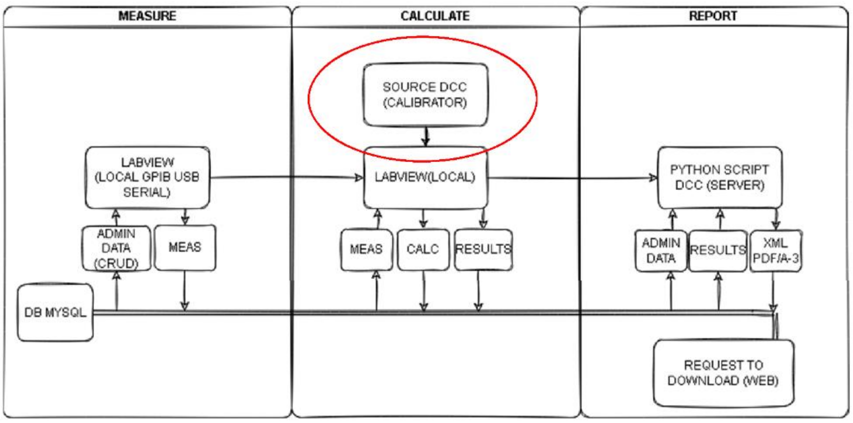
INTI

Integration of database and DCC

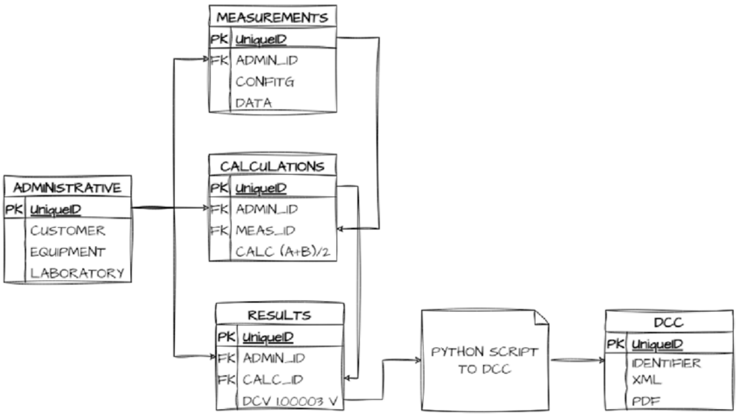
Digital Calibration Environment for Digital Multimeter
Data flow



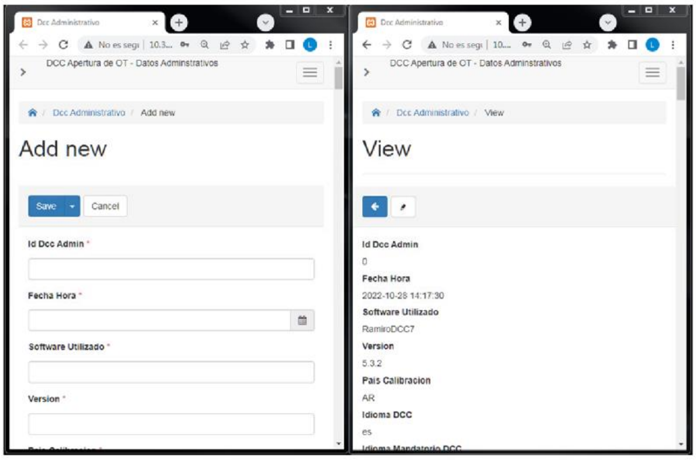
Digital Calibration Environment for Digital Multimeter
Data flow

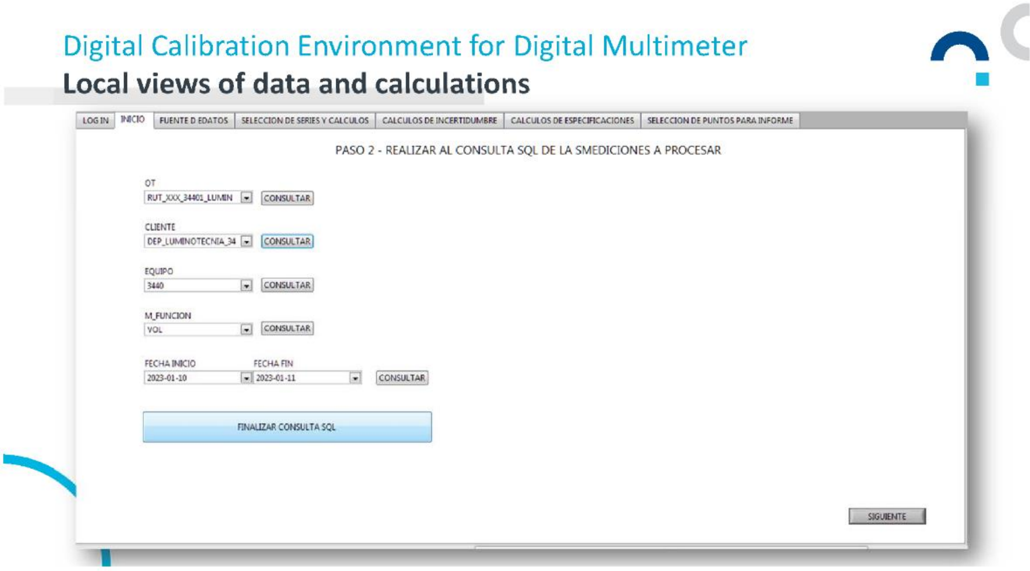


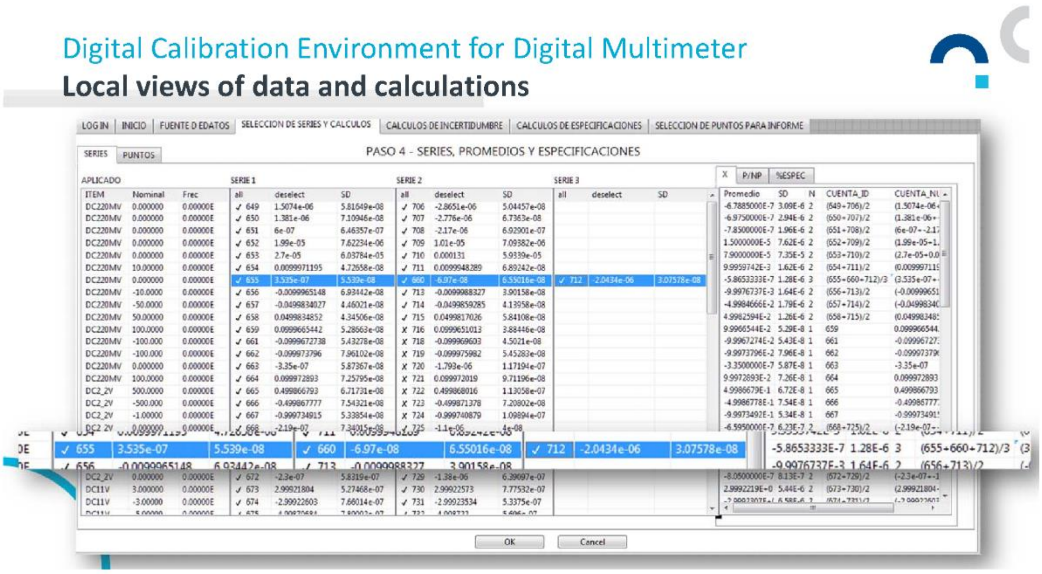
Digital Calibration Environment for Digital Multimeter
Information structures on data base



Digital Calibration Environment for Digital Multimeter
Administrative data




Digital Calibration Environment for Digital Multimeter
Local views of data and calculations
LOG IN
INICIO
FUENTE D EDATOS
SELECCION DE SERIES Y CALCULOS
CALCULOS DE INCERTIDUMBRE
CALCULOS DE ESPECIFICACIONES
SELECCION DE PUNTOS PARA INFORME
PASO 2 - REALIZAR AL CONSULTA SQL DE LA SMEDICIONES A PROCESAR
OT
CONSULTAR
CLIENTE
DEP_LUMINOTECNIA_34
CONSULTAR
EQUIPO
3440
CONSULTAR
M_FUNCION
VOL
CONSULTAR
FECHA INICIO
FECHA FIN
2023-01-10
2023-01-11
CONSULTAR
FINALIZAR CONSULTA SQL
SIGUIENTE


Digital Calibration Environment for Digital Multimeter
Local views of data and calculations
LOG IN
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CALCULOS DE ESPECIFICACIONES
SELECCION DE PUNTOS PARA INFORME
SERIES
PUNTOS
PASO 4 - SERIES, PROMEDIOS Y ESPECIFICACIONES
APLICADO
SERIE 1
SERIE 2
SERIE 3
ITEM
Nominal
Frec
all
deselect
SD
P/NP
%ESPEC
Promedio
N
CUENTA_ID
OK
Cancel

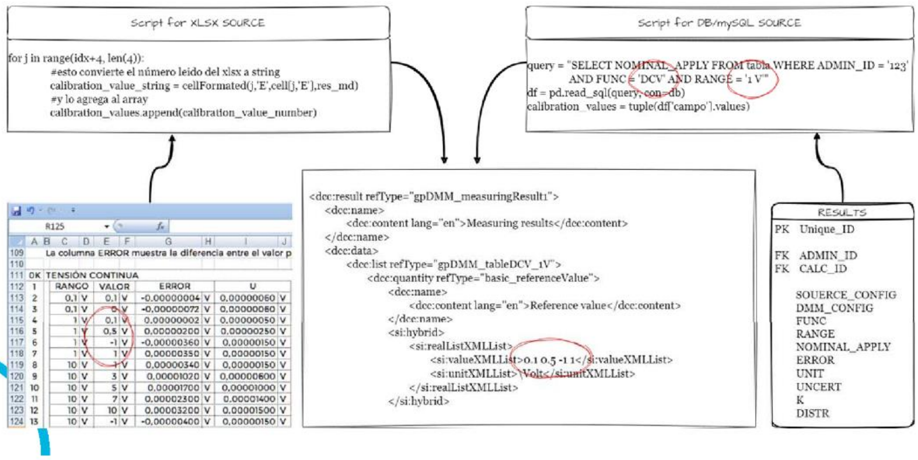
Digital Calibration Environment for Digital Multimeter

DCC generation

See "Software for the Creation of Machine and Human Readable Reports" by D. Coppa

Digital Calibration Environment for Digital Multimeter

DCC generation



Digital Calibration Environment for Digital Multimeter

Conclusion

- The database was successfully integrated to the former software.
- The calculation software reduces the workload.
- DCC generation from spreadsheets is already available but the application of the database improves the data flow.

Thank you

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canalinti

Instituto Nacional de Tecnología Industrial
INTI

Ministerio de Economía Argentina

Secretaría de Industria y Desarrollo Productivo

21 DKD's Contribution to DCC Harmonisation and Coordinated Development

Presenting author: Thomas Krah, Physikalisch-Technische Bundesanstalt, Germany

E-mail address: Thomas.krah@ptb.de

Additional authors: Martin Czaske, Wolfgang Schmid, Shanna Schönhals

Abstract
The development of the DCC schema has reached a maturity stage which brings its practical implementation in operative environment in a reaching distance. However, to ensure a harmonised use and development of interoperable processes and structures, the development of good practice examples by the individual technical communities is considered to be the most effective way.

In Germany, the German Calibration Service (Deutscher Kalibrierdienst DKD) offers an ideal environment to facilitate the technical discussion at the national level and to agree on the required conventions, as it represents more than 400 accredited laboratories and companies from the various metrology disciplines. The DKD is also open for accredited calibration laboratories outside of Germany. It is organised in 13 technical committees (TCs) that are responsible for specific technical subjects. In 2022, subgroups have been established in many of the TCs that discuss the implementation of the DCC. They are actively supported by the PTB. Additionally, a cross-sectoral committee has been established to discussed general and overarching topics. Another essential task of the DKD working groups is to document their work in DKD expert reports which serve as guidelines and have the character of pre-normative documents. This talk will give an insight of this work and associated workflows.

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Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin
Nationales Metrologieinstitut

DKD's Contribution to DCC Harmonisation and Coordinated Development

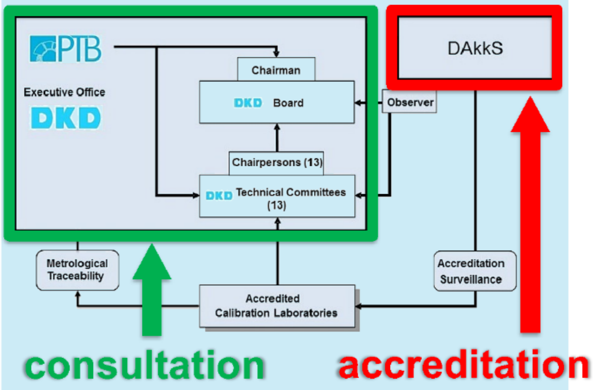
3rd International DCC Conference

T. Krah,	Dep. 9.4
M. Czaske, W. Schmid,	Section 9.11
S. Schönhals,	WG 1.24

What is the DKD?

- Abbreviation for **D**eutscher **K**alibrier**d**ienst (German Calibration Service)
- Is a board of PTB for the technical exchange between PTB and over 500 accredited calibration laboratories.

Structure



Tasks

- Develops calibration guidelines and good practice guides.
- Actively participates in setting international rules in the field of calibration.
- Facilitates the metrological infrastructure in the sense of the propagation of the units.
- Offers workshops and courses for the DKD members.
- Promotes interlaboratory comparisons.

What is the DKD?

Technical committees

1. Direct Current and Low Frequency
2. High Frequency and Optics
3. Force, Acceleration and Acoustics
4. Length
5. Temperature and Humidity
6. Pressure and Vacuum
7. Mass and Weighing Instruments
8. Chemical Measurands and Material Properties
9. Materials Testing Machines
10. Torque
11. Flow Measurands
12. Measurands in Laboratory Medicine
13. Measurement Uncertainty

What are the TCs doing?

- Preparing calibration guidelines at national level.
- Discuss good practice in calibration based on latest state of technology.
  → Regularly reviewing existing calibration guidelines.
- Informing members about developments in the field of calibration.

Why is the DKD dealing with the DCC?

DKD's goals for the DCC

- Bring calibration to the 21st century via digitalisation.
- Disseminating clear, unambiguous, and error free calibration data.
- Supporting a faster usability of calibration data by automatisation.
- Achieve widely harmonised DCC for all metrology fields and users.

Why is DKD best suited for contributing to the goals?

- DKD brings together expert knowledge from fundamental metrology (PTB) and industrial practicioners.
- DKD covers all relevant metrology areas.
- DKDs cross-sectoral cooperation fosters harmonisation and at the same time shapes subject-specific DCCs.

Current activities of the DKD

Work within the committees

- Sub-committees created focussing on **D**CC development.
- Development of **D**CCs for particularly relevant measurands and measurement equipment types.
- **Output:**
  - Good practices (templates) for selected important measurands.
  - Expert reports.
  - Harmonised wording.

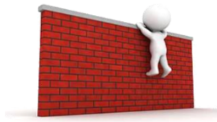
Current activities of the DKD

Measurand	Harmonised wording	Good practice	Expert report
Mass	✓	✓✓	✓✓
Scales	✓	✓	✓
Temperature	✓	✓	✓
Humidity	✓	✓	✓
Length	✓	✓	✔
Air pressure	✓	✓	
Torque	✓	✓	
Force	✓	✓	
Chem. measurands	✓	✓	
Laboratory medicine	✓	✓	

✓✓ Ready to use
✓ Work started
✔ Planning started

www.ptb.de/cms/en/metrological-services/dkd/publications.html --> tab *Expert Reports*

Current activities of the DKD



Work beyond the committees:

- Aligning with the German accreditation body about accreditation requirements.

DAkkS Deutsche Akkreditierungsstelle

Outlook and challenges

Goal for Germany:

- Developing a harmonised concept for the DCC which will be used within the German accreditation.
- Continue the coordination with the German accreditation body.
- Expand the concept to all measurands and measurement equipment types.

Goal internationally:

- Harmonisation on European and world wide level.
- Expand concept to all measurands.

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www.ptb.de

Stand: 03/23

22 GEMIMEG-II – Status and Progress Report

Presenting author: Dr. Thomas Engel, Siemens AG, Germany

E-mail address: EngelThomas@Siemens.com

Abstract

The GEMIMEG-II project is a German lighthouse project to path a way for digitalization in metrology. The acronym reflects the project aspiration by combining GEMIni for the digital twin of the MEtrology equipment for Global application. The central element of this digitalization initiative is the digital calibration certificate (DCC) and its fully automated application in modern industrial IT and IOT infrastructures. The user story is a calibration together with the related DCC that is created (automatically) in the calibration process and then transferred safely and without human intervention to the customer of the calibration. At the customer site, the DCC is read, processed, and interpreted automatically by machines in truly digital workflows in typical Industry 4.0 scenarios. The information extracted from the DCC will be used to update the plant management system (ERP) and all calibration related information in production.

This talk presents an overview of the recent project status of GEMIMEG-II in its final phase. It shares some insights on the concept developed and solutions implemented so far. 5 RealBeds will be setup in the project to showcase and prove the applicability of the GEMIMEG concept in the fields of the i) Digital Competence Centre for Wind power (d-CCW) at PTB (Germany), ii) fab of the future, iii) process- and pharma industry and iv) mobility for autonomous driving and v) a legal simulation.

The GEMIMEG-II project is funded by the German ministry for economic affairs and climate action based on a decision by the German Bundestag under grant number 01 MT20001A.

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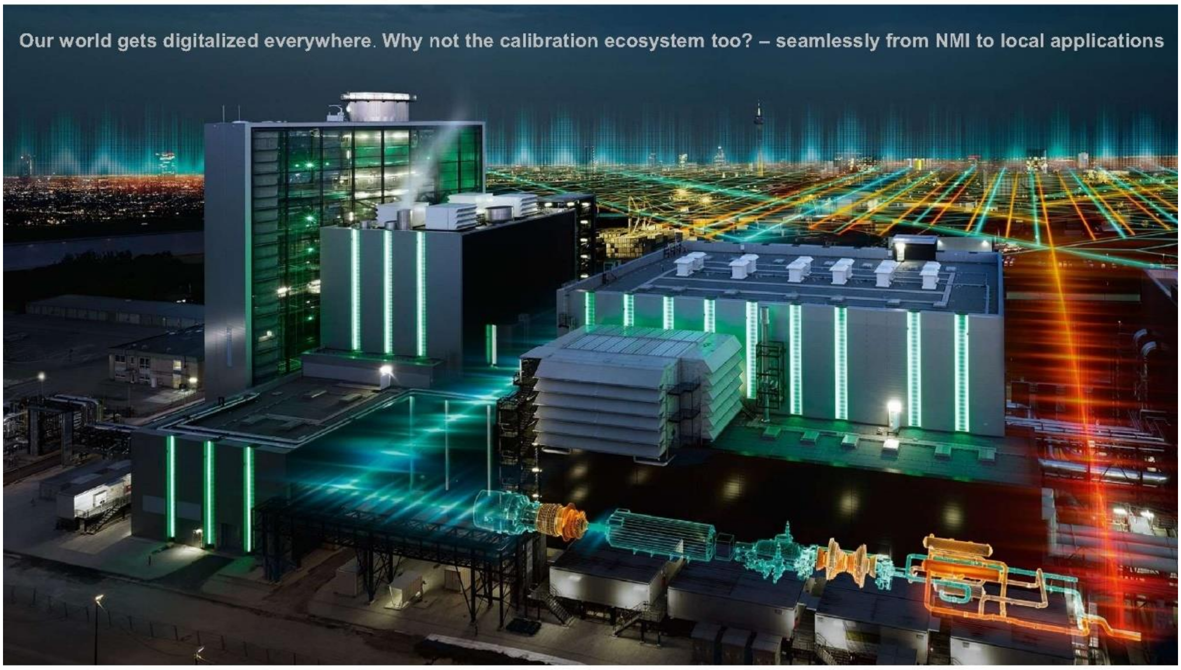
GEMIMEG-II:
Status and progress report
Dr. Thomas Engel
Project Coordinator GEMIMEG-II
3rd International DCC Conference, PTB, Braunschweig, Germany
March 2nd, 2023
SIEMENS


Our world gets digitalized everywhere. Why not the calibration ecosystem too? – seamlessly from NMI to local applications

The Project in a Nutshell

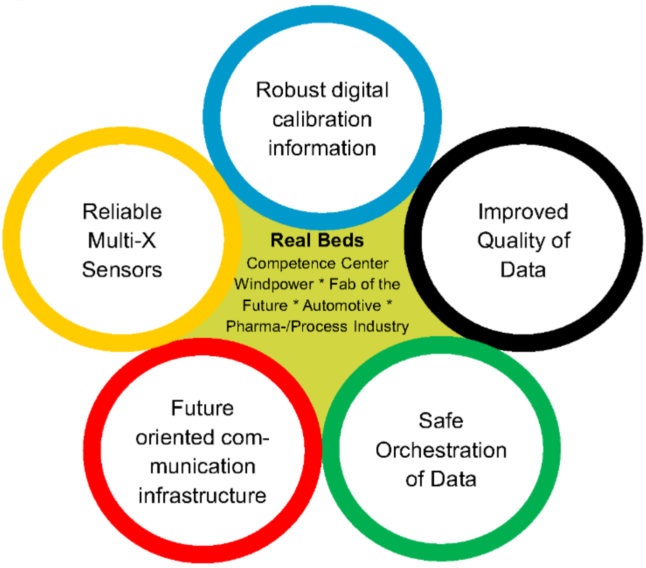
Project start:	01.08.2020	
Funding budget:	11,2 M€	
Total project budget:	17,9 M€	
Project duration:	36 months	
Project end:	31.07.2023	
Project partners:	13	
	Industry:	8
	NMI:	PTB
	Applied Research:	1
	University:	3

Supported by:

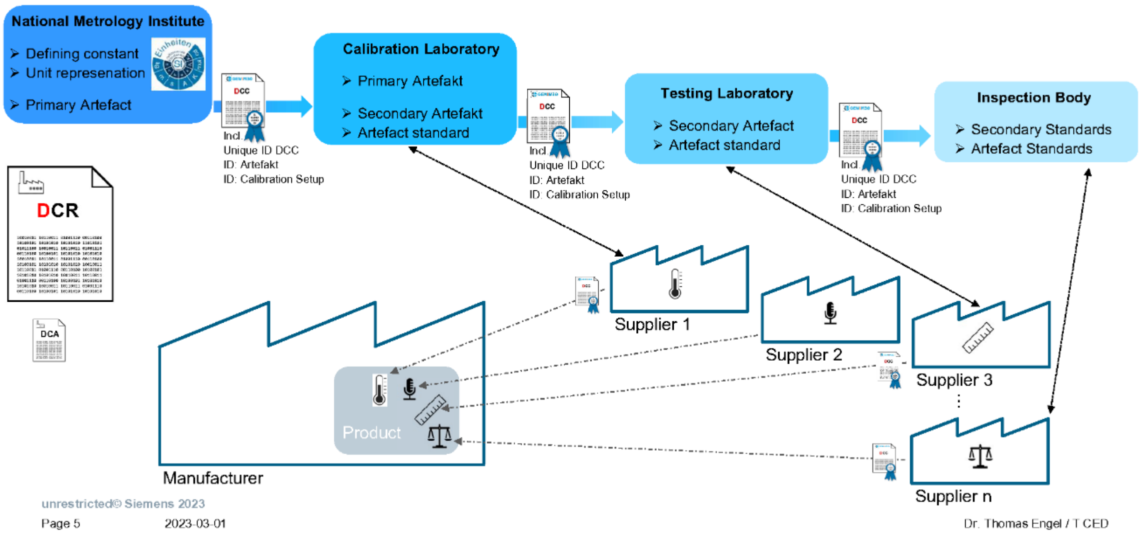
Federal Ministry for Economic Affairs and Climate Action

on the basis of a decision by the German Bundestag

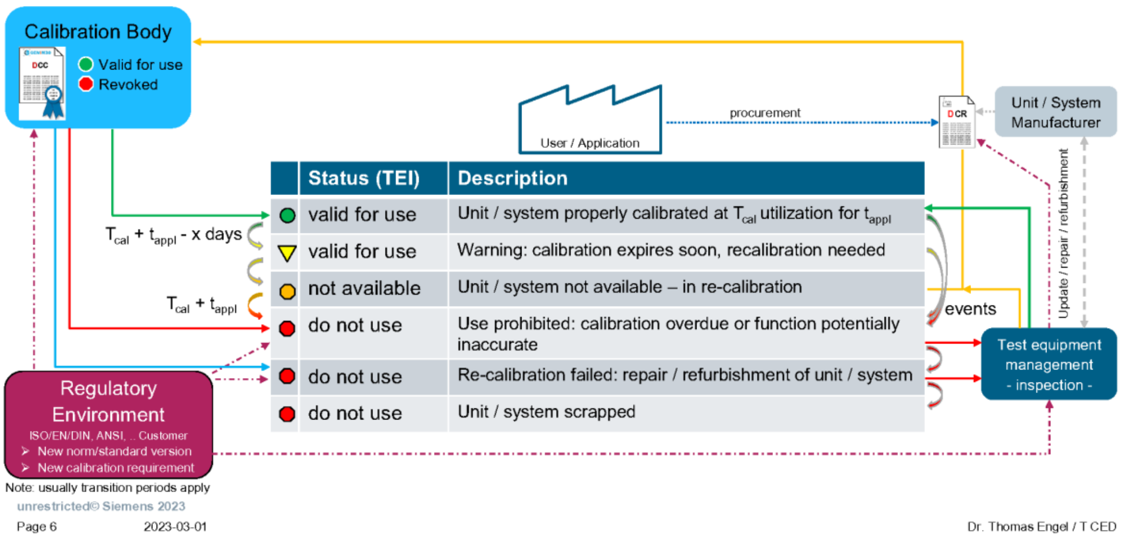
Our Research Agenda



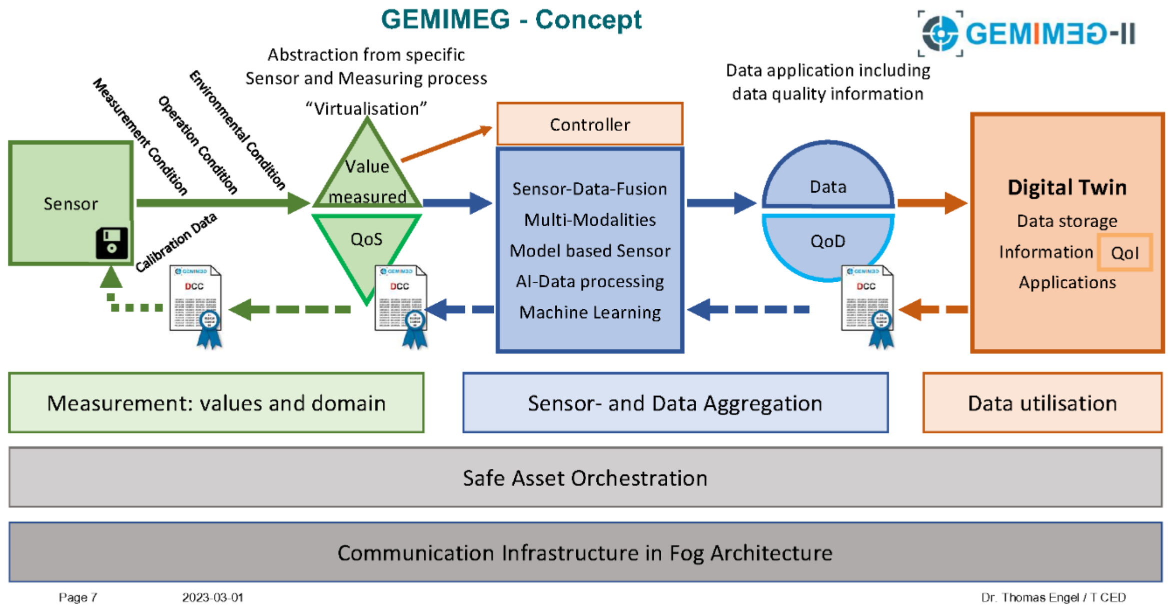
UseCase: System integration aspects of industrial products and in entire industrial production systems (fabrication plants)



Typical System Status for Test Equipment Inventory



Status (TEI)	Description
valid for use	Unit / system properly calibrated at T_{cal} utilization for t_{appl}
valid for use	Warning: calibration expires soon, recalibration needed
not available	Unit / system not available – in re-calibration
do not use	Use prohibited: calibration overdue or function potentially inaccurate
do not use	Re-calibration failed: repair / refurbishment of unit / system
do not use	Unit / system scrapped


GEMIMEG - Concept
GEMIMEG-II
Abstraction from specific
Sensor and Measuring process
“Virtualisation”
Measurement Condition
Operation Condition
Environmental Condition
Calibration Data
Sensor
Value
measured
QoS
DCC
Controller
Sensor-Data-Fusion
Multi-Modalities
Model based Sensor
AI-Data processing
Machine Learning
Data application including
data quality information
Data
QoD
Digital Twin
Data storage
Information
QoI
Applications
Measurement: values and domain
Sensor- and Data Aggregation
Data utilisation
Safe Asset Orchestration
Communication Infrastructure in Fog Architecture
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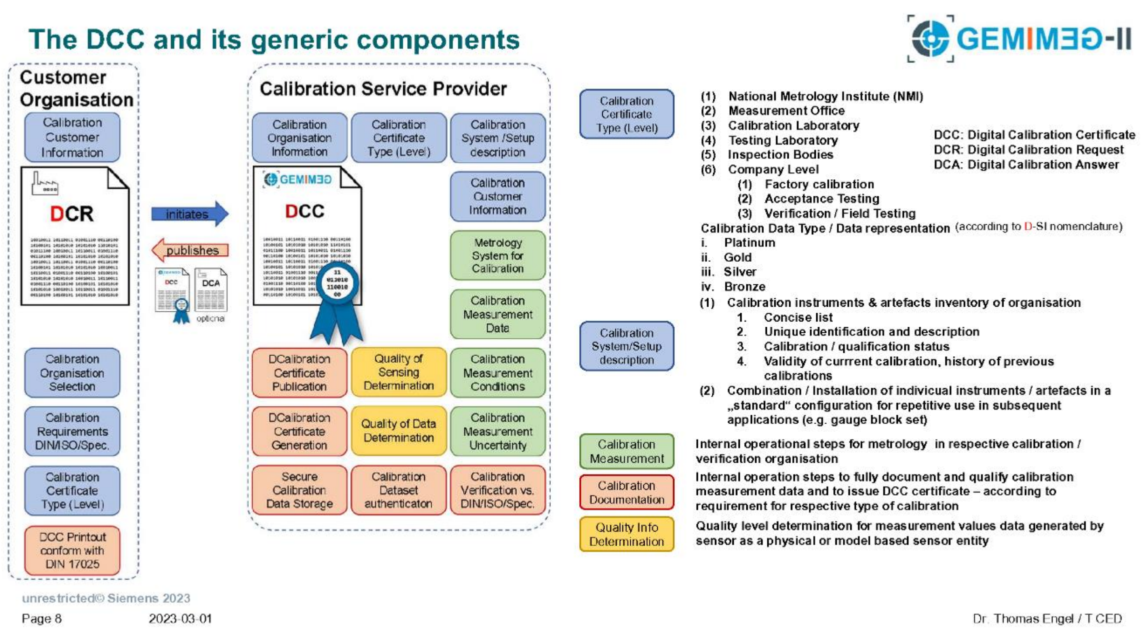
Dr. Thomas Engel / T CED


The DCC and its generic components
GEMIMEG-II
Customer Organisation
Calibration Customer Information
DCR
initiates
publishes
DCC
DCA
optional
Calibration Organisation Selection
Calibration Requirements DIN/ISO/Spec.
Calibration Certificate Type (Level)
DCC Printout conform with DIN 17025
Calibration Service Provider
Calibration Organisation Information
Calibration Certificate Type (Level)
Calibration System /Setup description
Calibration Customer Information
Metrology System for Calibration
Calibration Measurement Data
DCalibration Certificate Publication
Quality of Sensing Determination
Calibration Measurement Conditions
DCalibration Certificate Generation
Quality of Data Determination
Calibration Measurement Uncertainty
Secure Calibration Data Storage
Calibration Dataset authenticaton
Calibration Verification vs. DIN/ISO/Spec.
Calibration Certificate Type (Level)
(1) National Metrology Institute (NMI)
(2) Measurement Office
(3) Calibration Laboratory
(4) Testing Laboratory
(5) Inspection Bodies
(6) Company Level
(1) Factory calibration
(2) Acceptance Testing
(3) Verification / Field Testing
DCC: Digital Calibration Certificate
DCR: Digital Calibration Request
DCA: Digital Calibration Answer
Calibration Data Type / Data representation (according to D-SI nomenclature)
i. Platinum
ii. Gold
iii. Silver
iv. Bronze
Calibration System/Setup description
(1) Calibration instruments & artefacts inventory of organisation
1. Concise list
2. Unique identification and description
3. Calibration / qualification status
4. Validity of currrent calibration, history of previous calibrations
(2) Combination / Installation of indivicual instruments / artefacts in a „standard“ configuration for repetitive use in subsequent applications (e.g. gauge block set)
Calibration Measurement
Internal operational steps for metrology in respective calibration / verification organisation
Calibration Documentation
Internal operation steps to fully document and qualify calibration measurement data and to issue DCC certificate – according to requirement for respective type of calibration
Quality Info Determination
Quality level determination for measurement values data generated by sensor as a physical or model based sensor entity
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2023-03-01
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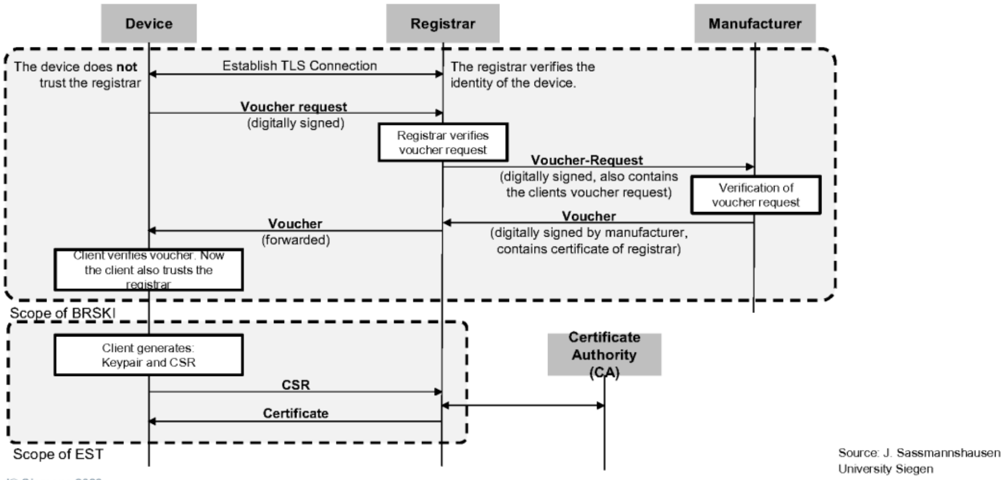
Secure enrollment of devices (EST & BRSKI)



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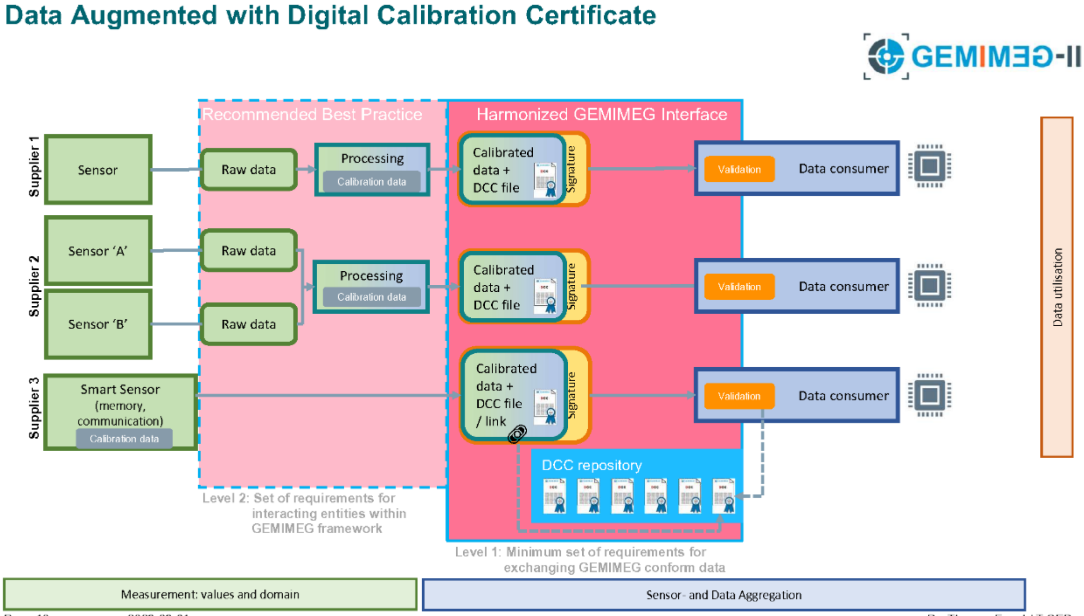
Data Augmented with Digital Calibration Certificate



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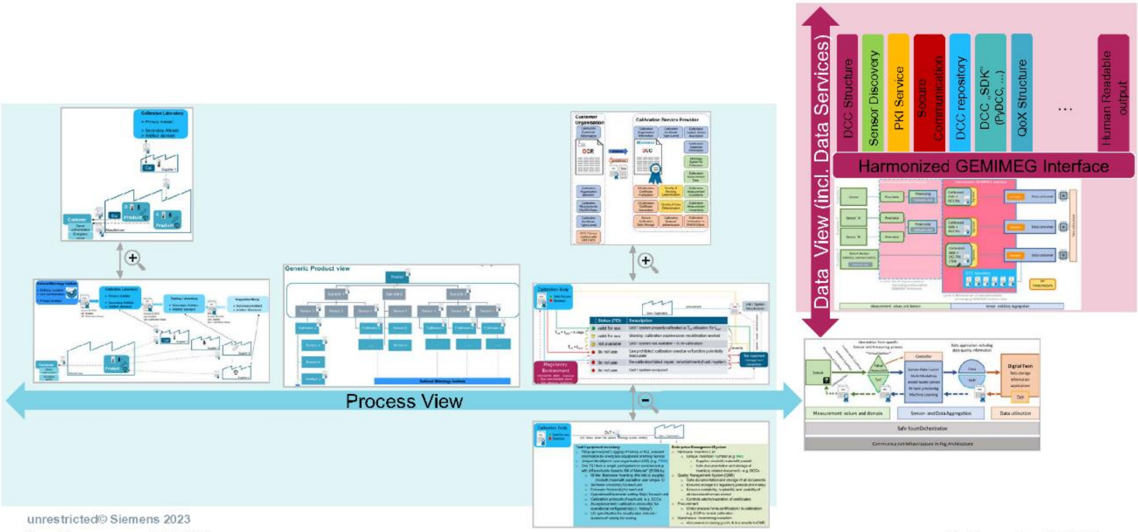
Process and Data Flow Overview



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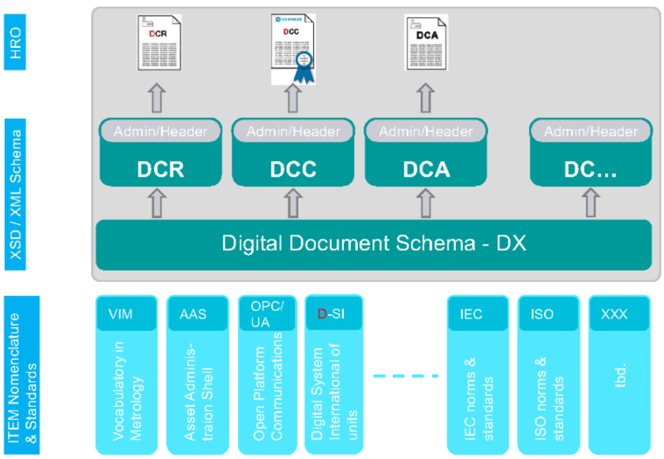
The Digital Calibration Document „Ecosystem"
A generic view…



Concept:
One common DX-Schema with Semantics
(as XSD / XML-Schema as parent schema)

Multiple different sub-schemata of DX as children / branches for
- DCR
- DCC → governed by ISO 17025 requirements
- DCA
- DC…

HRO: Multi-language available → automatic conversion / generation from (signed) DCx.XML file

Acronyms:
DCA: Digital Calibration Answer
DCC: Digital Calibration Certificate
DCR: Digital Calibration Request
HRO: Human Readable Output

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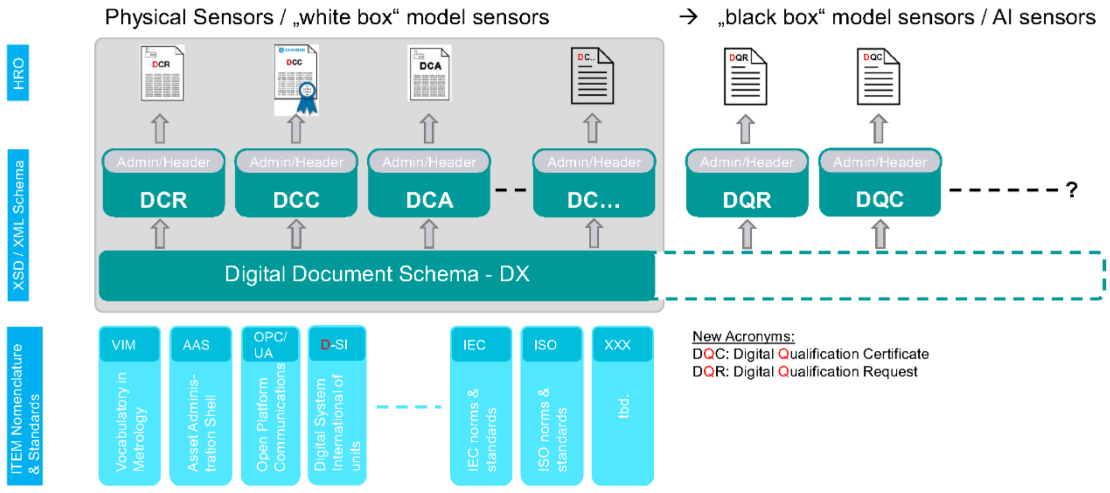
The Digital Calibration Document „Ecosystem“
A generic view…



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How to make the DX and the DCC sustainable for routine application worldwide

- The DX and DCC and further derived documents perspectively need to be hosted and maintained by a „neutral“ organisation with key interest for seamless international kooperation in the field of metrology
  - Potential „owner“: CIPM and ist operative unit BIPM as „neutral“ but internationally established organisation for metrology
  - Potential „Maintainer“: NMI or group of NMI with an official mandate by BIPM to do so
  - This is just a suggestion, to foster international acceptance and support as much as possible
- What needs to be maintained:
  - DX – the digital document schema – including version control
    - Structure
    - Semantics
    - Ontologies
  - DCC – as the international platform for DCC (with sole language in english) – including versions
    - Sensor and Calibration related submodells to the AAS
  - Vocabulary – complementing the VIM – vocabulary in metrology
    - Including language packs with translations for all vocabulary to all languages needed
      - Preferably, each language pack is maintained by group of native speakers
    - Vocabulary / Language packs preferably in conformance with VIM, AAS, OPC/UA …

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Quality of X
X: Sensing, Data, Information, …

A complete measurement result typically consists of:

(corrected) Measured Value + Measurement Unit + Measurement Uncertainty + Statistical Information

Example: Length measurement 8.412 µm (10^{-6} m) ± 10 µm (GUM) 3 σ

Additional quality related information for the measurement process of sensing (S) or data aggregation (D) and evaluation (D) or the information (I) gained from the data are possible:

Sensor System or Data Type	Type of physical sensor or software/model based sensor
Quality Indicator	Sensor System parameter to be characterized internal parameter: e.g. operational, functional external parameter: e.g. environmental
Indicator Description Definition	Detailed/explicit determination scheme, traceable, version controlled formula for calculation incl. input parameters allowed range of values, value type
Indicator Metric	Scale for Indicator (absolute + unit, relative, %, dB, …)
Indicator interpretation:	Status interpretation (good, acceptable, bad, info only – low trust level, …)
…	

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Contact

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Supported by:
Federal Ministry for Economic Affairs and Climate Action
on the basis of a decision by the German Bundestag

Grant: 01 MT20001A.

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Parallel Session 1: DCC-Tools

Presentations that would also fit into this session:

23 The GEMIMEG Tool – A Software for Creating Digital Calibration Certificates (DCCs)

Presenting author: Moritz Jordan, PTB, Germany

E-mail address: moritz.jordan@ptb.de

Additional authors: Muhammed-Ali Demir, Jan Loewe, Justin Jagieniak (all PTB)

Abstract

The GEMIMEG-Tool in its current state is a web application that offers a user-friendly way to create and edit DCCs without the need of XML skills. A rich graphical user interface guides the user through the process of filling in administrative and calibration data. The user can choose between multiple different Good-Practice examples as a template, create a new DCC from scratch, or edit any existing DCC that follows the Good-Practice guidelines.

A human-readable HTML as well as an XML preview of the DCC complement the feature set. Furthermore, the software automatically validates any DCC with the schema version 3 or later and updates the used schema to the latest version.

In this presentation, we give an overview of the most recent developments in the GEMIMEG-Tool:

- Improved interface for adding multiple languages to the DCC
- Optional HTML Human Readable attachment in document element
- Integrated references to DCC Wiki
- Viewer for files that are attached to the DCC
- Update on release of standalone desktop version

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Physikalisch-Technische Bundesanstalt
Nationales Metrologieinstitut

The GEMIMEG Tool

A Software for Creating Digital Calibration Certificates (DCCs)

Moritz Jordan, Muhammed-Ali Demir, Jan Loewe
Working Group 1.24

Scope

- Graphical user interface for creating and editing DCCs
- The following Good Practice Examples are built-in:
  - Temperature
  - Air Pressure
  - Humidity
- Support for localization

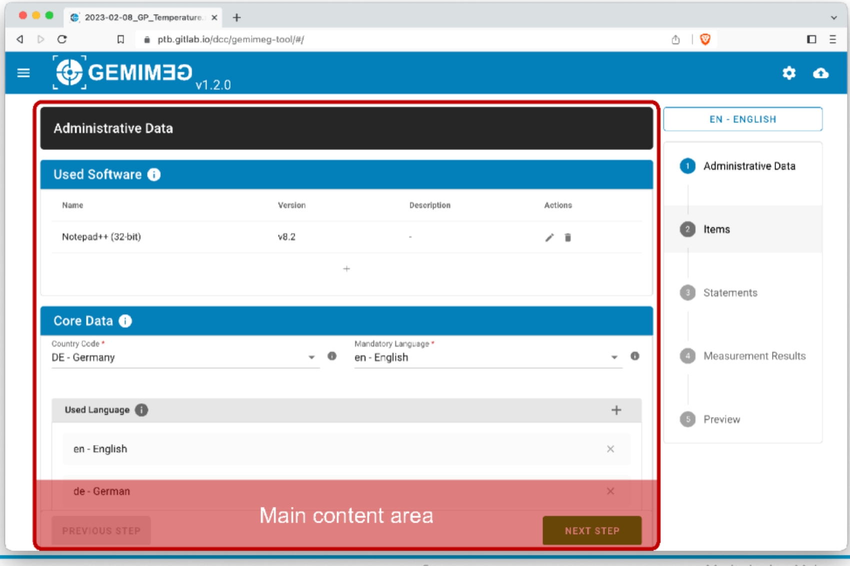
Architecture

- Web Application
  - Static HTML, no real backend needed
  - Everything is done on the client side using JavaScript/TypeScript
  - Vue.js is used as a framework
- Your DCCs are never sent to a Server
- Platform independent
- Desktop version using Electron

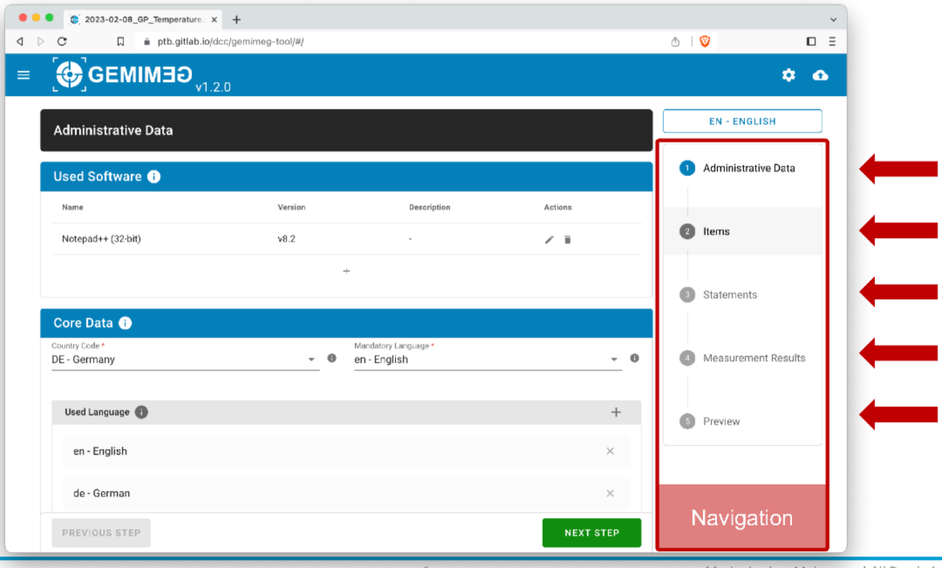
Features

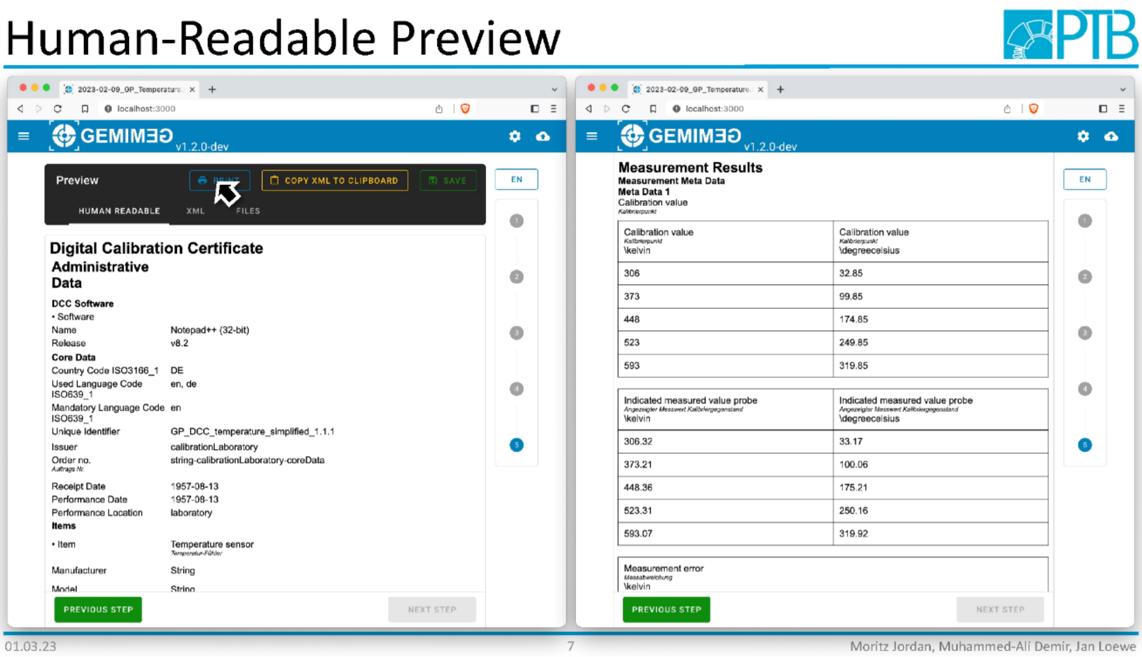
- Automatic schema validation (v3.x.x)
- File attachment
- LaTeX formulas
- Human readable generation using XSLT
- DCC file viewer
- Built-in wiki links

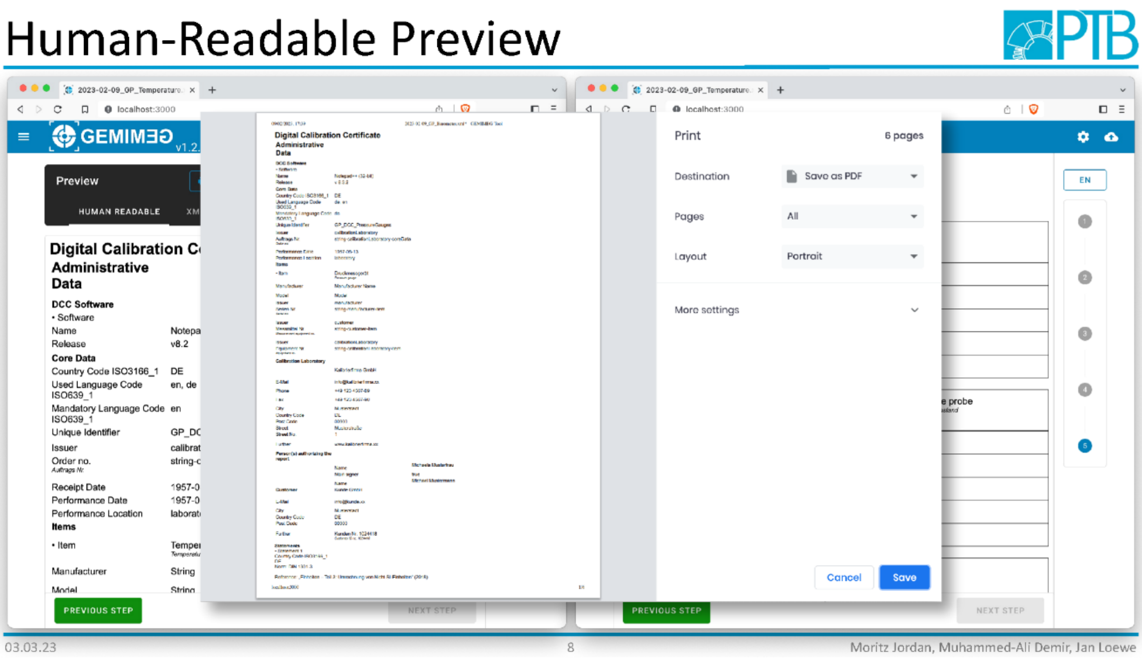
Layout of the GEMIMEG Tool



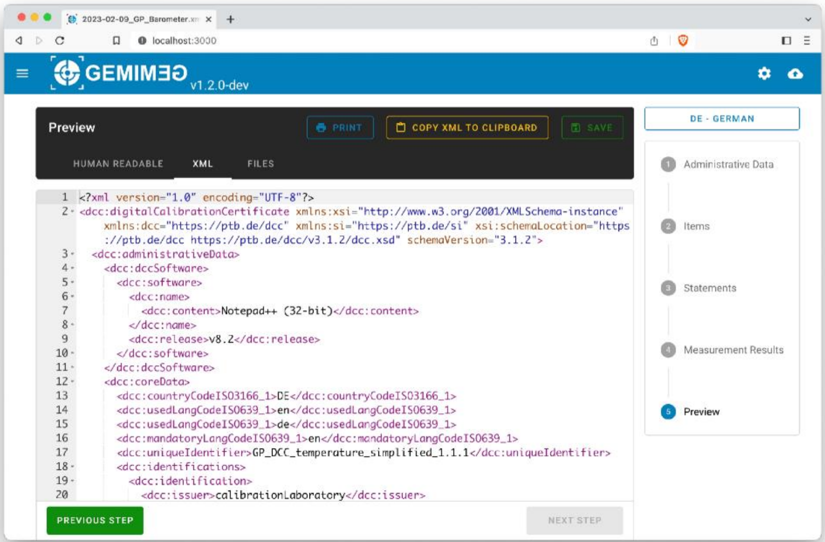
Layout of the GEMIMEG Tool



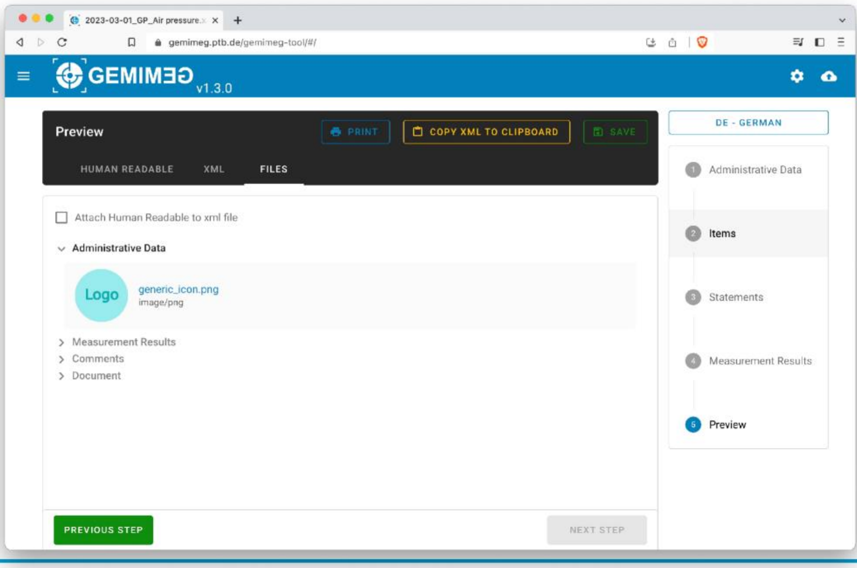

Human-Readable Preview
GEMIMEG v1.2.0-dev
Preview
COPY XML TO CLIPBOARD
SAVE
HUMAN READABLE
XML
FILES
Digital Calibration Certificate
Administrative
Data
DCC Software
Name
Notepad++ (32-bit)
Release
v8.2
Core Data
Country Code ISO3166_1
DE
Used Language Code ISO639_1
en, de
Mandatory Language Code ISO639_1
en
Unique Identifier
GP_DCC_temperature_simplified_1.1.1
Issuer
calibrationLaboratory
Order no.
string-calibrationLaboratory-coreData
Receipt Date
1957-08-13
Performance Date
1957-08-13
Performance Location
laboratory
Items
Temperature sensor
Manufacturer
String
PREVIOUS STEP
NEXT STEP
Measurement Results
Measurement Meta Data
Meta Data 1
Calibration value
\kelvin
\degreecelsius
306
32.85
373
99.85
448
174.85
523
249.85
593
319.85
Indicated measured value probe
306.32
33.17
373.21
100.06
448.36
175.21
523.31
250.16
593.07
319.92
Measurement error
EN
01.03.23
7
Moritz Jordan, Muhammed-Ali Demir, Jan Loewe


Human-Readable Preview
Print
6 pages
Destination
Save as PDF
Pages
All
Layout
Portrait
More settings
Cancel
Save
Digital Calibration Certificate
PREVIOUS STEP
NEXT STEP
03.03.23
8
Moritz Jordan, Muhammed-Ali Demir, Jan Loewe

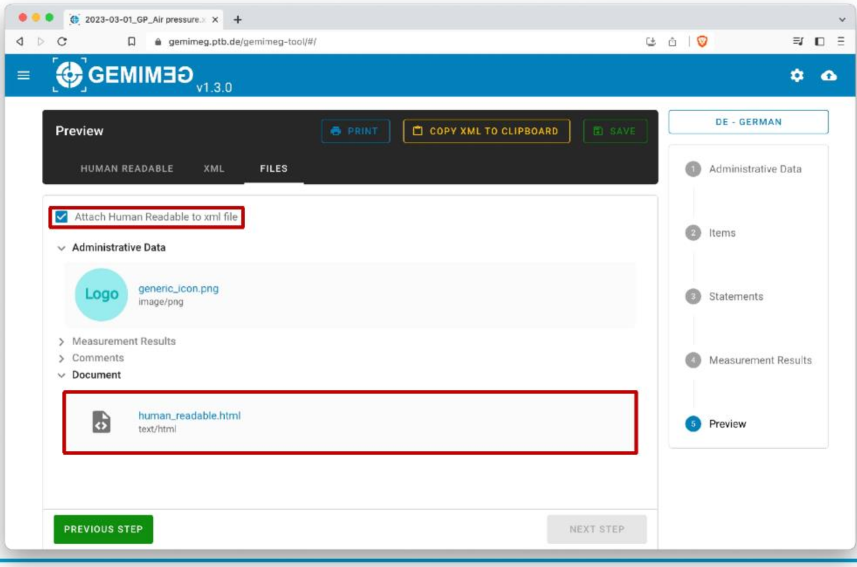
XML Preview



File Viewer



Attach b64-encoded Human Readable



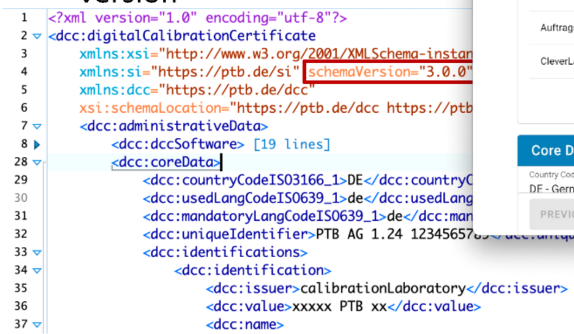
Handling Old Schema Versions

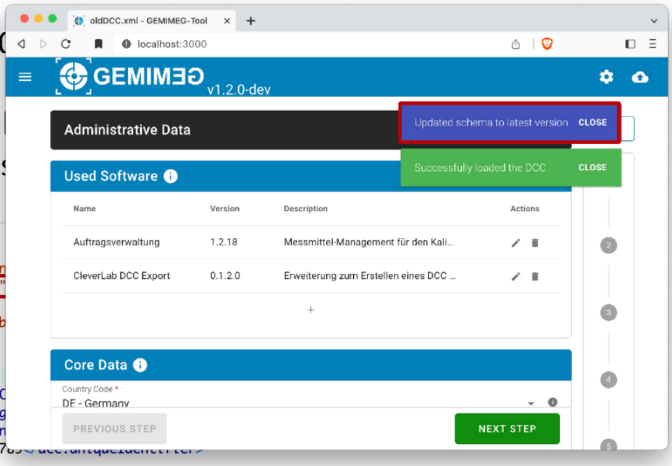
- DCCs of schema version 3.0.0 or later are supported
- GEMIMEG Tool will update all DCCs of version 3.x.x to the latest schema version

```
<?xml version="1.0" encoding="utf-8"?>
<dcc:digitalCalibrationCertificate
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xmlns:si="https://ptb.de/si" schemaVersion="3.0.0"
    xmlns:dcc="https://ptb.de/dcc"
    xsi:schemaLocation="https://ptb.de/dcc https://ptb.de/dcc/v3.0.0/dcc.xsd">
    <dcc:administrativeData>
        <dcc:dccSoftware> [19 lines]
        <dcc:coreData>
            <dcc:countryCodeISO3166_1>DE</dcc:countryCodeISO3166_1>
            <dcc:usedLangCodeISO639_1>de</dcc:usedLangCodeISO639_1>
            <dcc:mandatoryLangCodeISO639_1>de</dcc:mandatoryLangCodeISO639_1>
            <dcc:uniqueIdentifier>PTB AG 1.24 1234565789</dcc:uniqueIdentifier>
            <dcc:identifications>
                <dcc:identification>
                    <dcc:issuer>calibrationLaboratory</dcc:issuer>
                    <dcc:value>xxxxx PTB xx</dcc:value>
                    <dcc:name>
```

Handling Old Schema Versions

- DCCs of schema version 3.0.(
  later are supported
- GEMIMEG Tool will update a
  of version 3.x.x to the latest s
  version





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Handling Old Schema Versions

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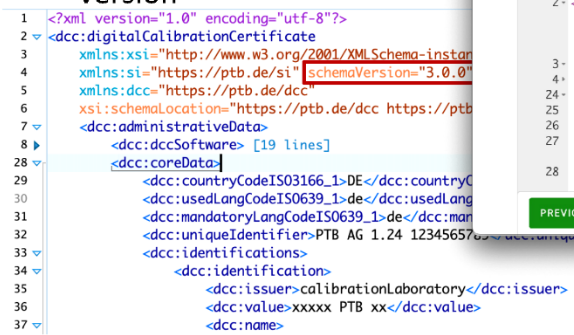
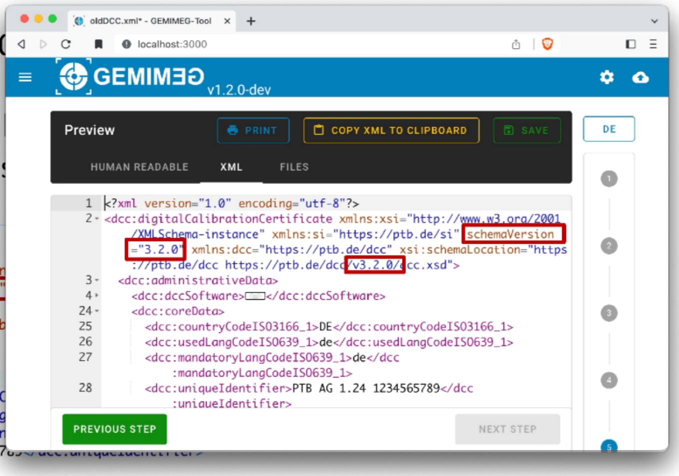
  version





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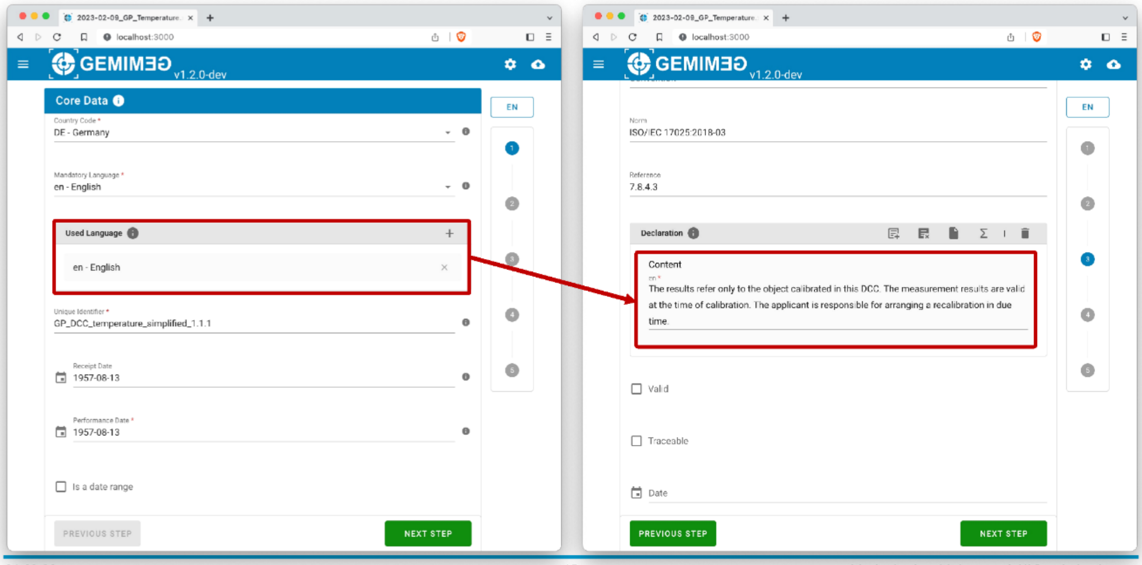
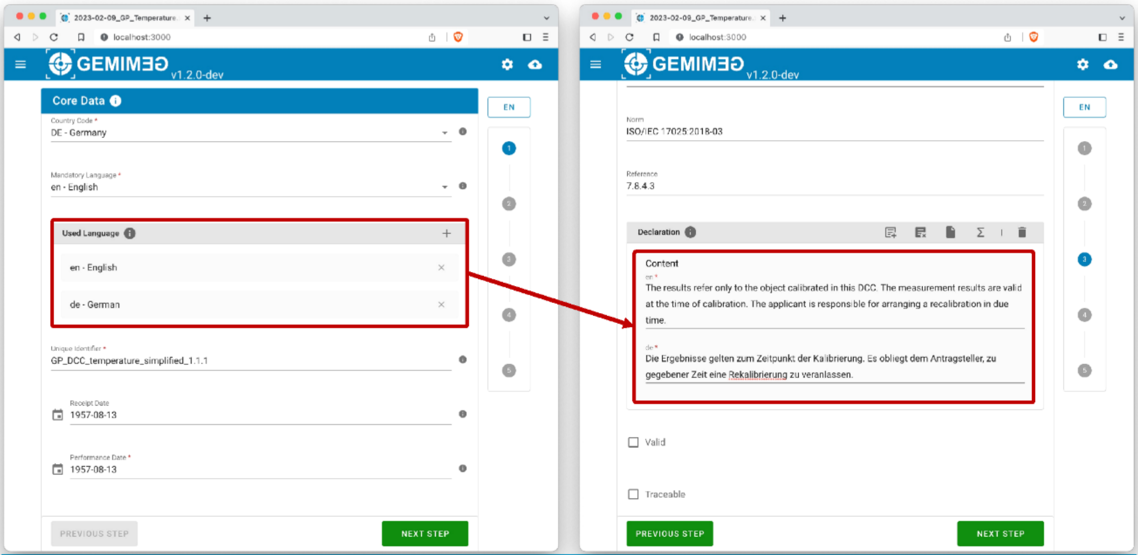
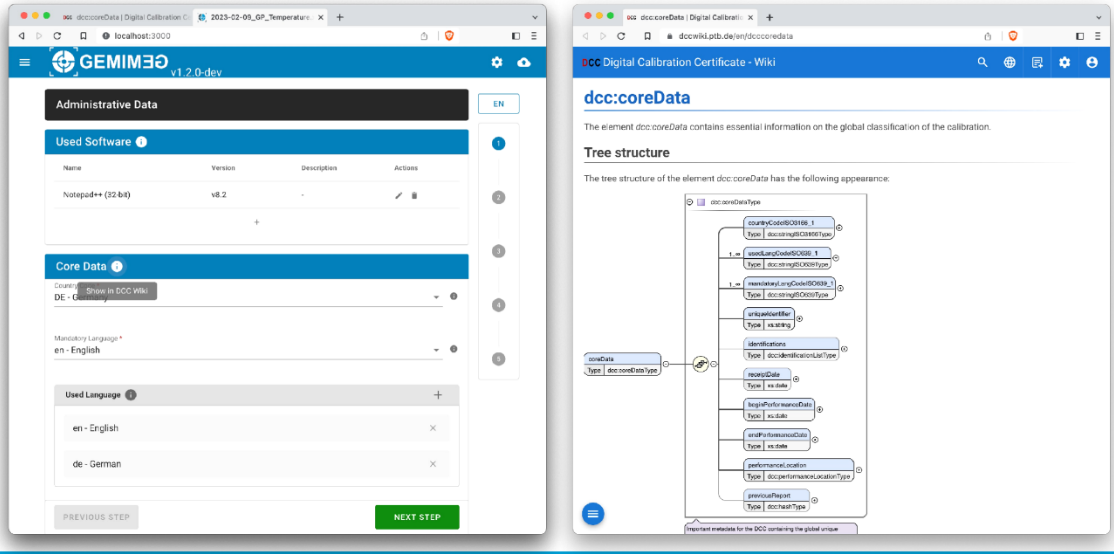
DCCs with Multiple Languages



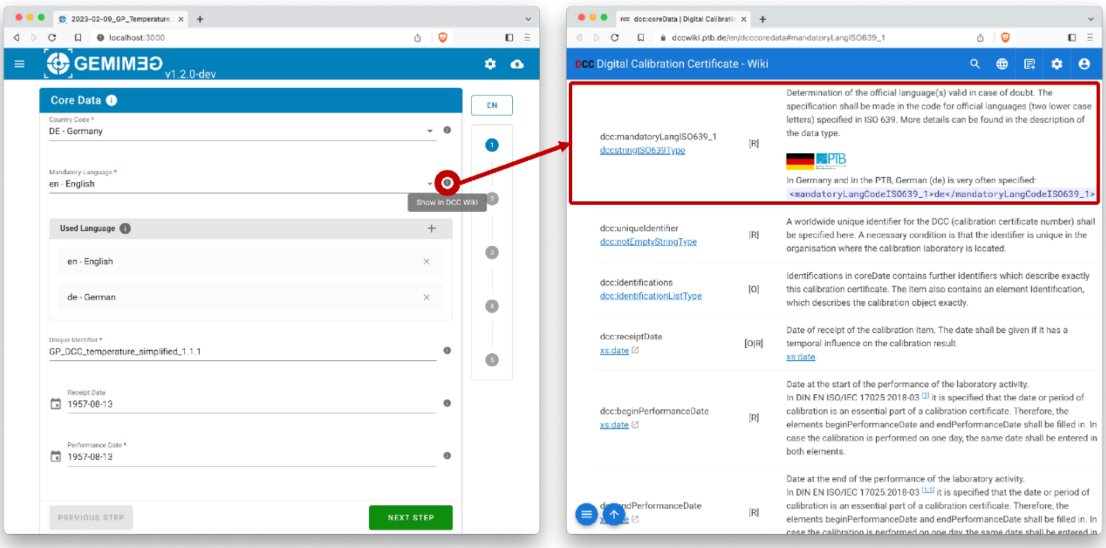
DCCs with Multiple Languages



Direct Links to DCC Wiki



Direct Links to DCC Wiki



Try it Yourself!

Stable version:
https://www.gemimeg.ptb.de/gemimeg-tool

Desktop version:
https://gitlab.com/ptb/dcc/gemimeg-tool-desktop/-/releases

Latest features:
https://ptb.gitlab.io/dcc/gemimeg-tool

Future of the GEMIMEG-Tool

- Desktop version for MacOS
- Adding WYSIWYG formula editor / MathML support
- XSLT template system
- Extension API

Please contribute to the project by creating an issue on
https://gitlab.com/ptb/dcc/gemimeg-tool

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GEMIMEG

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GEMIMEG

Thank you for your attention!

Do you have any questions or comments?

Moritz Jordan, Muhammed-Ali Demir, Jan Loewe
Working Group 1.24

24 Python Tools Examples for the Transition to DCC

Presenting author: Francese, Claudio - INRIM - Italy

E-mail address: c.francese@inrim.it

Additional authors: Facello Alessio - INRIM - Italy, Germito Gabriele - INRIM - Italy

Abstract
Digital Calibration Certificates (DCC) offer well known advantages over the traditional paper or pdf based ones and impact only the final phase of the calibration process. Nevertheless during the transition period to DCC, both certificate models could coexist and some efforts should be made in order to keep consistency of data and ease integration of the DCC software with the existing software setups of the laboratory.

This work describes a modular software divided into three steps for the certification phase of the calibration process. Every step is further divided into specialized submodules. The interchange of data is performed using a human readable textual format. The first step collects the calibration data. Data series from old certificates can be imported automatically or manually input by means of separated specialized submodules. New incoming calibration data can also be read in this step by means of another dedicated submodule. The second step processes the data e.g. adding mandatory fields required by DCC standard which were not present in the historical data. The third step generates the certificate in DCC and legacy formats. Keeping the steps separated and splitting the tasks into submodules eases debugging, developing efficiency and data consistency verification. Another advantage of software modularization is the possibility to centralize steps 2 and 3 into a dedicated server, yet allowing the laboratories to send their calibration data to the server by means of a specialized submodule of step 1. This reduces the distribution of unnecessary submodules to each laboratory and eases the overall software maintenance and version tracking.

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DI RICERCA METROLOGICA
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Python Tools Examples for the Transition to DCC

Claudio Francese
Alessio Facello
Gabriele Germito

DCC 3rd International Digital Calibration Certificate (DCC) Conference - Tuesday, 28 February 2023 to Thursday, 2. March 2023 - Virtual Conference

About DCC and INRiM

IMGC – Gustavo Colonnetti (CNR)

IEN – Galileo Ferraris

2006

More information on *https://www.inrim.it/en*

INRiM Mission

- NMI for Italy (excluding ionizing radiations)
- Scientific & Technological **Research**
- **Knowledge Transfer**

Transition to «Digital»

- DCC
- RDM
- D-SI
- ...

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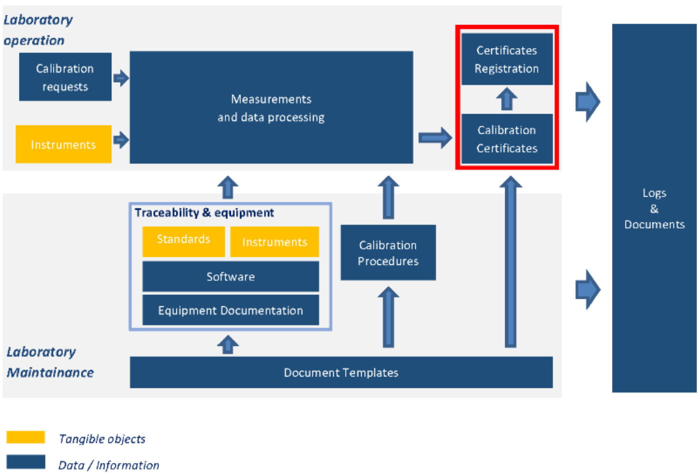
Simplified workflow of a Calibration

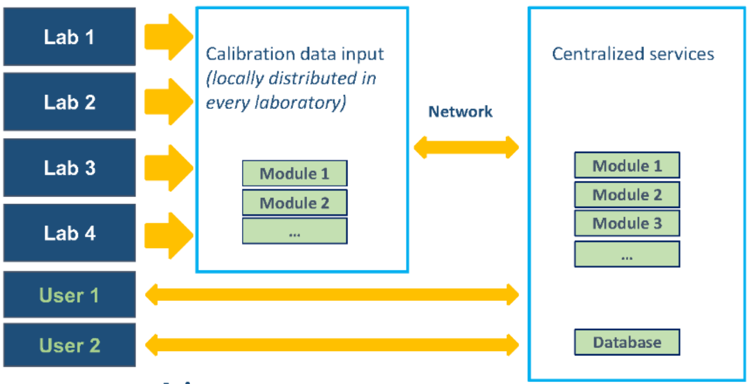


Different perspectives

- Quality System Manager
- Calibration Laboratory Responsible
- Operator
- Customers
- Administration
- …

Same data !

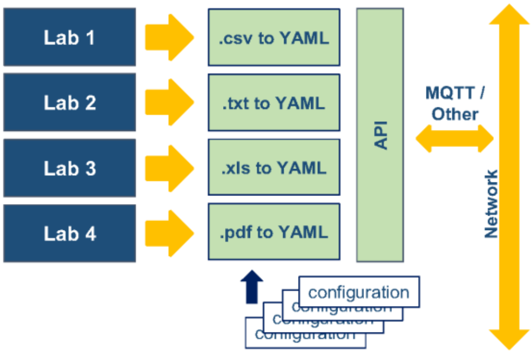
Modular software architecture



Advantages

- Easier coding, deployment, debugging and maintenance
- Distributed access
- Centralized management of data, data protection

Modular approach to data collection



Description

Each laboratory is given their own set of scripts, which work on the specific data format they use.

→ No extra work for the labs

The scripts are currently in Python, migration to other languages is not an issue

YAML is lightweight and human readable

MQTT is a lightweight and IoT oriented protocol

The architecture allows

- Simple usage for the labs
- Tailoring on user needs (through local yaml configuration files)
- Scalability to many labs
- Gradual roll-out

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Traditional Calibration Certificate

Certificate management

- Stored locally in pdf
- **Printed**, signed and sent to customer

Certificate elements

Validity

- **Template compliance**
- **Registry code** and **embossed stamp** of INRIM in the first page

Approval and authorizations

- Release authorization by signature on every page

Common mandatory fields

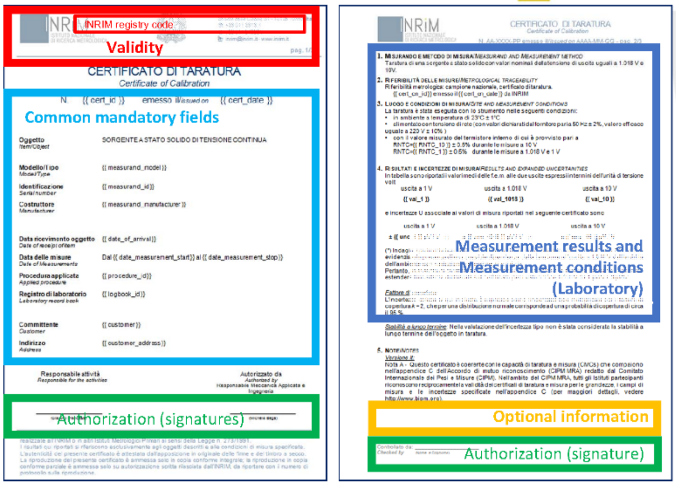
- ID, date of the Certificate
- Customer and Measurand information in the first page

Lab-specific results

- Starting from the 2nd page

Optional information and notes

- At the end of the certificate



Certificate template

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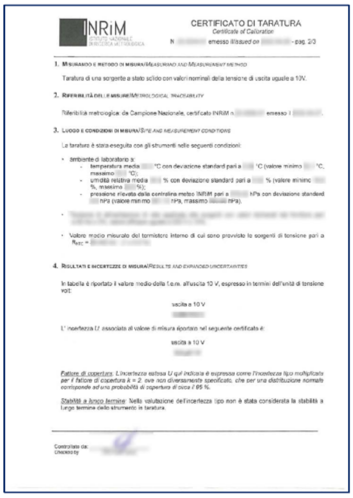
Example of DC Voltage Calibration Certificate



Simple case

- Zener based Voltage Standard (Fluke 732 B)
- Scalar real value
- Certified measurement result at the 10 V output

Templating

Python package **docxtpl**

Cover page — **Calibration results**

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Example of DC Voltage Calibration Certificate

Output YAML file


```yaml
---
# UNSIGNED DIGITAL CERTIFICATE
# BASE DATA FROM /cp004/LegacySoftware/Tools/Base.yaml

# CERTIFICATE DATA
traceability:
  - condition: 10
    certificate:
      id: 22-xxxx-xx
      date: '2022-xx-xx'

customer:
  name: I.N.Ri.M.
  address: "Strada delle Cacce, 91\n10135 \u2014 Torino\n"

measurand:
  measurand_id: xxxxxx
  measurand_manufacturer: J. Fluke
  measurand_model: 732 B
  date_of_arrival: 2023-01-03
```


Traceability data

Customer info

Measurand info

continues ...

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Example of DC Voltage Calibration Certificate


```yaml
calibration:
  calibration_id: 23-01-demo
  operator: Claudio Francese
  date_measurement_start: 2023-01-10
  date_measurement_stop: 2023-02-06
  logbook_id: CP0-VVR-01
  procedure_id: XXX.YY
  laboratory_id: cp004

environment:
  temperature:
    value: 22.3
    max: 23.2
    min: 22.1
    stddev: 0.1
    unit: "\xB0C"

  humidity:
    value: 25.1
    max: 33.1
    min: 14.0
    stddev: 3.8
    unit: "%"
```


Lab info

Measurement conditions

continues ...


```yaml
requirements:
- '10'

rntc:
  - condition: 10
    value: "38465"
    unit: "\u03A9"
    uncertainty:
      relative: 1e-3

results:
  - condition: 10
    value: 9.999913
    unit: V
    uncertainty:
      absolute: 5
      unit: "\xB5V"
```


Calibration request

Auxiliary data

Calibration results

End of file

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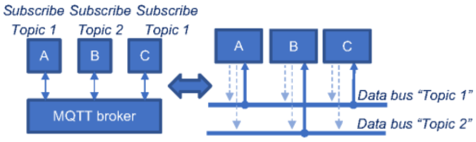
MQTT communication protocol

Analogy to data busses



Publish data on "Topic1"

```python
import paho.mqtt.client as mqtt
client = mqtt.Client()

client.tls_set(ca_certs=r'ca.crt', tls_version=2)
client.username_pw_set('xxxx', 'xxxx')
client.connect("x.y.z", 123, 60)

client.publish('topic1', 'message')
```

Subscribe to topic

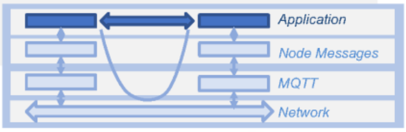
```python
import paho.mqtt.client as mqtt
import time

# connect to the MQTT Broker
client.tls_set(ca_certs=r'ca.crt', tls_version=2)
client.username_pw_set('xxxx', 'xxxx')
client.connect("x.y.z", 123, 60)

def on_connect(client, userdata, flags, rc): # upon new connections
    client.subscribe("#") # subscribe to all topics
client.on_connect = on_connect

def on_message(client, userdata, msg): #  callback for new data
    print( '(' + msg.topic + '): ' + str(msg.payload)) # handle data
client.on_message = on_message

client.loop_start() # Wait for incoming data
while True:
    time.sleep(0.1)
client.loop_stop()
```



Python objects are YAML encoded and encapsulated in the MQTT payload ➡ **Applications can exchange structured data**

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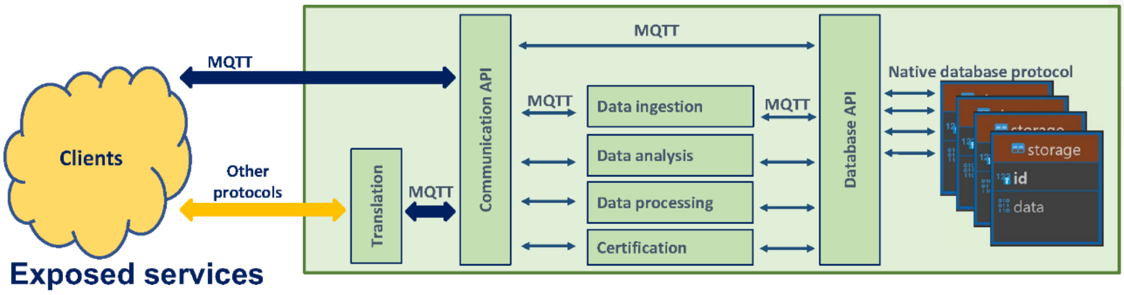
Centralized services

Communication protocols

- MQTT among Python scripts
- MQTT and other protocols for users, e.g. web access



Exposed services

- Data storage and processing
- Certification
- Reporting, Business intelligence
- Other

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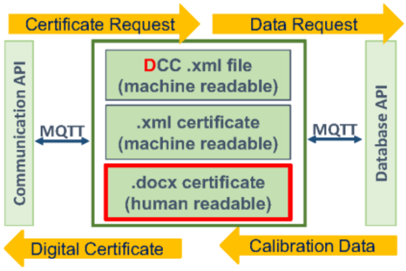
Centralized services – Certificates generation

Data flow



Many format converters can be implemented, depending on the end user requirements

XML is suitable both for DCC standards or other machine readable formats.

.docx certificate generation example

initialization

```
from docxtpl import DocxTemplate, yaml

# (. . . omitted code . . )
# - digitalCertificate, templateName are read from MQTT payload
# - pcktIdentifier is set to match request and reply

tpldata = open(templateName,"rb").read() # template for .docx certificate

with io.BytesIO(tpldata) as inMemoryFileIn: # store .docx template in memory
    doc = DocxTemplate(inMemoryFileIn)
    doc.render(digitalCertificate)

    with io.BytesIO() as inMemoryFileOut: # store .docx certificate in memory
        doc.save(inMemoryFileOut)
        inMemoryFileOut.flush()
        inMemoryFileOut.seek(0,0)

        mqttClient.publish("replyTopic", { # send back the .docx object
            "pcktIdentifier" : pcktIdentifier,
            "data" : yaml.dump(inMemoryFileOut.read())
        })
```

fill in with calibration data

reply

At the moment human readable .docx files are still **necessary** for our needs.
A QR code can be added to check the information against the central database.

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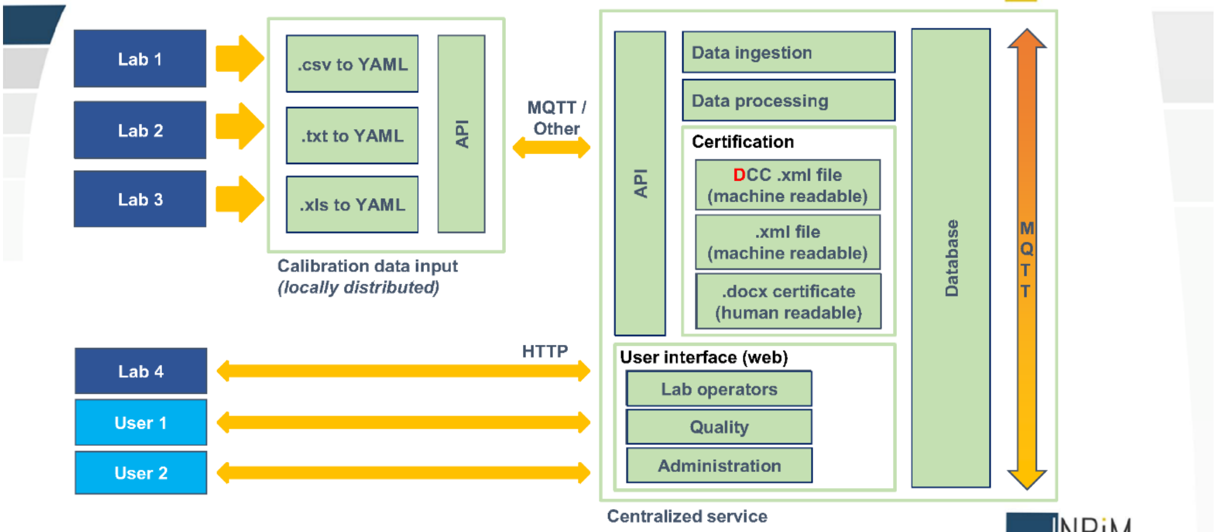
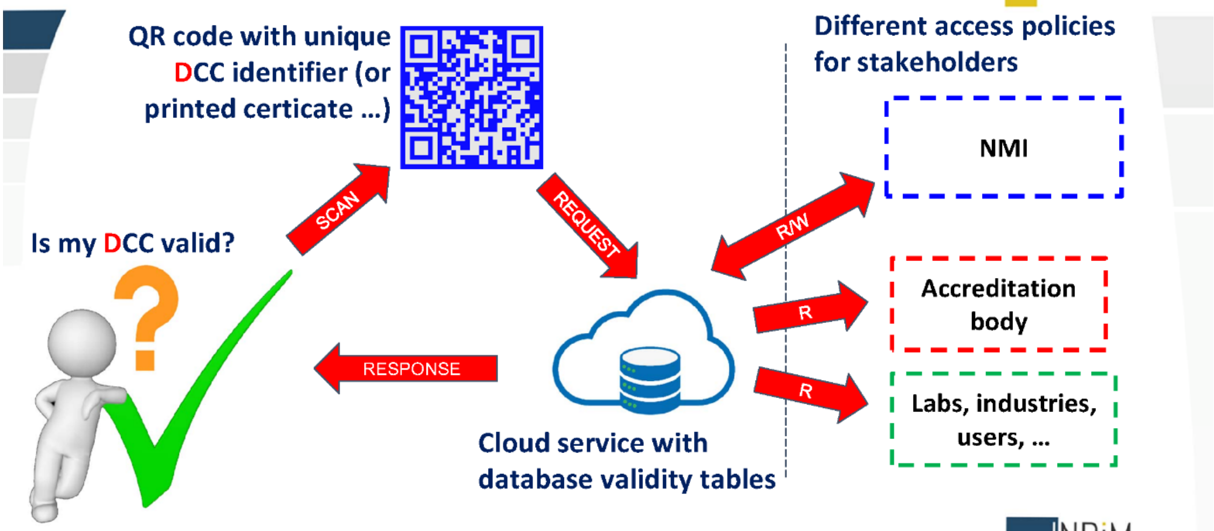
Overall software architecture



DCC Validity check and Withdrawal



Conclusions

Python is <u>one</u> of many good languages, other choices are available if needed

MQTT libraries for other languages

- **LVMQTT - MQTT Library for LabVIEW**
  https://github.com/DAQIO/LVMQTT
- **VSMQTT - Vsmqtt is a simple MQTT client integrated in vscode.**
  https://marketplace.visualstudio.com/items?itemName=rpdswtk.vsmqtt
- …

YAML is good for our development but JSON, XML and other formats exist

General considerations

- Modularity advantages
- Services centralization
- Flexibility and scalability
- Integration into existing systems and legacy applications
- Version tracking
- **Accessibility**
- …

↔ **Flexibility and opportunities of Digital Calibration Certificates**

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Thank you for your attention

For further details, please contact us

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Alessio **Facello** - a.facello@inrim.it
Gabriele **Germito** - g.germito@inrim.it

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25 Generation of Digital Calibration Certificates for Temperature Sensor Calibrations using Python and Excel

Presenting author: Ian Smith, National Physical Laboratory, UK

E-mail address: ian.smith@npl.co.uk

Abstract

At the second International DCC (Digital Calibration Certificate) Conference in 2022, I presented initial thoughts from the UK's National Physical Laboratory (NPL) on the use of the Python programming language to generate DCCs using information stored in Microsoft Excel workbooks [1]. A significant proportion of calibration services at NPL involves the capture of measurement data using Excel and it seemed reasonable to consider how DCC generation might be integrated into those services. Python is widely used nowadays and there are numerous packages available to implement different tasks, hence the decision to employ it.

While the primary focus of the 2022 presentation was the concept of developing an “Excel to DCC” pathway, this presentation describes initial efforts in the implementation of such a pathway. NPL and the National Composites Centre (NCC) [2] have conducted a case study involving the calibration of temperature sensors. NPL considered the storage of administrative data and measurement results in Excel workbooks, and subsequently developed Python software to extract that information and generate (and validate) DCCs. A small number of DCCs has been generated and provided to NCC, allowing them to gain experience of working with DCCs, better understand how their internal infrastructure and processes may need to be updated to work with DCCs, and provide feedback as a user of DCCs. A summary of the case study will be written and made openly available.

The presentation will centre on the aspects of information storage and DCC generation. Points discussed in the 2022 presentation will be revisited to review if the initial implementation of the “Excel to DCC” pathway has altered thoughts presented a year ago.

References

[1] Proceedings of 2nd International DCC Conference, pages 138–147, https://oar.ptb.de/resources/show/10.7795/820.20220411

[2] National Composites Centre, https://www.nccuk.com/

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NPL National Physical Laboratory

Generation of digital calibration certificates for temperature sensor calibrations using Python and Excel

Ian Smith, Data Science department, NPL

3rd International DCC Conference
28 February-2 March 2023

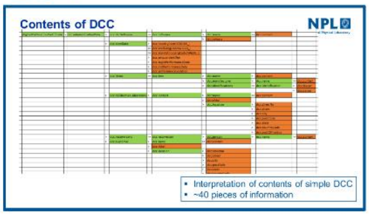
Outline

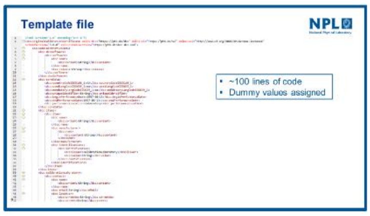
- Main points of 2022 presentation
- Case study with National Composites Centre (NCC)
  - Motivation and overview
  - Information (administrative data and measurement results) organisation
  - Software development
- Lessons learnt and revisiting last year's thoughts

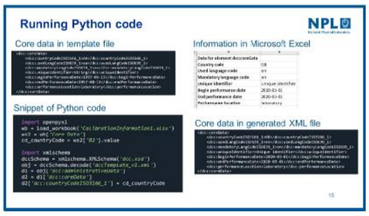
Main points of 2022 presentation

- Focused on first steps in generating DCCs at NPL
  - Many calibration services at NPL use Microsoft Excel workbooks to store measurement results
  - Python programming language in common use nowadays
  - Started to combine these two aspects to begin to develop an “Excel to DCC” pathway

2022







Case study with NCC
Motivation and overview

- Case study has two main aims
  1. NPL: Gain experience of DCC generation focusing on data stored in Excel workbooks and development of Python software
  2. NCC: Gain experience of working with DCCs and understanding how they can be integrated into existing workflows
- Focus only on provision of information
  - No consideration of aspects such as digital signature, security
- Selected calibration of temperature sensors
  - Measurement results “manageable” in terms of size
  - Availability of good practice material

Case study with NCC
Motivation and overview

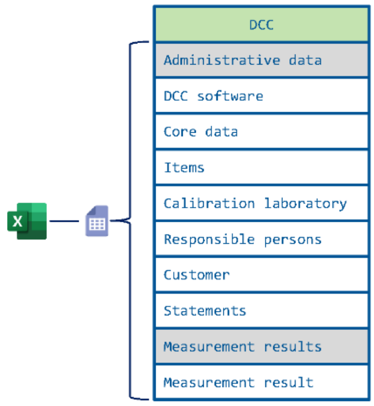
- This presentation concentrates on the first (NPL) aim
- Main aspects treated
  - Information organisation in Excel
  - Software development
- Keep things relatively simple but recognise that they can easily be more complicated

Case study with NCC
Information organisation – options

DCC
Administrative data
DCC software
Core data
Items
Calibration laboratory
Responsible persons
Customer
Statements
Measurement results
Measurement result

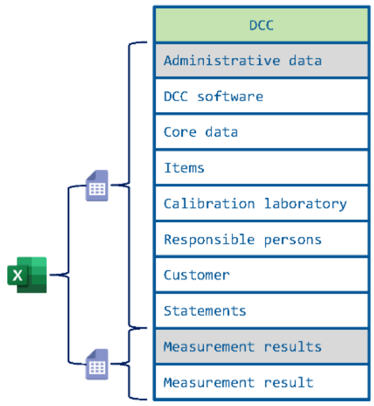
Case study with NCC
Information organisation – options

- **One workbook, one worksheet**



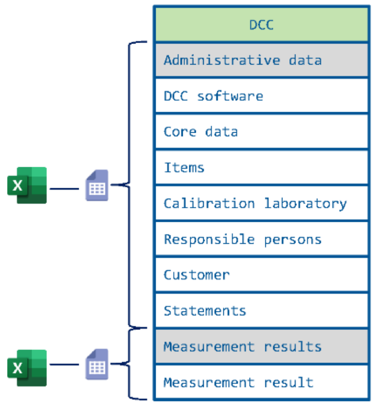
Case study with NCC
Information organisation – options

- One workbook, one worksheet
- **One workbook, two worksheets**



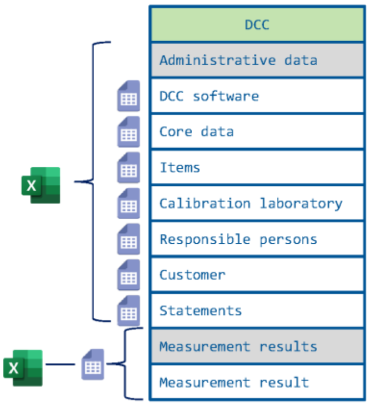
Case study with NCC
Information organisation – options

- One workbook, one worksheet
- One workbook, two worksheets
- **Two workbooks, one worksheet per workbook**



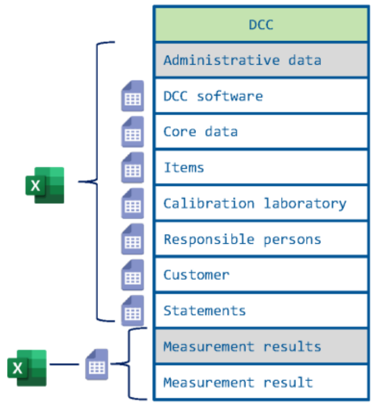
Case study with NCC
Information organisation – options

- One workbook, one worksheet
- One workbook, two worksheets
- Two workbooks, one worksheet per workbook
- **Two workbooks, one worksheet for each subcomponent of administrative data, one worksheet for measurement results**



Case study with NCC
Information organisation – options

- One workbook, one worksheet ✖
- One workbook, two worksheets ✖
- Two workbooks, one worksheet per workbook ✖
- **Two workbooks, one worksheet for each subcomponent of administrative data, one worksheet for measurement results** ✓
- Individual worksheets reusable, e.g.,
  - Calibration laboratory
  - Items
  - Customer



Case study with NCC
Software development – approach

- Decode template DCC to Python dictionary
  - Minimal, dummy information, valid
- For each worksheet
  - Read information
  - Generate dictionary value
  - Update component of template DCC dictionary
- Save DCC
- Validate DCC against D-SI and DCC schemas

Case study with NCC
Software development - overview

- **Main aim is to develop Python software that works**
- Not aiming for “perfect” software
  - Modular approach
  - Document assumptions about how information is presented in Excel worksheets
- Use Python libraries `openpyxl` and `xmlschema`
- Press a button to run

Case study with NCC
Software development – XML & dictionaries

```
<name>
  string
</name>
```
➡ `{'name': 'string'}`

```
<name>
  string1
</name>
<name>
  string2
</name>
```
➡ `{'name': ['string1', 'string2']}`

```
<name1>
  <name2>
    string
  </name2>
</name1>
```
➡ `{'name1': {'name2': 'string'}}`

Case study with NCC
Software development

- DCC components – structure, Excel, Python code, dictionary, XML
  - Core data
  - DCC software
  - Statements
  - Measurement result

DCC
Administrative data
DCC software
Core data
Items
Calibration laboratory
Responsible persons
Customer
Statements
Measurement results
Measurement result

Case study with NCC
Software development – core data

- Assumptions
  - Optional subcomponents not used
  - One instance only of used language code and mandatory language code
  - Seven pieces of information (in specified cells) in Excel worksheet

Country code	GB
Language code	en
Mandatory language code	en
Unique identifier	2022070197/1
Calibration start date	2022-07-19
Calibration end data	2022-07-19
Performance location	laboratory

CORE DATA
Country code
Used language code
Mandatory language code
Unique identifier
Identifications
Receipt date
Calibration start date
Calibration end date
Performance location
Previous report

Case study with NCC
Software development – core data

NPL National Physical Laboratory

Python code (with comments removed)

```
def generateCoreDataDictionaryValue(workbook, worksheetName):
ws = workbook[worksheetName]
  nCD = 7
  coreDataList = ['a'] * nCD
  for iCD in range(0, nCD):
    coreDataList[iCD] = ws.cell(iCD+2, 3).value
  coreDataDictValue = {'dcc:countryCodeISO3166_1':      [coreDataList[0]], \
                       'dcc:usedLangCodeISO639_1':      [coreDataList[1]], \
                       'dcc:mandatoryLangCodeISO639_1': [coreDataList[2]], \
                       'dcc:uniqueIdentifier':          [coreDataList[3]], \
                       'dcc:beginPerformanceDate':      [coreDataList[4]], \
                       'dcc:endPerformanceDate':        [coreDataList[5]], \
                       'dcc:performanceLocation':       [coreDataList[6]]}
  return coreDataDictValue
```

- Relatively simple Python function

Case study with NCC
Software development – core data

NPL National Physical Laboratory

Dictionary value

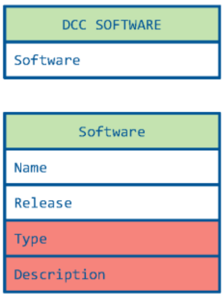
```
{'dcc:countryCodeISO3166_1': ['GB'],
 'dcc:usedLangCodeISO639_1': ['en'],
 'dcc:mandatoryLangCodeISO639_1': ['en'],
 'dcc:uniqueIdentifier': ['2022070197/1'],
 'dcc:beginPerformanceDate': ['2022-07-19'],
 'dcc:endPerformanceDate': ['2022-07-19'],
 'dcc:performanceLocation': ['laboratory']}
```

XML

```
<dcc:coreData>
  <dcc:countryCodeISO3166_1>GB</dcc:countryCodeISO3166_1>
  <dcc:usedLangCodeISO639_1>en</dcc:usedLangCodeISO639_1>
  <dcc:mandatoryLangCodeISO639_1>en</dcc:mandatoryLangCodeISO639_1>
  <dcc:uniqueIdentifier>2022070197/1</dcc:uniqueIdentifier>
  <dcc:beginPerformanceDate>2022-07-19</dcc:beginPerformanceDate>
  <dcc:endPerformanceDate>2022-07-19</dcc:endPerformanceDate>
  <dcc:performanceLocation>laboratory</dcc:performanceLocation>
</dcc:coreData>
```

Case study with NCC
Software development – DCC software

- Assumptions
  - Allow for any number of software instances
  - Optional type element not used
  - Optional description element used
  - Three pieces of information for each piece of software in Excel worksheet



Number of dcc:software instances	4
Software number	1
Name	DCV_NCC_GenerateDCC_EBRO.py
Release	v3.0
Description	Python software to generate DCC
Software number	2
Name	EBRO_administrativeInformation.xlsx
Release	v3.0
Description	Microsoft Excel workbook containing administrative information
Software number	3
Name	EBRO_measurementData.xlsx
Release	v2.0

Case study with NCC
Software development – DCC software

Python code (with comments removed)

```
def generateDccSoftwareDictionaryValue(workbook, worksheetName):
  ws = workbook[worksheetName]
  nS = ws['C2'].value # number of instances of dcc:software
  softwareList = [[['a'], 'b', ['c']]] * nS
  for iS in range(0, nS):
    softwareList[iS] = [[ws.cell(4*iS+4, 3).value], ws.cell(4*iS+5, 3).value, [ws.cell(4*iS+6, 3).value]]
  softwareDictValueList = [{}] * nS
  for iS in range(0, nS):
    nameDictValue, nameDict = generateNameDictionary(softwareList[iS][0])
    releaseDictValue = softwareList[iS][1]
    descriptionDictValue, descriptionDict = generateDescriptionDictionary(softwareList[iS][2])
    softwareDictValueList[iS] = {'dcc:name':        [nameDictValue], \
                                 'dcc:release':     [releaseDictValue], \
                                 'dcc:description': [descriptionDictValue]}
  dccSoftwareDictValue = {'dcc:software': softwareDictValueList}
  return dccSoftwareDictValue
```

- Slightly more complicated Python function
- Calls other simple functions

Case study with NCC
Software development – DCC software

NPL National Physical Laboratory

Dictionary value

```
{'dcc:software': [{'dcc:name': [{'dcc:content': ['DCV_NCC_GenerateDCC_EBRO.py']}],
   'dcc:release': ['v3.0'],
   'dcc:description': [{'dcc:content': ['Python software to generate DCC']}]},
  {'dcc:name': [{'dcc:content': ['EBRO_administrativeInformation.xlsx']}],
   'dcc:release': ['v3.0'],
   'dcc:description': [{'dcc:content': ['Microsoft Excel workbook containing administrative information']}]},
  {'dcc:name': [{'dcc:content': ['EBRO_measurementData.xlsx']}],
   'dcc:release': ['v2.0'],
   'dcc:description': [{'dcc:content': ['Microsoft Excel workbook containing measurement data']}]},
  {'dcc:name': [{'dcc:content': ['dccV3.1.2_Template.xml']}],
   'dcc:release': ['v4.0'],
   'dcc:description': [{'dcc:content': ['Template XML file']}]}]}
```

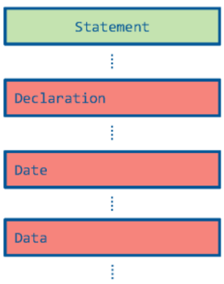
XML (portion)

```
<dcc:dccSoftware>
  <dcc:software>
    <dcc:name>
      <dcc:content>DCV_NCC_GenerateDCC_EBRO.py</dcc:content>
    </dcc:name>
    <dcc:release>v3.0</dcc:release>
    <dcc:description>
       <dcc:content>Python software to generate DCC</dcc:content>
    </dcc:description>
  </dcc:software>
  <dcc:software>
    <dcc:name>
      <dcc:content>EBRO_administrativeInformation.xlsx</dcc:content>
```

Case study with NCC
Software development – statements

NPL National Physical Laboratory

- Assumptions
  - Allow for any number of statements
  - Elements used depends on type of statement
  - Variable numbers of pieces of information in Excel worksheet depending on type of statement



Number of statements	3				
Statement number	1	Statement number	2	Statement number	3
Statement type	Recalibration	Statement type	Resolution	Statement type	Calibration range
Declaration	Date on or before which the item is to be recalibrated.	Declaration	Measurement resolution.	Declaration	The digital thermometer and associated probe were submitted for calibration over the specified temperature range in terms of the International Temperature Scale of 1990.
Date	2023-07-18	Value	0.1	Label 1	Lower limit
		Unit	\degreeCelsius	Value 1	0
				Unit 1	\degreeCelsius
				Label 2	Upper limit
				Value 2	150
				Unit 2	\degreeCelsius

Case study with NCC
Software development – statements

Python code (with comments removed)

```
def generateStatementsDictionaryValue(workbook, worksheetName):
ws = workbook[worksheetName]
  nS = ws['C2'].value # number of instances of dcc:statement
  statementDictValueList = [{}] * nS
  for iS in range(0, nS):
    statementType = ws.cell(4, 2*iS+3).value
    if statementType == 'Recalibration': # 2 rows of information
      nRow = 2 #  number of rows of information
      statementList = ['a'] * nRow
      for iRow in range(0, nRow):
        statementList[iRow] = ws.cell(5+iRow, 2*iS+3).value
      declarationDictValue, declarationDict = generateDeclarationDictionary(statementList[0])
      statementDictValueList[iS] = {'@refType': ['basic_calibration'], \
                                    'dcc:declaration': declarationDictValue, \
                                    'dcc:date': [statementList[1]]}
    elif statementType == 'Resolution': # 3 rows of information
      nRow = 3 #  number of rows of information
      statementList = ['a'] * nRow
      for iRow in range(0, nRow):
        statementList[iRow] = ws.cell(5+iRow, 2*iS+3).value
      declarationDictValue, declarationDict = generateDeclarationDictionary(statementList[0])
      resolutionStatementDataDictValue, resolutionStatementDataDict = generateResolutionStatementDataDictionary(statementList[1:3])
      statementDictValueList[iS] = {'dcc:declaration': declarationDictValue, \
                                    'dcc:data': [resolutionStatementDataDictValue]}
    elif statementType == 'Calibration range': # 7 rows of information
      nRow = 7 #  number of rows of information
      statementList = ['a'] * nRow
      for iRow in range(0, nRow):
        statementList[iRow] = ws.cell(5+iRow, 2*iS+3).value
      declarationDictValue, declarationDict = generateDeclarationDictionary(statementList[0])
      calibrationRangeStatementDataDictValue, calibrationRangeStatementDataDict = generateCalibrationRangeStatementDataDictionary(statementList[1:7])
      statementDictValueList[iS] = {'dcc:declaration': declarationDictValue, \
                                    'dcc:data': [calibrationRangeStatementDataDictValue]}
  statementsDictValue = {'dcc:statement': statementDictValueList}
  return statementsDictValue
```

- More complicated Python function to generate dictionary value
- Calls other functions
- Attribute also set

Case study with NCC
Software development – measurement result

- Assumptions
  - Layout of information (values, units and uncertainty information)
  - Number of data points specified explicitly

Number of data points	5				
Quantity name	**ITS-90 Temperature**	**Measured temperature**	**Correction**	**Lower limit**	**Upper limit**
Value	0.00	0.0	0.0	-0.3	0.3
Value	49.97	49.9	0.1	49.7	50.3
Value	100.01	100.0	0.0	99.7	100.3
Value	150.04	149.9	0.1	149.7	150.3
Value	0.00	0.0	0.0	-0.3	0.3
Unit	\degreeCelsius	\degreeCelsius	\degreeCelsius	\degreeCelsius	\degreeCelsius
Expanded uncertainty		0.2			
Coverage factor		2			
Coverage probability		0.95			

Lessons learned and revisiting last year's thoughts

- The Excel to DCC pathway introduced last year can be applied to real calibrations
  - Perhaps a more simple implementation is possible but the approach described is useful to better understand the depths of DCCs
- Software and software quality
  - Imperative to ensure reliability and robustness
  - Testing may be challenging
  - Development of generic functionality important for software reuse
- Importance of collaboration, e.g., among NMI community

Acknowledgements

- Radka Veltcheva, NPL
- Dan Griffin, Paul Addicott, NCC
- DCC development team

26 Dynamic Web Tool for Generating DCC

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Abstract

CENAM currently generates the calibration certificates electronically (PDF format) for which it has an internally developed web system in which, through an identifier of the service performed, data that is already in a database is retrieved, most of these data can be defined as administrative data (customers, dates, calibration location, etc.); the results are uploaded in a pdf file; at the end the system combines the result file with the one generated with the administrative data to obtain the electronic certificate.

Now with the digital certificate, CENAM has the vision of also generating a web system, based on the current one, where administrative data can be obtained in the same way; for the results it is going to have two options, one is going to be through capturing the results individually, the second one is upload xml files (with the format of the digital certificate schema) generated by other tools developed inside the laboratories or by excel files currently used by metrologists to analyze their results. If an xml file is uploaded, the system would combine it with the one generated with the administrative data; otherwise, the system would generate the digital certificate in its entirety.

Anticipating that the schema may have changes over time, the system will be dynamic and configurable with respect to the schema, that is, it will generate the fields according to the schema provided; and it will be configurable for non-mandatory elements and that for reasons of processes within the institute may not be necessary, they are not going to be showed.

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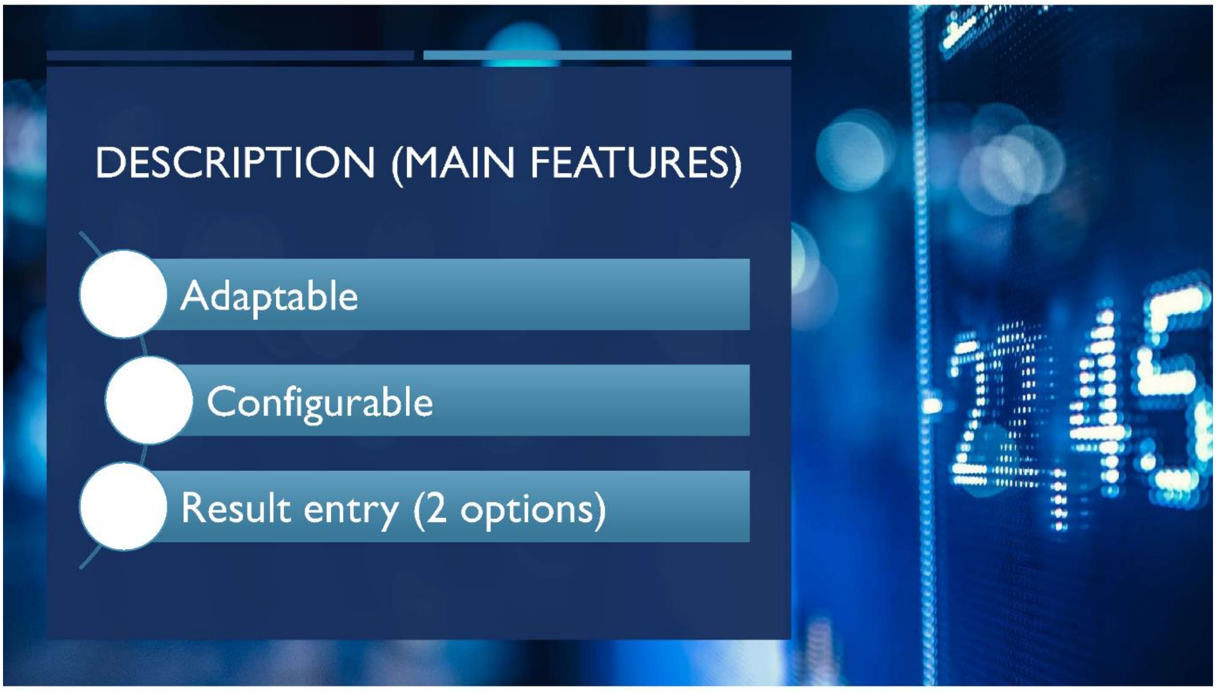
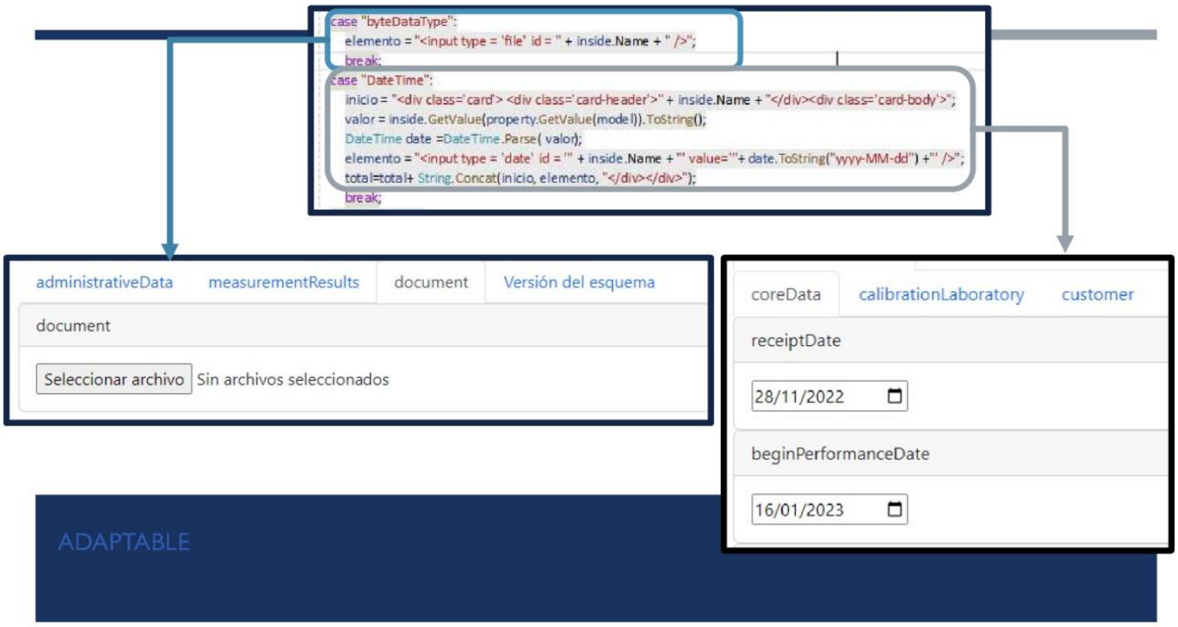
DESCRIPTION

- It is based on our current system for generating certificates, which begins by requesting a service number. With it, we can get most of administrative data from our database.
- For the results, a pdf file is requested, which is attached to the cover page, generated with the administrative data.
- Web application
  - Current: .Net Framework
  - New: .Net Core MVC



ADAPTABLE

- Adaptable to schema changes
  - Through schema deserialization, elements are read, and controls are built according to their type at runtime.



CONFIGURABLE (EXCLUDED ELEMENTS)

- There may be elements that do not need to be displayed to the user when the dcc is been created, they can be configurable in another moment. Ej. Country code, languages, etc.
  - All this elements are excluded of being build at runtime

CONFIGURABLE — Excluded items

```
foreach (System.Reflection.PropertyInfo inside in property.GetValue(model).GetType().GetProperties())
{
  if (!Model.squema.Excluidos.Contains(inside.Name))
  {
    switch (inside.PropertyType.Name)
    {
```

dccSoftware is in the excluded elements

administrativeData | measurementResults | document
coreData | calibrationLaboratory | customer

CONFIGURABLE (LANGUAGES)

- Languages

The tool get te content [stringWithLang] elements according to the languages specified

Idiomas

Nuevo idioma

Idioma	Código	Principal	Eliminar
Español	es	✔	🗑
Inglés	en		🗑

```
public static stringWithLangType[] Content(String texto)
{
    Models.Configuracion configuracion = new Models.Configuracion();
    List<stringWithLangType> stringWithLangs = new List<stringWithLangType>();
    if (texto == "") return stringWithLangs.ToArray();
        stringWithLangType stringWithLang = new stringWithLangType();
    stringWithLang.Value = texto;
    stringWithLang.lang = configuracion.MandatoryLang;
    stringWithLangs.Add(stringWithLang);
    foreach (string lang in Helpers.Herramientas.Idiomas())
    {
        texto = HttpUtility.HtmlAttributeEncode(texto);
```

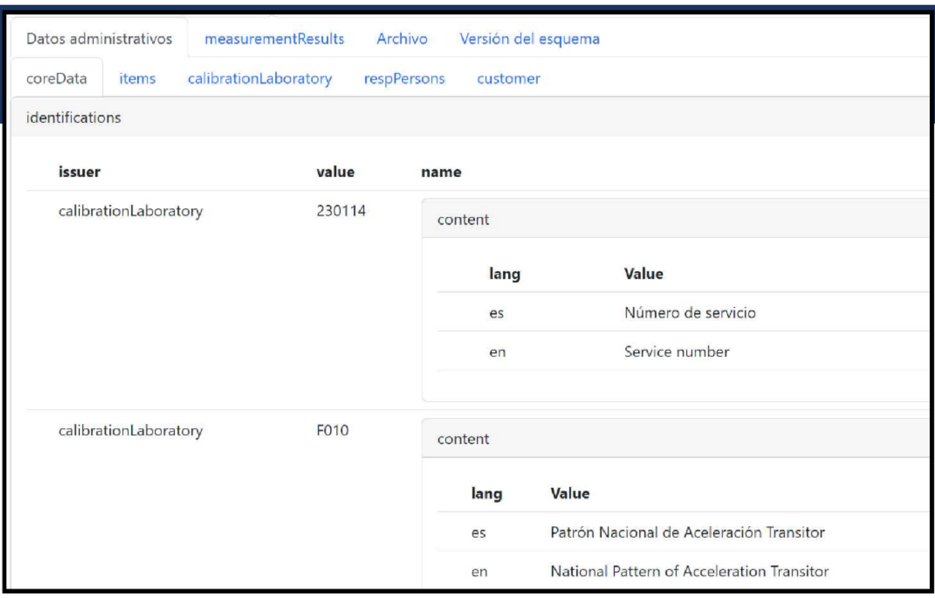
CONFIGURABLE (TRASLATION)

- Name elements traslation

```
<button class="nav-link" data-bs-toggle="tab" data-bs-target="@String.Concat("#", property.Name)">
    @{
        string traduccion = string.Empty;
        if (!Model.squema.ElementoTraduccion().TryGetValue(property.Name, out traduccion))
        { @property.Name; }
        else { @traduccion; }

    }
</button>
```

Elemento	Traducción	Eliminar
administrativeData	Datos administrativos	
squemaVersion	Versión del esquema	
document	Archivo	

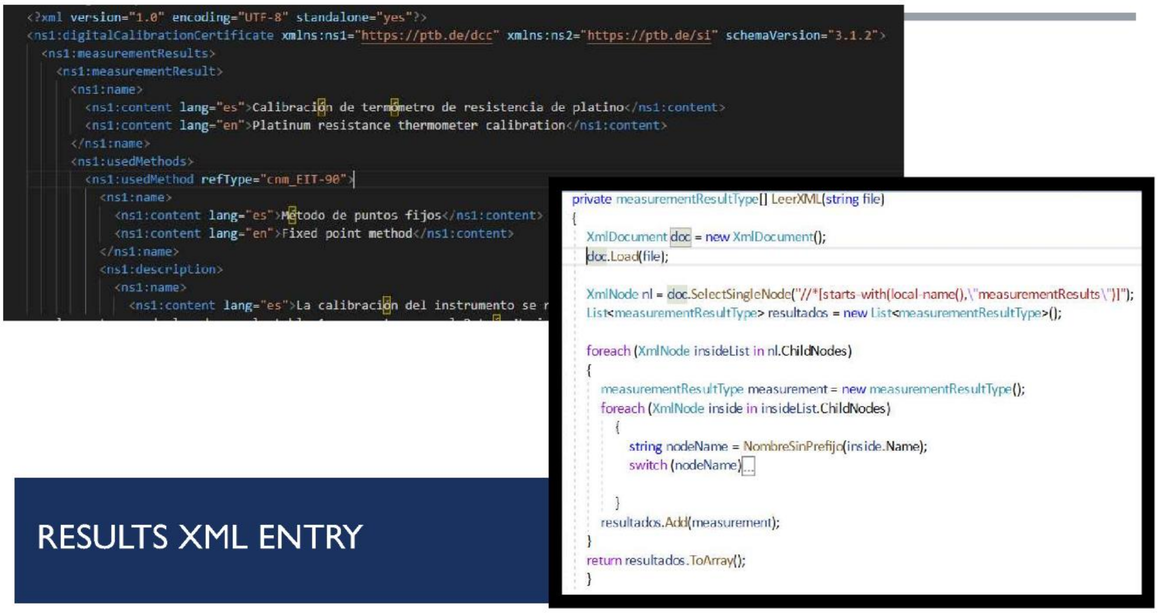


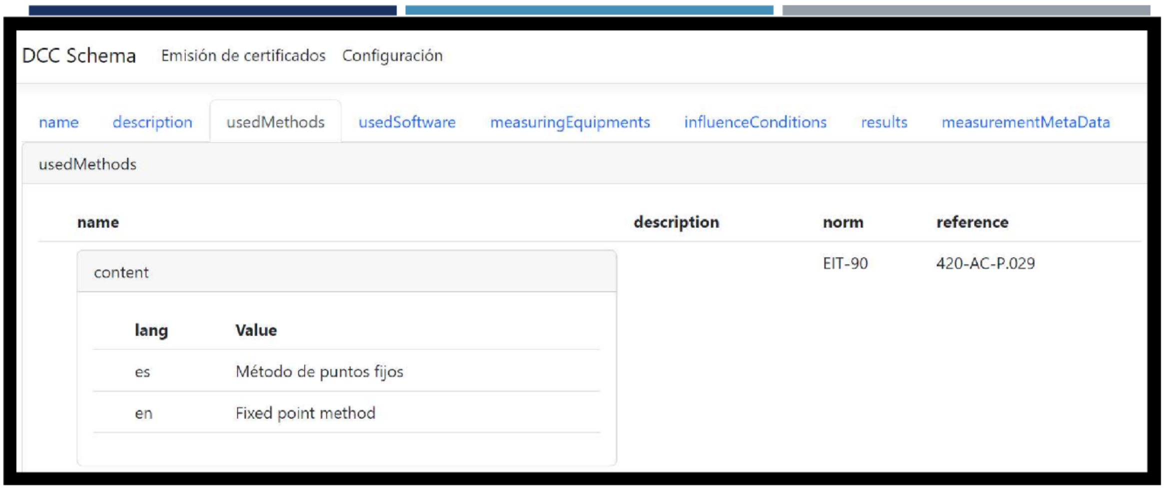
RESULTS ENTRY

RESULT ENTRY BY XML FILE

- The xml must have DCC schema format
  - Tags names
  - The namespaces name could be other or omitted

- The elements are searched with Xpath, if found they are placed in the corresponding object


<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<ns1:digitalCalibrationCertificate xmlns:ns1="https://ptb.de/dcc" xmlns:ns2="https://ptb.de/si" schemaVersion="3.1.2">
<ns1:measurementResults>
<ns1:measurementResult>
<ns1:name>
<ns1:content lang="es">Calibración de termómetro de resistencia de platino</ns1:content>
<ns1:content lang="en">Platinum resistance thermometer calibration</ns1:content>
</ns1:name>
<ns1:usedMethods>
<ns1:usedMethod refType="cnm_EIT-90">
<ns1:name>
<ns1:content lang="es">Método de puntos fijos</ns1:content>
<ns1:content lang="en">Fixed point method</ns1:content>
</ns1:name>
<ns1:description>
<ns1:name>
<ns1:content lang="es">La calibración del instrumento se r
RESULTS XML ENTRY
private measurementResultType[] LeerXML(string file)
{
XmlDocument doc = new XmlDocument();
doc.Load(file);
XmlNode nl = doc.SelectSingleNode("//*[starts-with(local-name(),\"measurementResults\")]");
List<measurementResultType> resultados = new List<measurementResultType>();
foreach (XmlNode insideList in nl.ChildNodes)
{
measurementResultType measurement = new measurementResultType();
foreach (XmlNode inside in insideList.ChildNodes)
{
string nodeName = NombreSinPrefijo(inside.Name);
switch (nodeName)
}
resultados.Add(measurement);
}
return resultados.ToArray();
}


DCC Schema
Emisión de certificados
Configuración
name
description
usedMethods
usedSoftware
measuringEquipments
influenceConditions
results
measurementMetaData
usedMethods
name
description
norm
reference
content
EIT-90
420-AC-P.029
lang
Value
es
Método de puntos fijos
en
Fixed point method

FUTURE WORK

- Include configuration for best practices (refId).
- Configuration for creating subschemas in order to be used with excel tool to create xml of the measurement results.
- Security for the DCC
- This tool will be finished at the end of these year.

GRACIAS

CENAM DCC TEAM

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27 The Use of (Anonymised) Timestamps in the DCC

Presenting author: Gamze Söylev-Öktem & PTB & Germany

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Abstract

For measurements and analyses, it can be important to record the point in time when the data is collected. For example, the sequence of data recording or the sequence of data analysis can be documented. The accuracy of the recording of the time can be handled in very different ways. This flexibility is made possible by the format used by the DCC.

However, in some situations it might be preferrable to not use exact time of recorded data. This might be due to various reasons, such as labour law or issues with the protection of personal data. The sequence of the recording of e.g., data collection, in other words which data is recorded first, second, and so on, could still be important and could be possible in this way without additional effort.

In this presentation, we show one solution to this issue, namely using anonymised time stamps. The anonymised time stamps allow a conclusion to be drawn about the sequence without giving rise to the problems of time recording. The DCC team has developed a demonstration tool for anonymised timestamps. In the presentation, an example is used to present this tool and explain how it works.

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Physikalisch-Technische Bundesanstalt
Braunschweig and Berlin
National Metrology Institute

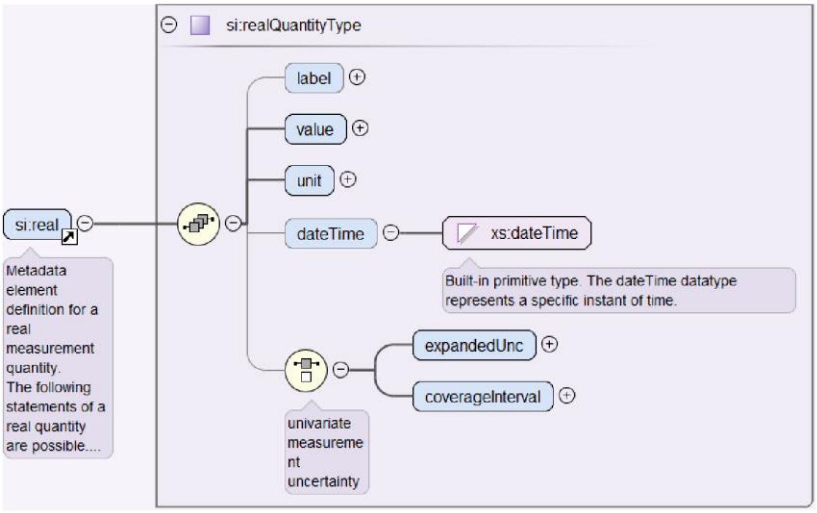
The Use of (Anonymised) Timestamps in the DCC

Gamze Söylev-Öktem, PTB

Datetime in DCC

- DCC allows to record the date and time of every measurement

Datetime in DCC



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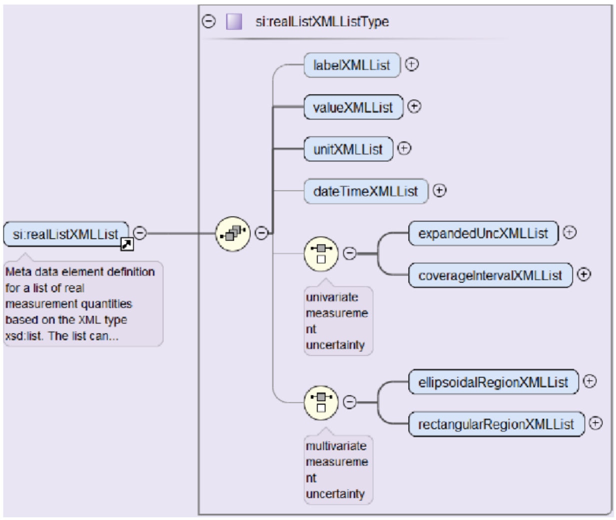
2023-03-01 3

Datetime in DCC



Physikalisch-Technische Bundesanstalt ■ Braunschweig and Berlin National Metrology Institute
2023-03-01 4

Datetime in DCC

```xml
<si:hybrid>
  <si:realListXMLList>
    <si:valueXMLList>306.245 373.127 448.249 523.321 593.151</si:valueXMLList>
    <si:unitXMLList>\kelvin</si:unitXMLList>
    <si:dateTimeXMLList>1957-08-13T08:15:00Z 1957-08-13T09:15:00Z 1957-08-13T10:15:00Z 1957-08-13T11:15:00Z 1957-08-13T12:15:00Z</si:dateTimeXMLList>
  </si:realListXMLList>
  <si:realListXMLList>
    <si:valueXMLList>33.095 99.977 175.099 250.171 320.001</si:valueXMLList>
    <si:unitXMLList>\degreecelsius</si:unitXMLList>
  </si:realListXMLList>
</si:hybrid>
```


xs:dateTime

- xs:dateTime
  - YYYY-MM-DDThh:mm:ss
    - <startdate>2002-05-30T09:00:00</startdate>
  - YYYY-MM-DDThh:mm:ssZ
    - <startdate>2002-05-30T09:30:10Z</startdate>

xs:dateTime

- xs:dateTime
  - YYYY-MM-DDThh:mm:ss
    - <startdate>2002-05-30T09:00:00</startdate>
  - YYYY-MM-DDThh:mm:ssZ
    - <startdate>2002-05-30T09:30:10Z</startdate>

xs:dateTime

- xs:dateTime
  - YYYY-MM-DDThh:mm:ss
    - <startdate>2002-05-30T09:00:00</startdate>
  - YYYY-MM-DDThh:mm:ssZ
    - <startdate>2002-05-30T09:30:10Z</startdate>

xs:dateTime

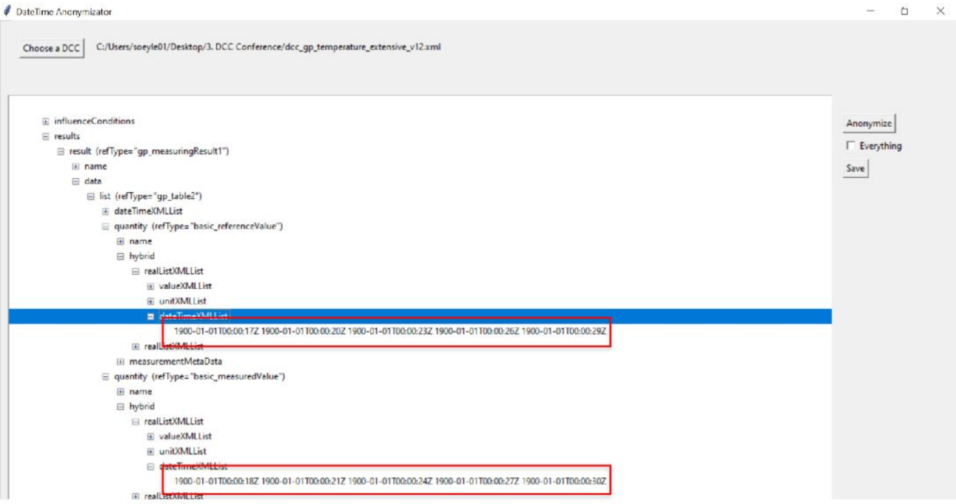
- xs:dateTime
  - YYYY-MM-DDThh:mm:ss
    - <startdate>2002-05-30T09:00:00</startdate>
  - YYYY-MM-DDThh:mm:ssZ
    - <startdate>2002-05-30T09:30:10Z</startdate>

Anonymised Timestamps

- What do we mean by ‚Anonymised Timestamp'?
  - Using si:dateTime or si:dateTimeXMLList with a meaningless content as just an index
    - <si:dateTimeXMLList>1957-08-13T08:15:00Z 1957-08-13T09:15:00Z 1957-08-13T10:15:00Z 1957-08-13T11:15:00Z 1957-08-13T12:15:00Z</si:dateTimeXMLList>
    - <si:dateTimeXMLList>1900-01-01T00:00:01Z 1900-01-01T00:00:02Z 1900-01-01T00:00:03Z 1900-01-01T00:00:04Z 1900-01-01T00:00:05Z</si:dateTimeXMLList>
- Why do we need that?
  - It can be a legal requirement not to disclose the exact time of the measurement
  - The calibration laboratory might not want to disclose the exact time of the measurement

Datetime Anonymizator

- Demo



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Braunschweig and Berlin
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38116 Braunschweig
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Parallel Session 2: DCC and Machines

Presentations that would also fit into this session:

28 Pilot Comparison Project in Terms of Air Kerma in Radiation Protection between Digital Twin Laboratories

Presenting author: Eric Matos Macedo – Labprosaud/IFBA - Brazil

E-mail address: ematosmacedo@gmail.com

Additional authors: Igor Fernando Modesto Garcia, Matheus Rebello do Nascimento, Jeovana Santos Ferreira, José Guilherme Pereira Peixoto, Marcus Vinicius Teixeira Navarro.

Abstract

Proficiency Testing (PT) activities, especially in ionizing radiation, are an essential tool for continuously monitoring the performance of laboratories in their processes and maintaining the reliability of participants and other interested parties. However, PT events bring operational challenges, mainly logistics. Even big international programs have some years-long PT events. Technologies from the fourth industrial revolution and metrology 4.0 can be used to mitigate these difficulties. The objective is to develop a technical framework for comparisons in terms of air kerma between digital twin laboratories, using physical measurements taken in the physical laboratory (kerma_P and spec_P) and virtual measurements from the digital twin (kerma_V and spec_V) simulated in Monte Carlo. The idea is to dispense with equipment logistics so that the provider laboratory (lab_prov) only delivers a virtual transfer chamber to the participating laboratory (lab_part). Such measures are used to calculate the normalized error (En) of each PT event from lab_prov and lab_part's digital calibration certificates (DCC) issued. The characterization of virtual laboratories, simulated in EGSnrc, has brought promising results such as average energy differences of 1.4% between raw experimental and simulated spectra of N-60 radiation quality (ISO 4037). When the spectra are corrected, the differences become non-significant. Some challenges in measurements of kerma_V in ionization chambers, in the same scenario, are not converging to kerma_P yet. Data generated from physical calibrations and quality control tests performed periodically in laboratories are used to predict trends and infer the status of the physical system promoting corrections and improvements in the digital and physical systems.

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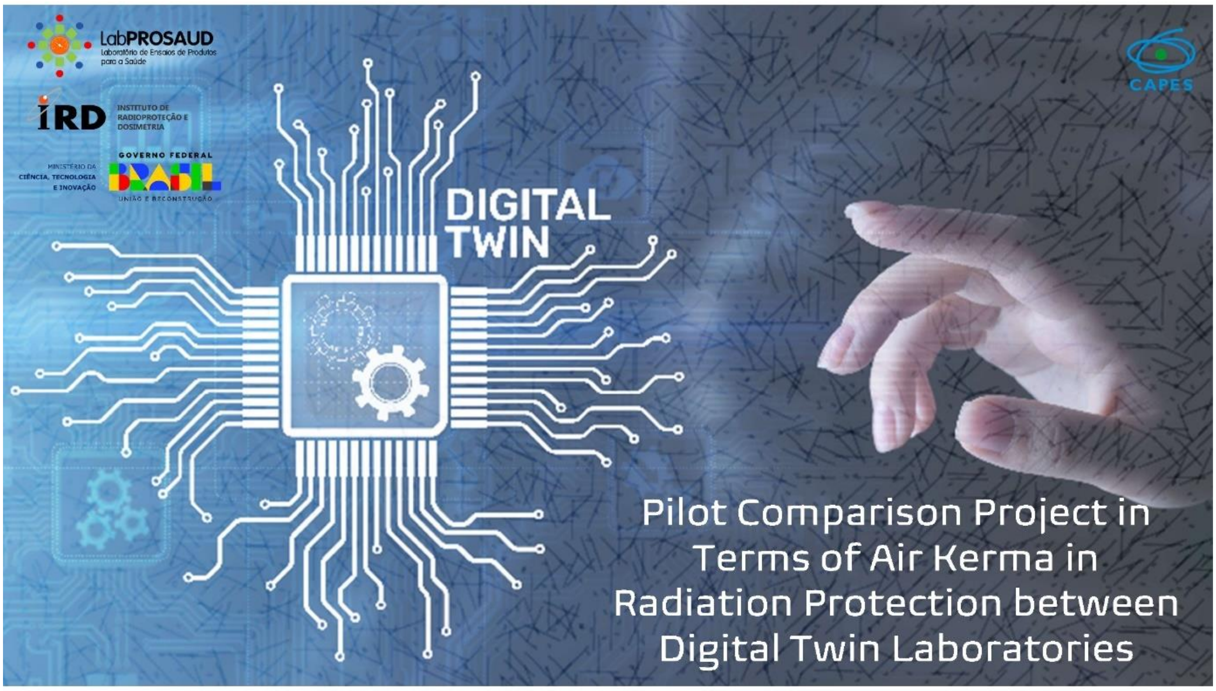
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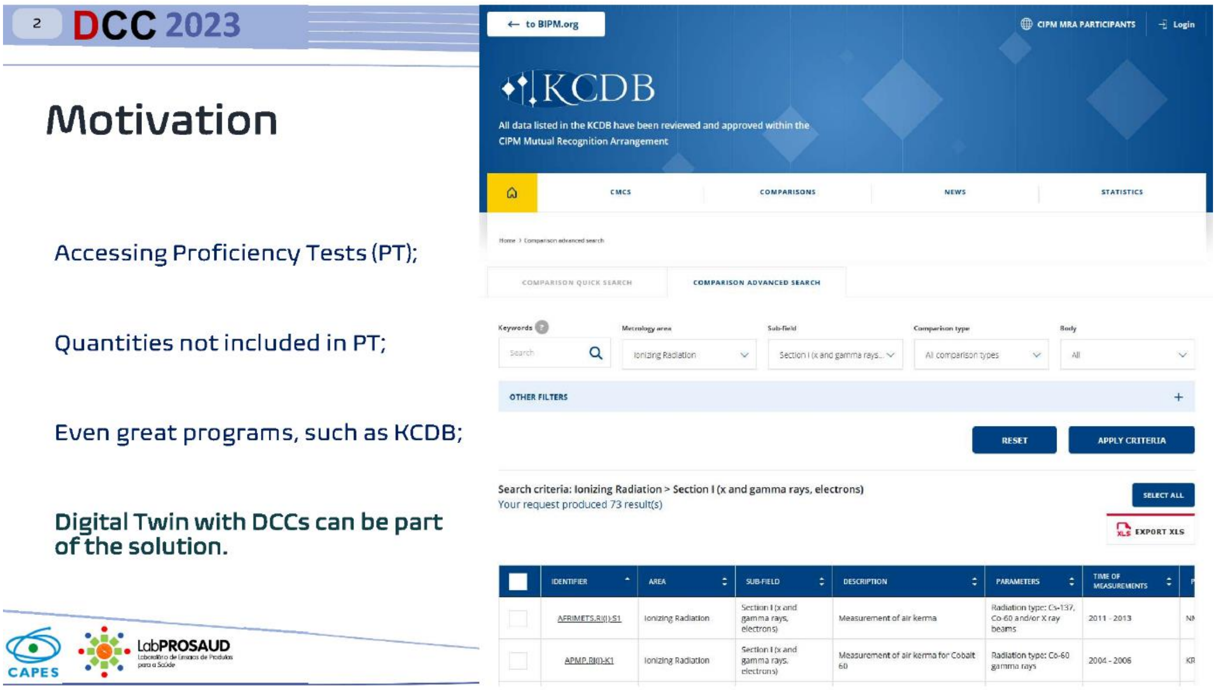
Laboratório de Ensaios de Produtos para a Saúde
IRD
INSTITUTO DE RADIOPROTEÇÃO E DOSIMETRIA
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO
GOVERNO FEDERAL
BRASIL
UNIÃO E RECONSTRUÇÃO
CAPES
DIGITAL TWIN
Pilot Comparison Project in Terms of Air Kerma in Radiation Protection between Digital Twin Laboratories


2
DCC 2023
Motivation
Accessing Proficiency Tests (PT);
Quantities not included in PT;
Even great programs, such as KCDB;
Digital Twin with DCCs can be part of the solution.
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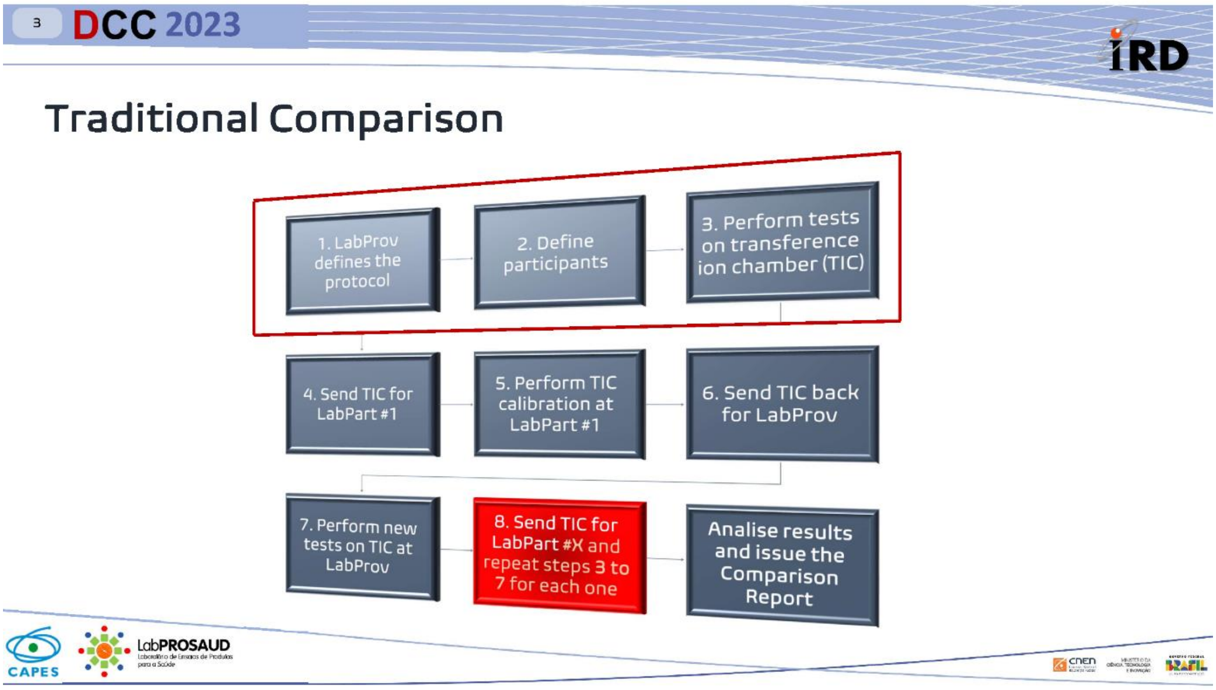
to BIPM.org
CIPM MRA PARTICIPANTS
Login
KCDB
All data listed in the KCDB have been reviewed and approved within the CIPM Mutual Recognition Arrangement
CMCS
COMPARISONS
NEWS
STATISTICS
COMPARISON QUICK SEARCH
COMPARISON ADVANCED SEARCH
Keywords
Metrology area
Sub-field
Comparison type
Body
Ionizing Radiation
All comparison types
All
OTHER FILTERS
RESET
APPLY CRITERIA
Search criteria: Ionizing Radiation > Section I (x and gamma rays, electrons)
Your request produced 73 result(s)
SELECT ALL
EXPORT XLS
IDENTIFIER
AREA
SUB-FIELD
DESCRIPTION
PARAMETERS
TIME OF MEASUREMENTS
AFRIMETS.RI(I)-S1
Ionizing Radiation
Section I (x and gamma rays, electrons)
Measurement of air kerma
Radiation type: Cs-137, Co-60 and/or X ray beams
2011 - 2013
APMP.RI(I)-K1
Ionizing Radiation
Section I (x and gamma rays, electrons)
Measurement of air kerma for Cobalt 60
Radiation type: Co-60 gamma rays
2004 - 2006


3
DCC 2023
IRD
Traditional Comparison
1. LabProv defines the protocol
2. Define participants
3. Perform tests on transference ion chamber (TIC)
4. Send TIC for LabPart #1
5. Perform TIC calibration at LabPart #1
6. Send TIC back for LabProv
7. Perform new tests on TIC at LabProv
8. Send TIC for LabPart #X and repeat steps 3 to 7 for each one
Analise results and issue the Comparison Report
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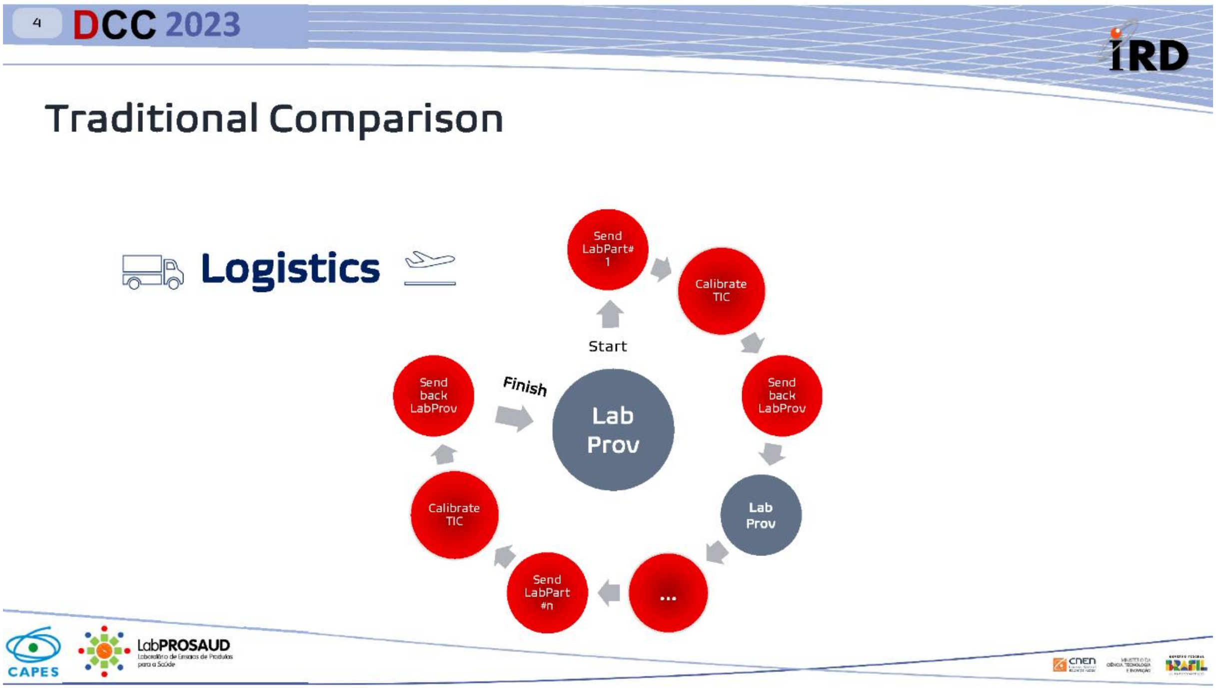
4
DCC 2023
IRD
Traditional Comparison
Logistics
Send LabPart# 1
Calibrate TIC
Send back LabProv
Lab Prov
...
Send LabPart #n
Calibrate TIC
Send back LabProv
Start
Finish
Lab Prov
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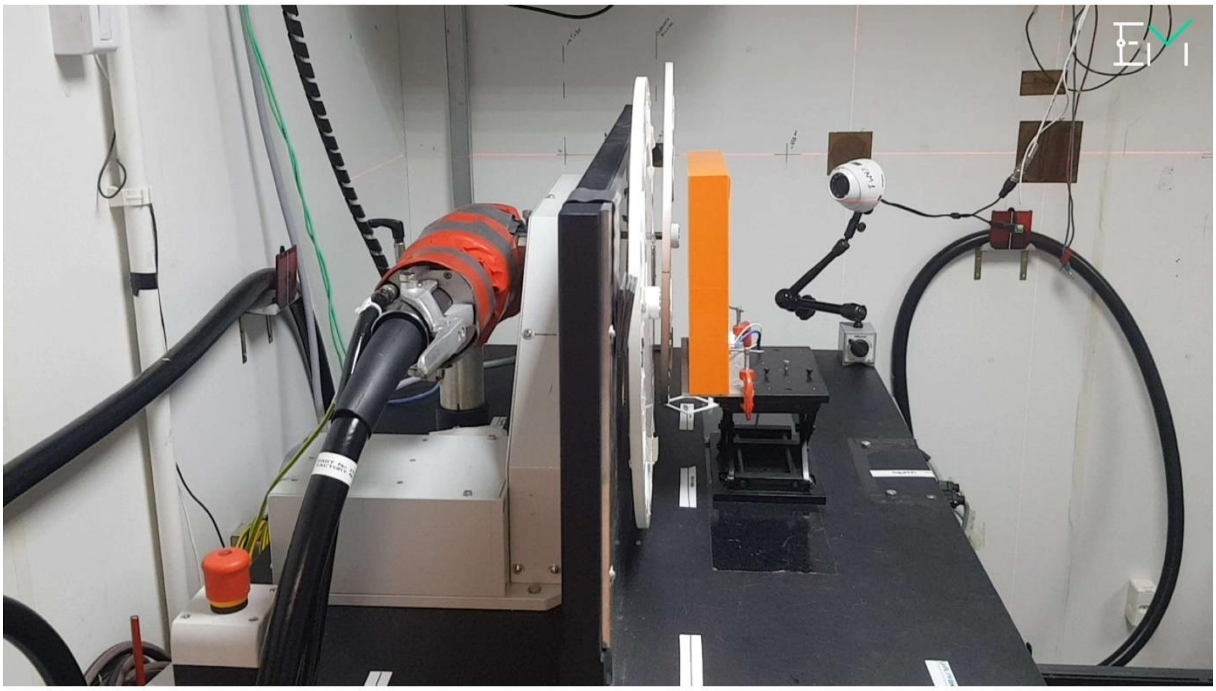

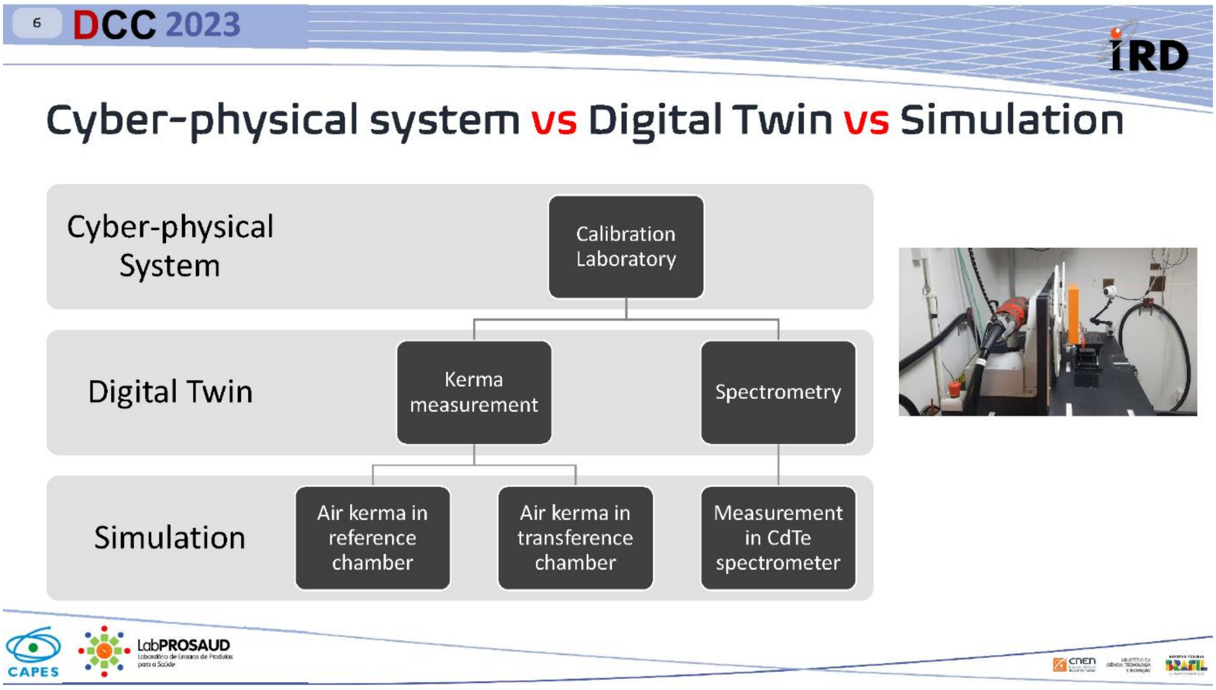
6
DCC 2023
iRD
Cyber-physical system vs Digital Twin vs Simulation
Cyber-physical System
Calibration Laboratory
Digital Twin
Kerma measurement
Spectrometry
Simulation
Air kerma in reference chamber
Air kerma in transference chamber
Measurement in CdTe spectrometer
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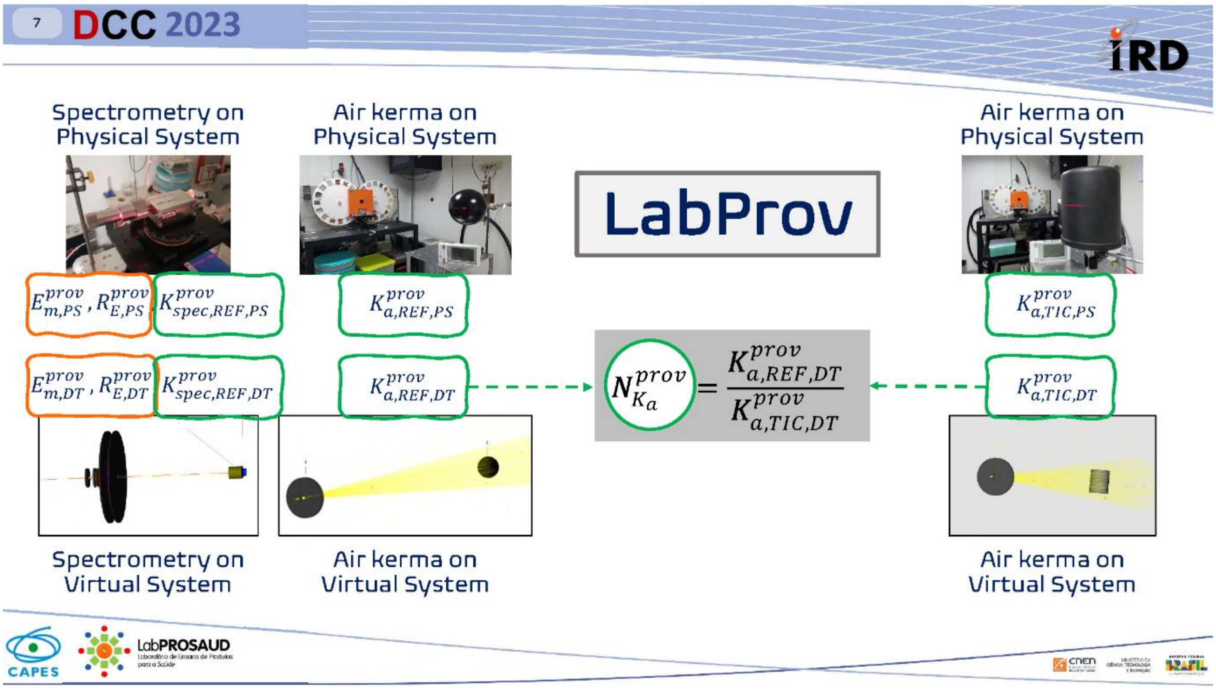
7
DCC 2023
IRD
Spectrometry on Physical System
Air kerma on Physical System
LabProv
Air kerma on Physical System
$E^{prov}_{m,PS}$, $R^{prov}_{E,PS}$
$K^{prov}_{spec,REF,PS}$
$K^{prov}_{a,REF,PS}$
$K^{prov}_{a,TIC,PS}$
$E^{prov}_{m,DT}$, $R^{prov}_{E,DT}$
$K^{prov}_{spec,REF,DT}$
$K^{prov}_{a,REF,DT}$
$N^{prov}_{K_a} = \frac{K^{prov}_{a,REF,DT}}{K^{prov}_{a,TIC,DT}}$
$K^{prov}_{a,TIC,DT}$
Spectrometry on Virtual System
Air kerma on Virtual System
Air kerma on Virtual System
CAPES
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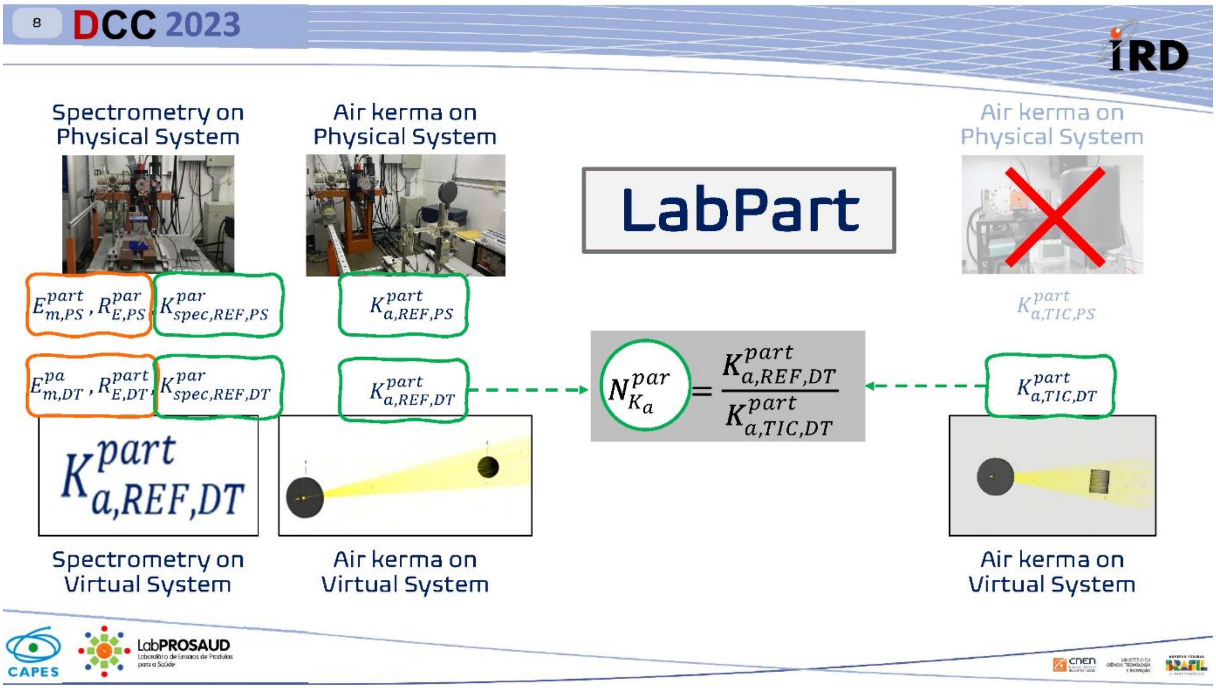
8
DCC 2023
IRD
Spectrometry on Physical System
Air kerma on Physical System
LabPart
Air kerma on Physical System
$E^{part}_{m,PS}$, $R^{par}_{E,PS}$
$K^{par}_{spec,REF,PS}$
$K^{part}_{a,REF,PS}$
$K^{part}_{a,TIC,PS}$
$E^{pa}_{m,DT}$, $R^{part}_{E,DT}$
$K^{par}_{spec,REF,DT}$
$K^{part}_{a,REF,DT}$
$N^{par}_{K_a} = \frac{K^{part}_{a,REF,DT}}{K^{part}_{a,TIC,DT}}$
$K^{part}_{a,TIC,DT}$
$K^{part}_{a,REF,DT}$
Spectrometry on Virtual System
Air kerma on Virtual System
Air kerma on Virtual System
CAPES
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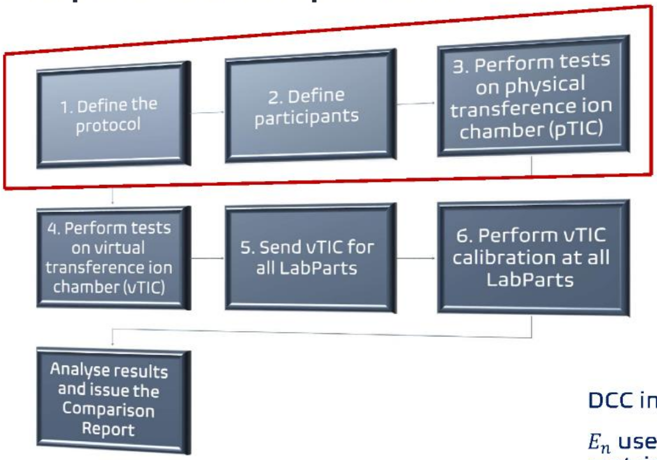
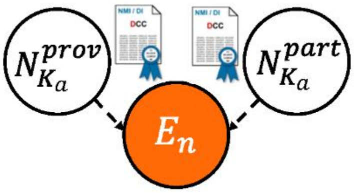
Proposed vComparison





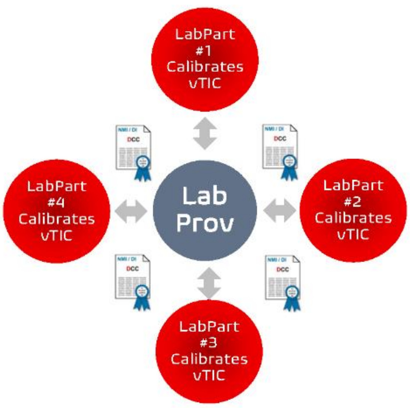
DCC in the process;

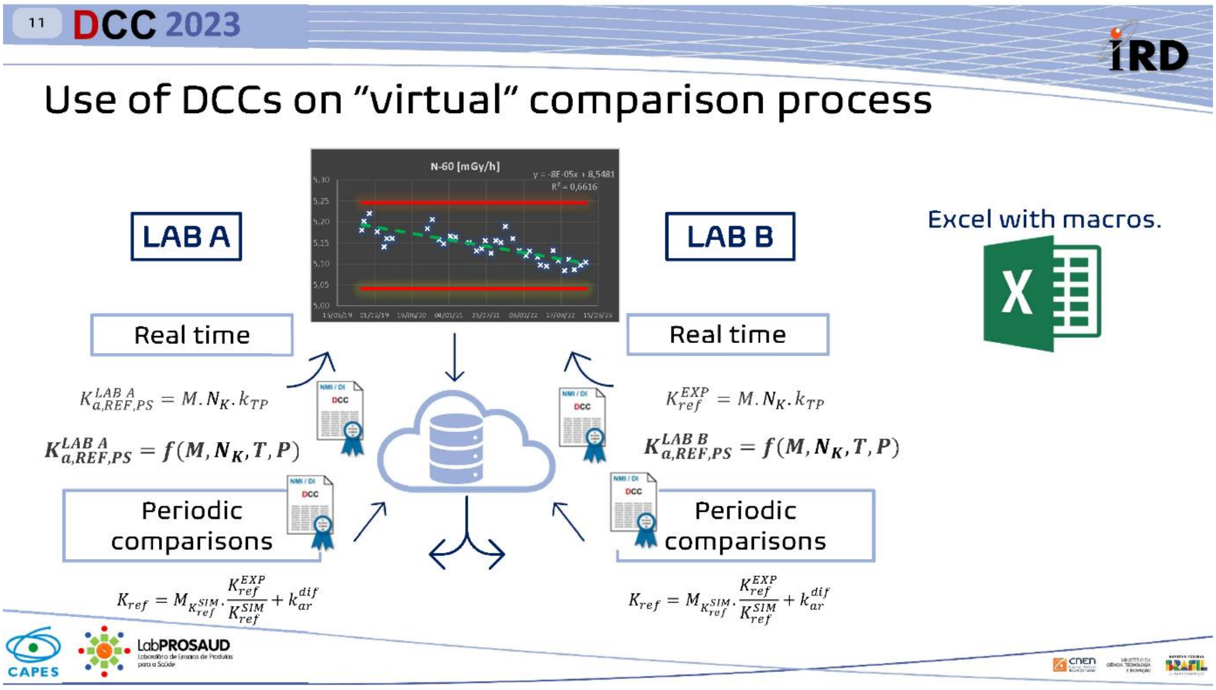
E_n used for two labs. Other metrics can be used for evaluate several labs in PT programs;

Proposed vComparison

Time reduced;

Risks to instrumentation integrity;




11 DCC 2023
IRD
Use of DCCs on "virtual" comparison process
N-60 [mGy/h]
y = -8E-05x + 8,5481
R² = 0,6616
LAB A
LAB B
Excel with macros.
Real time
Real time
$K^{LAB\ A}_{a,REF,PS} = M.N_K.k_{TP}$
$K^{EXP}_{ref} = M.N_K.k_{TP}$
$K^{LAB\ A}_{a,REF,PS} = f(M, N_K, T, P)$
$K^{LAB\ B}_{a,REF,PS} = f(M, N_K, T, P)$
NMI / DI
DCC
Periodic comparisons
Periodic comparisons
$K_{ref} = M_{K^{SIM}_{ref}} . \frac{K^{EXP}_{ref}}{K^{SIM}_{ref}} + k^{dif}_{ar}$
$K_{ref} = M_{K^{SIM}_{ref}} . \frac{K^{EXP}_{ref}}{K^{SIM}_{ref}} + k^{dif}_{ar}$
CAPES
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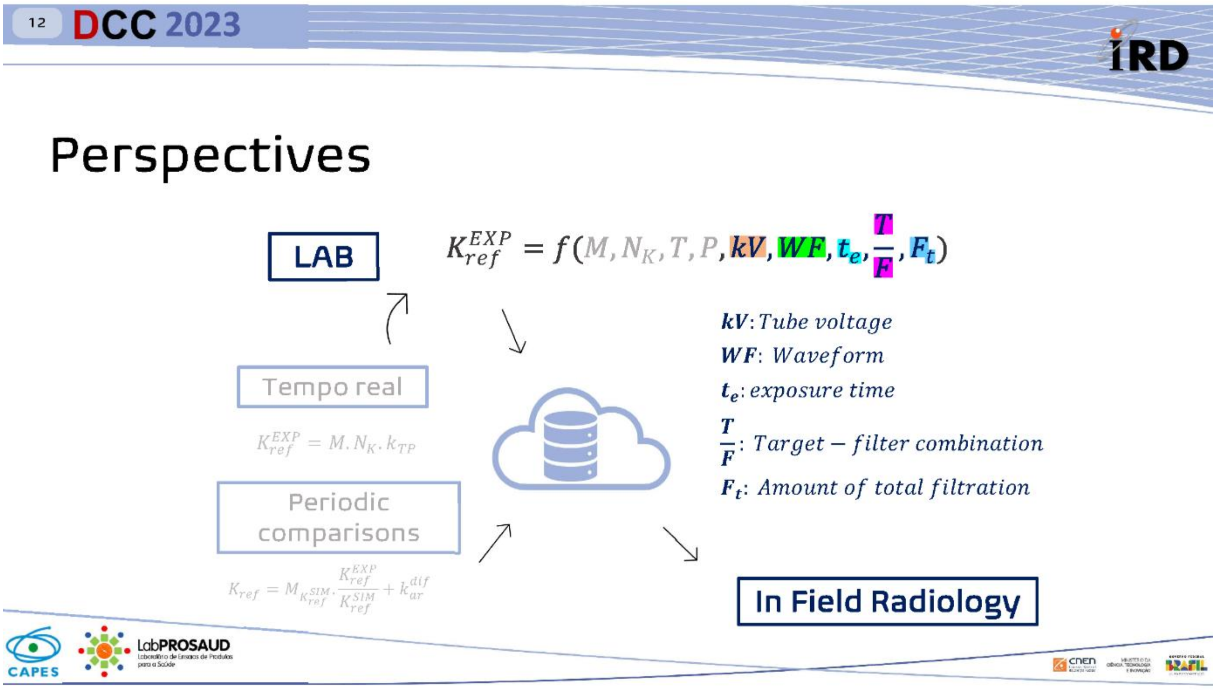
12 DCC 2023
IRD
Perspectives
LAB
$K^{EXP}_{ref} = f(M, N_K, T, P, kV, WF, t_e, \frac{T}{F}, F_t)$
kV: Tube voltage
WF: Waveform
t_e: exposure time
$\frac{T}{F}$: Target − filter combination
F_t: Amount of total filtration
Tempo real
$K^{EXP}_{ref} = M.N_K.k_{TP}$
Periodic comparisons
$K_{ref} = M_{K^{SIM}_{ref}} . \frac{K^{EXP}_{ref}}{K^{SIM}_{ref}} + k^{dif}_{ar}$
In Field Radiology
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Limitations

Challenges to representing physical features in the virtual system, such as electronics, material degradation, environment variables, etc.

It is an MC simulation-based technology, and a robust process of validation of virtual measurements is necessary;

It was presented a difficulty of PT programs in Brazil, relating to calibrations for diagnostic radiology applications, which may not occur at the same level in other applications or countries;

The vComparison depends on adopting of other calibration labs to its metrological consolidation as a comparison possibility. It also depends on acceptance by regulation bodies in the future;

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NRC/CANADA. Add a spectrum scoring application egs_phd #492. National Research Council of Canada. Metrology Research CentreNational Research Council of Canada. Metrology Research Centre. Available im: <https://github.com/nrc-cnrc/EGSnrc/pull/492>. Acessed in: 4/4/2022.

Acknowledgement

DCC

3rd International Digital Calibration Certificate (DCC) Conference

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LCR

IRTech!

IRD INSTITUTO DE RADIOPROTEÇÃO E DOSIMETRIA

CNEN Comissão Nacional de Energia Nuclear

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29 Data Analysis and Business Intelligence - Digital Metrology

Presenting author: Talaat Al-Rahali, NMCC, Saudi Arabia

E-mail address: t.rahali@saso.gov.sa

Abstract

The aim of this work is to identify the impact of business intelligence on strategic performance in the measurement and calibration sectors. Our focus will be on digital transformation for the use of reference materials for calibration of measuring equipment. This needs the development of algorithms and models for data analysis and extraction of "information" for a number of objectives. An example for the application of our proposal can be the calibration of a gas monitor using a certified reference material through the following steps:

1. Obtaining data related to the one-point calibration using a reference gas (R).
2. Processing and checking the obtained data.
3. Making three measurements of the sample (S) and calculating the average.
4. Building, developing, and applying the algorithms and models necessary for calculating the concentration and uncertainty of the unknown sample (S).
5. Presenting the final results to the decision makers, in an automated way by machine learning and artificial intelligence.

The main tasks required to achieve the proposed work are: 1) predating data from previous measurements regarding the number of injections, calibration points of the GC-TCD measuring machine. 2) testing the data for outliers. 3) calculation of the concentration and uncertainty. 4) Testing the relationship between the reference values and measured concentration of the sample (S). 5) checking the quality of the algorithms to ensure quality of the obtained results.

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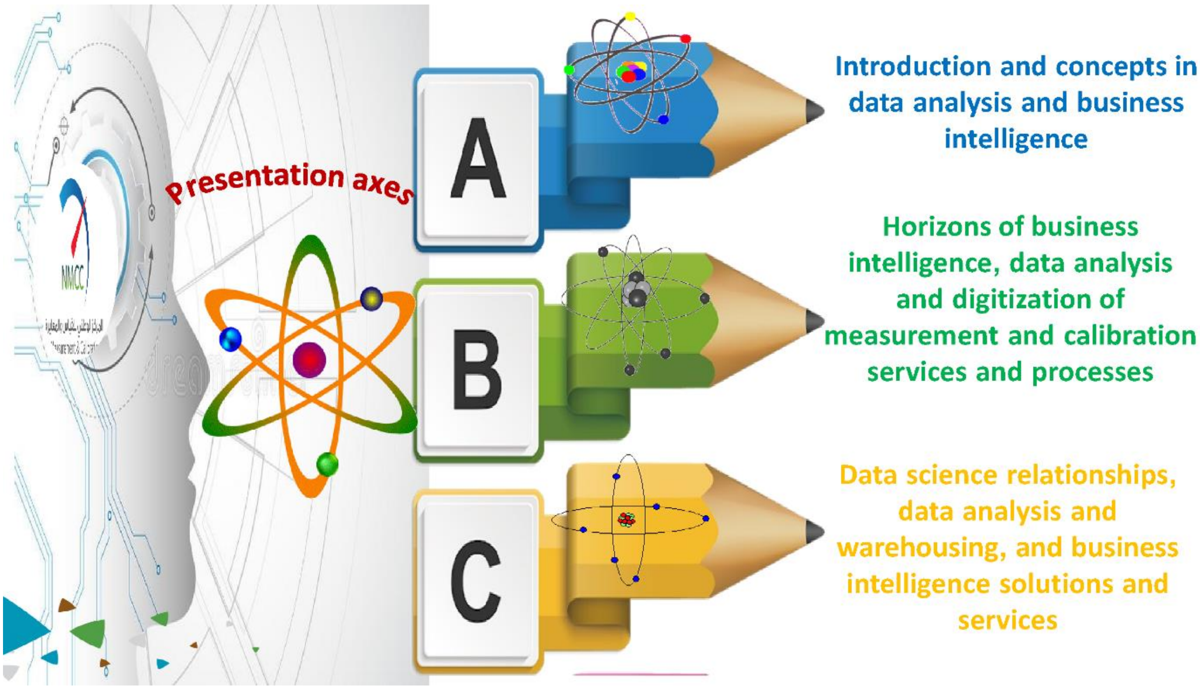
3rd International DCC Conference to be held from 28 February to 28/02 March 2023

Session (C) – Parallel Session (2) # (29)

Chosen Conference Topic: Digital Certificates for Reference Materials (DRM) / Section (DCC and Machines)

Data analysis and business intelligence in metrology sectors

Provided by / Eng. Talaat ALRahali
Advisor to the National Center for Measurement and Calibration/ SASO



Introduction and concepts in data analysis and business intelligence

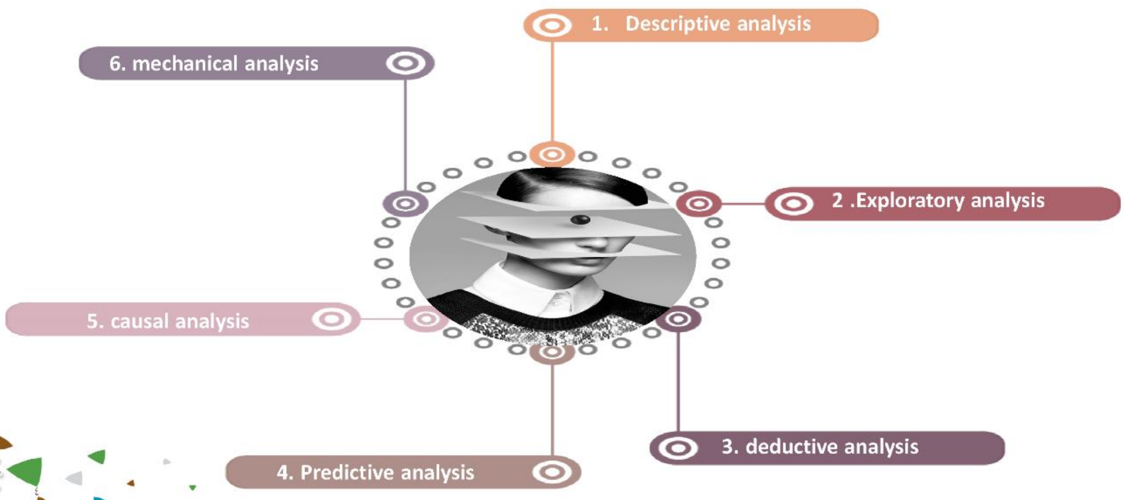
Big data analytics

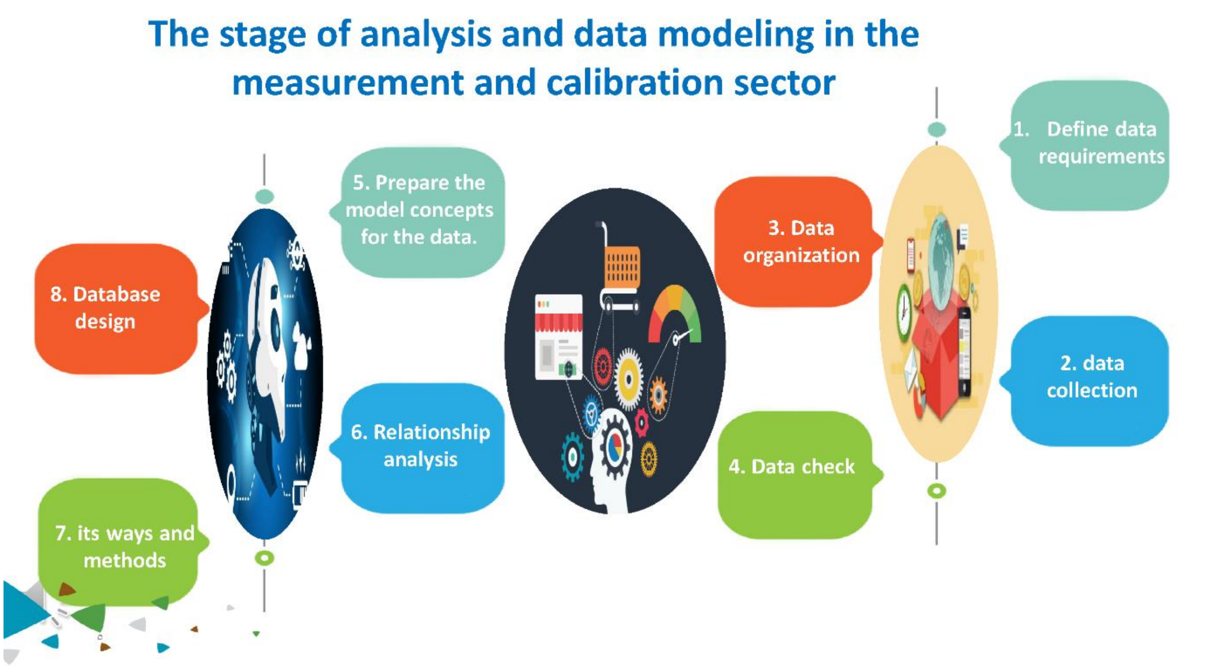
It is the use of advanced analytical techniques against large and diverse sets of big data that includes structured, semi-structured and unstructured data, from different sources, and of different sizes. It is processed and managed with high efficiency and low latency because it is driven by artificial intelligence (AI) and emerging technologies (eg IoT). .) and sensors and on a very large scale. As cost-effective data processing and warehousing tools designed to handle the volume of data being generated

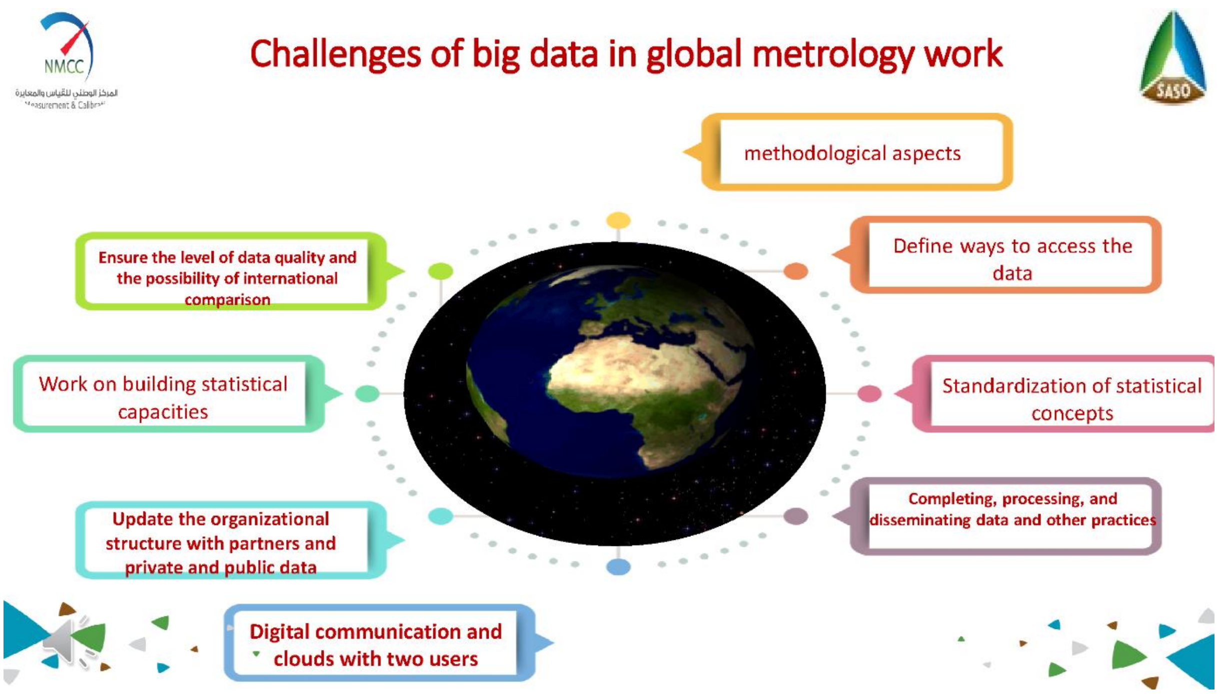
Benefits of big data analytics

1. Make Faster, Better Decisions NMCC institutes and centers can access a large volume of data and analyze a wide variety of data sources to gain new insights and take action.
2. Cost Reduction and Operational Efficiency NMCC institutes' flexible data processing and storage tools can help save costs in storing and analyzing large amounts of data. Discover patterns and insights that help you determine the performance of (measurement and calibration) activities more efficiently.
3. Enhanced Data-Driven Access to Measurement and Calibration Market, Capacity Building, Research and Studies Analyzing data from sensors, devices, records, and applications enables NMCC institutes and centers to be data-driven. Measuring customer needs and potential risks and creating new products and services in the measurement and calibration market.

Data Analysis Classes (DA) Data Analysis

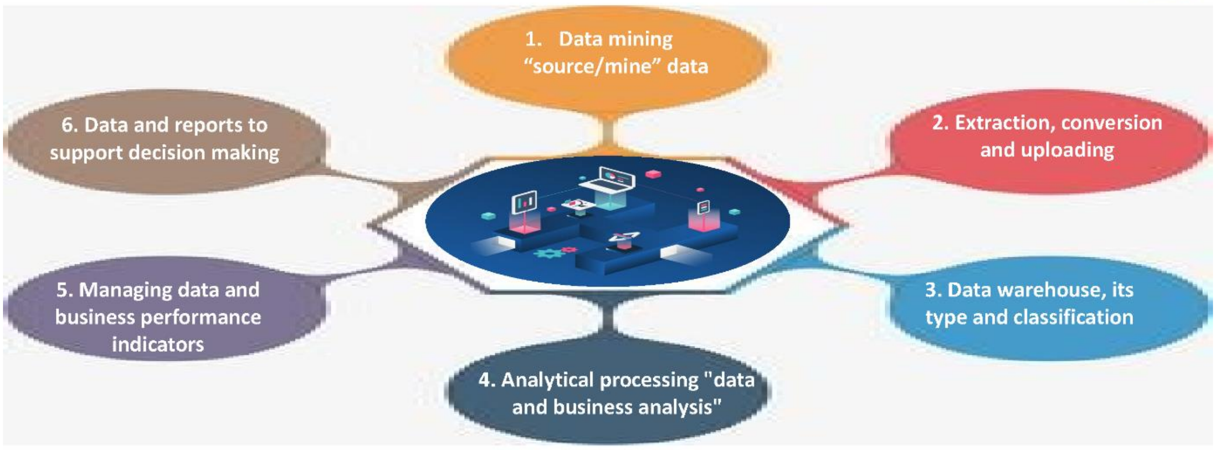


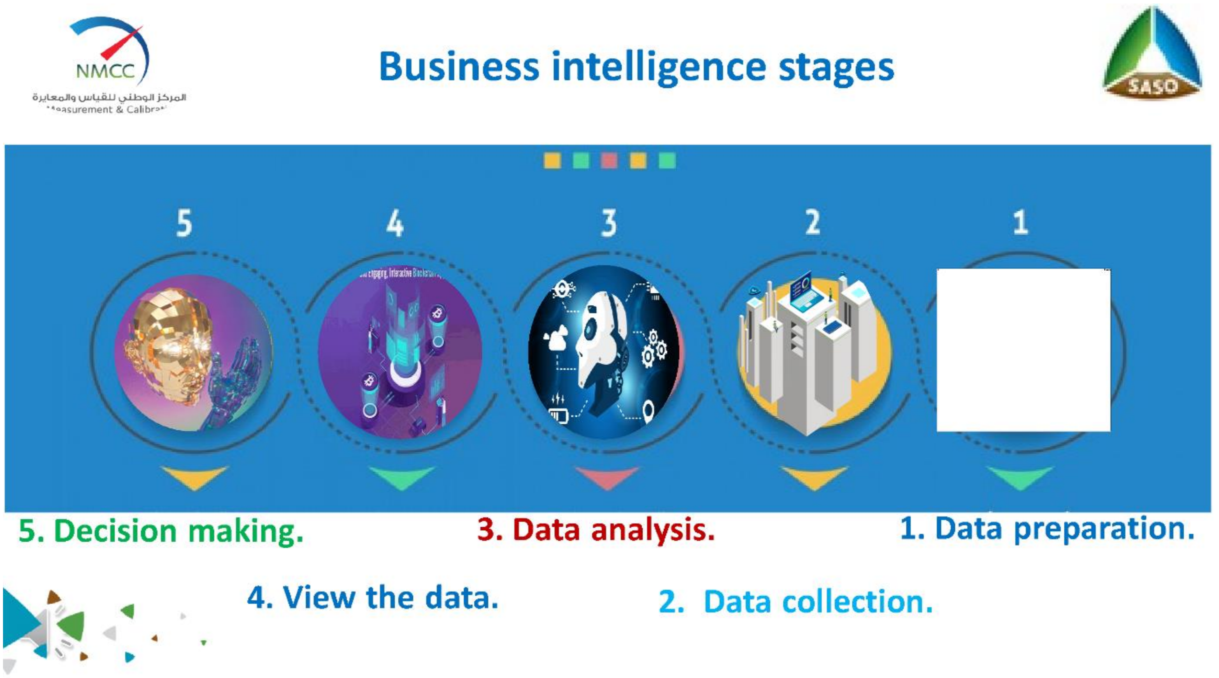

The stage of analysis and data modeling in the measurement and calibration sector
1. Define data requirements
2. data collection
3. Data organization
4. Data check
5. Prepare the model concepts for the data.
6. Relationship analysis
7. its ways and methods
8. Database design

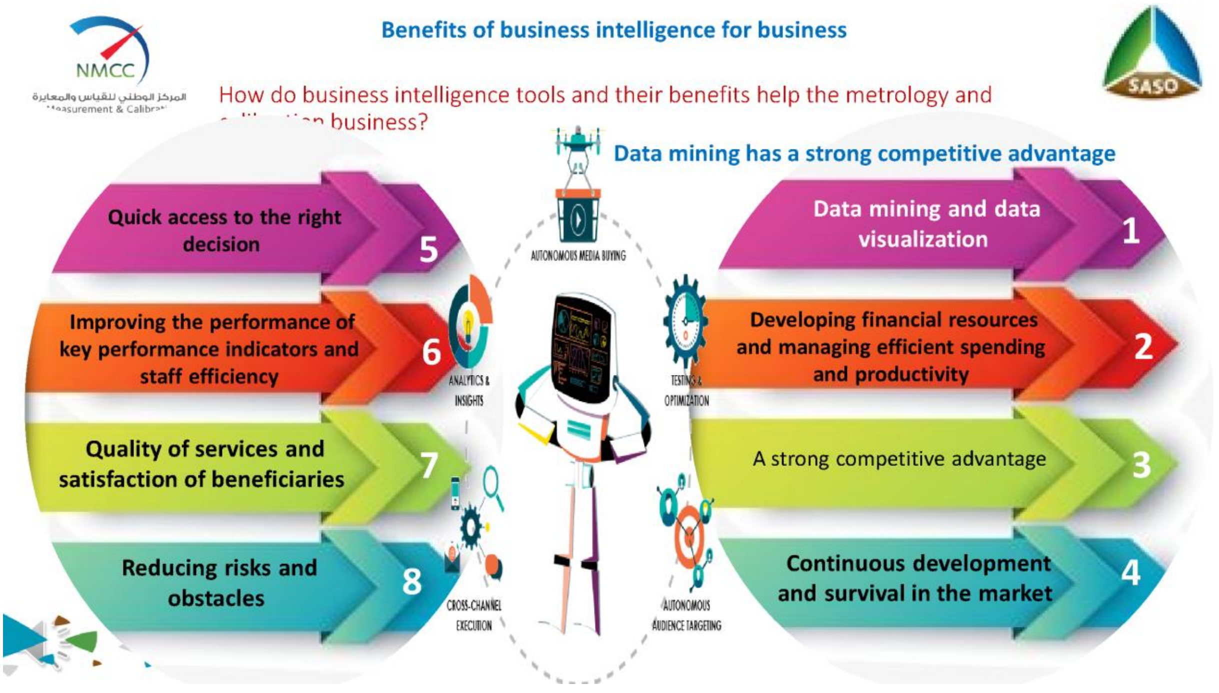

NMCC
Challenges of big data in global metrology work
SASO
methodological aspects
Define ways to access the data
Standardization of statistical concepts
Completing, processing, and disseminating data and other practices
Ensure the level of data quality and the possibility of international comparison
Work on building statistical capacities
Update the organizational structure with partners and private and public data
Digital communication and clouds with two users

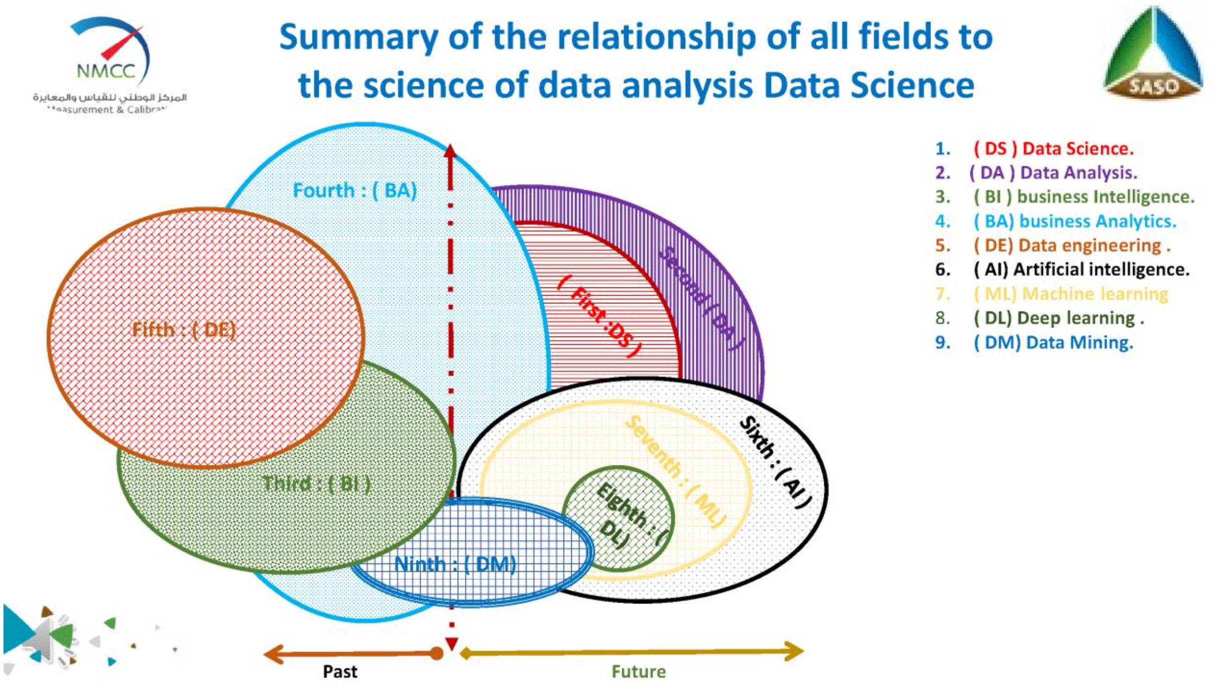
business intelligence "BI"

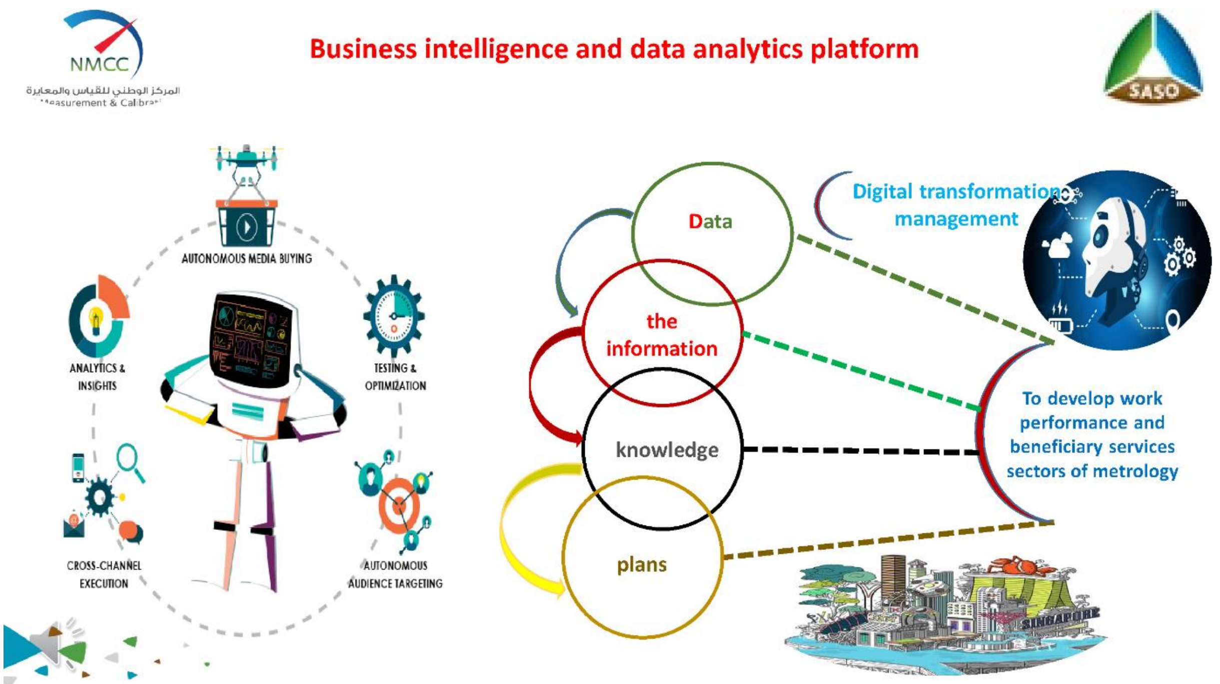
Components of business intelligence methodology

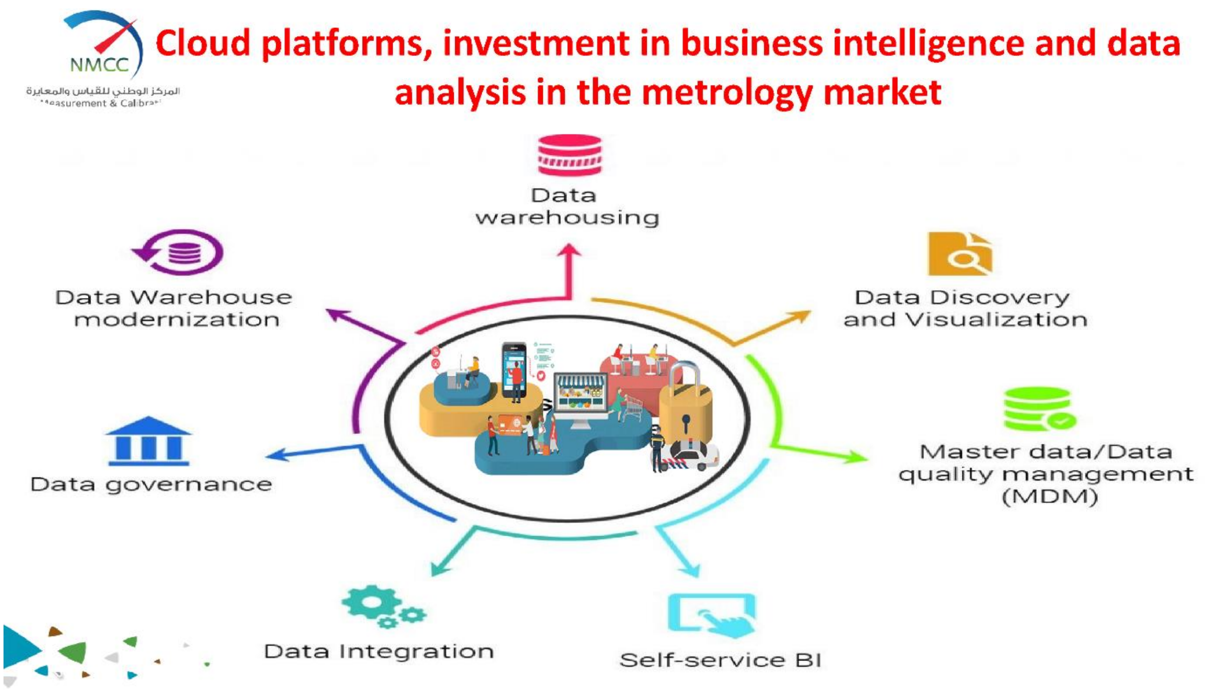


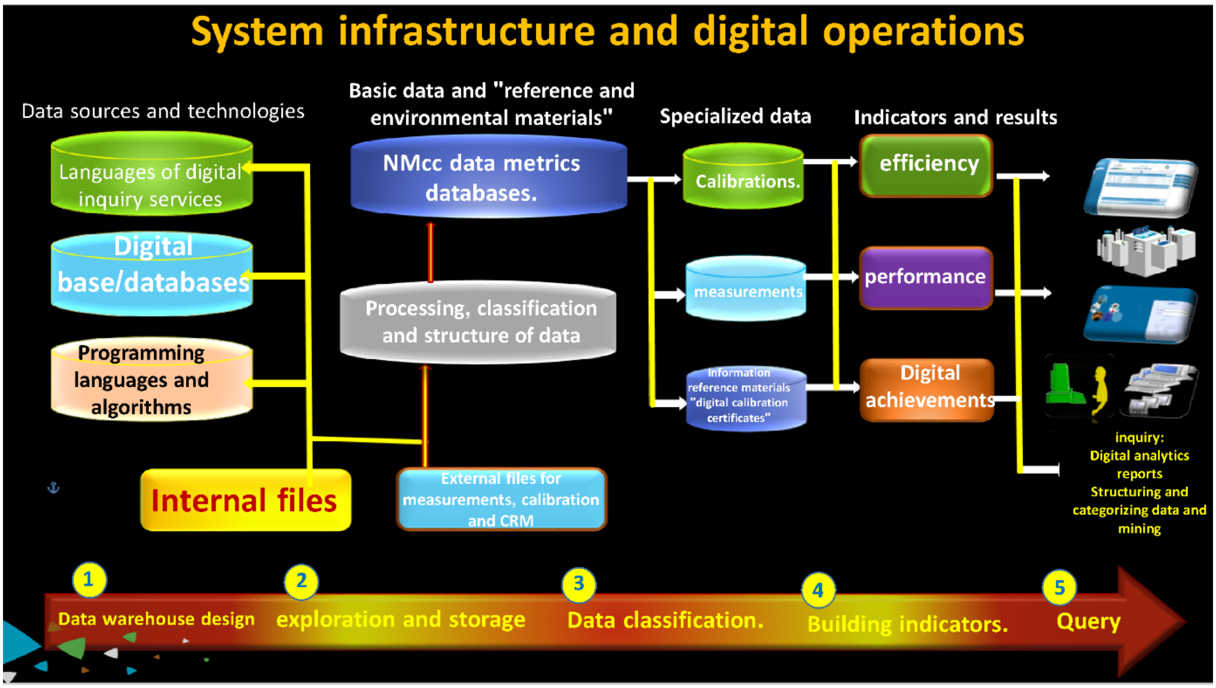

NMCC
Business intelligence stages
SASO
5
4
3
2
1
5. Decision making.
3. Data analysis.
1. Data preparation.
4. View the data.
2. Data collection.


NMCC
Benefits of business intelligence for business
SASO
How do business intelligence tools and their benefits help the metrology and
business?
Data mining has a strong competitive advantage
Quick access to the right decision 5
Improving the performance of key performance indicators and staff efficiency 6
Quality of services and satisfaction of beneficiaries 7
Reducing risks and obstacles 8
AUTONOMOUS MEDIA BUYING
ANALYTICS & INSIGHTS
TESTING & OPTIMIZATION
CROSS-CHANNEL EXECUTION
AUTONOMOUS AUDIENCE TARGETING
Data mining and data visualization 1
Developing financial resources and managing efficient spending and productivity 2
A strong competitive advantage 3
Continuous development and survival in the market 4


Summary of the relationship of all fields to the science of data analysis Data Science
NMCC
Fourth : (BA)
Fifth : (DE)
Third : (BI)
Ninth : (DM)
(First :DS)
Second (DA)
Sixth : (AI)
Seventh : (ML)
Eighth : (DL)
Past
Future
SASO
1. (DS) Data Science.
2. (DA) Data Analysis.
3. (BI) business Intelligence.
4. (BA) business Analytics.
5. (DE) Data engineering .
6. (AI) Artificial intelligence.
7. (ML) Machine learning
8. (DL) Deep learning .
9. (DM) Data Mining.


Business intelligence and data analytics platform
NMCC
SASO
AUTONOMOUS MEDIA BUYING
ANALYTICS & INSIGHTS
TESTING & OPTIMIZATION
CROSS-CHANNEL EXECUTION
AUTONOMOUS AUDIENCE TARGETING
Data
the information
knowledge
plans
Digital transformation management
To develop work performance and beneficiary services sectors of metrology


NMCC
Cloud platforms, investment in business intelligence and data analysis in the metrology market
Data warehousing
Data Warehouse modernization
Data Discovery and Visualization
Data governance
Master data/Data quality management (MDM)
Data Integration
Self-service BI


System infrastructure and digital operations
Data sources and technologies
Basic data and "reference and environmental materials"
Specialized data
Indicators and results
Languages of digital inquiry services
Digital base/databases
Programming languages and algorithms
Internal files
NMcc data metrics databases.
Processing, classification and structure of data
External files for measurements, calibration and CRM
Calibrations.
measurements
Information reference materials "digital calibration certificates"
efficiency
performance
Digital achievements
inquiry:
Digital analytics reports
Structuring and categorizing data and mining
1
Data warehouse design
2
exploration and storage
3
Data classification.
4
Building indicators.
5
Query

Digitization of gas reference material production and measurement processes in support of environmental sustainability

Steps to perform a single point calibration

Step: A

Choose the calibration gas mixture whose response cannot be statistically be distinguished from the response of the unknown sample and take at test 3 reading

Step: B

Take at least 3 readings from the unknown sample and calculate the mean peak area (y_s) and its standard uncertainty, u(y_s).

A mixture of (R) gas and sample are considered indistinguishable if they meet the following condition:

$$\frac{|y_r - y_s|}{2 \times \sqrt{u^2(y_r) + u^2(y_s)}} \leq 1$$

Step: C

If the condition of distinguishing of the two responses is fulfilled, the mole fraction (x) of unknown sample can be calculated from the equation:

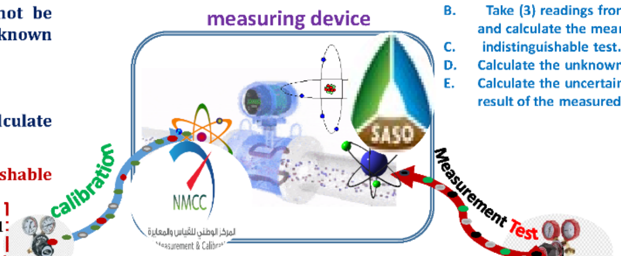
$$x_s = x_r \cdot \frac{y_s}{y_r}$$

x_s	*The mole fraction of the unknown sample*
x_r	*The mole fraction of the CRM*
y_s	*The peak area of the unknown sample*
y_r	*The peak area of the CRM*

Step: D

Repeat the gas mixture readings to verify system stability

The sequence of injection of the reference and the measured sample is as follows:
R (1) – R (2) – R (3) – S (1) –S (2) – S (3) – R (4) – R (5) – R (6)



Step: E

The uncertainty of the mole fraction is calcul[ated by] the following equation:

$$u(x_s) = \sqrt{u^2(x_r) - \frac{x_r^2}{y_r^2} \cdot \left[u^2(y_s) + u^2(\ldots\right.}$$

where

$u(x_s)$	*Standard uncertainty in the mole fraction of unknown sample*
$u^2(x_r)$	*The standard uncertainty in the mole fraction of the CRM*
x_r	*Mole fraction of the unknown sample*
y_r	*Peak area of the CRM*
$u(y_s)$	*Uncertainty of the peak area of the unknown sample*
$u(y_r)$	*Uncertainty of the peak area of the CRM*

A. Choose the reference gas (R) and measure it 3 Times .
B. Take (3) readings from the sample and calculate the mean.
C. indistinguishable test.
D. Calculate the unknown sample (S).
E. Calculate the uncertainty in the result of the measured sample (S).

مقطع

Thank you for attending and appreciating your participation and time

Advisor to the National Center for Measurement and Calibration
Saudi Standards, Metrology and Quality Organization
Eng. .Talaat Rahali

For further communication and inquiries, we welcome you to:

@SASOGOV

www.saso.gov.sa
T.rahali@saso.gov.sa 920009772

Parallel Session 2: Good Practice (GP)

Presentations that would also fit into this session:

- 06 The General DCC Rulebook and the Rules under the Aspects of Accreditation
- 10 Persistent Identification of Instruments and the Digital Calibration Certificate
- 17 The Digital NIST: Pilot Project for the Digital Transformation of NIST's Measurement Services
- 21 DKD's Contribution to DCC Harmonisation and Coordinated Development
- 22 GEMIMEG-II – Status and Progress Report
- 45 Digital Transformation of NMI: Practical Experience on DCC and Beyond @ NIS-Egypt
- 51 How does a Machine Distinguish the Different Types of DCCs?
- 54 Digital Calibration Certificate with MetricodeHUB, a Real Implementation Case

30 Calibration 4.0: A DCC Implementation in Electrical Metrology for the Calibration of Digital Multimeters

Presenting author: J. C. Suarez Baron, INTI, Argentina

E-mail address: jsuarez@inti.gob.ar

Additional authors: R.J. Iuzzolino and A. Tonina (both INTI)

Abstract

This work presents a case of study of a DCC applied to the calibration of digital multimeters at INTI. Such calibration requires over 50 points of measurement including DC, AC voltage and current and resistance. The calibration process is automated, and its results are stored in a spreadsheet file format. This file acts as input to a tool that generates an XML metadata-based file and finally a human readable certificate. In this way possible errors and workloads are reduced.

The DCC automation process will be presented to the calibration of a 6 ½ digit multimeter on the quantities described above, where its different functions and ranges with the corresponding uncertainties are finally reported.

This work applies solutions based on DCC and digital SI based on the structure scheme proposed by PTB. It also includes a validation scheme for data quality and trustworthiness.

Back to "Table of Contents" at page 1 | 2 | 3 | 4

Calibration 4.0: A DCC implementation in electrical metrology for the calibration of digital multimeters

Juan Carlos Suárez Barón, Alejandra Tonina, Ricardo Iuzzolino, Diego Coppa, Diego Calero
INTI and INCALIN-UNSAM

3rd International Digital Calibration Certificate (DCC) Conference
28th February 2023 - 2nd March 2023

Instituto Nacional de Tecnología Industrial
INTI

Ministerio de Economía Argentina

Secretaría de Industria y Desarrollo Productivo

Outline

- Identification of case study
- Case study implementation
  - Input
  - Output
  - Approach (Information flow)
  - Modules
  - Spreadsheets processing and XML generation
  - XML-DCC complexity
  - PDF/A-3 generation
- Next steps

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Identification of case study

Identification of case study

DCC generation for a HP 34401A DMM, 6½ Digit

Input

Spreadsheets (XSLX file) : Administrative data, calibration information and comments

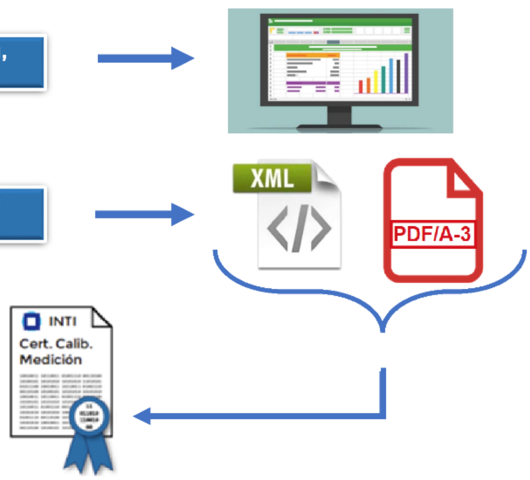
Output

DCC whose content adheres to D-SI and DCC schemas

DCC schema version: 3.0
D-SI schema version: 2.0

Validated DCC

GO FAIR



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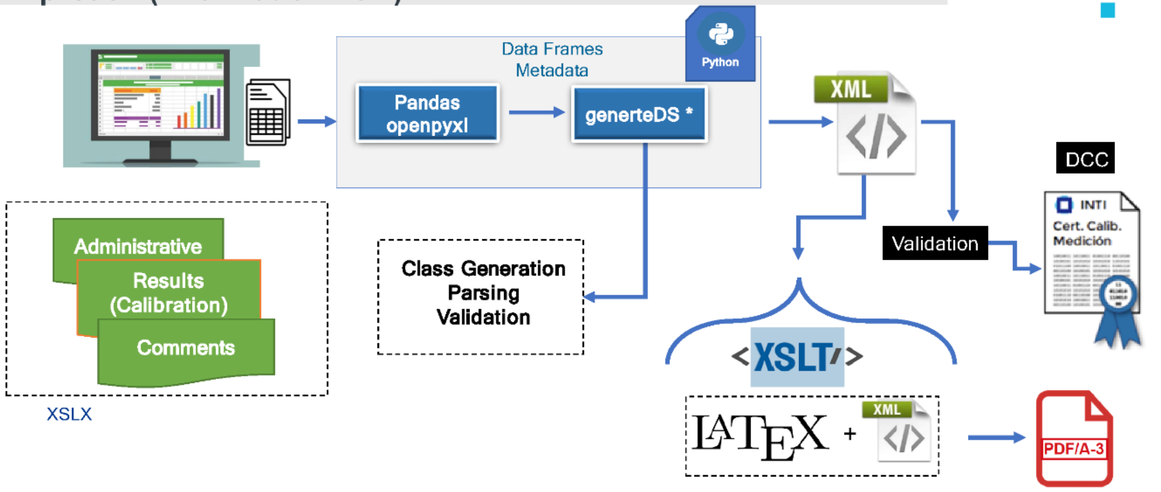
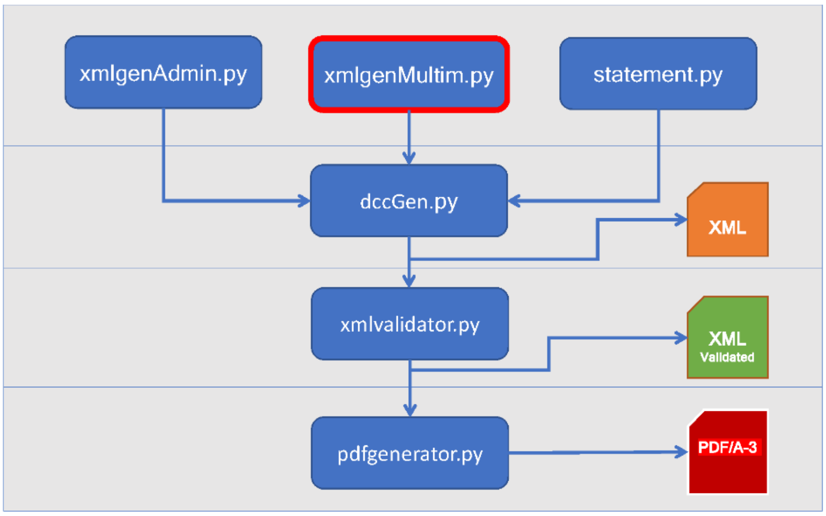
Case study implementation

Case study implementation
Aproach (information flow)



* For more information see:
Software for the creation of Machine-Readable and Human-Friendly Reports
by Diego Coppa at 12:30 (UTC) Wednesday.

Case study implementation
Modules



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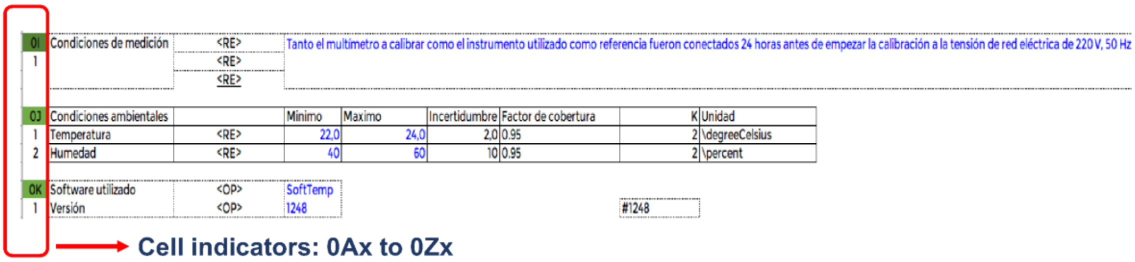
Spreadsheets processing and XML generation

Case study implementation

Spreadsheets processing and xml generation



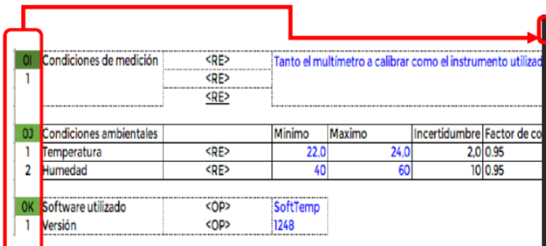
Cell indicators: 0Ax to 0Zx

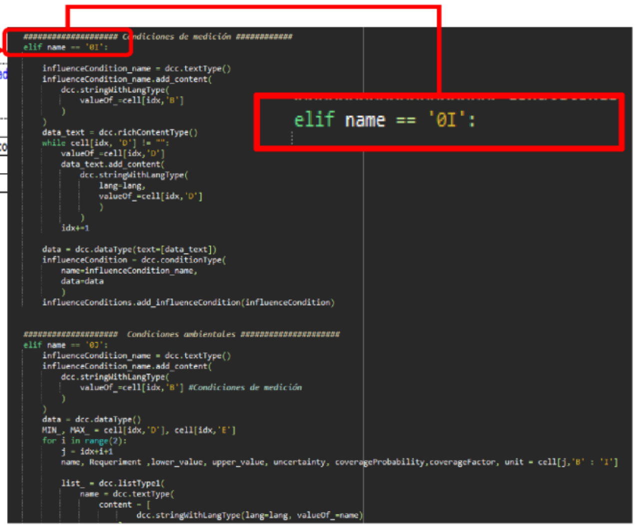
Fields:
<RE> Required
<OP> Optional

Information
Blue: Fields are editable by the metrologist.
Black: The fields are not editable by the metrologist.

Case study implementation

Spreadsheets processing and xml generation

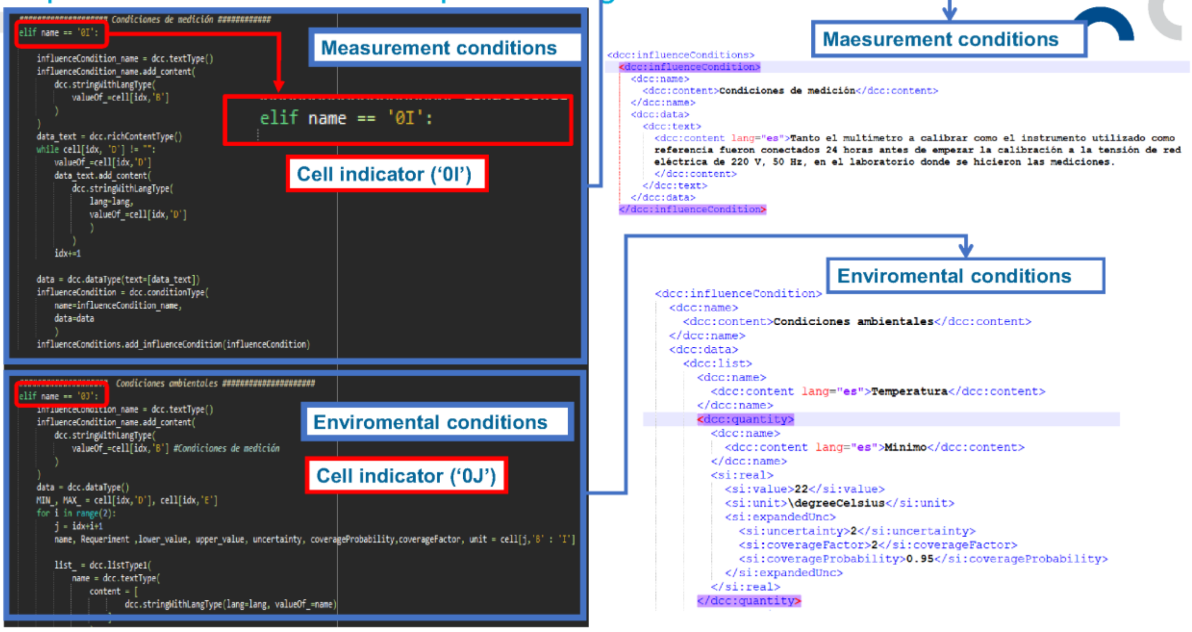




Cell indicators: 0Ax to 0Zx

<RE> Required
<OP> Optional

Spreadsheets: Read and processing it



Case study implementation

Spreadsheets processing and xml generation

Cell indicator

Results table example for DC Voltage

0M TENSIÓN CONTINUA

		RANGO		VALOR NOMINAL		ERROR		U		K	Nivel confianza
1	<RE>										
2	<RE>	0.1	\si{\volt}	0.1	\si{\volt}	-0.0000017	\si{\volt}	0.000002	\si{\volt}	2	0.95
3	<RE>	0.1	\si{\volt}	-0.1	\si{\volt}	0.0000015	\si{\volt}	0.000002	\si{\volt}		
4	<RE>	1	\si{\volt}	0.1	\si{\volt}	-0.0000003	\si{\volt}	0.000002	\si{\volt}		
5	<RE>	1	\si{\volt}	0.5	\si{\volt}	-0.0000011	\si{\volt}	0.000005	\si{\volt}		
6	<RE>	1	\si{\volt}	-1	\si{\volt}	0.0000029	\si{\volt}	0.000008	\si{\volt}		
7	<RE>	1	\si{\volt}	1	\si{\volt}	-0.0000024	\si{\volt}	0.000008	\si{\volt}		
8	<RE>	10	\si{\volt}	1	\si{\volt}	-0.000003	\si{\volt}	0.00001	\si{\volt}		
9	<RE>	10	\si{\volt}	3	\si{\volt}	-0.000012	\si{\volt}	0.00003	\si{\volt}		
10	<RE>	10	\si{\volt}	5	\si{\volt}	-0.000019	\si{\volt}	0.00005	\si{\volt}		
11	<RE>	10	\si{\volt}	7	\si{\volt}	0.000025	\si{\volt}	0.00007	\si{\volt}		
12	<RE>	10	\si{\volt}	10	\si{\volt}	0.00003	\si{\volt}	0.00008	\si{\volt}		

Administrativo | Resultados | Comentarios

Spreadsheets

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XML-DCC complexity

Case study implementation

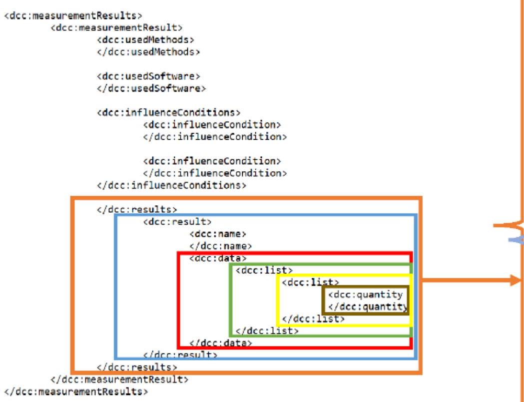
XML-DCC Complexity

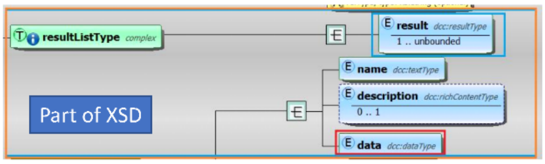
```xml
<dcc:measurementResults>
    <dcc:measurementResult>
        <dcc:usedMethods>
        </dcc:usedMethods>

        <dcc:usedSoftware>
        </dcc:usedSoftware>

        <dcc:influenceConditions>
            <dcc:influenceCondition>
            </dcc:influenceCondition>

            <dcc:influenceCondition>
            </dcc:influenceCondition>
        </dcc:influenceConditions>

        <dcc:results>
                <dcc:result>
                    <dcc:name>
                        </dcc:name>
                    <dcc:data>
                        <dcc:list>
                                <dcc:list>
                                    <dcc:quantity
                                        <quantity_1>
                                    </dcc:quantity>
                                    <dcc:quantity
                                        <quantity_2>
                                    </dcc:quantity>
                                    .
                                    .
                                    .
                                    <dcc:quantity
                                        <quantity_n>
                                    </dcc:quantity>
                                </dcc:list>
                        </dcc:list>
                    </dcc:data>
                </dcc:result>
        </dcc:results>
    </dcc:measurementResult>
</dcc:measurementResults>
```

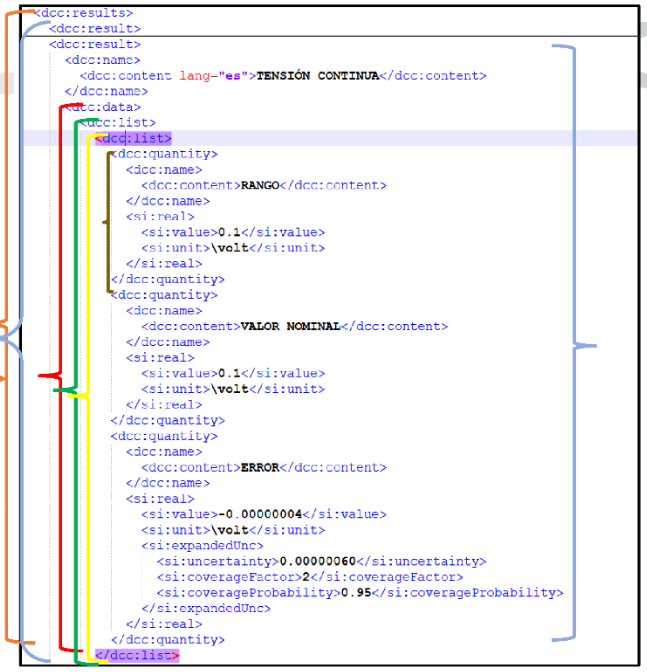
~6400 lines of code

Lists of quantities

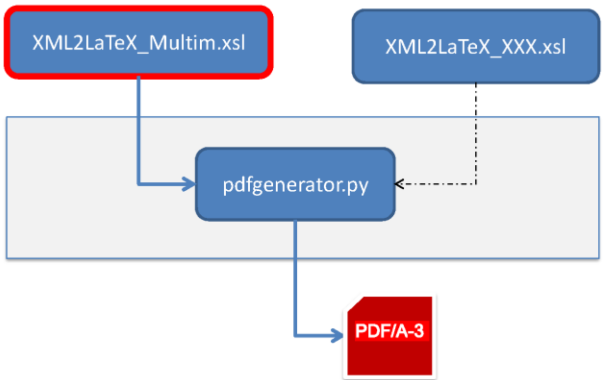
Case study implementation
XML-DCC Complexity







Case study implementation
PDF/A-3 generation



* For more information about PDF/A-3 generation process for DCC see:
Software for the creation of Machine-Readable and Human-Friendly Reports
by Diego Coppa at 12:30 (UTC) Wednesday.

XSL File

```
<?xml version="1.0" encoding="UTF-8"?>
<xsl:stylesheet xmlns:xsl="http://www.w3.org/1999/XSL/Transform"
                xmlns:dcc="https://ptb.de/dcc"
                xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                xmlns:si="https://ptb.de/si"
                xmlns:ext="extension"
                version="1.0">
    <xsl:strip-space elements="*"/>
    <xsl:output method="text" encoding="UTF-8" indent="no" omit-xml-declaration="yes"/>


<?test?>
<!--
documentclass: https://texblog.org/2013/02/13/latex-documentclass-options-illustrated/
test
-->
    <xsl:template match="/">
      <!--
      template general
      -->
      <xsl:text>
        \documentclass[a4paper]{article}
        \usepackage[includeheadfoot,
                    left=1.5cm,
                    right=1.5cm,
                    top=1.5cm,
                    bottom=1.5cm,
                    headheight=90pt,
                    ]{geometry}
        \usepackage{longtable}
        \usepackage{tabularx}
        \usepackage{lastpage}
        \usepackage{siunitx}
        \usepackage{fancyhdr}
        \usepackage{graphicx}
        \usepackage{enumitem}
        \usepackage{datetime2}
        \usepackage[utf8x]{inputenc}
```

LATEX XSL

```
<xsl:template match="dcc:results/dcc:result[2]">
  <xsl:text>
    \section*{
    </xsl:text>
    <xsl:value-of select="dcc:name/dcc:content"/>
    <xsl:text>
    }
  </xsl:text>
  <!-- <xsl:value-of select="dcc:description/dcc:content"/> -->
    <xsl:text>
    \begin{center}
    \begin{longtable}
    {|S[table-format=4.4, detect-weight]|S[table-format=4.4, detect-all]|S[table-format=4.4, detect-all]
     |S[table-format=4.4, detect-all]|}
    \hline
    \multicolumn{1}{|c|}{\textbf{Rango}} &amp;
    \multicolumn{1}{|c|}{\textbf{Valor nominal}} &amp;
    \multicolumn{1}{|c|}{\textbf{Error}} &amp;
    \multicolumn{1}{|c|}{\textbf{Incertidumbre}} \\ \hline
    \endfirsthead
    \endhead
    \endfoot
    \endlastfoot
    </xsl:text>
    <xsl:for-each select="dcc:data/dcc:list/dcc:list">
        <xsl:variable name = "rang_dcv" select="dcc:quantity[1]/si:real/si:value"/>
        <xsl:variable name = "unit_rang_dcv" select="dcc:quantity[1]/si:real/si:unit"/>
        <xsl:variable name = "valNom_dcv" select="dcc:quantity[2]/si:real/si:value"/>
        <xsl:variable name = "unit_valNom_dcv" select="dcc:quantity[2]/si:real/si:unit"/>
        <xsl:variable name = "error_dcv" select="dcc:quantity[3]/si:real/si:value"/>
        <xsl:variable name = "unit_error_dcv" select="dcc:quantity[3]/si:real/si:unit"/>
        <xsl:variable name = "uncert_dcv" select="dcc:quantity/si:real/si:expandedUnc/si:uncertainty"/>
            <!-- <xsl:value-of select="concat($rang_dcv,'', $unit_rang_dcv)"/> -->
            <xsl:value-of select="concat('\SI{',$rang_dcv,'}{',$unit_rang_dcv,'} ')"/>
                <xsl:text>&amp;</xsl:text>
            <xsl:value-of select="concat('\SI{',$valNom_dcv,'}{',$unit_valNom_dcv,'} ')"/>
                <xsl:text>&amp;</xsl:text>
            <xsl:value-of select="concat('\SI{',$error_dcv,'}{',$unit_error_dcv,'} ')"/>
                <xsl:text>&amp;</xsl:text>
            <xsl:value-of select="concat('\SI{',$uncert_dcv,'}{',$unit_error_dcv,'} ')"/>
                 <xsl:text>\\ \hline</xsl:text>
    </xsl:for-each>

    \end{longtable}
    \end{center}
</xsl:template>
```

HP 34401A DMM Calibration Certificate (PDF/A-3)

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Ministerio de Desarrollo Productivo Argentina

OT 00000222-00001423-Único
Página 1 de 11

Certificado de Calibración

Elemento
Objeto: tr
Fabricante/Marca: Hewlett Packard / Agilent
Modelo/Número de serie: 34401A
Id. del usuario: item 96

Determinaciones requeridas

Fecha de recepción 05/03/2022

Fecha de calibración Desde 11/03/2022 hasta 16/03/2022

Solicitante

Lugar de realización
INTI-GOMYC-SOMCEI-Departamento de Metrología Cuántica
Avenida General Paz 5445, Edificio 3 y 44 [CP 1650]
San Martín, Provincia de Buenos Aires, República Argentina
Teléfono: (54 11) 4752 5402 / (54 11) 4724 6200 (interno 7444)
E-mail: fisicaymetrologia@inti.gob.ar

Tensión Continua

Rango	Valor nominal	Error	Incertidumbre
0.1 V	0.1 V	-0.0000017 V	0.0000020 V
0.1 V	-0.1 V	0.0000015 V	0.0000020 V
1 V	0.1 V	-0.0000003 V	0.0000020 V
1 V	0.5 V	-0.0000011 V	0.0000050 V
1 V	-1 V	0.0000029 V	0.0000080 V
1 V	1 V	-0.0000024 V	0.0000080 V
10 V	1 V	-0.000003 V	0.000010 V
10 V	3 V	-0.000012 V	0.000030 V
10 V	5 V	-0.000019 V	0.000050 V
10 V	7 V	0.000025 V	0.000070 V
10 V	10 V	-0.000030 V	0.000080 V

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Next steps

Next steps

Migrate to DCC 3.1.X (PTB)

- Upgrade to D-SI 2.1.0
  - XMLList
- Attribute lists
- Relative uncertainty
  - <dcc:relativeUncertainty>

```xml
    </dcc:measurementMetaData>
</dcc:quantity>
<dcc:quantity refType="basic_measuredValue">
    <dcc:name>
        <dcc:content lang="en">Indicated measured value probe</dcc:content>
    </dcc:name>
        <si:hybrid>
            <si:realListXMLList>
                <si:valueXMLList>306.35 373.45 448.05 523.05 593.35</si:valueXMLList>
                <si:unitXMLList>\kelvin</si:unitXMLList>
            </si:realListXMLList>
            <si:realListXMLList>
                <si:valueXMLList>33.2 100.3 174.9 249.9 320.2</si:valueXMLList>
                <si:unitXMLList>\degreecelsius</si:unitXMLList>
            </si:realListXMLList>
        </si:hybrid>
</dcc:quantity>
```

refType_area1	basic_measuredValue	basic_measurementError				
	Measured value/ K	Measurement error / K	U (Measurement error)			
			/ K			
refType_area2						
refType_area3						
	306.35	0.105	0.89	2	0.95	normal
	373.45	0.323	0.89	2	0.95	normal
	448.05	-0.199	0.89	2	0.95	normal
	523.05	-0.271	0.89	2	0.95	normal
	593.35	0.199	0.89	2	0.95	normal

Example taken from
dcc_gp_temperature_simplified_v12.xml
https://dccwiki.ptb.de/en/gp_home

For more information see DOI: https://doi.org/10.7795/820.20220411 and https://www.ptb.de/dcc/v3.1.2/

Next steps

Migrate to DCC 3.1.X (PTB)

refType_area1	basic_measuredValue	basic_measurementError				
	Measured value/ K	Measurement error / K	U (Measurement error)			
			/ K			
refType_area2						
refType_area3						
	306.35	0.105	0.89	2	0.95	normal
	373.45	0.323	0.89	2	0.95	normal
	448.05	-0.199	0.89	2	0.95	normal
	523.05	-0.271	0.89	2	0.95	normal
	593.35	0.199	0.89	2	0.95	normal

```xml
    </dcc:measurementMetaData>
</dcc:quantity>
<dcc:quantity refType="basic_measuredValue">
    <dcc:name>
        <dcc:content lang="en">Indicated measured value probe</dcc:content>
    </dcc:name>
        <si:hybrid>
            <si:realListXMLList>
                <si:valueXMLList>306.35 373.45 448.05 523.05 593.35</si:valueXMLList>
                <si:unitXMLList>\kelvin</si:unitXMLList>
            </si:realListXMLList>
            <si:realListXMLList>
                <si:valueXMLList>33.2 100.3 174.9 249.9 320.2</si:valueXMLList>
                <si:unitXMLList>\degreecelsius</si:unitXMLList>
            </si:realListXMLList>
        </si:hybrid>
</dcc:quantity>
<dcc:quantity refType="basic_measurementError">
    <dcc:name>
        <dcc:content lang="en">Measurement error</dcc:content>
    </dcc:name>
    <si:realListXMLList>
        <si:valueXMLList>0.105 0.323 -0.199 -0.271 0.199</si:valueXMLList>
        <si:unitXMLList>\kelvin</si:unitXMLList>
        <si:expandedUncXMLList>
            <si:uncertaintyXMLList>0.89</si:uncertaintyXMLList>
            <si:coverageFactorXMLList>2</si:coverageFactorXMLList>
            <si:coverageProbabilityXMLList>0.95</si:coverageProbabilityXMLList>
            <si:distributionXMLList>normal</si:distributionXMLList>
        </si:expandedUncXMLList>
    </si:realListXMLList>
    <dcc:measurementMetaData>
```

- Upgrade to D-SI 2.1.0
    - XMLList
- Attribute lists
- refType
- Relative uncertainty
    - <dcc:relativeUncertainty>

Example taken from
dcc_gp_temperature_simplified_v12.xml
https://dccwiki.ptb.de/en/gp_home

For more information see DOI: https://doi.org/10.7795/820.20220411 and https://www.ptb.de/dcc/v3.1.2/

<Thank you for your attention!!!>
<jsuarez@inti.gob.ar>

INTIArg
@INTIargentina
INTI
@intiargentina
canalinti

Instituto Nacional
de Tecnología Industrial
INTI

Ministerio de Economía
Argentina

Secretaría de Industria
y Desarrollo Productivo

31 DCCs for Non-Automatic Weighing Instruments (NAWIs) – Current Status of a Respective Working Group Elaborating "Good Practice" Conventions

Presenting author: Dr. Julian Haller, Sartorius Lab Instruments GmbH & Co. KG, Germany

E-mail address: julian.haller@sartorius.com

Abstract

The advantages of the digital calibration certificate (DCC) for the management of test equipment and further processing of calibration data are obvious. The XML scheme developed by the PTB for the DCC is designed to be very flexible so that it can be applied to all possible measuring devices with their peculiarities. However, due to the great flexibility of the DCC schema, there are different possible ways of implementation in accordance with the XML schema for almost every aspect. This entails the risk that the implementations of different laboratories are not compatible with each other and that users have to adapt their input software to the implementation of the respective laboratory. Such lack of compatibility may jeopardize user acceptance and ultimately the success of the entire DCC implementation.

Therefore, it is inevitable that "good practice" agreements should be made for general aspects as well as for instrument-specific aspects.

For the calibration of non-automatic weighing instruments (NAWIs), a working group has been established within the Technical Committee "Mass and Weighing Instruments" of the DKD (German Association of Accredited Calibration Laboratories) to define and formulate the corresponding "good practice" agreements. The group consists of experts from PTB, EURAMET and renowned manufacturers and calibration laboratories for NAWIs.

The purpose of this presentation is to present the current status of the working group's progress in defining "good practice" agreements for NAWIs and provide an overview of the expected timetable.

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```xml
<dcc:result>
 <dcc:name>Error of Indication, Test Load 3</dcc:name>
 <dcc:description>Error of Indication, Test Load 3</dcc:description>
<dcc:data>
<dcc:quantity>
     <dcc:name>
          <dcc:content lang="en">Nominal Load</dcc:content>
     </dcc:name>
     <si:real>
          <si:value>100</si:value>
           <si:unit>\gram</si:unit>
     </si:real>
</dcc:quantity>
<dcc:quantity>
     <dcc:name>
               <dcc:content lang="en">ReferenceValue</dcc:content>
     </dcc:name>
     <si:real>
          <si:value>0.00004</si:value>
           <si:unit>\gram</si:unit>
           <si:expandedUnc>
           <si:uncertainty>0.000012</si:uncertainty>
           <si:coverageFactor>2</si:coverageFactor>
           <si:coverageProbability>0.95</si:coverageProbability>
           </si:expandedUnc>
     </si:real>
</dcc:quantity>
<dcc:quantity>
     <dcc:name>
               <dcc:content lang="en">MeasuredValue</dcc:content>
     </dcc:name>
     <si:real>
          <si:value>0.00004</si:value>
           <si:unit>\gram</si:unit>
           <si:expandedUnc>
           <si:uncertainty>0.000016</si:uncertainty>
           <si:coverageFactor>2</si:coverageFactor>
           <si:coverageProbability>0.95</si:coverageProbability>
           </si:expandedUnc>
     </si:real>
</dcc:quantity>
<dcc:quantity>
     <dcc:name>
               <dcc:content lang="en">Deviation</dcc:content>
     </dcc:name>
     <si:real>
          <si:value>0.00004</si:value>
           <si:unit>\gram</si:unit>
           <si:expandedUnc>
           <si:uncertainty>0.000022</si:uncertainty>
           <si:coverageFactor>2</si:coverageFactor>
           <si:coverageProbability>0.95</si:coverageProbability>
           </si:expandedUnc>
```


DCCs for NAWIs – current status of a respective working group elaborating "Good Practice" conventions

Dr. Julian Haller, Sartorius Lab Instruments GmbH & Co. KG, 01.03.2023

DKD Working Group DCC „Best Practice" for NAWIs

- DKD Working Group established with members of the DKD expert committee "Mass and Weighing Instruments"
- Aim:
  - Quickly publish a simple best practice example to establish a standard for NAWIs
  - Provide proper documentation of the best practice conventions
  - Publish further, more complex examples
- Kick-off meeting March 2022
- Several meetings online, face-to-face meeting on 29.11.2022
- "Simple" DCC NAWI Best Practice Example almost finished

Members

D. Knopf (PTB)

S. Hackel (PTB)

K. Fritsch, K. Müller (Mettler-Toledo)

M. Häfner (Häfner)

P. Straubinger (Bizerba)

S. Osang (Minebea, DKD-FA)

M. Turino (Kern)

Z. Zelenka (BEV, EURAMET TC-M)

J. Haller (Sartorius)

Support

J. Pedro Santos da Costa (BEV, EURAMET DCC Support Officer)

C. Müller-Schöll (Mettler-Toledo)

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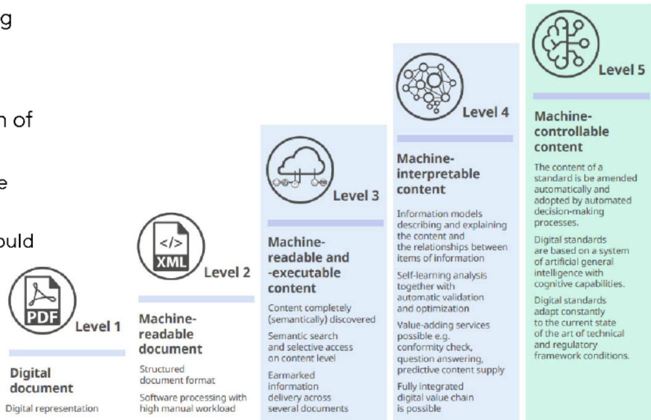
Why are best practice conventions necessary?

- „Level 2" can be achieved quite easily – e.g. using PTB's GEMIMEG tool
- For a universal (i.e. not proprietary) digitalization of processes, we need ***at least*** Level 3:
  - DCCs from different labs must be machine-readable with the same software
  - DCCs for similar types of measuring instruments should be machine-interpretable
  - -> Harmonization



Source: DIN/DKE: Scenarios for digitizing standardization and standards, White Paper (2021)

Different presentations in analogue certificates

Messung *Measuring*	Wiederholbarkeit *Repeatability* Prüflast(Nennwert) 1000 g
1	1000,0000 g
2	1000,0000 g
3	1000,0002 g
4	1000,0000 g
5	1000,0000 g
Standardabweichung *Standard deviation*	s = 0,00009 g

Prüfung auf Wiederholbarkeit

bei Prüflast von: 10 kg

Messung	Anzeige	
Nr.	vor Justage	nach Justage
1	9,9995 kg	
2	9,9995 kg	
3	9,9995 kg	
4	9,9995 kg	
5	9,9995 kg	
Mittelwert	9,99950 kg	
Standardab-weichung	0,00000 kg	

Wiederholbarkeit / *Repeatability*

Last *Load*	110 g
Messung *Measurement*	Anzeige *Indication*
1	110,0001 g
2	109,9998 g
3	109,9998 g
4	109,9998 g
5	109,9999 g
6	110,0000 g

Standardabweichung / *Standard deviation*

s aus 6 Messungen *s from 6 measurements*	0,00013 g

Repeatability test (measurements) **בדיקת הדירות (מדידות)**

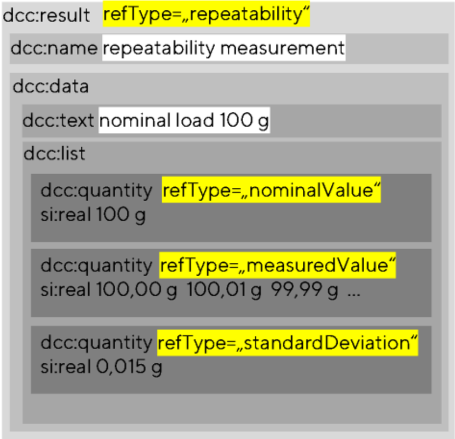
תוצאות מדידה Measurement results	מסה מועמסת Load Mass	תוצאות מדידה Measurement results	מסה מועמסת Load Mass
200.00003	200.00000	99.99994	100.00000
199.99999		99.99996	
199.99998		99.99992	
199.99997		99.99996	
199.99998		99.99994	
200.00004		99.99995	

Challenge for a machine (Software):

Identify…

- …the nominal load
- …the standard deviation
- …the mean value
- …that this is a repeatablity measurement

Using refType attributes in DCCs



- Allows for machines (software) to „understand“, what is inside a dcc element
- Needs clear definitions:

measuredValue

quantity value representing a measurement result

PREFIX:	basic_
NOTE:	compare VIM 2.10 "measured quantity value"
ELEMENT:	dcc:quantity

- Which refTypes are specific for NAWIs (prefix NAWI_) and which are universal (prefix basic_)

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Using refType attributes in DCCs

- Close collaboration concerning refType definitions with the DCC Mass Best Practice team, see next presentation:

32	Digital Calibration Certificates for Weights and Mass Standards: Rules and Applications	Gisa Foyer, PTB, Germany

- Procedure established to suggest universal („basic_“) refType definitions, see respective presentation tomorrow:

49	Processes and Conventions for the DCC – Results of PTB's 100-Day Programmes in 2022	Shanna Schönhals, PTB, Germany

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DCCs for NAWIs – current status, Julian Haller

Further prerequisite for universal usage: General structure

Example: How to present results of multiple range instruments?

Option 1

- dcc:measurementResults
  - dcc:measurementResult range1
    - dcc:usedMethods
    - dcc:influenceConditions
      - dcc:influenceCondition (Max=120 g d=0,01 mg)
    - dcc:measuringEquipment
    - dcc:results
      - dcc:result repeatability
      - dcc:result eccentricity
      - dcc:result errorOfIndication
  - dcc:measurementResult range2
    - dcc:usedMethods
    - dcc:influenceConditions
      - dcc:influenceCondition (Max=220 g d=0,1 mg)
    - dcc:measuringEquipment
    - dcc:results
      - dcc:result repeatability
      - dcc:result eccentricity
      - dcc:result errorOfIndication

Option 2

- dcc:measurementResults
  - dcc:measurementResult
    - dcc:usedMethods
    - dcc:influenceConditions
      - dcc:influenceCondition range 1 (Max=120 g d=0,01 mg)
      - dcc:influenceCondition range 2 (Max=120 g d=0,01 mg)
    - dcc:measuringEquipment
    - dcc:results
      - dcc:result repeatability range1
      - dcc:result eccentricity range1
      - dcc:result errorOfIndication range1
      - dcc:result repeatability range2
      - dcc:result eccentricity range2
      - dcc:result errorOfIndication range2

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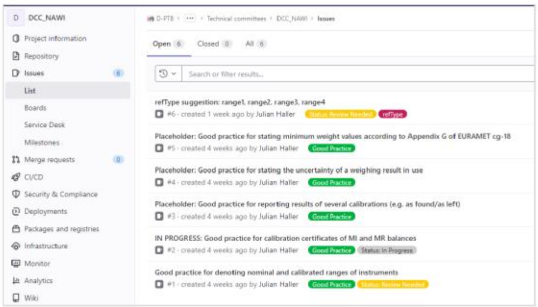
DCCs for NAWIs – current status, Julian Haller

Documentation

Discussion, documentation,.... in a PTB hosted Gitlab project for DCC NAWI:



Concerning the Gitlab work, see also:

32	Digital Calibration Certificates for Weights and Mass Standards: Rules and Applications	Gisa Foyer, PTB, Germany
49	Processes and Conventions for the DCC – Results of PTB's 100-Day Programmes in 2022	Shanna Schönhals, PTB, Germany

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DCC „Best Practice“ for NAWIs – next steps

- Implement the „simple“ Best Practice Example into PTB's dccwiki and GEMIMEG tool
  - Finalization of the example still to be done
- Create and publish list of NAWI_refTypes
  - List has been created – definitions and explanations still to be completed
- Create and publish accompanying document
- Discuss and document conventions for topics above the „simple“ example:
  - Structure for MR and MI instruments
  - Multiple measurements (e.g. „as found/as left“)
  - Conformity statemenents
  - Formulas for characteristic curves and uncertainty
  - Minimum net weight
  - ...

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Conclusion

- „Simple“ DCC NAWI Good Practice Example is almost finished. Proper documentation still to be copleted
- Extensions above the „simple“ case (MR/MI, „Uncertainty in use“, Minimum net weight,....) still to be discussed/documented
- An infrastructure has been established to foward topics to be discussed, decided and documented for universal considerations
- The industry is called upon to participate with concrete proposals for harmonization
- Users must prepare to be able to handle changes
- **Not much visible to the outside world (yet), but a lot is happening....**

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Thank you.

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32 Digital Calibration Certificates for Weights and Mass Standards: Rules and Applications

Presenting author: Gisa Foyer, Physikalisch-Technische Bundesanstalt, Germany and Martin Häfner, Häfner Gewichte GmbH, Germany

E-mail address: gisa.foyer@ptb.de, mh@haefner.de

Additional authors: Julian Haller, Sartorius Lab instruments GmbH & Co. KG, Germany; Christian Müller-Schöll, Mettler-Toledo GmbH, Switzerland

Abstract

In 2021, the DKD technical committee "Mass and Weighing Instruments" formed an expert group to discuss the use of the digital calibration certificate schema for the calibration of weights. The results of the extensive discussions were published in an expert report "Instructions on how to use the DCC schema to create a digital calibration certificate for weights" in 2022. The expert group refocused afterwards on applying the instructions on the calibration certificates of mass standards as well as on more detailed discussions about conventions and good practices.

The first part of the presentation will give an overview of the work within the DKD technical committee on weights. This includes mass specific topics such as the reporting of the actual results in a machine-readable and -identifiable way for both conventional weight and mass and describing the calibration item for weight sets and mass standards. Furthermore, more general topics as for example reporting of different locations, the indication of compliance with CMCs or the use of the refType-attribute have been discussed and a summary of the results will be given.

In the second part of the presentation, an example of a practical application of a DCC for weights will be shown. The example shows how a DCC for a weight set, as a future industry standard, can be imported into a balance calibration software. In this process, detailed information on weights, such as conventional mass, measurement uncertainty, maximum permissible error, marking, density, etc., is digitally processed. Until now, this information has been imported via proprietary formats or had to be entered manually by hand, resulting in significant time effort and the risk of transmission errors.

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Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin
Nationales Metrologieinstitut

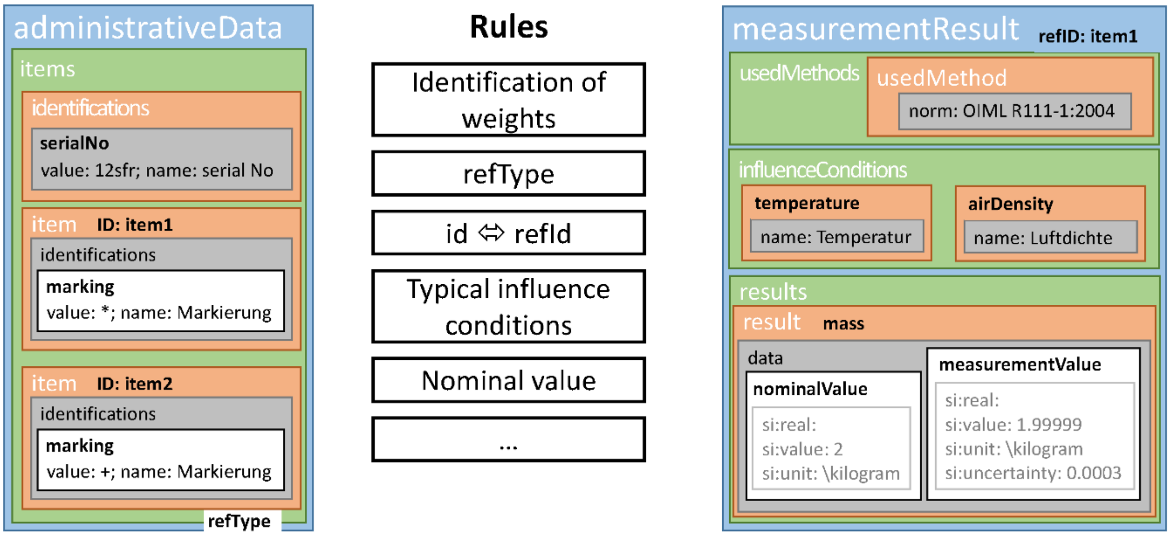
DKD

Digital calibration certificates for weights and mass standards: rules and applications – Part 1: Rules

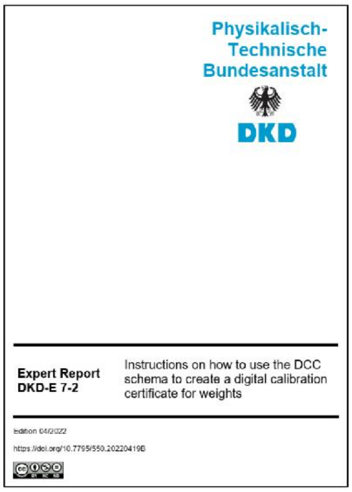
Gisa Foyer, Martin Häfner, Julian Haller, Christian Müller-Schöll

3rd International DCC Conference

The DCC for weights ➔ rules in example



Expert report (April 2022)


Physikalisch-
Technische
Bundesanstalt

DKD

Expert Report
DKD-E 7-2

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

Edition 04/2022

https://doi.org/10.7795/550.20220419B

Main element	Sub-element	Sample value	refType
influenceCondition	*name*	Temperature	*temperature (influenceCondition)*
	data	21.5°C U = 0.5°C (k = 2)	-
influenceCondition	*name*	Density of the weight	*density (influenceCondition)*
	data	8010 kg/m³ U = 30 kg/m³ (k = 2)	-
influenceCondition	*name*	Air density	*airDensity (influenceCondition)*
	data	1.1635 kg/m³ U = 0.0035 kg/m³ (k = 2)	-
influenceCondition	*name*	Relative humidity	*humidity (influenceCondition)*
	data	0.417 U = 0.020 (k = 2)	-
influenceCondition	*name*	Air pressure	*airPressure (influenceCondition)*
	data (with 2 *quantity* elements)	1008.04 hPa U = 0.06 hPa (k = 2)	*min*
		1008.18 hPa U = 0.06 hPa (k = 2)	*max*

Table 6: Example of contents in the element *influenceCondition*

List of identified possible *refTypes* especially in the results part (usable in the elements *influenceCondition* – chapter 4.2, results – chapter 4.4 und *measurementMetaData* – chapter 4.5):

- *humidity*
- *temperature*
- *airpressure*
- *volume*
- *density*
- *mass*
- *conventionalWeighingValue*
- *min*
- *max*
- *nominalValue* (only to be used in the *result* element)
- *measurementValue* (only to be used in the *result* element)
- *referencedValue*
- *measurementDeviation* (only to be used in the *result* element)
- *meanValue*

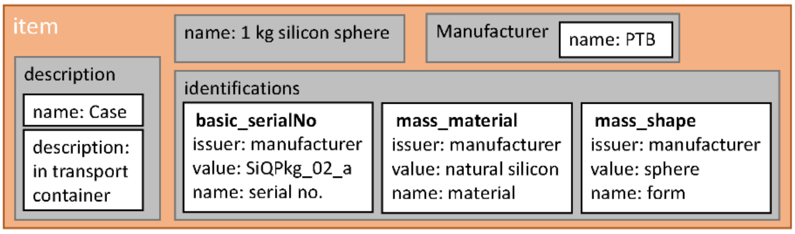
Element (English)	Element (German)	Remarks, Explanation	necessary, optional	DCC Element	Erläuterung
Material	Material	Text, for verification of correctness by human only	optional	dcc:administrativeData: items:item: identifications: identification	issuer: manufacturer value: stainless steel description: "Material"
Differentiator	Unterscheidungs-merkmal	Differentiator marking if two items with the same nominal value in the set	necessary if two items with same nominal	dcc:administrativeData: items:item: identifications: identification	issuer: manufacturer value: " description: "Zusatz-identifikation"
UserMarking1	Benutzermarkierung 1	User marking on weight	optional	dcc:administrativeData: items:item: identifications: identification	issuer: owner value: 213 description: "Nutzer-markierung 1"
UserMarking2	Benutzermarkierung 2	User marking on weight	optional	dcc:administrativeData: items:item: identifications: identification	issuer: owner value: ABC description: "Nutzer-markierung 2"
Method of density determination	Methode der Dichte-bestimmung	For OIML can be structured reference to OIML R111	necessary	dcc:measurementResults: measurementResult: influenceConditions: influenceCondition: data:quantity: usedMethods: usedMethod	

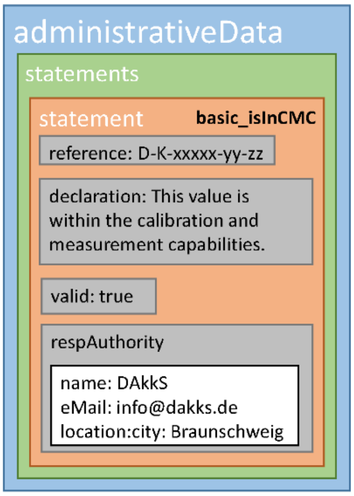
Appendix B Example of a digital calibration certificate for a single weight


```
<?xml version="1.0" encoding="UTF-8"?>

<dcc:digitalCalibrationCertificate
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="https://ptb.de/dcc https://ptb.de/dcc/v3.0.0/dcc.xsd"
xmlns:dcc="https://ptb.de/dcc"
xmlns:si="https://ptb.de/si" schemaVersion="3.0.0">

<!-- This is an example for a single weight. The example has been created by DKD's Technical Committee Mass and Weighing Instruments
    Version of the example: V1.3 , Date: 19.04.2022   -->

<dcc:administrativeData>
<dcc:dccSoftware>
<dcc:software>
<dcc:name>
<dcc:content>WebStorm</dcc:content>
</dcc:name>
<dcc:release>2019.1.3</dcc:release>
</dcc:software>
</dcc:dccSoftware>
```


What happened next…

Expert group active again since September 2022





nominalValue

rounded or approximate value of a characterizing quantity of a measuring instrument or measuring system that provides guidance for its appropriate use

PREFIX:	mass_
NOTE 1:	VIM 4.6 „nominal quantity value"
NOTE 2:	nominal value can be a means of identification and part of a result
ELEMENT 1:	dcc:identification in dcc:item
ELEMENT 2:	dcc:quantity

Digital calibration certificates for weights and mass standards: rules and applications – Part 2: Applications

A practical realization of the DCC for weights

Martin Häfner

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Expert Working Group for DCC-Mass

Further Members:
PTB, BEV, Mettler, Sartorius

Group meetings
(e.g. sprint meetings with 2 100 days programs)

Important basic work in the development of the DCC for mass since 2019.
The result was the implementation of a DCC in "Good Practice“ with model examples.

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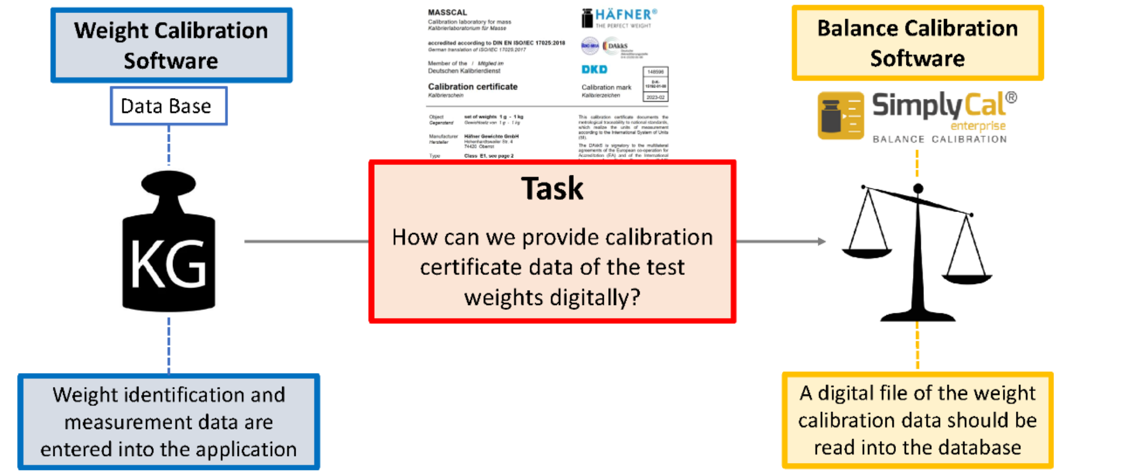
Use Case for Test Weights



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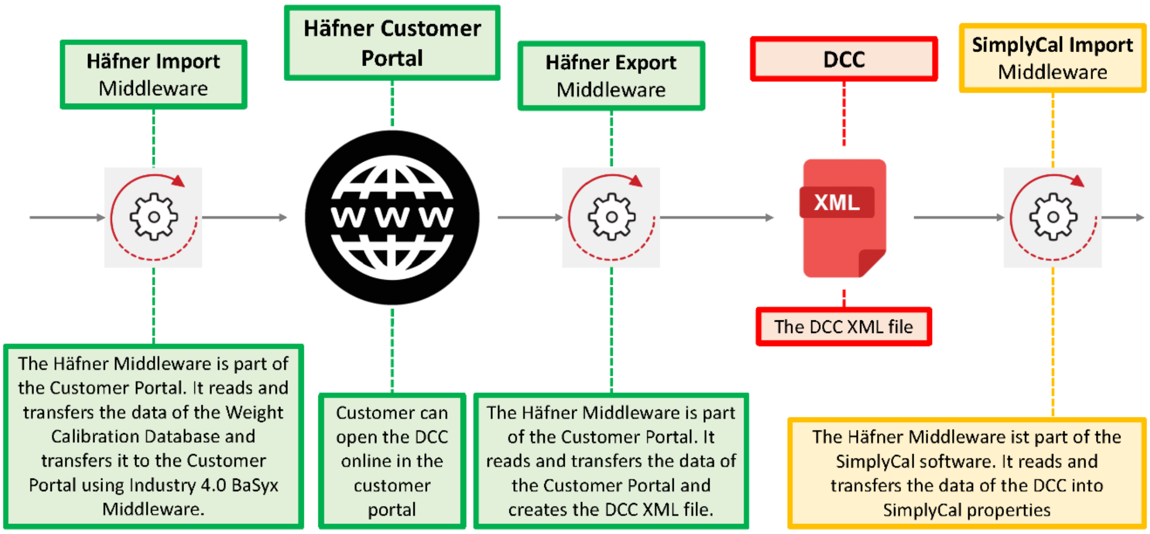
Implementation of a DCC for weights



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From Calibration Certificate to DCC

HÄFNER® THE PERFECT WEIGHT

Gegenstand *Object*	**Gewichtsatz von 1 g - 1 kg** ***set of weights 1 g - 1 kg***
Hersteller *Manufacturer*	**Häfner Gewichte GmbH** **Hohenhardtsweiler Str. 4** **74420 Oberrot**
Typ *Type*	**Klasse E2, siehe Seite 2** ***Class E2, see page 2***
Fabr./Ser.-Nr. *Serial number*	**1600508**
Ident-Nr. *Ident number*	
Auftraggeber *Customer*	**Ebinger Waagenbau GmbH** **Obere Riedwiesen 15** **D-74427 Fichtenberg**
Auftragsnummer *Order No.*	**171232**
Anzahl der Seiten des Kalibrierscheines *Number of pages of the certificate*	**4**
Datum der Kalibrierung *Date of calibration*	**25.02.2020 - 26.02.2020**

ilac-MRA DAkkS Deutsche Akkreditierungsstelle D-K-15192-01-00

Kalibrierzeichen
Calibration mark

115030
D-K-15192-01-00
2020-02

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The Customer Portal from Häfner

HÄFNER® THE PERFECT WEIGHT

HÄFNER® THE PERFECT WEIGHT — Calibration certificate portal — Sign out

You are logged in as Mr. Max Mustermann

Dashboard / Overview of my calibration certificates / Calibration certificate details

Calibration certificate details

Here you can see all the details of your calibration certificate.

Calibration certificate no.	Order no. (calibration laboratory)	Order no. (customer)
115030	171232	2020#0120
Calibration date	**Calibration mark**	**Reference normals**
2020-02-26	115030 - D-K-15192-01-00 - 2020-03	--- - GS 13 - ---
Calibration status		
4 from 4		

to the weight set

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Details of the Weight Set

HÄFNER® THE PERFECT WEIGHT

HÄFNER® THE PERFECT WEIGHT

Calibration certificate portal

Sign out

You are logged in as Mr. Max Mustermann

Dashboard / Overview of my weight sets / Weight set details

Weight set details

Here you can see all the details of your weight set.

Your ID no.	Designation	Serial no.
Id-19731211	1 g - 1 kg	1600508

Manufacturer	Weight class	Error limit system
Häfner Gewichte GmbH	F2	OIML

Current calibration status: 4

Recalibration interval (months): 48

Calibration date	Recalibration date (Self-determined)	Recalibration date (Laboratory recommendation)
2020-02-26	2024-02-26	2024-01-10

Save

Details of the weights

HÄFNER® THE PERFECT WEIGHT

Weights

Nominal value	Marking	Conventional mass value	Measurement uncertainty U(k=2)	MPE	En-value	Valuation MPE
1 g	[without]	1 g +0.014 mg	0.010 mg	±0.03 mg	0.35	0.80
2 g	[without]	2 g +0.015 mg	0.012 mg	±0.04 mg	0.06	0.68
2 g	.	2 g +0.011 mg	0.012 mg	±0.04 mg	0.06	0.58
5 g	[without]	5 g +0.021 mg	0.016 mg	±0.05 mg	0.09	0.74
10 g	[without]	10 g +0.025 mg	0.020 mg	±0.06 mg	0.35	0.75

Download of DCC

HÄFNER® THE PERFECT WEIGHT

Calibration certificate downloads

Here you can find all downloads for your calibration certificate.

File name	File type	File size
Download PDF	PDF	1.28 MB
Download SimplyCal	CSV	0.14 MB
Download DCC	XML	1.97 MB

Rules in application: items

HÄFNER® THE PERFECT WEIGHT

```xml
<dcc:items>
  <dcc:name>
    <dcc:content lang="en">1 set of weights with 13 weights, 1 g - 1 kg</dcc:content>
  </dcc:name>
  <dcc:equipmentClass id="itemsEC1">
    <dcc:reference>OIML R111-1:2004</dcc:reference>
    <dcc:classID>E2</dcc:classID>
  </dcc:equipmentClass>
  <dcc:description id="housing">
    <dcc:content lang="en">in a box</dcc:content>
  </dcc:description>
  <dcc:owner>
  <dcc:identifications>
    <dcc:identification refType="mass_serialNo">
      <dcc:issuer>manufacturer</dcc:issuer>
      <dcc:value>1600508</dcc:value>
```

Definition of OIML weight class

Human-readable description of "packaging"

Current refType-terms

Rules in application: measurementResults

HÄFNER® THE PERFECT WEIGHT

```
<dcc:measurementResult refId="weight01">
  <dcc:name>
    <dcc:content lang="en">Measurement results</dcc:content>
  </dcc:name>
  <dcc:usedMethods>
  <dcc:influenceConditions>
    <dcc:influenceCondition refType="basic_temperature">
    <dcc:influenceCondition refType="basic_humidityRelative">
    <dcc:influenceCondition refType="basic_airPressure">
    <dcc:influenceCondition refType="basic_volume">
    <dcc:influenceCondition refType="basic_density">
  </dcc:influenceConditions>
  <dcc:results>
    <dcc:result refType="mass_conventionalMass">
    <dcc:result refType="mass_mass">
  </dcc:results>
</dcc:measurementResult>
```

Reference to item

One influenceConditon-element for each ambient condition and influencing characteristic

One result for conventionalMass and one for mass

Rules in application: quantities

HÄFNER® THE PERFECT WEIGHT

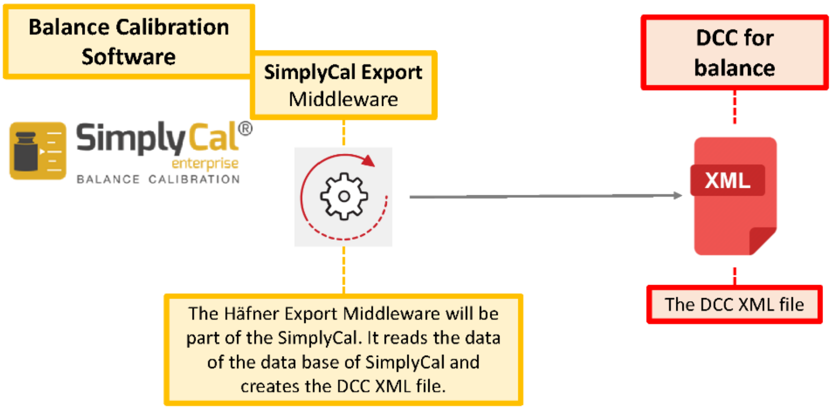
```
<dcc:results>
  <dcc:result refType="mass_conventionalMass">
    <dcc:name>
    <dcc:data>
      <dcc:quantity refType="basic_nominalValue">
      <dcc:quantity refType="basic_measuredValue">
        <dcc:name>
          <dcc:content lang="en">Conventional mass value</dcc:content>
        </dcc:name>
        <si:real>
          <si:label>1 g +0,014 mg</si:label>
          <si:value>0.001000014</si:value>
          <si:unit>\kilogram</si:unit>
          <si:dateTime>2020-02-25T16:00:14</si:dateTime>
          <si:expandedUnc>
            <si:uncertainty>4E-09</si:uncertainty>
            <si:coverageFactor>2</si:coverageFactor>
            <si:coverageProbability>0.95</si:coverageProbability>
          </si:expandedUnc>
        </si:real>
        <dcc:influenceConditions>
        <dcc:measurementMetaData>
          <dcc:metaData refType="basic_referenceTemperature">
        </dcc:measurementMetaData>
      </dcc:quantity>
      <dcc:quantity refType="basic_measurementError">
    </dcc:data>
  </dcc:result>
```

Three quantities in conventional mass result: nominal value, measured value & measurement error

Quantity-values in D-SI

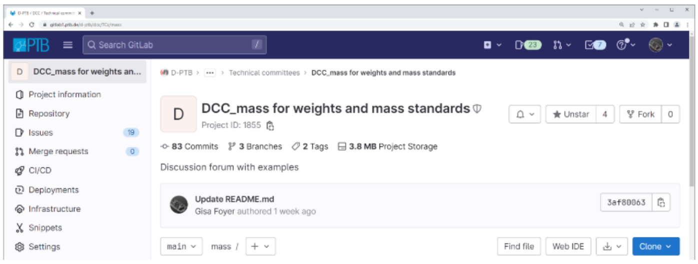
Metadata for results

The next step – DCC for balance



Thanks to all experts in the expert group DCC mass!

Discussions complete on PTB-gitlab:
https://gitlab1.ptb.de/d-ptb/dcc/TCs/mass



33 DCC Good Practice Examples for Air Humidity and Air Pressure – Current Status of Respective Working Groups

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Additional authors: Regina Deschermeier, Carolyn Eckerleben, Mattias Brennecke (all PTB)

Abstract
Together with temperature, air humidity and air pressure are among the ambient influence conditions that are required for virtually any measurement and thus within any digital calibration certificate. Therefore, good practice examples for these measurands and associated measuring equipment are urgently required. Whereas temperature good practice examples have been developed and published in early 2022 in a common effort with the PTB-internal calibration lab, the other two measurand followed later in the year.

In this talk, selected structures of the good practice examples for humidity and air pressure will be presented and discussed. These are especially suited to represent how similarities but also differences between the measurands contribute to the implementation of harmonised structures within DCCs. Also, an insight on the current status of the coordination discussions within the respective working groups of the German Calibration Service (Deutscher Kalibrierdienst, DKD) will be given.

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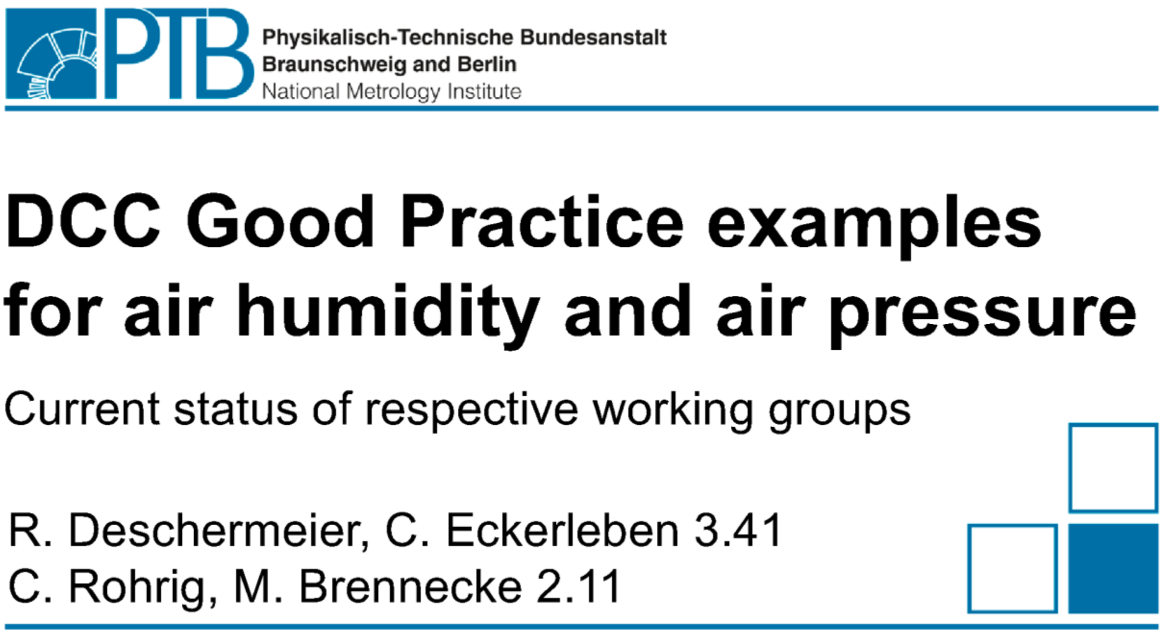


Overview

- Where to start
- Composing the DCCs
- Measurement values
- Future development

Where to start

- National calibration norms by DKD
  - DKD-R 5-8 – Humidity
  - DKD-R 6-1 – Pressure gauges
- Advantages:
  - Standardized procedures
  - Detailed descriptions (uncertainty, hysteresis, etc.…)

Where to start

- National calibration norms by DKD
  - DKD-R 5-8 – Humidity
  - DKD-R 6-1 – Pressure gauges

Important: Interpretation by machines!

- Advantages:
  - Standardized procedures
  - Detailed descriptions (uncertainty, hysteresis, etc.…)

Where to start

- Using refTypes
  - Identifies data contained
  - Guideline for machines

  - Need to be developed by responsible community

Important: Interpretation by machines!

Composing the DCCs

- Humidity

```xml
<dcc:item>
    <dcc:name>
        <dcc:content lang="de">Anzeigegerät</dcc:content>
        <dcc:content lang="en">Display unit</dcc:content>
    </dcc:name>
    <dcc:manufacturer>
        <dcc:name>
            <dcc:content>Feuchtemesstechnik GmbH</dcc:content>
        </dcc:name>
    </dcc:manufacturer>
    <dcc:model>Display 1234-5</dcc:model>
    <dcc:identifications>
        <dcc:identification>
            <dcc:issuer>manufacturer</dcc:issuer>
            <dcc:value>123456789 Ma</dcc:value>
            <dcc:name>
                <dcc:content lang="de">Serien Nr.</dcc:content>
                <dcc:content lang="en">Serial no.</dcc:content>
            </dcc:name>
        </dcc:identification>
        <dcc:identification>
            <dcc:issuer>customer</dcc:issuer>
            <dcc:value>123456789 Hu</dcc:value>
            <dcc:name>
                <dcc:content lang="de">Messmittel Nr.</dcc:content>
                <dcc:content lang="en">Measurement equipment no.</dcc:content>
            </dcc:name>
        </dcc:identification>
        <dcc:identification>
            <dcc:issuer>calibrationLaboratory</dcc:issuer>
            <dcc:value>Eq 123456789</dcc:value>
            <dcc:name>
                <dcc:content lang="de">Equipment Nr.</dcc:content>
                <dcc:content lang="en">Equipment no.</dcc:content>
            </dcc:name>
        </dcc:identification>
    </dcc:identifications>
</dcc:item>
```

```xml
<dcc:item>
    <dcc:name>
        <dcc:content lang="de">Feuchtesensor</dcc:content>
        <dcc:content lang="en">Humidity sensor</dcc:content>
    </dcc:name>
    <dcc:manufacturer>
        <dcc:name>
            <dcc:content>Feuchtemesstechnik GmbH</dcc:content>
        </dcc:name>
    </dcc:manufacturer>
    <dcc:model>H2OMeas 6789-1</dcc:model>
    <dcc:identifications>
        <dcc:identification>
            <dcc:issuer>manufacturer</dcc:issuer>
            <dcc:value>Fs 135792468 Hu</dcc:value>
            <dcc:name>
                <dcc:content lang="de">Serien Nr.</dcc:content>
                <dcc:content lang="en">Serial no.</dcc:content>
            </dcc:name>
        </dcc:identification>
        <dcc:identification>
            <dcc:issuer>customer</dcc:issuer>
            <dcc:value>Be 123456789 kk</dcc:value>
            <dcc:name>
                <dcc:content lang="de">Messmittel Nr.</dcc:content>
                <dcc:content lang="en">Measurement equipment no.</dcc:content>
            </dcc:name>
        </dcc:identification>
        <dcc:identification>
            <dcc:issuer>calibrationLaboratory</dcc:issuer>
            <dcc:value>Cl 123456789 By</dcc:value>
            <dcc:name>
                <dcc:content lang="de">Equipment Nr.</dcc:content>
                <dcc:content lang="en">Equipment no.</dcc:content>
            </dcc:name>
        </dcc:identification>
    </dcc:identifications>
</dcc:item>
```


Composing the DCCs

- Humidity

Important:
Unique
identification!


```xml
<dcc:item>
    <dcc:name>
        <dcc:content lang="de">Anzeigegerät</dcc:cont
        <dcc:content lang="en">Display unit</dcc:cont
    </dcc:name>
    <dcc:manufacturer>
        <dcc:name>
            <dcc:content>Feuchtemesstechnik GmbH</dcc:conte
        </dcc:name>
    </dcc:manufacturer>
    <dcc:model>Display 1234-5</dcc:model>
    <dcc:identifications>
        <dcc:identification>
            <dcc:issuer>manufacturer</dcc:issuer>
            <dcc:value>123456789 Ma</dcc:value>
            <dcc:name>
                <dcc:content lang="de">Serien Nr.</dcc:content>
                <dcc:content lang="en">Serial no.</dcc:content>
            </dcc:name>
        </dcc:identification>
        <dcc:identification>
            <dcc:issuer>customer</dcc:issuer>
            <dcc:value>123456789 Hu</dcc:value>
            <dcc:name>
                <dcc:content lang="de">Messmittel Nr.</dcc:content>
                <dcc:content lang="en">Measurement equipment no.</dcc:content>
            </dcc:name>
        </dcc:identification>
        <dcc:identification>
            <dcc:issuer>calibrationLaboratory</dcc:issuer>
            <dcc:value>Eq 123456789</dcc:value>
            <dcc:name>
                <dcc:content lang="de">Equipment Nr.</dcc:content>
                <dcc:content lang="en">Equipment no.</dcc:content>
            </dcc:name>
        </dcc:identification>
    </dcc:identifications>
</dcc:item>
```

```xml
me>
cc:content lang="de">Feuchtesensor</dcc:content>
cc:content lang="en">Humidity sensor</dcc:content>
name>
manufacturer>
dcc:name>
    <dcc:content>Feuchtemesstechnik GmbH</dcc:content>
</dcc:name>
c:manufacturer>
c:model>H2OMeas 6789-1</dcc:model>
c:identifications>
        <dcc:identification>
            <dcc:issuer>manufacturer</dcc:issuer>
            <dcc:value>Fs 135792468 Hu</dcc:value>
            <dcc:name>
                <dcc:content lang="de">Serien Nr.</dcc:content>
                <dcc:content lang="en">Serial no.</dcc:content>
            </dcc:name>
        </dcc:identification>
        <dcc:identification>
            <dcc:issuer>customer</dcc:issuer>
            <dcc:value>Be 123456789 kk</dcc:value>
            <dcc:name>
                <dcc:content lang="de">Messmittel Nr.</dcc:content>
                <dcc:content lang="en">Measurement equipment no.</dcc:content>
            </dcc:name>
        </dcc:identification>
        <dcc:identification>
            <dcc:issuer>calibrationLaboratory</dcc:issuer>
            <dcc:value>Cl 123456789 By</dcc:value>
            <dcc:name>
                <dcc:content lang="de">Equipment Nr.</dcc:content>
                <dcc:content lang="en">Equipment no.</dcc:content>
            </dcc:name>
        </dcc:identification>
    </dcc:identifications>
</dcc:item>
```

Composing the DCCs

- Humidity
  - 2 Items
    - Display
    - Sensor
  - MetaData

```xml
<dcc:statement refType="basic_validityRange">
    <dcc:declaration>
        <dcc:content lang="de">Angabe des kalibrierten Bereichs der relativen Feuchte bei der vorgegebenen Gastemperatur: </dcc:content>
        <dcc:content lang="en">Specification of the calibrated range of the relative humidity at the given gas temperature:</dcc:content>
    </dcc:declaration>
```

```xml
<dcc:quantity refType="basic_validityRangeMin">
    <dcc:name>
        <dcc:content lang="de">Unteres Limit des kalibrierten Bereichs</dcc:content>
        <dcc:content lang="en">Lower limit of the calibrated range</dcc:content>
    </dcc:name>
    <si:hybrid>
        <si:real>
            <si:value>0.1</si:value>
            <si:unit>\one</si:unit>
        </si:real>
        <si:real>
            <si:value>10</si:value>
            <si:unit>\percent</si:unit>
        </si:real>
    </si:hybrid>
</dcc:quantity>
```


Composing the DCCs

- Humidity
  - 2 Items
    - Display
    - Sensor
  - MetaData

```xml
<dcc:statement refType="basic_validityRange">
    <dcc:declaration>
        <dcc:content lang="de">Angabe des kalibrierten Bereichs der relativen Feuchte bei der vorgegebenen Gastemperatur: </dcc:content>
        <dcc:content lang="en">Specification of the calibrated range of the relative humidity at the given gas temperature:</dcc:content>
    </dcc:declaration>
```

```xml
<dcc:quantity refType="basic_validityRangeMin">
    <dcc:name>
```

```xml
<dcc:quantity refType="basic_validityRangeMax">
    <dcc:name>
        <dcc:content lang="de">Oberes Limit des kalibrierten Bereichs</dcc:content>
        <dcc:content lang="en">Upper limit of the calibrated range</dcc:content>
    </dcc:name>
    <si:hybrid>
        <si:real>
            <si:value>0.8</si:value>
            <si:unit>\one</si:unit>
        </si:real>
        <si:real>
            <si:value>80</si:value>
            <si:unit>\percent</si:unit>
        </si:real>
    </si:hybrid>
</dcc:quantity>
```

Composing the DCCs

- Humidity
  - 2 Items
    - Display
    - Sensor
  - MetaData

```
<dcc:statement refType="basic_validityRange">
    <dcc:declaration>
        <dcc:content lang="de">Angabe des kalibrierten Bereichs der relativen Feuchte bei der vorgegebenen Gastemperatur: </dcc:content>
        <dcc:content lang="en">Specification of the calibrated range of the relative humidity at the given gas temperature:</dcc:content>
    </dcc:declaration>
```

```
<dcc:quantity refType="basic_validityRangeMin">
    <dcc:name>
```

```
<dcc:quantity refType="basic_validityRangeMax">
    <dcc:name>
```

```
<dcc:quantity refType="basic_validitySecondaryCondition">
    <dcc:name>
        <dcc:content lang="de">Vorgegebene Gastemperatur</dcc:content>
        <dcc:content lang="en">Given gas temperature</dcc:content>
    </dcc:name>
    <si:hybrid>
        <si:real>
            <si:value>293.15</si:value>
            <si:unit>\kelvin</si:unit>
        </si:real>
        <si:real>
            <si:value>20</si:value>
            <si:unit>\degreecelsius</si:unit>
        </si:real>
    </si:hybrid>
</dcc:quantity>
```


Composing the DCCs

- Humidity
  - 2 Items
    - Display
    - Sensor
  - MetaData
    - Validity range
    - DUT measurement range

```
<dcc:statement refType="basic_validityRange">
    <dcc:declaration>
        <dcc:content lang="de">Angabe des kalibrierten Bereichs der relativen Feuchte bei der vorgegebenen Gastemperatur: </dcc:content>
        <dcc:content lang="en">Specification of the calibrated range of the relative humidity at the given gas temperature:</dcc:content>
    </dcc:declaration>
```

```
<dcc:statement refType="basic_measurementRange">
    <dcc:declaration>
    <dcc:data>
        <dcc:quantity refType="basic_measurementRangeMin">
        <dcc:quantity refType="basic_measurementRangeMax">
```

Composing the DCCs

- Humidity
  - 2 Items
    - Display
    - Sensor
  - MetaData
    - Validity range
    - DUT measurement range
  - InfluenceConditions

```
<dcc:influenceCondition refType="basic_valueSettlingTime gp_valueAdjustmentTime">
<dcc:influenceCondition refType="gp_valueFlowVelocity">
<dcc:influenceCondition refType="basic measurementDimension">
<dcc:influenceCondition refType="basic measurementRangeScaleInterval">
```


Composing the DCCs

- Humidity
  - 2 Items
    - Display
    - Sensor
  - MetaData
    - Validity range
    - DUT measurement range
  - InfluenceConditions

```
<dcc:influenceCondition refType="basic_valueSettlingTime gp_valueAdjustmentTime">
<dcc:influenceCondition refType="gp_valueFlowVelocity">
<dcc:influenceCondition refType="basic measurementDimension">
<dcc:influenceCondition refType="basic measurementRangeScaleInterval">
```

2 Namespaces for more details

Composing the DCCs

- Humidity
  - 2 Items
    - Display
    - Sensor
  - MetaData
    - Validity range
    - DUT measurement range
  - InfluenceConditions

```
<dcc:influenceCondition refType="basic_valueSettlingTime gp_valueAdjustmentTime">
<dcc:influenceCondition refType="gp_valueFlowVelocity">
<dcc:influenceCondition refType="basic measurementDimension">
<dcc:influenceCondition refType="basic measurementRangeScaleInterval">
```

Data for air chamber

Physikalisch-Technische Bundesanstalt ■ Braunschweig and Berlin
2023-03-02 14
National Metrology Institute
GP air humidity and air pressure

Composing the DCCs

- Humidity
  - 2 Items
    - Display
    - Sensor
  - MetaData
    - Validity range
    - DUT measurement range
  - InfluenceConditions

```
<dcc:influenceCondition refType="basic_valueSettlingTime gp_valueAdjustmentTime">
<dcc:influenceCondition refType="gp_valueFlowVelocity">
<dcc:influenceCondition refType="basic measurementDimension">
<dcc:influenceCondition refType="basic measurementRangeScaleInterval">
```

Dimension delivered by DUT

Physikalisch-Technische Bundesanstalt ■ Braunschweig and Berlin
2023-03-02 15
National Metrology Institute
GP air humidity and air pressure

Composing the DCCs

- Humidity
  - 2 Items
    - Display
    - Sensor
  - MetaData
    - Validity range
    - DUT measurement range
  - InfluenceConditions

```xml
<dcc:influenceCondition refType="basic_valueSettlingTime gp_valueAdjustmentTime">
<dcc:influenceCondition refType="gp_valueFlowVelocity">
<dcc:influenceCondition refType="basic measurementDimension">
<dcc:influenceCondition refType="basic measurementRangeScaleInterval">
```

Resolution of DUT

Composing the DCCs

- Air pressure
  - 1 Item

```xml
<dcc:item>
    <dcc:name>
        <dcc:content lang="de">Druckmessgerät</dcc:content>
        <dcc:content lang="en">Pressure gauge</dcc:content>
    </dcc:name>
    <dcc:manufacturer>
        <dcc:name>
            <dcc:content>Manufacturer Name</dcc:content>
        </dcc:name>
    </dcc:manufacturer>
    <dcc:model>Model</dcc:model>
    <dcc:identifications>
        <dcc:identification>
            <dcc:issuer>manufacturer</dcc:issuer>
            <dcc:value>string-manufacturer-item</dcc:value>
            <dcc:name>
                <dcc:content lang="de">Serien Nr.</dcc:content>
                <dcc:content lang="en">Serial no.</dcc:content>
            </dcc:name>
        </dcc:identification>
        <dcc:identification>
            <dcc:issuer>customer</dcc:issuer>
            <dcc:value>string-customer-item</dcc:value>
            <dcc:name>
                <dcc:content lang="de">Messmittel Nr.</dcc:content>
                <dcc:content lang="en">Measurement equipment no.</dcc:content>
            </dcc:name>
        </dcc:identification>
        <dcc:identification>
            <dcc:issuer>calibrationLaboratory</dcc:issuer>
            <dcc:value>string-calibrationLaboratory-item</dcc:value>
            <dcc:name>
                <dcc:content lang="de">Equipment Nr.</dcc:content>
                <dcc:content lang="en">Equipment no.</dcc:content>
            </dcc:name>
        </dcc:identification>
    </dcc:identifications>
</dcc:item>
```

Composing the DCCs

- Air pressure
  - 1 Item
  - MetaData
    - Validity range
    - DUT measurement range

```xml
<dcc:statement refType="basic_measurementRange">
    <dcc:data>
        <dcc:quantity refType="basic_measurementDimension">
        <dcc:quantity refType="basic_measurementRangeMin">
        <dcc:quantity refType="basic_measurementRangeMax">
        <dcc:quantity refType="basic_validityRangeMin">
        <dcc:quantity refType="basic_validityRangeMax">
        <dcc:quantity refType="basic_measurementRangeScaleInterval">
```

Analog to GP Humidity

Composing the DCCs

- Air pressure
  - 1 Item
  - MetaData
    - Validity range
    - DUT measurement range
  - InfluenceConditions

```xml
<dcc:quantity refType="basic_valueSettlingTime">
    <dcc:name>
        <dcc:content lang="de">Wartezeit bis zur Ablesung nach jeder Druckänderung</dcc:content>
        <dcc:content lang="en">Waiting time until reading after each pressure change</dcc:content>
    </dcc:name>
    <si:hybrid>
        <si:real>
            <si:value>180</si:value>
            <si:unit>\second</si:unit>
        </si:real>
        <si:real>
            <si:value>3</si:value>
            <si:unit>\minute</si:unit>
        </si:real>
    </si:hybrid>
</dcc:quantity>
```

Composing the DCCs

- Air pressure
  - 1 Item
  - MetaData
    - Validity range
    - DUT measurement range
  - InfluenceConditions

```xml
<dcc:quantity refType="basic_valueSettlingTime">
    <dcc:name>
        <dcc:content lang="de">Wartezeit bis zur Ablesung nach jeder Druckänderung</dcc:content>
        <dcc:content lang="en">Waiting time until reading after each pressure change</dcc:content>
    </dcc:name>
    <si:hybrid>
        <si:real>
            <si:value>
            <si:unit>\
        </si:real>
        <si:real>
            <si:value>
            <si:unit>\
        </si:real>
    </si:hybrid>
</dcc:quantity>
```

```xml
<dcc:influenceCondition refType="basic_cycleDelay">
    <dcc:name>
    <dcc:data>
        <dcc:quantity refType="basic_valueSettlingTime">
            <dcc:name>
                <dcc:content lang="de">Wartezeit zwischen den beiden Mess
                </dcc:content>
                <dcc:content lang="en">Waiting time between the two measu
                </dcc:content>
            </dcc:name>
            <si:hybrid>
                <si:real>
                    <si:value>600</si:value>
                    <si:unit>\second</si:unit>
                </si:real>
                <si:real>
                    <si:value>10</si:value>
                    <si:unit>\minute</si:unit>
                </si:real>
            </si:hybrid>
        </dcc:quantity>
    </dcc:data>
</dcc:influenceCondition>
```


Measurement values

- Air pressure
  1. Applying pressure
  2. Reference value
  3. Measured value by DUT
  4. Calculating deviation

```xml
<dcc:list refType="gp_pressure">
    <dcc:quantity refType="basic_referenceValue">
    <dcc:quantity refType="basic_measuredValue">
    <dcc:quantity refType="basic_measurementError">
```

Measurement values

- Humidity

1. Create Humidity in chamber
2. Reference value
3. Measured value by DUT
4. Calculating deviation

```
<dcc:results>
    <dcc:result refType="gp_relativeGasHumidityAboveWater">
        <dcc:name>
        <dcc:data>
            <dcc:list>
                <dcc:quantity refType="basic referenceValue">
                <dcc:quantity refType="basic measuredValue">
                <dcc:quantity refType="basic measurementError">
                <dcc:influenceConditions>
                    <dcc:influenceCondition refType="gp_gasTemperature">
```


Measurement values

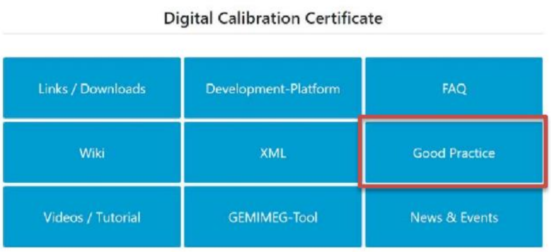
- Humidity

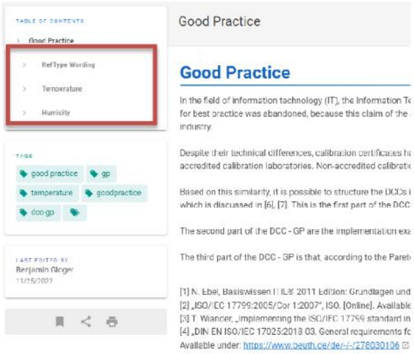
1. Create Humidity in chamber
2. Reference value
3. Measured value by DUT
4. Calculating deviation
5. Influence condition: gas temperature

```
<dcc:results>
    <dcc:result refType="gp_relativeGasHumidityAboveWater">
        <dcc:name>
        <dcc:data>
            <dcc:list>
                <dcc:quantity refType="basic referenceValue">
                <dcc:quantity refType="basic measuredValue">
                <dcc:quantity refType="basic measurementError">
                <dcc:influenceConditions>
                    <dcc:influenceCondition refType="gp_gasTemperature">
```

Getting the GPs

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





Future development

- More and detailed refTypes necessary
  - *Example: reference layer (pressure)*
- Automated import of data
  - *Correction of following measurements*
- WIP: GP for multi purpose calibrator (electricity)

The End

Thanks for your Interest!

?

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E-Mail: christian.rohrig@ptb.de
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Stand: 2023-03

Parallel Session 3: In Development

Presentations that would also fit into this session:

- 01 Digital Calibration Certificate as part of an Ecosystem
- 06 The General DCC Rulebook and the Rules under the Aspects of Accreditation
- 10 Persistent Identification of Instruments and the Digital Calibration Certificate
- 17 The Digital NIST: Pilot Project for the Digital Transformation of NIST's Measurement Services
- 25 Generation of Digital Calibration Certificates for Temperature Sensor Calibrations using Python and Excel
- 26 Dynamic Web Tool for Generating DCC
- 28 Pilot Comparison Project in Terms of Air Kerma in Radiation Protection between Digital Twin Laboratories
- 31 DCCs for Non-Automatic Weighing Instruments (NAWIs) – Current Status of a Respective Working Group Elaborating "Good Practice" Conventions
- 38 The Quality of Sensing, of Data or of Information
- 39 Two Implementations of Digital Calibration Certificates in Industrial and Metrological Services
- 45 Digital Transformation of NMI: Practical Experience on DCC and Beyond @ NIS-Egypt
- 53 DCC Middleware – Obstacles and Approaches
- 56 DCC via iPhone (or iPad)

34 The DCC in its Role as Networked Data Source

Presenting author: Benjamin Gloger, Physikalisch-Technische Bundesanstalt (PTB), Germany

E-mail address: Benjamin.Gloger@ptb.de

Additional authors: Gamze Söylev Öktem, Siegfried Hackel, Moritz Jordan, Justin Jagieniak (all PTB)

Abstract

The Digital Calibration Certificate (DCC) is not simply a translation of an analogue calibration certificate into a digital format. The digital calibration certificate contains much more information than can be found anywhere in the analogue calibration certificate. This additional information is available in the DCC and is even machine-readable and machine interpretable.

The links and the subsequent self-description of a SemantikWeb show here the advantages of using DCCs. In this talk, the reliability and verifiability of DCCs will be discussed with the possibilities of the flexibility of Industrie 4.0 machines. The attribute "refType" in the DCC will be used for this purpose.

The goal is that the DCC can be audited by humans. The following sentence summarises this. "For a human with an appropriate metrological background (e. g. an auditor or a trained employee of the calibration laboratory or its customers), a DCC without refTypes must be fully comprehensible in terms of content."

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Physikalisch-Technische Bundesanstalt
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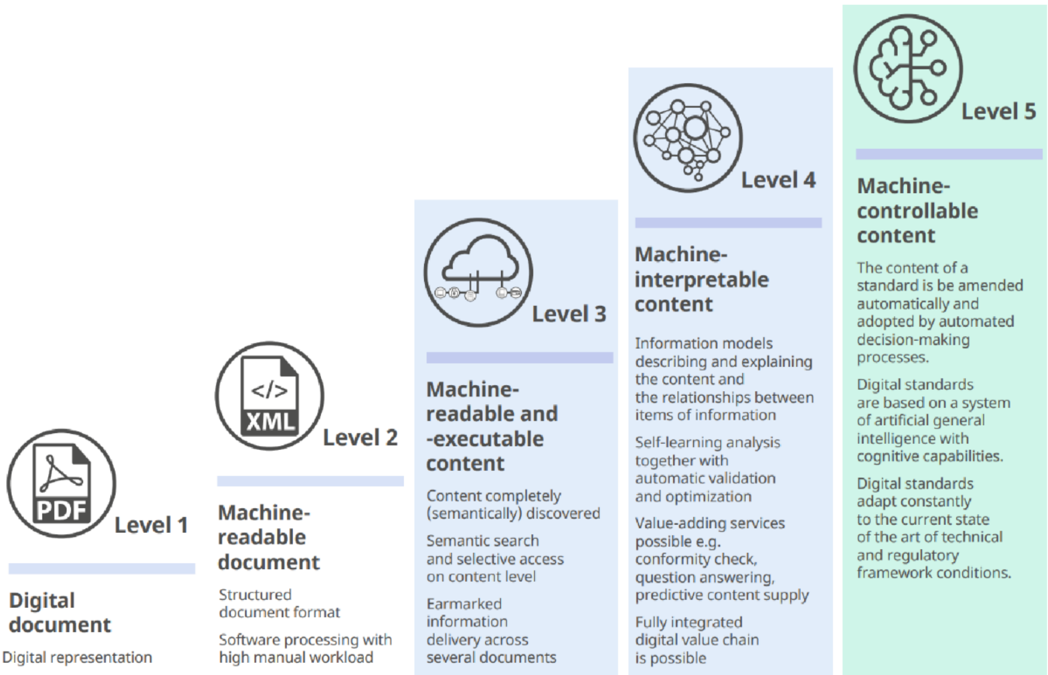
National Metrology Institute

The DCC in its role as networked data source

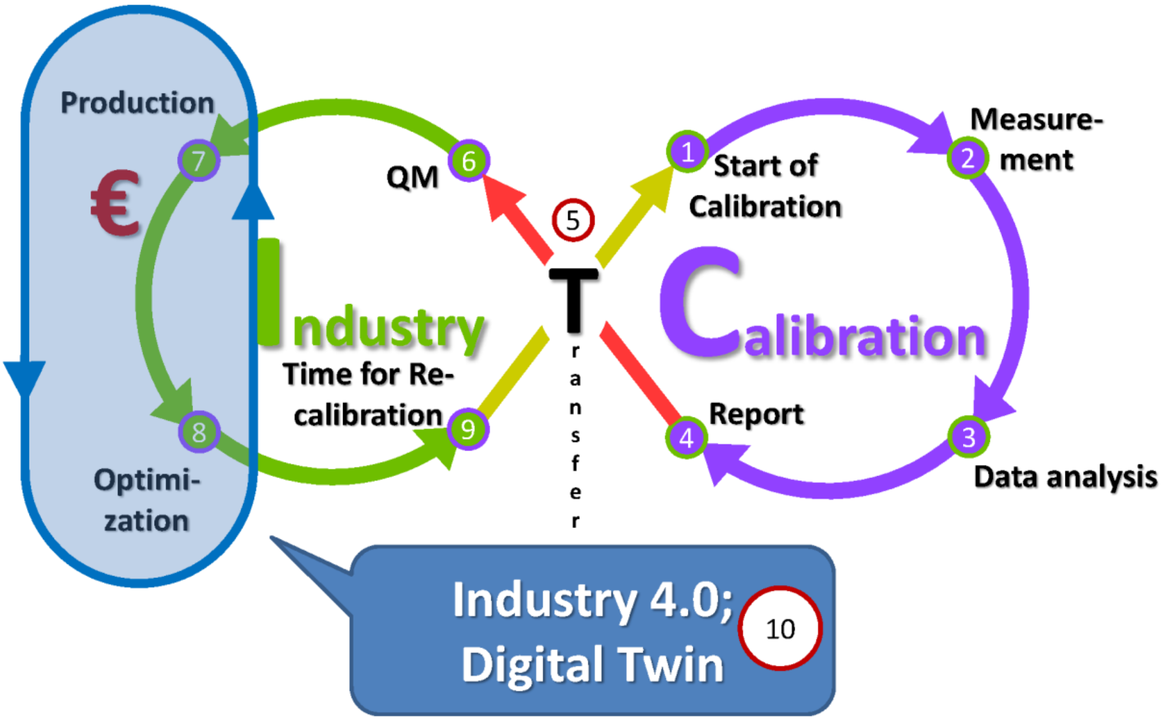
Benjamin Gloger, AG 1.24

The Utility Model

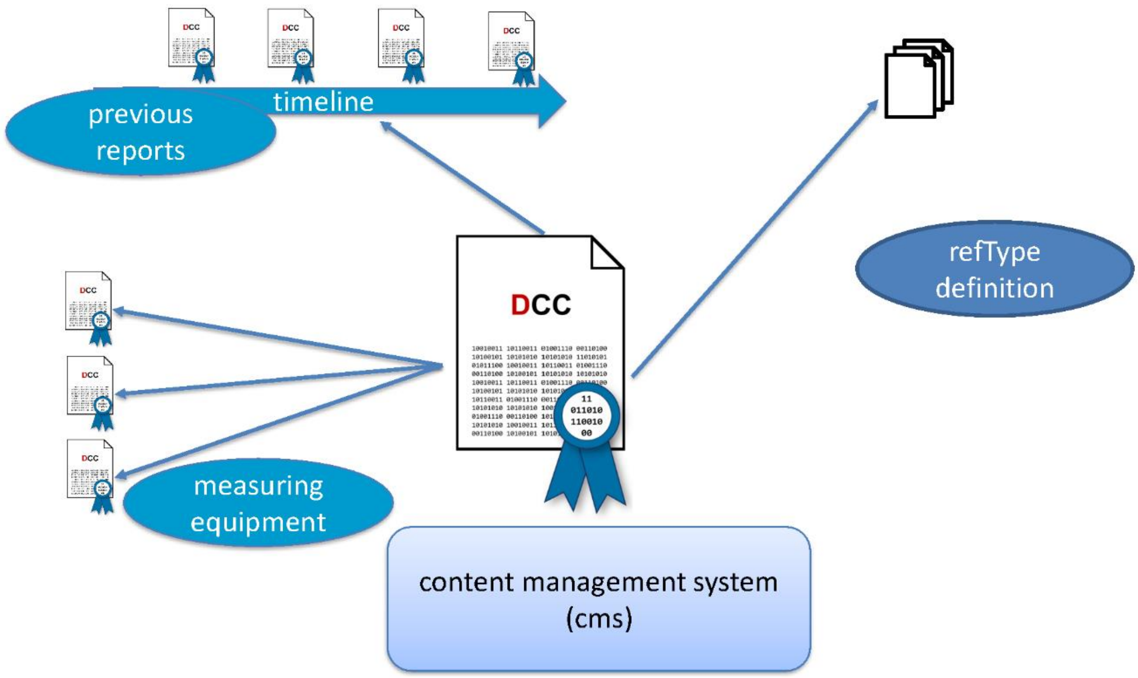


From: „IDiS – Initiative Digitale Standards“. [Online]. see: https://www.dke.de/idis

The Production Cycle

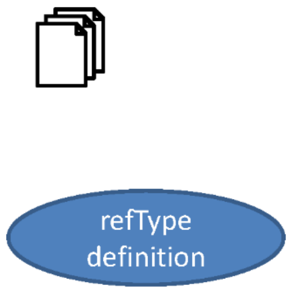


Content Management System



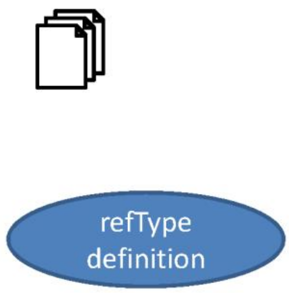
Simple refType Definition

refType	immersionDepth
Name	Immersion depth
Note	Immersion depth of a sensor.
Used Element	dcc:influenceCondition

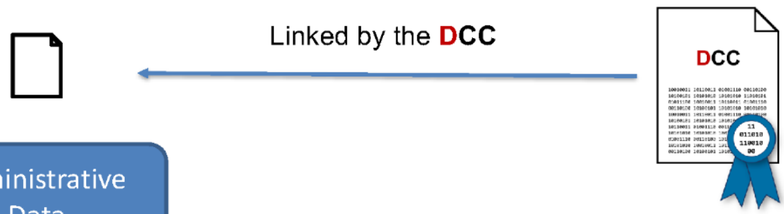


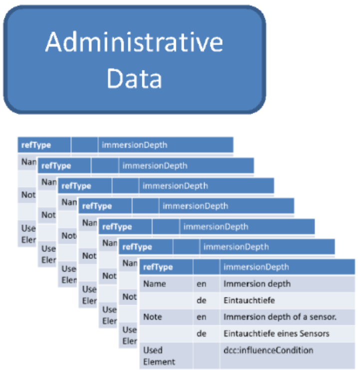
Simple refType definition

refType		immersionDepth
Name	en	Immersion depth
	de	Eintauchtiefe
Note	en	Immersion depth of a sensor
	de	Eintauchtiefe eines Sensors
Used Element		dcc:influenceCondition



refType Definition File

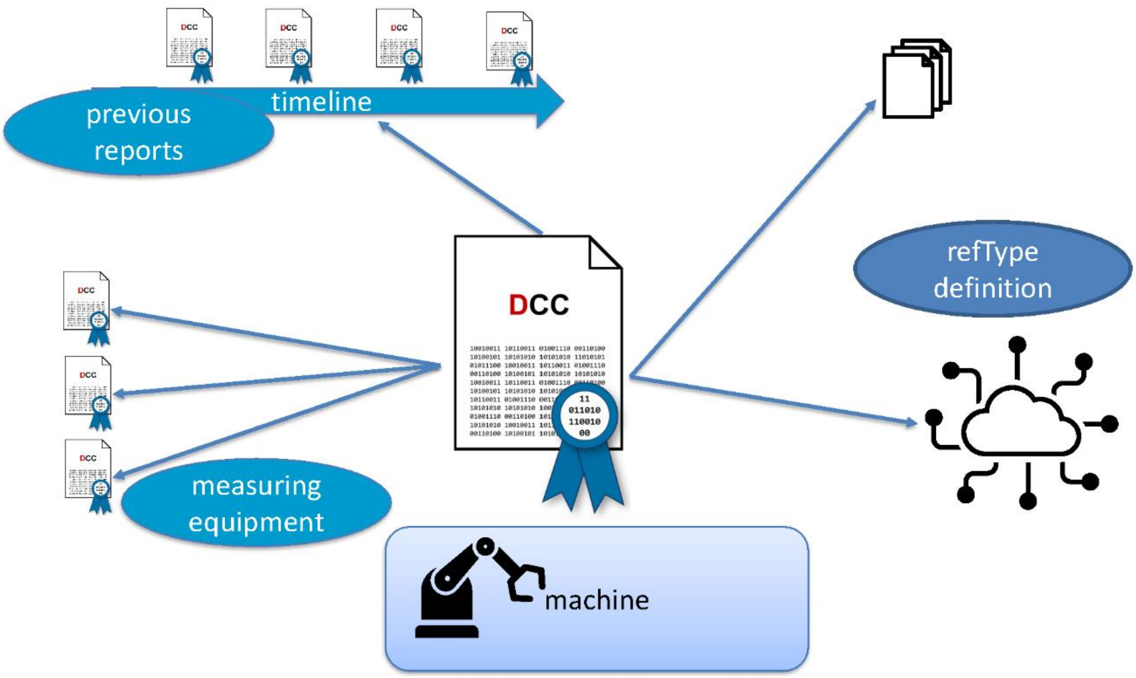




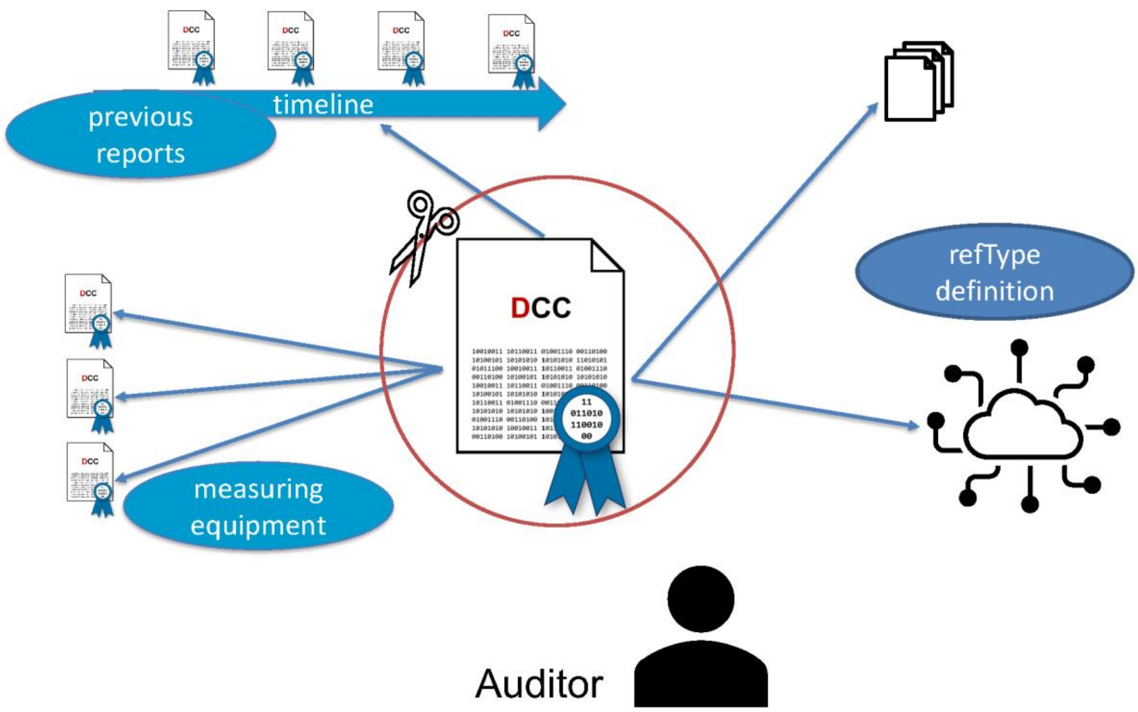
dcc:refTypeDefinition	
dcc:name	temperature
dcc:namespace	gp
dcc:link	extern or intern

Useable in the DCC as refType="gp_immersionDepth"

Machine - Online

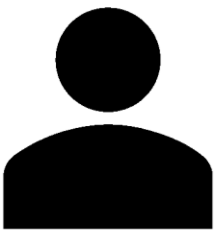


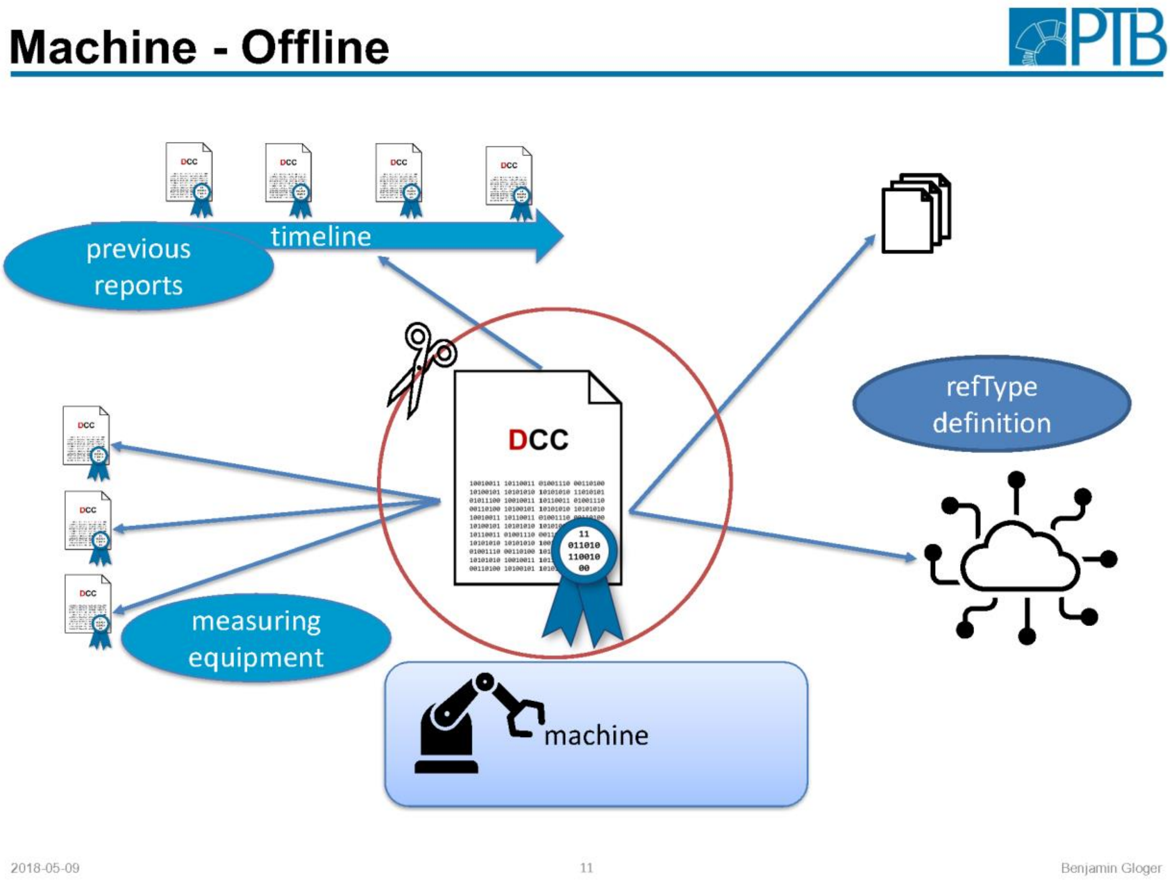
Auditor



Auditor

"For a human with an appropriate metrological background (e.g. an auditor or a trained employee of the calibration laboratory or its customers), a DCC without refTypes must be fully comprehensible in terms of content."





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www.ptb.de/dcc

Stand: 02/23

35 The Digital SchemaX (DX)

Presenting author: Justin Jagieniak, Physikalisch-Technische Bundesanstalt, Germany

E-mail address: justin.jagieniak@ptb.de

Additional authors: Benjamin Gloger, Gamze Söylev-Öktem, Jan Loewe, Moritz Jordan, Muhammed-Ali Demir, Siegfried Hackel, Shanna Schönhals (all PTB)

Abstract
DX is the short form for Digital SchemaX. The Digital SchemaX is a modularisation of the Digital Calibration Certificate (DCC) schema and will be used for the future development for of the DCC schema in the version 4.0.0 and up. Furthermore, the DX can be used as an inheritance for other kinds of certificates related to the DCC, because the DX does not contain any XML-like Tree Structure and contains the typically types of a DCC schema instead. This structure makes the DX useful for other certificates. The intention behind the DX is to create a base for certificates in metrology. For example, for the Digital Calibration Request (DCR), the Digital Calibration Answer (DCA), the Digital Certificate for Reference Materials (D-CRM) and the Digital Certificate of Conformity Metrology (D-CoCM). The presentation gives you an overview of news in this development.

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Digital SchemaX (DX)

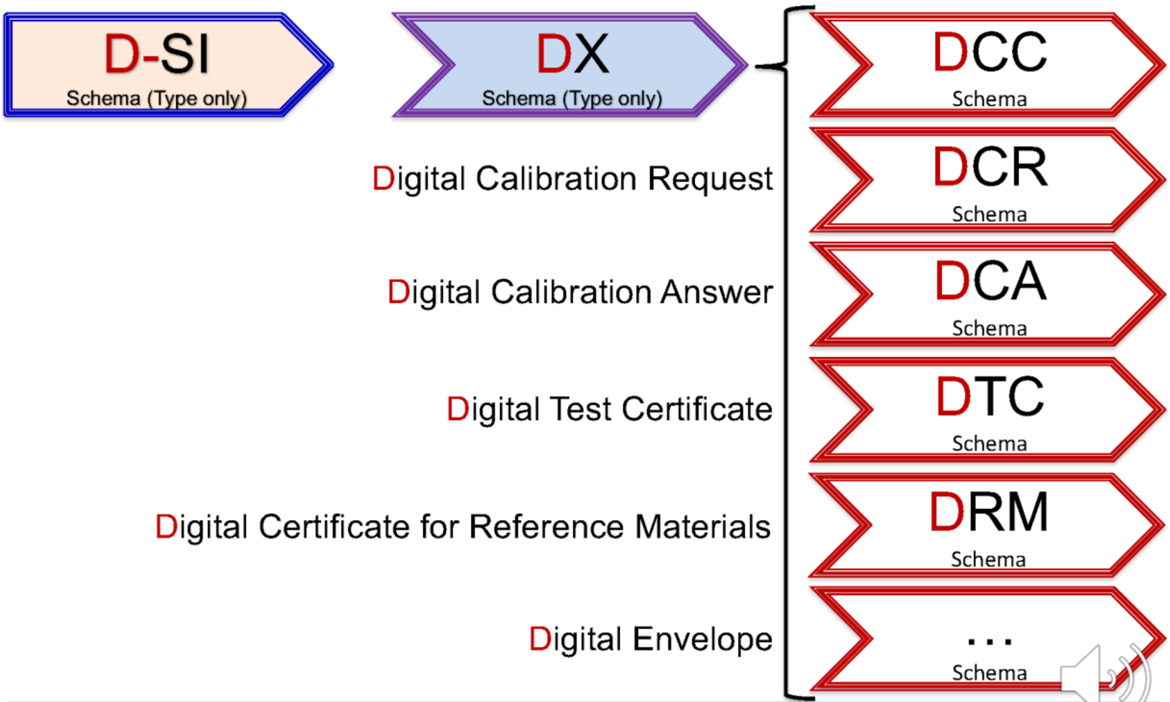
Modularisation of the
Digital Calibration Certificate (DCC)

Presenting author:
Justin Jagieniak, AG 1.24

Advantages of Modularisation

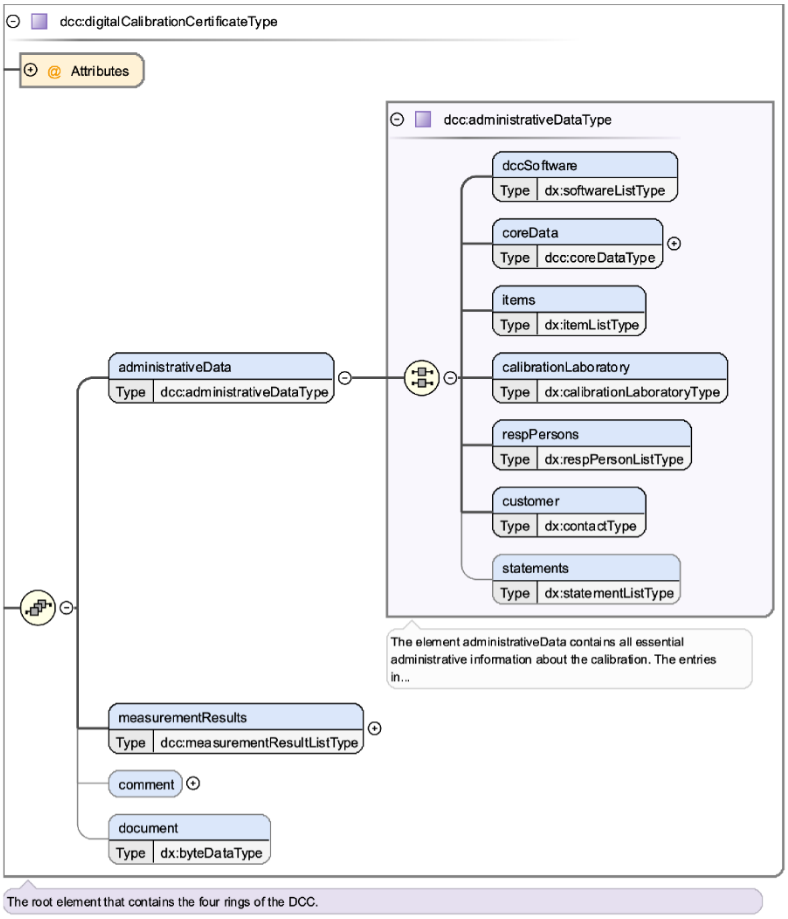
- Better reading comfort of the DCC
  - Better understanding
  - Avoid mistakes
- Allows inheritance
  - Not only the DCC profites from the DX:
    - DCR (Digital Calibration Request)
    - DCA (Digital Calibration Answer)
    - DTC (Digital Test Certificate)
    - DRM (Digital Certificate for Reference Materials)
    - EDC (Envelope Digital Certificate)
    - ...

Advantages of Modularisation

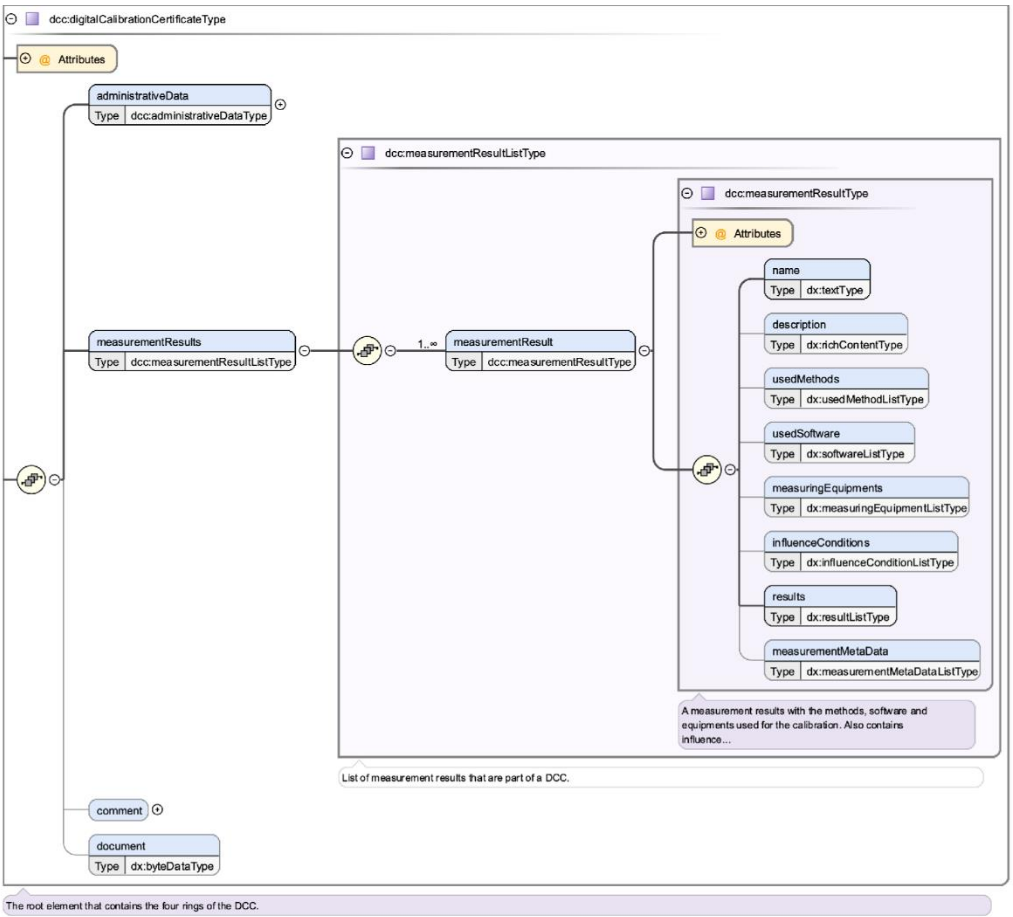


DCC 4.0 and DX

- DCC
  - Contains tree structures and related elements
  - Refers to DX
- DX
  - Contains types only
  - Doesn‘t have a tree structure, every type is independend


dcc:digitalCalibrationCertificateType
Attributes
dcc:administrativeDataType
dccSoftware
Type dx:softwareListType
coreData
Type dcc:coreDataType
items
Type dx:itemListType
administrativeData
Type dcc:administrativeDataType
calibrationLaboratory
Type dx:calibrationLaboratoryType
respPersons
Type dx:respPersonListType
customer
Type dx:contactType
statements
Type dx:statementListType
The element administrativeData contains all essential administrative information about the calibration. The entries in...
measurementResults
Type dcc:measurementResultListType
comment
document
Type dx:byteDataType
The root element that contains the four rings of the DCC.

2023-03-01


dcc:digitalCalibrationCertificateType
Attributes
administrativeData
Type dcc:administrativeDataType
dcc:measurementResultListType
dcc:measurementResultType
Attributes
name
Type dx:textType
description
Type dx:richContentType
usedMethods
Type dx:usedMethodListType
usedSoftware
Type dx:softwareListType
measurementResults
Type dcc:measurementResultListType
1..∞
measurementResult
Type dcc:measurementResultType
measuringEquipments
Type dx:measuringEquipmentListType
influenceConditions
Type dx:influenceConditionListType
results
Type dx:resultListType
measurementMetaData
Type dx:measurementMetaDataListType
A measurement results with the methods, software and equipments used for the calibration. Also contains influence...
List of measurement results that are part of a DCC.
comment
document
Type dx:byteDataType
The root element that contains the four rings of the DCC.

How to use DX in XSD?

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema version="4.0.0" xmlns:xs="http://www.w3.org/2001/XMLSchema"
           xmlns:dcc="https://ptb.de/dcc"
           xmlns:dx="https://ptb.de/dx"
           targetNamespace="https://ptb.de/dcc"
           elementFormDefault="qualified">

    <xs:import
        namespace="https://ptb.de/dx"
        schemaLocation="dx.xsd"/>
```


How to use DX in XSD?

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema version="4.0.0" xmlns:xs="http://www.w3.org/2001/XMLSchema"
           xmlns:dcc="https://ptb.de/dcc"
           xmlns:dx="https://ptb.de/dx"
           targetNamespace="https://ptb.de/dcc"
           elementFormDefault="qualified">

    <xs:import
        namespace="https://ptb.de/dx"
        schemaLocation="dx.xsd"/>
```

Notes:

- It is not intented to use the DX for a XML file.
- The intension is to use it as an modular extension for another scheme.

How to use DX in XSD?

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema version="4.0.0" xmlns:xs="http://www.w3.org/2001/XMLSchema"
           xmlns:dcc="https://ptb.de/dcc"
           xmlns:dx="https://ptb.de/dx"
           targetNamespace="https://ptb.de/dcc"
           elementFormDefault="qualified">

    <xs:import
        namespace="https://ptb.de/dx"
        schemaLocation="dx.xsd"/>
```

```
<xs:complexType name="administrativeDataType">
    <xs:annotation>
        <xs:documentation>
            The element administrativeData contains all essential administrative information about the calibration.
            The entries in this area are basically the same and regulated in all DCCs.
        </xs:documentation>
    </xs:annotation>
    <xs:all>
        <xs:element name="dccSoftware" type="dx:softwareListType"/>
        <xs:element name="coreData" type="dx:coreDataType"/>
        <xs:element name="items" type="dcc:itemListType"/>
        <xs:element name="calibrationLaboratory" type="dx:calibrationLaboratoryType"/>
        <xs:element ref="dx:respPersons"/>
        <xs:element ref="dx:customer"/>
        <xs:element name="statements" type="dcc:statementListType" minOccurs="0"/>
    </xs:all>
</xs:complexType>
```

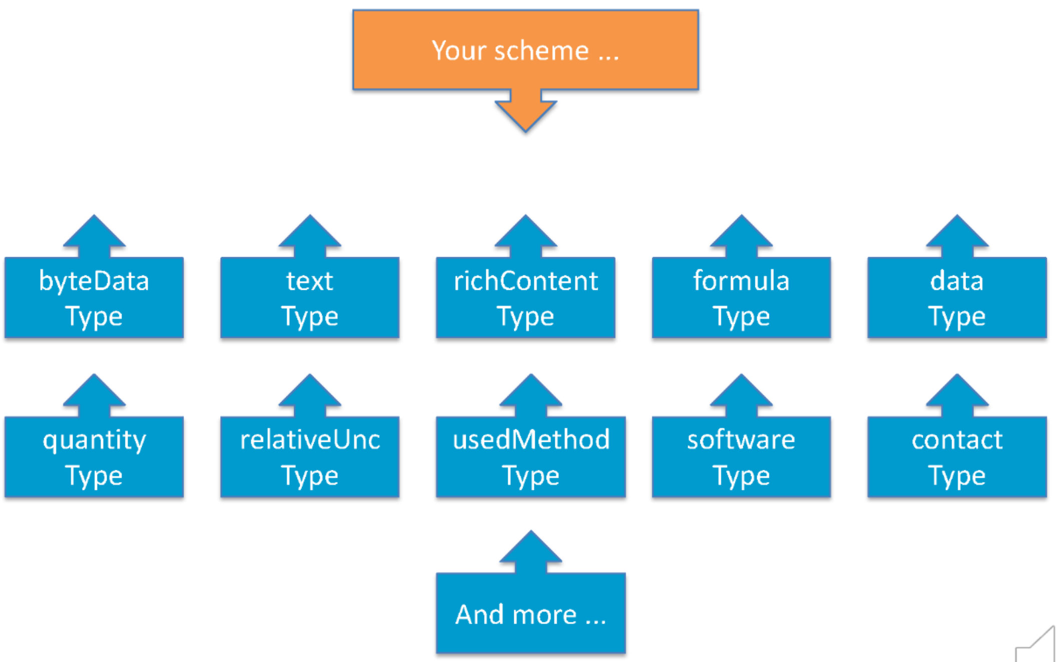

How to use DX in XML?

```
<dcc:digitalCalibrationCertificate
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="https://ptb.de/dcc dcc.4.0.0-beta.xsd"
    xmlns:dcc="https://ptb.de/dcc"
    xmlns:dx="https://ptb.de/dx"
    xmlns:si="https://ptb.de/si"
    schemaVersion="4.0.0">
```

How to use DX in XML?

```xml
<dcc:administrativeData>
    <dcc:dccSoftware>
        <dx:software>
            <dx:name>
                <dx:content>Notepad++ (32-bit)</dx:content>
            </dx:name>
            <dx:release>v 8.2</dx:release>
        </dx:software>
    </dcc:dccSoftware>
    <dcc:coreData>
        <dx:countryCodeISO3166_1>DE</dx:countryCodeISO3166_1>
        <dx:usedLangCodeISO639_1>de</dx:usedLangCodeISO639_1>
        <dx:usedLangCodeISO639_1>en</dx:usedLangCodeISO639_1>
        <dx:mandatoryLangCodeISO639_1>de</dx:mandatoryLangCodeISO639_1>
        <dx:uniqueIdentifier>GP_DCC_temperature_typical_1.0</dx:uniqueIdentifier>
        <dx:identifications>
            <dx:identification>
                <dx:issuer>calibrationLaboratory</dx:issuer>
                <dx:value>string-calibrationLaboratory-coreData</dx:value>
                <dx:name>
                    <dx:content lang="de">Auftrags Nr.</dx:content>
                    <dx:content lang="en">Order no.</dx:content>
                </dx:name>
            </dx:identification>
        </dx:identifications>
        <dx:beginPerformanceDate>1957-08-13</dx:beginPerformanceDate>
        <dx:endPerformanceDate>1957-08-13</dx:endPerformanceDate>
        <dx:performanceLocation>laboratory</dx:performanceLocation>
    </dcc:coreData>
```


Build your own scheme



Outlook for future

- The modular DX allows us a common understanding of DCC type and can be refound in different xml schemes.
- In this way different projects and organisations or persons can profite from following:
  - Common understanding of used xml elements.
  - Common programming modules.
    - Programs can recognize these types and synchronize the data in xml files with different schemes based on DX.
- The DCC 4.0.0 will be based on DX. But the DCC 3.x.x has long term support and will still be supported!

Physikalisch-Technische Bundesanstalt ■ Braunschweig and Berlin | National Metrology Institute

2023-03-01 | 13 | ppt-folie-vorlage

Thank you for your attention!

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Dr. Shanna Schönhals (shanna.schoenhals@ptb.de)
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Dr. Lutz Doering (lutz.doering@ptb.de)
Moritz Jordan (moritz.jordan@ptb.de)
Muhammed Demir (muhammed.demir@ptb.de)

Parallel Session 3: DCC and Industry

Presentations that would also fit into this session:

- 01 Digital Calibration Certificate as part of an Ecosystem
- 05 Bringing the Digital Accreditation Symbol and the Digital Calibration Report (DCC) into Practice
- 09 The Semantics of Measured Quantities
- 11 DCC and Digitisation versus Digitalisation and Digital Transformation
- 21 DKD's Contribution to DCC Harmonisation and Coordinated Development
- 22 GEMIMEG-II – Status and Progress Report
- 31 DCCs for Non-Automatic Weighing Instruments (NAWIs) – Current Status of a Respective Working Group Elaborating "Good Practice" Conventions
- 32 Digital Calibration Certificates for Weights and Mass Standards: Rules and Applications

36 Pharmaceutical Test Case of a DCR- and DCC Implementation in an Accredited Calibration Laboratory

Presenting author: Jakob Fester, Danish Technological Institute, Denmark

E-mail address: jafe@teknologisk.dk

Additional authors: Jonas Emil Vind

Abstract

The practical implementation of digital calibration certificates (DCC) and -requests (DCR) meet a range of requirements and regulations and must link solutions to existing data- and quality infrastructure (QI). These aspects of DCC and DCR can represent serious bottlenecks in the efforts towards implemented solutions before the administrative benefits of the paper less- and machine assisted calibration process can be achieved. In this study, we present a test case together with a major Danish pharmaceutical company where the whole chain from DCR to DCC is demonstrated and evaluated based on a thermometer calibration performed at the designated temperature laboratory (DI) at the Danish Technological Institute (DTI). The DCC and DCR formats are constructed starting from the current good practice examples and online material already published by PTB, and the templates are reviewed with a focus on suggestions for future improvements, as evaluated from both views of the customer and calibration laboratory, respectively. The DCR and DCC versions in the study are XML-based, machine read and automatically exported by internal software. We describe the transfer of data to- and from the internal QI system at DTI and designed an integrated solution where the customer can create and send the DCR through a browser. The primary focus is to provide feedback to the current DCR- and DCC templates and inspire further practical implementations by potential users in industry.

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PHARMACEUTICAL TEST CASE OF A DCR- AND DCC IMPLEMENTATION IN AN ACCREDITED CALIBRATION LABORATORY

Jonas Emil Vind and Jakob Fester (presenter)
Danish Technological Institute (DTI)
Contact: jafe@teknologisk.dk

3rd international Digital Calibration Certificate (DCC) conference

Wednesday 1 Marts 2023 (on-line)

TEKNOLOGISK INSTITUT

OUTLINE

1. Who are we?
2. Motivation and purpose of the case study
3. Technical details
4. Conclusions and summary of learnings

TEKNOLOGISK INSTITUT

WHO ARE WE?

Danish Technological Institute (DTI)

- Self-owned non-profit institute with +1000 employees.
- Designated Institute (DI) for contact thermometry, water content, flow, anemometry and geometry.
- Calibration and Metrology services also include pressure, force, humidity, mass, hardness and DC electricity
- > 75.000 pieces of equipment calibrated for more than 3000 customers per year.
- Accredited by The Danish Accreditation Service, DANAK (member of EA (European Co-operation for Accreditation) and ILAC (International Laboratory Accreditation)

Novo Nordisk

- Danish multinational pharmaceutical company
- Production facilities in eight countries + affiliated offices in 80 countries.
- Employs more than 55,000 people globally and markets its products in 180 countries.
- Requests calibration from suppliers for approximate 15.000 measuring devices per year

TEKNOLOGISK INSTITUT

MOTIVATION – WHY IMPLEMENT DCC AND DCR?

Danish Technological Institute

Benefits:

- Implementation of DCC and DCR services for calibration **customers**
- Facilitate uptake in Danish Industry in coordination and collaboration with partners in the Danish system of Research and Technology Organisations ("GTS institutes") as well as by participating in EURAMET working groups and projects
- Automization of **internal** calibrations and calibration orders
- Collaborate with Danish companies to provide input to the **international** harmonization of DCC and DCR

Novo Nordisk

Benefits:

- Transferer of calibration results automatically into SAP QM will **reduce time** spend (up to 20 min. for each calibration).
- **Remove manual work** and improve EHS (environment, health and safety for NN employees)
- Reduce time spend on requesting calibration (up to 25 min. for each calibration)
- **Reduce errors**. 5% of errors in revised certificates originate from the original request documentation from Novo Nordisk

TEKNOLOGISK INSTITUT

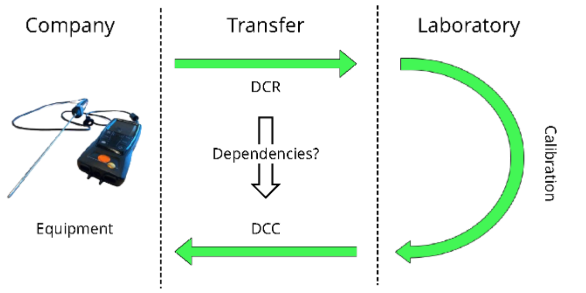
THE CASE STUDY

Activities:

- We performed a real calibration of a Novo Nordisk thermometer using early versions of DCR and DCC service tools implemented in the calibration laboratory at DTI

Purpose:

1. Acquire new “real-life” learnings to
   - Better **help other companies** to digitalize their calibration processes (NMI’s/DI’s/customers)
   - Provide **feedback and user-based suggestions** to reach the best possible harmonized formats of DCC and DCR
2. Provide a **showcase** to inspire further practical implementations by potential users in industry



TEKNOLOGISK INSTITUT

IMPLEMENTATION APPROACH

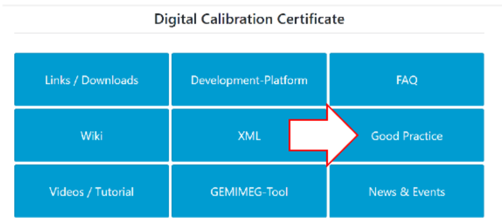
Use of templates and formats:

DCC:

- XML constructed based on Good Practice (GP) examples published by PTB
- schemaVersion = 3.1.2

DCR:

- XML constructed based on video tutorial from the 1st international conference on DCC
- Adapted and extended to identified needs



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

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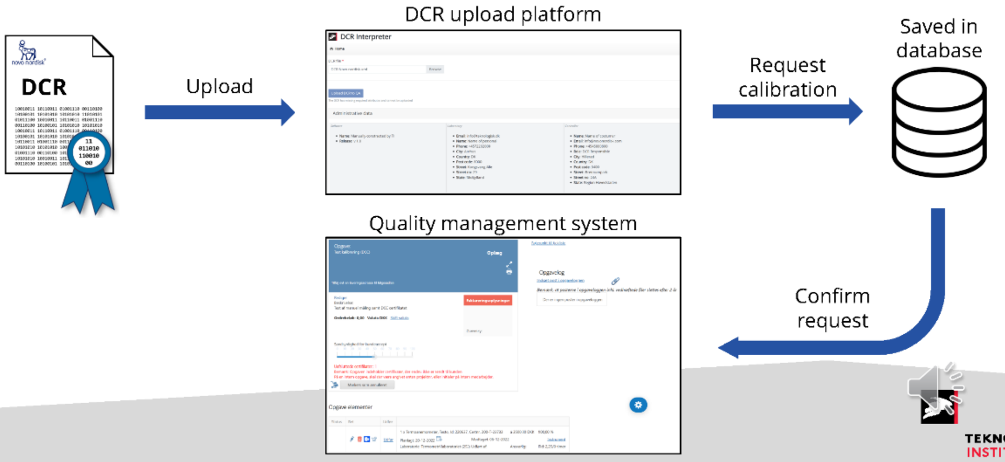
DCR TRANSFER

- Administrative data and calibration information automtically transferred to internal QM system without manual typing of data



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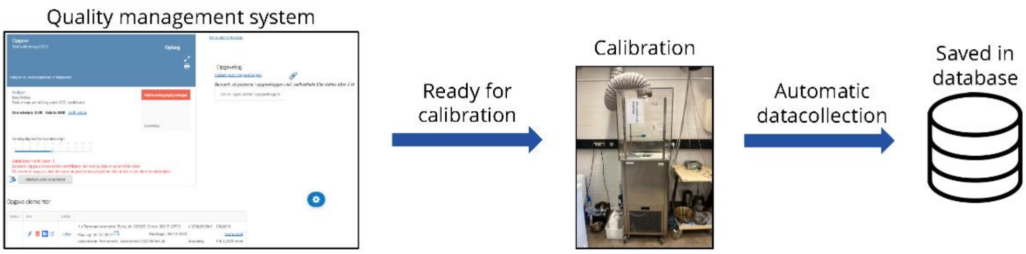
CALIBRATION AND DATA COLLECTION

- Digitalized data collection enables automatic transfer of calibration data to database using intermediate software



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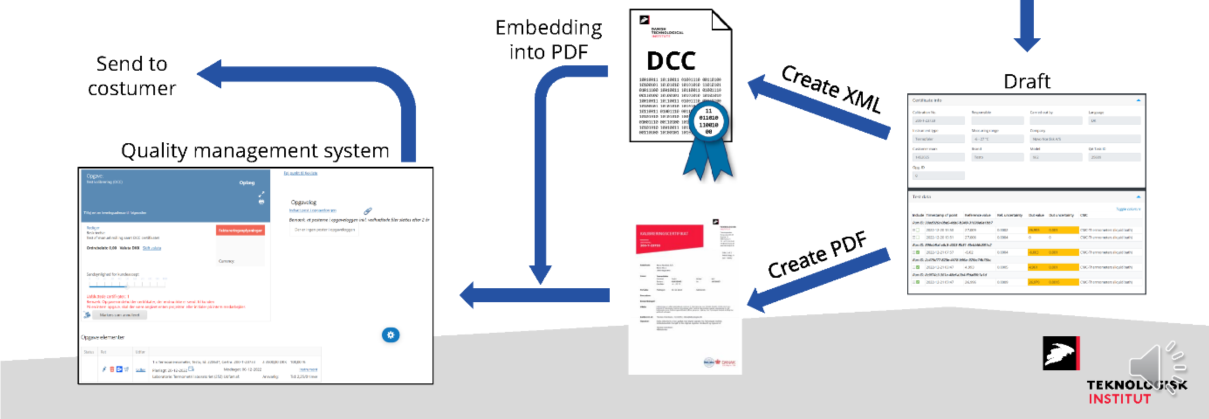
DCC GENERATION

- Validate conformity between generated pdf and XML files
- Options for inspection and control/proofreading of generated files



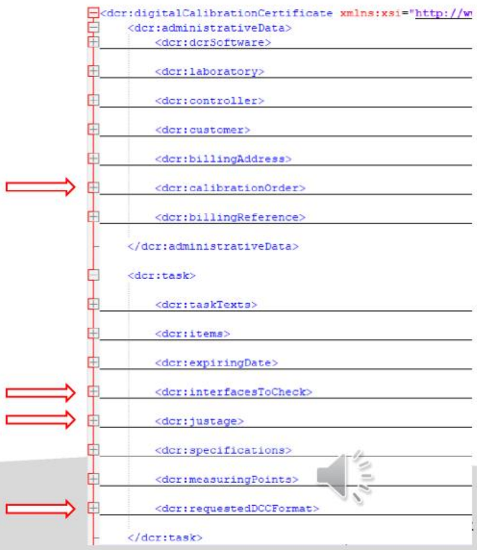
CONSTRUCTION OF THE DCR FILE (XML)

Identified need for additional fields (**implemented**):

- Requested DCC format
- Requested units in DCC
- MPE and adjustment limits
- Interfaces to check
  - Check conformity with accreditation requirement (true/false)
  - Requested MPE conformity assessment
  - Requested full calibration after adjustment

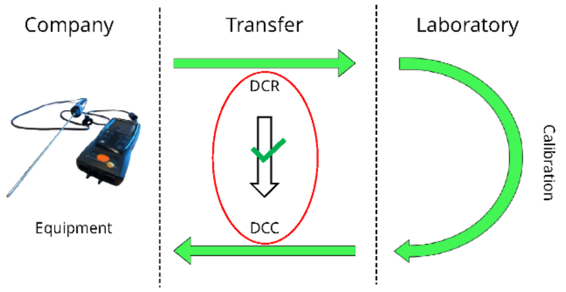
Requested by Novo Nordisk but **not implemented**:

- Requirements to calibration environment conditions, instructions regarding the calibration and calibration setup requirements
- Requirements to uncertainty level and method



TRANSFER OF INFORMATION FROM DCR TO DCC

- Adminstrative data is efficiently transferred
- Other information that can be transferred:
  - Customers Equipment ID (existing field)
  - Requested DCC version (added field)
  - Requested stated units in DCC (added field)



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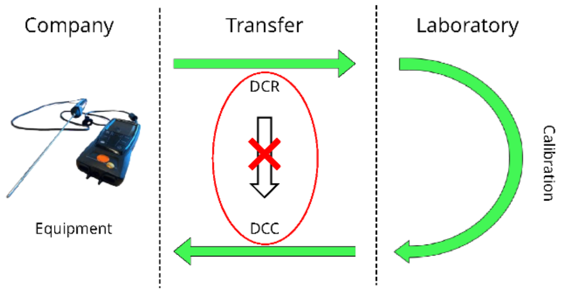
TRANSFER OF INFORMATION FROM DCR TO DCC

No satisfactory solution found:

- Customer Calibration ID (e.g., SAP Inspection Lot number at Novo Nordisk) transfer to DCC? (added field)
  - No place a "customerCalibrationID" (e.g., inspection lot number in SAP system Novo Nordisk) in DCC
- Answer/confirmation in DCC to accreditation requirement in DCR (true/false) (added field)
  - We apply the statement section under administrative data in the DCC, but request a more suitable field



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TRANSFER OF INFORMATION FROM DCR TO DCC

No satisfactory solution found:

- ❌ Customer Calibration ID (e.g., SAP Inspection Lot number at Novo Nordisk) transfer to DCC? (added field)
  - No place a "customerCalibrationID" (e.g., inspection lot number in SAP system Novo Nordisk) in DCC
- ❌ Answer/confirmation in DCC to accreditation requirement in DCR (true/false) (added field)
  - We apply the statement section under administrative data in the DCC, but request a more suitable field

DCR


```
<dcr:administrativeData>
    <dcr:dcrSoftware>
    <dcr:laboratory>
    <dcr:controller>
    <dcr:customer>
    <dcr:billingAddress>
    <dcr:calibrationOrder>
        <dcr:content>140000587117</dcr:content>
    </dcr:calibrationOrder>
```


DCC


```
<dcc:statements>
    <dcc:statement refType="DANAK">
        <dcc:countryCodeISO3166_1>DK</dcc:countryCodeISO3166_1>
        <dcc:traceable>true</dcc:traceable>
        <dcc:norm>DS/EN ISO/IEC 17025:2017</dcc:norm>
        <dcc:reference>4-0200</dcc:reference>
        <dcc:declaration>
          <dcc:name>
            <dcc:content lang="dk">DANAK</dcc:content>
            <dcc:content lang="en">DANAK</dcc:content>
          </dcc:name>
        </dcc:declaration>
        <dcc:valid>true</dcc:valid>
    </dcc:statement>
    <dcc:statement>
        <dcc:traceable>true</dcc:traceable>
        <dcc:norm>ISO/IEC 17025:2017</dcc:norm>
        <dcc:reference>D1-2.2</dcc:reference>
        <dcc:declaration>
            <dcc:content lang="dk">Kalibreringen er udført akkrediteret
            <dcc:content lang="en">This Accredited calibration was was
        </dcc:declaration>
        <dcc:valid>true</dcc:valid>
    </dcc:statement>
</dcc:statements>
```


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NEXT IMPROVEMENTS AND CONTINUED WORK

- Accomodate identified needs to be able to return
  - Requested DCC version
  - Requested units stated in DCC
  - Unambiguous customer calibration ID from DCR to DCC
- Adaption to updated templates and version control
- Full machine based dispatch and receipt of DCR and DCC over time
- At Novo Nordisk:
  - Gradual transition towards implementation
  - Needs to go from test environment to actual calibration system
  - Define new relevant internal standards for IT system
  - Semi-automatic dispatch and receipt of DCR and DCC where fx employees will double check the automatic transfer of data by visual inspection

Future receipt of DCR
- ➢ Browser based?
- ➢ Mail bot?
- ➢ QM system?
- ➢ Cloud service?
- ➢ …?

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CONCLUSIONS AND NEXT STEPS

Conclusions:

- Benefits were demonstrated for both calibration laboratory and customer
- Practical learnings achieved
- Requests for specific content in future DCR (and DCC) good practice examples or standards identified by calibration provider and customer togehter.

Planned next steps:

- Dissemination towards Danish industry
- Pass on learnings and feedback through the Danish coordinated DCC-collaboration group among GTS institutes the international DCC community and working groups (TC-IM 1448, …)

Danish Agency for Higher Education and Science

Acknowledgement: This study was supported by a grant from Danish Technological Institutes performance contract 2021-2024, entered with the Danish Agency for Higher Education and Science, under The Ministry of Higher Education and Science Denmark. Collaborators are greatly acknowledged.

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37 Development of a Universal Measurement Model Framework

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Abstract

Calibration processes and software have largely been developed with a direct measurement comparison method at the forefront. While adequate for many routine calibration processes, this approach becomes insufficient for more complex calibrations and often leads to the creation of special processes, tests, or workarounds which are neither ideal nor sustainable over the long term. In some cases, these inadequacies initiate the development of a completely new and separate calibration processes and software designed to specifically address a single calibration discipline or measurement problem. Here we discuss a complete and universal measurement model framework capable of accommodating routine and complex calibration scenarios alike and allows the use of the various comparison types including direct, indirect, ratio, differential, transfer, and substitution measurement techniques. Additionally, the framework generates a comprehensive set of records to include, all original observations, calculations, corrections, conversions, environmental factors, and measurement results, allowing for step-by-step auditing of every measurement performed. When used in conjunction with the Digital Calibration Certificate or DCC, we enable the ability for measurement processes to be exchanged in their entirety in a manner which can facilitate full and complete interoperability.

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Background

300 psig - Pressure Gauge

Range	Nominal	Lower Limit	Measured	Upper Limit	Result
300 psig	60.0 psig	54.0	62	66.0	Pass
	120.0 psig	117.0	122	123.0	Pass
	180.0 psig	177.0	181	183.0	Pass
	240.0 psig	234.0		246.0	
	300.0 psig	294.0		306.0	
	240.0 psig	234.0		246.0	
	180.0 psig	177.0		183.0	
	120.0 psig	117.0		123.0	
	60.0 psig	54.0		66.0	
	0.0 psig	-6.0		6.0	

Torque - Clockwise (lbf · ft)

#	Range	Nominal	Applied	Readings			Measurement Results
1	50 to 250 lbf · ft	50 lbf · ft	50	49.7	48.5	49.6	49.3; 48 – 50 lbf · ft – 52
2	50 to 250 lbf · ft	150 lbf · ft	150				144 – 150 lbf · ft – 156
3	50 to 250 lbf · ft	250 lbf · ft	250				240 – 250 lbf · ft – 260

Length - Outside (mm)

#	Range	Nominal	Applied	Readings			(Lower)	Expected	(Upper)
1	0 to 100 mm	21 mm	21.0				20.999	21.0	21.001
2		42 mm	42.0				41.999	42.0	42.001
3		60.5 mm	60.5				60.499	60.5	60.501
4		81.5 mm	81.5				81.499	81.5	81.501
5		100 mm	100.0				99.999	100.0	100.001

100 gram Precision Balance

Mass Accuracy

Range	Cardinal Point	Applied	Lower Limit	*Measured	Upper Limit
0 - 100 g	10 g	10.000	9.990		10.010
	25 g	25.000	24.990		25.010
	50 g	50.000	49.990		50.010
	75 g	75.000	74.990		75.010
	95 g	95.000	94.990		95.010

Repeatability

Range	Applied	*Measured
0 - 100 g	50.000	
	50.000	
	50.000	
	50.000	
	50.000	
	50.000	
	50.000	
	50.000	
	50.000	
	50.000	

$$s_x = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

Upper Limit
S_x <= 0.1 g

Off-Center Shift

Range		Applied	*Measured	Error
0 - 100 g	Center	50.000		
	Top Left	50.000		
	Top Right	50.000		
	Bottom Left	50.000		
	Bottom Right	50.000		

Max Error — Upper Limit: Max Error <= 0.1 g

Calibration Datasheet

100 gram Precision Balance

Mass Accuracy

Range	Cardinal Point	Applied	Lower Limit	*Measured	Upper Limit
0 - 100 g	10 g	10.000	9.990		10.010
	25 g	25.000	24.990		25.010
	50 g	50.000	49.990		50.010
	75 g	75.000	74.990		75.010
	95 g	95.000	94.990		95.010

Repeatability

Range	Applied	*Measured
0 - 100 g	50.000	
	50.000	
	50.000	
	50.000	
	50.000	
	50.000	
	50.000	
	50.000	
	50.000	
	50.000	

$$s_x = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

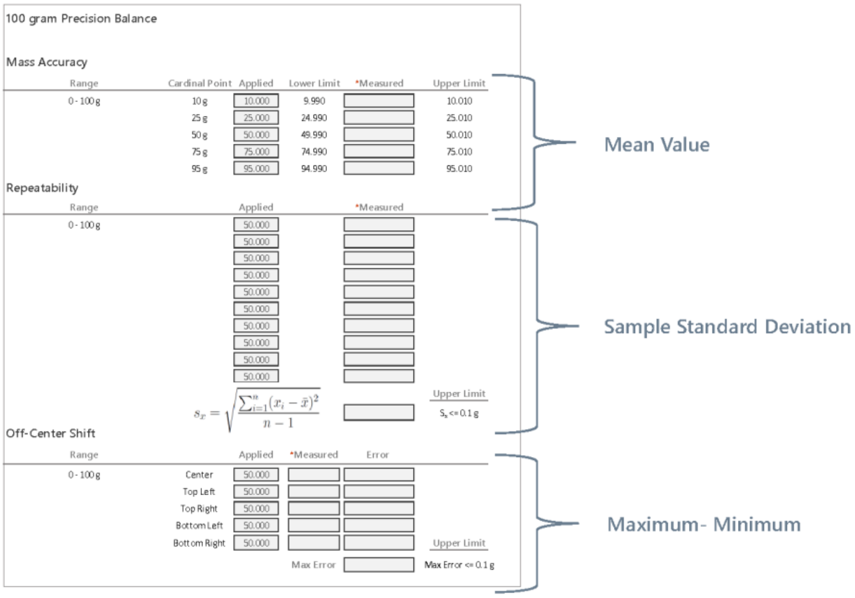
Upper Limit
S_x <= 0.1 g

Off-Center Shift

Range		Applied	*Measured	Error
0 - 100 g	Center	50.000		
	Top Left	50.000		
	Top Right	50.000		
	Bottom Left	50.000		
	Bottom Right	50.000		

Max Error — Upper Limit: Max Error <= 0.1 g

Calibration Datasheet


100 gram Precision Balance

Mass Accuracy

Range	Cardinal Point	Applied	Lower Limit	*Measured	Upper Limit
0 - 100 g	10 g	10.000	9.990		10.010
	25 g	25.000	24.990		25.010
	50 g	50.000	49.990		50.010
	75 g	75.000	74.990		75.010
	95 g	95.000	94.990		95.010

Repeatability

Range	Applied	*Measured	Upper Limit
0 - 100 g	50.000		
	50.000		
	50.000		
	50.000		
	50.000		
	50.000		
	50.000		
	50.000		
	50.000		
	50.000		
	$s_x = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$		S_x <= 0.1 g

Off-Center Shift

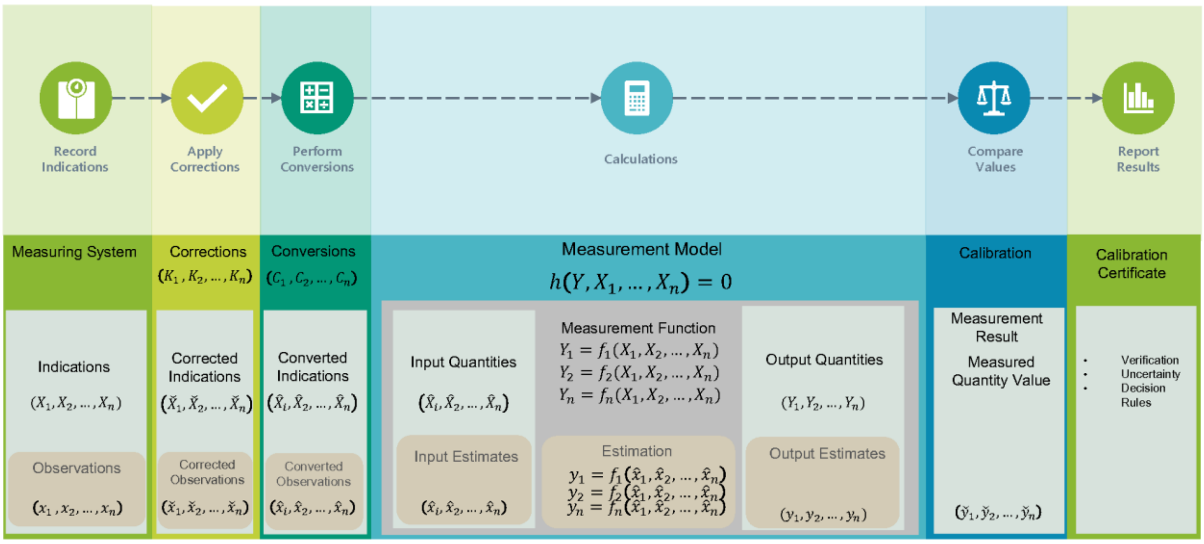
Range		Applied	*Measured	Error	Upper Limit
0 - 100 g	Center	50.000			
	Top Left	50.000			
	Top Right	50.000			
	Bottom Left	50.000			
	Bottom Right	50.000			
			Max Error		Max Error <= 0.1 g

From - Every Calibration is Different and Unique

From - Every Calibration is Different and Unique

To - Every Calibration Consists of 6 Basic Steps

Measurement Process



100 gram Precision Balance

Calibration of 100 g Balance at 50 g with a single measurement

Indications					$\bar{x}$	min	max	σ	σ^2	$Span$	Mo	MR	Cv
50 g Mass Standard	x_1	g	50.000	g	50.00000	50.0000	50.0000	0.000	0.000	0.000	NaN	50.000	0.00%
DUT	x_2	g	49.995	g	49.99500	49.9950	49.9950	0.000	0.000	0.000	NaN	49.995	0.00%
Corrections					$\bar{x}$	min	max	σ	σ^2	$Span$	Mo	MR	Cv
	K_1		a 1.0										
	$\check{x}_1$	g	50.0000	g	50.00000	50.0000	50.0000	0.000	0.000	0.000	NaN	50.000	0.00%
	K_2		a 1.0										
	$\check{x}_2$	g	49.995	g	49.99500	49.9950	49.9950	0.000	0.000	0.000	NaN	49.995	0.00%
Conversions					$\bar{x}$	min	max	σ	σ^2	$Span$	Mo	MR	Cv
	C_1		1.0										
	$\hat{x}_1$	g	50.0000	g	50.00000	50.0000	50.0000	0.000	0.000	0.000	NaN	50.000	0.00%
	C_2		1.0										
	$\hat{x}_2$	g	49.995	g	49.99500	49.9950	49.9950	0.000	0.000	0.000	NaN	49.995	0.00%
Output Quantities					$\bar{x}$	min	max	σ	σ^2	$Span$	Mo	MR	Cv
Applied	y_1	g	50.0000	g	50.0000	50.0000	50.0000	0.000	0.000	0.000	NaN	50.000	0.00%
Expected	$\hat{y}_1$	g	50.000	g	50.000	50.0000	50.0000	0.000	0.000	0.000	NaN	50.000	0.00%
Measured	y_2	g	49.995	g	49.995	49.9950	49.9950	0.000	0.000	0.000	NaN	49.995	0.00%

#	Range	Nominal	Applied	Expected	Lower Limit	Measured	Upper Limit
1	0 to 100 gram	50 g	50.0000 g	50.000 g	49.990 g	49.995 g	50.010 g

100 gram Precision Balance

Repeatability of 100 g Balance at 50 g with 5 measurements

Indications									$\bar{x}$	min	max	σ	σ^2	$Span$	Mo	MR	Cv
50 g Mass Standard	x_1	g	50.0000	50.0000	50.0000	50.0000	50.0000	g	50.00000	50.0000	50.0000	0.000	0.000	0.000	50.000	50.000	0.00%
DUT	x_2	g	49.991	50.000	50.002	50.004	49.995	g	49.99840	49.9910	50.0040	0.005	0.000	0.013	NaN	49.998	0.01%
Corrections									$\bar{x}$	min	max	σ	σ^2	$Span$	Mo	MR	Cv
	K_1		a 1.0														
	$\check{x}_1$	g	50.0000	50.0000	50.0000	50.0000	50.0000	g	50.00000	50.0000	50.0000	0.000	0.000	0.000	50.000	50.000	0.00%
	K_2		a 1.0														
	$\check{x}_2$	g	49.99100	50.00000	50.00200	50.00400	49.99500	g	49.99840	49.9910	50.0040	0.005	0.000	0.013	NaN	49.998	0.01%
Conversions									$\bar{x}$	min	max	σ	σ^2	$Span$	Mo	MR	Cv
	C_1		1.0														
	$\hat{x}_1$	g	50.0000	50.0000	50.0000	50.0000	50.0000	g	50.00000	50.0000	50.0000	0.000	0.000	0.000	50.000	50.000	0.00%
	C_2		1.0														
	$\hat{x}_2$	g	49.99100	50.00000	50.00200	50.00400	49.99500	g	49.99840	49.9910	50.0040	0.005	0.000	0.013	NaN	49.998	0.01%
Output Quantities									$\bar{x}$	min	max	σ	σ^2	$Span$	Mo	MR	Cv
Applied	y_1	g	50.0000	50.0000	50.0000	50.0000	50.0000	g	50.00000	50.0000	50.0000	0.000	0.000	0.000	NaN	50.000	0.00%
Expected	$\hat{y}_1$	g	50.000	50.000	50.000	50.000	50.000	g	50.00000	50.0000	50.0000	0.000	0.000	0.000	NaN	50.000	0.00%
Measured	y_2	g	49.991	50.000	50.002	50.004	49.995	g	49.99840	49.9910	50.0040	0.005	0.000	0.013	NaN	49.998	0.01%

#	Range	Nominal	Applied	Expected	Lower Limit	Measured	Upper Limit
1	0 to 100 gram	0 g	0.000 g	0.000 g	0.000 g	0.005 g	0.010 g

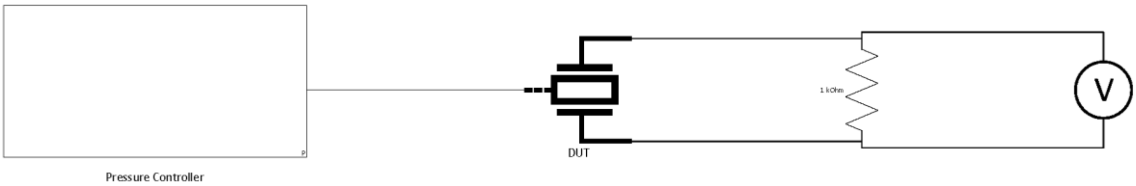
100 µL Pipette

Accuracy and Precision of 100 µL Pipette at 10 µL with 10 measurements

								$\bar{x}$	min	max	σ	σ^2	$Span$	Mo	MR	Cv
Indications																
DUT Test Volume																
	x_1	µL	10.0	10.0	10.0	10.0	10.0	10.000	10.000	10.000	0.000	0.000	0.000	10.000	10.000	0.00%
			10.0	10.0	10.0	10.0	10.0									
Precision Balance																
	x_2	mg	10.02	10.00	10.02	10.03	10.00	10.014	9.980	10.030	0.016	0.000	0.050	10.020	10.005	0.16%
			10.03	9.98	10.02	10.01	10.03									
Corrections								$\bar{x}$	min	max	σ	σ^2	$Span$	Mo	MR	Cv
	K_1	a	1.0													
	$\check{x}_1$	µL	10.0	10.0	10.0	10.0	10.0	10.000	10.000	10.000	0.000	0.000	0.000	10.000	10.000	0.00%
			10.0	10.0	10.0	10.0	10.0									
	K_2	a	1.0031	<<<<< Liquid Density Correction												
	$\check{x}_2$	mg	10.0511	10.0310	10.0511	10.0611	10.0310	10.045	10.011	10.061	0.017	0.000	0.050	10.051	10.036	0.16%
			10.0611	10.0109	10.0511	10.0410	10.0611									
Conversions								$\bar{x}$	min	max	σ	σ^2	$Span$	Mo	MR	Cv
	C_1		1.0													
	$\hat{x}_1$	µL	10.00	10.00	10.00	10.00	10.00	10.000	10.000	10.000	0.000	0.000	0.000	10.000	10.000	0.00%
			10.00	10.00	10.00	10.00	10.00									
	C_2		1.0	<<<<< Convert from g to uL												
	$\hat{x}_2$	µL	10.0511	10.0310	10.0511	10.0611	10.0310	10.045	10.011	10.061	0.017	0.000	0.050	10.051	10.036	0.16%
			10.0611	10.0109	10.0511	10.0410	10.0611									
Output Quantities								$\bar{x}$	min	max	σ	σ^2	$Span$	Mo	MR	Cv
Applied	y_1	µL	10.00	10.00	10.00	10.00	10.00	10.000	10.000	10.000	0.000	0.000	0.000	10.000	10.000	0.00%
			10.00	10.00	10.00	10.00	10.00									
Expected	$\hat{y}_1$	µL	10.00	10.00	10.00	10.00	10.00	10.000	10.000	10.000	0.000	0.000	0.000	10.000	10.000	0.00%
			10.00	10.00	10.00	10.00	10.00									
Measured	y_2	µL	10.0511	10.0310	10.0511	10.0611	10.0310	10.045	10.011	10.061	0.017	0.000	0.050	10.051	10.036	0.16%
			10.0611	10.0109	10.0511	10.0410	10.0611									

#	Range	Description	Nominal	Applied	Expected	Lower Limit	Measured	Upper Limit
1	100 µL	Accuracy	10 µL	10.00 µL	10.00 µL	9.65 µL	10.05 µL	10.35 µL
2	100 µL	Precision	0%	0.00%	0.00%	-1.00%	0.16%	1.00%

0 psi to100 psi Pressure Transducer (4 mA to 20 mA)



$$X_1 \rightarrow Y_1 = f_1(X_1) \rightarrow Y_1 = \hat{\bar{x}}_1$$

$$X_2, X_3 \rightarrow Y_2 = f_2(X_2, X_3) \rightarrow Y_2 = rangemin + (rangemax - rangemin) \cdot \frac{\left(\frac{V}{R}\right) - outputmin}{outputmax - outputmin}$$

$$y_2 = 0 + (100 - 0) \cdot \frac{\left(\frac{\hat{\bar{x}}_2}{\hat{\bar{x}}_3}\right) - 4}{16}$$

100 psi Pressure Transducer

Calibration of 100 psi Pressure Transducer at 75 psi with 5 measurements

Indications									$\bar{x}$	min	max	σ	σ^2	$Span$	Mo	MR	Cv
Pressure Controller	x_1	psi	74.9988	75.0031	74.9979	75.0012	75.0018	psi	75.00056	74.9979	75.0031	0.002	0.000	0.005	NaN	75.001	0.00%
Voltmeter	x_2	V	15.99865	15.9946	15.9985	15.99914	15.9993	V	15.99804	15.9946	15.9993	0.002	0.000	0.005	NaN	15.997	0.01%
Current Shunt	x_3	kΩ	0.99999879	0.99999879	0.99999879	0.99999879	0.99999879	kΩ	0.99999879	1.0000	1.0000	0.000	000.0E+0	0.000	1.000	1.000	0.00%
Corrections									$\bar{x}$	min	max	σ	σ^2	$Span$	Mo	MR	Cv
	K_1		a 1.0	b 1.0	c 1.0												
	$\breve{x}_1$	psi	74.9988	75.0002	74.9979	75.0012	75.0018	psi	74.99998	74.9979	75.0018	0.001	0.000	0.004	NaN	75.000	0.00%
	K_2		a 1.0														
	$\breve{x}_2$	V	15.99865	15.99460	15.99850	15.99914	15.99930	V	15.99804	15.9946	15.9993	0.002	0.000	0.005	NaN	15.997	0.01%
	K_3		a 1.0														
	$\breve{x}_3$	kΩ	0.99999879	0.99999879	0.99999879	0.99999879	0.99999879	kΩ	1.00000	1.0000	1.0000	0.000	000.0E+0	0.000	1.000	1.000	0.00%
Conversions									$\bar{x}$	min	max	σ	σ^2	$Span$	Mo	MR	Cv
	C_1		1.0														
	$\hat{x}_1$	psi	74.9988	75.0002	74.9979	75.0012	75.0018	psi	74.99998	74.9979	75.0018	0.001	0.000	0.004	NaN	75.000	0.00%
	C_2		1.0														
	$\hat{x}_2$	V	15.99865	15.99460	15.99850	15.99914	15.99930	V	15.99804	15.9946	15.9993	0.002	0.000	0.005	NaN	15.997	0.01%
	C_3		1.0														
	$\hat{x}_3$	kΩ	0.99999879	0.99999879	0.99999879	0.99999879	0.99999879	kΩ	1.00000	1.0000	1.0000	0.000	000.0E+0	0.000	1.000	1.000	0.00%
Output Quantities									$\bar{x}$	min	max	σ	σ^2	$Span$	Mo	MR	Cv
Applied	y_1	psi	74.9988	75.0002	74.9979	75.0012	75.0018	psi	74.99998	74.9979	75.0018	0.001	0.000	0.004	NaN	75.000	0.00%
Expected	$\hat{y}_1$	psi	74.999	75.000	74.998	75.001	75.002	psi	75.0000	74.9980	75.0020	0.001	0.000	0.004	NaN	75.000	0.00%
Measured	y_2	psi	74.9917	74.9664	74.9907	74.9947	74.9957	psi	74.98786	74.9664	74.9957	0.011	0.000	0.029	NaN	74.981	0.01%

#	Range	Nominal	Applied	Expected	Lower Limit	Measured	Upper Limit
1	0 to 100 psi	75 psi	74.9998 psi	75.0000 psi	74.9813 psi	74.98786 psi	75.0188 psi

Various Reported Results

#	Range	Nominal	Applied	Expected	Lower Limit	Measured	Upper Limit
1	0 to 100 psi	75 psi	74.9998 psi	75.0000 psi	74.9813 psi	74.98786 psi	75.0188 psi

Various Reported Results

#	Range	Nominal	Applied	Expected	Lower Limit	Measured	Upper Limit
1	0 to 100 psi	75 psi	74.9998 psi	75.0000 psi	74.9813 psi	74.98786 psi	75.0188 psi

#	Range	Nominal	Applied	Expected	Lower Limit	Measured	Upper Limit
1	0 to 100 psi	16 mA	74.9998 psi	15.9999 mA	15.9970 mA	15.9980 mA	16.0030 mA

Various Reported Results

#	Range	Nominal	Applied	Expected	Lower Limit	Measured	Upper Limit
1	0 to 100 psi	75 psi	74.9998 psi	75.0000 psi	74.9813 psi	74.98786 psi	75.0188 psi

#	Range	Nominal	Applied	Expected	Lower Limit	Measured	Upper Limit
1	0 to 100 psi	16 mA	74.9998 psi	15.9999 mA	15.9970 mA	15.9980 mA	16.0030 mA

#	Range	Nominal	Applied	Expected	Lower Limit	Measured	Upper Limit
1	0 to 100 psi	16 V	74.9998 psi	15.9998 V	15.9969 V	15.9979 V	16.0029 V

Various Reported Results

#	Range	Nominal	Applied	Expected	Lower Limit	Measured	Upper Limit
1	0 to 100 psi	75 psi	74.9998 psi	75.0000 psi	74.9813 psi	74.98786 psi	75.0188 psi

#	Range	Nominal	Applied	Expected	Lower Limit	Measured	Upper Limit
1	0 to 100 psi	16 mA	74.9998 psi	15.9999 mA	15.9970 mA	15.9980 mA	16.0030 mA

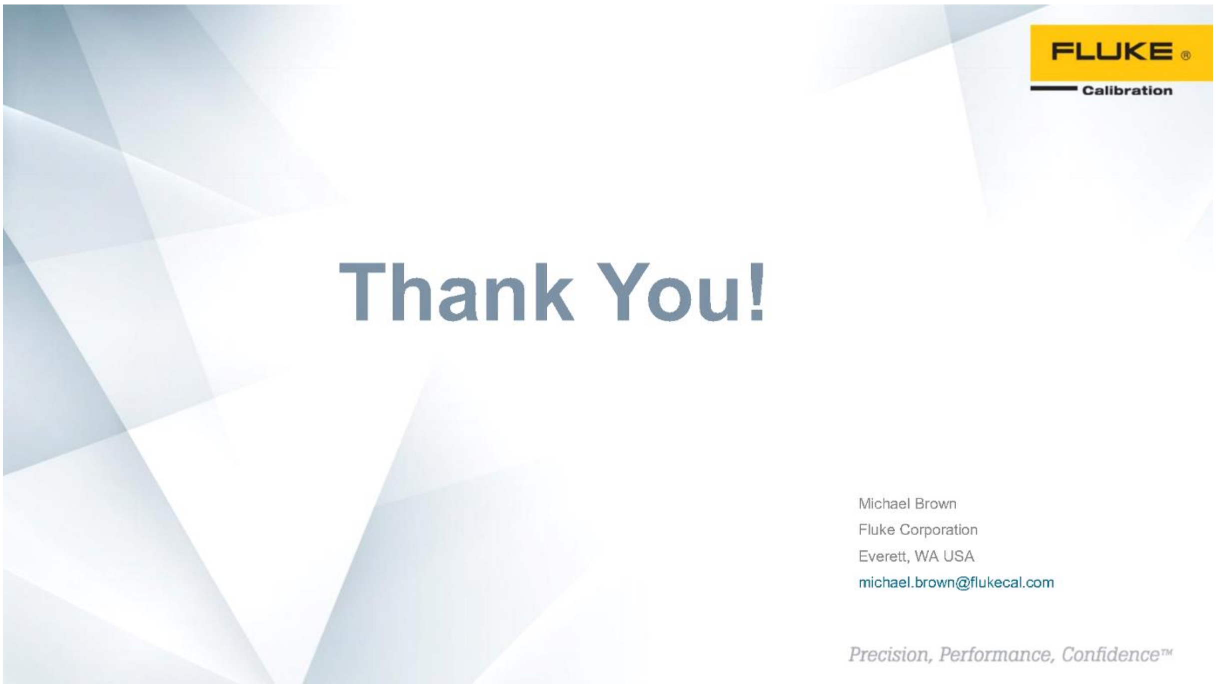
#	Range	Nominal	Applied	Expected	Lower Limit	Measured	Upper Limit
1	0 to 100 psi	16 V	74.9998 psi	15.9998 V	15.9969 V	15.9979 V	16.0029 V

Without knowing the measurement function, we cannot understand the true relationship between the measurement result and the intended application.

Conclusion

- Every calibration can be performed by implementing 6 basic functional steps
- A quantity value consisting of only a number and unit is incomplete without identifying what type of statistic the number represents
- The measurement result can be assigned one of several summary statistics produced by a measurement function
- A complete record of all observations, calculations, and conversions is maintained, facilitating a step-by-step audit of any measurement
- Defining and including the measurement function in DCC's can be used to facilitate interoperability

- Proposal :
  A Universal Measurement Model (UMM) namespace to include the full measurement process in DCC's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38 The Quality of Sensing, of Data or of Information

Presenting author: Dr. Thomas Engel, Siemens AG, Germany

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Abstract

In a digital world, data scientists have to rely on the data they get from the various sources. For the metrology domain it is important to not only have the measured value plus its tolerances and unit but also to have some additional information about the conditions where the measurement was performed. The approach of QoX, where X is an abbreviation for Sensing (S), Data(D) and Information (I), is intended to convey supplementary information about the measurement conditions or environment parallel to the data. It is intended as an open but concise concept to report, transport, and propagate QoX in parallel to the measured data, when they are processed in order to provide respective QoX indicators also for the result. The QoX do reflect the domain where they are generated. This is of great value for data scientist to understand where a specific QoX was generated in the process to trace back easily the origin of the data used.

This talk will introduce to the concept of QoX and present some related methods how to determine QoX values. Furthermore, early concept ideas how to propagate QoX of input values into meaningful QoX related to the output of respective operations or evaluations on the input values will be shared.

This work to optimize the quality of data is part the GEMIMEG-II project which is funded by the German ministry for economic affairs and climate action based on a decision by the German Bundestag under grant number 01 MT20001A.

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Motivation

Future Vision of Industry 4.0:
In a fully automized quality infrastructure, the interacting parties are machines or computer systems.

All data/information contained in data files are taken for granted by the chain of IT systems. There is no space attributed to assess the quality of a datum itself or of the information content attributed to the data.

Today‘s good practice:
The metrologist observes the measurement and even other external conditions around the measurement. She/he only trusts the measurement to full extent, when she/he feels comfortable with the data measured <u>and all</u> her/his observations – conscious or incidential – around the measurement

Open Question:
How to close the **„digitalization gap“** to convey the positive **„gut feeling“** of the metrologist or data scientist about the values measured, the data derived or the information gained along with the data?

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The QoX Concept

Quality Information can be derived for data in different domains. To make fully transparent in which domain / which expert the quality information has been derived, the following structure is suggested:

Quality of Sensing (QoS):

- Characterizing the sensing domain → Attributed to data by metrologist / sensing expert
- Sensor values are preferably agnostic to specific sensor system used to improve interoperability in subsequent processes

Quality of Data (QoD):

- Characterizing the data evaluation, data operations and data fusion → Attributed to data by data scientist
- Propagate the QoS of incomming data and incorporates also effects of data operations

Quality of Information (QoI):

- Characterizing the trust level or trustworthiness of information → attributed to information by data scientist
- Propagate the QoS and QoD of incomming data and incorporate also effects of information generation

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Quality of X: QoX
X: Sensing, Data, Information; …

A measurement result typcially consists of:

(corrected) Measured Value + Measurement Unit + Measurement Uncertainty + Statistical Information

Example: Length measurement

8.412 µm (10^{-6} m) ± 10 µm (GUM) 3 σ

In addition, there can be much more quality related information for the measurement process itself or the data aggregation and evaluation or the information gained from the data, like e.g.

QoS	QoD	QoI
Signal strength/level	Software / model based sensor	Accuracy of information derived
Signal/Noise ratio (SNR)	Data fusion: residual error level	Machine/system status, DT
Battery status of sensor	Battery capacity of sensor	Remaining Battery Life
Motion blurring	Sensor network data, modalities	AI: Classification quality / %
Sensor motion/Doppler effects	Redundancy/Diversity of Data	Anomaly detected (yes/no)

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Quality of X
X: Sensing, Data, Information, …

Suggested functional elements for a concise QoX description:

Sensor System Type	Type of physical sensor or software/model based sensor
Quality Indicator	Sensor System parameter to be characterized internal parameter: e.g. operational, functional external parameter: e.g. environmental
Indicator Description Definition	Detailed/explicit determination scheme, traceable, version controlled formula for calculation incl. input parameters allowed range of values, value type
Indicator Metric	Scale for Indicator (absolute + unit, relative, %, dB, …)
Indicator interpretation:	Status interpretation (good, acceptable, bad, info only – low trust level, …)
…	

A first suggestion for semantics can be found in:
Vedurmudi, A. P.; Neumann, J.; Gruber M.; Eichstädt, S.; ***Semantic Description of Quality of Data in Sensor Networks***, Submitted for publication to Sensors

Additonal aspects have been derived in the project and will be published soon in Measurement Science and Technology in a special issue of CIM 2023 conference

How to combine QoX values?

Goal / Aspiration:
Resulting QoX values should reflect the quality of the related datum/information in a conclusive way based on the QoX values of all contributing data values/information used while generating the datum/information.

Implications:
- Different input data differ in influence on result data/information → QoX should reflect it
  - Weighting should be possible while combining QoX
  - Weighting factors according to computation of data / numbers
- For ease of combining QoX, they should be scaled to [0 1] with 0: no quality and 1: optimal quality
  - Preferably, QoX are unit less, e.g. by scaling to best possible value
  - Caution: For some computations, a value of 0 can be critical

General Concept
Averaging functions applied to QoX

For the application with QoX the formulas read:

A) Arithmetic Mean

$$\bar{x} = \sum_{k=1}^{n} \frac{QoX_k}{n}$$

or weighted arithmetic mean

$$\bar{x} = \frac{\sum_{k=1}^{n} w_k \, QoX_k}{\sum_{k=1}^{n} w_k}$$

B) Geometric Mean

$$\bar{x} = \sqrt[n]{\prod_{k=1}^{n} QoX_k}$$

or weighted geometric mean

$$\bar{x} = \sqrt[\sum_{k=1}^{n} w_k]{\prod_{k=1}^{n} {QoX_k}^{w_k}}$$

C) Harmonic Mean

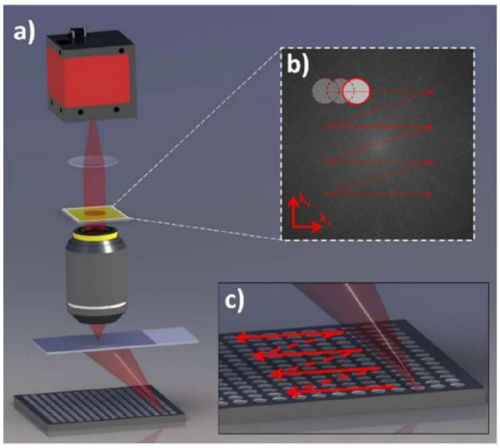
$$\bar{x} = n \left(\sum_{k=1}^{n} \frac{1}{QoX_k} \right)^{-1}$$

or weighted harmonic mean

$$\bar{x} = \frac{\sum_{k=1}^{n} w_k}{\sum_{k=1}^{n} \frac{w_k}{QoX_k}} = \left(\frac{\sum_{k=1}^{n} w_k \; QoX_k^{-1}}{\sum_{k=1}^{n} w_k} \right)^{-1}$$

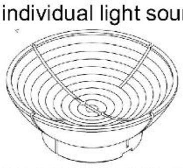
D) General Mean / Hölder mean is also valid and applicable for QoX, which are positive real numbers.

Example: Fourier Ptychography Microscope (FPM)



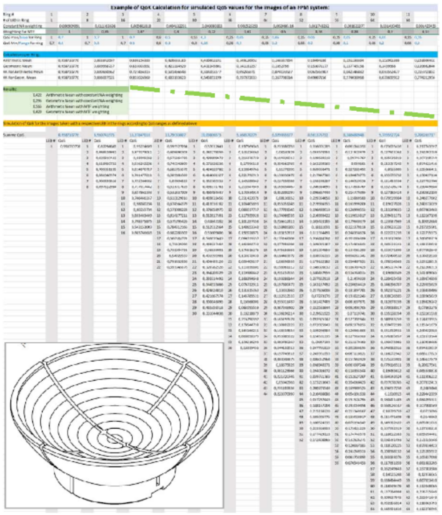
Synthetic aperture imaging microscope

- Multitude of individual light sources for illumination



- High resolution high aperture images are fused from low resolution low aperture images of one / few light sources
- Depending of illumination aperture, single images have different image quality → QoS
- Question:
  What is the quality of the image fused? → QoD

Example: Fourier Ptychography Microscope (FPM)



The table shows generic QoS assigned to each LED of the illimination system and respective contribution weight factors for each ring with related aperture of illumination.

Results:	
0,422	Arithmetic Mean with constant NA weighting
0,295	Geometrix Mean with constant NA weighting
0,565	Arithmetic Mean with MTF weighting
0,429	Geometrix Mean with MTF weighting

A lower weighting of images with higher aperture illumination reflects the effect of a typical modulation transfer function (MTF) of the respective optical system and thus improve the final QoD for the image fused.

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Conclusion

- How to incorporate the QoX into the DCC?
  - QoX can be added as supplemented information in the DCC schema – discussions are started
    - Clear and unique definition of respective QoX needed
    - Definition of formula for calculation
    - Structured notation of QoX input channels with related weighting factors

- QoX do contain additional information about the quality of sensing, data and information
  - QoX are supplementary information about the data/information and do not compete with measurement uncertainties or measurement errors
  - QoX are optional information attributing the data or information

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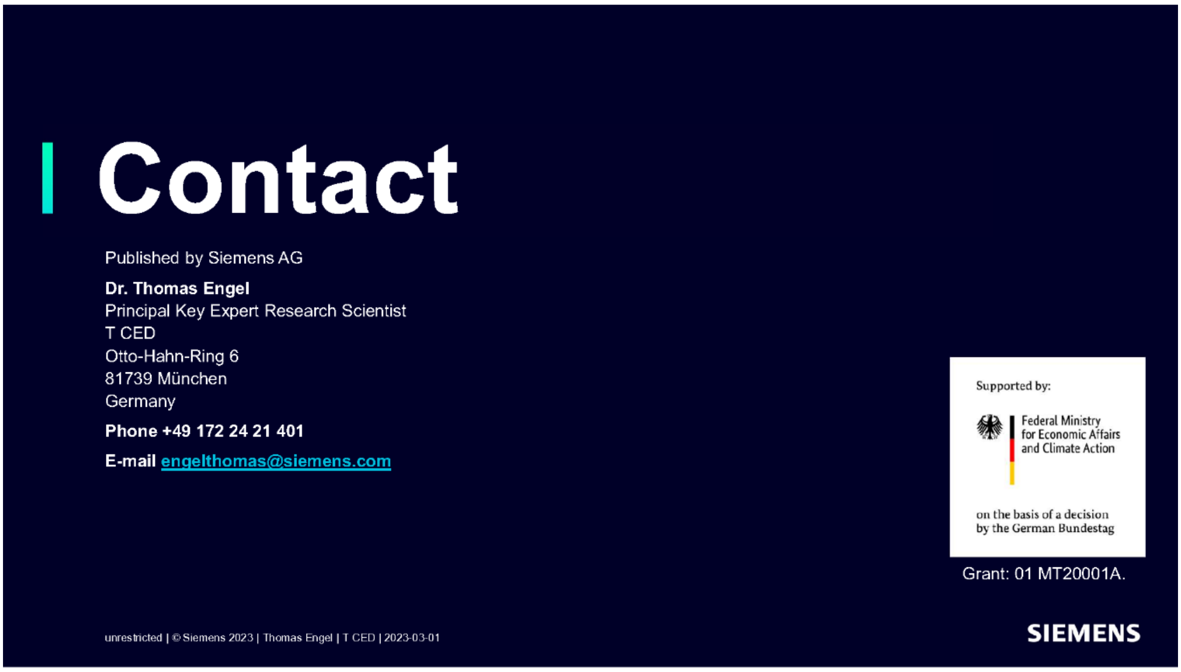
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39 Two Implementations of Digital Calibration Certificates in Industrial and Metrological Services

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E-mail address: mbierzychudek@inti.gob.ar

Additional authors: D. Coppa, A. Toran, L. Di Lillo, C. Muzzio, L. Gurevich, N. Dini, F. Wainstein, F. Serrano, R. Benevenia, A. Zapata, D. Calero Costa, J. C. Suarez Barón and L. Álvarez.

Abstract

This work presents the implementation of the DCC in two traceability chains from the national standards maintained at INTI (Instituto Nacional de Tecnología Industrial) up to the services of the company HITEC. INTI can provide a DCC to the company's standards. Then, HITEC can perform a metrology service using that DCC and writing a new DCC for the customer.

The first traceability chain is applied in electrical metrology for the calibration of multifunction calibrators. These standards are broadly used in the industry because they are required to realize the performance verification of hand multimeters and other instruments. The calibration procedure includes the measurements of more than 100 points. Thus, the DCC can help to improve the usability and control of all this data. In addition, the DCC eliminates the errors and the workload associated with the human-readable calibration certificate.

The second traceability chain starts with the vibration standard at INTI, and finished with the vibration sensors of the Terative system developed by HITEC. This system analyses the sensor data utilizing an IA algorithm for predictive maintenance of rotating machines. The first step is the calibration of an accelerometer by INTI, which is used to calibrate a shaker at HITEC. Then, the sensors are calibrated and finally, the data generated for these sensors can be corrected before the data processing. This case of use allows embedding the DCC in machine learning software, taking full advantage of new trends.

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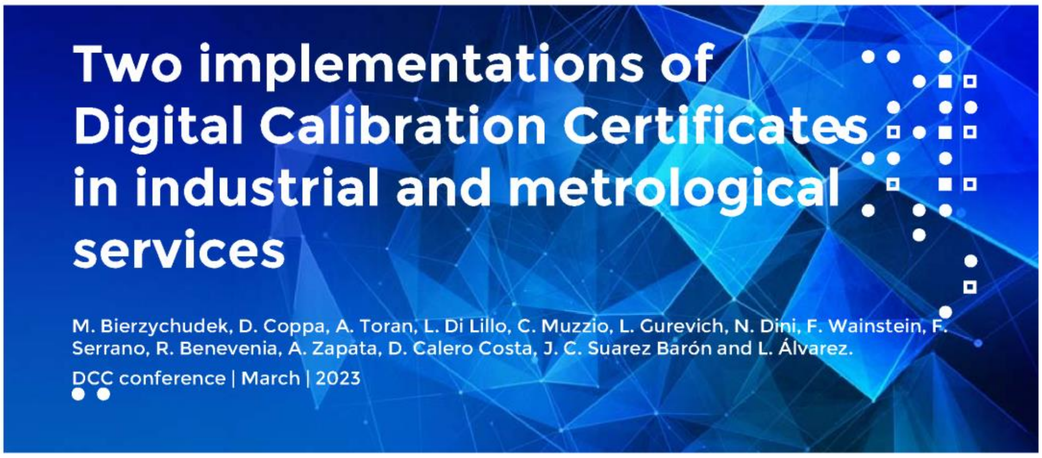


Instituto Nacional de Tecnología Industrial INTI

Ministerio de Economía Argentina

Secretaría de Industria y Desarrollo Productivo

Project overview

Associative research project funded by the Ministry of Science and Technology of Argentina.

Partners:

HITEC SRL sensing & control

Instituto Nacional de Tecnología Industrial INTI

Project overview

Objetives

To ensure the calibration data quality in its generation, use and transference by means of a digital calibration certificate.

Project overview

Traceability chains

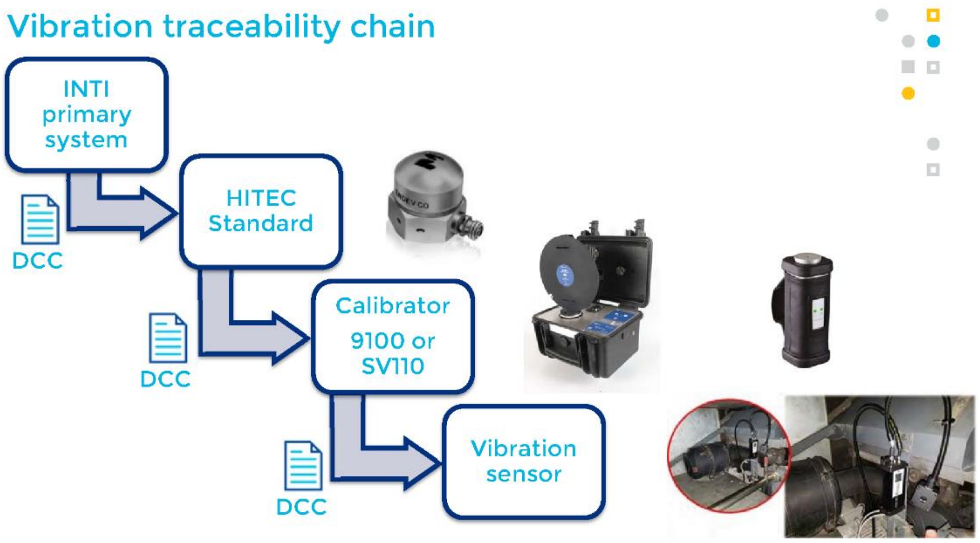
- To implement a digital traceability chain from the vibration standard at INTI up to the sensors produced by HITEC. The work involves a new standard for INTI and the implementation of calibration procedures at HITEC.

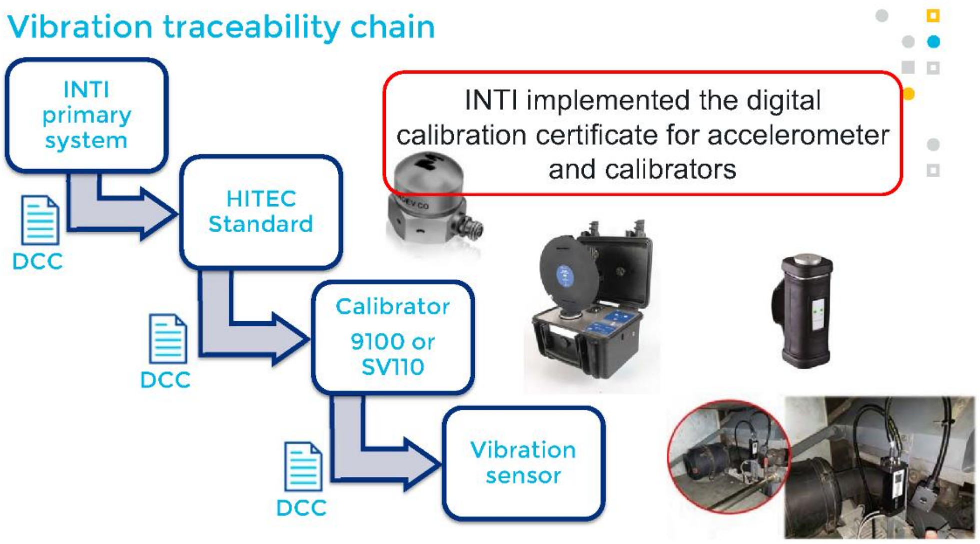
- To implement a digital traceability chain in an automated process of calibration of multifunction calibrators. The work involves the development of the calibration procedure, software and a multivariable multiplexer.

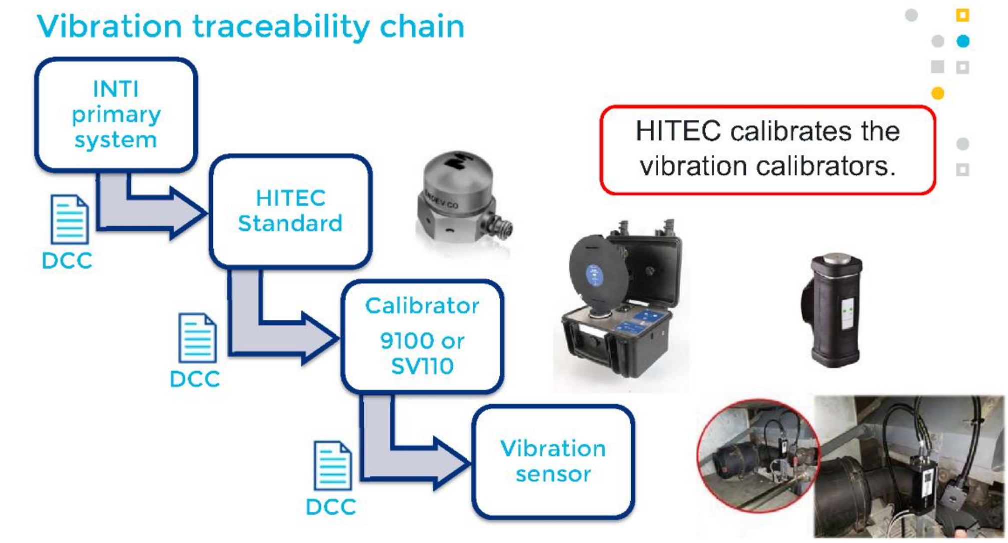
DCC

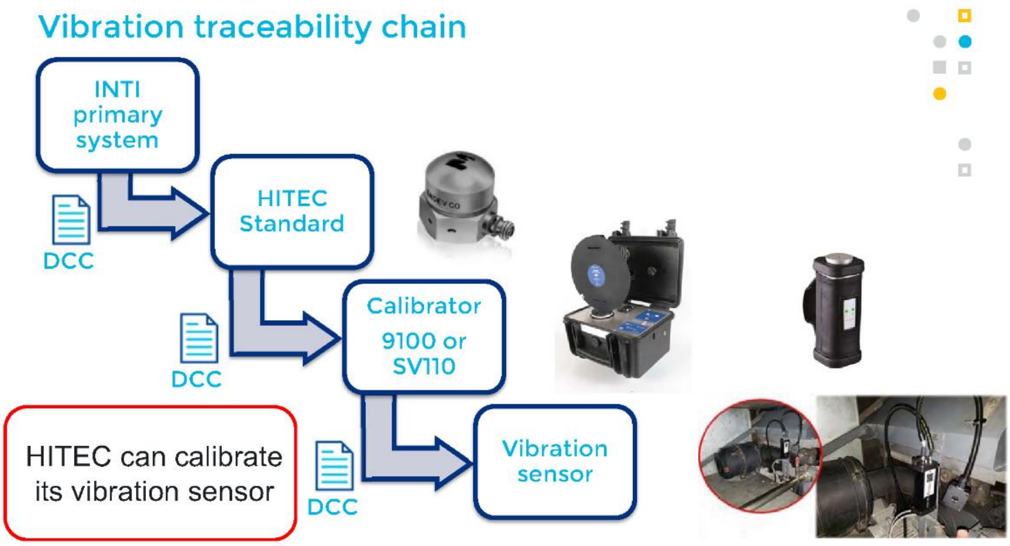
INTI develop a software to DCC generation, for more information see:

“Software for the Creation of Machine and Human Readable Reports” by Diego Coppa at 12:30 h (UTC) Wednesday.


Vibration traceability chain
INTI primary system
DCC
HITEC Standard
DCC
Calibrator 9100 or SV110
DCC
Vibration sensor


Vibration traceability chain
INTI primary system
DCC
HITEC Standard
DCC
Calibrator 9100 or SV110
DCC
Vibration sensor
INTI implemented the digital calibration certificate for accelerometer and calibrators


Vibration traceability chain
INTI primary system
DCC
HITEC Standard
DCC
Calibrator 9100 or SV110
DCC
Vibration sensor
HITEC calibrates the vibration calibrators.


Vibration traceability chain
INTI primary system
DCC
HITEC Standard
DCC
Calibrator 9100 or SV110
DCC
Vibration sensor
HITEC can calibrate its vibration sensor

Vibration traceability chain

Terative system analyses the vibration sensor data utilizing an AI algorithm for predictive maintenance of rotating machines.

Calibration of sensor within Terative system to provide

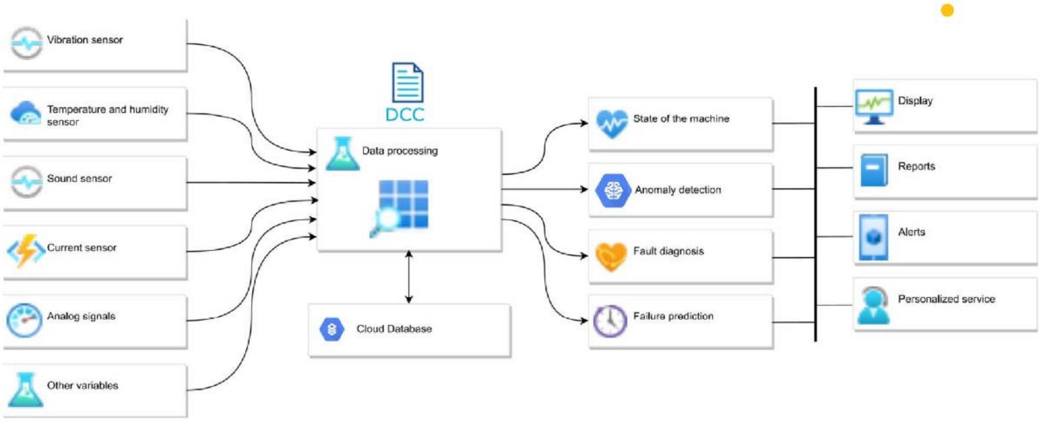
- Traceability (ensure quality of data)
- Compatibility between sensors
- Uncertainty calculation

Vibration traceability chain

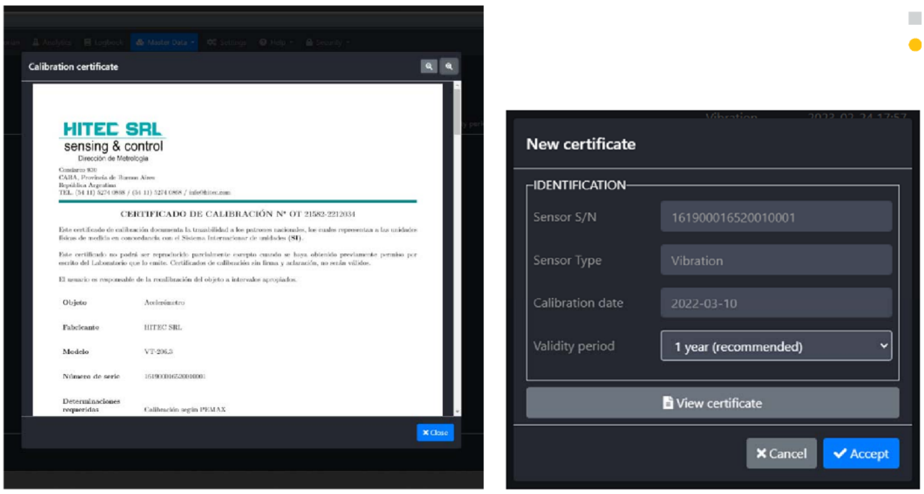
The integration of DCC in Terative software allows to design the software with the ISO/IEC 17025 approach (equipment (6.4), traceability (6.5), technical register (7.5) and assurance of the validity of results (7.7))

- DCC database and automatic identification of the device
- Automatic date control and verification of calibration period
- Automatic evaluation of error measurement to determine that the device is within specification
- Control chart
- Automatic measurement error correction

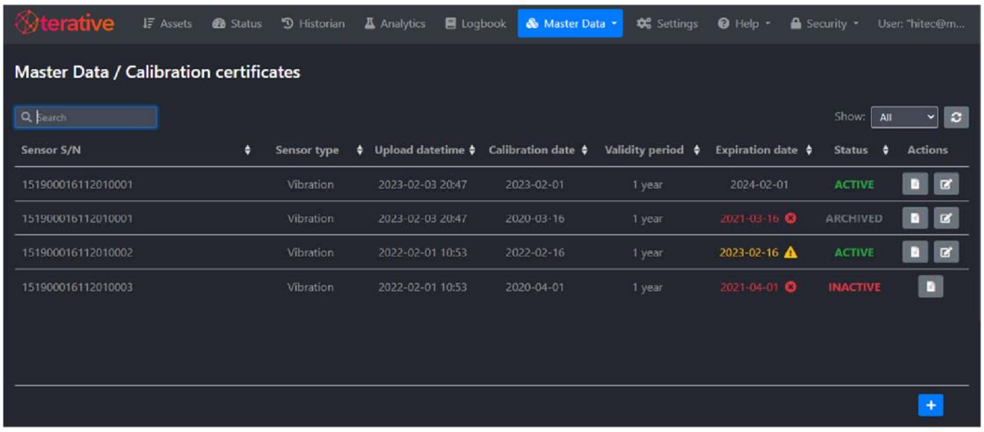
Vibration traceability chain



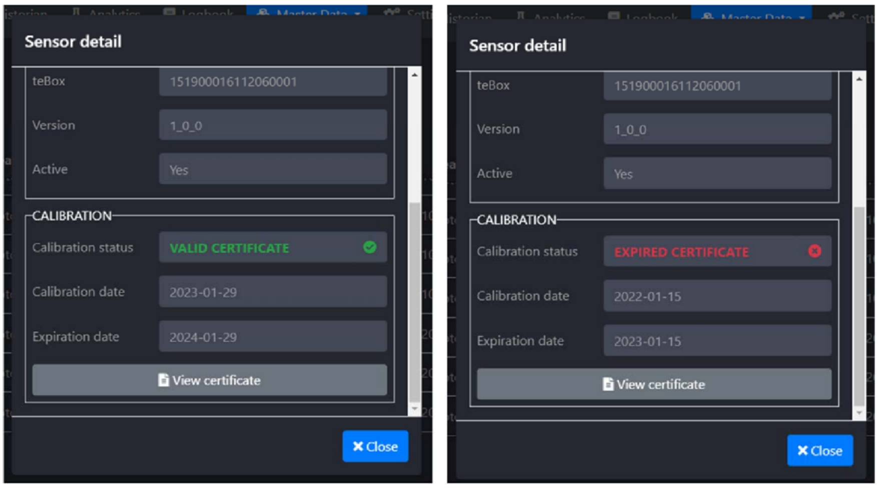
Vibration traceability chain



Vibration traceability chain



Vibration traceability chain



Instituto Nacional de Tecnología Industrial

DCC in an Electrical Traceability Chain

Electrical traceability chain

Electrical traceability chain

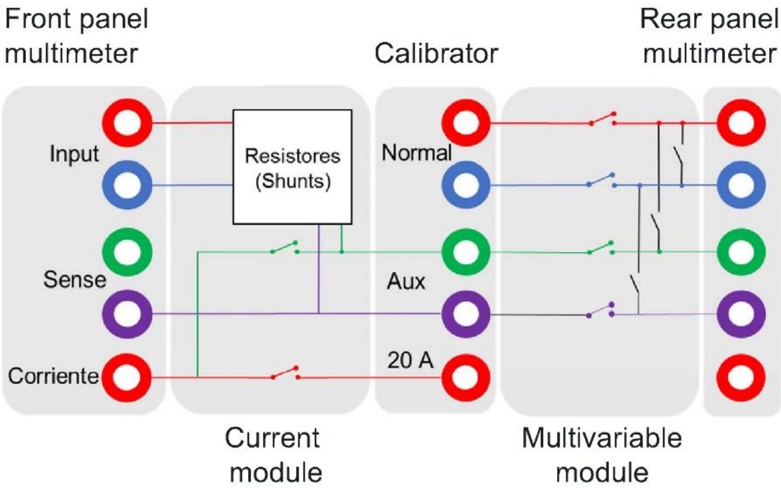
- More than 100 point of calibration
- The analysis of measurement errors is complex
- The application of correction allows to use data history to reduce uncertainty
- Service with high workload

Electrical traceability chain

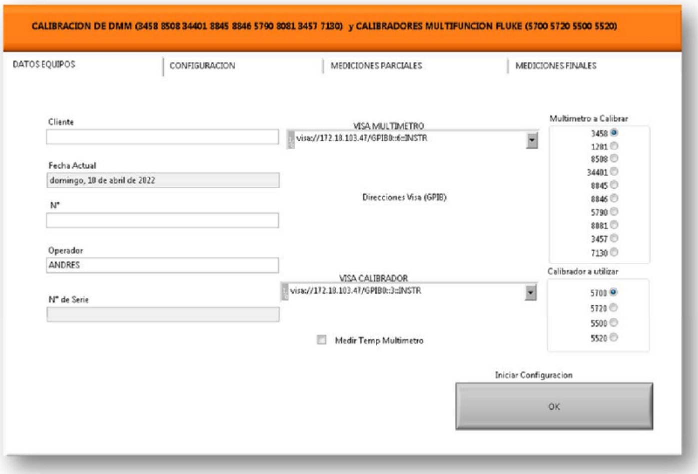
Fully automated system to calibrate multifunction calibrators.

Magnitude	Range
DC voltage	100 mV – 1000 V
AC voltage	100 mV – 1000 V up to 10 kHz
DC current	10 µA – 20 A
AC current	10 µA – 20 A up to 5 kHz
Resistance	1 Ω – 1 GΩ
Capacitance	1 nF – 100 µF
Frequency	10 MHz

Electrical traceability chain



Electrical traceability chain



For more information see: A Proof of Concept for a Digital Calibration Environment or Digital Multimeters, 12:45 h (UTC) Thursday.

INTI | 65 Años
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Conclusions

Conclusion

The Digital Calibration certificate platform was implemented.

The partners are working to establish two digital traceability chain from primary standard up to vibration sensors and high accuracy calibrators.

A fully automated system to calibrate multifunction calibrator is under test.


Thank you
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Secretaría de Industria
y Desarrollo Productivo

Parallel Session 4: Human Readable DCC

Presentations that would also fit into this session:

- 01 Digital Calibration Certificate as part of an Ecosystem
- 12 Development of PDF based Digital Calibration Certificates at NMIJ, AIST
- 53 DCC Middleware – Obstacles and Approaches
- 56 DCC via iPhone (or iPad)

40 Human Readable Digital Calibration Certificate for Piston-Operated Volumetric Apparatus

Presenting author: G.D.Thilini Asoka Pathiragoda, Industrial Technology Institute, Sri Lanka

E-mail address: thilini@iti.lk, pathiragodat@gmail.com

Additional authors:

Abstract

The high demand for calibration of piston operated volumetric apparatus fulfilled through digitalization from customer request to issuing calibration certificate. Internationally competitive calibration services provided to local and foreign customers along with digital calibration certificate. This electronic human-readable version reduce handling, storage, retrieval time and more efficient than the analog version in hardcopy. Report preparation and reviewing time has reduced significantly. Each Single page auto generated volumetric apparatus calibration certificate contain delivered volume with uncertainty. Calibration measurement capability(CMC) 0.3µl for micropipette of 20µl. Customer shall extend or reduce recalibration interval over time with trend analysis, statistical process or other methods analyzing the previous data using E_n ratio. Similarly to ensure validity of results and quality assurance; the degree of equivalence evaluated by E_n number statistical formula for measurement results management.

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Digital calibration certificate (Human readable) for Piston operated volumetric apparatus

3rd DCC conference - Online

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Introduction

Problem :

Measuring equipment characteristics influence the measured results/ products deviation from required quality standards. It affect the acceptability/ uniformity of measurement results/products worldwide. Metrology laboratory faces the challenge of issuing calibration reports reliable with the increase in demand for calibration.

Solution :

Develop digitization methods to establish and guarantee the measurement accuracy of the measurement infrastructure to increase the efficiency of calibration work, with international standards to meet MEMC to CMR.

Terms

- **Industrial Metrology:** Application of measurement to manufacturing and other processes use in society, ensuring the suitability of measurement instruments, their calibration and quality control.
- **Calibration:** Process of comparing the test equipment /instrument or the value of a material measure against reference value of a measurement standard with uncertainties under specified conditions.
- **Metrological Traceability:** Value of a measurement standard or measuring instrument determined by an unbroken chain of comparisons with a series of higher level standards with stated uncertainties.
- **Metrological confirmation :** set of operations required to ensure that measuring equipment conforms to the requirements for its intended use [3] (calibration and verification, adjustments or repair, subsequent recalibration, sealing, labeling)

- **MEMC** - Measuring equipment Metrological characteristic - distinguishing feature which can influence the results of measurement.
- **CMR** - Customer metrological requirement
- **Measuring system** - set of devices including any regents assembled to generate measured volume
- **POVA** - Piston operated volumetric apparatus
- **CMC** - Calibration measurement capability, realizable optimum measurement uncertainty of the laboratory
- **Conformity assessment** - The process used to show that a product, service or system meets specified requirements in relevant standards through inspection, validation or accreditation process to enable buyers, sellers, consumers, and regulators to have confidence

Digital transformation in metrology

- Business transformation enabled by digitalization and industry 4.0 for accredited or non accredited calibration providers, industrialists, testing laboratories and all metrology users.

- Difference in Digitization Vs Digitalization is making analog information/ physical attributes to digital and use of digital technologies to change enabling/ improving process increasing efficiency and productivity and reducing cost

- The implementation of Digital Calibration Certificate is crucial for the quality infrastructure in industrial internet of things(IIOT), metrology community and sensor networks to meet the challenges in digital era

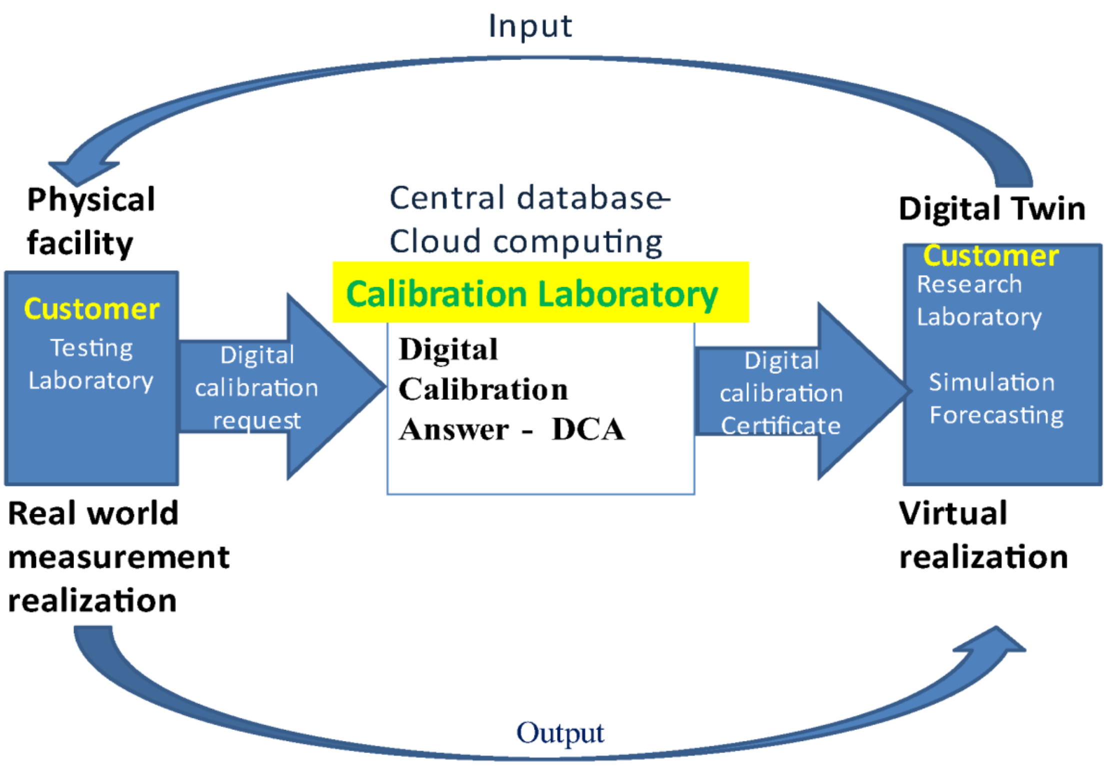

Figure 1 : The model of real world measurement optimization and virtual optimization for calibration and testing laboratories.

Process digitalization

- Digitization used to fulfill the high demand for calibration in the process from customer request to issuing calibration certificate.
- Calibration procedure use is ISO 8566:2022 standards[1,2]
- Data analysis, uncertainty calculation, Draft calibration report reviewing arranged to do in excel, saved softcopy in network/cloud computing facilities.
- Human readable digital calibration certificate were programmed in one page and saved as PDF with electronic signature to deliver customer maintaining data security aspects.

Each single page piston operated volumetric apparatus calibration certificate contain volume with uncertainty and international traceability.

Piston operated volumetric apparatus

- Micropipettes with fixed or variable volume
- Multi channel pipettes
- Piston burettes
- Dispensers, dilutors

Requirements for calibration

- Environment monitoring equipment
- Micro balance with evaporation trap
- ISO 8655:2022 international standard [1,2]
- Electronic worksheets programmed for data analysis and measurement uncertainty
- Programmed Digital calibration certificate(Excel to pdf)

Data Analysis

- Converted each mass values(m_i) in 10 cycles to volume(v_i) by applying the Z correction factors at the mean temperature and barometric pressure measured
- Calculated the average volume delivered by the piston operated volumetric apparatus.
- Calculated the measurement uncertainty with factors influence for piston operated volumetric apparatus calibration.

Uncertainties are calculated in accordance with the methods laid down in "Guide to Expression of uncertainty in measurement (GUM) JCGM 100:2008"[4].

Measurement uncertainty Budget

Source	Factor	Type	Calculation (multiply by sensitivity coefficient)	Standard Uncertainty
Mass Measurement	Resolution of the balance	B	$resolution \div 2\sqrt{3}$	U1
	Calibratoin Uncertainty	B	*Correction + (Exp. uncertainty ÷2)*	U2
	Scatter	A	$SD \div \sqrt{10}$	U3
	Evaporation Loss of liquid	A	$\frac{\sqrt{U(m10)^2 + U(m11)^2}}{10}$	U10
Temperature Measurement	Calibratoin Uncertainty	B	*Exp. uncertainty ÷ 2*	U4
	Scatter	A	$SD \div \sqrt{N}$	U5
Density of Water		B	$0.2\ kgm^{-3} * \Delta t$	U6
Density of air		B	$0.0012\ mg/cm^3$	U7
Density of weights		B	$0.1\ gcm^{-3}$	U8
Cubical thermal expansion coefficient		B	$u^2(\gamma)$	U9

$$\text{Combined Standard Uncertainty} = \sqrt{U_1^2 + U_2^2 + U_3^2 + \ldots\ldots\ldots + U_{10}^2}$$

Expanded uncertainty (k=2) , $U_{95} = 2 * U(V_{20})$

The reported expanded uncertainty of measurement is based as the standard uncertainty of measurement multiplied by a coverage factor k=2, corresponding to a coverage probability of approximately 95%.

Calibration measurement capability(CMC) for calibration of piston operated calibration apparatus 0.3µl for 20µl.

ISO 17025:2018 Std clause 7 process requirements fulfilled[5] in Human readable electronic Calibration certificate

Calibration Certificate of Micropipette

Issued by xxxxx

Certificate No: xxx

Reference No	xxxxxxx		
Customer	xxxxxxxxxxxxxxx		
Description	xxxxxxxxx		
Capacity/Range	20µl	Resolution	0.1µl
Manufacture	Eppendorf	S.No / ID No	xxxx
Received Condition	No visual damage	Location of calibration	xxxxxxxxx
Request Date	xxxx	Calibration Date	xxxx
Temperature	20 ± 1 ˚ C	Relative Humidity	50 ± 10%

Reference standards and Traceability

• Set of weights of accuracy class E2 traceable to primary standards at xxxxxx

• Working Standard Platinum Resistance Thermometer Fluke traceable to xxxxxx

Method used : ISO 8566:2022 Piston xxxxxxxxxxxxxxxxxxxxxxxxx

Auxiliary Equipments used

Micro Balance	xxxx	0.001mg
xxxxxxxxxx	xxxx	0.1°C

Calibration Results

Nominal Capacity(µl)	Volume at reference temperature of 20°C(µl)	Deviation (µl)	Expanded Uncertainty U(µl)
5	4.9	0.1	0.2
10	9.9	0.1	0.4
20	20.0	0.0	0.3

The measurement results can be varied ± *U*

UNCERTAINTY:

The reported expanded uncertainty of measurement is based as the standard uncertainty of measurement multiplied by a coverage factor k=2, corresponding to a coverage probability of approximately 95%. The standard uncertainty of measurement has been determined in accordance with Guide to the expression of uncertainty in measurement (GUM-JCGM 100: 2008)

- Customer obliged to recalibrate the instrument at appropriate intervals

Multi Channel Pipettes

Set of single channel pipettes and all delivery units operated simultaneously.

For the calibration,

Each channel regarded as a single channel and calibrated.
Fill the test liquid to all channels and expel only the test liquid by the channel being testes into the vessel
(MCP not available)

12 Multichannel pipette calibration results in 12 pages transferred into digital calibration certificate in pdf report

Discussion

- Calibration laboratory work load can be managed efficiently and effectively using the electronic version of documents. Quality of measurements managed with international standards to meet MEMC to CMR.
- It reduce handling, storage, retrieval time and paper work.
- Eco friendly : A4, paper consumption/service - Final 3 -1-0, draft 3-1-0, Data analysis and uncertainty 2-1-0, Data recording 2-0, other 3-1-0 Total 13*7000 = 91,000 paper saving with toners per year planned.
- Training and familiarity with the system undergoing
- Ensure validity of results, with degree of equivalence E_n ratio for measurement results management requirements of ISO 17025:2018[5]
- Extend or reduce recalibration interval over time with trend analysis, statistical process ,etc analyzing the previous data OIML D10[6].
- Human readable digital calibration certificate converting to machine readable version is planned to transfer the calibrated data directly to the machines(Still the stakeholder requirement not raised).

References

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2. ISO 8655-6:2022 : Piston operated volumetric apparatus - Part6 : Gravimetric methods for the determination of measurement error.
3. ISO 10012:2003; Measurement management systems - Requirements for measurement processes and measuring equipment
4. JCGM 100:2008: Evaluation of measurement data – Guide to the expression of uncertainty in measurement.
5. ISO/IEC 17025:2018 General requirements for the competence of testing and calibration laboratories
6. ILAC G24, OIMLD10:2022(E) Guidelines for the determination of calibration intervals of measuring equipment.

Thank you

41 Generating DCC and Human-Friendly Readable Using Auto-Generated XML Schema

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E-mail address: ms.praiya@gmail.com

Additional authors: Narin Chantawong and Jariya Buajarern

Abstract
This work aims to transform a calibration certificate into a Digital Calibration Certificate (DCC) for preparing a machine-readable process. The way to create the DCC, we add the process which transfers data into an XML file. However, laboratory staff uses Microsoft Excel to compute measurement results and issue certificates. And then print the certificate in a PDF file to give to the customer. Therefore, the process to produce the DCC is using Microsoft Excel and add-in an XML map function for converting it into an XML file. The XML map guidelines from the DCC good practice on GEMIMEG-II. Our XML map design is less complicated because of the limitation of Microsoft Excel. In this work, we use the certificate of a standard capacitor as an example of the transition process. There are accredited by the Thai Industrial Standards Institute (TISI). The transition process result, our XML map can be imported into Microsoft Excel and elements from the XML source pane can be dropped into data and can be exported to the XML file. This XML file is the DCC which can be uploaded to a cloud network or used in machine-readable form. We program an XSL file to generate a web browser and link data from the XML file to preview the DCC on the web browser for human-readable purposes.

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Generating DCC and human-friendly readable using auto-generated XML schema

Ms.Praiya Thongluang

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National Institute of Metrology (Thailand)

Overview

- Introduction
- Objective
- Current issuing a certificate of calibration process
- How to issue a DCC
- Conclusion

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Introduction

- According to the Industry 4.0 era, the global has been a trend to digital transformation
- Digital transformation in metrology has been started with Digital Calibration Certificates (DCC) by PTB
- The theme of the World Metrology Day in 2022 is “Metrology in the Digital Era”.
- In 2022, NIMT proposed the implementation of a digital calibration certificate at the second international DCC conference.

Implementation of Digital Calibration Certificate

Objective

To transform the certificate of calibration into the DCC by using an XML file for machine-readable and converting it to a preview on web browser for human readable.

Current issuing a certificate of calibration process

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Digital Calibration Certificate (DCC)

- Long-term archiving
- Machine-readable
- Traceable directly to the national standards
- Constitute proof of metrological traceability
- May include additional information
- Cryptographic signatures

Ref: EURAMET TC IM 1448

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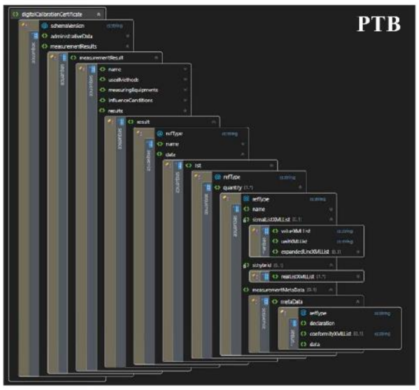
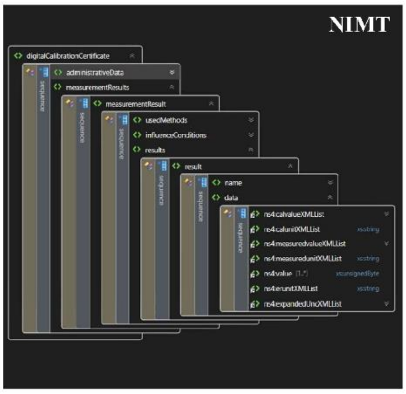
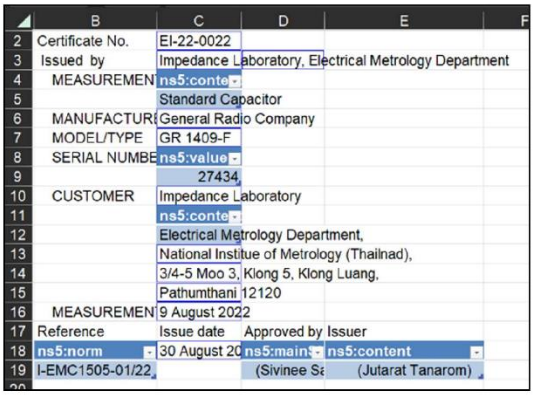
Creating the DCC process

1. Creating XML map before import to excel





2. Importing the XML map into Microsoft Excel and exporting it to the XML file

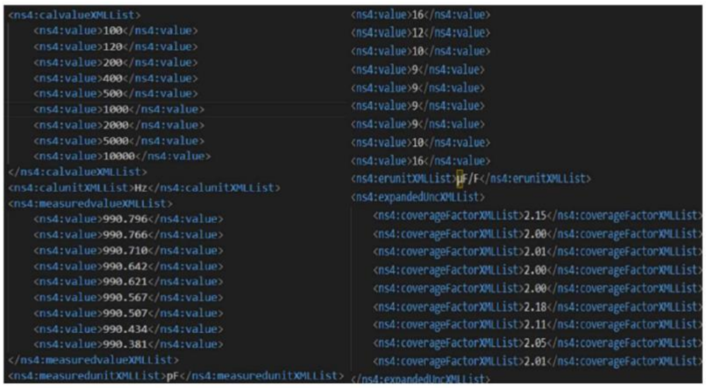


XML Source pane

Convert sheet

Data collection

- We use the certificate of a standard capacitor as an example of the transition process.
- The measurement result in this certificate has
  - frequency,
  - measured value,
  - uncertainty, and
  - coverage factor (k).



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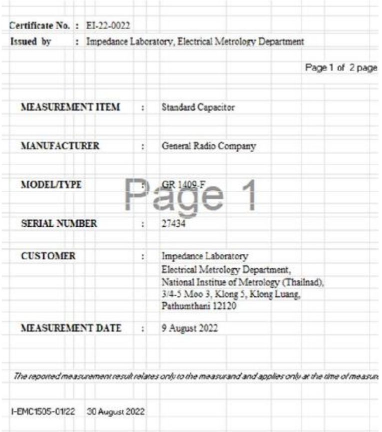
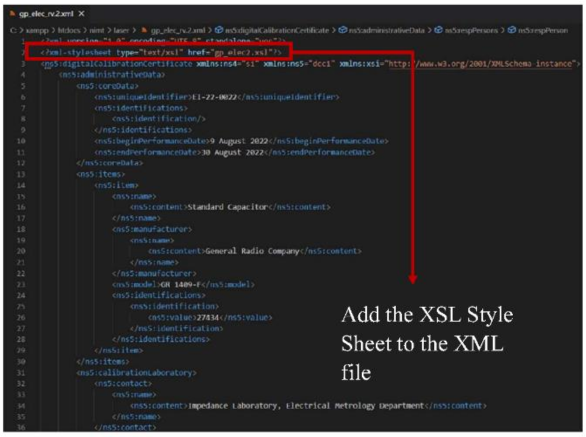
Excel to XML



Excel



XML

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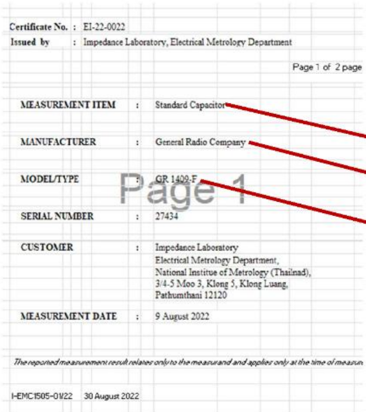
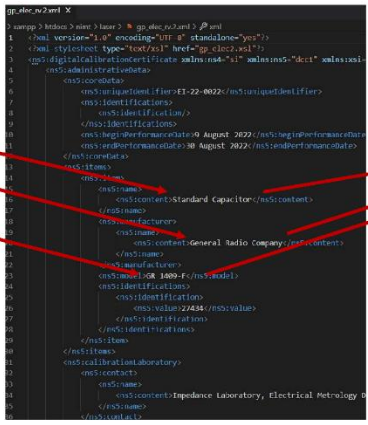
Transition Process



Excel



XML

PDF Preview

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DCC

Administrative Data

National Institute of Metrology (Thailand)
Ministry of Higher Education, Science, Research and Innovation
NIMT

Calibration of Certificate

NSC-TISI-TIS 17025
Calibration 0144

Certificate No. : EI-22-0022
Issued by : Impedance Laboratory, Electrical Metrology Department

Page 1 of 2 Pages

MEASUREMENT ITEM	: Standard Capacitor
MENUFACTURER	: General Radio Company
MODEL/TYPR	: GR 1409-F
SERIAL NUMBER	: 27434
CUSTOMER	: Impedance Laboratory 3/4-5 Moo 3, Klong 5, Klong Luang, National Institue of Metrology (Thailnad), Pathumthani 12120
MEASUREMENT DATE	: 9 August 2022

The reported measurement result relates only to the measurand and applies only at the time of measurement.

Reference:	Date:	Approved by:	Performed by:
I-EMC1505-01/22	30 August 2022	(Sivinee Sawatdiaree)	(Jutarat Tanarom)

Partial reproduction of this certificate is permitted only with a written permission from NIMT.

Technopolis Office,3/4-5 Moo 3, Klong 5, Klong Luang, Pathumthani 12120 Thailand, Telephone:66 2577 5100, Facsimile: 66 2577 3659

Measurement Results

Page 2 of 2 Pages

Continuation of Certificate of Calibration Number EI-22-0022

ENVIRONMENTAL CONDITION

The measurement was carried out in an ambient temperature of (23.0 ± 1.0) °C and relative humidity of (50 ± 15) %.

MEASUREMENT METHOD

Capacitance of the standard capacitor was directly measured by an ultra-precision capacitance bridge at requested frequencies. The value of three-terminal capacitance was measured with the GND terminal unconnected to the LO terminal.

UNCERTAINTIES OF MEASUREMENT

The stated measurement uncertainties are the expanded measurement uncertainties obtained from the combined standard measurement uncertainties multiplied by the coverage factor k. The coverage factors $k = 2$ are implied in all cases except where different values of k are explicitly stated. They are determined in accordance with JCGM 100: 2008 "Evaluation of measurement data - Guide to the expression of uncertainty in measurement". The values of the measurand lie within the assigned range of values with a probability of approximately 95 %.

TRACEABILITY

This certificate provides traceability of measurement to recognized national standards, and to the realization of the International System of Units (SI).

MEASUREMENT RESULTS

3-terminal measurement

Freauency:	Measured Value	Uncertainty	k
100 Hz	990.796 pF	16 µF/F	2.15
120 Hz	990.766 pF	12 µF/F	2.00
200 Hz	990.710 pF	10 µF/F	2.01
400 Hz	990.642 pF	9 µF/F	2.00
500 Hz	990.621 pF	9 µF/F	2.00
1000 Hz	990.567 pF	9 µF/F	2.18
2000 Hz	990.507 pF	9 µF/F	2.11
5000 Hz	990.434 pF	10 µF/F	2.05
10000 Hz	990.381 pF	16 µF/F	2.01

End of Certificate of Calibration

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Digital Calibration Certificate (DCC)

- Long-term archiving
- Machine-readable
- Traceable directly to the national standards
- Constitute proof of metrological traceability
- May include additional information
- Cryptographic signatures

Ref: EURAMET TC IM 1448

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Conclusion

- Our XML map can be imported into Microsoft Excel and elements from the XML source pane can be dropped into data.
- We can transform excel file to XML file for **machine-readable** process.
- The DCC can preview on the web browser for **human-readability**.

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Thank you

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42 A Human Readable Form for the DCC

Presenting author: Muhammed-Ali Demir, Physikalisch Technische Bundesanstalt, Germany

E-mail address: muhammed.demir@ptb.de

Additional authors: Jan Loewe, Moritz Jordan, Justin Jagieniak, Siegfried Hackel, Shanna Schönhals

Abstract

The common interpretation of the Digital Calibration Certificate (DCC) is to electronically store and transmit authenticated, encrypted and signed calibration results + enabling uniform interpretation. The DCC must be machine readable, interpretable and at the end must enable the automation of the processing of (digital) calibration certificates.

Regardless, a human readable version of the DCC is required since the DCC is optimized for machines. In the presentation, it will be shown, how a HTML5 and PDF human readable format can be generated from the DCC XML with the GEMIMEG tool of the PTB. The GEMIMEG tool uses XSLT to generate the Human Readable form of the DCC. The presentation ends with an outlook on a possible road map.

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National Metrology Institute

A HUMAN READABLE FORM FOR THE DCC

The Human Readable in the GEMIMEG Tool

Muhammed-Ali Demir, Justin Jagieniak
Moritz Jordan, Jan Loewe

Content

- The Human Readable Form of the DCC
  - Initial intent for the HR
  - Possibilities to generate the HR
  - HR in the GEMIMEG Tool
  - Examples for text, multilingual text, pictures and tables
  - Comparison between XML and HR
- Conclusion

Human Readable (HR) of the DCC (1)

- Initial intent of the HR
  - The DCC is optimized for machines

    Need for a document, that can vizualize the data contained in a DCC optimized for human beings
  - During the transition period: possibility to digitally generate the analoguos caliberation certificate (also called Conventional Calibration Certificate, CCC) off the DCC and print it out

Human Readable (HR) of the DCC (2)

- Multiple ways to achieve this:
  - Commercial software tools: e.g. Altova StyleVision
  - Open Source tools: e.g. the GEMIMEG Tool
  - Programming languages: C#, Java, …
  - XML transformation language: XSLT

Human Readable (HR) of the DCC (2)

- The GEMIMEG Tool uses XSLT (Extensible Stylesheet Language Transformation), because…
  - Specifically designed for transformation of XML documents
  - Syntax similar to XML
  - Programming overhead minimal
- Transformation of DCC XML to HTML5 enables you using whole design features of HTML5 (incl. jQuery or own scripts)
- HTML5 document can be printed out as a PDF

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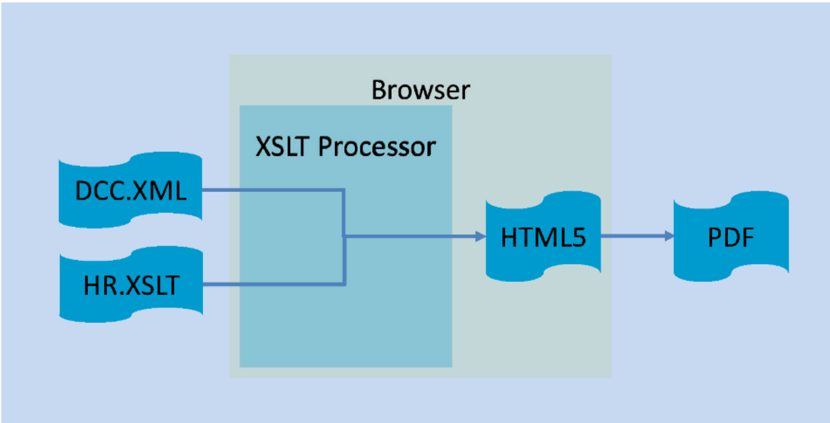
Using XSLT (1)

- XSLT (eXtensible Stylesheet Language Transformation)



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Using XSLT (2)

- Every aspect of the schema of the DCC must be covered
- DCC consists of block -> XSLT will handle one block after another beginning at the top
- DCC contains following information
  - Plain texts
  - Multilingual texts
  - Images
  - Tables

Using XSLT – Plain text

```xml
<dcc:administrativeData>
  <dcc:dccSoftware>
    <dcc:software>
      <dcc:name>
        <dcc:content>Notepad++ (32-bit)</dcc:content>
      </dcc:name>
      <dcc:release>v 8.4.6</dcc:release>
    </dcc:software>
  </dcc:dccSoftware>
  <dcc:coreData>
    <dcc:countryCodeISO3166_1>DE</dcc:countryCodeISO3166_1>
    <dcc:usedLangCodeISO639_1>en</dcc:usedLangCodeISO639_1>
    <dcc:usedLangCodeISO639_1>de</dcc:usedLangCodeISO639_1>
```

```xml
<xsl:variable name="usedLangCodesLength"
    select="count(dcc:usedLangCodeISO639_1)"/>
<p class="text-primary">Used Language Code ISO639_1</p>
<p>
    <xsl:for-each select="dcc:usedLangCodeISO639_1">
        <xsl:choose>
            <xsl:when test="position() &lt; $usedLangCodesLength">
                <xsl:value-of select="."/>,
            </xsl:when>
            <xsl:otherwise>
                <xsl:value-of select="."/>
            </xsl:otherwise>
        </xsl:choose>
    </xsl:for-each>
</p>
```

$\underbrace{\text{XML} \quad + \quad \text{XSLT}}$

Used Language Code ISO639_1	en, de

Using XSLT – Multilingual text (1)

- Determination of primary and secondary language, in case of multiple languages specified in a DCC

Primary Language: e.g. first mandatory language

```
<xsl:variable name="primaryLang" select="dcc:digitalCalibrationCertificate/dcc:administrativeData/dcc:coreData/dcc:mandatoryLangCodeISO639_1[1]"/>
```

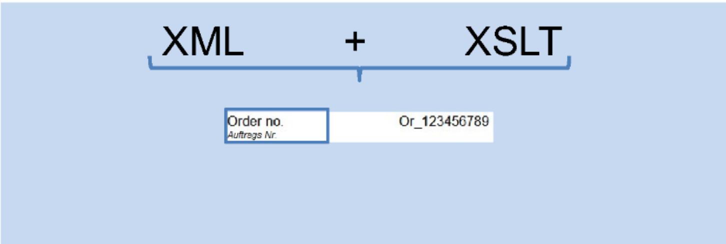
Secondary Language: e.g. used language not equal to primary language

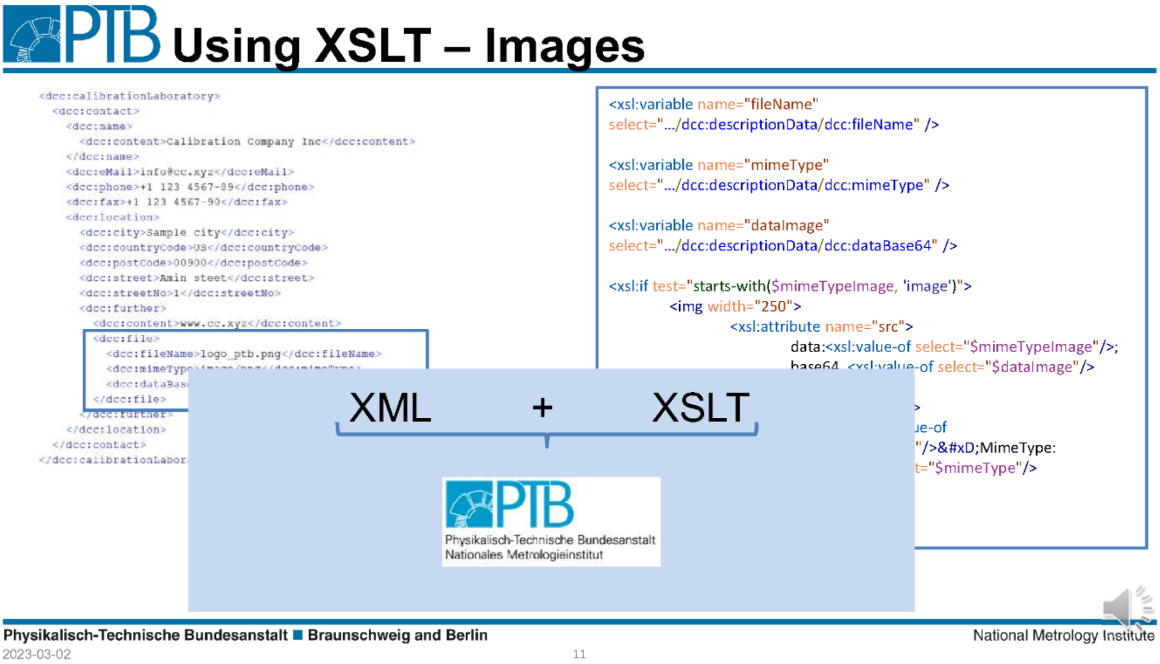
```
<xsl:variable name="secondaryLang" select="dcc:digitalCalibrationCertificate/dcc:administrativeData/dcc:coreData/dcc:usedLangCodeISO639_1[text() != $primaryLang]"/>
```


Using XSLT – Multilingual text (2)

```
<dcc:identifications>
  <dcc:identification>
    <dcc:issuer>calibrationLaboratory</dcc:issuer>
    <dcc:value>Or_123456789</dcc:value>
    <dcc:name>
      <dcc:content lang="en">Order no.</dcc:content>
      <dcc:content lang="de">Auftrags Nr.</dcc:content>
    </dcc:name>
  </dcc:identification>
</dcc:identifications>
```

```
...
<xsl:if test="self::dcc:content[@lang=$primaryLang]">
  <p class="text-primary">
    <xsl:value-of select="."/>
  </p>
 </xsl:if>
...
<xsl:if test="self::dcc:content[@lang=$secondaryLang]">
  <p class="description-secondary">
    <i><xsl:value-of select="."/><i>
  </p>
</xsl:if>
...
```




Using XSLT – Images
<dcc:calibrationLaboratory>
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</dcc:name>
<dcc:eMail>info@cc.xyz</dcc:eMail>
<dcc:phone>+1 123 4567-89</dcc:phone>
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<dcc:location>
<dcc:city>Sample city</dcc:city>
<dcc:countryCode>US</dcc:countryCode>
<dcc:postCode>00900</dcc:postCode>
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<dcc:streetNo>1</dcc:streetNo>
<dcc:further>
<dcc:content>www.cc.xyz</dcc:content>
<dcc:file>
<dcc:fileName>logo_ptb.png</dcc:fileName>
</dcc:file>
</dcc:location>
</dcc:contact>
<xsl:variable name="fileName" select=".../dcc:descriptionData/dcc:fileName" />
<xsl:variable name="mimeType" select=".../dcc:descriptionData/dcc:mimeType" />
<xsl:variable name="dataImage" select=".../dcc:descriptionData/dcc:dataBase64" />
<xsl:if test="starts-with($mimeTypeImage, 'image')">
<img width="250">
<xsl:attribute name="src">
data:<xsl:value-of select="$mimeTypeImage"/>;
XML + XSLT
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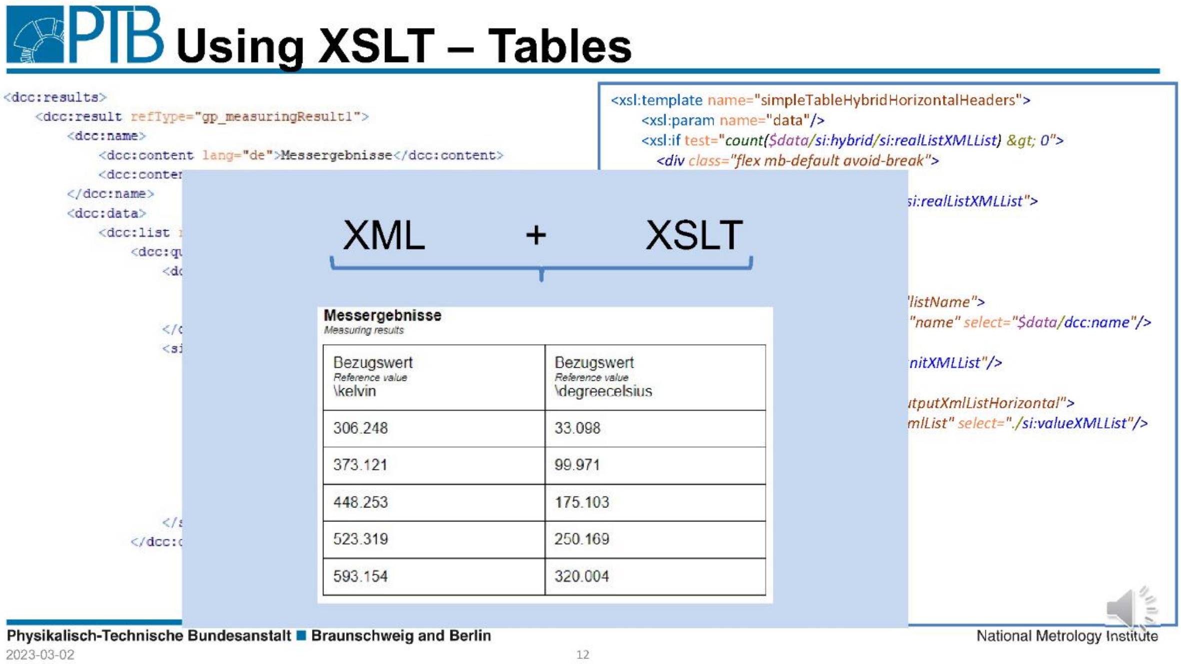
Using XSLT – Tables
<dcc:results>
<dcc:result refType="gp_measuringResult1">
<dcc:name>
<dcc:content lang="de">Messergebnisse</dcc:content>
</dcc:name>
<dcc:data>
<xsl:template name="simpleTableHybridHorizontalHeaders">
<xsl:param name="data"/>
<xsl:if test="count($data/si:hybrid/si:realListXMLList) > 0">
<div class="flex mb-default avoid-break">
XML + XSLT
Messergebnisse
Measuring results
Bezugswert
Reference value
\kelvin
Bezugswert
Reference value
\degreecelsius
306.248
33.098
373.121
99.971
448.253
175.103
523.319
250.169
593.154
320.004
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Where to find what data in the HR? (1)


```xml
<?xml version="1.0" encoding="UTF-8"?>
<dcc:digitalCalibrationCertificate>
  <dcc:administrativeData>
    <dcc:dccSoftware>
      <dcc:software>
        <dcc:name>
          <dcc:content>Notepad++ (32-bit)</dcc:content>
        </dcc:name>
        <dcc:release>v8.2</dcc:release>
      </dcc:software>
    </dcc:dccSoftware>
    <dcc:coreData>
      <dcc:countryCodeISO3166_1>DE</dcc:countryCodeISO3166_1>
      <dcc:usedLangCodeISO639_1>en</dcc:usedLangCodeISO639_1>
      <dcc:usedLangCodeISO639_1>de</dcc:usedLangCodeISO639_1>
      <dcc:mandatoryLangCodeISO639_1>en</dcc:mandatoryLangCodeISO639_1>
      <dcc:uniqueIdentifier>GP_DCC_temperature_simplified_1.1.1</dcc:uniqueIdentifier>
      <dcc:identifications>
        <dcc:identification>
          <dcc:issuer>calibrationLaboratory</dcc:issuer>
          <dcc:value>string-calibrationLaboratory-coreData</dcc:value>
          <dcc:name>
            <dcc:content lang="de">Auftrags Nr.</dcc:content>
            <dcc:content lang="en">Order no.</dcc:content>
          </dcc:name>
        </dcc:identification>
      </dcc:identifications>
      <dcc:receiptDate>1957-08-13</dcc:receiptDate>
      <dcc:beginPerformanceDate>1957-08-13</dcc:beginPerformanceDate>
      <dcc:endPerformanceDate>1957-08-13</dcc:endPerformanceDate>
      <dcc:performanceLocation>laboratory</dcc:performanceLocation>
    </dcc:coreData>
```


Digital Calibration Certificate

Administrative Data

DCC Software	
• Software	
Name	Notepad++ (32-bit)
Release	v8.2

Core Data	
Country Code ISO3166_1	DE
Used Language Code ISO639_1	en, de
Mandatory Language Code ISO639_1	en
Unique Identifier	GP_DCC_temperature_simplified_1.1.1
Issuer	calibrationLaboratory
Order no. *Auftrags Nr.*	string-calibrationLaboratory-coreData
Receipt Date	1957-08-13
Performance Date	1957-08-13
Performance Location	laboratory

Where to find what data in the HR? (2)


```xml
<dcc:items>
  <dcc:item>
    <dcc:name>
      <dcc:content lang="de">Temperatur-Fühler</dcc:content>
      <dcc:content lang="en">Temperature sensor</dcc:content>
    </dcc:name>
    <dcc:manufacturer>
      <dcc:name>
        <dcc:content>String</dcc:content>
      </dcc:name>
    </dcc:manufacturer>
    <dcc:model>String</dcc:model>
    <dcc:identifications>
      <dcc:identification>
        <dcc:issuer>manufacturer</dcc:issuer>
        <dcc:value>string-manufacturer-item</dcc:value>
        <dcc:name>
          <dcc:content lang="de">Serien Nr.</dcc:content>
          <dcc:content lang="en">Serial no.</dcc:content>
        </dcc:name>
      </dcc:identification>
      <dcc:identification>
        <dcc:issuer>customer</dcc:issuer>
        <dcc:value>string-customer-item</dcc:value>
        <dcc:name>
          <dcc:content lang="de">Messmittel Nr.</dcc:content>
          <dcc:content lang="en">Measurement equipment no.</dcc:content>
        </dcc:name>
      </dcc:identification>
      <dcc:identification>
        <dcc:issuer>calibrationLaboratory</dcc:issuer>
        <dcc:value>string-calibrationLaboratory-item</dcc:value>
        <dcc:name>
          <dcc:content lang="de">Equipment Nr.</dcc:content>
          <dcc:content lang="en">Equipment no.</dcc:content>
        </dcc:name>
      </dcc:identification>
    </dcc:identifications>
  </dcc:item>
</dcc:items>
```


Items	
• Item	Temperature sensor *Temperatur-Fühler*
Manufacturer	String
Model	String
Issuer	manufacturer
Serial no. *Serien Nr.*	string-manufacturer-item
Issuer	customer
Measurement equipment no. *Messmittel Nr.*	string-customer-item
Issuer	calibrationLaboratory
Equipment no. *Equipment Nr.*	string-calibrationLaboratory-item

Calibration Laboratory	
	Kalibrierfirma GmbH
E-Mail	info@kalibrierfirma.xx
Phone	+49 123 4567-89
Fax	+49 123 4567-90
City	Musterstadt
Country Code	DE
Post Code	00900
Street	Musterstraße
Street No.	1

Where to find what data in the HR? (3)

```xml
<dcc:calibrationLaboratory>
  <dcc:contact>
    <dcc:name>
      <dcc:content>Kalibrierfirma GmbH</dcc:content>
    </dcc:name>
    <dcc:eMail>info@kalibrierfirma.xx</dcc:eMail>
    <dcc:phone>+49 123 4567-89</dcc:phone>
    <dcc:fax>+49 123 4567-90</dcc:fax>
    <dcc:location>
      <dcc:city>Musterstadt</dcc:city>
      <dcc:countryCode>DE</dcc:countryCode>
      <dcc:postCode>00900</dcc:postCode>
      <dcc:street>Musterstraße</dcc:street>
      <dcc:streetNo>1</dcc:streetNo>
      <dcc:further>
        <dcc:content>www.kalibrierfirma.xx</dcc:content>
      </dcc:further>
    </dcc:location>
  </dcc:contact>
<dcc:respPersons>
  <dcc:respPerson>
    <dcc:person>
      <dcc:name>
        <dcc:content>Michaela Musterfrau</dcc:content>
      </dcc:name>
    </dcc:person>
    <dcc:mainSigner>true</dcc:mainSigner>
  </dcc:respPerson>
  <dcc:respPerson>
    <dcc:person>
      <dcc:name>
        <dcc:content>Michael Mustermann</dcc:content>
      </dcc:name>
    </dcc:person>
  </dcc:respPerson>
</dcc:respPersons>
<dcc:customer>
  <dcc:name>
    <dcc:content>Kunde GmbH</dcc:content>
  </dcc:name>
  <dcc:eMail>info@kunde.xx</dcc:eMail>
  <dcc:location>
    <dcc:city>Musterstadt</dcc:city>
    <dcc:countryCode>DE</dcc:countryCode>
    <dcc:postCode>00900</dcc:postCode>
    <dcc:further>
      <dcc:content lang="de">Kunden Nr. 1024418</dcc:content>
      <dcc:content lang="en">Customer ID no. 1024418</dcc:content>
    </dcc:further>
  </dcc:location>
</dcc:customer>
```

Calibration Laboratory

	Kalibrierfirma GmbH
E-Mail	info@kalibrierfirma.xx
Phone	+49 123 4567-89
Fax	+49 123 4567-90
City	Musterstadt
Country Code	DE
Post Code	00900
Street	Musterstraße
Street No.	1
Further	www.kalibrierfirma.xx

Person(s) authorizing the report

Name	Michaela Musterfrau
Main signer	true
Name	Michael Mustermann

Customer	Kunde GmbH
E-Mail	info@kunde.xx
City	Musterstadt
Country Code	DE
Post Code	00900
Further	Customer ID no. 1024418 *Kunden Nr. 1024418*

Where to find what data in the HR? (4)

```xml
<dcc:statements>
  <dcc:statement>
    <dcc:norm>ISO/IEC 17025:2018-03</dcc:norm>
    <dcc:reference>7.8.4.3</dcc:reference>
    <dcc:declaration>
      <dcc:content lang="de">Die Ergebnisse gelten zum Zeitpunkt de
      <dcc:content lang="en">The results refer only to the object c
      </dcc:content>
    </dcc:declaration>
  <dcc:statement refType="basic_validityRange">
    <dcc:declaration>
      <dcc:content lang="de">Angabe des Temperaturbereichs, in dem
      <dcc:content lang="en">Specification of the temperature range
    </dcc:declaration>
    <dcc:data>
      <dcc:quantity refType="basic_validityRangeMin">
        <dcc:name>
          <dcc:content lang="de">Unteres Limit</dcc:content>
          <dcc:content lang="en">Lower limit</dcc:content>
        </dcc:name>
        <si:real>
          <si:value>306</si:value>
          <si:unit>\kelvin</si:unit>
        </si:real>
      </dcc:quantity>
      <dcc:quantity refType="basic_validityRangeMax">
        <dcc:name>
          <dcc:content lang="de">Oberes Limit</dcc:content>
          <dcc:content lang="en">Upper limit</dcc:content>
        </dcc:name>
        <si:real>
          <si:value>593</si:value>
          <si:unit>\kelvin</si:unit>
        </si:real>
      </dcc:quantity>
    </dcc:data>
```

Statements

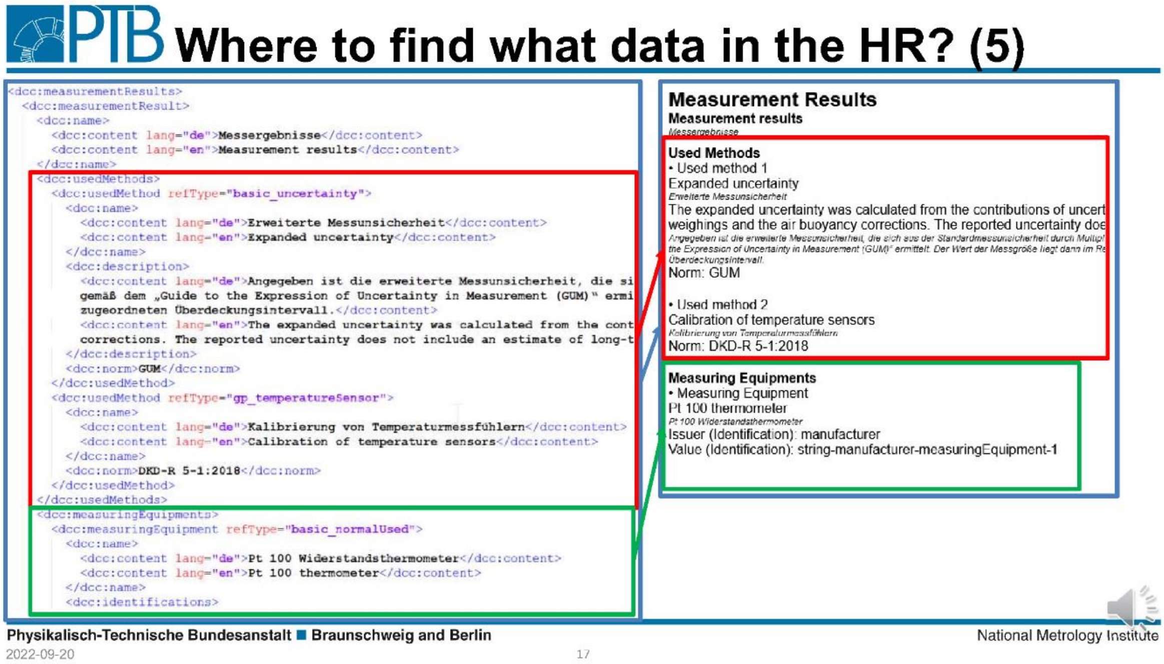
- Statement 1

The results refer only to the object calibrated in this DCC. The measuremen
applicant is responsible for arranging a recalibration in due time.
Die Ergebnisse gelten zum Zeitpunkt der Kalibrierung. Es obliegt dem Antragsteller, zu gegebener Zeit eine
Norm: ISO/IEC 17025:2018-03
Reference: 7.8.4.3

- Statement 2

Specification of the temperature range in which calibration was performed:
Angabe des Temperaturbereichs, in dem kalibriert wurde:

Lower limit *Unteres Limit* \kelvin
306
Upper limit *Oberes Limit* \kelvin
593


Where to find what data in the HR? (5)
<dcc:measurementResults>
<dcc:measurementResult>
<dcc:name>
<dcc:content lang="de">Messergebnisse</dcc:content>
<dcc:content lang="en">Measurement results</dcc:content>
</dcc:name>
<dcc:usedMethods>
<dcc:usedMethod refType="basic_uncertainty">
<dcc:name>
<dcc:content lang="de">Erweiterte Messunsicherheit</dcc:content>
<dcc:content lang="en">Expanded uncertainty</dcc:content>
</dcc:name>
<dcc:description>
<dcc:norm>GUM</dcc:norm>
</dcc:usedMethod>
<dcc:usedMethod refType="gp_temperatureSensor">
<dcc:name>
<dcc:content lang="de">Kalibrierung von Temperaturmessfühlern</dcc:content>
<dcc:content lang="en">Calibration of temperature sensors</dcc:content>
</dcc:name>
<dcc:norm>DKD-R 5-1:2018</dcc:norm>
</dcc:usedMethod>
</dcc:usedMethods>
<dcc:measuringEquipments>
<dcc:measuringEquipment refType="basic_normalUsed">
<dcc:name>
<dcc:content lang="de">Pt 100 Widerstandsthermometer</dcc:content>
<dcc:content lang="en">Pt 100 thermometer</dcc:content>
</dcc:name>
<dcc:identifications>
Measurement Results
Measurement results
Used Methods
• Used method 1
Expanded uncertainty
Norm: GUM
• Used method 2
Calibration of temperature sensors
Norm: DKD-R 5-1:2018
Measuring Equipments
• Measuring Equipment
Pt 100 thermometer
Issuer (Identification): manufacturer
Value (Identification): string-manufacturer-measuringEquipment-1
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National Metrology Institute
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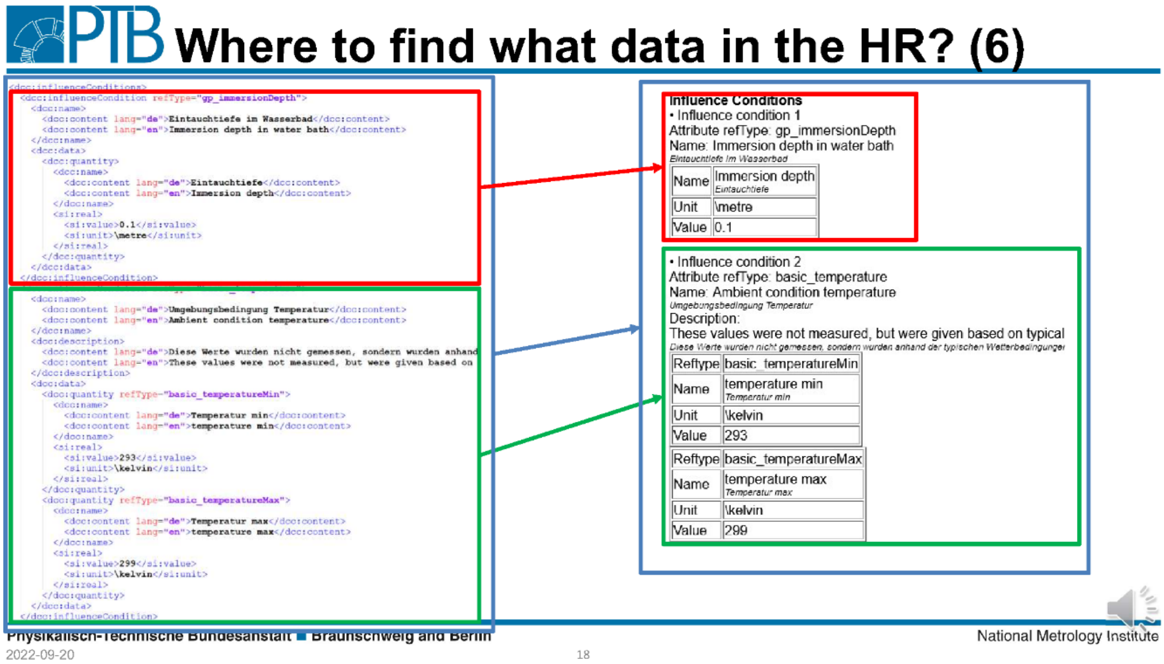
Where to find what data in the HR? (6)
Influence Conditions
• Influence condition 1
Attribute refType: gp_immersionDepth
Name: Immersion depth in water bath
Name | Immersion depth
Unit | \metre
Value | 0.1
• Influence condition 2
Attribute refType: basic_temperature
Name: Ambient condition temperature
Description:
These values were not measured, but were given based on typical
Reftype | basic_temperatureMin
Name | temperature min
Unit | \kelvin
Value | 293
Reftype | basic_temperatureMax
Name | temperature max
Unit | \kelvin
Value | 299
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Where to find what data in the HR? (7)


```xml
<dcc:influenceCondition refType="basic_humidityRelative">
  <dcc:name>
    <dcc:content lang="de">Umgebungsbedingung relative Luftfeuchte</dcc:content>
    <dcc:content lang="en">Ambient condition relative humidity</dcc:content>
  </dcc:name>
  <dcc:description>
    <dcc:content lang="de">Diese Werte wurden nicht gemessen, sondern wurden anhan
    <dcc:content lang="en">These values were not measured, but were given based on
  </dcc:description>
  <dcc:data>
    <dcc:quantity refType="basic_humidityRelativeMin">
      <dcc:name>
        <dcc:content lang="de">Feuchte min</dcc:content>
        <dcc:content lang="en">humidity min</dcc:content>
      </dcc:name>
      <si:real>
        <si:value>0.20</si:value>
        <si:unit>\one</si:unit>
      </si:real>
    </dcc:quantity>
    <dcc:quantity refType="basic_humidityRelativeMax">
      <dcc:name>
        <dcc:content lang="de">Feuchte max</dcc:content>
        <dcc:content lang="en">humidity max</dcc:content>
      </dcc:name>
      <si:real>
        <si:value>0.70</si:value>
        <si:unit>\one</si:unit>
      </si:real>
    </dcc:quantity>
  </dcc:data>
</dcc:influenceCondition>
```


- Influence condition 3

Attribute refType: basic_humidityRelative

Name: Ambient condition relative humidity

Umgebungsbedingung relative Luftfeuchte

Description:

These values were not measured, but were given based on

Diese Werte wurden nicht gemessen, sondern wurden anhand der typischen Wetterbe

Reftype	basic_humidityRelativeMin
Name	humidity min *Feuchte min*
Unit	\one
Value	0.20

Reftype	basic_humidityRelativeMax
Name	humidity max *Feuchte max*
Unit	\one
Value	0.70

Where to find what data in the HR? (8)


```xml
<dcc:results>
  <dcc:result refType="gp_measuringResult1">
    <dcc:name>
      <dcc:content lang="de">Messergebnisse</dcc:content>
      <dcc:content lang="en">Measuring results</dcc:content>
    </dcc:name>
    <dcc:data>
      <dcc:list refType="gp_table1">
        <dcc:quantity refType="basic_referenceValue">
          <dcc:name>
            <dcc:content lang="de">Bezugswert</dcc:content>
            <dcc:content lang="en">Reference value</dcc:content>
          </dcc:name>
          <si:hybrid>
            <si:realListXMLList>
              <si:valueXMLList>306.248 373.121 448.253 523.319 593.154</si:valueXM
              <si:unitXMLList>\kelvin</si:unitXMLList>
            </si:realListXMLList>
            <si:realListXMLList>
              <si:valueXMLList>33.098 99.971 175.103 250.169 320.004</si:valueXMLLi
              <si:unitXMLList>\degreecelsius</si:unitXMLList>
            </si:realListXMLList>
          </si:hybrid>
          <dcc:measurementMetaData>
            <dcc:metaData refType="basic_calibrationValue">
              <dcc:declaration>
                <dcc:content lang="de">Kalibrierpunkt</dcc:content>
                <dcc:content lang="en">Calibration value</dcc:content>
              </dcc:declaration>
              <dcc:data>
                <dcc:quantity>
                  <si:hybrid>
                    <si:realListXMLList>
                      <si:valueXMLList>306 373 448 523 593</si:valueXMLList>
                      <si:unitXMLList>\kelvin</si:unitXMLList>
                    </si:realListXMLList>
                    <si:realListXMLList>
                      <si:valueXMLList>32.85 99.85 174.85 249.85 319.85</si:valueXM
                      <si:unitXMLList>\degreecelsius</si:unitXMLList>
                    </si:realListXMLList>
                  </si:hybrid>
                </dcc:quantity>
              </dcc:data>
```


Results

Measuring results

Messergebnisse

Reference value *Bezugswert* \kelvin	Reference value *Bezugswert* \degreecelsius
306.248	33.098
373.121	99.971
448.253	175.103
523.319	250.169
593.154	320.004

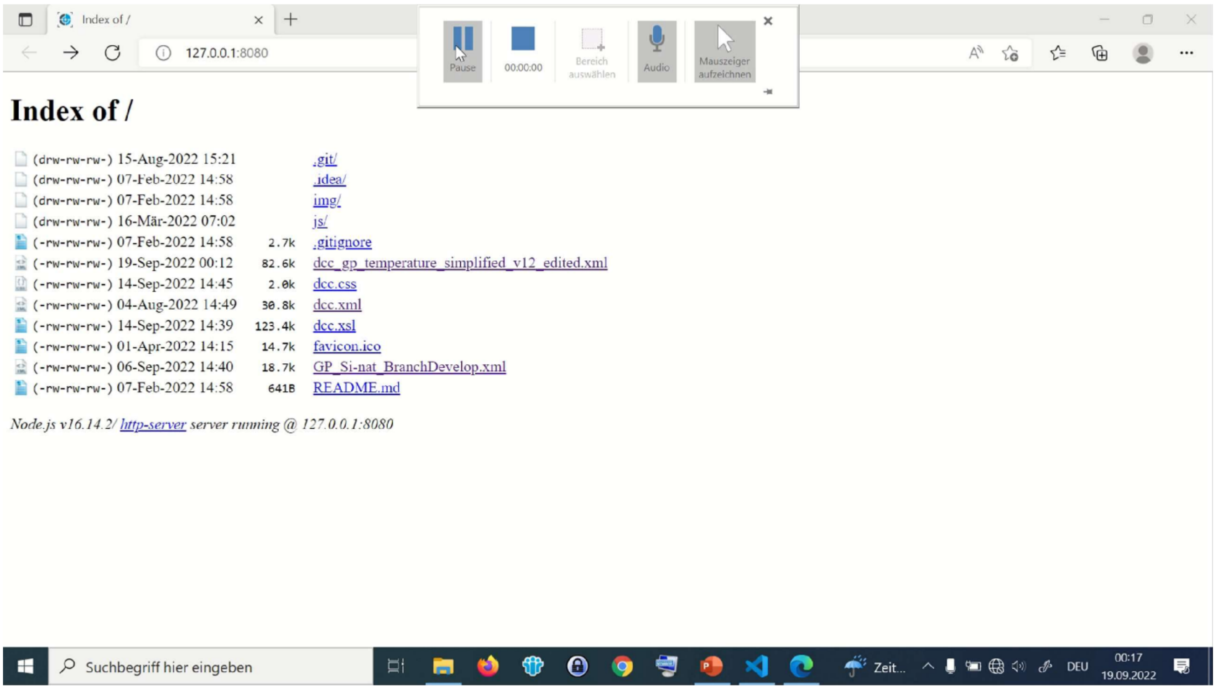
Measurement Meta Data

Meta Data

Calibration value

Kalibrierpunkt

Calibration value *Kalibrierpunkt* \kelvin	Calibration value *Kalibrierpunkt* \degreecelsius
306	32.85
373	99.85
448	174.85
523	249.85
593	319.85



Conclusion

- How a Human Readable for the DCC can be generated
- How the Gemimeg-Tool generates a Human Readable form
- Topics to be covered in the future
  - Dynamic form to display tables
  - Extending complex tables
  - Updates of the DCC Schema
  - …

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Conclusion

- Generati
- Topics to
  - Dynam
  - Extend
  - Update
  - …

For more information and contribution to the project, please have a look at
→ **https://www.ptb.de/dcc**

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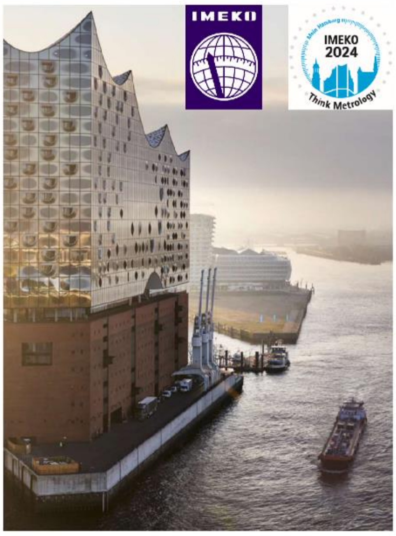
www.ptb.de/dcc

Stand: 03/23

IMEKO World Congress 2024

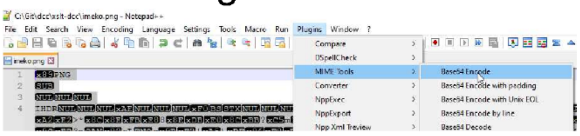


26-29 August 2024
Hamburg, Germany

www.imeko2024.org

Appendix: How to encode Images manually

- Open picture with Notepad++
- Select the whole content in Notepad++ (Ctrl + A)
- Click on Plugins -> MIME Tools -> Base64 Encode



- Copy the encoded content from Notepad++

Appendix: How to encode Images manually

- Insert the encoded Base64 to the DCC, e.g. at this position

```
<dcc:calibrationLaboratory>
   <dcc:contact>
   ...
   <dcc:descriptionData id="Logo">
      <dcc:name>
         <dcc:content>Your image</dcc:content>
      </dcc:name>
      <dcc:fileName>YourImage.png</dcc:fileName>
      <dcc:mimeType>image/png</dcc:mimeType>
      <dcc:dataBase64>...</dcc:dataBase64>
   </dcc:descriptionData>
```

Input your encoded base64 string here!

Appen.: How to split XML lists with XSLT 1

- In XSLT we have to define our own template to split XML Lists, in order to put each value in it's own cell

```
<xsl:template name="outputXmlListHorizontal">
    <xsl:param name="xmlList"/>

    <xsl:variable name="newXmlList" select="concat(normalize-space($xmlList), ' ')" />
    <xsl:variable name="firstElement" select="substring-before($newXmlList, ' ')" />
    <xsl:variable name="remainingElements" select="substring-after($newXmlList, ' ')" />

    <div class="cell">
       <xsl:value-of select="$firstElement" />
    </div>

    <xsl:if test="$remainingElements">
       <xsl:call-template name="outputXmlListHorizontal">
          <xsl:with-param name="xmlList" select="$remainingElements" />
       </xsl:call-template>
    </xsl:if>
</xsl:template>
```

Parallel Session 4: DCC Tools

Presentations that would also fit into this session:

- Parallel Session 1: DCC-Tools
- 07 Qualified Electronic Seals - The Peace of Westphalia in the Laboratory Sector
- 19 Analyzing the Conformance of DCC Prototype Architecture to Calibration Laboratory Expectations Report
- 23 The GEMIMEG Tool – A Software for Creating Digital Calibration Certificates (DCCs)
- 24 Python Tools Examples for the Transition to DCC
- 25 Generation of Digital Calibration Certificates for Temperature Sensor Calibrations using Python and Excel
- 26 Dynamic Web Tool for Generating DCC
- 27 The Use of (Anonymised) Timestamps in the DCC
- 53 DCC Middleware – Obstacles and Approaches
- 56 DCC via iPhone (or iPad)

43 Using a Spreadsheet to generate XML Based on XSD Schema

Presenting author: José Armando Lopez-Celis, CENAM, México

E-mail address: jolopez@cenam.mx

Additional authors: Carlos Galvan-Hernández, Itzel Dominguez-Mendoza, Aldo Adrián Garcia-Gonzalez, , Hugo Gasca-Aragón, Oscar Ramos-Monzalvo

Abstract

The generation of calibration certificates at the National Metrology Center (CENAM) is based on spreadsheets (MS-Excel). Metrologists analyze the measurements and generate the report of the measurement results directly or using a word processor (MS-Word).

In order to avoid modifying the data analysis process for the time being and to favor natural change, it was decided to find a way to export the results directly from the work environment to the XML file. Given the variety of services, the work of programming the individual generation of the XML can become a very large task, therefore a way to export the measurement results directly from MS-Excel tables is presented.

At the moment we are not considering how the raw data of the measurements are obtained and we will concentrate on the digitalization of the calibration results to be able to integrate them in the creation of the DCC, this is a task that requires a lot of work thinking that the great majority of the laboratories of the National Metrology Center make use of spreadsheets to process the information of the measurements and from there to obtain the reports that will be used to create the calibration certificates in PDF format.

Exporting the calibration results to an XML digital exchange format and structuring them in the DCC schema becomes a job that must be carried out individually for each of the different services due to the nature of each one of them. For this purpose, the CDD development team at CENAM makes use of the import of subschemas derived from the main CDD schema. These subschemas contain the necessary elements that each service requires and are aligned to the rules established by the DCC structure.

In this way, the direct export of calibration results to XML can be achieved avoiding the coding of specific routines to generate XML files. It is possible to generalize in most cases the necessary elements for each of the services with similar subschemas, simply by linking the elements of the subschema with the cells in the spreadsheet containing the results to be exported. This reduces the work to generating subschemas for the service variants.

Finally, it remains to link the measurement XML with the XML containing the administrative and comments sections, which in CENAM are generated from a centralized system from the service management databases, thus obtaining the complete DCC.

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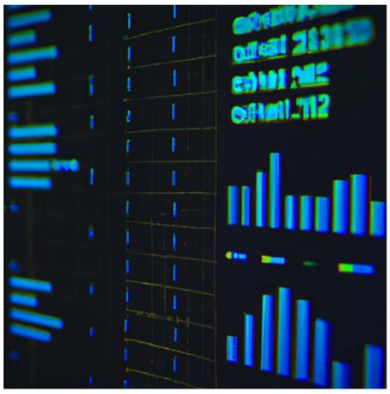
TOOLS TO GENERATE A CALIBRATION CERTIFICATE

- Spreadsheets : Data analysis, uncertainty estimations, …
- Word processors: Generate document, insert photos, images, descriptions, tables, formulas, etc.



SPREADSHEETS IN PROCESS

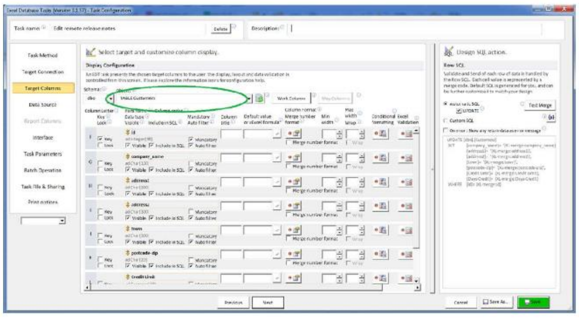
Flexible tool to make different tasks

- Data connection
- Measurements processing
- Data analysis
- Uncertainty estimation
- ……

- Most of metrologist in our NMI uses a spreadsheet to generate a Calibration Certificate

IMPORT/EXPORT DATA WITH A SPREADSHEET

- Spreadsheets can export data to different formats (CSV, Databases, communications protocols, XML)
- An XML Schema can be used to export data

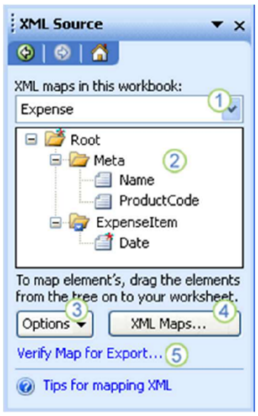


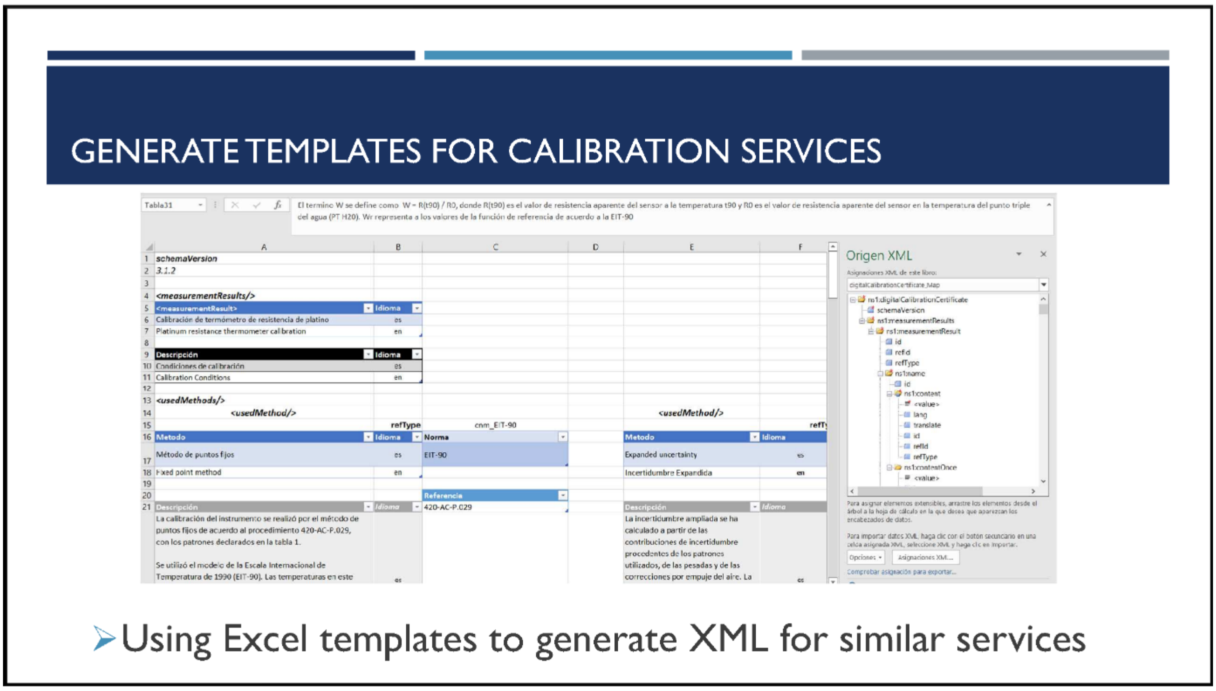
USING A XSD IN A SPREADSHEET

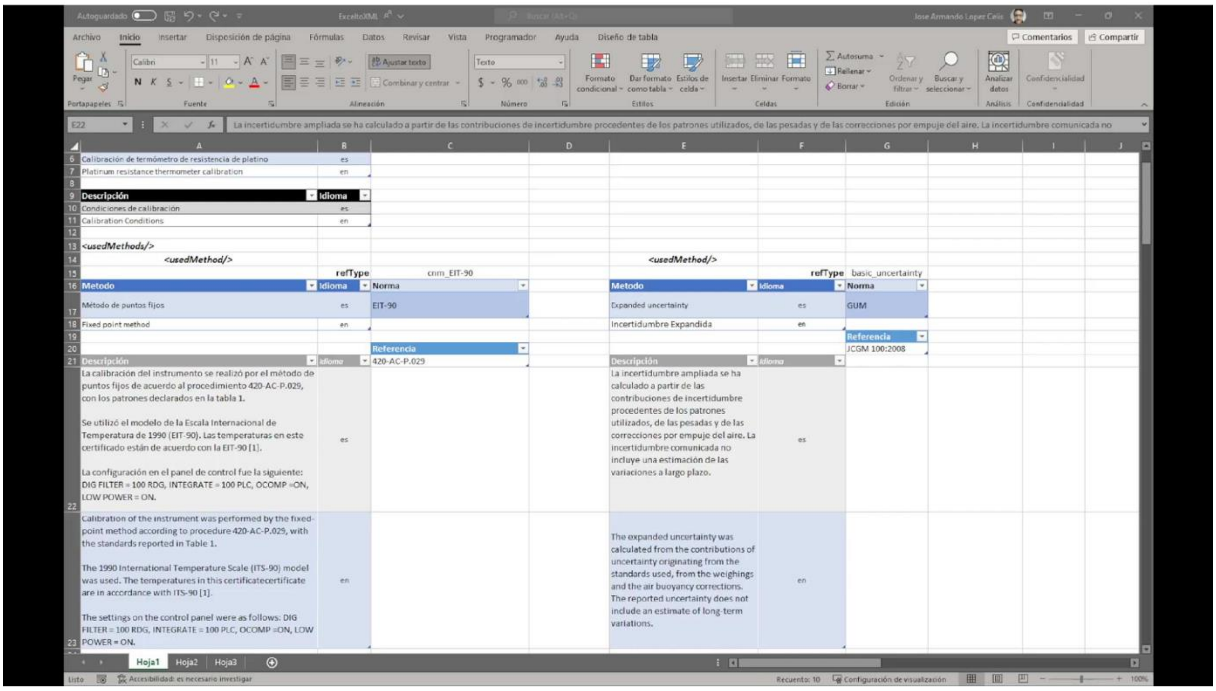
- A XSD file can be used to define an XML Map for data export
- DCC schema may be complex to define a XML Map, but can be adapted

CONFIGURING DCC SCHEMA IN A SPREADSHEET

- Import DCC Schema (XSD)
- Link elements to Excel Data




GENERATE TEMPLATES FOR CALIBRATION SERVICES
Using Excel templates to generate XML for similar services




THANK YOU
JOLOPEZ@CENAM.MX
DCC CENAM TEAM
CENAM
CENTRO NACIONAL DE METROLOGÍA

44 XML Tree Editor

Presenting author: Justin Jagieniak, Physikalisch-Technische Bundesanstalt (PTB), Germany

E-mail address: justin.jagieniak@ptb.de

Additional authors: Benjamin Gloger, Shanna Schönhals, Siegfried Hackel (all PTB)

Abstract
The XML Tree Editor is a Qt development written in Python. The aim of the development is to get a better overview of an XML file and to edit it. Similar to the well-known XML Notepad by Microsoft it can be used to load an XML file into a tree view. But the XML tree editor has some differences. One big difference is that the XML tree editor load the scheme out of the XML file (via web or via local file) and use it to construct a skeleton in the program memory. This skeleton can be used to validate the data and to create new nodes inside the tree view. There is no option to create a node with a name by oneself. Instead, you have to use the names suggested by the xml scheme. This prevents errors by the user and is all-designed to be user friendly. The XML Tree Editor aims to be used not for the digital calibration certificate only. It can be also used for other certificates e.g., the Digital Calibration Request (DCR), the Digital Calibration Answer (DCA). The presentation shows the program functions in an early stage of development and gives an overview about planed rollouts in the future.

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Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin
Nationales Metrologieinstitut

XML Tree Editor

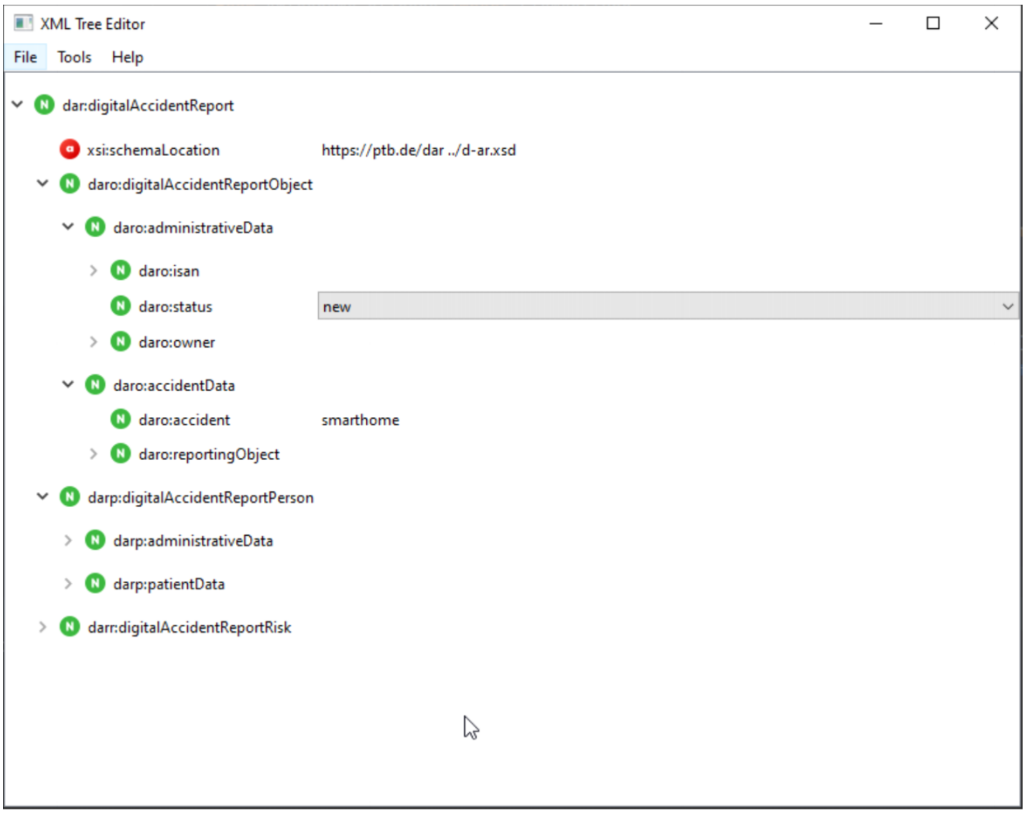
Presenting author:
Justin Jagieniak, AG 1.24

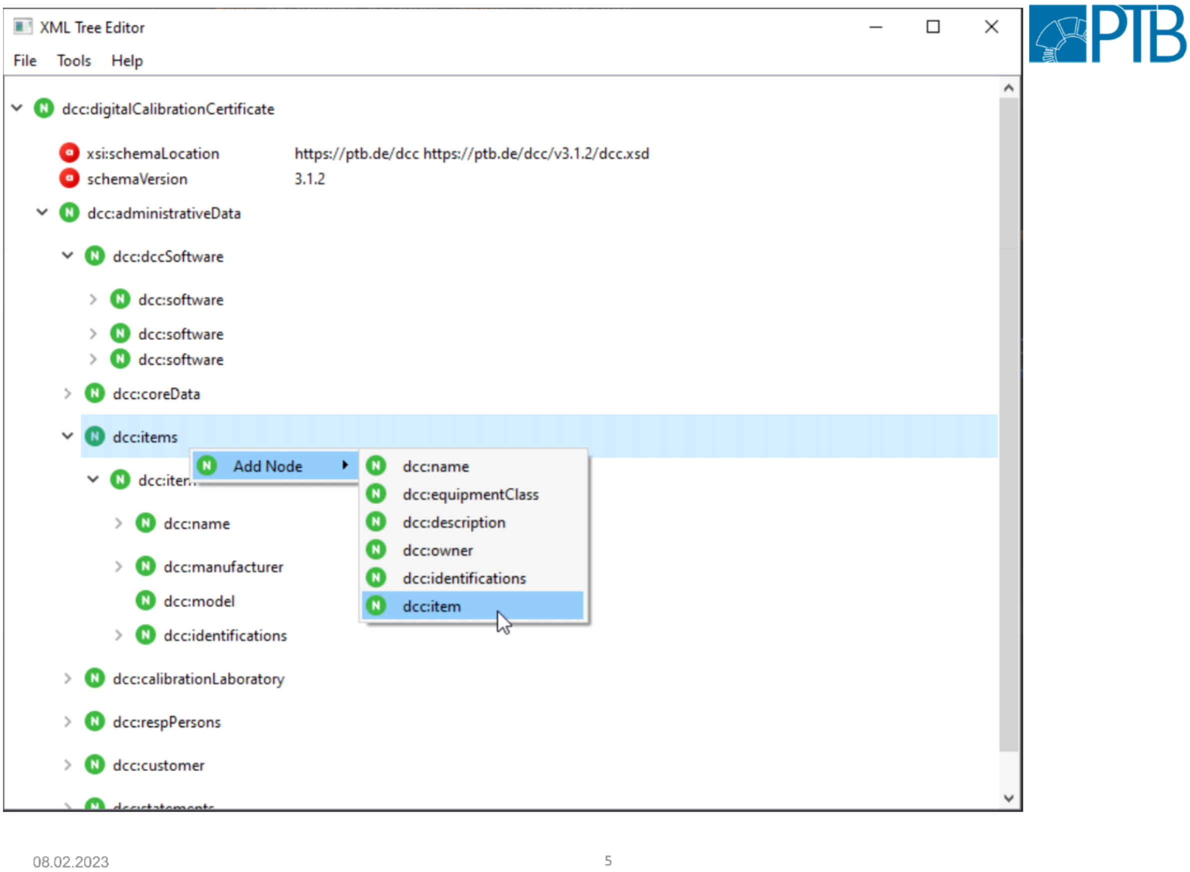
Stakeholder

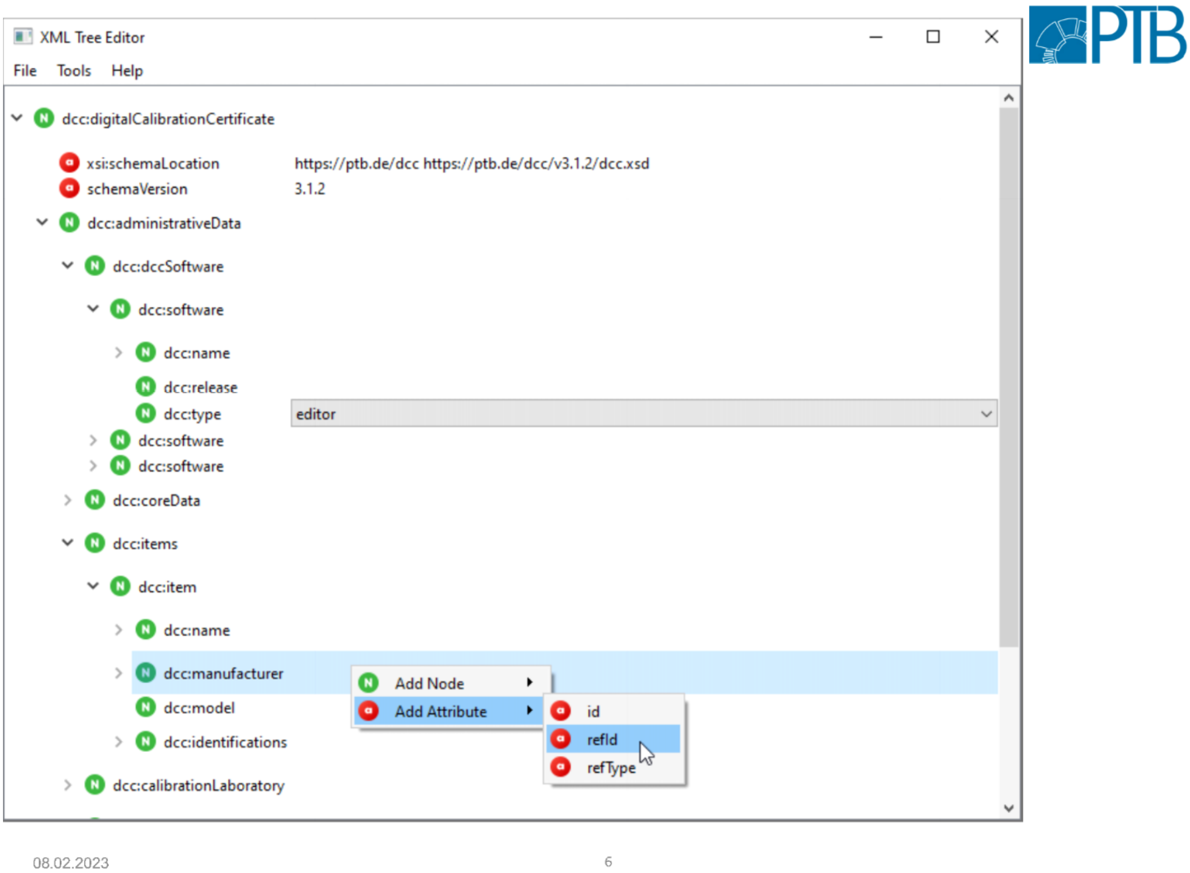
- Users, who aren‘t familiar with XML and want to administrate, edit and validate and XML file.
- Experienced users, who would like to have a better overview of the XML file and to work faster with it.

PTB Functions

- The tool should crawl the xml schemas out of the xml file and download it by itself.
- The tool should work with every XML file and a scheme (XSD, RelaxNG, etc.)
- If there aren‘t schemas the XML is editable, but the functions aren‘t made for this and it has a limited use for this.




XML Tree Editor
File Tools Help
dcc:digitalCalibrationCertificate
xsi:schemaLocation https://ptb.de/dcc https://ptb.de/dcc/v3.1.2/dcc.xsd
schemaVersion 3.1.2
dcc:administrativeData
dcc:dccSoftware
dcc:software
dcc:software
dcc:software
dcc:coreData
dcc:items
dcc:iter
Add Node
dcc:name
dcc:equipmentClass
dcc:description
dcc:owner
dcc:identifications
dcc:item
dcc:name
dcc:manufacturer
dcc:model
dcc:identifications
dcc:calibrationLaboratory
dcc:respPersons
dcc:customer
08.02.2023
5


XML Tree Editor
File Tools Help
dcc:digitalCalibrationCertificate
xsi:schemaLocation https://ptb.de/dcc https://ptb.de/dcc/v3.1.2/dcc.xsd
schemaVersion 3.1.2
dcc:administrativeData
dcc:dccSoftware
dcc:software
dcc:name
dcc:release
dcc:type editor
dcc:software
dcc:software
dcc:coreData
dcc:items
dcc:item
dcc:name
dcc:manufacturer
Add Node
Add Attribute
id
refId
refType
dcc:model
dcc:identifications
dcc:calibrationLaboratory
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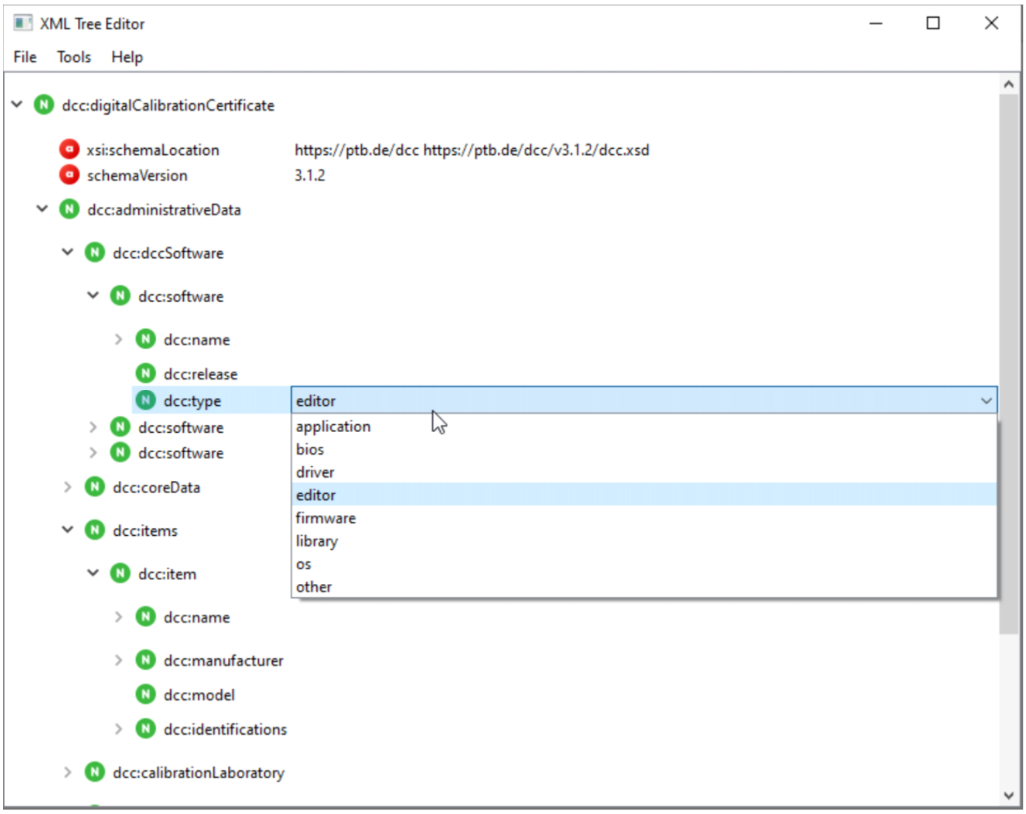
6



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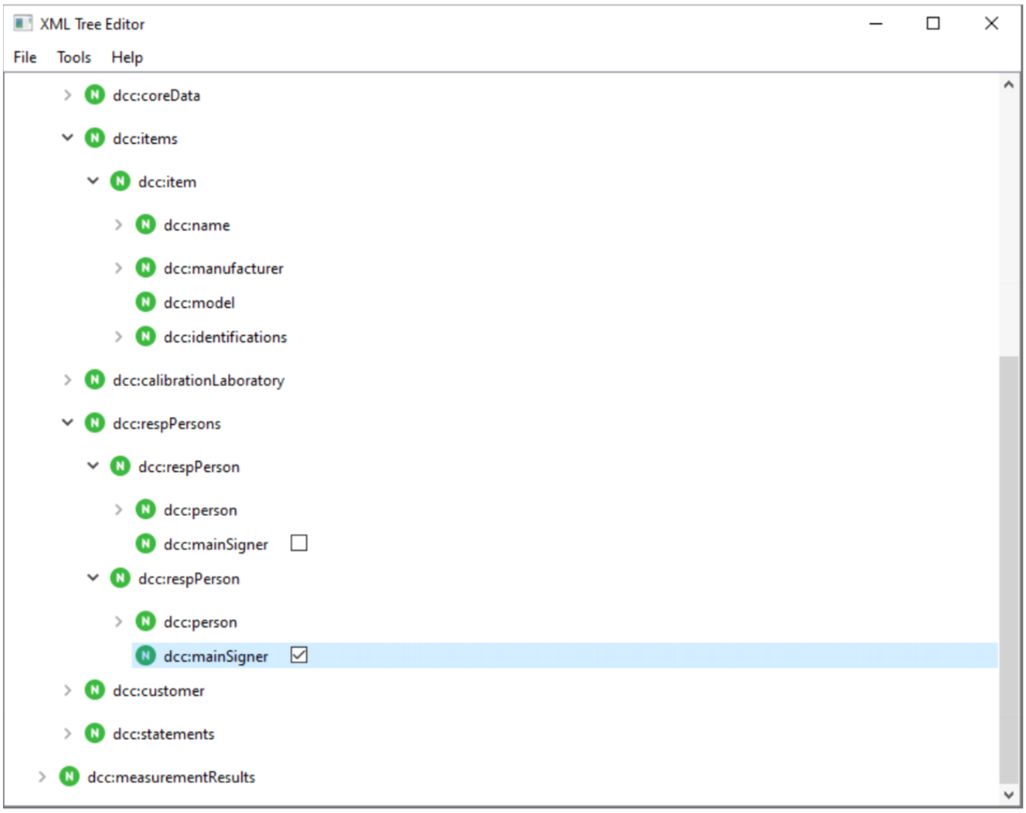

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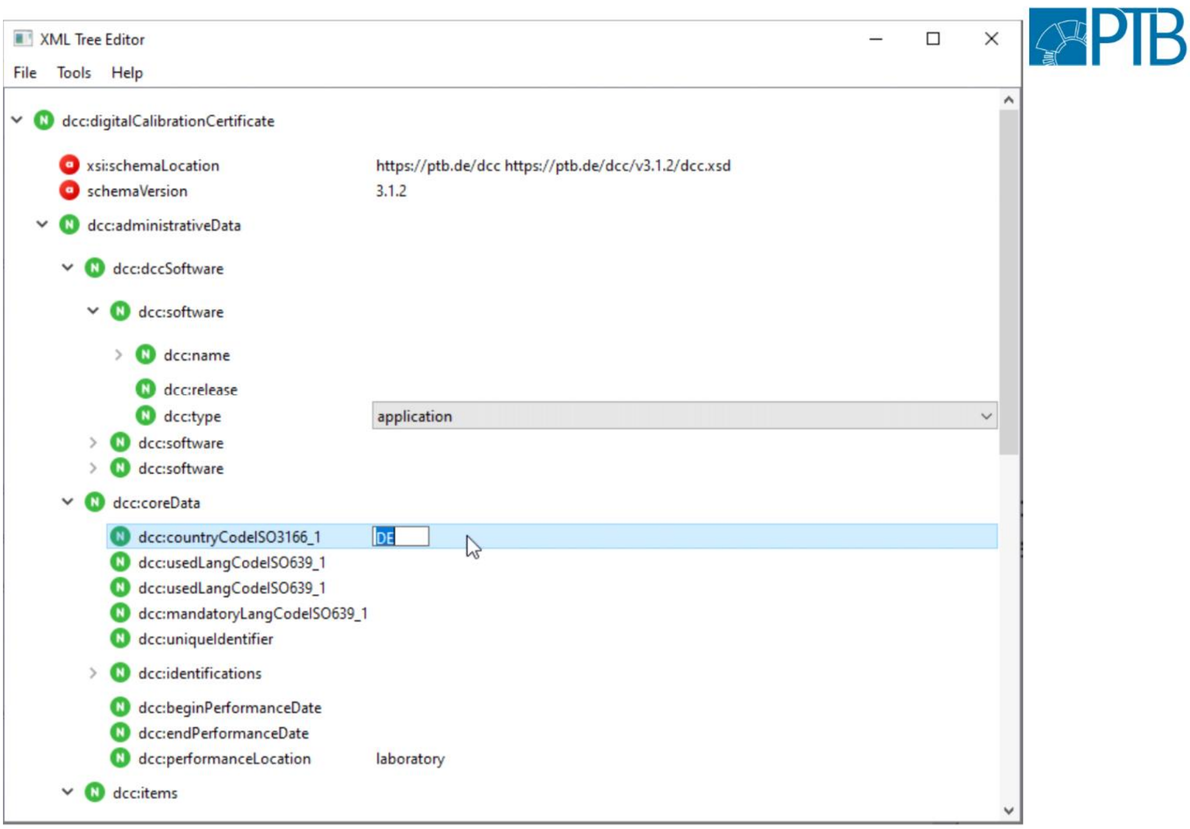

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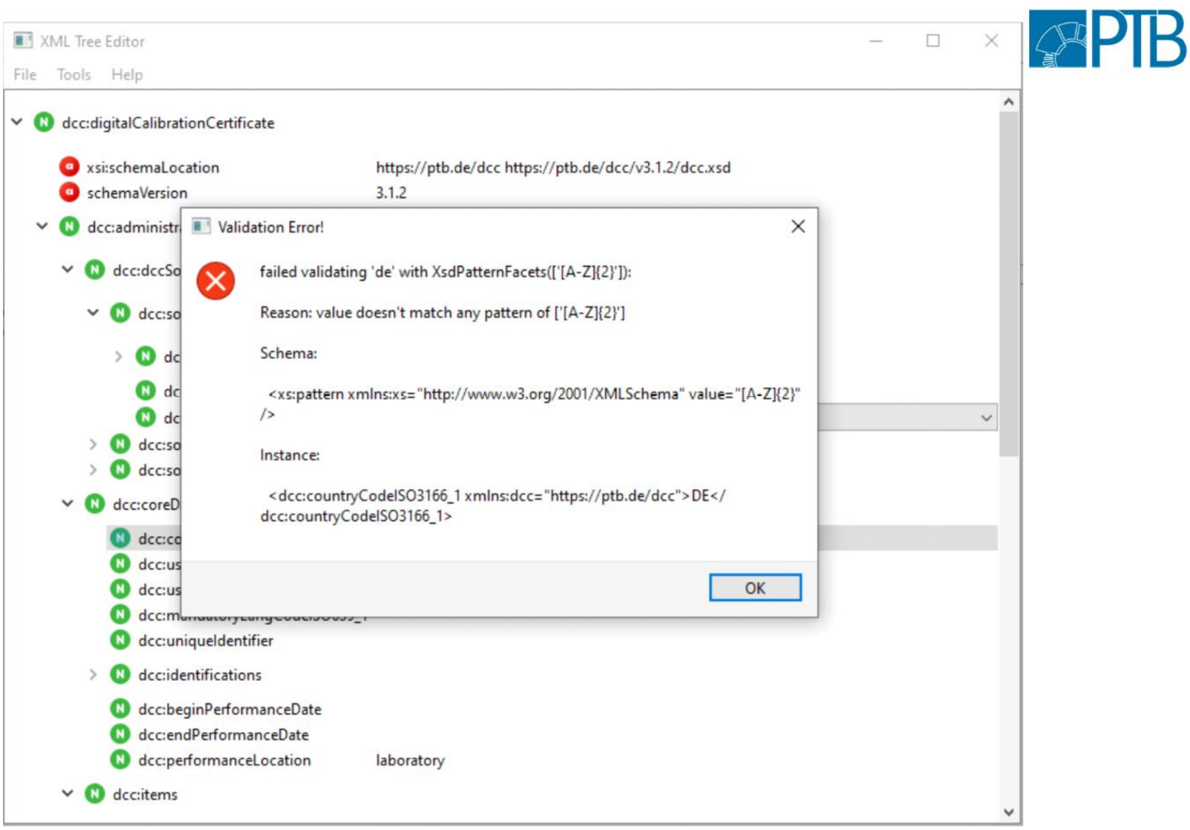

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XML Tree Viewer

```
dcc:digitalCalibrationCertificate
  xsi:schemaLocation          https://ptb.de/dcc https://ptb.de/dcc/v3.1.1/dcc.xsd
  schemaVersion               3.1.1
  dcc:administrativeData
    dcc:dccSoftware
    dcc:coreData
    dcc:items
    dcc:calibrationLaboratory
    dcc:respPersons
    dcc:customer
    dcc:statements
      dcc:statement
        refType               basic_conformity
        dcc:declaration
        dcc:respAuthority
        dcc:conformity        pass
      dcc:statement
  dcc:measurementResults
    dcc:measurementResult
      dcc:name
      dcc:usedMethods
      dcc:measuringEquipments
      dcc:influenceConditions
      dcc:results
        dcc:result
          refType             gp_measuringResult1
          dcc:name
          dcc:data
            dcc:list
```

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XML Tree Viewer

```
dcc:results
  dcc:result
    refType                   gp_measuringResult1
    dcc:name
    dcc:data
      dcc:list
        refType               gp_table1
        dcc:quantity
          refType             basic_referenceValue
          dcc:name
          si:hybrid
            si:realListXMLList
              si:valueXMLList 306.248 373.121 448.253 523.319 593.154
              si:unitXMLList  \kelvin
            si:realListXMLList
              si:valueXMLList 33.098 99.971 175.103 250.169 320.004
              si:unitXMLList  \degreecelsius
        dcc:quantity
          refType             basic_measuredValue
          dcc:name
          si:hybrid
            si:realListXMLList
              si:valueXMLList 306.32 373.21 448.36 523.31 593.07
              si:unitXMLList  \kelvin
            si:realListXMLList
              si:valueXMLList 33.17 100.06 175.21 250.16 319.92
              si:unitXMLList  \degreecelsius
        dcc:quantity
          refType             basic_measurementError
          dcc:name
```

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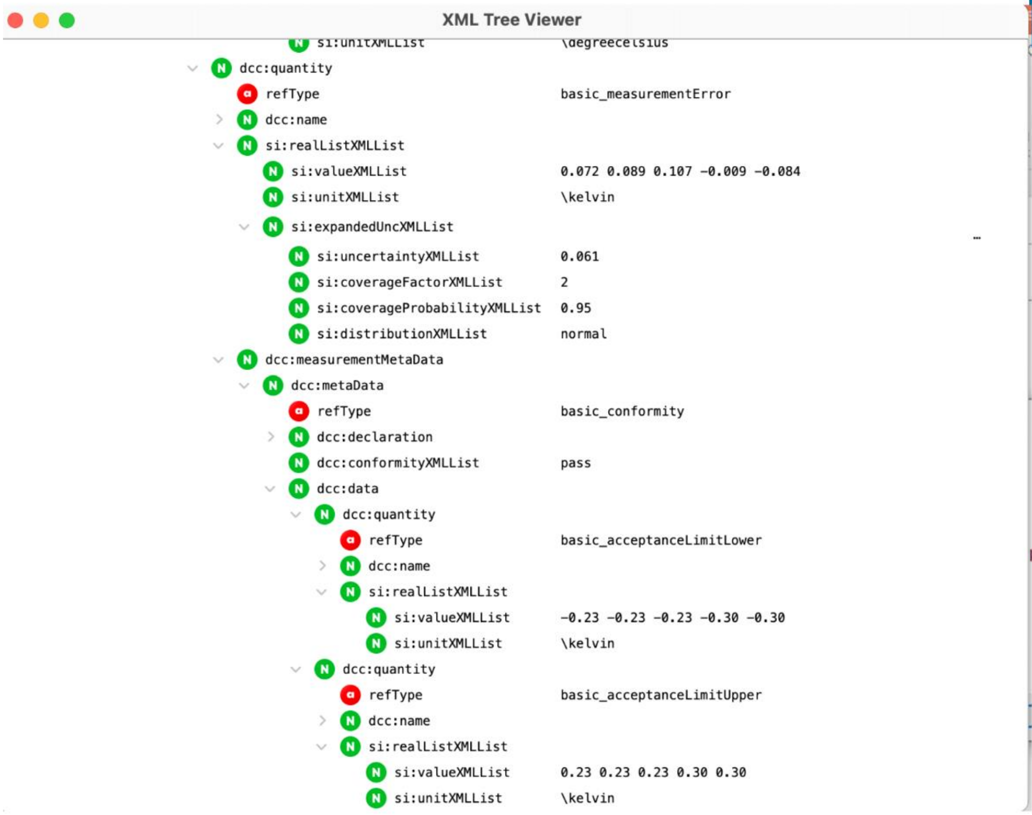

Plans for the future

- Convert lists to Qt Tables
- Recognize files in base64 and show it as file elements:
  - Make previews for image files
  - double click to change and upload another file
- Create a dashboard to make the tool as a part of the GEMIMEG tool.

Thank you for your attention!

Please keep in mind that the development is in an alpha stage and can‘t be released right now.

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Parallel Session 5: Adoption of DCC at NMI's

Presentations that would also fit into this session:

45 Digital Transformation of NMI: Practical Experience on DCC and Beyond @ NIS-Egypt

Presenting author: Ahmed H. Ali & National Institute for Standards & Egypt

E-mail address: ahmed.hussien@nis.sci.eg

Additional authors: Reham Abdellatif abouhogail, Mohammed Gadelrab, Mohammed Elsheikh

Abstract

Generally, sharing experience and information is a good practice in the human communities. Its importance increases in emerging scientific or technical fields as it helps people to learn from each other and apply new technologies faster without repeatedly committing same mistakes. The digital transformation in metrology is an ideal example of this practice where experts share generously their experience with fellows. In this presentation, we present our practical experience regarding the digital transformation (DX) and the digital calibration certificate (DCC) at the National Institute of Standards (the NMI of Egypt). We describe how we approached the problem from the early beginning with a clear vision. Not only we describe how we developed a comprehensive plan to make the transition from traditional systems to become fully digitalized. We also explain how we reached this plan through a comprehensive analysis of the status quo of our institute. Besides the IT infrastructure necessary for the digital transformation and the DCC, our plan also covered the metrology-related processes and the metrology artifacts.

Unlike other presentations, ours may explain some overlooked or uncovered issues that might never be confronted by NMIs in more advanced countries. Therefore, we believe that presenting NIS experience could be beneficial for many NMIs that have similar situations or environment such as ours (i.e., with respect to DX/DCC readiness, available facilities, skills/personnel and budget).

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Digital Transformation of NMI: Practical Experience on DCC and Beyond @ NIS-Egypt

National Institute of Standards (NIS-Egypt)

1- Ahmed H. Ali (Ahmed.hussien@nis.sci.eg)
2- Reham A. Abouhogail
3- Mohammed Gadelrab
4- Muhammad ElSheikh

Outline

2

Vision

- **Vision**: Digital Transformation not only current metrological services and metrology-related activities but also opening the door for future, innovative services and applications.
- **Approach**:
  Where we are?
  How can we realize our vision?

3

Status Quo: Where we were?

- Quite obsolete infrastructure
- Manual processes and disjoint workflows
- Paper-based CC
- Limited DX Awareness & Know-how
- Legislative Aspects: National laws in place

4

Status Quo: What can be digitally transformable?

- **Activities (Processes):**
  - Measurement
  - Calibrate/Test
  - Inter-Compare
  - Audits
  - Administration/ Managment

- **Measurement Artifacts:**
  - Measurement instrument (HW, SW)
  - Measurement Data
  - Calibration Certificate
  - Reference Material/Standard
  - Digital Twin

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Holistic DX Plan

- Upgrading infrastructure
- DX of the institutional departments
- Re-engineering the process of the calibration service:
  - Reviewing calibration process workflows
  - Building a new calibration management system
- Digital Calibration Certificate (DCC)
- Training
- Research:
  - M4DT
  - DT4M

6

Practical steps for plan execution: Infrastructure upgrade

- ✓ Network re-design
- ✓ New network equipments
- ✓ High-speed Internet
- ✓ Inter-building fiber-optic links
- ✓ Build a local data-center
- ✓ Build a private cloud

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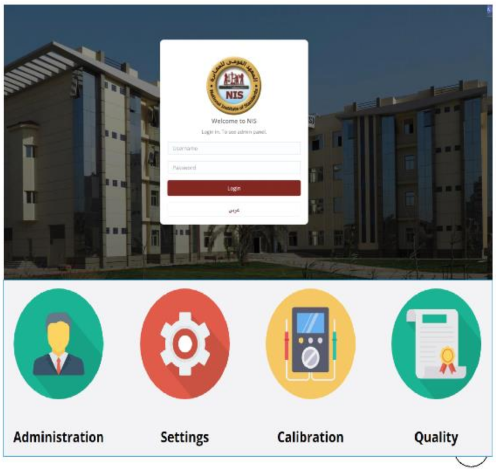
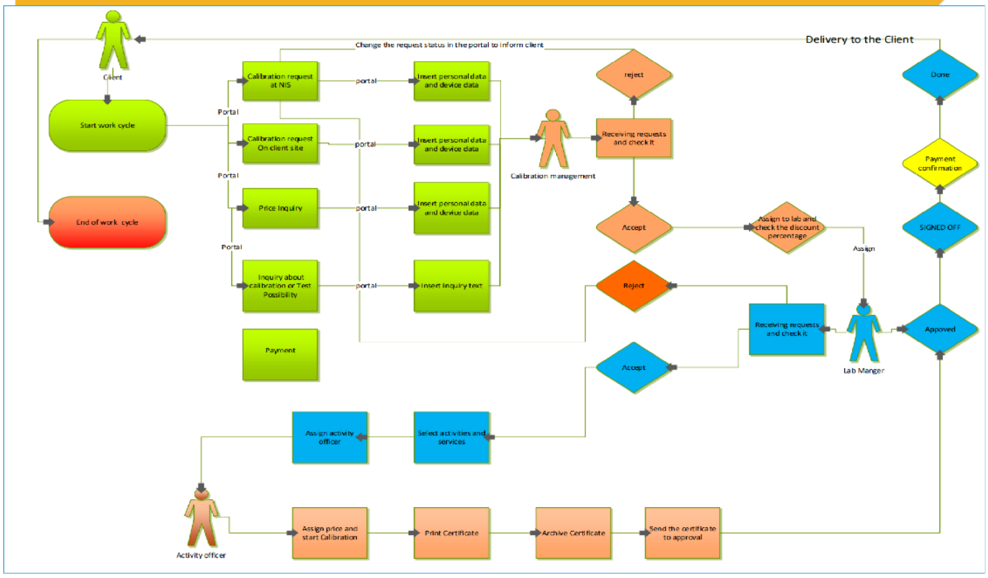
Practical steps for plan execution: Platform upgrades

- ✓ NIS mail server:
  - ✓ Enhanced reliability and security
- ✓ NIS service web-portal:
  - ✓ Calibration / Test / Ref Material / Training / Consultation
- ✓ NIS calibration management system:
  - ✓ End-2-end process view
  - ✓ Integrated quality system
  - ✓ Automated workflow



Practical steps for plan execution: Process re-engineering



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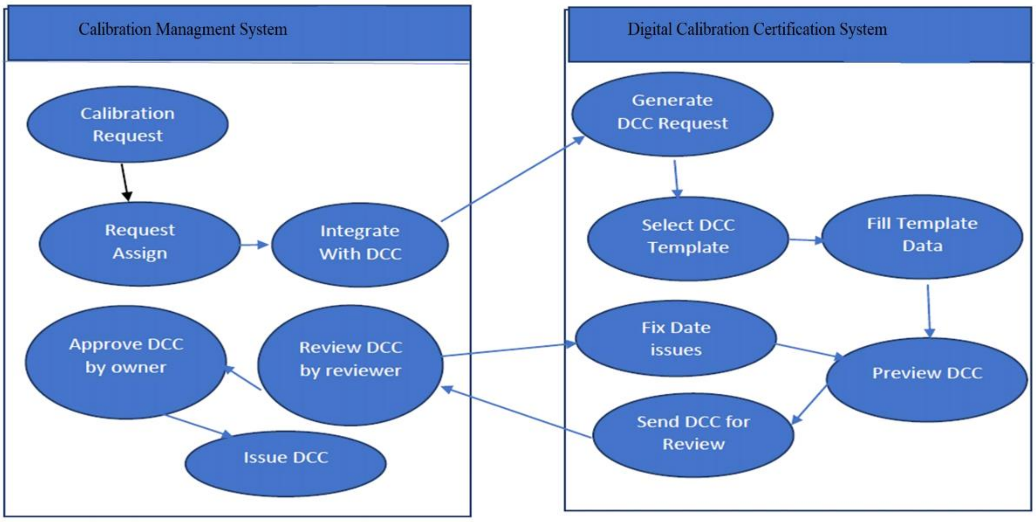
Practical steps for plan execution: Process re-engineering



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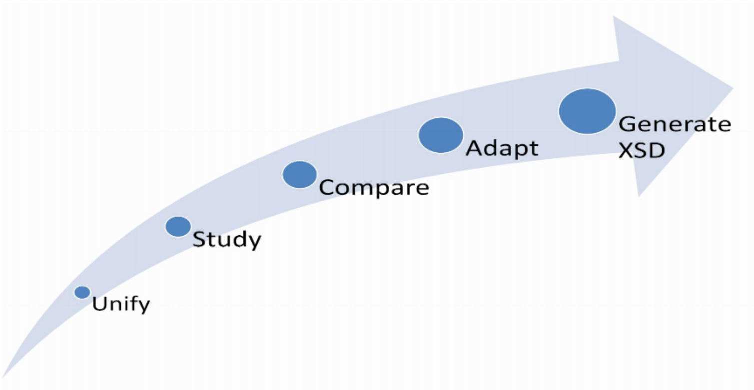
Steps towards fully implemented DCC

- Unify CC from all departments to a standard template
- Analyze its current contents
- Compare with PTB suggested DCC scheme
- Adapt and add CC fields
- Generate own DCC scheme



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DCC Road-Map

1st Gen	2nd Gen	3rd Gen	4th Gen	5th Gen
Digital Image of the paper-based certificate	XML-based certificate + signed paper-based certificate	XML-based certificate signed using digital signature	Standard DCC XML format	Blockchain-based DCC

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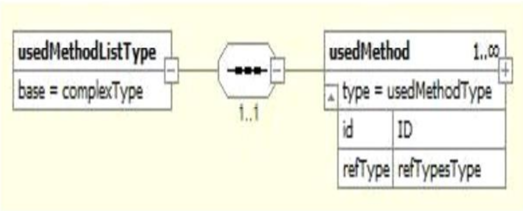
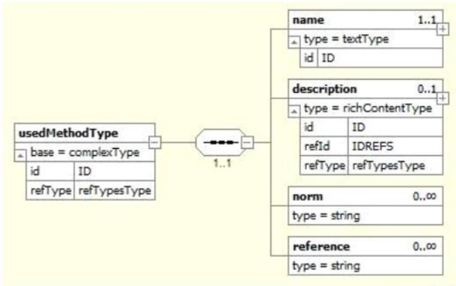
Example of adaptation

- “Calibration Method ” Field: NIS SOP (Service Operation Process) or a standard procedure (e.g., IEC 60060-1 and ISO 171234 (2012))
- “Uncertainty Method” Field: Like “Calibration Method ” Field
- “Calibration Mode” Field: The function to be calibrated in a multi-function device





13

<table>
<tr><td>“Calibration Method ” Field</td><td>NIS SOP (Service Operation Process) or a standard procedure (e.g., IEC 60060-1 and ISO 171234 (2012))</td><td><pre><dcc:usedMethod refType="nis_calibrationMethod">
    <dcc:name>
        <dcc:content lang="en">Calibration Method</dcc:content>
        <dcc:content lang="ar"></dcc:content>
    </dcc:name>
    <dcc:norm> <!-- ‘‘SOP or Standard’’ --> </dcc:norm>
</dcc:usedMethod></pre></td></tr>
<tr><td>“Uncertainty Method” Field</td><td>Like “Calibration Method ” Field</td><td><pre><dcc:usedMethod refType="nis_uncertaintyMethod">
    <dcc:name>
            <dcc:content lang="en">Uncertainty Method</dcc:content>
                <dcc:content lang="ar"></dcc:content>
        </dcc:name>
        <dcc:norm> <!-- ‘‘SOP or Standard’’ --> </dcc:norm>
</dcc:usedMethod></pre></td></tr>
<tr><td>“Calibration Mode” Field</td><td>The function to be calibrated in a multi-function device</td><td><pre><dcc:usedMethod refType="nis_calibrationMode">
    <dcc:name>
        <dcc:content lang="en">Calibration Mode</dcc:content>
        <dcc:content lang="ar"></dcc:content>
    </dcc:name>
    <dcc:description> <!-- ‘‘Functions to be calibrated’’ --> </dcc:description>
</dcc:usedMethod></pre></td></tr>
</table>

Example of adaptation

1. Localization in DCC XML
2. User-interface localization
   - ✓ PTB DCC scheme Multi-Language support
   - ✓ Field Translations
   - ✓ Multi-language GUI

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Legislative Aspects: National laws related to DX

- Law No. 203 of 2020 on Organizing measurement and calibration work (Metrology).
- Law No. 15 of 2004 on E-signature and Establishment of the Information Technology Industry Development Authority (ITIDA).
- Law No. 151 of 2020 on Personal Data Protection.
- Law No. 175 of 2018 on Anti-Cyber and Information Technology Crimes.

16

Research Aspects: R &D Team Is Useful

➢**Published:**

- Mohammed S. Gadelrab, Reham A. Abouhogail, “Towards a New Generation of Digital Calibration Certificate: Analysis and Survey”, Journal of the International Measurement Confederation (Measurement), Volume 181, August 2021. https://www.sciencedirect.com/science/article/pii/S0263224121005844

➢**In progress:**

- Topic 1: A New Generation of Digital Calibration Certificate: Blockchain-Based DCC.
- Topic 2: Digital transformation in metrology.

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Learned Lessons & Challenges

- obsolete Infrastructure
- Shortage of financial budget
- Shortage of qualified and experience team members
- none unified CC template for all department
- staff Resistance for Automation Systems

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Authors List

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- Muhammad ElSheikh (muhammad.elsheikh@nis.sci.eg)

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Thanks

47 Equipment Management and Tracking System - Cloud Service for Calibration Certificate Management

Presenting author: Sunantiya Parana, NIMT, Thailand

E-mail address: Sunantiya.pa@gmail.com

Additional authors: Narin Chantawong, Jariya Buajarern, and Praiya Thongluang

Abstract

The NIMT has created an Equipment Management and Tracking System (EMTs) that will provide customers with an open service. The EMTs is created following the ISO17025 standard, the general requirements for the competence of testing and calibration laboratories. The EMTs is a platform to approach the problem of storing calibration certificates. The main purpose of EMTs is to store calibration certificates of various equipment in electronic form and manage data storing calibration results for customers. The benefits of this system are easy-to-find documents, privacy, and security of data. The EMTs planning is divided into two phases. The first phase will be used in the NIMT to test the system and receive inner feedback to improve the system. Then it will be launched for third parties and review the comment to improve the system again before the official launch.

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1

Equipment Management and Tracking System (EMTs)

- Cloud service for calibration certificate management.

Presented by: Sunantiya P.

สถาบันมาตรวิทยาแห่งชาติ
National Institute of Metrology (Thailand)

2

Overview

- Introduction
- What is EMTs
- How does the EMTs work?
- Future work

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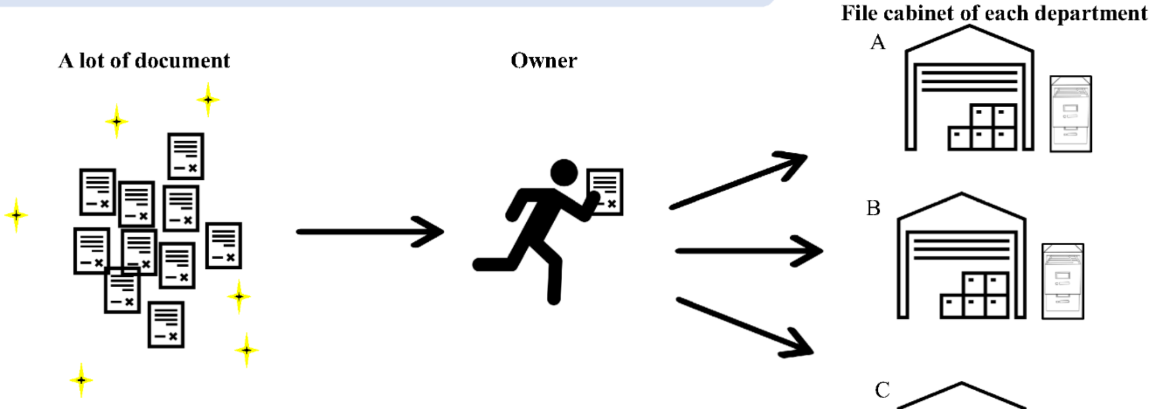
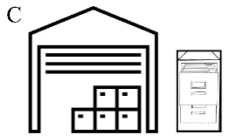
Introduction

3





Customers store a document in paper form and they keep it in a file cabinet of each department. The large document resulted in some issues i.e. finding and losing the document. Because finding document operation depends on storage system of organization.

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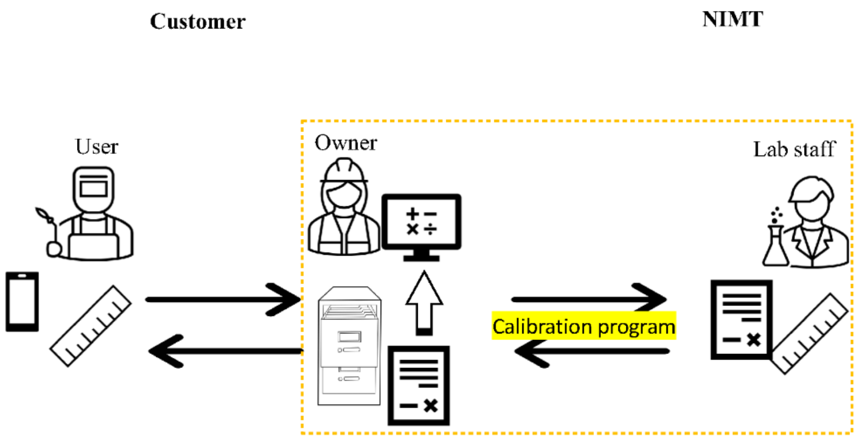
Current issuing certificate process

4



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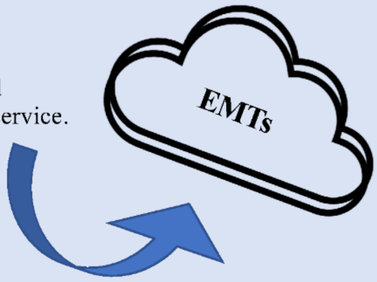
5

To approach this issue,

The NIMT has created an Equipment Management and Tracking System (EMTs) that will provide customers as a public service.



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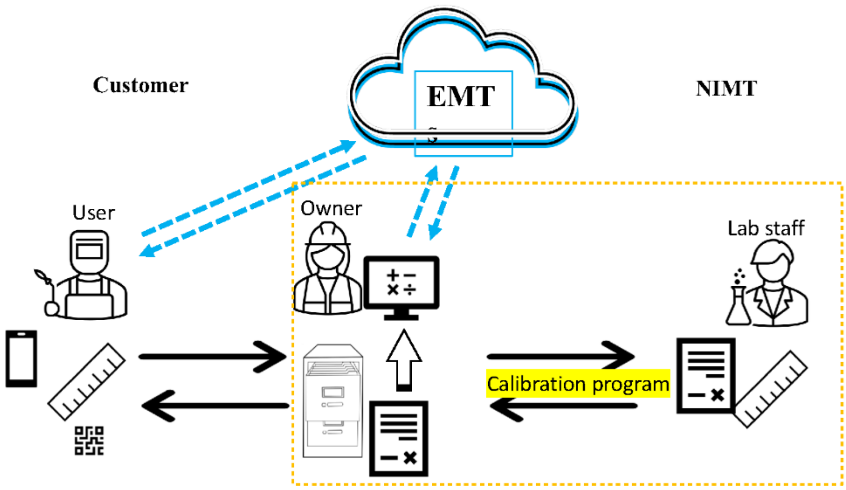
Depicts storing data management system - EMTs.

6



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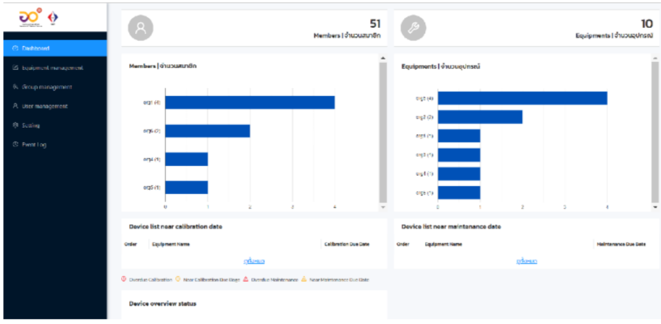
What is EMTs

7

The EMTs is a platform to approach the problem of storing calibration certificates

- The main purpose of this system is to store calibration certificates of various equipment in electronic form and manage data storing calibration results for customers.
- The benefits of this system are easy-to-find documents, privacy, and security of data.



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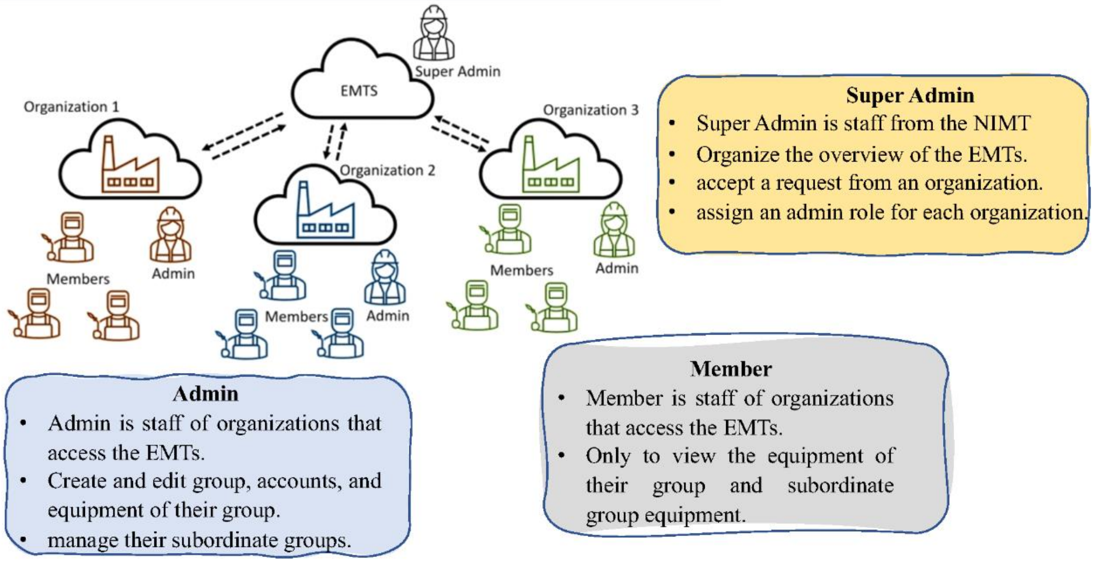
NIMT

The roles of users in the EMTs

8



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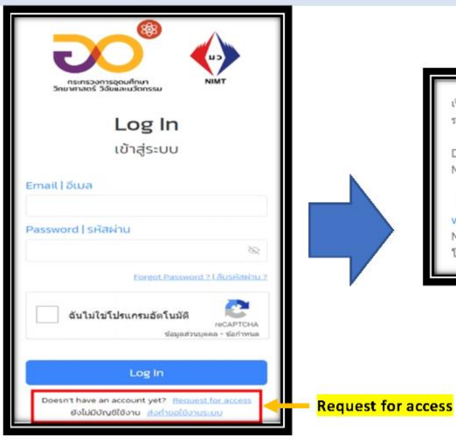
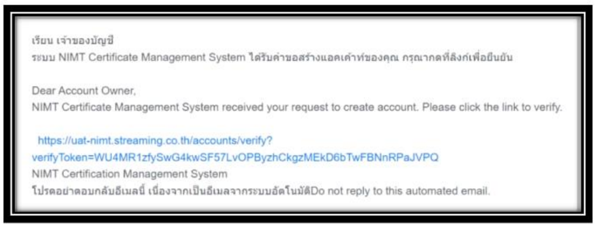
How does the EMTs work?

9





Admin created an account for a user, the account user will receive a verification via email to log in.

EMTs registration must be sent a request to the https://emt.nimt.or.th website

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Dashboard

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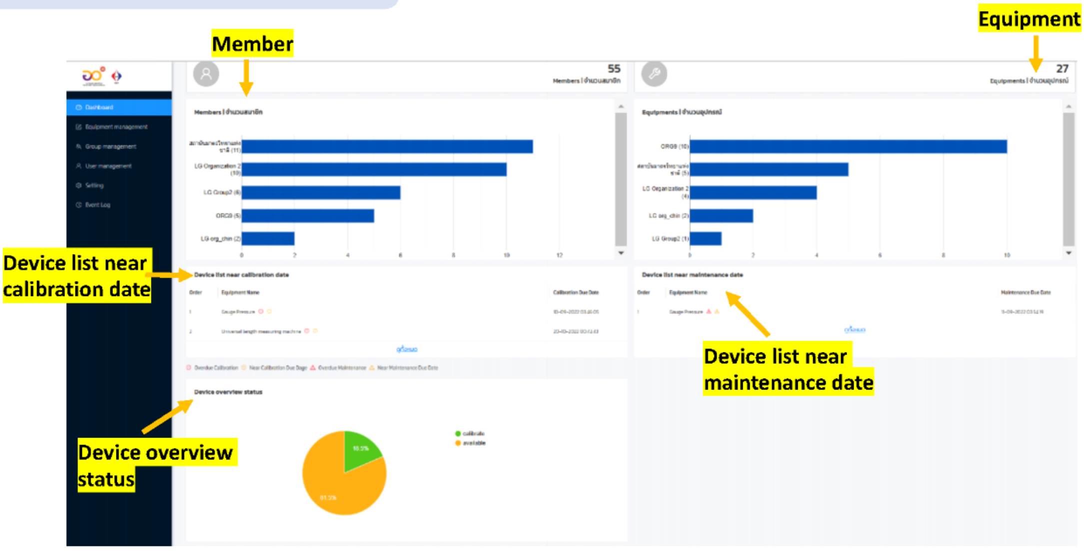

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Equipment Management

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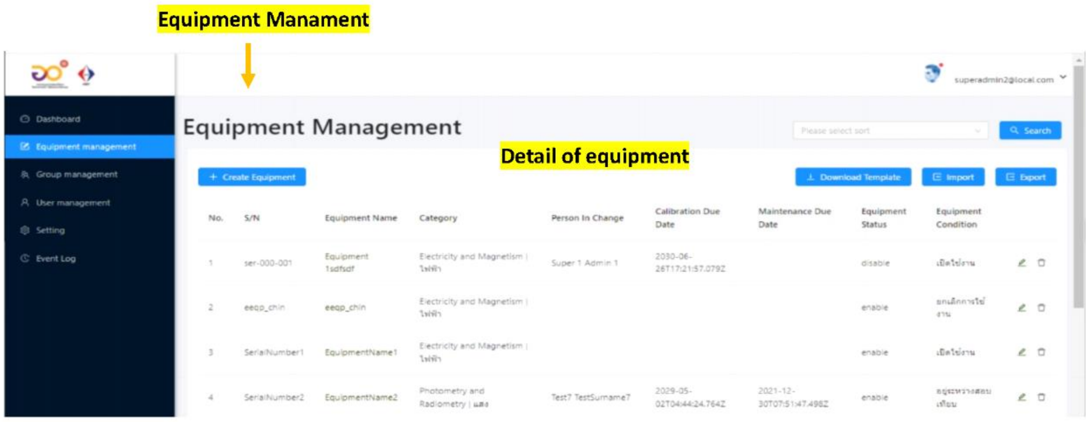

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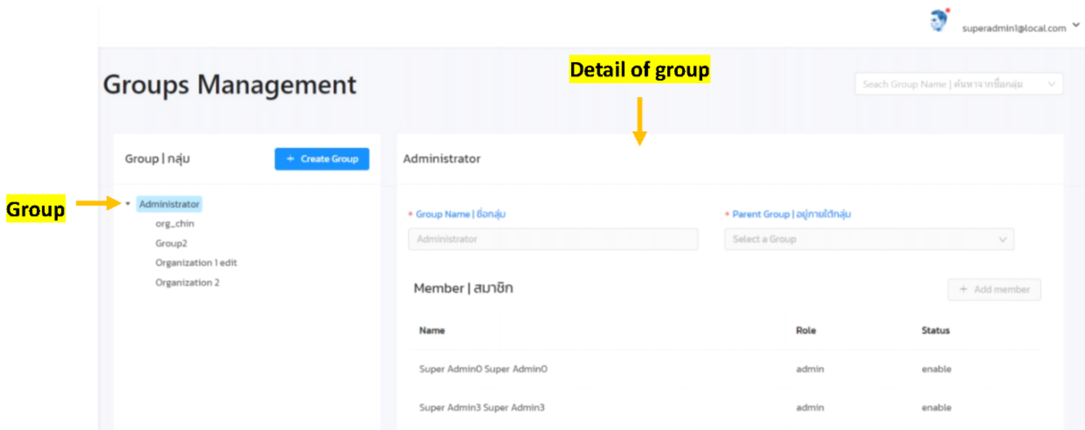
Group Management

12



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User Management

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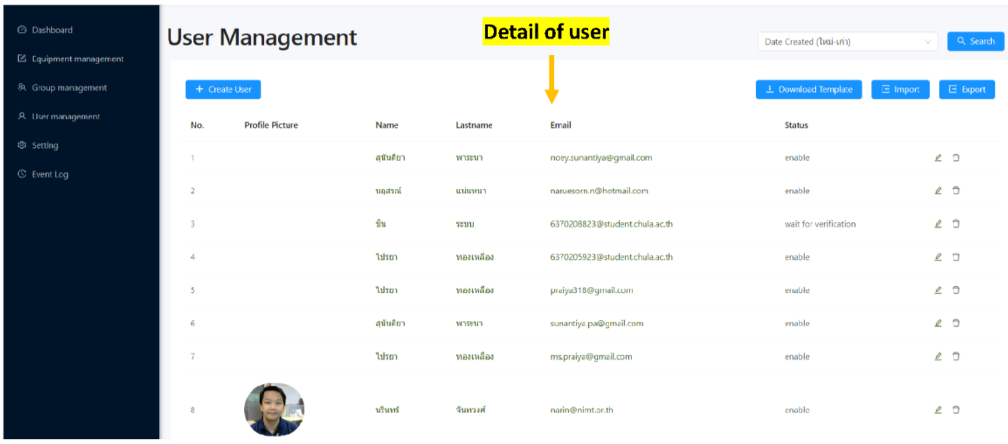

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Conclusion

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▪
- EMTs is a cloud service for management and approaching the problem of storing calibration certificates.
- The benefits of this system
  - easy-to-find documents,
  - Privacy
  - security

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Future Work.

15

First phases

March 2023

- **NIMT** test the system.
- Receive feedback.
- Improve the system.

Second phases

around July 2023

- **Customer** test the system.
- Receive feedback.
- Improve the system again before the official launch.

Next step

Develop the EMTs to support a DCC

- The NIMT will develop the EMTs to be able to support a digital calibration certificate (DCC).

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THANK YOU FOR YOUR ATTENTION

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48 Mapping of Processes and Risks in the Digital Transformation in Metrology of Ionizing Radiation - A Case Study in X-Ray Air Kerma Calibration

Presenting author: Igor Fernando Modesto Garcia, Labprosaud/IFBA, Brazil

E-mail address: lem.labprosaud@ifba.edu.br

Additional authors: Eric Matos Macedo, Marcus Vinicius Teixeira Navarro, José Guilherme Pereira Peixoto

Abstract

To solve the metrological challenges of an increasingly digitized world, countries are developing applications, infrastructure for DCC and researching the comparability of real and virtual measurements. Objective: to map the processes and risks related to the digital transformation of kerma calibration in air in X-rays. For quantification of risks related to the process, the FMEA was used, which is a method widely used in the aviation and automotive industry due to its reliability. The results presented showed and compared the mappings of processes and risks related to contemporary calibration and the 4.0 model projection for x-ray air kerma magnitude. In the contemporary calibration process 18 risks were found. The main identified risk was the error in the analysis and use of the calibration certificate by the user which uses the CC. The main vectors were complexity and number of magnitudes related to the area of ionizing radiation; lack of user metrological training; lack of metrological management of equipment by the user; manual certificate analysis process associated with the complexity in presenting the results of calibration certificates by laboratories and cultural factors (perception of the meaning of the word “calibration” as “adjustment. This result is important because, of all the risks listed in this process, this is the one that presents the greatest harm to metrological reliability. In the case of 4.0 calibration that uses the DCC as premise, the risk of error in the analysis and use of the certificate was significantly lower because the structure of DCC mitigates the main factors related to the CC. The main level of risk in the case of 4.0 is associated with the sensor/actuator chosen, with the reliability and integrity of the communication network.

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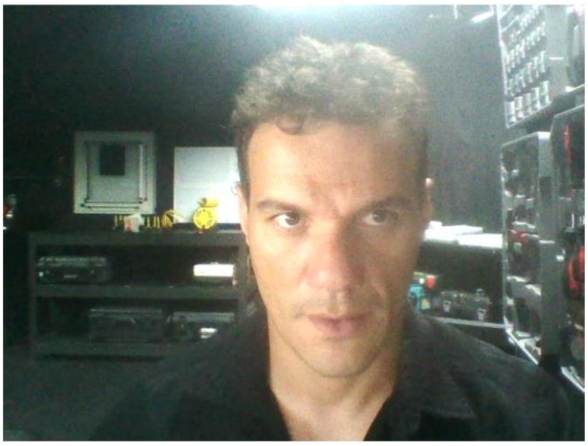
Presented by: MSc. Igor Garcia

IRD



Contact: lem.labprosaud@ifba.edu.br

- 11 years of experience in calibration laboratories (2012 – 2023)
- PhD candidate in the graduate program in Radioprotection and Dosimetry at the IRD in the area of metrology (2021).
- Training in x-ray calibration with secondary standard laboratory dosimetry from the IAEA (2018)
- Master's degree in Health Technologies (2017)
- Degree in Medical Radiology Technology (2011)

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BRIEF

Mapping processes and risks in the digital transformation

The contemporary calibration for x-rays **VS** The 4.0 calibration projection for x-rays

Digital copy of the Calibration Certificate CC

Human readable

Digital calibration certificate DCC

Human and machine readable

METHODOLOGY

- To quantify the risks related to the process, the Failure Mode and Effect Analysis – FMEA method was used, with the following sequence:

1. The criteria were defined (table 1)

Table 1. Definition of criteria by effect

Value	Effect	Description
Criteria for severity (S)		
1	No effect	No effect on the calibration process
2	Lesser effect	Small effect on the calibration process
3	Greater effect	Reasonable effect on the calibration process
4	Critical	Great effect on the calibration process
5	Catastrophic	Interruption of the calibration process
Criteria for occurrence (O)		
1	Never	Never happens
2	Rare	1% chance per year
3	Occasional	5% chance per year
4	Likely	10% chance per year
5	Frequent	>10% chance per year
Criteria for detectability (D)		
1	Easy	Can be easily detected by observation before starting the process
2	Not so easy	Can be observed after some process checks
3	Medium	It is necessary to use standard checking tools
4	Difficult	It is necessary to use specific tools
5	Not detected	Cannot be detected

Source: research data

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METHODOLOGY

2. The Risk Priority Number RPN was calculated;
   RPN = (S x O x D)

3. RPN was classified (table 2);

Table 2. RPN classification

S	O	D	RPN	Classification	Treatment
1	1	1	1	Acceptable RPN< 27	No corrective action needed
2	2	2	8		
3	3	3	27	Relevant 27 ≤ RPN< 64	Demands corrective action
4	4	4	64		
5	5	5	125	Unacceptable RPN > 64	Urgent corrective action required

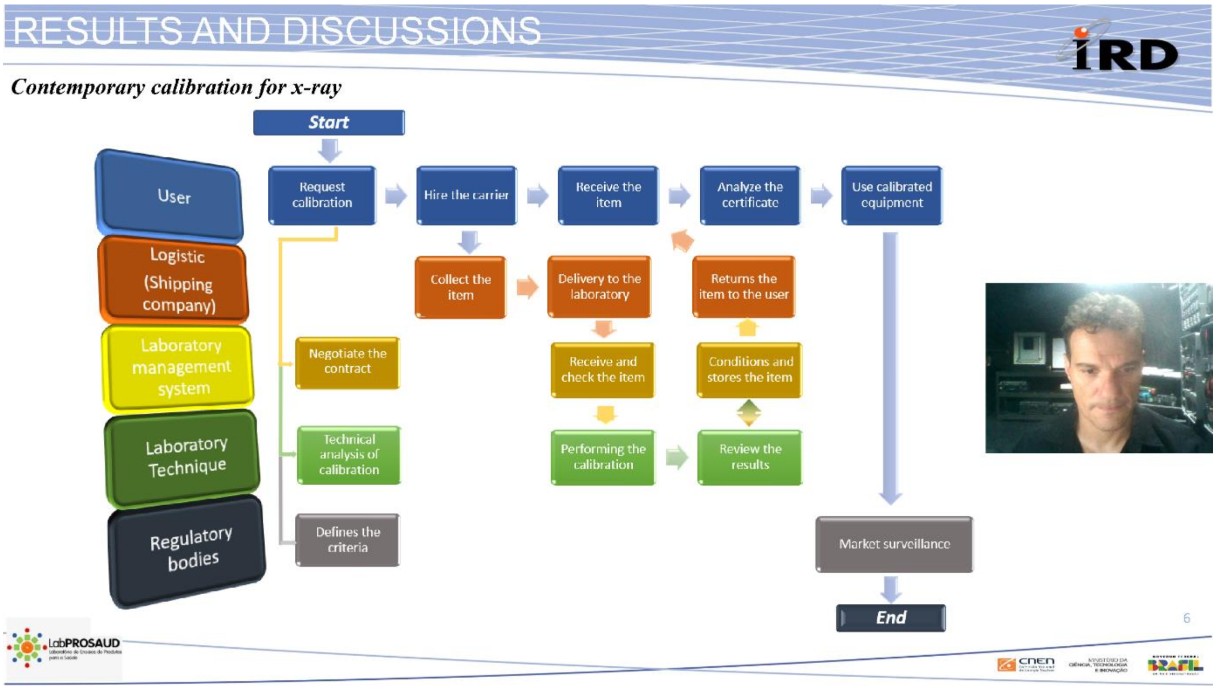
Additional criteria:
1 Any RPN < 27 is residual risk and can be addressed in the continuous improvement process.
2 If any of the criteria is 5, the RPN should be classified as "Relevant".

Source: research data

4. Corrective actions were applied;

5. After the corrective actions, we quantified the RPN again to verify the effectiveness of the actions in mitigating risks.

5


RESULTS AND DISCUSSIONS
IRD
Contemporary calibration for x-ray
Start
User
Logistic (Shipping company)
Laboratory management system
Laboratory Technique
Regulatory bodies
Request calibration
Hire the carrier
Receive the item
Analyze the certificate
Use calibrated equipment
Collect the item
Delivery to the laboratory
Returns the item to the user
Negotiate the contract
Receive and check the item
Conditions and stores the item
Technical analysis of calibration
Performing the calibration
Review the results
Defines the criteria
Market surveillance
End
6
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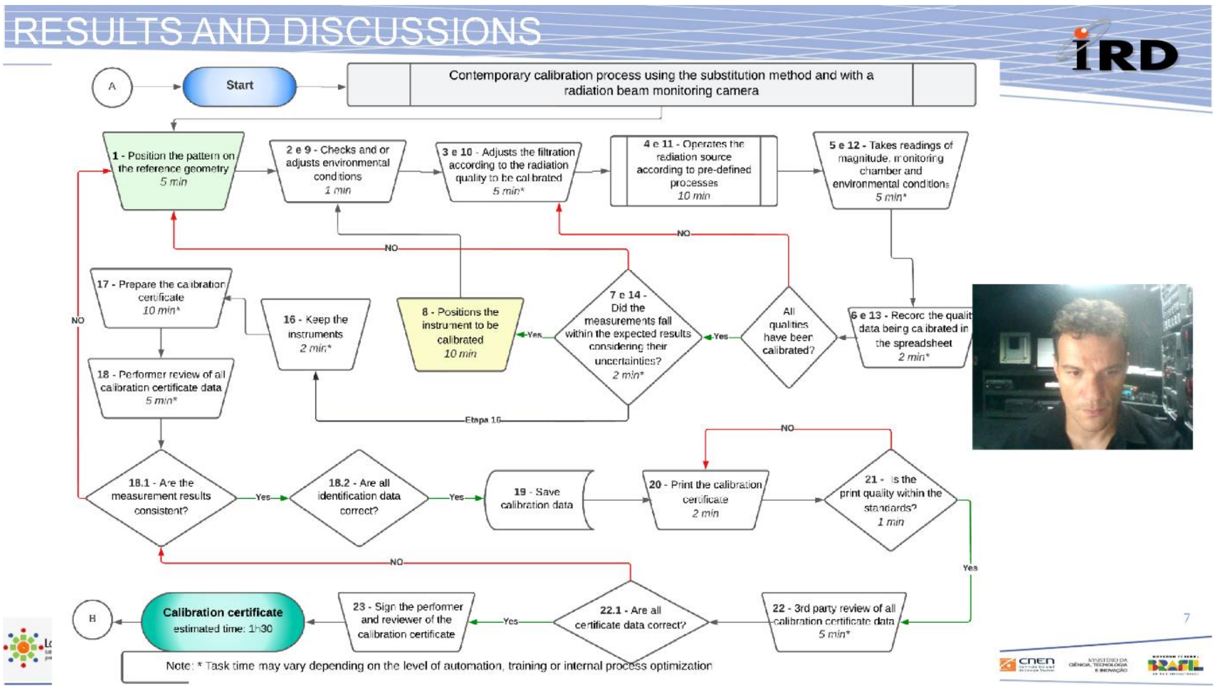
RESULTS AND DISCUSSIONS
IRD
A
Start
Contemporary calibration process using the substitution method and with a radiation beam monitoring camera
1 - Position the pattern on the reference geometry 5 min
2 e 9 - Checks and or adjusts environmental conditions 1 min
3 e 10 - Adjusts the filtration according to the radiation quality to be calibrated 5 min*
4 e 11 - Operates the radiation source according to pre-defined processes 10 min
5 e 12 - Takes readings of magnitude, monitoring chamber and environmental conditions 5 min*
NO
17 - Prepare the calibration certificate 10 min*
16 - Keep the instruments 2 min*
8 - Positions the instrument to be calibrated 10 min
7 e 14 - Did the measurements fall within the expected results considering their uncertainties? 2 min*
All qualities have been calibrated?
6 e 13 - Record the data being calibrated in the spreadsheet 2 min*
Yes
18 - Performer review of all calibration certificate data 5 min*
Etapa 16
18.1 - Are the measurement results consistent?
18.2 - Are all identification data correct?
19 - Save calibration data
20 - Print the calibration certificate 2 min
21 - Is the print quality within the standards? 1 min
B
Calibration certificate estimated time: 1h30
23 - Sign the performer and reviewer of the calibration certificate
22.1 - Are all certificate data correct?
22 - 3rd party review of all calibration certificate data 5 min*
Note: * Task time may vary depending on the level of automation, training or internal process optimization
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RESULTS AND DISCUSSIONS

Contemporary calibration for x-ray

Table 1. Definition of criteria by effect

Value	Effect	Description
Criteria for severity (S)		
1	No effect	No effect on the calibration process
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2	Not so easy	Can be observed after some process checks
3	Medium	It is necessary to use standard checking tools
4	Difficult	It is necessary to use specific tools
5	Not detected	Cannot be detected

Table 3. Quantification of the risks of the traditional calibration process (FMEA).

Agent	Effect	Risk	S	O	D	RPN	Actions	S	O	D	RPN
User	Inaccurate calibration	Error in defining calibration criteria	4	2	2	16	User training and laboratory advice	3	3	2	18
		Error in the analysis and use of the calibration certificate	**4**	**4**	**4**	**64**		**3**	**3**	**4**	**36**
Logistics	Calibration not performed	Damage or theft of user equipment	5	3	3	45	Insurance contract	4	2	2	16
		excessive delay	3	3	2	18	Internal controls	5	1	2	10
Laboratory management	Inaccurate calibration	Failure to comply with calibration requirements	4	3	3	36	Procedures for quality controls, internal and external audits	3	2	2	12
		Conflict of interest and confidentiality	4	2	3	24		3	1	2	6
	Calibration not performed	Receiving, handling, transport, and storage	4	2	3	24		4	2	2	16
		Break-in or theft of laboratory facilities	5	3	3	45	Security system	4	1	2	8
Laboratory calibration technique	Inaccurate calibration	Errors in calibration measurements	4	3	4	48	Constant team training, internal and external audits	4	3	2	24
		Use of inappropriate equipment	4	3	2	24		4	2	2	16
		Equipment identification errors	3	3	3	27		3	3	2	18
		Errors in the calibration certificate information	4	3	4	48		4	3	2	24
		Errors in uncertainty calculations	4	3	4	48		4	2	2	16
		unstable environmental conditions	3	3	3	27	Reservation system	2	1	2	4
	Calibration not performed	Patterns stop working	5	3	2	30		2	2	2	8
		User equipment does not work	5	2	2	20	Checklists and footage	2	2	2	8
Regulatory bodies	Inaccurate calibration	User equipment does not work	4	2	1	8	Team training	3	2	2	12
		Market surveillance error	4	2	4	32		3	2	2	12
					Total	*614*				*Total*	*266*

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RESULTS AND DISCUSSIONS

IRD

Contemporary calibration for x-rays

The main identified was:

Table 3. Quantification of the risks of the traditional calibration process (FMEA).

Agent	Effect	Risk	S	O	D	RPN	Actions	S	O	D	RPN
User	Inaccurate calibration	Error in defining calibration criteria	4	2	2	16	User training and laboratory advice	3	3	2	18
		Error in the analysis and use of the calibration certificate	**4**	**4**	**4**	**64**		**3**	**3**	**4**	**36**

The main vectors for this:

1- Manual certificate analysis process associated with the complexity in presenting the results of the CC
2- Complexity and number of magnitudes related to the area of ionizing radiation;
3- Lack of user metrological training;
4- Lack of metrological management of equipment by the user;
5- Cultural factors (perception of the meaning of the word "calibration" as "adjustment")

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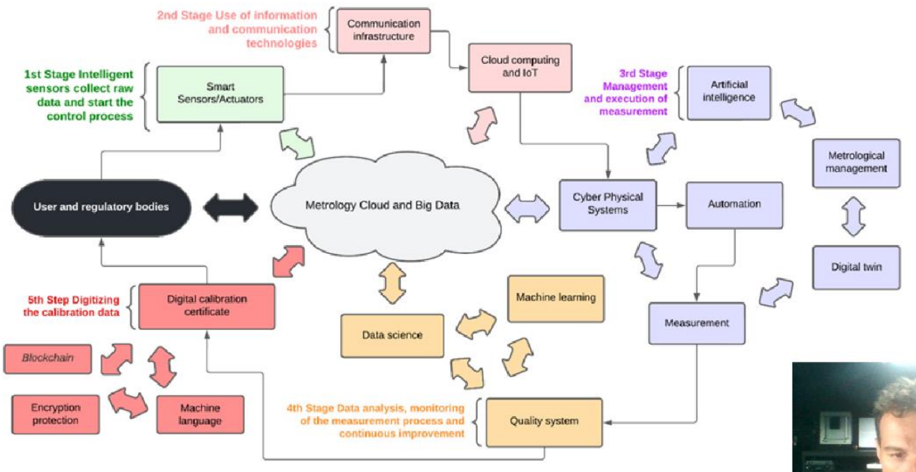
RESULTS AND DISCUSSIONS

Overview of metrology 4.0



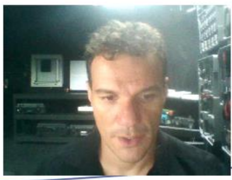


Figure 3. Metrology 4.0 relationship diagram
Source: Research data

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RESULTS AND DISCUSSIONS

The 4.0 calibration projection for x-rays

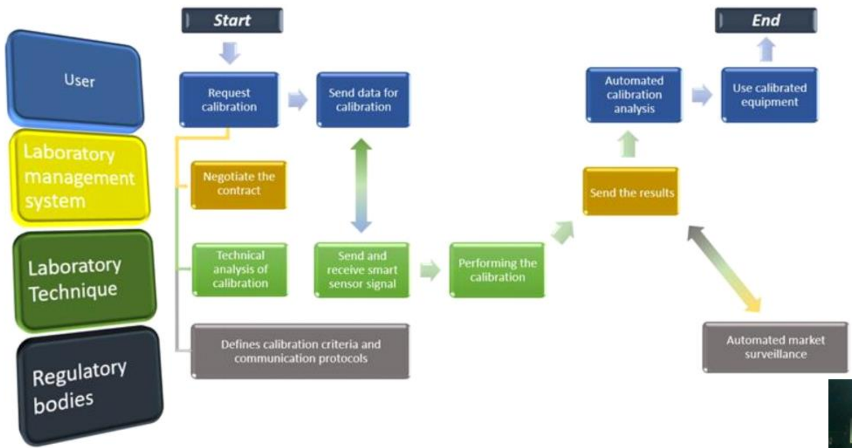


Figure 4. Possible macro flow of the 4.0 calibration process for ionizing radiation
Source: Research data

RESULTS AND DISCUSSIONS

The 4.0 calibration projection for x-rays

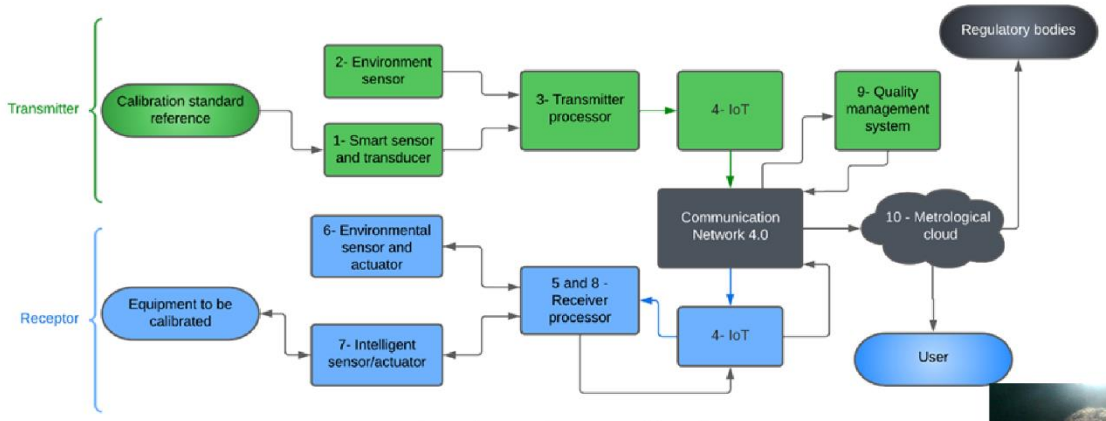
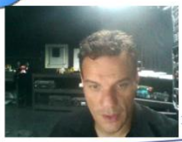


Figure 5. Flowchart of a 4.0 calibration process

Source: Adapted from Calibration for Industry 4.0 Metrology: Touchless Calibration(Andonov S. 2018)



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RESULTS AND DISCUSSIONS

Table 4. Quantification of risks related to the 4.0 calibration process (FMEA).

Agent	Effect	Risk	S	O	D	RPN	Actions	S	O	D	RPN
User	Inaccurate calibration	Error in defining calibration criteria	4	2	2	16	Use of intelligent software, user training and laboratory advice	3	1	1	3
		***Error in the analysis and use of the calibration certificate**	**4**	**1**	**4**	**16**		3	1	1	3
Laboratory management	Inaccurate calibration	Failure to comply with calibration requirements	3	3	3	27	Use of intelligent software, automation, procedures for quality controls, internal and external audits	3	2	1	6
		Conflict of interest and confidentiality	3	2	3	18		3	1	1	3
	Calibration not performed	Break-in or theft of laboratory facilities	5	3	3	45	Security system	5	1	2	10
Laboratory calibration technique	Inaccurate calibration	Errors in calibration measurements	3	3	4	36	Constant team training, internal and external audits	2	3	1	6
		Errors in uncertainty calculations	3	3	4	36		2	2	1	4
		*Laboratory personnel not trained for Calibration Method 4.0	5	2	3	30		1	2	2	4
		unstable environmental conditions	3	3	3	27	Security system	2	1	2	4
		Patterns stop working	5	3	2	30		2	1	2	4
		User equipment does not work	5	2	2	20	Checklists and footage	2	2	2	8
	Calibration not performed	*Network communication error	5	3	2	30	Check connections, system backup	5	2	1	10
		*Transmitting processor error	5	3	1	15		5	2	1	10
		*Error in the receiving processor	5	4	1	20		5	2	1	10
		*Error in sensors/actuators	5	4	1	20		5	2	1	10
		*Standard sensors error	5	3	1	15		5	2	1	10
Regulatory bodies	Inaccurate calibration	Definition of calibration criteria	4	2	1	8	Security system	3	1	1	3
		*Market surveillance error	3	1	4	12		3	1	1	3
					Total	**452**				**Total**	**108**
		Difference (in relation to the contemporary) -26%								*Difference -56%*	

The estimated risk for 4.0 calibration x-rays

- There is a significant reduction in the risk of ***analysis and use of the calibration certificate*** and ***total estimated risk of the process.***
- However, there are new risks exclusive to the 4.0 model and all with criteria of 5 (interruption of the calibration process), This increases the need for control actions.

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RESULTS AND DISCUSSIONS

Study limitations:

- Risk is calculated by mathematical means (data statistics). As the calibration process is "company secrets", there is a lack of "typical data values".

- Different laboratories use different processes, so a particular independent approach would be the best way to do the risk analysis.
- Risk is different from risk perception. Although judgments must be made based on facts. Cultural, religious, social, and political factors can influence the perception of risks among the agents involved.

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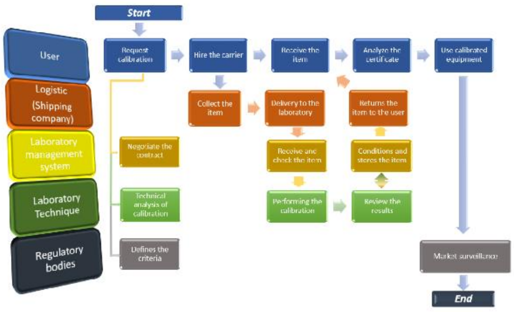
CONCLUSION

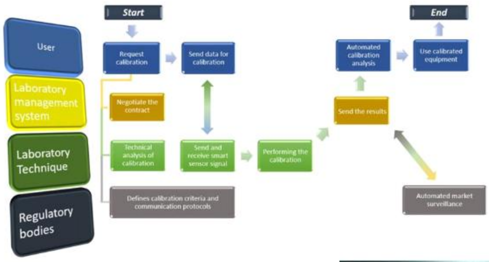
Contemporary calibration

Except for the "calibration request" step, each member of the process performs its task independently



The 4.0 calibration projection for x-rays

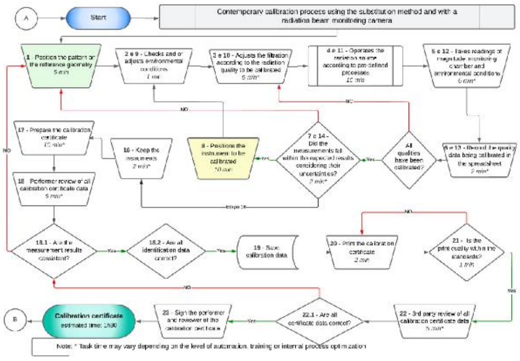
There is no logistics agent Market surveillance is interconnected with the calibration laboratory database



CONCLUSION

Contemporary calibration

There is a detailed mapping of the calibration process



The 4.0 calibration projection for x-rays

There is a flowchart of the 4.0 projection for x rays calibration

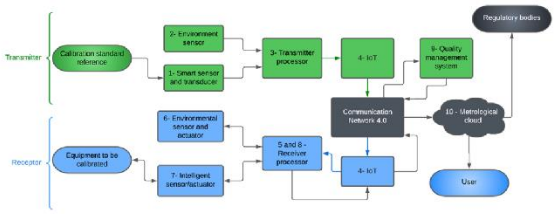


Figure 5. Flowchart of a 4.0 calibration process

CONCLUSION

Contemporary calibration

The main identified risk in the process:

The error in the analysis and use of the CC

The 4.0 calibration projection for x-rays

The same risk was significantly lower because the DCC structure mitigates the main factors related to the CC

Table 3. Quantification of the risks of the traditional calibration process (FMEA).

Agent	Effect	Risk	S	O	D	RPN	Actions	S	O	D	RPN
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Logistics	Calibration not performed	Damage or theft of user equipment	5	3	3	45	Insurance contract	4	2	2	16
		excessive delay	3	3	2	18	Internal controls	5	1	2	10
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		Use of inappropriate equipment	4	3	2	24		4	2	2	16
		Equipment identification errors	3	3	3	27		3	3	2	18
		Errors in the calibration certificate information	4	3	4	48		4	3	2	24
		Errors in uncertainty calculations	4	3	4	48		4	2	2	16
		unstable environmental conditions	3	3	3	27	Reservation system	2	1	2	4
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		Market surveillance error	4	2	4	32		3	2	2	12
				Total		*614*			*Total*		*266*

Table 4. Quantification of risks related to the 4.0 calibration process (FMEA).

Agent	Effect	Risk	S	O	D	RPN	Actions	S	O	D	RPN
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		***Error in the analysis and use of the calibration certificate**	4	**1**	4	**16**		3	1	1	3
Laboratory management	Inaccurate calibration	Failure to comply with calibration requirements	3	3	3	27	Use of intelligent software, automation, procedures for quality controls, internal and external audits	3	2	1	6
		Conflict of interest and confidentiality	3	2	3	18		3	1	1	3
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		*Transmitting processor error	5	3	1	15		5	2	1	10
		*Error in the receiving processor	5	4	1	20		5	2	1	10
		*Error in sensors/actuators	5	4	1	20		5	2	1	10
		*Standard sensors error	5	3	1	15		5	2	1	10
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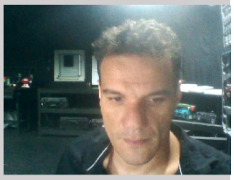

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ACKNOWLEDGMENT

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49 Processes and Conventions for the DCC – Results of PTB's 100-Day Programmes in 2022

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Additional authors: Muhammed-Ali Demir, Gisa Foyer, Benjamin Gloger, Frank Härtig, Siegfried Hackel, Moritz Jordan, Thomas Krah, Beatrice Rodiek (all PTB), Julian Haller (Sartorius), Christian Müller-Schöll (Mettler-Toledo)

Abstract

During the past year 2022, significant advancement towards an operational use of digital calibration certificates has been made. PTB has conducted all together three 100-day programmes, focusing on selected aspects of DCC development and roll-out. Whereas the first programme has been carried out as an internal project, with the major goal to advance the development of the GEMIMEG tool, the consecutive two 100-day programmes involved external partners from other NMIs, calibration service providers, and industry.

General aspects such as accreditation and signing of digital certificates were addressed, but also the development of good practice examples for weighing applications were in the focus of these projects. Moreover, a communication workflow for conventions and harmonisation with the core development team has been established to support the current work of technical committees developing good practice example DCCs within various areas of metrology. Selected results of the 100-day-programmes will be presented in this talk, with an emphasis on processes and conventions for the DCC.

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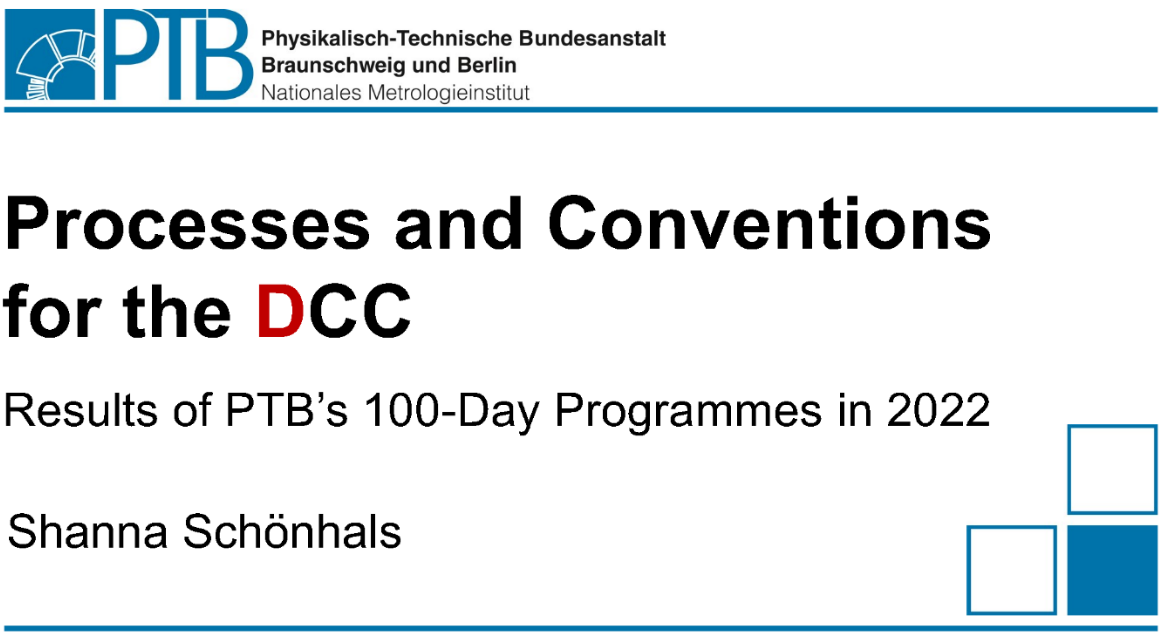
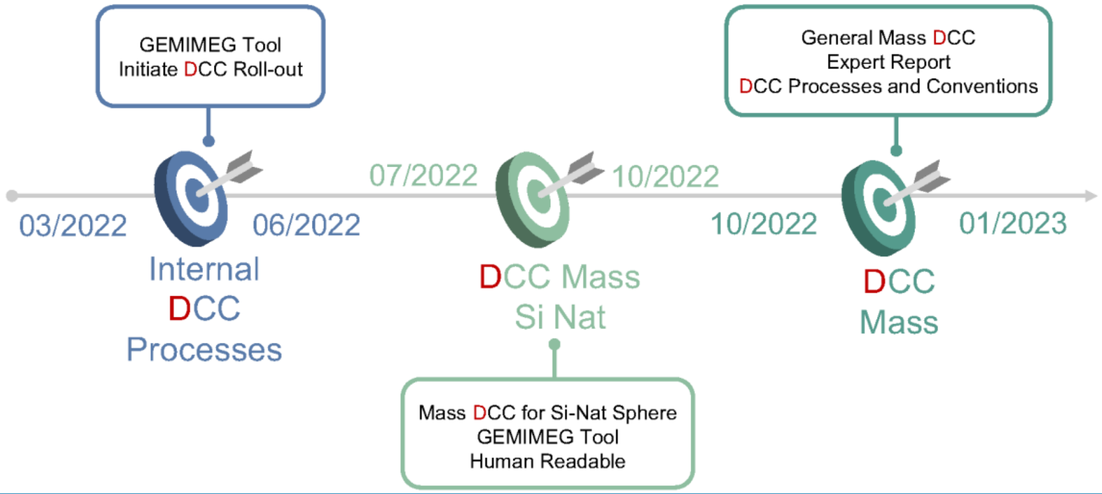


2022 in Three 100-Days Programmes



100-Programme Team

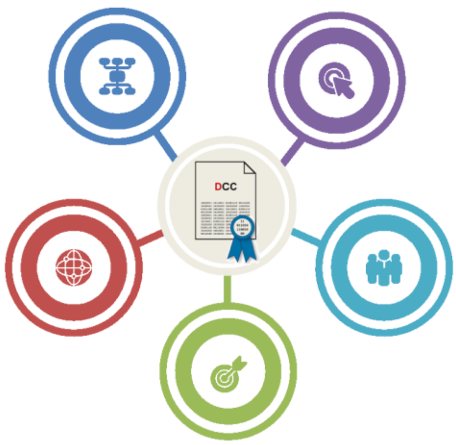
PTB DCC Core Team

PTB Mass Experts

Dept. 1.1 Mass
WG 1.14 Communications
Technology of Weighing Instruments

BEV

Zoltan Zelenka,
EURAMET TC-M Chair



PTB Vice President

Industry Stakeholders

Häfner
Mettler-Toledo
Sartorius

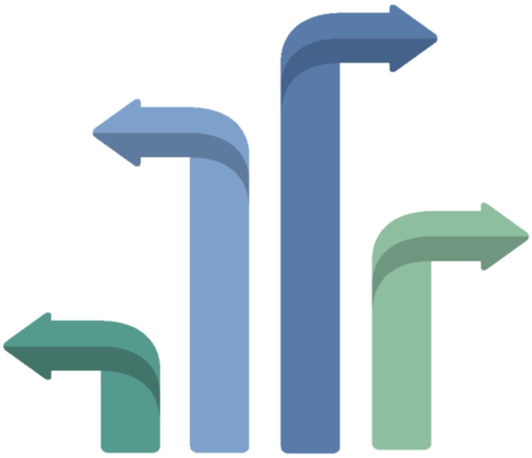
PTB Selected Outcomes for the DCC

1st	Definition of accreditation aspects, establishing of regular exchange between accrediation and DCC developers, pilot project	Accreditation
2nd	General legal requirements of digital signatures or seals for DCCs	Digital Signatures
3rd	Establishing standardised harmonisation processes	Interaction with DKD
4th	Communication workflow between DCC contributors for conventions (schema elements, refTypes, structures)	Processes and Conventions

PTB Accreditation

Long-term goal	Acceptance of the DCC by accreditation authorities
Starting point	Cooperation between PTB and DAkkS
Pilot project	Within the scope of QI Digital project
PTB objectives	Supporting selected pilot accredited labs in DCC implementation Facilitating guidance and support for auditors

Current Harmonisation Processes of DCC



EURAMET TCs

Digitalisation Subcommittees, also Dealing with DCCs

EURAMET TC-IM 1448

Interdisciplinary Project Focusing on the DCC

DKD

German Calibration Service Technical Subcommittees for Harmonisation of DCC Examples, Wording, Expert Reports

DAkkS Pilot Project

In Scope of QI- Digital; Digital Accreditation Symbol with DCC Use Cases

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02.03.2023 6 3rd International DCC Conference

DCC within DKD-TCs

1. Direct Current and Low Frequency
2. High Frequency and Optics
3. ✓ Force and Acceleration
4. ✓ Length
5. ✓ Temperature and Humidity
6. ✓ Pressure and Vacuum
7. ✓ Mass and Weighing Instruments
8. ✓ Chemical Measurands and Material Properties
9. ✓ Materials Testing Machines
10. ✓ Torque
11. ✓ Flow Measurands
12. ✓ Measurands in Laboratory Medicine
13. Messurement Uncertainty (interdisciplinary) → Cross-Sectional SC, also on DCC

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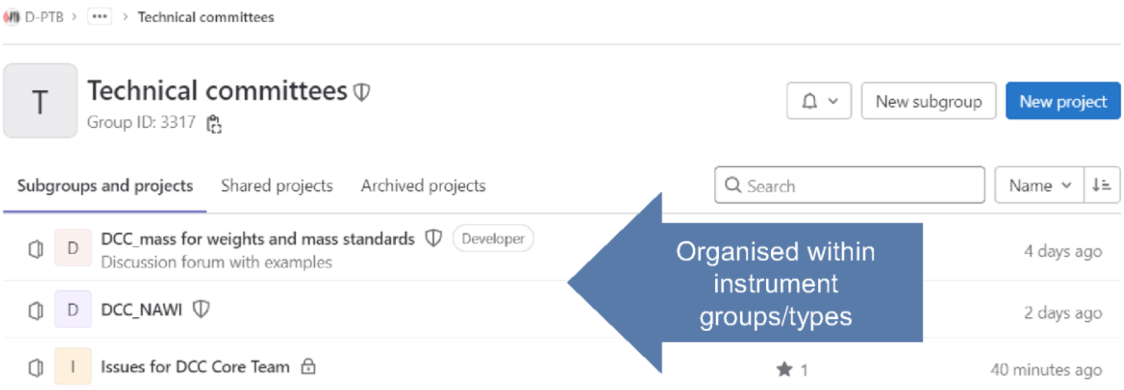
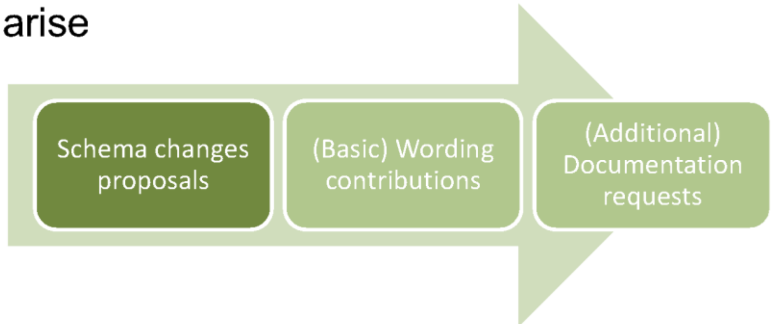
DKD-Technical Committees in Gitlab1

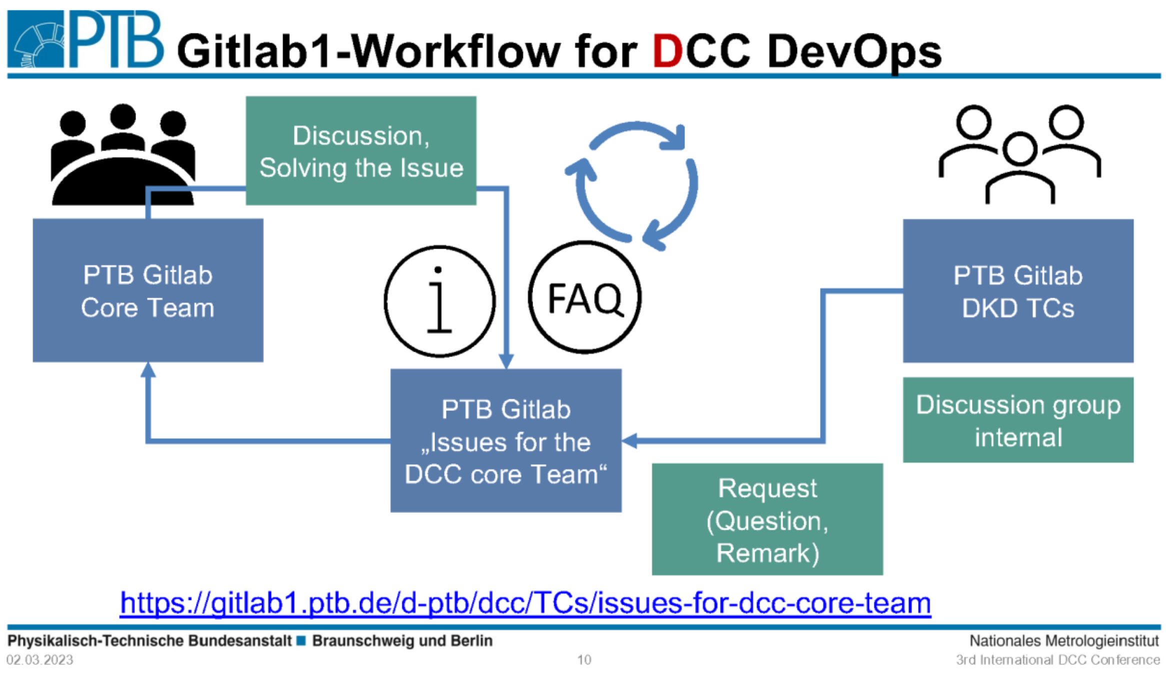


Background: Processes and Conventions

- As DCC implementation progresses, requests and discussion points arise



- Well-defined and standardised workflow processing required


Gitlab1-Workflow for DCC DevOps
Discussion, Solving the Issue
PTB Gitlab Core Team
FAQ
PTB Gitlab DKD TCs
PTB Gitlab „Issues for the DCC core Team“
Discussion group internal
Request (Question, Remark)
https://gitlab1.ptb.de/d-ptb/dcc/TCs/issues-for-dcc-core-team
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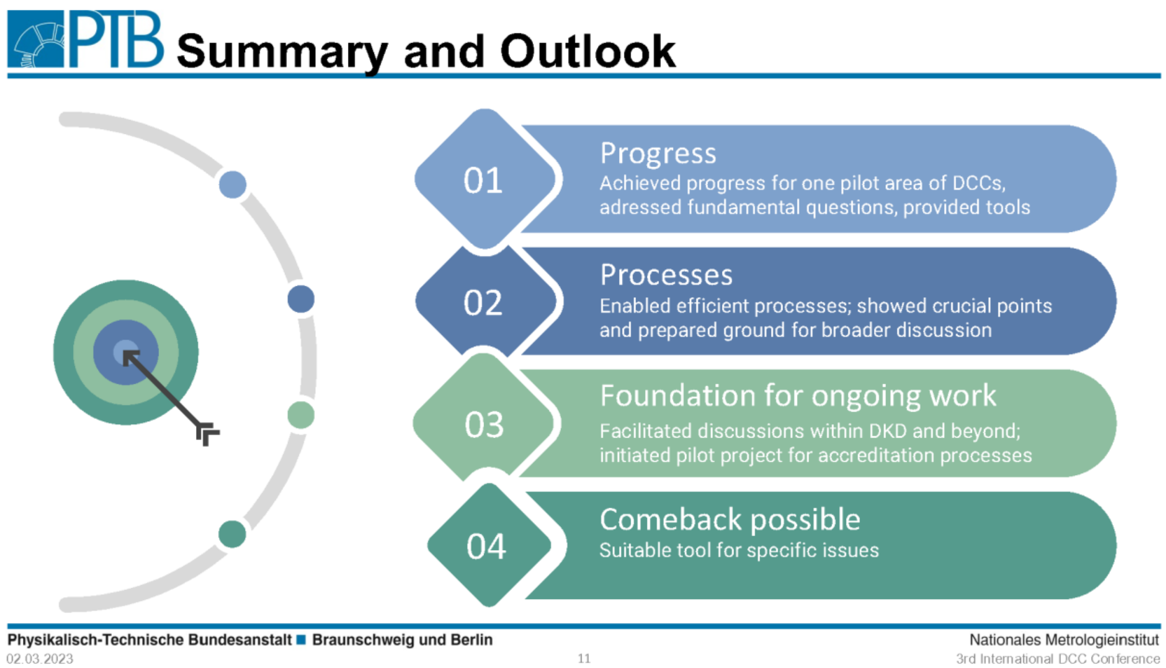
Nationales Metrologieinstitut
02.03.2023
10
3rd International DCC Conference


Summary and Outlook
01
Progress
Achieved progress for one pilot area of DCCs, adressed fundamental questions, provided tools
02
Processes
Enabled efficient processes; showed crucial points and prepared ground for broader discussion
03
Foundation for ongoing work
Facilitated discussions within DKD and beyond; initiated pilot project for accreditation processes
04
Comeback possible
Suitable tool for specific issues
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Nationales Metrologieinstitut
02.03.2023
11
3rd International DCC Conference

Credits to the programme participants

- Muhammed-Ali Demir,
- Gisa Foyer,
- Benjamin Gloger,
- Martin Häfner,
- Frank Härtig,
- Siegfried Hackel,
- Julian Haller,
- Moritz Jordan,
- Justin Jagieniak,
- Jan Loewe,
- Thomas Krah,
- Christian Müller-Schöll,
- Beatrice Rodiek,
- Shanna Schönhals,
- Gamze Söylev-Öktem,
- Zoltan Zelenka.

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38116 Braunschweig

Dr.-Ing. Shanna Schönhals
Phone: +49 531 592-1240
Email: shanna.schoenhals@ptb.de
www.ptb.de/dcc

Stand: 03/23

Parallel Session 5: RMO Activities around DCC

Presentations that would also fit into this session:

- 17 The Digital NIST: Pilot Project for the Digital Transformation of NIST's Measurement Services

50 DCC2GO - Supporting the Implementation of Digital Calibration Certificates in the European Metrology Community

Presenting author: Anke Keidel, Physikalisch-Technische Bundesanstalt, Germany

E-mail address: anke.keidel@ptb.de

Additional authors: David Balslev-Harder (DFM), Peter Friis Østergaard (DTI), Lauri Lillepea (Metrosert), Alen Bosnjakovic (IMBiH), Anu Kärkkäinen (VTT), Daniel Hutzschenreuter (PTB), Clifford Brown (PTB)

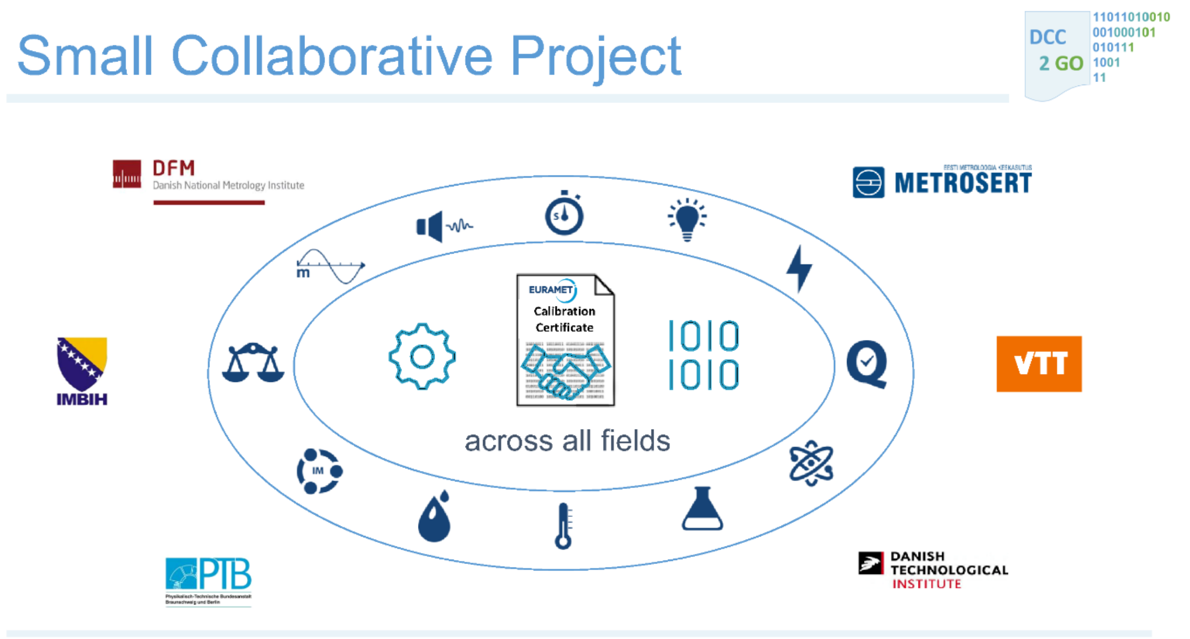
Abstract

The Project "DCC2GO" is a "Small Collaborative Project" (SCP) funded by EURAMET. The overall strategic aim of this instrument for capacity building by EURAMET is to fund support activities targeted at emerging EURAMET NMIs/DIs. The project "DCC2GO" supports the implementation of DCCs within the European metrology community, through the coordinated production and sharing of training material. The 2 main outputs from this project will be (1) a DCC training compendium, and (2) a DCC starter kit.

- The DCC training compendium will include the current state-of-the-art of DCC development and usage. It will cover a range of information from the basic properties and advantages of DCCs for NMIs, DIs and stakeholders, to full technical specifications for metrology practitioners and technical support (e.g., IT information), to overview documents for senior management and other stakeholder organisations in the metrology community e.g., CIPM, International Organisation of Legal Metrology (OIML) etc. The DCC training compendium will also categorise DCCs currently in use or in development in terms of different types of functionalities, application areas, as well as their benefits and requirements. This should then enable providers and users of calibrations to decide which types of DCCs are the most feasible and appropriate for specific use-cases.
- The DCC starter kit will contain step-by-step guidance for the creation, practical implementation and secure delivery of temperature and pressure DCCs, The guidance will provide knowledge and experience on (i) IT tools for the creation and usage of DCCs, (ii) how cryptographic tools, in particular digital signatures can be securely used with DCCs to protect and validate content and (iii) will consider the large number of issued calibration certificate types and their wide range of applications.

- *Back to "Table of Contents" at page 1 | 2 | 3 | 4*


EURAMET
EMPIR
DCC 2 GO
DCC2GO
Supporting the implementation of Digital Calibration Certificates in the European metrology community
Anke Keidel (PTB), David Balslev-Harder (DFM), Peter Friis Østergaard (DTI), Lauri Lillepea (Metrosert), Alen Bosnjakovic (IMBiH), Anu Kärkkäinen (VTT), Daniel Hutzschenreuter (PTB), Clifford Brown (PTB)
Digital innovation photo created by rawpixel.com - www.freepik.com


Small Collaborative Project
DCC 2 GO
DFM
Danish National Metrology Institute
METROSERT
IMBIH
VTT
PTB
DANISH TECHNOLOGICAL INSTITUTE
EURAMET
Calibration Certificate
across all fields

Capacity Building

DCCs are insufficiently known and understood at the TC level

- Need for
  - Very practical examples for DCCs and their use
  - Understanding of what DCC really means
  - Understanding of what changes with DCC compared to analogue CC
  - Bridge gap of technical understanding within EURAMET and within the NMIs (e.g., DCC is typically considered in IT department rather than in the cal lab)
- Suggestions
  - Questionnaire on maturity of digital transformation and needs in EURAMET
  - Concrete example supported by a guideline project by a TC (guideline as annex to existing one)
  - Circulate more information at plenary meetings, e.g. TC plenary
  - Invite TCs to seminars organised by individual NMIs
  - Develop arguments / business cases
- Open questions
  - Open (software) toolbox that can be used by NMIs and smaller calibration labs?
  - How to involve TC-QM and quality management at the NMIs in particular?
  - Relation of DCC and FAIR data in industry and science? What is required from a DCC to provide information according to the FAIR+X principles

Capacity Building

DCCs are insufficiently known and understood at the TC level

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  - Circ ... ngs, e.g. TC plenary
  - ... dividual NMIs
  - ... cases
- O
  - ... toolbox that can be used by NMIs and smaller calibration labs?
  - ... volve TC-QM and quality management at the NMIs in particular?
  - Relation of DCC and FAIR data in industry and science? What is required from a DCC to provide information according to the FAIR+X principles

SCP DCC2GO

Work Packages

WP1: Creation of a general knowledge base for DCCs

The aim of WP1 is to produce structured and **easy-to-understand information material** that can provide a clear understanding of DCCs, their benefits and necessary requirements. The general knowledge base for DCCs will be used to produce a **DCC training compendium**, that can be used by stakeholders with **no prior knowledge** of DCCs to gain basic knowledge on DCCs. The DCC training compendium should be suitable for a wide range of stakeholders with particular focus on the SEND community.

WP2: Development of practical guidance for metrology institutes to start working with DCCs

The aim of WP2 is to produce **practical guidance** for metrology institutes to **be able to start** working with DCCs. The practical guidance will be used to produce a DCC starter kit for DCC implementation, containing **step-by-step** guidance for the creation, practical implementation and secure delivery of **temperature and pressure DCC**. The DCC starter kit will be focussed on the SEND community and will consider the large number of calibration certificate types issued and their wide range of applications. The applicability of the DCC starter kit will be ensured by validation by the project partners in the domain of temperature followed by an adaption to the domain of pressure calibration.

Training compendium (WP1)

Task 1.1: Collation of basic knowledge on DCCs relevant for NMIs and DIs (PTB)

The aim of this task is to collate together information on the basic properties and advantages of DCCs from the perspective of the NMIs and DIs. The information should be suitable for use by NMIs/DIs that have little or no prior knowledge of DCCs. Relevant standards/regulations will be included, as well as technical specifications for metrology practitioners, technical support (e.g. IT information) and overview documents for senior management.

Task 1.2: Collation of basic knowledge on DCCs relevant for NMI and DI stakeholders (VTT)

The aim of this task is to collate together information on the basic properties and advantages of DCCs from the perspective of NMI and DI stakeholders, e.g. in industry and other stakeholder organisations in the metrology community e.g. CIPM, OIML. The information should be suitable for use by stakeholders that have little or no prior knowledge of DCCs and will include how DCCs will impact collaborations between stakeholders and NMIs and DIs.

Task 1.3: Creation of a structured and easy-to-understand overview on DCCs (PTB)

The aim of this task is to produce a structured and easy-to-understand overview of the types and different functionalities of DCCs. The overview will categorise DCCs currently in use or in development in terms of different types of functionalities, application areas, as well as their benefits and requirements. This should then enable providers and users of calibrations to decide which types of DCCs are the most feasible and appropriate for specific use-cases.

Starter-Kit (WP2)

DCC 2 GO

Task 2.1: Collation of information on DCC types, their handling and available IT tools (DFM, DTI)

This task aims to collate together knowledge on working with different DCC types in use or in development, including explanatory comments, hands-on examples and (where available) IT tools for the creation and use of DCCs. Based on the information collated, guidelines on the creation and implementation steps for DCCs will be produced.

Task 2.2: Collation of cryptographic tool information for DCC protection and validation (Metrosert)

The aim of this task is to collate together knowledge on how cryptographic tools and in particular digital signatures can be used with DCCs in order to protect and validate the content from manipulation. The work will include different levels of security, the validation of digital signatures and relevant regulations and will contribute to the practical guide in A2.1.3.

Task 2.3: Application and validation of the DCC starter kit (IMBiH)

The aim of this task is to produce, apply, and validate a DCC starter kit. The work will include the implementation of DCCs for temperature according to the practical guide produced in Task 2.1. The application of the DCCs in the field of pressure will also be demonstrated and based on this, guidelines on how to adapt DCCs for use in other metrological domains will be produced.

DCC 2 GO

- ✓ Project ends in October 2023
- ✓ A very early stage of the created material can be found on Github:

https://github.com/DCC2GO-Project

DFM Danish National Metrology Institute

PTB

METROSERT

VTT

DANISH TECHNOLOGICAL INSTITUTE

IMBIH

EMPIR EURAMET

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

E-mail dcc2go@ptb.de

Webpage http://www.ptb.de/dcc2go

Parallel Session 6: Community-Feedback for Further Developments of the DCC

Presentations that would also fit into this session:

- **Session D: Community-Feedback for Further Developments of the DCC**
- 06 The General DCC Rulebook and the Rules under the Aspects of Accreditation
- 09 The Semantics of Measured Quantities
- 11 DCC and Digitisation versus Digitalisation and Digital Transformation
- 17 The Digital NIST: Pilot Project for the Digital Transformation of NIST's Measurement Services
- 18 On the Construction and the Dissemination of Digital Metrology Datasets for Research and Development Purposes
- 19 Analyzing the Conformance of DCC Prototype Architecture to Calibration Laboratory Expectations Report
- 20 A Proof of Concept for a Digital Calibration Environment for Digital Multimeters
- 21 DKD's Contribution to DCC Harmonisation and Coordinated Development
- 22 GEMIMEG-II – Status and Progress Report
- 31 DCCs for Non-Automatic Weighing Instruments (NAWIs) – Current Status of a Respective Working Group Elaborating "Good Practice" Conventions
- 39 Two Implementations of Digital Calibration Certificates in Industrial and Metrological Services
- 48 Mapping of Processes and Risks in the Digital Transformation in Metrology of Ionizing Radiation - A Case Study in X-Ray Air Kerma Calibration

51 How does a Machine Distinguish the Different Types of DCCs?

Presenting author: Siegfried Hackel, Physikalisch-Technische Bundesanstalt (PTB), Germany

E-mail address: siegfried.hackel@ptb.de

Additional authors: Muhammed Ali Demir, Lutz Doering, Benjamin Gloger, Justin Jagieniak, Moritz Jordan, Christian Keilholz, Jan Loewe, Kai Mienert, Shanna Schönhals, Gamze Söylev Öktem (in alphabetical order, all PTB)

Abstract

The community has raised the question of how different types of calibration can be addressed in the DCC in such a way that a machine "understands" what kind of calibration is involved in the DCC at issue. This question is made more difficult by the fact that it cannot be derived from the calibration item alone. An obvious example of the calibration job is a digital multimeter (amps, volts, DC, AC, ...). But also, a mass piece cannot only be calibrated with regard to its weight. Often other properties of the mass piece are calibrated, such as density.

The solution to this problem is complex, as it concerns at least two different areas:

A unique storage location in the DCC:

It is intended to use an element in analogy to the element dcc:equipmentClass, as it is already used for the elements dcc:items, dcc:item, dcc:measuringequipments and dcc:measuringequipment. The name for the element is still open.

A directory of calibration types:

We are looking for a directory of calibration types that allows a clear assignment to the DCC. So far, directories of this kind are only rudimentary, see e.g. [1]. The necessity of setting up and operating such a directory service is explained and the community is asked to help.

[1] https://www.ptb.de/cms/en/metrological-services/calibration-and-measurement-capabilities-of-ptb.html

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Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin
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How does a Machine Distinguish the Different Types of DCCs?

Siegfried Hackel

02

1st problem

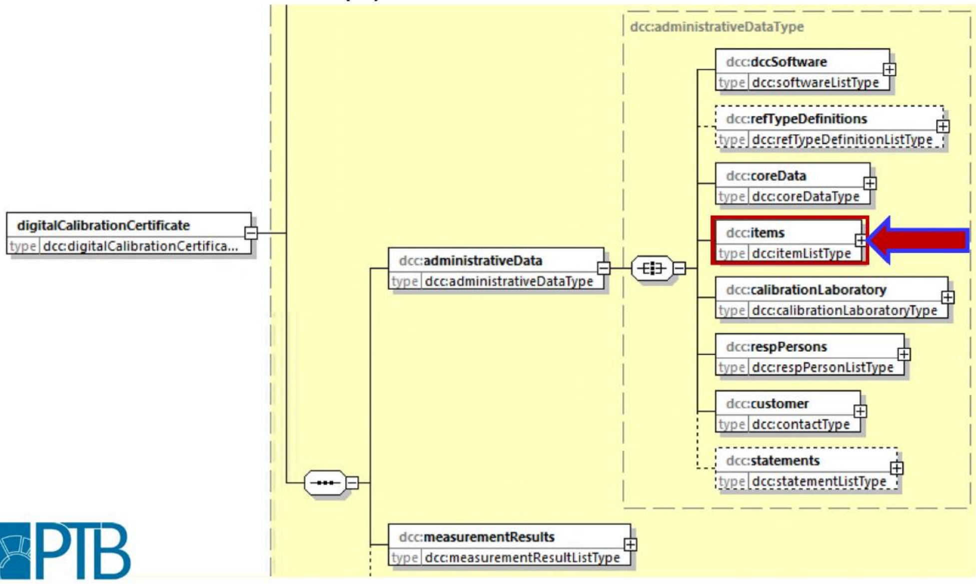
- Names are not clearly interpretable
  - Example: Caliper gauge
    - ? Or Caliper?
    - ? Or Vernier caliper?
    - ? Or Calliper gauge?

  - German example:
    - Until the 90's: Meßschieber
    - In between: Messchieber
    - Now: Messschieber
  - And? What is it?

03a

1st (solution) approach for items and measurement equipments

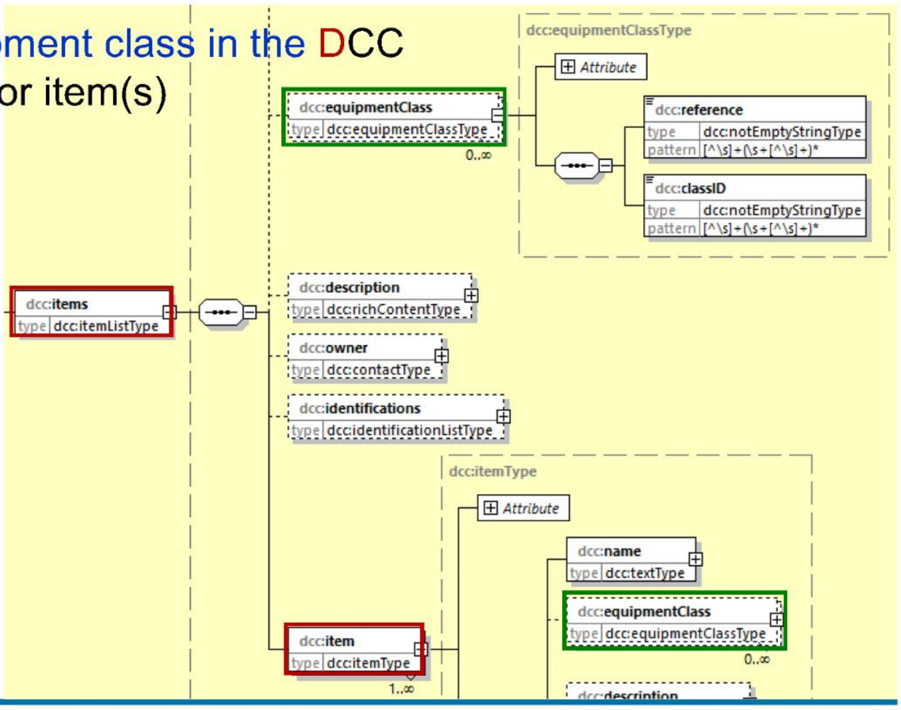
- Equipment class in the DCC
  - For item(s)



03b

1st (solution) approach for items and measurement equipments

- Equipment class in the DCC
  - For item(s)

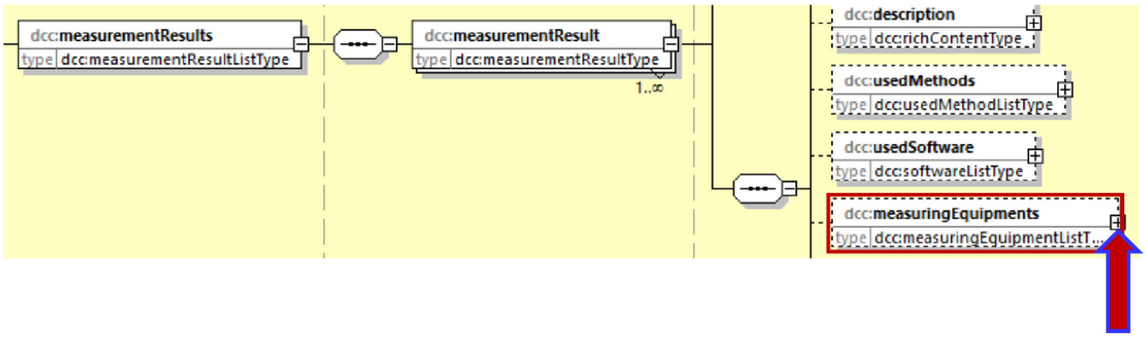


3rd international DCC-Conference

03c

1st (solution) approach for items and measurement equipments

- Equipment class in the DCC
  - For item(s)
  - For measurement equipment(s)



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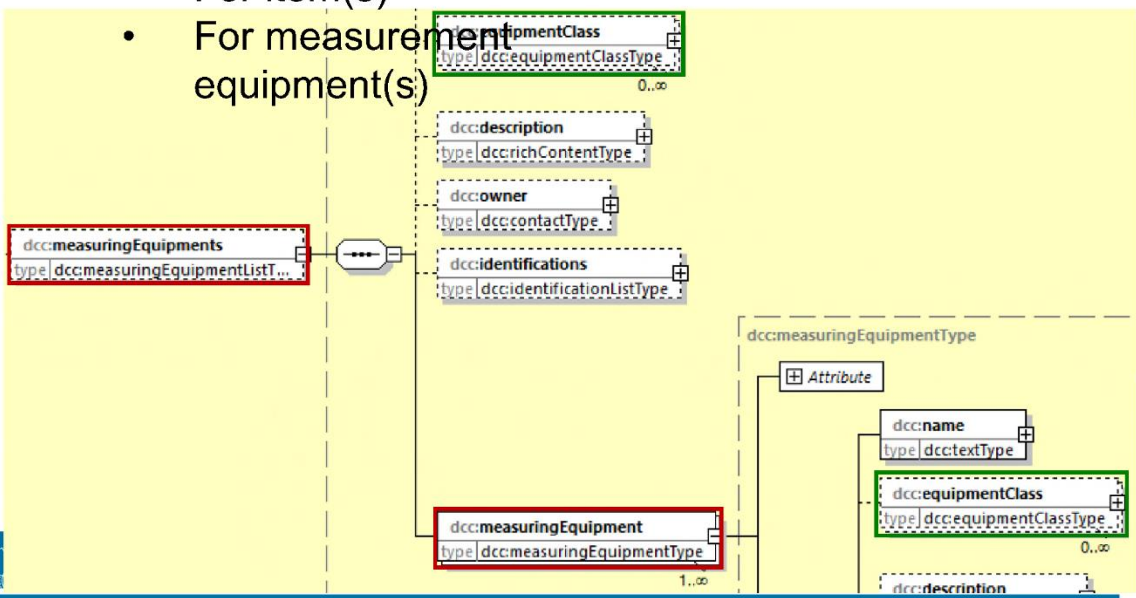
03c

1st (solution) approach for items and measurement equipments

- Equipment class in the DCC
  - For item(s)
  - For measurement equipment(s)



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04

1st (solution) approach for items and measurement equipments

- Are there classifications that can be used?
  - ✓ VDI/VDE 2623
    - Internationally respected German standard
    - @Thorsten Ring: Thanks for the work!
  - ✓ OIML R 111-1 (2004)
    - Weights of classes E_1, E_2, F_1, F_2, M_1, M_{1-2}, M_2, M_{2-3} and M_3
  - ? Who knows of other classifications?
    - Please give us feedback

05

1st (solution) approach for items and measurement equipments

- Equipment class and VDI/VDE 2623
  - Example: Caliper gauge
    - ✓ "Messschieber" corresponds to "1-1-1-26"

A clearly defined nomenclature is the basis

  - Example: Set of weights
    - ≈ "Gewichtsstück-Satz" corresponds to "2-2-2-1"
  - Example: Weight piece
    - ≈ "Gewichtsstück" corresponds to "2-2-2-2"
- Equipment class and OIMR R 111-1 (2004)
  - Example: Set of weights or Weight piece
    - ✓ Very precise definition of a large part of the objects used

06

From the community: 2nd problem

- How does a machine distinguish different types of DCCs?
  - Example: Digital multimeter
    - ? Amps?
    - ? Volts?
    - ? DC, or/and AC?
    - ? ...
  - Example: Weight piece
    - ? Mass?
    - ? Density?
    - ? Magnetism?
    - ? ...

Complex Problem!

07

2nd problem; here: 1st part of the (solution) approach

- Implementation of a new element for this case in analogy to dcc:equipmentClass
  - Place:
    - In the area of dcc:administrativeData
  - Name:
    - ? Not yet determined

08

2nd problem; here: 2nd part of the approach

- Implementation of a directory of calibration types
  - Objective of the directory:
    - Unique classification and description of calibrations
  - I know only rudimentary directories of this kind:
    - https://www.ptb.de/cms/en/metrological-services/calibration-and-measurement-capabilities-of-ptb.html
- Questions:
  - ? Do you know such a directory?
  - ? Are there existing activities on this?
  - ? Who can bring input to the issue?
  - ? Who would like to get involved in this area?
  - ? ...

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09

nth problem and (solution) approach

- Presentation of Mark Kuster
  - ✓ *„The Semantics of Measured Quantities“*
  - ✓ Talk # 9
- Presentation of Markus Stocker
  - ✓ *“Persistent Identification of Instruments and the Digital Calibration Certificate”*
  - ✓ Talk # 10

Physikalisch-Technische Bundesanstalt ■ Braunschweig und Berlin — Nationales Metrologieinstitut

The Co-Authors

alphabetical sequence

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Kai Mienert
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2023-03-02

Parallel Session 6: Traceability

Presentations that would also fit into this session:

- 01 Digital Calibration Certificate as part of an Ecosystem
- 05 Bringing the Digital Accreditation Symbol and the Digital Calibration Report (DCC) into Practice
- 10 Persistent Identification of Instruments and the Digital Calibration Certificate
- 51 How does a Machine Distinguish the Different Types of DCCs?

52 Traceability

Presenting author: Abdullah Al Mamun, Bangladesh Standards and Testing Institution (BSTI), Bangladesh

E-mail address: mamun.bsti@yahoo.com

Abstract
Traceability comprises of two words i. e. trace and ability. Trace means to find someone or something and ability means to a skill, capability, or talent to do something.

International System of Units (SI). The implementation of Metrology is divided into three basic overlapping activities;

- The definition of units of measurement;
- The realization of these units of measurement in practice;
- Traceability—linking measurements made in practice to the reference standards.

In measurement science, the term “Traceability” means Comparability. Its indicate the ability to compare the results of measurements between different laboratories by the use of a common reference.

According to the Vocabulary in Metrology (VIM) definition ‘Traceability’s a property of a measurement result whereby the result can be related to a reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty.

Traceability refers to the procedures and records that are used and maintained to demonstrate that calibrations made by a local calibration laboratory accurately represent the quantities of interest.

To support the claim of traceability, the calibration laboratory must have documented measurement procedures and provide a description of the chain of comparisons to a particular stated reference.

Traceability of a measurement result aim that to a certified value of a common international or national reference standard or the definition of an SI unit; to the measurement results measured with nationally or internationally recognized reference methods.

Each country should have its own national metrology laboratory, which should provide guidance and services to other laboratories in compliance with ISO 17025:2015 requirements. It should maintain national standards and under the prescribed conditions. Such standards should be traceable to international standardization bodies.

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3rd International Conference on Metrology

welcome
from
BSTI, Dhaka

#52
Traceability

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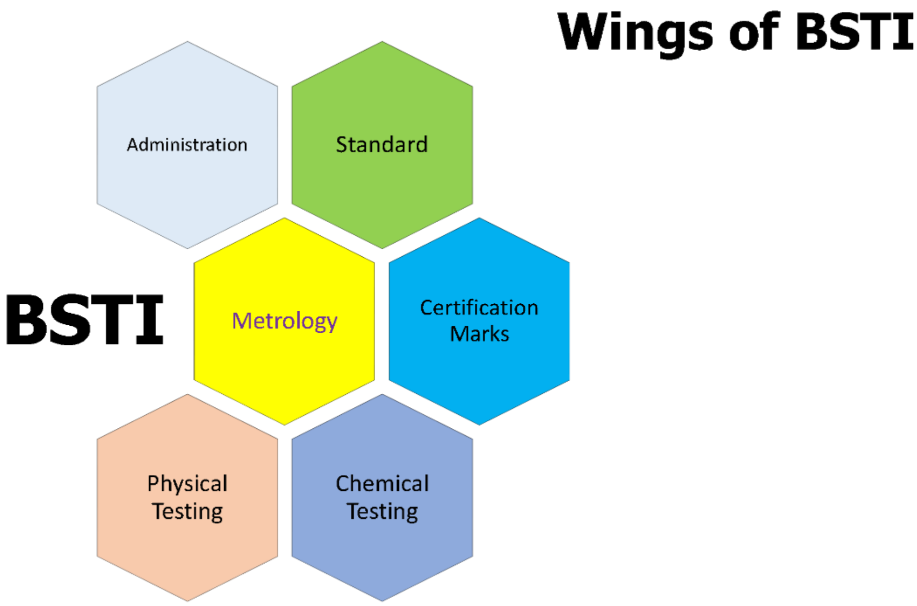
Dhaka, Bangladesh



Traceability in Metrology

The implementation of Metrology is divided into three basic overlapping activities. These are:

- The *definition of units* of measurement;
- The *realization* of these units of measurement in practice; and
- *Traceability*—linking measurements made in practice to the reference standards.

Traceability

Traceability comprises of two words i.e. **trace** and **ability**.

Trace means to find someone or something and

Ability means to a skill, capability, or talent to do something.

Therefore, traceability simply means

✓The ability to trace the requirement;

✓To provide better quality;

✓To find any risk ;

✓To keep and verify the record of history and

✓Documented identification.

Traceability contd.

According to the Vocabulary in Metrology (VIM) definition

'Traceability's is a **property of a measurement result** whereby the result can be related to a reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty.

Traceability contd.

In measurement science, the term "**Traceability**" means **Comparability**. Its indicate the ability to compare the results of measurements between different laboratories, the use of a common reference.

Metrological traceability is the property of measurement result which allows measurements made under different conditions (e.g. at different times, by different people, in different locations, using different measurement procedures) to be compared in a meaningful way.

Traceability contd.

Traceability is termed as the back bone of metrology.

THREE major facts are mutually agreed in order to maintain traceability.

1. Worldwide adoption of the SI Units as the basic system of units of weights and measures;

2. The establishment of national laboratories, which are responsible for the maintenance of the representations of the SI units and their transfer to calibration laboratories;

3. Definition, implementation and use of methods and procedures that allow individual calibration laboratories to compare their local standards with those of the national laboratories.

Traceability contd.

Calibration (contd.)

A calibration is an operation that establishes a relation between a measurement standard with a known measurement uncertainty and the device that is being evaluated. The process will determine the measurement value and uncertainty of the device that is being calibrated and create a traceability link to the measurement standard. The **four primary reasons for calibrations** are:

- To provide traceability;
- To ensure that the instrument (or standard) is consistent with other measurements;
- To determine accuracy and
- To establish reliability

Traceability contd.

Traceability to Previous Calibrations:

Traceability works as a pyramid, at the top level there is the international standards; at the next level national metrology institutes calibrate the primary standards through realization of the units creating the traceability link from the primary standard and the unit definition.

Traceability contd.

Metrology traceability pyramid:

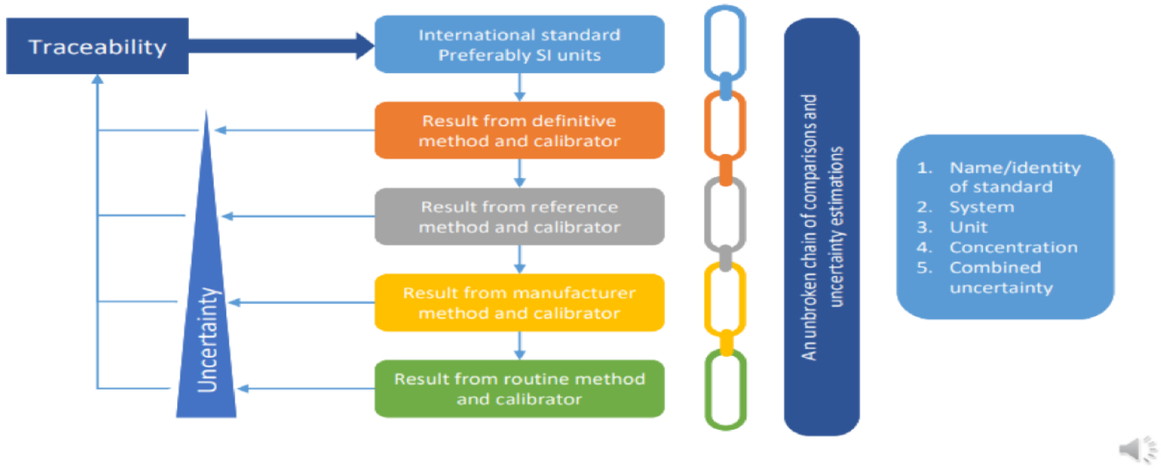
Traceability contd.

Traceability refers to a process that ensures all equipment and test procedures are calibrated using standards directly from recognized international standardization bodies

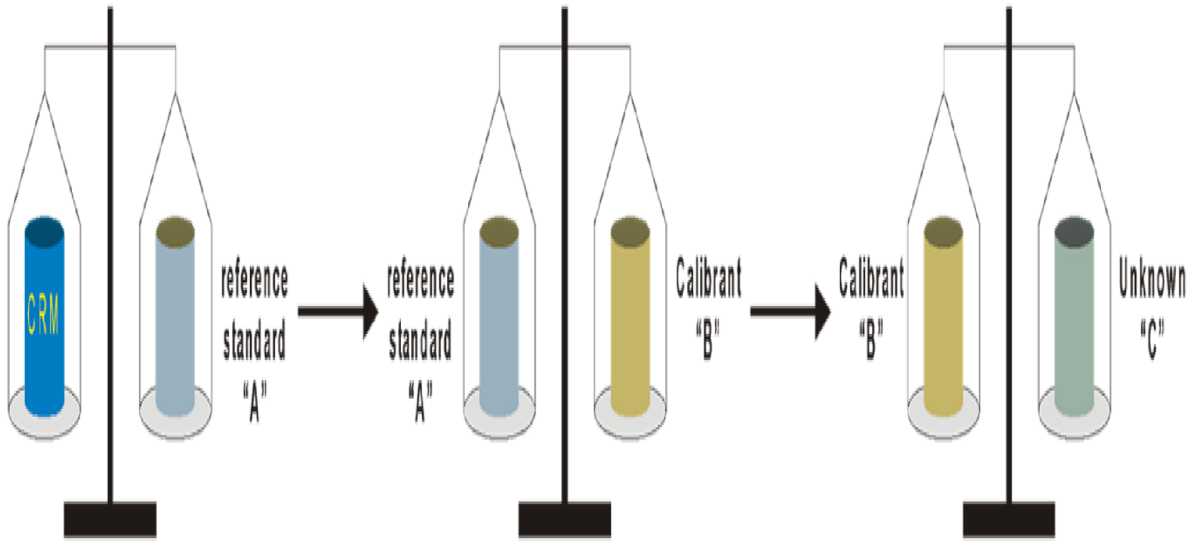
or

At least an unbroken chain of comparisons can be established between the standard and the standardization body.

Traceability contd.
Unbroken Chain of Comparison



Traceability contd.
Comparison to Certified Referance Material (CRM)



Traceability contd.

Maintaining traceability

- The chain of comparison must not be interrupted;
- The measurement uncertainty must be known in each stage of the calibration chain so that the total measurement uncertainty can be calculated each step.
- Calibration chain must be documented including the measurement results;
- All bodies carrying out a stage in the chain must prove their competence by means of accreditation; and
- Calibration must be repeated at appropriate intervals. The periods depend on the demanded measurement accuracy and the technical requirements.

Conclusion

- Metrology traceability is the sequential step of calibration process;
- It is necessary for understanding the laboratory calibration capability and accuracy status;
- For reliability of accuracy of calibration inter laboratory calibration is necessary for the confidence and checking the acceptability of calibration;
- It shows the gradual improvement of potential for future development of Metrology laboratory.

thank you

Parallel Session 6: Commercial Approaches to DCC

Presentations that would also fit into this session:

➢ 01 Digital Calibration Certificate as part of an Ecosystem

53 DCC Middleware – Obstacles and Approaches

Presenting author: Hans Koch, da+d, Germany

E-mail address: hans.drkoch@da-plus-d.de

Abstract

When calibration laboratories want to generate DCCs, or, when their customers want to extract information from the DCC, the desirable overall aim should be user friendliness. The handling of the data transfer from and to the respective IT infrastructures should be quick, simple, self-explaining and largely automatic. “Middleware” is the software which supports this data mapping. However, since the individual data management and data formats of the IT of the calibration laboratories and of their customers dispose of a very broad diversity, the middleware must be “personalised”. Often a 1 to 1 mapping is not sufficient, and the data need to be reformatted or modified during transfer to and from the DCC elements.
This presentation will discuss several common cases of such mapping obstacles and describes some practical middleware approaches.

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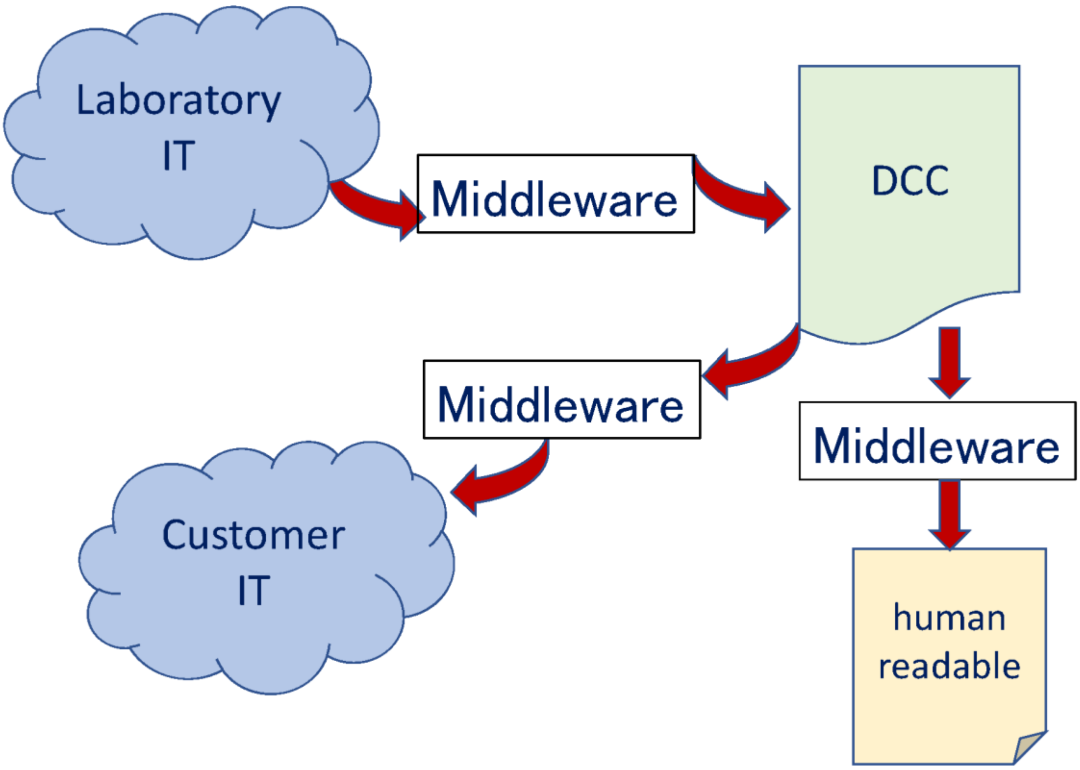
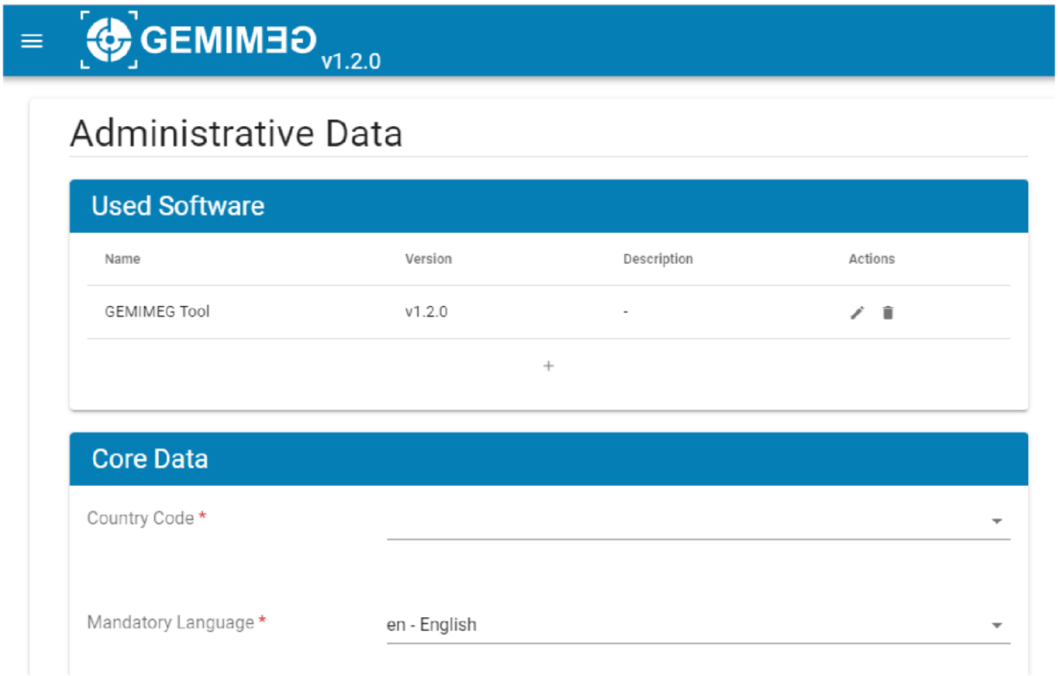
DCC Middleware
-
Obstacles and Approaches

Hans Koch

www.da-plus-d.de



'Getting started'- approach:



Conclusion:

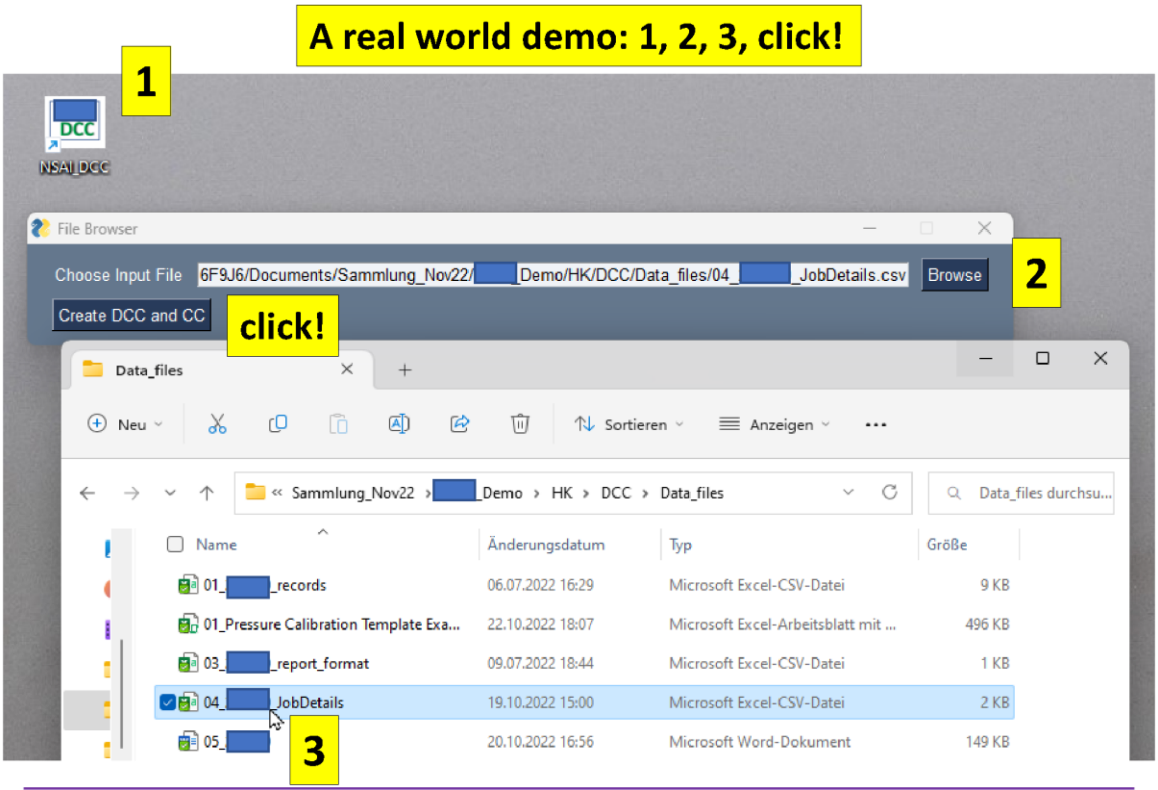
The handling of DCC Middleware should be simpler.

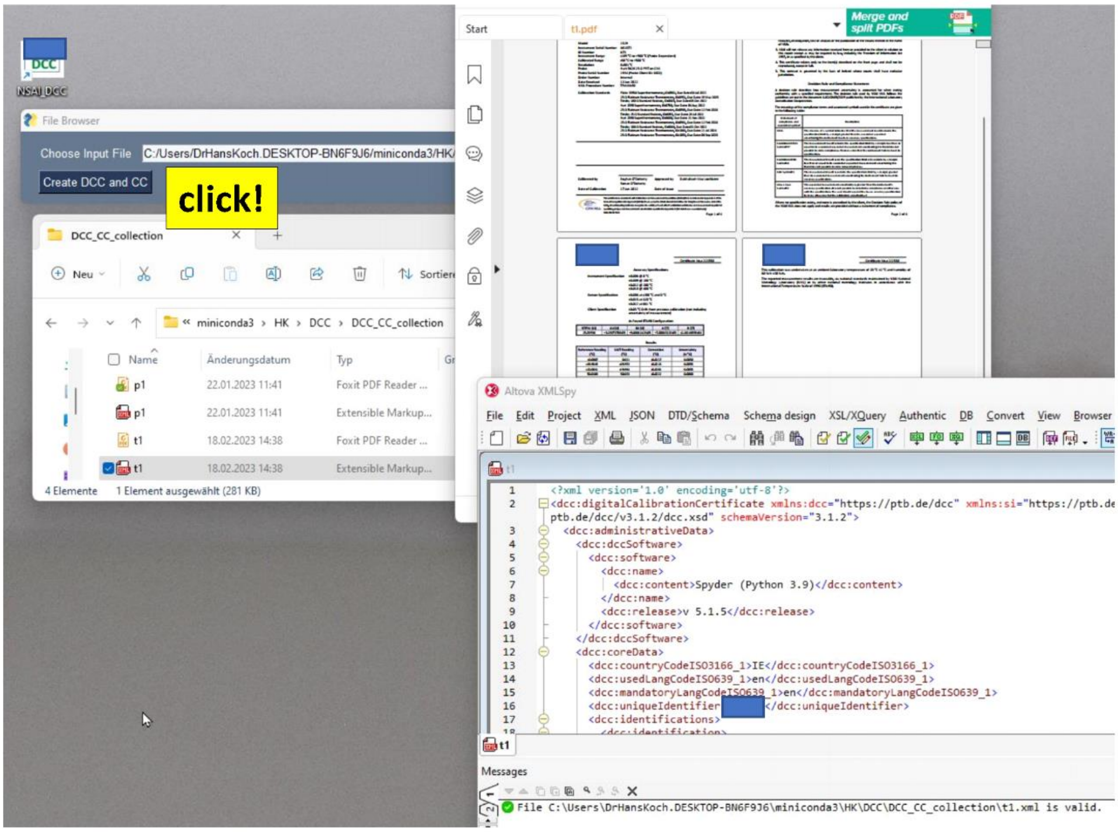
On the other hand it must be more **"personalised"**, because it depends on:

- **individual** IT structures and custom data formats of the labs
- **individual** calibration procedures required by standards/guidelines
- **individual** measurement uncertainty budgets
- **individual** customer requests

Thus: a general purpose middleware is not in sight!

However: for an individual calibration lab or for individual calibration procedures a fully automatic middleware is feasible!


A real world demo: 1, 2, 3, click!
1
NSAI_DCC
File Browser
Choose Input File
6F9J6/Documents/Sammlung_Nov22/[redacted]Demo/HK/DCC/Data_files/04_[redacted]_JobDetails.csv
Browse
2
Create DCC and CC
click!
Data_files
Neu
Sortieren
Anzeigen
Sammlung_Nov22 › [redacted] Demo › HK › DCC › Data_files
Data_files durchsu...
Name
Änderungsdatum
Typ
Größe
01_[redacted]_records 06.07.2022 16:29 Microsoft Excel-CSV-Datei 9 KB
01_Pressure Calibration Template Exa... 22.10.2022 18:07 Microsoft Excel-Arbeitsblatt mit ... 496 KB
03_[redacted]_report_format 09.07.2022 18:44 Microsoft Excel-CSV-Datei 1 KB
04_[redacted]_JobDetails 19.10.2022 15:00 Microsoft Excel-CSV-Datei 2 KB
05_[redacted] 20.10.2022 16:56 Microsoft Word-Dokument 149 KB
3


NSAI_DCC
File Browser
Choose Input File
C:/Users/DrHansKoch.DESKTOP-BN6F9J6/miniconda3/HK/
Create DCC and CC
click!
DCC_CC_collection
miniconda3 › HK › DCC › DCC_CC_collection
Name
Änderungsdatum
Typ
p1 22.01.2023 11:41 Foxit PDF Reader ...
p1 22.01.2023 11:41 Extensible Markup...
t1 18.02.2023 14:38 Foxit PDF Reader ...
t1 18.02.2023 14:38 Extensible Markup...
4 Elemente 1 Element ausgewählt (281 KB)
Start
t1.pdf
Merge and split PDFs
Altova XMLSpy
File Edit Project XML JSON DTD/Schema Schema design XSL/XQuery Authentic DB Convert View Browser
Messages
File C:\Users\DrHansKoch.DESKTOP-BN6F9J6\miniconda3\HK\DCC\DCC_CC_collection\t1.xml is valid.

Advantage: all remains as it was!

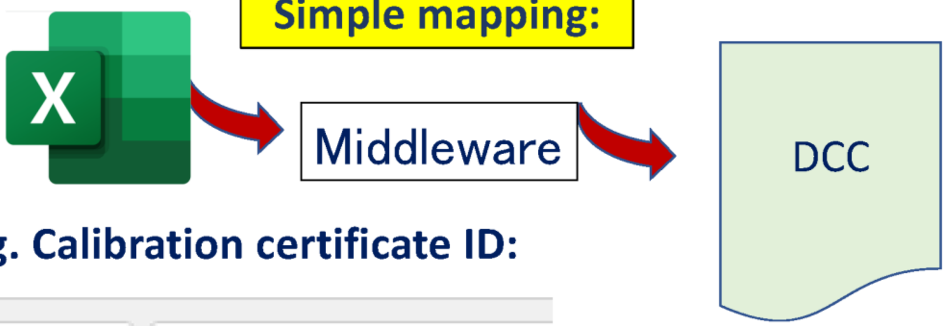
- **No change in the lab's IT structure**
- **No change in the calibration workflow**
- **No staff training required**

Only the person responsible for authorization of the DCC has to browse to the file which usually generates the classical certificate and with a button click the DCC is formed!

Note:
Although this conference slot is called
'Commercial Approaches to DCC'
this software is not commercially available.
Rather,
interested clients are trained in a workshop to
individually develop such a middleware for themselves.

Programming DCC Middleware
is not as difficult as you might expect!

Simple mapping:



e.g. Calibration certificate ID:

=Kalibrierschein! I10

```
E2xml('I10', 'uniqueIdentifier')
```

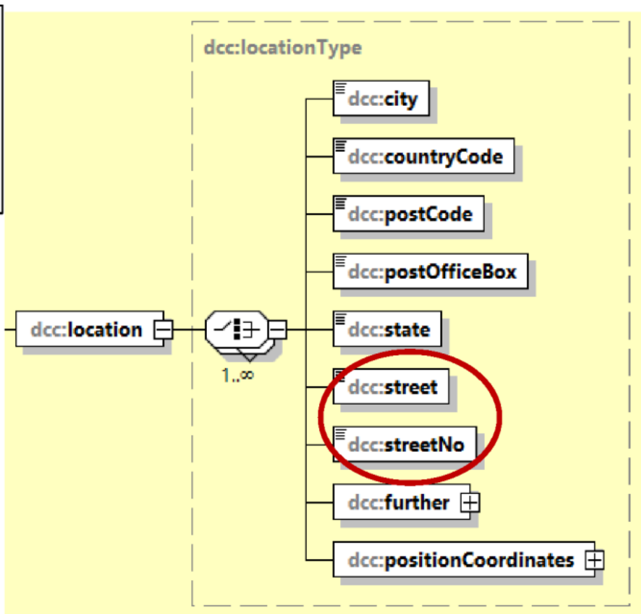
```
<dcc:uniqueIdentifier>2002</dcc:uniqueIdentifier>
```


Quite complicated mapping:

ChemTech SAS
120 avenue 3. Novembre
13006 Marseille
France

CMA Laboratory
Streekziekenhuis
Koningenpark 4a
7202 BN Wintersdijk
NL

Air Technologies Ltd
Mayford Business Park
Finagh, Mayford
Ireland

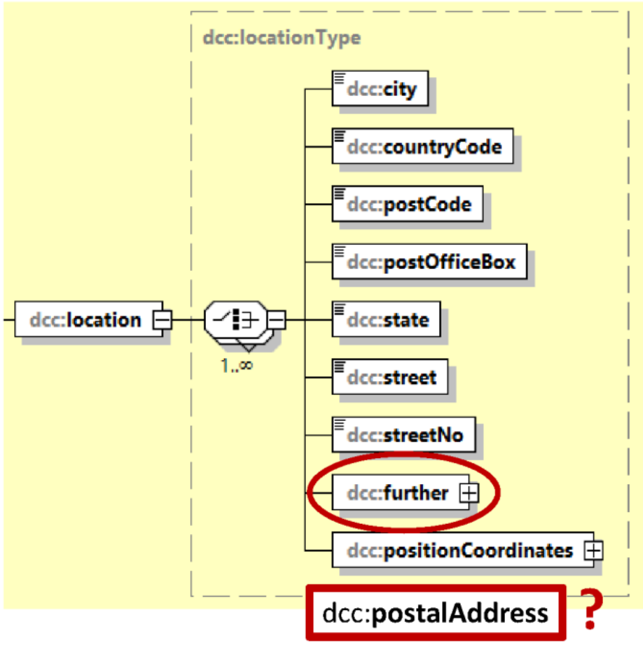


Quite complicated mapping:

European Commission
Joint Research Centre
B 2440 Geel
Belgium

CMA Laboratory
Streekziekenhuis
Koningenpark 4a
7202 BN Wintersdijk
NL

etc.
e.g. USA, China, ...



Reformatting required:

```
-<dcc:data>
  -<dcc:list refType="gp_table1">
    -<dcc:list refType="gp_value1">
      -<dcc:quantity>
        -<dcc:name>
            <dcc:content lang="de">1. Wert</dcc:content>
            <dcc:content lang="en">1. value</dcc:content>
         </dcc:name>
        -<si:realListXMLList>
            <si:labelXMLList/>
            <si:valueXMLList>36.12 35.41 </si:valueXMLList>
            <si:unitXMLList>\milli\mole\mole\tothe{-1}</si:unitXMLList>
            <si:dateTimeXMLList>2021-04-26T00:00:00Z 2021-05-03T00:00:00Z </si:dateTimeX
         </si:realListXMLList>
       </dcc:quantity>
     </dcc:list>
    -<dcc:list refType="gp_value2">
      -<dcc:quantity>
```

SI-units:

Python snippet:

```
# Unit:
if ws[0]['V23'].value[:2] == 'Pa':
    der_si_unit = '\pascal'
    si_unit = '\kilogram\metre\tothe{-1}\second\tothe{-2}'

data = root.find(".//dcc:quantity[@refType='basic_validityR
data.text = si_unit
```

DCC:

```
-<si:hybrid>
  -<si:real>
     <si:value>0</si:value>
     <si:unit>\pascal</si:unit>
   </si:real>
  -<si:real>
     <si:value>0</si:value>
     <si:unit>\kilogram\metre othe{-1}\second othe{-2}</si:unit>
   </si:real>
 </si:hybrid>
```

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SI-units:

Python snippet:

```
# Unit:
if ws[0]['V23'].value[:2] == 'Pa':
    der_si_unit = '\pascal'
    si_unit = '\kilogram\metre\\tothe{-1}\second\\tothe{-2}'

data = root.find(".//dcc:quantity[@refType='basic_validityRan
data.text = si_unit
```

DCC:

```
-<si:hybrid>
  -<si:real>
     <si:value>0</si:value>
     <si:unit>\pascal</si:unit>
   </si:real>
  -<si:real>
     <si:value>0</si:value>
     <si:unit>\kilogram\metre\tothe{-1}\second\tothe{-2}</si:unit>
   </si:real>
 </si:hybrid>
```

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Reformatting table data:

Excel table:

	Point	Reference Pressure	Instrument Reading
8			
9		(Pa, N/m2)	(Pa, N/m2)
10	1	0,00	0,00
11	2	100,00	100,00
12	3	200,00	200,00
13	4	250,00	250,01
14	5	300,00	300,01
15	6	350,00	350,00
16	7	400,00	400,01
17	8	450,00	450,00
18	9	500,00	500,00
19	10	550,00	550,00
20	11	600,00	600,01
21	12	650,00	650,00
22	13	700,00	700,00
23	14	750,00	750,10
24	15	800,00	800,01

Python snippet:

```
ind = []
for x in ws[1]['C10:C24']:
    ind.append(x[0].value)
print("from Excel: ", ind)
ind_XMLList = str(ind).replace(', ', ' ')[1:-1]
print("reformatted: ", ind_XMLList)
```

Printout:

```
from Excel:  [0, 100, 200, 250.01, 300.01,
350, 400.01, 450, 500, 550, 600.01, 650,
700, 750.1, 800.01]
reformatted:  0 100 200 250.01 300.01 350
400.01 450 500 550 600.01 650 700 750.1
800.01
```

DCC:

```
−<dcc:quantity refType="basic_measuredValue">
  −<dcc:name>
      <dcc:content>Indicated measured value probe</dcc:content>
    </dcc:name>
  −<si:hybrid>
    −<si:realListXMLList>
      −<si:valueXMLList>
          0 100 200 250.01 300.01 350 400.01 450 500 550 600.01 650 700 750.1 800.01
        </si:valueXMLList>
```

Reformatting:

- significant digits

GUM: 7 Reporting uncertainty

7.2.6 The numerical values of the estimate y and its standard uncertainty $u_c(y)$ or expanded uncertainty U should not be given with an excessive number of digits. It usually suffices to quote $u_c(y)$ and U [as well as the standard uncertainties $u(x_i)$ of the input estimates x_i] to at most two significant digits, In reporting final results, Output and input estimates should be rounded to be consistent with their uncertainties; for example, if y = 10,057 62 Ω with $u_c(y)$ = 27 mΩ, y should be rounded to 10,058 Ω.

Voids:

'', ' ', '-', 'x', 'None', '0', 'Nil', 'NaN'

<si:valueXMLList> does not allow NaN!?!

But it is needed, if a table has deliberate voids:

Date	*1. Value:* [mmol/mol]	*2. Value:* [mmol/mol]	*3. Value:* [mmol/mol]
24.01.2022	42,617	37,794	37,516
26.01.2022		37,091	37,339
28.01.2022	41,700	41,630	38,948
31.01.2022	37,586	38,597	
07.02.2022	39,717	39,816	39,314
07.02.2022	39,927	39,625	39,359

The End

Thank You!

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54 Digital Calibration Certificate with MetricodeHUB, a Real Implementation Case

Presenting author: Damiano Pietri, Metricode s.r.l., Italy

E-mail address: damiano.pietri@metricode.it

Additional authors: Paolo Bonacini, Metricode s.r.l., Italy – Paolo Solinas, A.B.C. Bilance s.r.l., Italy

Abstract
"Metricode HUB" is a "cloud based" platform designed to manage, centralize, integrate and automate the processes and the information generated by a "calibration laboratory".

The “Metricode HUB” software is developed by Metricode; regarding the implementation of the DCC in the platform, the activity is carried out in partnership with:

● PTB (Physikalisch Technische Bundesanstalt Institute) – GERMANY

● INRIM (Istituto Nazionale di Ricerca Metrologica) – ITALY

● A.B.C. Bilance s. r. l. (accredited calibration laboratory LAT 291) – ITALY

The software currently is focused on the management of the "mass calibration" process; specifically "Metricode HUB" will be able to read (and import) a DCC from third parties, and to generate a DCC relating to the calibration operations performed, following the scheme set by the PTB.

The planned validation of the DCC implementation project includes the following steps:

1) Preliminary verification of the DCC scheme, elaborated using the Metricode HUB SW by the PTB.
2) Validation of the software "Metricode HUB" by INRIM and ABC Bilance.
3) Calibration of a reference standard mass and elaboration of a DCC by INRIM, using
4) the "Metricode HUB" SW.
5) Automatic import of the DCC released by INRIM into the "Metricode HUB" SW by ABC Bilance.
6) Calibration of a working standard mass (using the reference standard mass referred to in point 1) and elaboration of a DCC by ABC Bilance, using the “Metricode HUB” SW.

DCCs will be a key part of a fully digitized calibration service delivery process.

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DCC
3rd International Digital Calibration Certificate (DCC) Conference
Tuesday, 28 February 2023 to Thursday, 2. March 2023

METRICODE

Digital Calibration Certificate with "MetricodeHUB", a real implementation case.

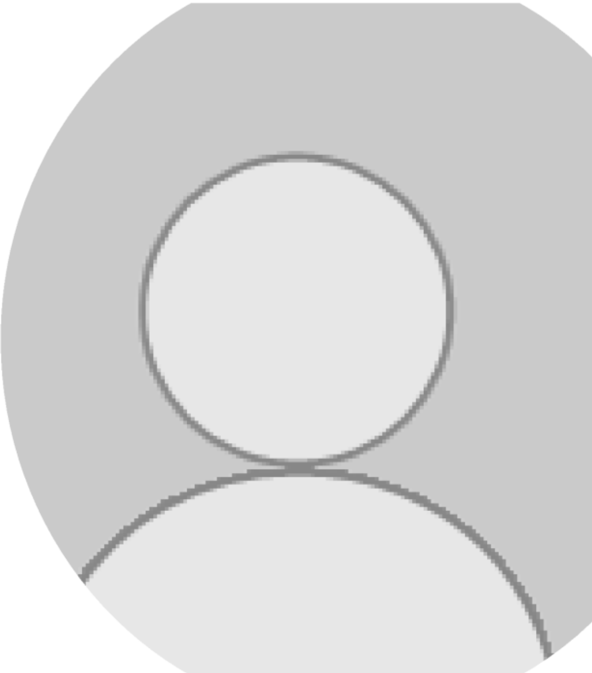
Presenting author: Damiano Pietri, Metricode s.r.l., Italy
E-mail address: damiano.pietri@metricode.it

Additional authors: Paolo Bonacini, Metricode s.r.l., Italy –
Paolo Solinas, A.B.C. Bilance s.r.l., Italy

1 METRICODE S.R.L.

AGENDA

- Metricode, what we do
- The Metricode HUB software, main features and output of the DCC
- Metrology network
- Validation of the DCC

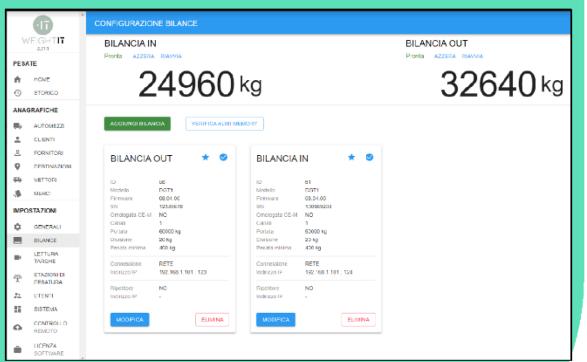


2 METRICODE S.R.L.

METRICODE

- Software for the management of scales
- High-level automation
- Rapid prototyping
- IOT: we connect scales to the internet
- Balance calibration software
- Mass calibration software
- CE marking software (NAWI)
- Periodic Verification Software
- Applications on web platform
- Smartphone app (for weighing)

WHAT DO WE DO



4 METRICODE S.R.L.

METRICODE HUB

Metricode HUB" is a "cloud based" platform designed to manage, centralize, integrate and automate the processes and the information generated by a "calibration laboratory".

https://hub.metricode.it

5 METRICODE S.R.L.

METRICODE HUB

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6 METRICODE S.R.L.

METRICODE HUB

The software currently is focused on the management of the "mass calibration" process.

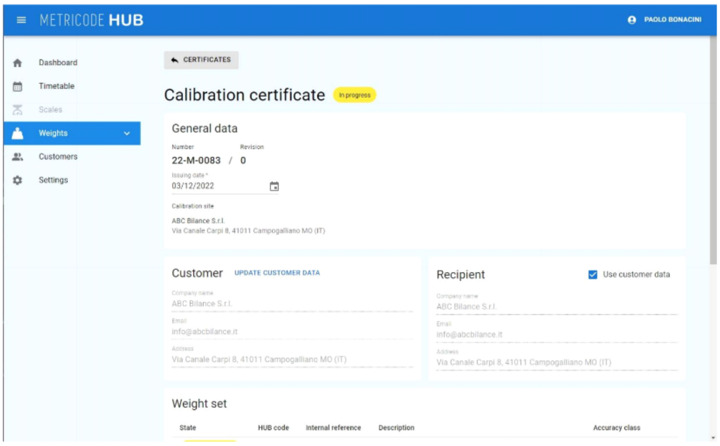
Specifically "Metricode HUB" will be able to read (and import) a DCC from third parties, and to generate a DCC relating to the calibrations performed, following the scheme set by the PTB.

METRICODE HUB

The software allows to start the process for the creation of a new calibration certificate.

Firstly, you have to choose the «name of the customer» and the «masses» to be calibrated.

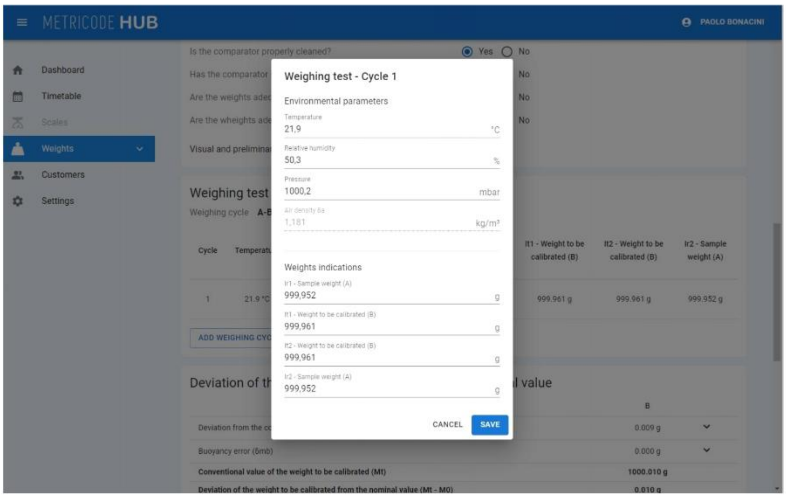
Secondly, the calibration process will be activated



METRICODE HUB

Once the calibration process starts, the software asks for the input of the calibration environmental data (from thermo-hygro-barometer) and the weighing results (from mass comparator)

The software, is able to read all the data directly from the devices, if they are compatible.

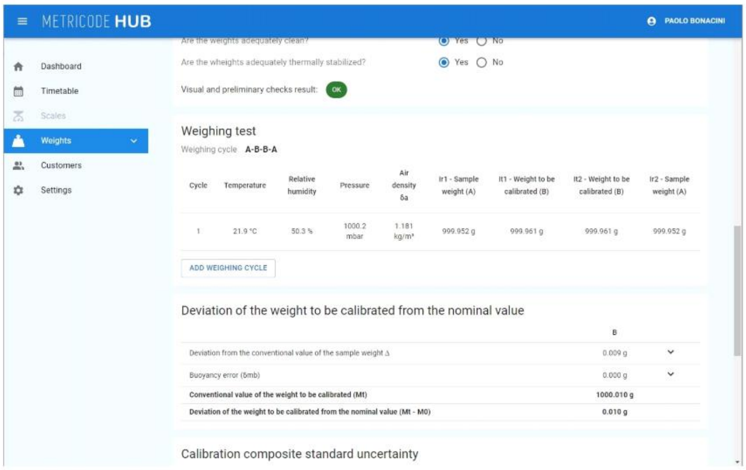


9 METRICODE S.R.L.

METRICODE HUB

Once the data are registered, they are elaborated to calculate:

- the Conventional value of the mass in calibration
- the Deviation of the mass calibrated from the nominal value.

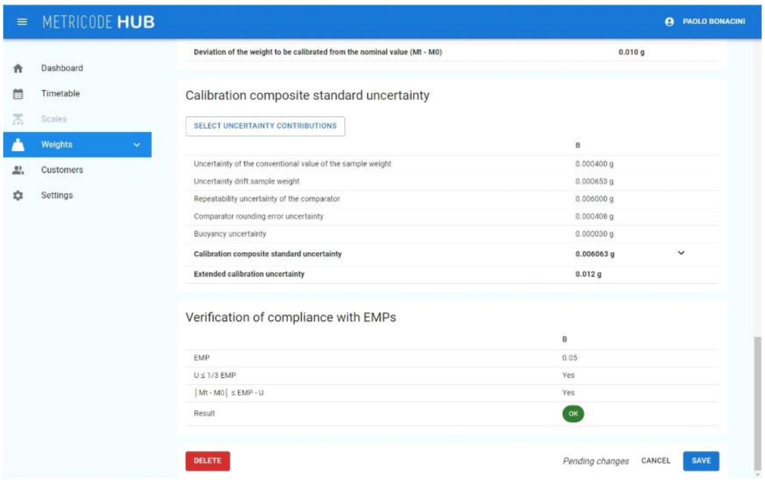


10 METRICODE S.R.L.

METRICODE HUB

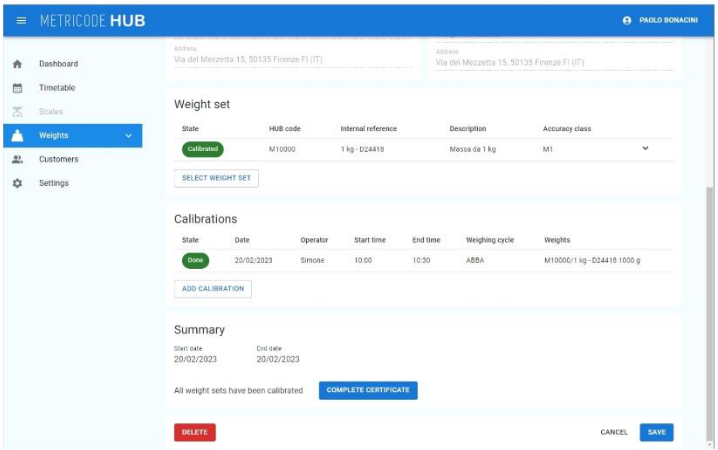
The software elaborates the uncertainty balance, and calculates the extended uncertainty for the mass calibration.

The verification of compliance with the Maximum Permissible Errors, if applicable, sets the calibration result (positive or negative).



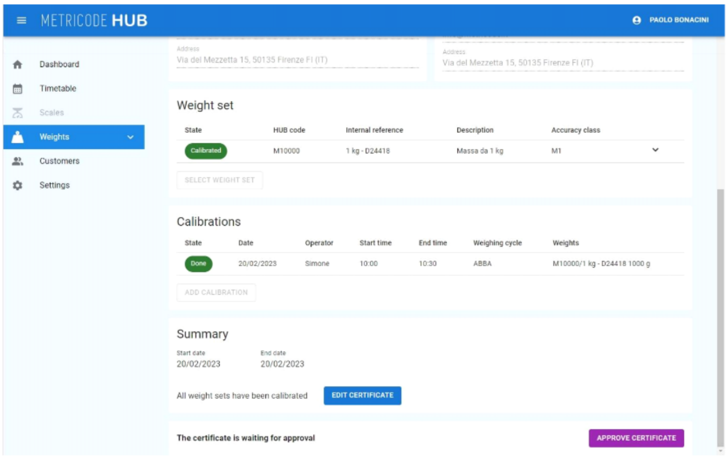
METRICODE HUB

When the process of calibration of all the masses indicated in the certificate is completed, it is possible to elaborate the certificate.



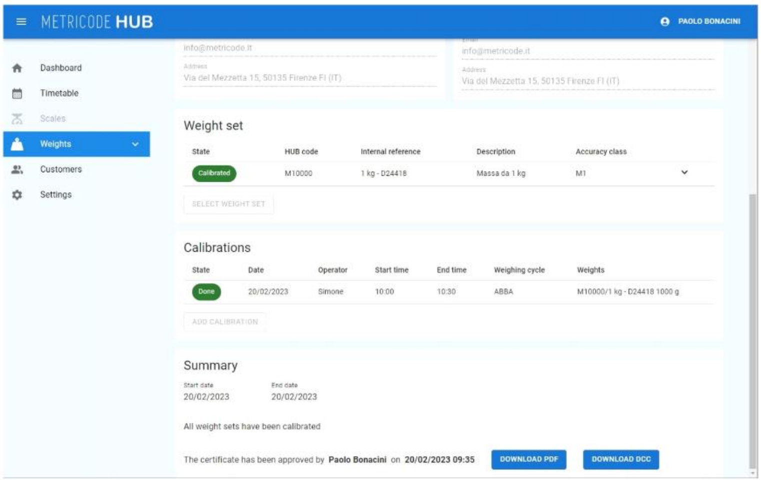
METRICODE HUB

The completed certificate can still be modified for possible corrections, and must be approved by the laboratory manager.



METRICODE HUB

Once the certificate has been approved, it can be downloaded in PDF or DCC format and be sent to the customer.



METRICODE HUB

This is the certificate made by MetricodeHUB.

On the left the PDF file «human readable» and on the right the DCC format «machine readable».

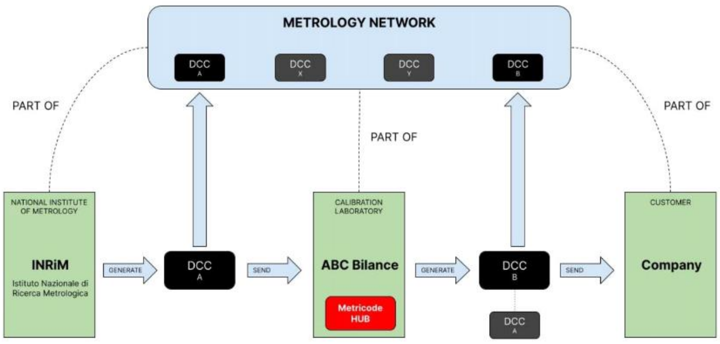
Both contain the same information.

15 METRICODE S.R.L.

METRICODE HUB

The DCC plays a key role in the digitization of the calibration service which sees the creation of a metrology network which will include national institutes, calibration centers and end customers.

The DCCs will be shared on the network and it will be possible to recover them in a safe and transparent way, going up the entire metrological chain.



16 METRICODE S.R.L.

METRICODE HUB

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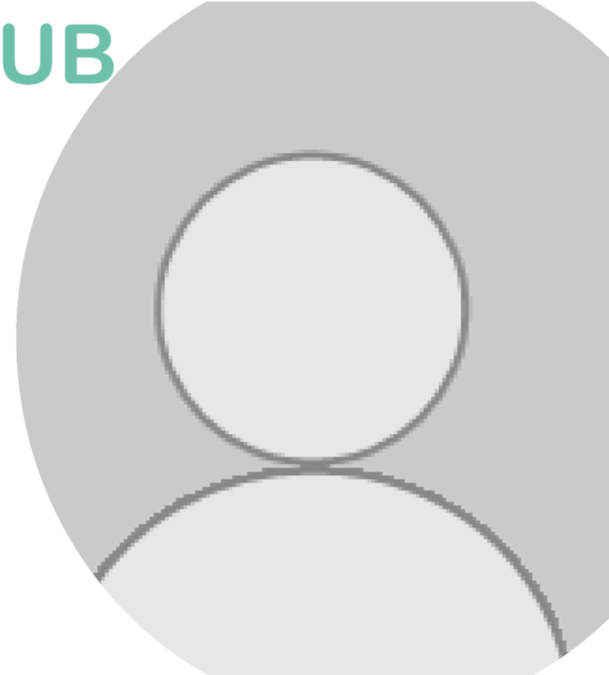
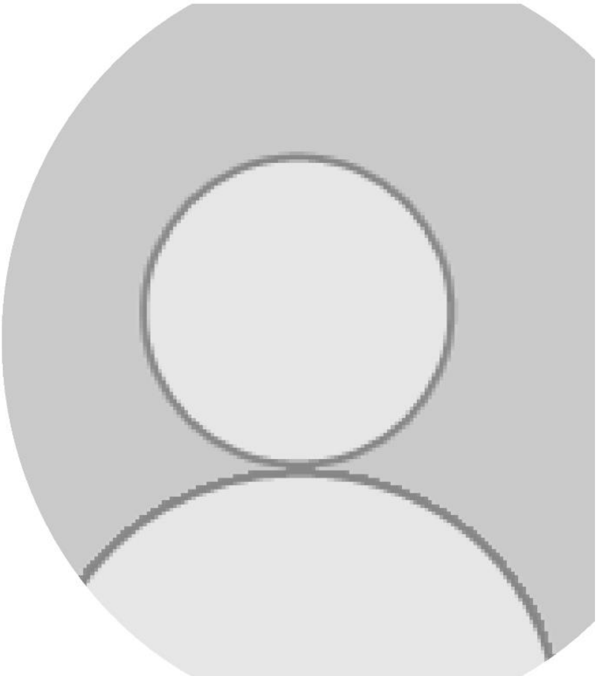
1. Preliminary verification of the DCC scheme elaborated using the Metricode HUB SW, by the PTB.
2. Validation of the software "Metricode HUB" by INRIM and ABC Bilance.
3. Calibration of a reference standard mass and elaboration of a DCC by INRIM, using the "Metricode HUB" SW.
4. Automatic import of the DCC released by INRIM into the "Metricode HUB" SW by ABC Bilance.
5. Calibration of a mass (using the reference standard mass referred to in point 3) and elaboration of a DCC by ABC Bilance, using the "Metricode HUB" SW.



17 METRICODE S.R.L.



damiano.pietri@metricode.it

www.metricode.it

18 METRICODE S.R.L.

55 Automatic Generation of Digital Calibration Certificates with AnyDCC

Presenting author: Maik Stotz

E-mail address: maik.stotz@stotz-software.de

Abstract

AnyDCC is software for automatically creating digital calibration certificates.

AnyDCC can be used to create a mapping between the computer system in the laboratory and the structure of the DCC.

Once such a mapping has been created, digital calibration certificates can then be created quickly and in large numbers. All information on the calibrations carried out flows from the laboratory's IT system into the AnyDCC template and is converted there into the XML structure of the digital calibration certificate.

Fluke's MET/CAL software will be used as the it system in the lecture. The MET/CAL software has the great advantage that all data for a performed calibration is stored in a central database. In the lecture, a mapping is set up for this MET/CAL database and digital calibration certificates for PT 100 sensors and handheld multimeters are then automatically created.

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STOTZ software

About

STOTZ software

Founded in 2001

Offering
- Individual Software-Development, databases and automations for calibration laboratories
- Training courses for MET/CAL and MET/TEAM

Located near Frankfurt, Germany

Page 2/6

STOTZ software

AnyDCC

In calibration laboratories data comes in many different forms:

Databases
SQL-Server
Oracle
Sybase
Access

Excel-Files

CSV-Files

. . .

ANY DCC Studio

Create Mapping / Transfer data

Customer data,
Asset data,
Measurement results,
…

DCC

➔ Automatic generation of DCC's 

Page 3/6

STOTZ software

AnyDCC

AnyDcc at a glance:

- made for use in every calibration laboratory
- can be adapted to any data source
- fully automatic creation of DCC
- a mapping for MET/CAL is included

Page 4

STOTZ software

Live Demos

Live Demo 1: Overview over AnyDCC an create a DCC from MET/CAL

Live Demo 2: Create DCC from Excel (➔ new Online-Tool)

Page 5

STOTZ software

Live Demo 1 – DCC from MET/CAL

AnyDcc consists of three parts

- Designer ➔ create Mapping-Templates
- Runtime ➔ use Templates to create DCC
- Viewer ➔ to view DCC's from service providers and transfer in DB

STOTZ software

Roadmap and Release

Thank you!!

- Roadmap
  - AnyDCC is currently being installed and tested in calibration laboratories in Germany
  - AnyDCC is being improved bit by bit
  - Final first version: summer 2023
  - More Information:
    maik.stotz@stotz-software.de

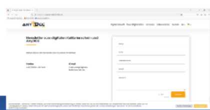
    www.digitaler-kalibrierschein.de

At the exhibition stand of imetrologie

www.metrologietage.de

Newsletter for AnyDCC:

Scroll down to newsletter



56 DCC via iPhone (or iPad)

Presenting author: Hans Koch, da+d, Germany

E-mail address: hans.drkoch@da-plus-d.de

Additional authors:

Abstract
A DCC is platform independent. Thus, it is ideally suited for distributed, multi-platform usage. This is particularly advantageous for mobile operations, e. g. out-door calibrations at the customer site or remote certificate authorization by the responsible person.
In this presentation a step-by-step DCC-generation during a sample workflow will be demonstrated, involving a PC and an iPhone at different stages. The workflow spans over several stations involving different users: creating a new case in the administration, entering item specific components by the specialist, entering measurement results by the technician, and finally authorization by the laboratory head out of office. The used middleware requires as few entries as possible by utilising data base entries. It performs the respected measurement uncertainty calculations and provides as output the DCC, a conventional Calibration Certificate as pdf-file and a printable uncertainty budget.
Finally, the extraction of data from the DCC by the customer with an iPhone will be presented as well.

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DCC via iPhone
(or via iPad)

Hans Koch

www.da-plus-d.de

DCC Conference 2023 1

XML Tutorial

❮ Home   Next ❯

XML stands for eXtensible Markup Language.

XML was designed to store and transport data.

XML was designed to be both human- and machine-readable.

This is, how the DCC is utilized in the following middleware approach

DCC as a data-storage and –transport vehicle

Workflow	In charge	DCC
DCC-ID, Order details	Administrator	
Item details, procedure, etc.	Calibration Expert	
Actual conditions	Operator	
Measurement results	Operator	
DCC-approval, digital signature	Laboratory Head	
Human readable	Public	
Uncertainty calculations	Auditor	
Data extraction	Customer	

```
–<dcc:digitalCalibrationCertificate xsi:schemaLocation="https://ptb.de/dcc https://ptb.de/dc
 –<dcc:administrativeData>
  –<dcc:dccSoftware>
   –<dcc:software>
    –<dcc:name>
       <dcc:content>UI2DCC.py</dcc:content>
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     <dcc:release>0.0.0</dcc:release>
    –<dcc:description>
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       <dcc:content lang="en">Custom development of Lab</dcc:content>
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   </dcc:software>
  </dcc:dccSoftware>
 –<dcc:coreData>
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  </dcc:coreData>
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    </dcc:name>
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      <dcc:content lang="en"/>
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   –<dcc:manufacturer>
    –<dcc:name>
```
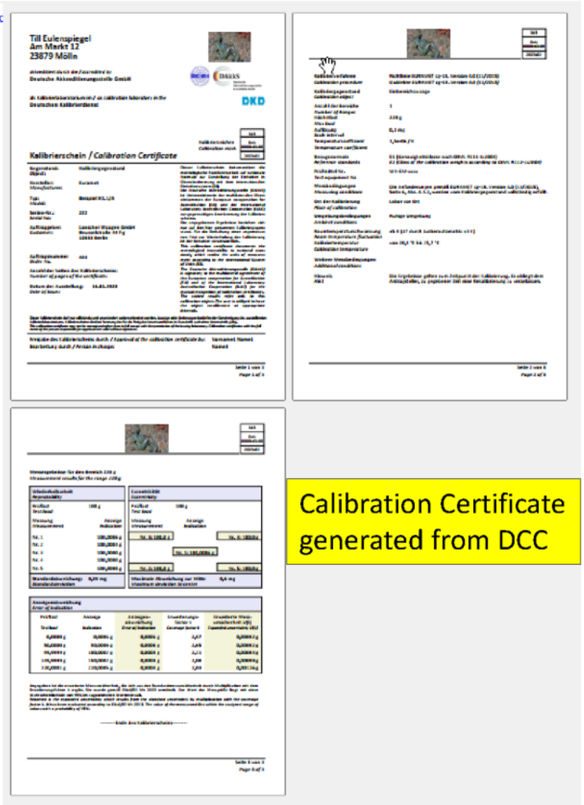
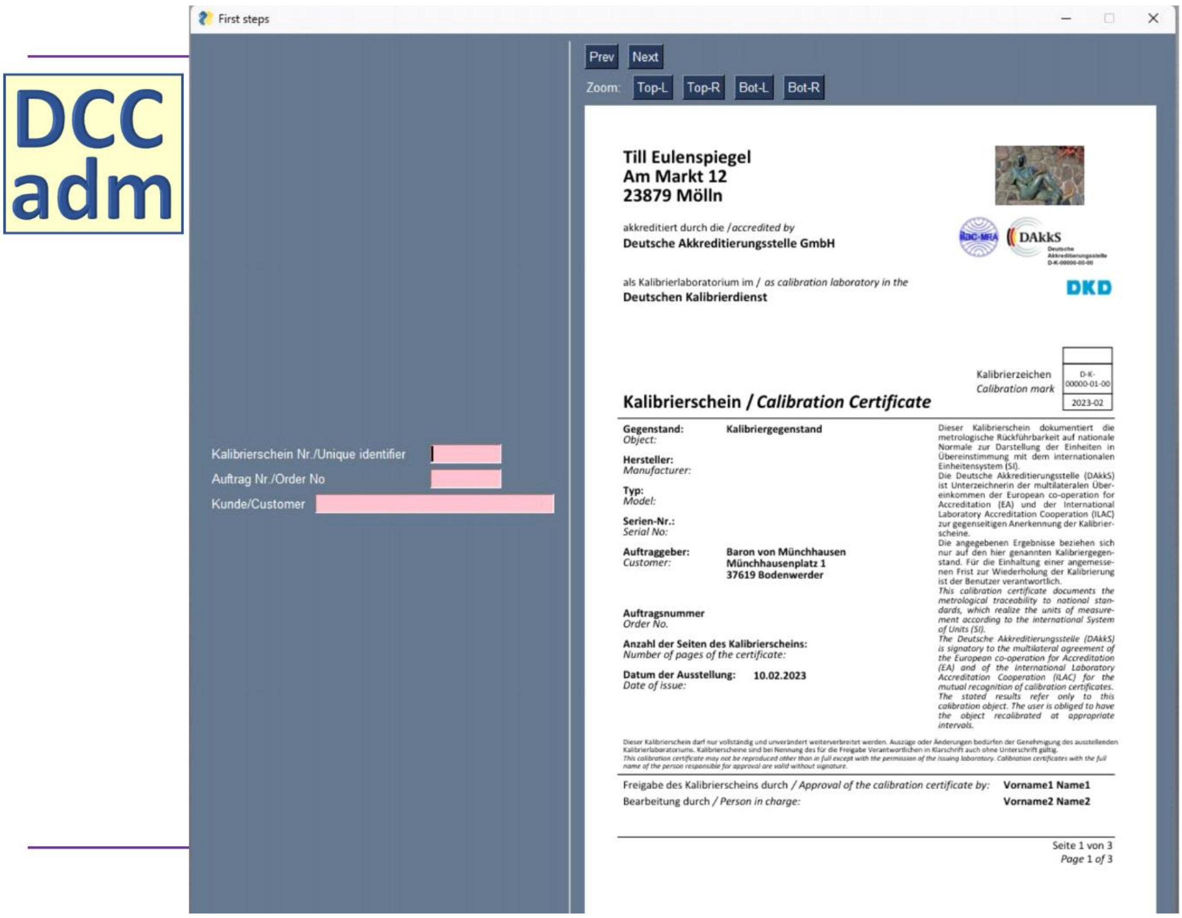


DCC

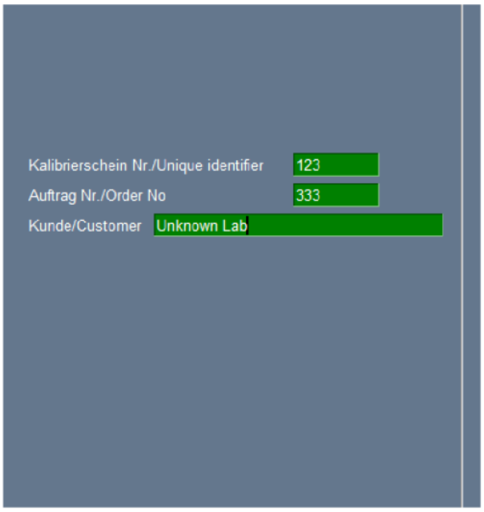


Calibration Certificate generated from DCC

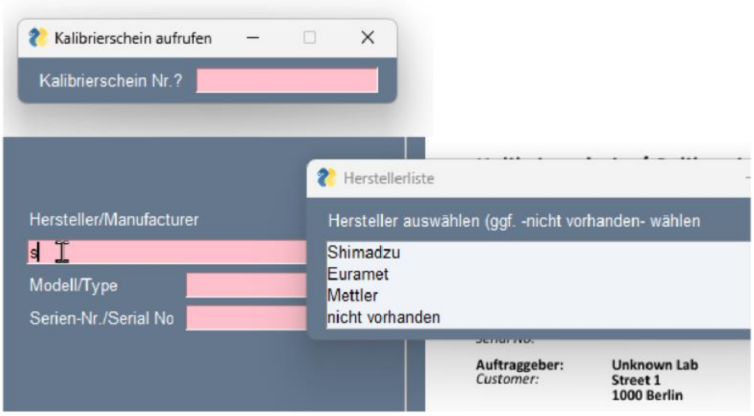
DCC Conference 2023 4

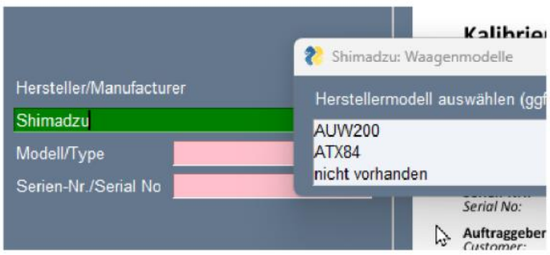


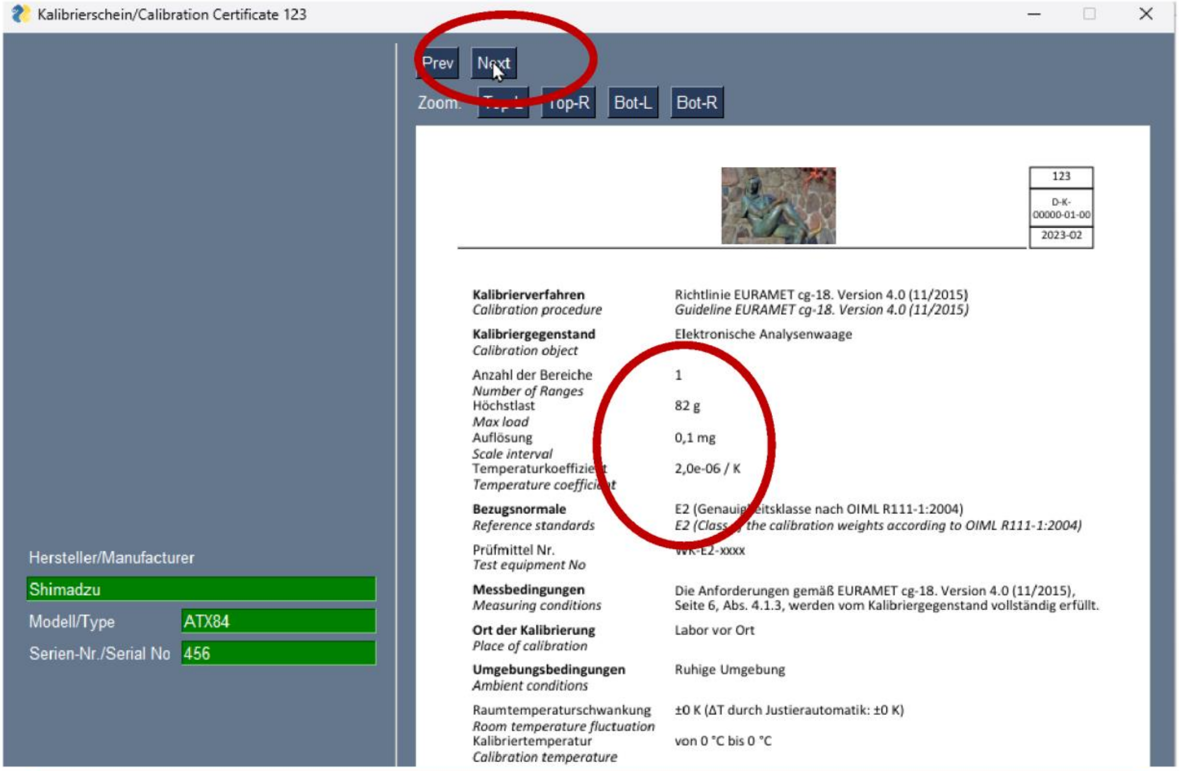
DCC adm



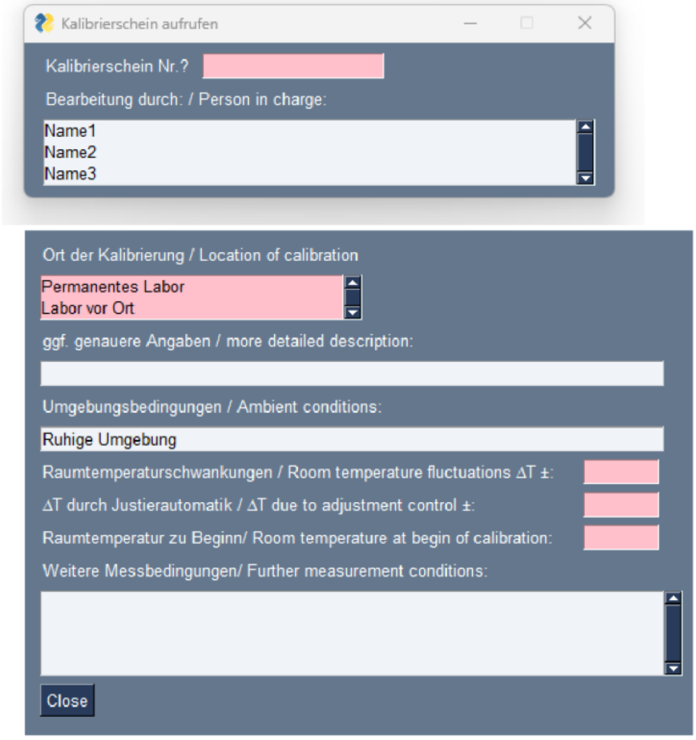
DCC item





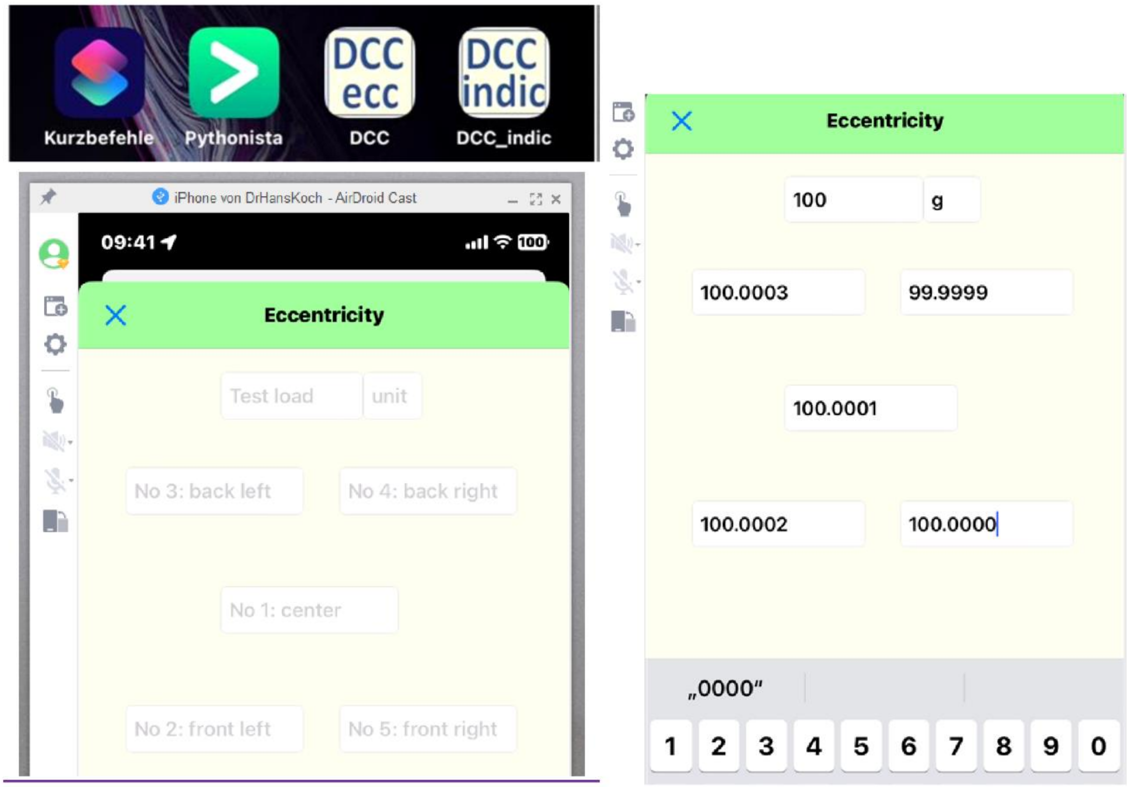

Kalibrierschein/Calibration Certificate 123
Prev
Next
Zoom:
Top-L
Top-R
Bot-L
Bot-R
Hersteller/Manufacturer
Shimadzu
Modell/Type
ATX84
Serien-Nr./Serial No
456
123
D-K-00000-01-00
2023-02
Kalibrierverfahren
Calibration procedure
Richtlinie EURAMET cg-18. Version 4.0 (11/2015)
Guideline EURAMET cg-18. Version 4.0 (11/2015)
Kalibriergegenstand
Calibration object
Elektronische Analysenwaage
Anzahl der Bereiche
Number of Ranges
1
Höchstlast
Max load
82 g
Auflösung
Scale interval
0,1 mg
Temperaturkoeffizient
Temperature coefficient
2,0e-06 / K
Bezugsnormale
Reference standards
E2 (Genauigkeitsklasse nach OIML R111-1:2004)
E2 (Class of the calibration weights according to OIML R111-1:2004)
Prüfmittel Nr.
Test equipment No
WK-E2-xxxx
Messbedingungen
Measuring conditions
Die Anforderungen gemäß EURAMET cg-18. Version 4.0 (11/2015), Seite 6, Abs. 4.1.3, werden vom Kalibriergegenstand vollständig erfüllt.
Ort der Kalibrierung
Place of calibration
Labor vor Ort
Umgebungsbedingungen
Ambient conditions
Ruhige Umgebung
Raumtemperaturschwankung
Room temperature fluctuation
±0 K (ΔT durch Justierautomatik: ±0 K)
Kalibriertemperatur
Calibration temperature
von 0 °C bis 0 °C

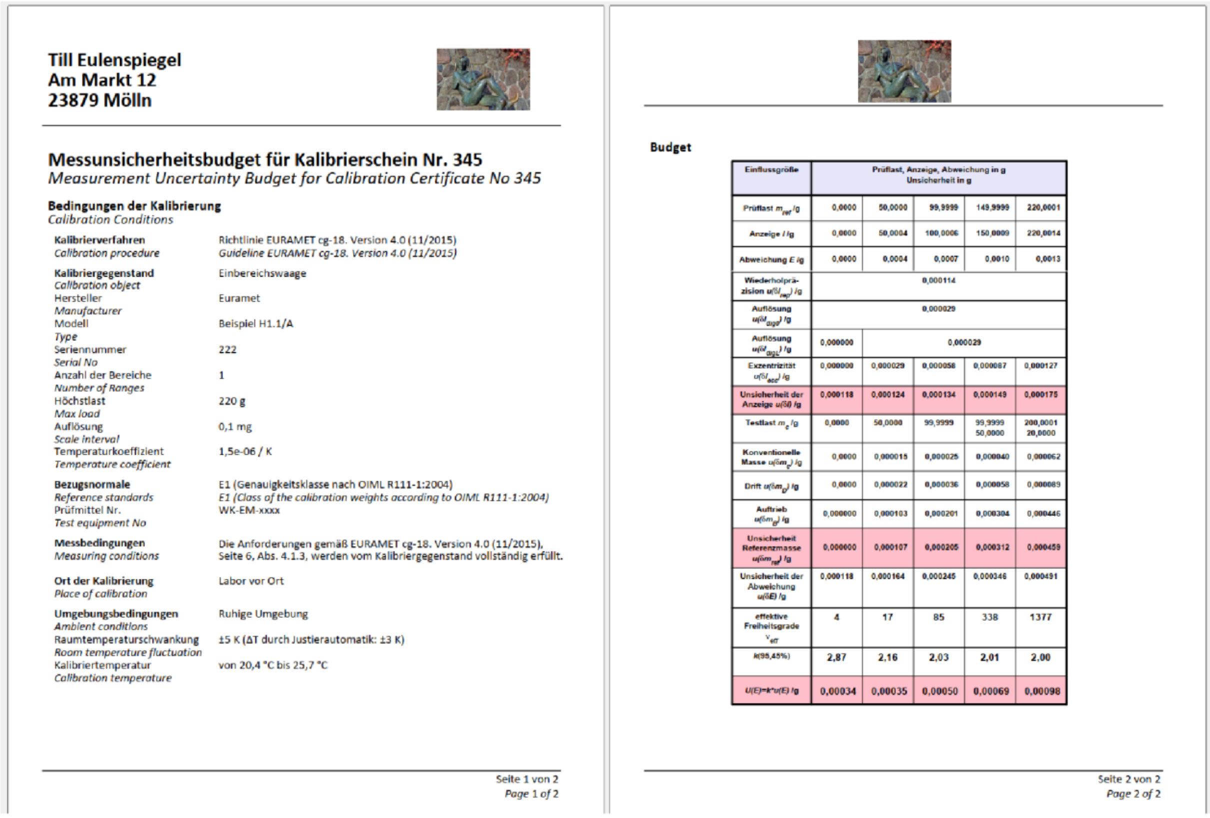
DCC env


Kalibrierschein aufrufen
Kalibrierschein Nr.?
Bearbeitung durch: / Person in charge:
Name1
Name2
Name3
Ort der Kalibrierung / Location of calibration
Permanentes Labor
Labor vor Ort
ggf. genauere Angaben / more detailed description:
Umgebungsbedingungen / Ambient conditions:
Ruhige Umgebung
Raumtemperaturschwankungen / Room temperature fluctuations ΔT ±:
ΔT durch Justierautomatik / ΔT due to adjustment control ±:
Raumtemperatur zu Beginn/ Room temperature at begin of calibration:
Weitere Messbedingungen/ Further measurement conditions:
Close


DCC rep
DCC ecc
DCC indic


Kurzbefehle
Pythonista
DCC ecc
DCC
DCC indic
DCC_indic
DCC rep
DCC_rep


Kurzbefehle
Pythonista
DCC ecc
DCC
DCC indic
DCC_indic
iPhone von DrHansKoch - AirDroid Cast
09:41
Eccentricity
Test load
unit
No 3: back left
No 4: back right
No 1: center
No 2: front left
No 5: front right
Eccentricity
100
g
100.0003
99.9999
100.0001
100.0002
100.0000
„0000"
1 2 3 4 5 6 7 8 9 0



Till Eulenspiegel
Am Markt 12
23879 Mölln

Messunsicherheitsbudget für Kalibrierschein Nr. 345
Measurement Uncertainty Budget for Calibration Certificate No 345

Bedingungen der Kalibrierung
Calibration Conditions

Kalibrierverfahren *Calibration procedure*	Richtlinie EURAMET cg-18. Version 4.0 (11/2015) *Guideline EURAMET cg-18. Version 4.0 (11/2015)*
Kalibriergegenstand *Calibration object*	Einbereichswaage
Hersteller *Manufacturer*	Euramet
Modell *Type*	Beispiel H1.1/A
Seriennummer *Serial No*	222
Anzahl der Bereiche *Number of Ranges*	1
Höchstlast *Max load*	220 g
Auflösung *Scale interval*	0,1 mg
Temperaturkoeffizient *Temperature coefficient*	1,5e-06 / K
Bezugsnormale *Reference standards*	E1 (Genauigkeitsklasse nach OIML R111-1:2004) *E1 (Class of the calibration weights according to OIML R111-1:2004)*
Prüfmittel Nr. *Test equipment No*	WK-EM-xxxx
Messbedingungen *Measuring conditions*	Die Anforderungen gemäß EURAMET cg-18. Version 4.0 (11/2015), Seite 6, Abs. 4.1.3, werden vom Kalibriergegenstand vollständig erfüllt.
Ort der Kalibrierung *Place of calibration*	Labor vor Ort
Umgebungsbedingungen *Ambient conditions*	Ruhige Umgebung
Raumtemperaturschwankung *Room temperature fluctuation*	±5 K (ΔT durch Justierautomatik: ±3 K)
Kalibriertemperatur *Calibration temperature*	von 20,4 °C bis 25,7 °C

Seite 1 von 2
Page 1 of 2

Budget

Einflussgröße	Prüflast, Anzeige, Abweichung in g Unsicherheit in g				
Prüflast m_{ref} /g	0,0000	50,0000	99,9999	149,9999	220,0001
Anzeige I /g	0,0000	50,0004	100,0006	150,0009	220,0014
Abweichung E /g	0,0000	0,0004	0,0007	0,0010	0,0013
Wiederholpräzision $u(\delta I_{rep})$ /g	0,000114				
Auflösung $u(\delta I_{dig0})$ /g	0,000029				
Auflösung $u(\delta I_{digL})$ /g	0,000000	0,000029			
Exzentrizität $u(\delta I_{ecc})$ /g	0,000000	0,000029	0,000058	0,000087	0,000127
Unsicherheit der Anzeige $u(\delta I)$ /g	0,000118	0,000124	0,000134	0,000149	0,000175
Testlast m_c /g	0,0000	50,0000	99,9999	99,9999 50,0000	200,0001 20,0000
Konventionelle Masse $u(\delta m_c)$ /g	0,0000	0,000015	0,000025	0,000040	0,000062
Drift $u(\delta m_D)$ /g	0,0000	0,000022	0,000036	0,000058	0,000089
Auftrieb $u(\delta m_B)$ /g	0,000000	0,000103	0,000201	0,000304	0,000446
Unsicherheit Referenzmasse $u(\delta m_{ref})$ /g	0,000000	0,000107	0,000205	0,000312	0,000459
Unsicherheit der Abweichung $u(\delta E)$ /g	0,000118	0,000164	0,000245	0,000346	0,000491
effektive Freiheitsgrade ν_{eff}	4	17	85	338	1377
k(95,45%)	2,87	2,16	2,03	2,01	2,00
$U(E)=k*u(E)$ /g	0,00034	0,00035	0,00050	0,00069	0,00098

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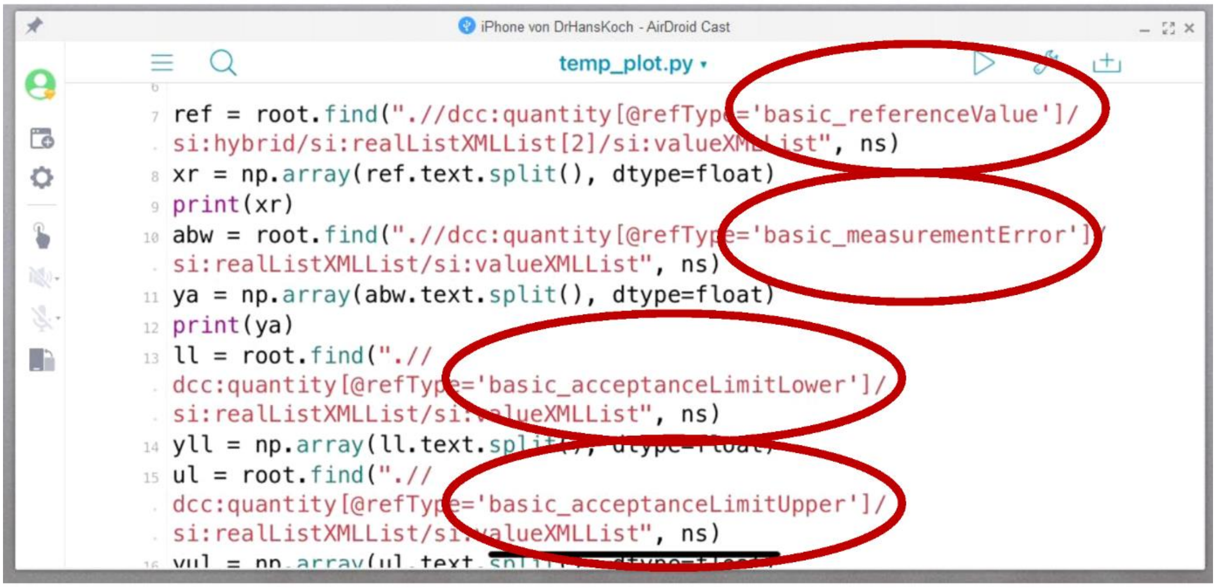
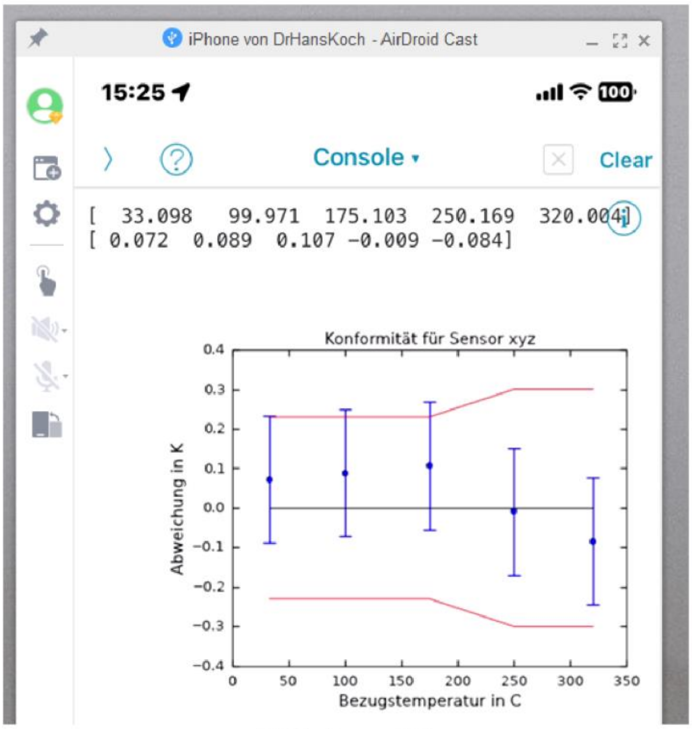
Page 2 of 2

Customer view:



Customer view:



The End

Thank You!

drhanskoch@t-online.de
www.da-plus-d.de

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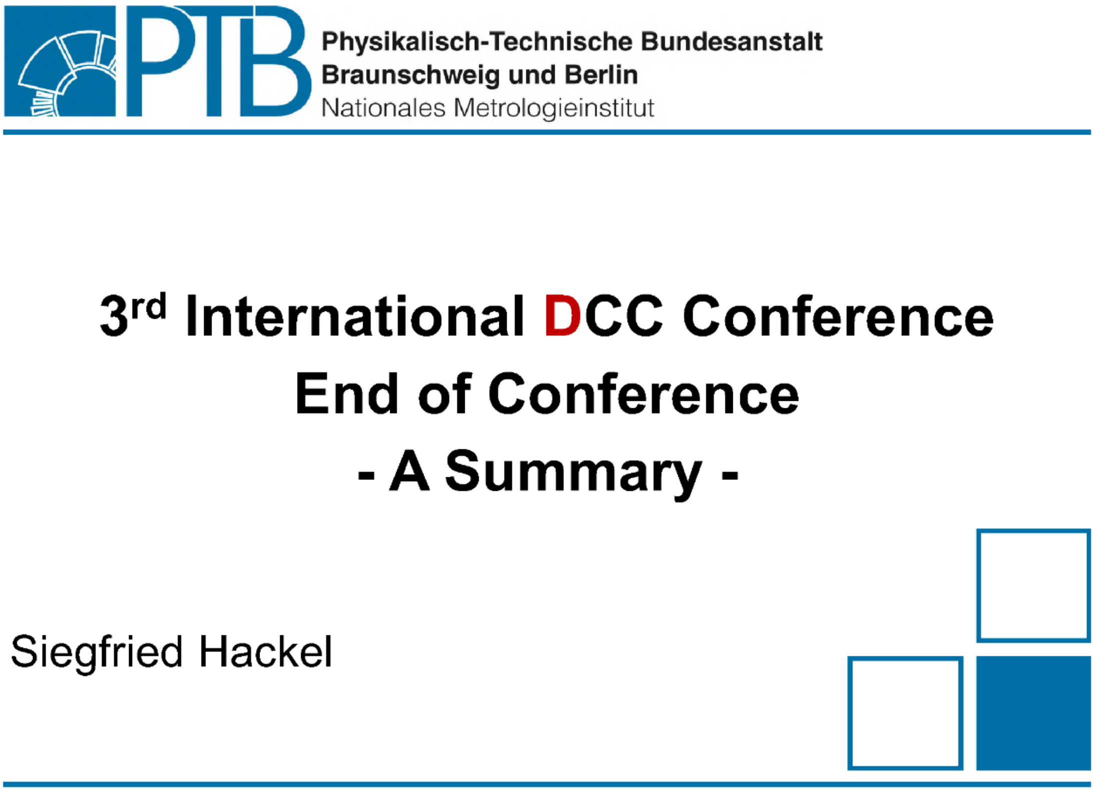
Session E: End of Conference

Siegfried Hackel, PTB, Germany



02

Statistics

- Number of Participants: 1146
- Number of Countries 93
- Continents:
  - Africa 85
  - America 207
  - Asia 257
  - Australia & Oceania 12
  - Europe 585

Physikalisch-Technische Bundesanstalt ■ Braunschweig und Berlin Nationales Metrologieinstitut

03

Statistics (cont.)

- Accreditation Body 136
- Calibration Laboratory 307
- Freelancer 19
- Government 89
- Industry 78
- Legal Metrology Agenca 37
- Lobby Association 1
- NMI 402
- Other 36
- Public Laboratory 6
- RMO 1
- Standardization Institute 20
- University 15

Physikalisch-Technische Bundesanstalt ■ Braunschweig und Berlin Nationales Metrologieinstitut

02

International Task Force on DCC Merging

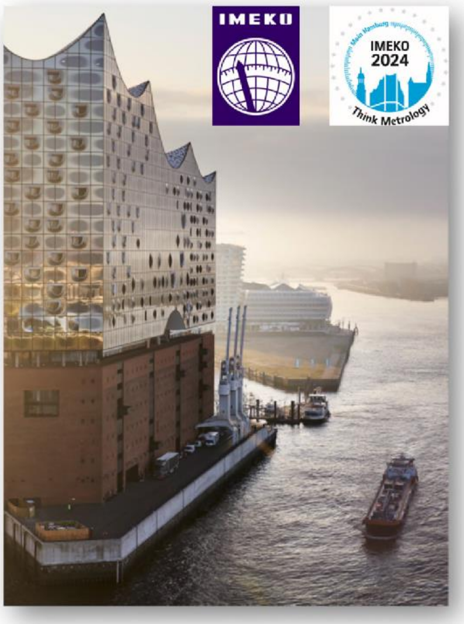
- Contributions & discussion shows:

  High Level of Agreement

- Installation of an international task force
  - ✓ To discuss and harmonise
  - ✓ To represent:
    - Industry end users
    - NMI
    - Calibration service provider
    - Accreditation bodies
- Invitation to all participants by mail

04

Save the Date: IMEKO World Congress 2024



26-29 August 2024
Hamburg, Germany

www.imeko2024.org

05

Save the Date: 4th International DCC Conference

- No conference fees, only registration required
- Pure online conference
- Conference language: English
- Date: 2024-02-27 to 2024-02-29
- Start: at 12:00 UTC each day
- Check the DCC homepage
  https://www.ptb.de/dcc

10

Thanks to the Programme Committee

alphabetical sequence

Blair Hall
Brett Hyland
Carlos Galvan-Hernandez
David Balslev-Harder
Girija Moona
Kim Nguyen
Mark Kuster
Peter Carter
Robert Hanisch
Wee Hoe Ng

Thanks to the Team at PTB

alphabetical sequence

Muhammed Ali Demir
Lutz Doering
Benjamin Gloger
Justin Jagieniak
Moritz Jordan
Christian Keilholz
Jan Loewe
Kai Mienert
Shanna Schönhals
Gamze Söylev Öktem

Physikalisch-Technische Bundesanstalt ■ Braunschweig und Berlin   Nationales Metrologieinstitut

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Braunschweig und Berlin
Bundesallee 100
38116 Braunschweig
Germany

More questions? Please contact:

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Phone: +49 531 592-1017
E-Mail: siegfried.hackel@ptb.de www.ptb.de/dcc

2023-03-02

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38116 Braunschweig, Germany

Dir. u. Prof. Dr. Siegfried Hackel
Phone: +49 531 592-1017
E-Mail: siegfried.hackel@ptb.de

www.ptb.de/dcc

As of: March 2023

Federal Ministry
for Economic Affairs
and Climate Action

The Physikalisch-Technische Bundesanstalt, the National Metrology Institute of Germany, is a scientific and technical higher federal authority falling within the competence of the Federal Ministry for Economic Affairs and Climate Action.