16th AFRIMETS GA : Egypt 2023

Digitalization workshop

“A New Generation of Digital Calibration Certificate”

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Agenda for Today

01 **Introduction**

02 **Calibration Certificate Analysis**

03 **Why Do We Need A New CC?**

04 **Digitalization of the Calibration Certificate**

05 **DCC at NIS Summary**

06 **R&D Activity Map**

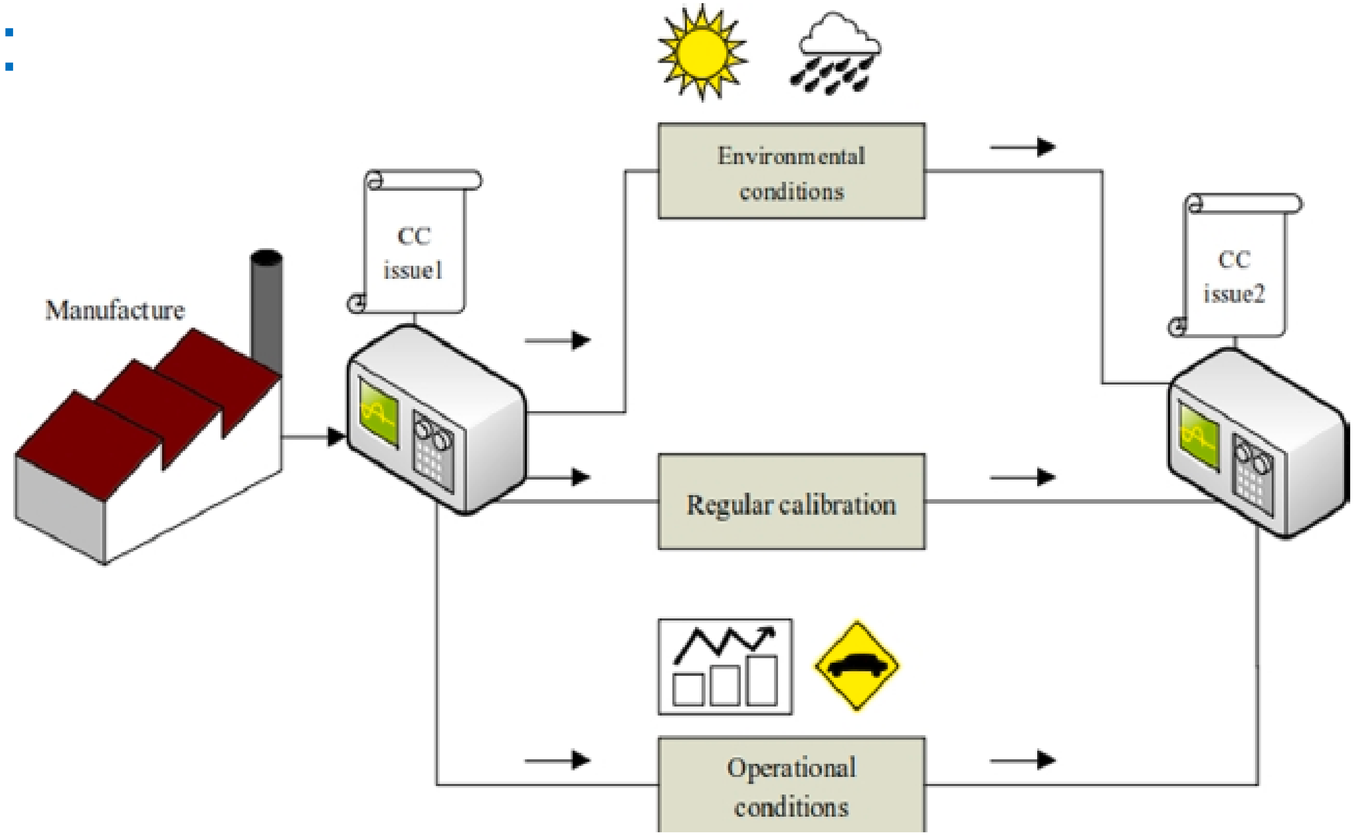
Introduction

- Measurements are too important to enabling the production and the exchange of products and goods.
- Maintaining the accuracy of measurement devices through regular calibrations is a vital task.
- Calibrations need to be repeated periodically at appropriate intervals, the length of which depends on a number of variables (uncert. required, freq. of use, type of use, equipment stability, etc.).
- No hard or fast rule for when a measurement device should be calibrated.

CC Definition & Issue Points

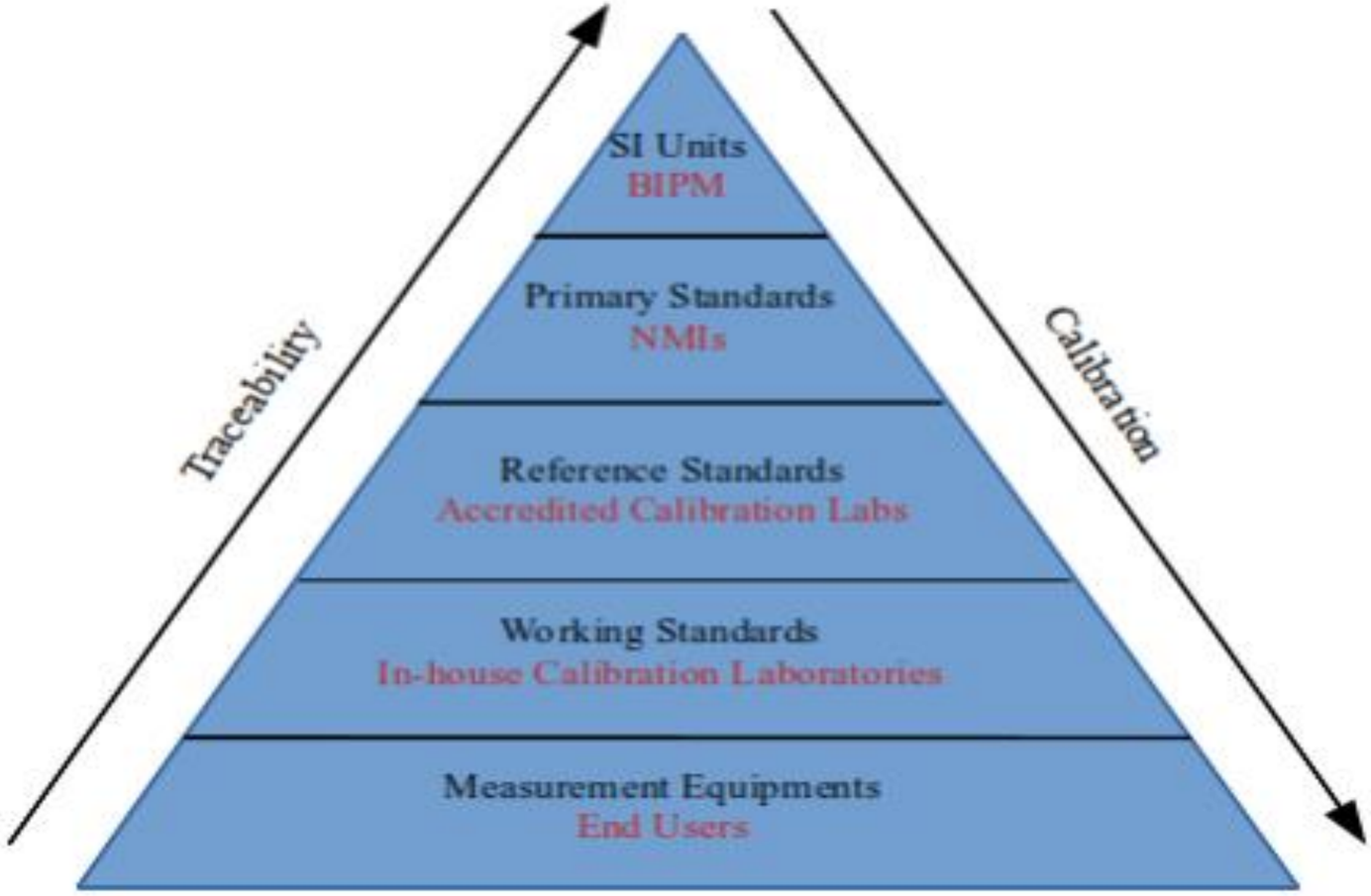
Instruments should be calibrated:

- Prior to the first use.
- At intervals according to the manufacturer's recommendation.
- If there is some reason to believe that an instrument is not providing accurate results.
- If the current calibration is no longer valid. Ex: returned from repair.
- Extra Cal. (env or operational conditions).



Measurement Traceability and Calibration Pyramid

- Each time a device is calibrated, a new CC is issued.
- Any CC should maintain an upward traceability to the top-level standards.
- In other words, the measurement device is calibrated by another, more accurate device or working standard.
- The calibrating device, in its turn, should be calibrated by a more accurate device or a reference standard and so on until we reach the top-level standard or the SI units.



Introduction

Millions of paper-based CCs are issued every year that provides info about measurement uncertainty and calibration traceability.

- A PTB report estimates # calibrations/ year in Germany to be ≈ 10,000 by the PTB itself and around a 100, 000 calibrations (with reference standards) by accredited calibration lab.
- In addition to certificate-less millions of calibrations against working standards by internal calibration laboratories or those carried by the manufacturer.

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DCC Contents

1- Administrative Data: Mandatory.

- Dcc ID.
- Calibration object.
- Calibration laboratory.
- Calibration date.
- Calibration location.

2- Measurement Results: Mandatory.

- Calibration Results.
- Calibration conditions.
- Influencing variables. (environmental conditions)
- Measuring used methods.
- Uncertainty.

3- Comments: Optional

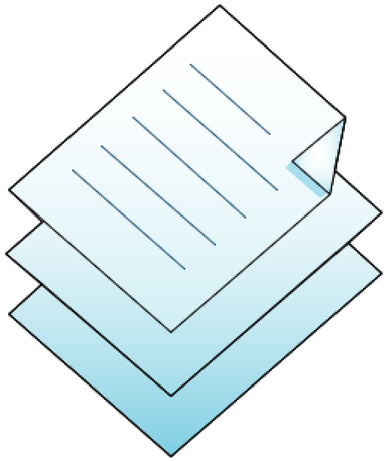
- Graphics.
- Additional information required by the customer.

4- Document: Optional.

- Human readable document.
- Printout conform with 17025.

Calibration Certificate Analysis

While paper-based CCs is still seen as the cheapest and the safest form of CC, it fails short with the emergence of new tech. & app that require auto creation, processing and updates



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DT in Metrology Can't be Completed without a New CC

Why Do We Need A New CC?

Developing a New kind of CCs is Becoming More Important for Several Reasons

1. The global move to DT.
2. The shortcomings of paper-based CC.

Why Do We Need A New CC?

3

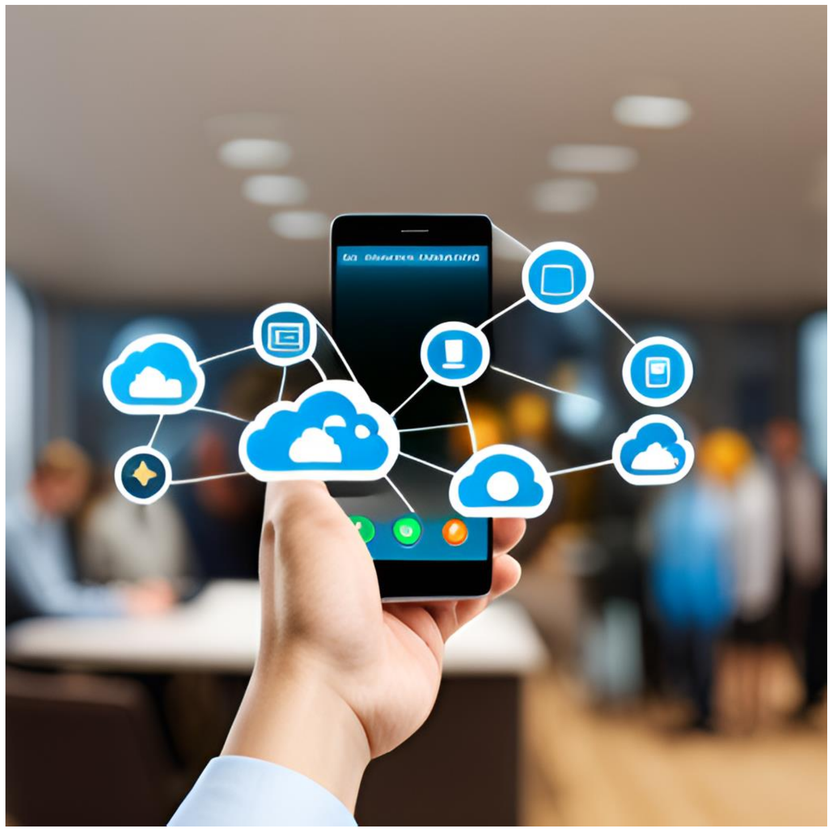
A need to track and compare changes between following calibrations of the same device by saving the provenance

Why Do We Need A New CC?

4 The Increasing Connectivity of Measurement Devices.

Why Do We Need A New CC?

5 **The increasing usage of IoT sys that have many measurement sensors**



Why Do We Need A New CC?

6 The Emergence of Many Measurement-Intensive Applications/Devices

Autonomous Robots

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Autonomous Cars

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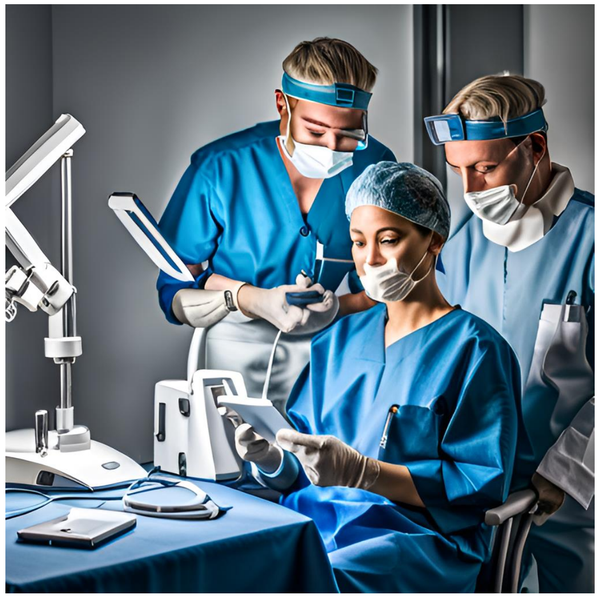
Remote surgical operations



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- Embedded measurement components req Cal & auto process
- Dependence on human to analyze & verify CC imposes limitations.

7 Security Issue

The manual systems follow several centralized storage architectures that make it vulnerable to hackers.

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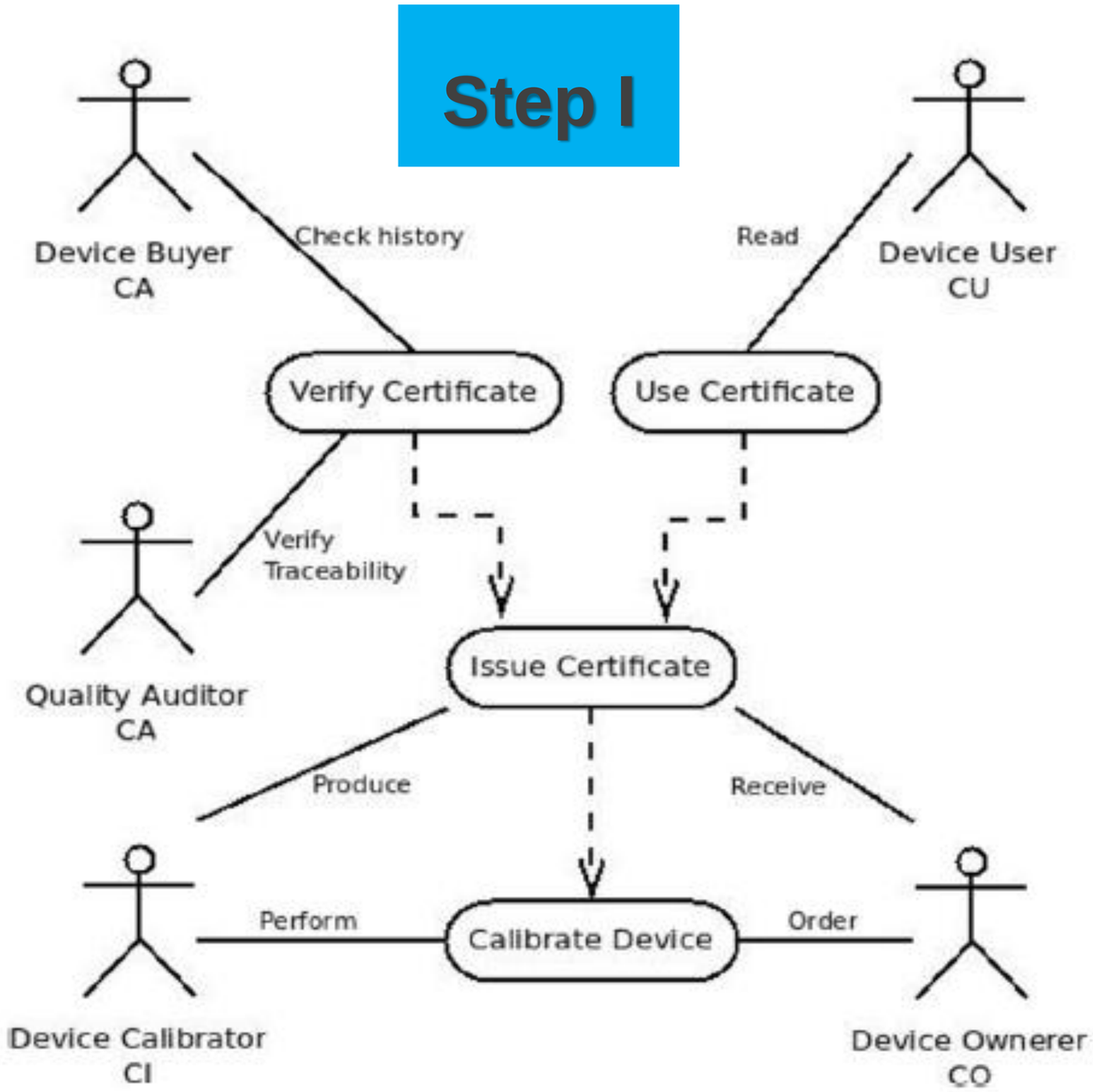
Digitalization of the Calibration Certificate

Stakeholders and Use-Cases

- Many new use-cases for the usage of DCC.
- CO: order & receive.
- CI: receive cal.order- perform cal.- issue DCC.
- CU: Ex: device operator (uncertainty- drift correc.) & inventory manager (cal. expiry date).
- CA: checks (authenticity & history & traceability chain). EX: quality auditor- lab accreditation assessor- legal metrology supervisor.
- Device buyer: check device history & DCC originality.
- In IOT, these entities could be a designed smart devices.



The suggested DCC should:

Step II

1) FAIR: Findable, Accessible, Inter-operable and Reusable.
2) Support and follow a standard DCC data format.
3) Support generating a paper-based version from the digital version.(indispensable)
4) Conform to relevant norms and regulations: VIM, SI units, GUM, ISO/IEC 17025, etc.
5) Maintain calibration traceability: Horizontal Traceability, Vertical Traceability.
6) Support extensibility in case we need to add more information.
7) Maintain security: By ensuring DCC confidentiality, integrity and authenticity.
8) Allow and show revocation information when applicable and needed.

Different Formats for DCC

What is the best solution for DCC?

A scan of the paper-based CC in some digital document format (e.g. pdf) or some image format (e.g. jpg) without any modification.

- Too simple.
- Widely used.

However, similarly to the paper-based:

- Not immune from falsification.
- Requires additional manual steps to prove the authenticity and the integrity of the certificate.
- Difficult to automatically process and read the detailed contents by the machines.

PDF or Image

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XML

Another digital format is the XML-based format.

- Extensible Markup Language.
- Allow: storing, transferring, and recreating arbitrary data.
- Human-readable and machine-readable.
- In this case, every single detail of the certificate is coded as an XML field or tag that has a meaning.
- The correctness of its contents can be verified by some inherent methods in XML schema (e.g. XML Schema Definition (XSD) or Document Type Definition (DTD)).

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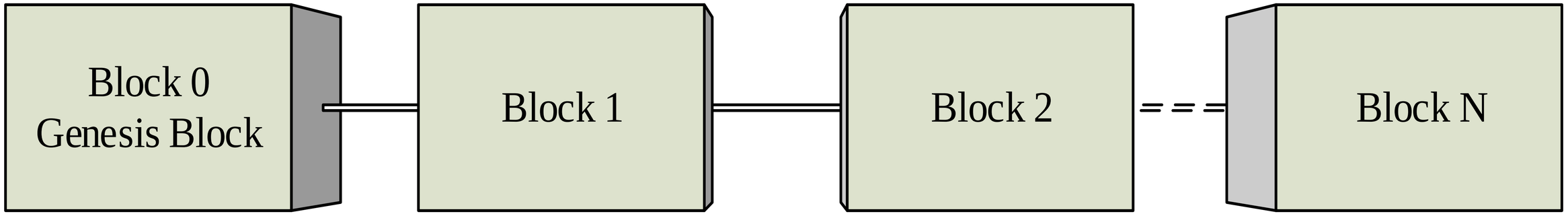
Blockchain

- It is a distributed and immutable ledger.
- Some scientists see that it will simplify some metrological controls.
- It shows proficiency in security.
- Costly- Storage.



Digitalization of the Calibration Certificate

Comparison of Different Formats for Calibration Certificates:

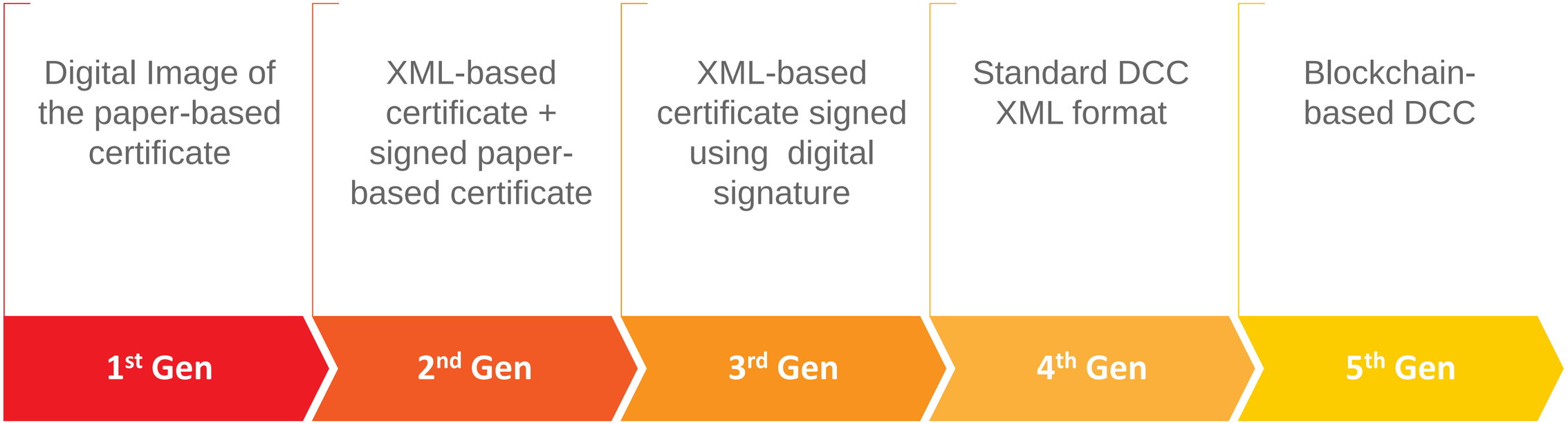
- Machine readability is extremely important for IoT applications and smart systems.
- Blockchain allows the automatic validation and usage of CCs.
- Blockchain enables traceability to the highest level of the traceability chain, calibration history, machine readability.

	Paper-based CC	XML-based	Blockchain-based
Readability and Interoperability	Human	Human & Machine	Machine
Tamper-proof	No	Possible	Yes
Traceability (vertical)	One-level	One-level	Whole chain
Calibration History (Horizontal Traceability)	No	No	Yes
Validation & Verification	Awarding Lab	Requires 3rd party	Yes: Distributed, P2P
Scope	Per Lab	Per Lab	Could be Universal/National/per Lab
Maintainability	Centralized at Laboratory	Centralized at Laboratory	Distributed
Support to other formats	No	Possible link to other formats	Yes
Single point of failure	No	Yes	No
Process automation	No	No	Yes: through smart contracts
Revocation	No	Possible	Yes

DCC at NIS Summary

1. **Implementation:**
   - Study and Compare.
   - NIS DCC XML Scheme.
2. **Knowledge transfer:**
   - **Organizing workshops:**
     - Fair Digital Data and Calibration Certificate, June 2021.
     - Metrology in the Digital Era, May 2022.
     - Prospects for Digital Transformation in Metrology, Oct. 2022.
   - **Attending Conferences:**
     - First & second & third int. DCC Conferences.
     - Participate by 2 presentations in the third one.
     - Etc.
3. **Research:**
   - **Study different DCC technologies.**
   - **One journal publication.**
   - **Another one in the written phase.**

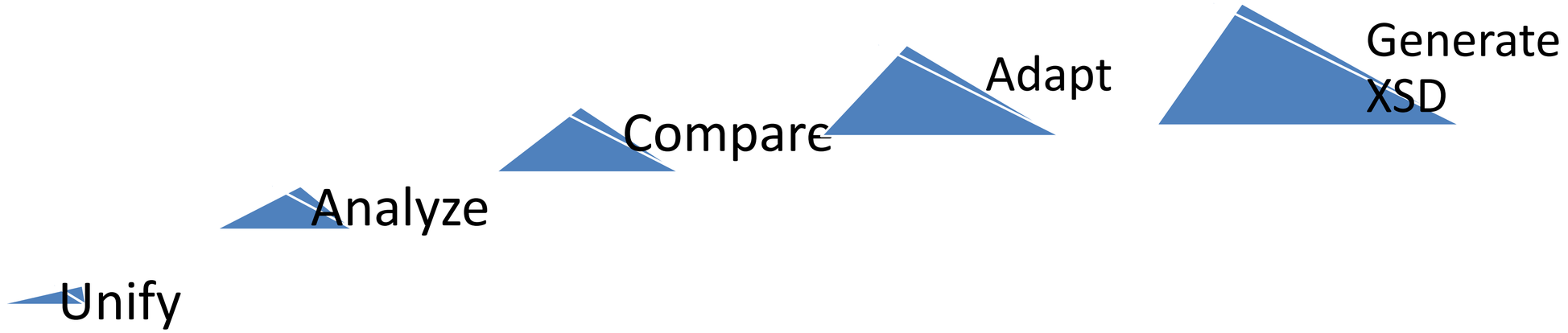
DCC Road Map



- In fifth generation: Using Smart Contracts.
- Integration with other NMI Systems.
- Apply ML/ DL/ Big Data Analytics.

DCC at NIS Summary

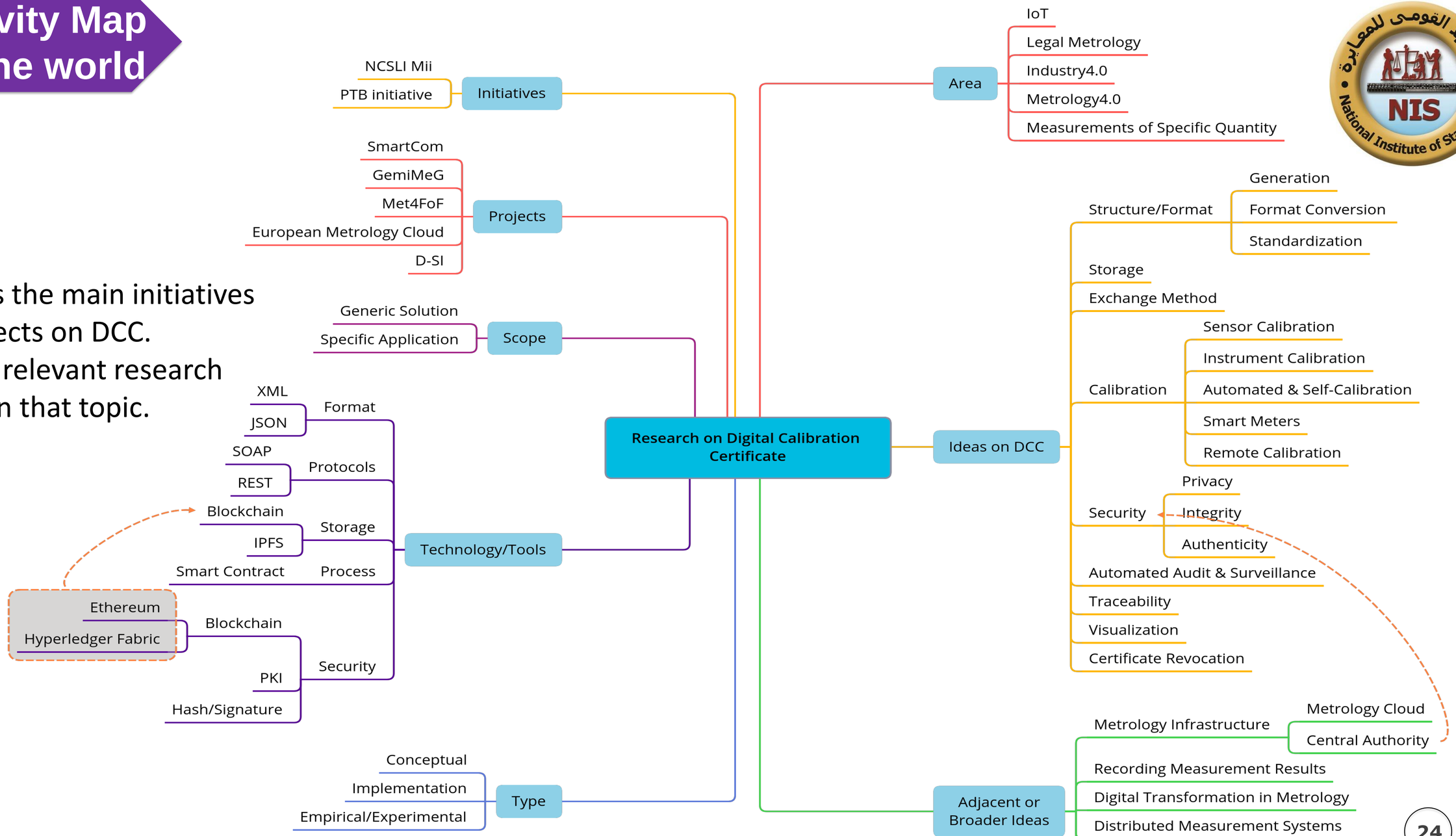
1. Unify CC from all departments to a standard template.
2. Analyze its current contents.
3. Compare with PTB suggested DCC scheme.
4. Adapt and add CC fields.
5. Generate own DCC scheme.



R&D Activity Map Around the world

This figure :

1. Identifies the main initiatives and projects on DCC.
2. Presents relevant research papers on that topic.



References

For more information, you can refer to the following references:

1. 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

2. S. Hackel, F. H¨artig, J. Hornig, T. Wiedenh¨ofer, The digital calibration certificate, PTB - Mitteilungen Forsch. Prufen 127 (Dec. 2017) 75–81.

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

4. Ahmed H. Aly, Mohammed S. Gadelrab, Muhammad H. Elsheikh, Reham A. Abouhogail, “Digital Transformation of NMI: Practical Experience on DCC and Beyond @ NIS-Egypt”, The third DCC conference, PTB, 2023.

5. https://www.youtube.com/watch?v=fQi9iBSZIdQ&feature=youtu.be

Q&A

Thanks

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