Digitalisation Strategy
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Trusted data, shared progress: a digital future for the European metrology community

Vision

The use of digital technologies and automated processes is increasing amongst the end users of metrology. They need their metrology data delivering in a digital form that can be easily integrated into their software tools and procedures. They need the trust that metrology brings (through data quality, data provenance, traceability and uncertainty evaluation) to be applicable to new data processing approaches such as Artificial Intelligence (AI). They need to be able to find, understand, and merge datasets, including historical data, from different types of measurement to investigate complex systems.

The use of digital technologies enables metrologists to automate processes, thus reducing error rates and freeing up the time of skilled staff to deliver their services and data in new and interactive forms, enabling customers to receive more data and gain new insights into their systems; and to analyse more complicated data sets and systems, bringing metrological rigour to new application areas.

These topics require continent-wide harmonisation because many of our customers operate across national boundaries and need unified approaches, and because the CIPM Mutual Recognition Arrangement (CIPM MRA), the Calibration and Measurement Capabilities (CMCs), key and other intercomparisons, audits and many other services in both National Measurement Institutes (NMI) and legal metrology organisations will be delivered more efficiently with a common digital approach. This harmonisation also needs to embrace the wider quality infrastructure, providing a unified and interoperable digital approach to all end users.

EURAMET will:

- Enable access to shared resources (e.g. code, expertise, reference data, computational power, data sharing platform, etc.) and support development of good practice guidance and training to accelerate digital transformation in all NMIs and DIs.
- Encourage collaboration with relevant expert groups within metrology, the quality infrastructure, and beyond to ensure that relevant existing best practice is applied and to share European digital metrology knowledge more widely.
- Develop harmonised and standardised approaches for sharing of machine-interpretable metrology data and synthetic data and for uncertainty evaluation for advanced analytics (e.g. machine learning, sensor networks, digital twins, etc.), ensuring that these methods are consistent with relevant global standards and good practice.
- Promote the benefits of digital approaches to metrology to end users via case studies and success stories, including provision of a glossary for demystification of jargon.

Details

In order to reduce misunderstandings, duplications and misinterpretations, which cost money and cause errors, it is essential to develop a common unambiguous language for the digital world and machines. Automation is increasing amongst end users of metrological data and services, and these end users therefore need NMIs and DIs to deliver data and services digitally.

Data aggregation will enable improved efficiency and the ability to get more insight from the data that is already gathered. In the longer term NMIs and DIs will be able to offer new services for equipment monitoring, extra information for instrument manufacturers, and support for customers to make informed decisions about investment in equipment.

Software already underpins the vast majority of metrological work, and it is vital to bring the same level of professionalism and proof of quality that is displayed in the making of measurements to the software that is developed and used in metrology. Adoption of a collaborative approach will accelerate the development of robust solutions across all NMIs and DIs.

In the long term, the ability to share data, services and software in a way that forms a federated dataspace will support the use and promotion of approved and endorsed software and datasets in a safe and secure manner, ensuring that trustworthiness of NMI and DI outputs is maintained.

Digital Calibration Certificates (DCCs) are a key tool for effective delivery of metrology data in a fully automated and machine-readable way, but successful development, deployment and use of DCCs requires a well-planned infrastructure and consideration of wider ecosystems. Organisations will apply design and development methods to establish ecosystems implementing services based in infrastructure components. Different applications will be run in these ecosystems.

Within infrastructure it is necessary to consider:

- Definition of units and their digital representation
- List of constants
- Representation of equations
- Schemas for DCCs, etc.
- Standards, procedures etc
- Organisation, laboratory databases
- Digital KCDB, CMCs,
- ….

Within the ecosystem it is important to develop

- Everything that helps to define and implement actual services
- Training and guidelines
- Collaboration with service providers to set up services
- Software such as middle ware, converters, validation software, etc.

Data is only meaningful when contextual information (metadata) is present. The question “is this the data I need?” can only be answered through examining this metadata. The FAIR principles enable data sharing across disciplines to support collaborative open science and to ensure that collaborative science projects generate data that can be found and reused after the project is completed. Supporting metrologists to make their data FAIR and to manage their research data effectively will mean that the money invested in EMP projects will bring meaningful impact in the long term.

Encouraging uptake of digital approaches, and highlighting that they are an investment not a cost, needs case studies, examples, templates and policies that NMIs, DIs and other organisations can adapt to suit their needs.

Quality Assurance Tools (QATs) have been developed and designed by EMN Mathmet to ensure that research outputs in the forms of data, software and guidelines are fit-for-purpose, achieve a sufficient level of quality, and are consistent with the aims of NMIs and DIs to provide quality-assured and trusted outputs. Starting from guidance already in place (like QATs for data), methods for harmonization of data quality assessment have to be developed in terms of common and recognized metrics. Standardization of those methods needs to be pursued in collaboration with related standardization bodies (ISO, IEC, CEN, CENELEC, etc.), and contact with industry and interested end-users.

The need for reference data, as well as for criteria for data quality and data handling, are at the very heart of evaluation, certification and conformity assessment of AI applications and of products with AI components. Criteria and methodologies are needed to produce reference datasets that are suitable to act as digital standards for both AI/ML tools (training and benchmarking) and for virtual models such as digital twins. Harmonization and standardization of (synthetic) reference datasets are needed to enable investigation of the uncertainty for advanced modern data analysis approaches, such as machine learning and computational modelling, and to contribute to their standardization in their turn. The area of advanced data analytics is generally changing rapidly, so guidance and standards will have to evolve as analytical methods develop.

Digitalisation is not solely a concern of European metrology, and in order to be successful the activities described above will need to be collaborative, in order to ensure interoperability, and should build on existing best practice in order to avoid reinvention of the wheel. Collaborative relationships with global metrology organisations (including other RMOs), the wider quality infrastructure and the wider scientific community are essential for successful digital transformation of metrology. These collaborations will also help to introduce the importance of metrology to science, particularly in areas such advanced analytics where awareness of metrology may be low.

All of the above require investment in dissemination and upskilling activities as well as in research. Training for NMI and DI staff and for end users, particularly around software and data quality assessment, is vital. This activity needs to include training and information for decision-makers as well as scientists, including provision of success stories that can demonstrate the financial benefits of digital approaches.

Theme	Activities	Who	Timelines: Short 1-3 years, medium 3-5 years, long 5+ years
Vocabulary, metadata and machine readability	Prepare an introduction to the NCSLI taxonomy for TCs.	M4D and TC-IM 1449	Short
	Identify which aspects of the taxonomy are most important to TCs and identify three (say) priority measurement capabilities where sharing calibration/performance information of the devices involved would be beneficial.	TCs	Short/medium
	Prepare a standardised data & metadata format for capture of information about the chosen capabilities in preparation for aggregation.	TCs supported by TC-IM 1449	Medium/long
	Implement the relevant metadata in their data-gathering processes.	NMIs & DIs	Medium/long
	Prepare an example of anonymised data aggregation for comparison of devices.	M4D, Mathmet and one TC	Medium
	Identify candidates for machine-readability amongst the standards & calibration guides that they follow, including identifying the data that needs to be machine readable.	TCs	Short/medium
	Prepare a relevant metadata structure to contain the machine-readable data.	M4D & TC-IM 1449	Medium
Software quality & good practice	Building on existing Mathmet Quality Assurance Tools and good practice in the wider world, work to embed software quality assessment and good practice as a key element of quality assessment.	Mathmet & TC-Q	Short/medium
	Prepare scopes for software good practice training for occasional coders and full-time coders with an emphasis on the needs of metrology (e.g. right is more important than fast).	Mathmet & M4D	Short/medium
	Develop and deliver training on software quality & good practice, possibly as a summer school.	EURAMET, Mathmet & M4D	Medium/Long
Sharing of endorsed software (with DCCs as a case study)	Define what the “building blocks” of software for DCC creation are and specify acceptability criteria for DCC software building blocks to be “EURAMET endorsed”.	TC-IM 1448	Short
	Identify which of their building blocks they can make open source and will share via a Github or similar.	NMIs & DIs, TC-IM 1448	Short/medium

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	Carry out peer review of one another's DCC creation software. Feed back learning, pitfalls etc. to EURAMET & global community.	NMIs & DIs coordinated by TC-IM 1448, EURAMET, CIPM TG-H-DCC	Medium/long
	Develop a "cut down" DCC-like format for exchange of intercomparison data with ingestion into analysis tools in mind.	TCs, TC-IM 1448	Medium/long
	Identify complex calculations in technical areas where sharing of software through a mechanism similar to the above would be useful.	TCs	Medium
Infrastructure and ecosystem for DCCs	Define essential infrastructure components for delivery of DCCs, assess the status quo, and identify what is under development and what still needs to be developed. Involve stakeholders beyond NMIs & DIs and liaise accordingly.	TC-IM 1448, CIPM TG-H-DCC, quality infrastructure bodies, end users	Short
	Initiate a dialogue with legal metrology authorities on machine-readable outputs and common database(s) for certificates.	TC-IM 1448, OIML, NMIs & DIs.	Short
	Develop joint roadmaps to specify and progress relevant/required harmonization work and to align goals (and vision), requirements and individual priorities.	TC-IM 1448, EURAMET TCs, EMNs, PG, WG.	Medium
	Establish special interest groups to exchange on developments on a regular basis (use cases, new application etc.).	TC-IM 1448, EURAMET TCs, EMNs, PG, WG, NMIs & DIs	Medium
	Establish and maintain a knowledge base and training capacities for all prioritised topics from external deployments and for producing guidelines where needed.	TC-IM 1448, EURAMET TCs, EMNs, PG, WG, NMIs & DIs	Medium
	Establish more content for infrastructure via reuse of existing material and collaborative development where needed: vocabularies, schemas, ontologies, digital VIM, etc.	TC-IM 1448, NMIs & DIs, BIPM/CIPM, general QI	Medium
Metadata standardisation to promote data FAIRness	Select priority domains to benefit from metadata standardisation	EURAMET & TC-IM	Short for domain selection, mid-term for development

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	Develop metadata recommendations for priority domains	TCs, EMNs, EPM projects	Short- to mid-term
Knowledge sharing and capability building	Develop funded cross-NMI digitalisation projects in order to establish a stronger collaborative network between digital experts who will develop digitalisation tools (quality metrics, automated processing pipelines, case studies, unique identifiers, standards, AI/ML tools,…)	TC-IM/M4D/EMNs to suggest projects, TCs, NMIs, EPM projects to run projects	Short to mid-term for smaller projects, long-term for collaborative network
	Set up regular knowledge exchange workshops involving multiple NMIs and DIs	EURAMET CB, EURAMET/TC-IM/EMNs to facilitate/coordinate, NMIs to provide material	Short term
	Investigate creation of an EU data space for metrology data: this would be a virtual repository for secure data and metadata sharing	NMIs, EURAMET to support, M4D to oversee/coordinate	Mid to long term
	Create a knowledge base (repository or website) to share case studies with examples of good data management	EURAMET, TC-IM, Mathmet	Short term
	Share AI/ML tools to aid data harmonization and digitalisation (tools for digitising screenshots of instrument readings, parsing unstructured data, …)	Mathmet & M4D to oversee, NMIs/Dis to implement	Mid term
Policy for data management	Develop example policies for NMIs & DIs, especially with a view to supporting smaller NMIs	EURAMET in collaboration with NMIs/DIs	Short to mid term
	Create a glossary of data management terms to inform directors and policy makers	TC-IM 1449/M4D	Short term
Digitalisation showcases	Build a portfolio of digitalisation ‘success stories’ starting from an agreed format and minimal set of information such as: area of metrology, challenge, technologies used, beneficiaries, financial or operational improvements, resources required, costs to make the stories useful for the community	NMIs & DIs, maybe other RMOs	Short to mid term

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Setting the framework for advanced analysis	Continuously monitor relevant topics in digital transformation of metrology and industry, in particular topics relevant to the artificial intelligence (AI), machine learning (ML), digital twins (DTs), virtual metrology (VM) and sensor network (SNs); analyse their relevance for EURAMET and its members and connect the individual developments to a harmonised approach in terms of testing, trustworthiness, explainability of the models, data quality assessment and metrics, and reference data.	EURAMET in collaboration with NMIs/DIs; TC-IM M4D and Mathmet	Continuous
	Create and maintain a searchable database for reference data and software (including commercial and freeware/open source).	TC-IM M4D and Mathmet	Mid to long term
	Develop good practice guidelines and digital tools (e.g. models and guidelines on trustworthy, certified and validated software tools) and strategic roadmaps (e.g. for TCs)	NMIs/DIs in collaboration with Mathmet and TC IM M4D	Mid to long term
Fostering collaborative projects, facilities and workspaces	Provide and maintain an open innovation platform to exchange ideas, suggestions and questions on trustworthy ML, DTs, VM and non-conventional calibration strategies e.g., co-calibration, in situ, virtual, and remote calibrations.	Mathmet?	Short to mid term
	Facilitate the provision of open-source tools for APIs and examples of trustworthy AI/DT	TC-IM M4D and Mathmet	Mid to long term
	Facilitate access to high performance computing clusters across member NMIs/Dis	EURAMET with NMIs/DIs	Mid term
Develop links with peer organizations	Linking with the BIPM digitalisation activities, including increasing the use of the digital SI framework	TC-IM M4D and Mathmet	Short term
	Linking with EURAMET EMNs, TCs and members, such as EMNs COO, Advanced Manufacturing, and POLMO	Mathmet	Short term
	Engage with external parties, such as RMOs including APMP-DXFG, SIM and WELMEC, OIML, JCGM, ADRA, EURADOS, EUROLAB, CIPM TG-AI, etc.	TC-IM M4D and Mathmet	Short to mid term