

# EURAMET TC-IM Working Group on Metrology for Digital Transformation

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## Vocabulary

### Metadata

*Data describing a datum or a data set. Ideally as structured, standardised set of information provided directly with the data it describes.*

#### Examples

- Measuring device manufacturer, serial number, traceability, environmental conditions for measurement data
- Date, camera settings, location, file type for a photo

Metadata can be stored as part of the file itself, as for image data, or separately, as for data repositories organised based on metadata information. Metadata is an important prerequisite to fulfil the FAIR principles for data

### QR code

*Camera-readable information in a standardised form. A QR code encodes a small amount of digital information and is usually used to encode the link to a website or similar resource.*

#### Examples

- QR code on a physical instrument that encodes the location where information about that instrument is stored. For instance, the location can be a website with calibration information or the link to a device management system
- The Digital Product Passport of a physical device may be accessed by a QR code that encodes the link to website containing the information.

With QR codes, the process for customers to access information provided by a calibration laboratory can be eased. Since the QR code is provided directly with the device, digital information is linked to the physical device.

### Ontology

*Semantic modelling of terms and their relation in a way that can be interpreted by software tools.*

## Examples

- Ontologies may be encoded in triples using structures similar to human language grammar (e.g., „Measurement“ „hasUnit“ „Second“). The relation „hasUnit“ encodes the property that the measurement is provided with a unit of measurement.

Ontologies are a tool to create interoperability for data sets of different sources, by using them to formulate the metadata in a semantic modelling language. That is, ontologies link annotations between different applications and domains.

## Machine readable

*Information provided such that it can be accessed (read) by a machine (software) autonomously (without human interaction)*

### Example

- Image information such as location, camera settings, and date made available such that a software can access that information. Enables, for instance, automated selection of all images with a certain property (e.g., aperture size)

Machine readable metadata is an important prerequisite for making data FAIR.

## Machine actionable

*Information provided such that it can be interpreted by a machine (software) autonomously (without human interaction)*

### Examples

- A QR code is machine actionable data when it contains the link to a website the software can automatically open. The actual content of the website is not machine actionable, though, without further efforts.
- Metadata for a measurement that contains information about the units of measurement using standardised formats (such as SI reference point of BIPM) can be interpreted by a software, e.g., for the combination with data from another source.

Machine actionable data is usually structured in a more granular way than machine readable data. Ontologies or other semantic information are usually used to make information machine actionable, because they encode human knowledge in a structured form.

## Application programming interface (API)

*Documented interface that can be accessed by a software as a means to share information between digital systems.*

### Examples

- Acts like a translator that helps machines / software to communicate with digital services. The API takes inputs and forwards this to a software or handling the request.
- APIs are a fundamental technology in web-based services and for providing digital services for predefined tasks. Especially server-based digital services can often be accessed by an API for automated processing.
- The software accessing the API does not need to know the functionality of the software / service and that service does not need to be on the same location as the software.

## FAIR principles

*Set of general rules and procedures for making data findable, accessible, interoperable and reusable*

*Findable: Data can be found based on its metadata information*

*Accessible: Data can be accessed without human interaction*

*Interoperable: Data can be combined / compared / aggregated with data from other sources without significant additional efforts (e.g., based on unified data types)*

*Reusable: Data can be used again and in other contexts (e.g., not restricted by licenses)*

The FAIR principles originate from the scientific community and a part of the international efforts to make research reproducible. However, the FAIR principles can also be applied to internal data management and to the provision of digital services.

## Digital calibration certificate (DCC)

*Machine actionable digital format of a calibration certificate*

### Examples

- An XML file based on a harmonised schema containing information and results of a calibration
- A PDF document is not machine actionable, because the information is only provided in a human readable way

## Digital calibration request (DCR)

*Machine actionable digital format encoding the information about a requested calibration*

### Examples

- An XML file based on a harmonised schema containing all relevant information for the laboratory to accept and perform the calibration request
- The DCR can be provided via a customer portal, by email or via an API

Related to a DCR is the DCA – the digital calibration answer. It encodes the DCC for the calibration together with other order-related information from the laboratory to the customer. DCR, DCA and DCC should ideally be based on very similar schema elements to avoid translation errors.

## Digital Product Passport

*Electronic / digital record containing key information about a physical asset (product, device, ...)*

### Examples

- A DPP may contain information about materials, origin, certificate of conformity for a given product
- A DPP may contain measurement information linked to a calibration, such as state-of-health measurement for a battery using a calibrated measuring system
- Access to a DPP may be provided via a QR code on the physical asset

DPPs are becoming mandatory for a wide range (almost all) product categories in the European Union over the next couple of years. International uptake and standardisation of DPPs are, for instance, supported by UNECE. The major motivation for DPPs is to enable verifiable statements about origin of materials, product properties and information for recycling and reuse in a digital way.

## Customer portal

*Digital way to interact with customers*

### Examples

- A simple example is a website with the possibility for customers to order a service
- The portal may provide a login-based access for customers to the history of their previous orders and ways to interact with the organisation

Access to the customer portal may be provided also via a QR code leading the customer directly to the corresponding part of the website with information about the measuring instrument. BEV in Austria and the legal metrology organisation of Singapore already use QR codes for their customers and end users to provide access to measuring device information and access to services such as ordering a re-verification.

## Machine learning (ML)

*Methodology to train algorithms / model parameters based on training data.*

Machine learning typically uses models that do not contain explicit physical / domain knowledge. That is, the domain knowledge has to be contained in the data used for training (model parameter identification).

## Deep learning / deep neural network

*Machine learning using artificial neural networks with many highly interconnected layers. Training (i.e., parameter identification) for a deep neural network is called deep learning.*

Many AI systems today use deep neural networks as model architecture with specialised layers and structure. For example, convolutional neural networks use elements from image processing (e.g., edge detection) as part of the neural network.

## Digital transformation (in metrology)

*Describing the process of implementing automated end-to-end digital workflows, providing machine actionable measurement data and reports, and software-based autonomous processes and services in metrology*

## Software development

*Process of creating a software to perform a predefined task in a reproducible way*

For high quality software, the development process should contain especially the following elements

- Consideration of the whole software development lifecycle (planning, implementation, maintenance)
- Software requirement specification documented
- Software transparency through documentation and annotation
- Software test cases (black box, white box, unit tests)

- Source code transparency and change traceability (who did what change when and why)
- Implementation of quality assurance frameworks

MATHMET developed a software quality assurance framework oriented at software used in measurement data analysis and modelling. Several ISO standards exist for software development practices.

Software transparency ensures reusability of software even when the developer team changes, and it creates trust and confidence in the software being developed.

## Digital quality infrastructure (Digital QI)

*Quality infrastructure (metrology, accreditation, conformity assessment, standardisation, market surveillance) with data, processes and information being digitally transformed*

### Examples

- DCCs and DPPs represent elements that together with automated workflows (e.g., based on DCR and DCA) form end-to-end digital QI processes

The aim of the digital QI is to make processes faster, more efficient and easier to use for everyone. It requires inputs, processes and outcomes to be digital and interoperable. A digital QI adheres to the FAIR principles and provides information and services in a machine actionable way.

## Data space

*System of data bases and services interconnected by means of shared access and metadata repositories*

The data in a data space can be stored, accessed and shared easily based on predefined rules and access rights. Architecture models for data spaces usually also contain elements such as metadata brokers, vocabulary services, and identity providers to ease automated data and service access and improve interoperability.

The European Commission aims for a „Common European Dataspace“ between industries, governmental and non-governmental services and data sources. Initiatives such as GAIA-X and International Data Spaces are coordinating about 200 data spaces in Europe.

A standardisation request from the EC to CEN/CENELEC is in preparation to harmonise technologies and requirements for data spaces in Europe. International standardisation for data spaces has been initiated at ISO.