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Towards a structural foundation of a quality infrastructure in the digital world

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Summary:
We offer a vision of a digitally transformed quality infrastructure (QI). Specifically, we analyze the interplay and data flow between the QI institutions and present digital certificates, cloud infrastructures as well as requirements with respect to interoperability that will enable a digitally-transformed QI.

Keywords: quality infrastructure, metrology, digital transformation, digital certificates, cloud

Introduction

The quality infrastructure (QI) is an established and effective system to guarantee the quality of products, services, and processes. Currently the world is undergoing a twin-transition. New digital technologies become available that fundamentally change industrial processes and enable completely new products and services. At the same time, the green transition requires a speedy transition towards renewable energy sources and more environmentally friendly production methods. The QI must transform itself to promptly address these novel technologies and create trust and acceptance by the consumers.

Here we analyze relevant QI processes, describe the digital tools that allow fully digital workflows, and report the most current developments related to digital certificates, cloud infrastructures and an interoperable digital QI.

Results

Business partners, authorities, factory control systems, end consumers need trustworthy information about a product or a service. In the QI, this information is provided in the form of test reports or certificates.

In the digital age, the information about a product – its “QI status” – must be provided in a digital, machine-readable way. An already well-developed use case is the digital calibration certificate (DCC), which has been available in a stable format since 2021 [1]. It uses the flexible and internationally recognized Extensible Markup Language (XML) format. The DCC XML scheme is based on the minimum requirements for the machine-readable exchange of metrological data as described, for instance, in the "Digital System of Units" (D-SI) metadata model and complies with all international standards and guidelines required for such a document, including the SI units, the International vocabulary of metrology (VIM), the GUM, the CODATA table review, and ISO/IEC 17025 [1]. The DCC can be equipped with an electronic signature, as a means for its cryptographic protection against manipulation. The DCC therefore allows to avoid media discontinuity in calibration services, and it permits an error-free transmission of the corresponding data and information. The structure of the DCC is divided into four areas: administrative data, measurement results, comments, and the analogue calibration certificate as human readable. This approach can be adapted to certificates of conformity and other result reports. As part of the initiative “QI-Digital”, the PTB is developing a digital, digital Certificate of Conformance (D-CoC) for conformity assessments according to ISO/IEC 17065 in legal metrology (D-CoC M) as well as in the legally regulated area of explosion protection (D-CoC Ex) [2].

The accreditation of a laboratory or company attests the competence for a certain type of service or product. In some cases, the accreditation of a conformity assessment body or calibration laboratory is required. In that case, this information must be made available via a central database or be provided with the certificate (e. g. as a digital signature) [3].

Conformity assessments thus form the contact points between QI and product and usually invoke the interplay of several QI elements. A digital QI platform must be aimed at optimizing the conformity assessment workflow - maximizing its efficiency while also guaranteeing cyber security and data autonomy.

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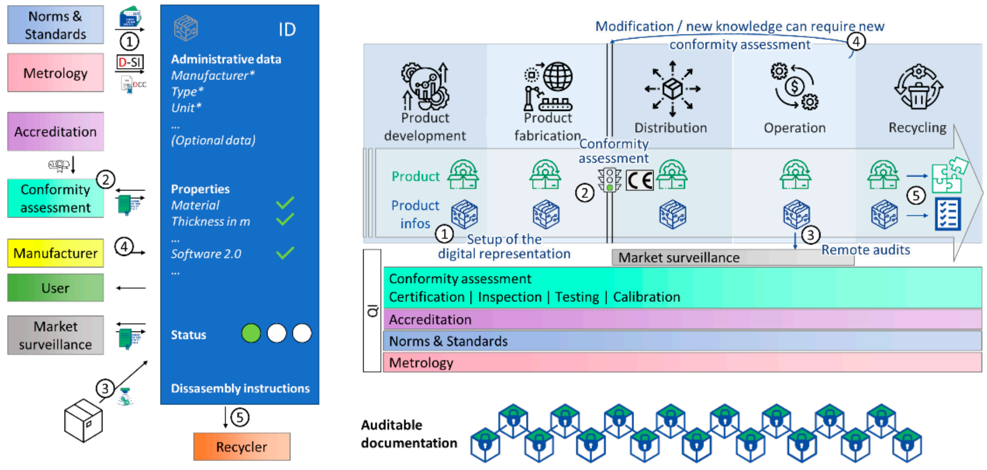

Fig. 1.: Critical points along a product's life cycle as well as corresponding QI processes and stakeholders.

From Fig. 1 we can collect important workflows for a digital QI platform: process initiation, retrieval of relevant norms and standards, providing product data relevant for the assessment (administrative data, test results, information from a calibration certificate, the accreditation status of the issuing laboratory), certificate distribution. In case the product is a digital asset (e. g., a software update), it should also be distributed over the same platform. Immutable process documentation, e. g. in form of a blockchain, makes the system auditable.

Initial developments towards the mutual access to information and data relevant for the digitalization of processes in the QI were undertaken in the initiative "European Metrology Cloud" [4]. The "Metrology Cloud" is a secured network of participants from the quality infrastructure. In this concept, data owners share their data with the network via mutual interfaces provided with the Metrology Cloud. That is, no data is circulated between parties unnecessarily, whilst still being able to support and streamline processes in the QI. A software could realize the automation of the QI processes based on the available data. Moreover, each network participant has a certain role, which specifies the information that is visible and accessible. As part of the initiative "QI-Digital" [2], the original Metrology Cloud will be further developed into an infrastructure that supports the digitalization of general processes in the quality infrastructure – the "QI Cloud".

Interoperability is the prerequisite to implement digital processes that involve more than one QI organization and to allow data flow between them via mutual interfaces. Moreover, it also allows to connect with the local infrastructures of companies and to enable them to readily integrate their own IT systems.

Importantly, the information should be distributed across the various sources, provided it can be found and accessed. Therefore, emphasis should be put on the adherence to the FAIR principles (findable, accessible, interoperable, and re-usable) in the design of the digital QI. Interoperability of data models is particularly important. For instance, information and data representation in a calibration certificate should ideally be very close, at least consistent, with the representation of similar information in a digital standard, an accreditation platform, etc. This minimizes the need for converters that add complexity and the potential for software bugs. This enables other entities (e.g., private companies) to contribute their solutions (e.g., lab software) to assist in improving and further streamlining the QI workflow. Automatically finding relevant information requires semantic information (PIDs, ontologies, etc.) and, thus, includes the transformation of human-oriented glossaries and definition lists into machine-readable knowledge representations.

In conclusion, we have described the digital tools for a fully digital QI. Note that likely also the regulatory framework will have to be adapted to fully support the digital processes.

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