European Partnership on Metrology
Call 2022 – Digital Transformation, Health, Integrated European Metrology, Normative and Research Potential

Selected Research Topic number: **SRT-d06**
Version: 1.0

Title: Metrology for digital transformation of quality control processes in advanced manufacturing industry

Abstract

Manufacturing operations in the EU need to modernise and innovate their technology to ensure longevity and competitiveness. A key factor toward that goal is the quality of manufactured products and the manufacturing process. Digital transformation will enable autonomous process, fully embedded digitised items into the production, thus ensuring traceability and uniformity of the digital approach, including digital calibration certificates.

Keywords

Digital transformation, quality, advanced manufacturing, CMM, metrology, machine learning, automated factories, product and process control, zero-defect manufacturing, digital twin.

Background to the Metrological Challenges

Efficient quality inspection in the manufacturing process is key to avoid defects. Minimising waste in production will also ensure the longevity of the product. Fully digitalised cyber-physical manufacturing requires that quality inspection and control processes are autonomous and digitally integrated with links to digital design and digital quality certificates (DQC).

Modern Coordinate Measuring Machines (CMM) are foremostly exploited for quality inspection in manufacturing with different sensor technologies. CMMs measurement tasks are automated and computer controlled. However, several issues prevent full efficiency and automation, such as the sensor technology and measurement strategy which is manual. In most cases, the measurement script controlling the movements of the measurement probe is manually generated. This process can take several days for an expert to complete. Afterwards, the measurement data is typically manually transferred and processed for the next steps in quality inspection. In the last few decades, instrument manufacturers have produced software to reduce the manual steps (Virtual CMM, automated script generation, statistical process control tools) but there is still a need for reduced workload and expertise requirements for the operator.

Measurement systems based on optical sensor technology, such as interferometry, photogrammetry, fringe projection or laser triangulation are also increasingly used for quality inspections, providing unique benefits in acquisition time and data density. Despite these benefits, optical sensors struggle to offer the same metrological data quality as traditional tactile CMMs. Thus, selecting the most suitable technology and measurement method within a task-specific quality control is a non-trivial task, depending on interrelated factors, such as metrological characteristics, inspection error risks/costs, and control effectiveness, which must be properly catered for, modelled, and estimated, according to the specific application.

The problem is exacerbated if one aims at the metrological quality control of bulk parts. Systems based on X-ray computed tomography (XCT) offer paradigm-shifting potential with the possibility to simultaneously provide quality control for geometry, form, texture, and subsurface/material inspection with a single sensor simplifying any fully digital data chain approach and enabling efficient generation of simulated/experimental digital twins. However, there are two major limiting factors. First is that no widely accepted standards have been published. Second, the costs associated with XCT are prohibitive, particularly for 100 % inspection of parts.

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Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the protocol.

The JRP shall focus on metrology research necessary to support digital transformation in manufacturing.

The specific objectives are:

1. To identify quality inspection data approaches for online control of digital manufacturing. To plan and design effective and cost-efficient in-line quality control procedures for at least two different use cases, using simulation of geometrical variation, Artificial Intelligence (AI) techniques, Machine Learning (ML) algorithms, and Digital Twins (DT).
2. To develop methods, knowledge, and rules for automatic selection of metrological instruments (tactile, optical and XCT) and measurement strategies. To develop methods for representing and storing measurement data (uncertainty, digital calibration certificate) for the use cases of objective 1.
3. To develop methods, knowledge, and rules for creating measurement protocols and selecting measurement parameters for the instrument selected in the previous objective. To develop methods to use measured data with a model of the manufacturing created for the purpose.
4. To provide metrological strategies to minimise defect propagation in the manufacturing process. To evaluate propagation of geometric variation in products and assembly by (i) approaching the goal of zero-defect manufacturing, (ii) minimising waste in the production and (iii) ensuring a long lifetime of the assembled product.
5. To facilitate the take up of the technology (digital twins and digital certificates) and measurement infrastructure developed in the project by the measurement supply chain, standards developing organisations (ISO 23952:2020 - Automation systems and integration - Quality information framework) and end users (aerospace, automotive, maritime, energy and medical industry).

These objectives will require large-scale approaches that are beyond the capabilities of single National Metrology Institutes and Designated Institutes. To enhance the impact of the research, the involvement of the appropriate user community such as industry, standardisation and regulatory bodies, and other European Partnerships is strongly recommended, both prior to and during methodology development.

Proposers should establish the current state of the art and explain how their proposed project goes beyond this.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 1.7 M€ and has defined an upper limit of 2.4 M€ for this project.

EURAMET also expects the EU Contribution to the external funded beneficiaries to not exceed 35 % of the total EU Contribution across all selected projects in this TP.

Any industrial beneficiaries that will receive significant benefit from the results of the proposed project are expected to be beneficiaries without receiving funding or associated partners.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the ‘end user’ community, describing how the project partners will engage with relevant communities during the project to facilitate knowledge transfer and accelerate the uptake of project outputs. Evidence of support from the ‘end user’ community (e.g. letters of support) is also encouraged.

You should detail how your JRP results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the manufacturing sector.

You should detail other impacts of your proposed JRP as specified in the document “Guide 4: Writing Joint Research Projects (JRPs)”

You should also detail how your approach to realising the objectives will further the aim of the Partnership to develop a coherent approach at the European level in the field of metrology and include the best available contributions from across the metrology community. Specifically, the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards
- the metrology capacity of EURAMET Member States whose metrology programmes are at an early stage of development to be increased
- organisations other than NMIs and DIs to be involved in the work.

Time-scale

The project should be of up to 3 years duration.