EMPIR Call 2017 – Industry, Fundamental, Normative and Research Potential

Selected Research Topic number: **SRT-r05**
Version: 1.0

Title: Research capabilities for coordinate metrology, contact measurement probes and stylus instruments

Abstract

The surface finish of manufactured parts is an important parameter for quality control as it relates to the functionality of the parts. Coordinate measuring machines (CMMs) with contact measurement probes and stylus instruments are used to characterise form and for surface roughness measurements. There is a need for traceable calibration of form and surface roughness measuring standards with uncertainties of 10 nm – 100 nm as well as a need for CMMs to have associated traceable methods which achieve submicron uncertainty levels for complex measurement objects. These needs require NMIs to improve their scientific knowledge, instruments, methods and research capability for coordinate metrology, contact measurement probes and stylus instruments.

Keywords

Surface roughness, tactile systems, form measurements, coordinate metrology, Coordinate measuring machine (CMM), error mapping, stylus instruments, contact measurement probes

Background to the Metrological Challenges

The surface finish, including both form and surface roughness, of manufactured parts is an important parameter for quality control as it relates to the functionality of the parts. A significant proportion of component failure starts at the surface due to either an isolated manufacturing discontinuity or gradual deterioration of the surface quality. Improvements in the calibration of form and surface roughness standards will enable various industries to obtain traceable and more reliable measurements of form and surface finish parameters. Surface finish can be measured using CMMs with contact measurement probes for form and stylus instruments for surface roughness. Both types of measurement are performed in dynamic mode.

Flick standards are used to provide traceability for contact measurements probes, these are primarily calibrated using fully characterised form measuring instruments. For emerging NMIs, if no calibrated flick standard is available, they have to develop the capability to calibrate their own measuring device and the customer flick standards in order to provide traceability. The calibration of flick standards is also an important issue for experienced NMIs. The results of a recent EURAMET comparison (EURAMET Project 649) between experienced NMIs revealed a partly unsatisfactory agreement between the measured values and strongly varying measurement uncertainties reported by the participating institutes, which do not seem to be consistent with the observed deviations. Work is needed to address these issues for both experienced and emerging NMIs. Depth setting standards/spheres are used to provide traceability for stylus instruments and are primarily calibrated using special interference microscopes however these are not available in most NMIs. An alternative method is to use piezo capacitive sensors that are traceable to laser displacement interferometers as these are available in most NMIs. However this approach requires a good knowledge and understanding of stylus instruments and their performance in dynamic mode.

Due to the demand for higher efficiencies and lower uncertainties CMMs have to work in scanning/dynamic mode which requires more complex measurements. Currently, the traceability and reliability of CMM measurements are provided through reference measurement artefacts, and measurements are performed in laboratory conditions according to ISO 10360. In complex measurements, the standard CMM verification procedure cannot be directly applied especially with sub-micrometre targeted accuracies. Additional influencing factors, such as environment conditions, clamping, and deflection due to gravity, related to both the CMM and the measurement object need to be taken into account. Nowadays, implementation of laser-interferometric techniques for calibration and error-mapping of CMMs is gradually increasing. The desire to improve the quality of products and requirements for improved accuracy for the measurement of more

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complex structures, particularly in countries with developing capability, requires better understanding and implementation of appropriate CMM measuring techniques to achieve lower uncertainties and reliable measurement results. This requires a close cooperation between metrology institutes to characterise, analyse and thus assess the reliability of the measurements.

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 the development of metrological capacity for surface and form measurements and coordinate metrology.

The specific objectives are:

1. To develop traceable and cost effective measurement capabilities for the calibration of form and surface roughness standards with uncertainties in the range 10 nm – 100 nm, including the development of noise reduction methods.
2. To develop novel methods for investigations of measurement probes and stylus instruments in unconventional measurement conditions.
3. To develop and implement modern error characterisation and elimination methods to reach submicron uncertainty levels for different multi-axis CMM machines.
4. To develop methods, applicable to CMM machines, for selecting measurement strategies, point densities, clamping, deflection due to gravity, and traceability routes for complex measurement objects.
5. For each participant, to develop an individual strategy for the long-term development of the capability developed including regulatory support, research collaborations, quality schemes and accreditation. They should also develop a strategy for offering calibration services from the established facilities to their own country and neighbouring countries. The individual strategies should be discussed within the consortium and with other EURAMET NMIs/DIs, to ensure that a coordinated and optimised approach to the development of traceability in this field is developed for Europe as a whole.

Joint Research Proposals submitted against this SRT should identify

- the particular metrology needs of stakeholders in the region,
- the research capabilities that should be developed (as clear technical objectives),
- the impact this will have on the industrial competiveness and societal needs of the region,
- how the research capability will be sustained and further developed after the project ends.

The development of the research potential should be to a level that would enable participation in other TPs.

Proposers should note that the programme funds the activity of researchers to develop the capability, not the required infrastructure and capital equipment, which must be provided from other sources.

EURAMET has defined an upper limit of 500 k€ for the EU Contribution to any project in this TP, and a minimum of 100 k€.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 10 % of the total EU Contribution to the project.

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,
- Provide a lasting improvement in the European metrological capability and infrastructure beyond the lifetime of the project,

- Facilitate improved industrial capability or improved quality of life for European citizens in terms of personal health or protection of the environment,
- Transfer knowledge to the engineering sector and the metrology community.

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 EMPIR 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.