EMPIR Call 2016 – Energy, Environment, Normative and Research Potential

Selected Research Topic number: **SRT-r06**
Version: 1.0

Title: Research capabilities in CMM metrology

Abstract

Manufacturing and quality control often require accurate and complex characterisation of products in three dimensions and industrial requirements are increasing. Advances in sensors, metrology software and controller technologies and improvements in measurement strategies and techniques will offer higher accuracy and improved capabilities for industrial CMM users. The new generation of sensors delivers a huge amount of data to produce a comprehensive characterisation of the measured objects, leading to the need to assess their quality and functional properties as accurately as possible. These developments will require smaller or emerging NMIs/DIs to develop their scientific knowledge, instruments, methods and research capability in 3D coordinate metrology to meet the new industrial demands.

Keywords

CMM, 3D measurements, research potential, error mapping, traceability, automation of measurements

Background to the Metrological Challenges

Nowadays modern industrial measurements undertaken as part of manufacturing and quality control processes often relate to geometrical dimensioning and tolerances, and this increasingly involves measurements made using coordinate measuring machines (CMM). In many industrial companies, the measuring volumes can be up to (1000 mm x 1000 mm x 2000 mm) for complex manufactured products such as turbines, car engines etc. For larger objects such wind turbine gear boxes, marine propulsion systems, high-accuracy robotic measuring arms and portable optical CMMs are often used. The general guidelines for ensuring correct functioning and providing reliability of CMM measurements are described in the ISO 10360 series of standards.

At present, industrial CMM users generally rely on laboratory calibration of a limited range of measurement artefacts such as gauge blocks, step gauges, ball plates, ring gauges, ball bars etc. At the workshop level, the accuracy and precision of industrial machinery (e.g. CNC machines) are verified with a number of methods, for example ball-bar tests, NAS or similar cutting tests, laser interferometry etc. The manufactured products are subject to quality control assessment using simple measuring equipment, e.g. height gauges, horizontal length machines etc, which lack the capabilities for 3D measurements (2D is possible to some extent). The use of such measuring equipment together with a combination auxiliary fixtures necessary for complex measurement tasks introduces unknown error sources and leads to incorrect measurement results. 3D CMMs are an attractive alternative to other common measuring instruments and are used for more sophisticated measurement tasks, however linking their performance to standard CMM verification procedures can be difficult. For such tasks, the principle of virtual CMM can be used for assuring traceability of measurement, however, such a calibration is very expensive and is mostly used for high level laboratory measurements.

An adequate understanding of the error components associated with the practical use of CMMs on the production floor is often lacking due to the versatility of available CMMs. The situation becomes even more complicated as the targeted accuracy improves, e.g. below micron level, as additional influencing factors related to both the CMM and the measurement object need to be taken into account e.g. environment, clamping, deflection due to gravity. The desire to improve the quality of products and requirements for improved accuracy for the measurement of more complex structures, particularly in countries with less developed capability, requires better understanding and implementation of appropriate CMM measuring techniques to achieve lower uncertainties and reliable measurement results.

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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 the development of metrological capacity in CMM metrology.

The specific objectives are

1. To increase understanding of, to develop and to implement modern error characterisation and elimination methods to reach submicron uncertainty level for CMM metrology, e.g. error separation using ball plate and similar standards, adoption of the concepts proposed in standard ISO10360-2 and multilateration with laser tracers, particularly related to different multi-axis machines such as tactile and optical CMMs, measuring arms, and industrial CNC stations.
2. To develop methods for selecting measurement strategies, point densities, clamping, deflection due to gravity, and traceability routes for complex measurement objects such as advanced automotive and aircraft parts, marine components, precise machine-tool parts, and medical products.
3. To develop methods for the automated calibration of transfer standards up to 1000 mm, e.g. gauge blocks by CMM using the substitution method, step gauges using a combination of CMM and laser interferometers or using a novel interferometric step gauge concept.
4. To undertake a comparison using CMM to evaluate the methods and techniques developed.
5. For each participant, to develop an individual strategy for the long-term operation of the capacity 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 manufacturing and industry sector that uses CMMs 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.