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

Selected Research Topic number: **SRT-i02**
Version: 1.0

Title: Traceable metrology for optical CMMs and quantitative microscopy in industry

Abstract

Optical dimensional metrology systems are widely used in quality control applications in industrial manufacturing, but a European calibration infrastructure for optical bidirectional quantities is currently lacking. Traceable and accurate dimensional optical measurements are necessary to support industry, therefore proposals in response to this SRT should address this issue by developing traceable methods for optical bidirectional measurements in industry using optical Coordinate Measuring Machines (CMMs) and quantitative microscopes.

Keywords

Bidirectional measurements, optical distance sensors, optical microscopy, machine vision, optical coordinate measurement machines

Background to the Metrological Challenges

In order to provide the necessary quality control in industry, measurement methods are needed which are able to provide high accuracy geometrical data much faster than tactile CMMs. Optical sensors are fast, non-destructive, contamination-free and suitable for in-line process control and in-line metrology applications. Thus there is an ongoing trend to replace tactile (mechanical) probing systems with optical sensors. However, measurements of industrial workpieces using CMMs equipped with optical sensors are often not traceable to the unit of length due to the workpiece characteristics, e.g. geometry, roughness and colour, influence on the measurement results.

Many investigations have previously been carried out to compare optical CMMs and to realise appropriate reference standards, as well as attempts to simulate the actual performance characteristics of optical sensors. However, in many cases traceability can only be achieved using workpieces calibrated with tactile probes in combination with a time consuming substitution method, and industry-level optical bidirectional measurements are limited to an uncertainty level of greater than 1 µm.

Currently internationally recognised bidirectional optical calibrations are lacking and according to the BIPM database only two laboratories offer optical linewidth (one example of bidirectional measurements) calibrations of end user samples. Furthermore, there is only one accredited laboratory worldwide, which can calibrate bidirectional measurands, but only on special types of photomasks. Therefore a metrological European infrastructure for the accurate calibration of optical CMMs and quantitative microscopes is needed.

The EURAMET Technical Committee for Length roadmap ‘Advanced manufacturing’, whose target is “robust 3D short range metrology 1 µm < L< 10 mm and 3D metrology L < 20 m” has highlighted that “procedures for verification, optimisation and calibration of non-contact and large scale measuring systems are essential as error sources and influences of measurement instruments of laser-and vision-based systems, laser trackers, photogrammetry are less known to metrologists”. In addition to this, ISO TC213 WG10, which is responsible for the (currently under development) standard ISO 10360-13 for optical 3D-CMS, has identified the need to consider the influence of the surface characteristics of the measured object.

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

EURAMET MSU, Hampton Road, Teddington, Middlesex, TW11 0LW, UK
Phone: +44 20 8943 6666 Email: msu@npl.co.uk
msu.euramet.org

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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 traceable bidirectional measurement and characterisation of 3D geometries using optical Coordinate Measuring Machines (CMMs) and quantitative microscopy in industry.

The specific objectives are

1. To develop validated methods to quantify the effect of workpiece characteristics, in particular size, shape and surface properties, on unidirectional and bidirectional measurements using optical 3D coordinate measuring systems (CMSs), optical CMMs and quantitative microscopy. This should include the development of test procedures, test artefacts representing typical scenarios, and simulations of optical signals.
2. To develop traceable and validated methods using optical distance- and video sensors and quantitative microscopes for the bidirectional measurement of surface features from 0.5 µm to a few millimetres with measurement uncertainties below 0.1 µm. The methods should be applicable to a wide range of different materials and include the development of a simulation software.
3. To establish a metrological European infrastructure for the accurate calibration of optical CMMs and quantitative microscopes. This will should include the development of a good practice guide for the use of optical bidirectional measurements.
4. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain e.g. metrology tool suppliers and calibration laboratories, standards developing organisations e.g. ISO TC213 WG10, and end users e.g. photonics industry, automotive industry and biomedical industry.

Proposers shall give priority to work that meets documented industrial needs and include measures to support transfer into industry by cooperation and by standardisation. An active involvement of industrial stakeholders is expected in order to align the project with their needs – both through project steering boards and participation in the research activities.

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 1.5 M€, and has defined an upper limit of 1.8 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 30 % of the total EU Contribution to the project.

Any industrial partners that will receive significant benefit from the results of the proposed project are expected to be unfunded 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 photonics, automotive and biomedical sectors.

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.