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

Selected Research Topic number: **SRT-n11**
Version: 1.0

# Title: Standards for the evaluation of the uncertainty of coordinate measurements in industry


## Abstract

Manufacturing is highly dependent on measurements, particularly for quality control purposes. Dimensional and coordinate measurements play a significant role in this and are used in automation and complex geometries in a wide range of processes ranging from prototyping to mass production and from micro components to large parts. In terms of coordinate measurements, industrial processes should comply with EN ISO 14253-1 and EN ISO 15530 standards. However, current methods for uncertainty evaluation lack any practical application for use in the industry. Therefore there is a need to develop simplified and validated methods for predicting the uncertainty of coordinating measurements in industry as well as a need to developing traceable methods that improve the validity of existing methods e.g. EN ISO 15530-3 and prEN ISO 15530-4.



## Keywords

Uncertainty, coordinating measuring, coordinating measuring system, coordinating measuring machine


## Background to the Metrological Challenges

A specific challenge in dimensional metrology is that the measurands are inherently coupled with the geometry of the inspected workpieces, which is virtually infinite in its possible instances. This is not only because of a continuous range of possible values, resulting in an infinity but because geometrical shapes also possess an infinite variety of possible combinations. Compared to other dimensional instruments, coordinate measuring systems or more specifically coordinate measurement machines (CMMs) are the option that addresses this challenge with sufficient generality without specialisation to individual measurement tasks.

However, due to this generalisation CMMs are challenging in terms of evaluating their uncertainty. This is not only due to their complex behaviour and numerous uncertainty components (typically 200+), but because each infinite possible measurand requires its own specific uncertainty evaluation. For example, the measurement of the coaxiality of two opposite thin bores shares very little similarity with that of the radius of a large lens (or curvature or focal length), but both can be carried out with the same CMM.

A large measurement uncertainty in manufacturing is unwanted as the margin left for machining is narrower, leading to increased manufacturing costs. Therefore practical applications for the evaluation of uncertainty of coordinate measurements in industry are urgently needed. In support of this EN ISO 14253-2, which applies to dimensional inspections in manufacturing, states that uncertainty is an essential component and ISO TC 213 WG10 has recently tried to provide CMM users with standardised methods in EN ISO 15530.

However, the current EN ISO 15530 series is not complete and Parts 2 & 5 remain unpublished. Part 5 which was originally conceived when the ISO 15530 series was designed was to be a method based on expert judgement, i.e. type B evaluation of uncertainty. This method has the potential to cover a large range of measurements with very little or no experimental effort. However, no supporting evidence has been completed on type B evaluation as the work was abandoned due to a lack of resources.

Other Parts of ISO 15530 describe practical methods for the uncertainty evaluation of coordinate measurements. For example, Part 3 requires a calibrated workpiece almost identical (in shape, size and material) to the workpieces under measurement and therefore shifts the burden of traceability and uncertainty evaluation to whomever provides the calibrated workpiece. However, the availability of such workpiece is simply assumed and no guidance on how to calibrate or to evaluate the calibration uncertainty is provided. Further to this, Part 4 addresses simulation methods for uncertainty evaluation. However these


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



The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

require specialised CMM software extensions and extensive experimental investigation of individual CMMs prior to usage. Therefore improvement of the existing methods in in EN ISO 15530-3 and prEN ISO 15530-4 are urgently needed.

## 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 metrology research necessary to support standardisation for the evaluation of uncertainty of coordinate measurements in industry

The specific objectives are

1. To develop traceable and standardised methods for evaluating coordinate measurements a posteriori. This should include the improvement of existing methods in EN ISO 15530-3 and prEN ISO 15530-4.
2. To develop a simplified and validated method for predicting the uncertainty of coordinating measurements a priori using type B evaluation (i.e. expert judgement).
3. To demonstrate the validity of existing methods and those from objective 1 & 2 in industrial conditions and evaluate their consistency and accuracy against the Guide to the Expression of Uncertainty in Measurement (GUM) and its supplements.
4. To contribute to revisions of EN ISO 15530 and EN ISO 14253-2 by providing the necessary data, methods, guidelines and recommendations, in a form that can be incorporated into the standards at the earliest opportunity. In addition, to collaborate with the technical committees CEN TC 290 and ISO TC 213 WG10 and the users of the standards they develop to ensure that the outputs of the project are aligned with their needs and recommendations for incorporation of this information into future standards at the earliest opportunity.

The proposed research shall be justified by clear reference to the measurement needs within strategic documents published by the relevant Standards Developing Organisation or by a letter signed by the convenor of the respective TC/WG. EURAMET encourages proposals that include representatives from industry, regulators and standardisation bodies actively participating in the projects. The proposal must name a “Chief Stakeholder”, not a member of the consortium, but a representative of the user community that will benefit from the proposed work. The “Chief Stakeholder” should write a letter of support explaining how their organisation will make use of the outcomes from the research, be consulted regularly by the consortium during the project to ensure that the planned outcomes are still relevant, and be prepared to report to EURAMET on the benefits they have gained from the project.

Proposers should establish the current state of the art, and explain how their proposed research goes beyond this and EMRP project NEW04 Uncertainty.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 0.6 M€, and has defined an upper limit of 0.8 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 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 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.

## Additional information

[1] CEN/CENELEC identified this topic as one of their priorities. Details are available at: https://msu.euramet.org/current_calls/pre_norm_2017/documents/SRT_related_CEN_priorities/cen_priority_007_2017.pdf