EMPIR Call 2019 – Energy, Environment, Normative and Research Potential

Selected Research Topic number: **SRT-r03**
Version: 1.0

Title: Improvement of the realisation of the mass scale

Abstract

In recent years, the requirements from industrial and technological sectors for mass metrology with uncertainties at, or beyond, the current state of the art has increased. Key to meeting these requirements is the reliable and effective realisation of the mass scale, with appropriate uncertainties, however, this capability does yet not exist in some small and developing NMIs. Proposers addressing this topic should focus on improving the realisation of the mass scale, in particular in emerging NMIs, through the development and implementation of appropriate traceability and calibration schemes including the subdivision method of calibration, the development and implementation of methods and software tools and the development of a draft EURAMET guide on the realisation of the mass scale.

Keywords

Mass standards, kilogram, mass scale realisation, mass scale dissemination, uncertainty, redefinition of the kilogram, CMC, traceability

Background to the Metrological Challenges

The measurement of mass is required in many aspects of our life: trade, healthcare, industry, including the pharmaceutical, petrochemical, construction and power generation industries, research and product development, and accredited calibration and verification laboratories. For a number of these end users direct traceability to the standards maintained by NMIs is required in order to achieve accuracy at the best level of the E1 class.

To meet current and future end user requirements, there are two challenges namely the realisation of the kilogram and the realisation of the mass scale. The first is the task of the leading national metrology institutes, particularly with the redefinition in May 2019 of the kilogram in terms of the Planck constant realised via the Kibble balance or the XRCD method with silicon spheres, the second remains a responsibility and prerogative of all NMIs which are responsible for maintaining the national mass scale.

Many small and developing NMIs have obtained modern and accurate weighing systems in recent years. However, due to limited experience many of these NMIs do not currently have the proficiency to realise the mass scale, as they cannot perform calibrations of a set of weights by the multiplication and subdivision methods starting from their 1 kg mass standard. These NMIs use sets of weights in range usually from 1 mg to 20 kg, which are calibrated by other NMIs. However, once the uncertainties of the calibration and the contributions of instabilities due to the transport conditions that often cause variations in the mass of the weights, the uncertainties do not fulfil the requirements for the calibration of mass standards at the level of class E1. There are other drawbacks to this approach as firstly calibrations in other NMIs takes time which leaves the institute without their highest reference standards, secondly due to the cost and time involved the mass sets may not be calibrated as frequently as recommended. Introducing the subdivision method of calibration into these laboratories would improve their measurements capabilities and meet the increasing demands of industry for better accuracies, while at the same time saving time and money.

Automation of the weighing procedures has already been or will shortly be implemented in many of these laboratories. Automated or robotic systems generally improve the efficiency and the repeatability of the measurements and more importantly they enable a large number of weighings to be performed in a short period of time. In order for this data to be easily elaborated and analysed sophisticated mathematical and software tools are required.

Some recent comparisons (e.g. CCM.M-K5) have included a number of discrepant results, indicating a need for better procedures for the realisation of the mass scale and for maintenance of the traceability. For a number of laboratories, the current realisation techniques are based on the unsatisfactorily short description in the

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international recommendations OIML R 111 and in some publications. A detailed guideline for dissemination of mass scale, which allows calibration of mass standards at E1 level or better, does not yet exist The EURAMET project 1210 (Best practice for dissemination of the kilogram collaboration in traceability) reviewed the current situation in many laboratories and concluded that the procedures used varied considerably between laboratories.

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 realisation and dissemination of the mass scale.

The specific objectives are

1. To analyse the methods for realisation and dissemination mass scale (e.g. 1 mg – 20 kg) including the impact from the recent redefinition of the kilogram, and to create an appropriate methodology in order to optimise different technical requirements and parameters (e.g. robustness, effectiveness, small uncertainty, properties of different weighing instruments, different types of weight sets, number of control weights or standards).
2. To develop and implement calibration methods to realise, improve and maintain the mass scale (e .g. from 1 mg to 20 kg) in countries where mass scale measurement capabilities are less developed, taking into account the requirements and the metrological needs of stakeholders. New or improved measurement capabilities to be validated by inter-laboratory comparisons to establish the degree of equivalence.
3. To develop advanced mathematical and statistical tools and software solutions to calculate the results from mass measurements and to evaluate the associated uncertainties (including correlations between standards and measurements and handling of outliers). To validate the mathematical and statistical tools via simulated and experimental data.
4. To develop a EURAMET guideline for the realisation of the mass scale in the range from 1 mg to 20 kg, including the establishment of reliable dissemination schemes and methods to check and improve the long-term mass stability (including examples involving different equipment and methods to be used to extend or reduce the range of calibration) and to submit it to EURAMET for approval.
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 including members of relevant the EMNs or JRPs, 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 JRP(s) or/and the joint European metrology structure initiative they refer to,
- 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 or European Metrology Networks.

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 0.5 M€ for the EU Contribution to any project in this TP, and a minimum of 0.1 M€.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 10 % of the total EU Contribution across all selected projects in this TP.

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, including the related JRP or EMN as applicable,
- 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 pharmaceutical, petrochemical, construction and power generation sectors, accredited calibration and verification laboratories 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.