EMRP Call 2011 - Health, SI Broader Scope & New Technologies

Selected Research Topic number: **SRT-n02**
Version: 1.0

Title: Traceability for computationally-intensive metrology

Abstract

Whilst a well-developed metrological infrastructure is available to prove traceability of physical measurement, for many newer metrology systems their output depends critically on complex computation. For all but the simplest computational tasks, the user has no way of knowing if the software implementing the computation is generating the correct answers. Traceability mechanisms have not kept pace with the expanding and enabling role of computation within metrology and action is required.

Conformity with the Work Programme

This Call for JRPs conforms to the EMRP Outline 2008, section on "Grand Challenges" related to Health, New Technologies & Fundamental Metrology on pages 14-15 and 42-43.

Keywords

Algorithm, computation, mathematical modelling, numerical artefact, software validation, numerical calibration, computationally-intensive metrology, Internet services, data analysis.

Background to the Metrological Challenges

Traceability requires that measurement results can be linked to standard units through an unbroken chain. If the chain involves computation, as it does in almost all modern measuring systems, it is necessary that all computational links are recognised explicitly and known to be operating correctly.

In an era in which metrology was essentially embodied in hardware, establishing traceability was achieved through a series of calibrations, performed according to documented/validated methods or documentary standards, using reference artefacts. The visibility of the traceability scheme was achieved through the calibration certificates along with the documented/validated methods or documentary standards. For metrology systems involving significant computation implemented in software, there are few comparable traceability mechanisms in place.

Complex metrological software modules are often embedded in measuring instruments. More recently, more and more software packages are available on the market that import measured coordinates (point clouds) and perform a large range of computations on them, often based on simple trial-and-error techniques. These software packages are independent products and are not tied to physical measurement: what needs to be traceable in this case is not a physical device – with embedded software – but the software package itself.

As an example, the problem is particularly acute in applications utilising intensive computation such as coordinate metrology involving complex geometries. There are of the order of 50 000 coordinate measuring machines in the EU, each using complex algorithms to measure a range of artefacts, so the impact of poorly performing software is potentially large. For measurement results that are determined from significant computation, there can be no real concept of traceability without proper consideration of the computational links in the chain. Developers of metrology software may well work hard to test and validate their software but they have no method of demonstrating to users, through an independent assessment according to internationally accepted procedures, that their software meets their requirements. From a user's point of view, they run software supplied as part of measurement systems every day but have no way of knowing if the software is working correctly or not for their particular application. Quality engineers have to ensure that measurements are traceable but for computationally-intensive metrology applications there is, in general, no accepted route for establishing traceability. The NMIs are tasked with enabling traceability to standard units for the complete range physical measurements. The metrological community rightly expects that the NMIs will provide approaches to ensuring traceability for computational links in the measurement chain.

Recent developments in internet-based services have revolutionised how software is used and maintained on computers. For example PCs might be constantly updated with software upgrades available in a 'cloud', often with the user unaware that these changes are made. The same technology has the potential to be used to deliver software validation or numerical calibration in a way that requires minimal user interaction and provide protocols to ensure that software components are maintained and validated, i.e., kept "in calibration".

Scientific and Technological 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 JRP-Protocol.

The JRP shall focus on the development of mechanisms, methods, references and the associated technology, to enable demonstration of the traceability and correctness of complex software and computational algorithms used in computational intensive metrology.

The methods to be developed shall have an underpinning character for a wide field of metrological applications.

The specific objectives are

1. To identify and prioritise computationally-intensive metrological key applications on the basis of stakeholder input.
2. To develop and validate a mechanism to enable a formal statement of the computational aim in clear, unambiguous terms to be available for use by the software.
3. To develop and validate reference data or 'numerical artefacts' associated with computational aims.
4. To develop and validate criteria to assess the performance of software, for example numerical correctness of the software and fitness of purpose of the software.
5. To develop and validate an ICT infrastructure to perform the software validation or 'numerical calibration', for example database of computational aims, numerical artefacts, data exchange within the NMI network, automatic certification taking into account information security, digital signatures, legal and commercial aspects.

ISO and other standards bodies shall be included at an early stage in order to enable the development of documentary standards for computationally-intensive metrology areas.

These objectives will require large-scale approaches that are beyond the capabilities of single National Metrology Institutes and Designated Institutes. To enhance the impact of the research, the involvement of the appropriate user community such as industry, and standardisation and regulatory bodies, is strongly recommended.

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

The total eligible cost of any proposal received for this SRT is expected to be around the 2.7 M€ guideline for proposals in this call.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the "end user" community. This may be through the inclusion of unfunded JRP partners or collaborators, or by including links to industrial/policy advisory committees, standards committees or other bodies. Evidence of support from the "end user" community (eg letters of support) is encouraged.

You should detail other impacts of your proposed JRP as detailed in the document "Guide 4: Writing a Joint Research Project"

You should detail how your JRP results are going to:

- feed into the development of urgent documentary standards through appropriate standards bodies, such as ISO and CEN
- transfer knowledge to industrial and engineering sectors
- transfer knowledge to the metrology community and professional organisations

You should also detail how your approach to realising the objectives will further the aim of the EMRP to develop a coherent approach at the European level in the field of metrology. 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 Member States and countries associated with the Seventh Framework Programme whose metrology programmes are at an early stage of development to be increased
- outside researchers & research organisations other than NMIs and DIs to be involved in the work

Time-scale

The project should be of up to 3 years duration.