European Partnership on Metrology
Call 2022 – Digital Transformation, Health, Integrated European Metrology, Normative and Research Potential

Selected Research Topic number: **SRT-n07**
Version: 1.0

Title: Digital sensitivity monitoring for industrial computed tomography by new gauges for Industry 4.0 and common applications down to 500 nm resolution

Abstract

Over the past 10 years the use of Industrial Computed Tomography (iCT) has grown exponentially, compared to other non-destructive testing (NDT) techniques. iCT is used as a quality assurance method used in industrial production including Industry 4.0 and common applications down to 500 nm resolution. However, the detection sensitivity of iCT systems is currently evaluated by human operators using objects with artificial or natural flaws, which can lead to human errors in iCT sensitivity. To address this issue, new test gauges with traceably calibrated features need to be manufactured for use with automated digital iCT evaluation, based on spatial-spectral noise frequency analysis that predicts the visibility of details in comparison to the new test gauges. To support the use of these new test gauges for automated digital iCT evaluation, input to and revision of the EN ISO 15708 series 'Non-destructive testing — Radiation methods for Computed Tomography' is needed.

Keywords

Industrial Computed Tomography, sensitivity monitoring, spatial resolution, gauges, Industry 4.0

Background to the Metrological Challenges

The global NDT market has been estimated as 10 billion US$ with an annual growth rate of approx. 7 %. iCT is an NDT method used in the (i) electronics industry, (ii) in industrial production (from the nm scale to large scale castings and complex parts such as cars or engines) and (iii) in additive manufacturing. iCT was developed from a scientific research technique into an industrial quality assurance tool, that can be used for the evaluation of products e.g. dimensional measurements and the characterisation of flaws. However, to date there are no standards that cover iCT methods.

In the US, ASTM International, (formerly known as American Society for Testing and Materials), has begun the process of updating its standards to include iCT via Committee E07 on NDT. To support the competitiveness of European industry CEN and ISO need to catch-up. There are currently four parts to the EN ISO 15708 series, but iCT is not yet included. This issue is particularly important as iCT is used by many industrial sectors as a quality assurance tool and hence used for testing the conformity and safety of products.

Currently, the sensitivity of iCT systems is evaluated by human operators using reference quality indicators, which are manufactured parts with artificial or natural flaws, similar to the material and geometry to be evaluated and the flaws to be detected. However, human detection can lead to human errors in the sensitivity monitoring (contrast sensitivity and spatial resolution) of iCT systems. New digital applications, such as in Industry 4.0, also require automated measurement and evaluation of iCT systems as well as surveillance of their performance in industrial applications. Therefore, more, accurate and reliable methods for automated digital iCT evaluation are needed, together with, new test gauges with traceably calibrated features.

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 metrology research necessary to support standardisation in digital sensitivity monitoring for iCT as needed for Industry 4.0 and common applications down to 500 nm resolution.

The specific objectives are

1. To develop accurate and reliable methods for iCT evaluation based on spatial-spectral noise frequency analysis and comparison with multi-scale gauges with traceably calibrated features. In addition, to develop and manufacture the multi-scale gauges with traceably calibrated features from a few mm down to 500 nm.
2. To improve existing numerical models of iCT systems and determine their detectability limits for noise and resolution performance (spatial and contrast resolution). The models and data should then be used to create iCT digital twins, that can predict the detection sensitivity of iCT systems including measurement uncertainties.
3. To develop reference software for iCT systems for the analysis of the detectability limits for small defects (down to 500 nm resolution). Long-term stability monitoring is required for quality assurance and should be developed based on a fully automated algorithm for evaluating the defect detectability of iCT systems using spatial frequency analysis of the contrast modulation and the contrast-to-noise distribution.
4. To validate the methods, test gauges, models and software developed in Objectives 1, 2 and 3 by performing intercomparisons. To then use the results to provide (i) sensitivity information, and (ii) detail detection limits, including uncertainties, for automated digital iCT evaluation, taking into account the requirements of Industry 4.0.
5. To contribute to a revision of the EN ISO 15708 series by providing the data, methods, guidelines and recommendations, which are necessary for the standardisation of iCT to CEN TC 138 WG 1 and ISO TC 135 SC5. Outputs should be in a form that is consistent with (i) ASTM E07.01 and (ii) the need stated in 015 CEN TC 138 digital sensitivity monitoring industrial computed tomography, and should be able to be incorporated into the standards at the earliest opportunity and communicated through a variety of media to the standards community and to end users (in the electronics industry, industrial production and additive manufacturing sectors).

The proposed research shall be justified by clear reference to the measurement needs within strategic documents published by the relevant Regulatory body or 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. In particular, proposers should outline the achievements of the EMPIR projects 17IND08 AdvanCT and 18NRM07 NanoXSpot and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 0.8 M€ and has defined an upper limit of 1.2 M€ for this project.

EURAMET also expects the EU Contribution to the external funded beneficiaries to not exceed 30 % of the total EU Contribution across all selected projects in this TP.

Any industrial beneficiaries that will receive significant benefit from the results of the proposed project are expected to be beneficiaries without receiving funding or associated 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 electronics industry, industrial production and additive manufacturing 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 the Partnership 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

The references were provided by PRT submitters; proposers should therefore establish the relevance of any references.

[1] *015 CEN TC 138 digital sensitivity monitoring industrial computed tomography*

https://www.metpart.eu/go/need15