EMPIR Call 2020 – Fundamental, Industry and Normative

Selected Research Topic number: **SRT-i24**
Version: 1.0

Title: Quality assurance of high value metal additive manufactured components for aerospace and space applications

Abstract

Additive manufacturing (AM) has experienced a significant growth over the last decade and is a key technology for the factory of the future. Applications of metal additive manufacturing (MAM) on high value, critical components are limited due to lack of quality assurance of the manufacturing. The goal of this project is to develop non-destructive quality assurance framework for metal additive manufacturing for aerospace and space applications using X-ray computed tomography (XCT). An improvement in the quality of MAM products at lower cost and higher efficiency will enable both industries to strengthen their position in the global market and to improve competitiveness of European XCT manufacturers, significantly enhancing the competency of aerospace and space sectors.

Keywords

Aerospace, space, quality assurance, dimensional metrology, X-ray computed tomography, metal additive manufacturing, non-destructive testing, surface form and texture

Background to the Metrological Challenges

Additive manufacturing (AM), particularly metal additive manufacturing (MAM), has experienced a significant growth over the last decade and is a key technology for the factory of the future (FoF). Techniques are increasingly being used in aerospace and space industries for high value components such as jet engine fuel nozzles and landing gear manifolds. Studies suggest the global aerospace additive manufacturing market will reach $3 billion by 2025.

The two motivations behind this increase are cost saving and reduced emissions. Enabled by advanced MAM techniques high value critical components can now be designed and manufactured with complex structures resulting in weight reduction, lower capital expenditure, reduced lead time, reduced material and fuel use, better customisation and local manufacture as well as repair. In contrast to applications of MAM in other industries, the extremely high value components used in aerospace and space applications with require stringent quality control and the quality assurance of these MAM components is a major barrier hampering their uptake. They require non-destructive inspection to evaluate both external and internal surface form and texture as well as to assess defects such as porosities and inclusions. At present, inspection of non line-of-sight features relies primarily on destructive tests, which are costly and time consuming. Limitations in current non-destructive techniques include depth of penetration in metal, thickness of materials, gaps between surfaces and low resolution of the imaging systems. Tolerances, surface finish, reproducibility, validation with a high level of confidence, process control to improve the precision and reliability of the manufacturing process are the challenges highlighted in space and aerospace applications. It is also emphasised that the quality and consistency of AM components should be well-maintained throughout all production cycles and corresponding standards should be established to allow certification of aerospace and space components.

Industrial X-ray computed tomography (XCT) is an emerging non-destructive technology that has dimensional capability of inspecting both internal and external features. The technology is superior to other non-destructive testing methods, owing to the capability to provide volumetric measurements of the test object, large depth of penetration in metal and high resolution to inspect small defects. EMPIR project 17IND08 AdvanCT studied the capability of XCT for dimensional metrology purposes but has identified areas where further improvement is needed. The geometric error calibration is currently primarily tested using spherical or cylindrical shaped samples, where the centre positions of these features are used to determine scale related issues within small cone angles. However, impact of systematic errors, such as cone beam errors, beam hardening errors, scattering on complex surface form and texture need to be evaluated. Robust calibration and traceability procedures for industrial XCT systems are lacking. Reference samples have been developed but they have predominately smooth surfaces compared to MAM parts and have visible and accessible features. Advanced reconstruction algorithms have been studied, but the process from reconstructed volumetric data to surface point cloud needs to be investigated.

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 traceable measurement and characterisation of high value metal additive manufactured components for aerospace and space applications.

The specific objectives are

1. To develop and calibrate a traceable tomographic measurement infrastructure for measuring MAM components. This should include the quantitative evaluation of type B errors (standard geometric, beam hardening, cone beam and scattering) and investigation into the limitations (e.g. spatial resolution and noise) of the technique.
2. To develop and manufacture reference samples with (i) external and internal surface form and (ii) surface textures concerning different MAM technologies, post-processing techniques and defects such as porosities. The samples should represent the typical features used in aerospace and space applications and be accessible using conventional instruments. In addition, an XCT measurement strategy, traceable to conventional techniques, should be developed to quantitatively evaluate and characterise these parameters.
3. To develop and validate an open access software from projection images to volumetric data to surface point cloud. This software should assess post-processes (e.g. reconstruction, surface determination and texture analyses) with a significantly improved efficiency.
4. To demonstrate, with appropriate aerospace and space case studies, suitable XCT measurement strategies for critical high value MAM components. The measurement uncertainty should be determined, evaluated and the results compared to CAD data.
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (NMIs and DIs), standards developing organisations (ISO TC 213) and end users (aerospace and space industries).

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. In particular, proposers should outline the achievements of the EMRP project IND59 Microparts and EMPIR projects 15HLT09 MetAMMI and 17IND08 AdvanCT and how their proposal will build on those.

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 across all selected projects in this TP.

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 aerospace and space 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.