EMRP Call 2012 – Open Excellence, Industry and SI Broader Scope

Selected Research Topic number: **SRT-i14**
Version: 1.0

Title: Development of novel non-destructive evaluation techniques and procedures for defect detection in composite structures

Abstract

A major barrier to the exploitation of fibre-reinforced plastic composites for primary load bearing and safety critical applications, such as commercial aircraft, bridges and off-shore platforms, is the availability of reliable and traceable procedures for the non-destructive detection and characterisation of both production and in-service defects. The JRP should develop and validate operational and calibration procedures for novel non-destructive evaluation (NDE) techniques, including microwave, active thermography, laser shearography and phased array ultrasonics to assess the detection, location and sizing of a range of defects in composite structures. The procedures which should be developed are expected to lead to improvements in safety, life expectancy, energy efficiency and sustainability, and to reductions in maintenance costs.

Conformity with the Work Programme

This Call for JRPs conforms to the EMRP Outline 2008, section on “Grand Challenges” related to Industry & Fundamental Metrology on pages 8, 14, 23, 26 and 42.

Keywords

Non-destructive evaluation (NDE), fibre reinforced plastic (FRP) composites, defect detection, defect sizing, microwave, ultrasonics, thermography, laser shearography.

Background to the Metrological Challenges

Composite materials are advantageous for manufacturers due to their higher performance and lower costs. The detection, identification and sizing of defects and damage that can reduce the strength and stiffness of a component and directly influence the safe working life of composite structures, needs to be addressed to enable composites to be used to their full potential. NDE techniques have been developed but few methods are used because standardised operational procedures are unavailable and because NDE is perceived to be too new, costly or complex. Also, there are no ISO NDE standards that are specific to defect detection in composites. Several ASTM composite NDE specific standards exist, but these are focussed on the aerospace sector. Widely applicable operational procedures need to be developed.

NDE is used to test high performance materials systems e.g. carbon fibre-reinforced plastics and metallic sandwich structures in the aerospace sector. The use of NDE in other sectors is not so straightforward: components are often thicker, more complex and variable in material quality. Also different types of damage and defects may be present. Existing procedures may be proprietary, too complex (requiring specialist knowledge) or even too simple.

NDE inspections are limited to visual inspection, tap testing, ultrasonic C-scan and X-ray radiography techniques. Such inspections are not necessarily suitable for inspecting complex composite structures (e.g. wind turbine blades – bonded hybrid structures), and not for investigating structures in service.

Novel NDE techniques such as microwave, active thermography, laser shearography and phased array ultrasonics show significant potential. However these techniques require further development and there is currently insufficient knowledge of their sensitivity and reliability for the inspection of complex composite constructions. There is a requirement to define detectability limits and probabilities of detection.

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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 traceable measurement and characterisation of novel non-destructive evaluation techniques and procedures for defect detection, location and sizing in composite structures.

The specific objectives are

1. To design and manufacture suitable reference defect artefacts (RDAs) that are representative of the materials and defects typically found in the aerospace, oil and gas, renewable energy, marine, transport and civil infrastructure sectors.
2. To develop operational procedures, drafted in the style of CEN and ISO standards, for microwave, active thermography, laser shearography, and phased array ultrasonic techniques. The metrology objectives are to:
    a. Comprehensively assess the probability of detection (POD) of each non-destructive evaluation (NDE) technique for the different defect types found in various composite material systems and formats.
    b. Establish the limits of detection for each technique i.e. the minimum sizes of defects that can be detected.
    c. Develop techniques for accurately sizing defects for the NDE techniques. The NDE results should be compared with independent characterisation.
3. To evaluate the POD methodology based on modelling simulations with the aim of reducing the cost and time requirements of POD trials.
4. To validate and refine operational procedures via intercomparison exercises and field trials in collaboration with industry. RDAs should be inspected using both in-house inspection techniques and the newly developed operational procedures.

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.

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. The available budget for integral Research Excellence Grants is 42 months of effort.

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 how your JRP results are going to:

- feed into the development of urgent documentary standards through appropriate standards bodies
- transfer knowledge to the aerospace, oil and gas, renewable energy, marine, transport and civil infrastructure sectors.

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

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 and includes 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 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.