EMPIR Call 2017 – Industry, Fundamental, Normative and Research Potential

Selected Research Topic number: **SRT-i06**
Version: 1.0

Title: Digitisation-ready metrology for drivetrain components

Abstract

The quality production of drivetrain components such as gears, shafts, and bearings is essential for the power transmission sector as geometrical deficiencies increase wear, minimise efficiency and can cause high operating or maintenance costs. Modern dimensional metrology, in the context of digitisation and the 4th Industrial revolution, is needed to fulfil the demands for increasingly fast, accurate, reliable, flexible and holistic measurements as set out in the Manufacturing Metrology Roadmap 2020. In addition, novel evaluation software and calibration strategies, are needed to meet the requirements for high-precision and traceable measurements of drivetrain components. This provision of a metrological infrastructure for the traceable measurement and characterisation of drivetrain components will support the competitiveness of the European drivetrain engineering industry from the wind energy system to the automotive scale.

Keywords

Drivetrain components, 4th Industrial revolution, digitisation, Manufacturing Metrology Roadmap 2020, optical sensors, multi-sensor systems, software testing, Model Based Definition, Digital Twin, in-situ metrology

Background to the Metrological Challenges

Highly accurate tactile measuring systems are currently used to measure the roughness, form, and dimensions of drivetrain components such as gears, shafts, and bearings. However, these systems are slow with most measurements taking up to 60 minutes to complete and consequently tactile measuring systems are only used to inspect certain areas of drivetrain components. To address this issue, new validated optical and multi-sensor systems, as well as existing high speed contact scanning methods using tactile probes, would offer comprehensive geometrical data (with uncertainties) on drivetrain components within a short time frame. This in turn would improve the economics of production quality control and it would ensure the reliability of ISO 14253 based conformity decisions.

The evaluation algorithms, and underlying models, used in the commercial measurement software for evaluating drivetrain components currently lacks verification. EMRP JRP NEW06 TraCIM addressed this issue in part by developing the "TraCIM system" which is an internet-based software validation system. However, the "TraCIM system" focused mainly on the validation of software for the fitting of geometric elements to data. Therefore, the measurement accuracy and reliability of software used for evaluating drivetrain components needs to be enhanced in order to improve the reliability of measurement results. In addition, novel methods for software testing, such as digital internet-based methods are needed, as well as a software test for gear evaluation parameters (needed to address the errors prone to gear geometry algorithms).

Further to this, measurement information for conformity checking and process control needs to be provided rapidly, during drivetrain component manufacturing, so that it does not slow down production. However, current verification or calibration procedures for coordinate measuring systems rely nearly exclusively on embodied standards which have to be measured in different positions using complex and time-consuming methods. This means that such verification measurements are rarely performed and any discrepancies are discovered too late. Therefore automated control and measurement processes, e.g. Model Based Definition (MBD) and Digital Twin software (to enable digital holistic workpiece characterisation), are needed during drivetrain component manufacturing in order to provide the link between the solid model and the measurement program of a measuring system, and an improvement in ISO 10360 testing.

Finally, validated and reliable calibration strategies are needed for in-situ machine tool drivetrain component inspection as these machines currently only implement basic metrological procedures and lack precise calibration. This limits both the achievable measurement accuracy and the production accuracy. The traceability of in-process dimensional measurements was investigated by EMRP JRP IND62 TIM and the results can be transferred to machine tools for drivetrain components. However, the accuracy of machine tool measuring stations needs to be investigated to ensure fast and flexible in-line measurements. In addition, self-calibration procedures for rotary axes were developed by the IND62 project but these need to be tested and transferred to the rotary axes of machine tools.

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 drivetrain components.

The specific objectives are

1. To develop validated optical and multi-sensor measurement systems for roughness, form, and dimensional measurements used for the evaluation of drivetrain components such as gears, shafts, and bearings. This should include (i) determination of the measurement uncertainty, and (ii) a comparison of the capabilities of the developed optical and multi-sensor measurement systems with existing high speed contact scanning methods using tactile probes.
2. To improve the measurement accuracy and reliability of the software used for evaluating drivetrain components. This should include the development of novel methods for software testing, such as digital internet-based methods, used for the reliable validation of measurement evaluation algorithms for drivetrain components.
3. To develop validated automated control and measurement procedures for measuring machines and workpieces for drivetrain components. This should include (i) an improvement in ISO 10360 testing, (ii) increased reliability by reducing error influences, and (iii) further development of Model Based Definition (MBD) and Digital Twin software to enable digital holistic workpiece characterisation.
4. To develop validated and reliable calibration strategies for in-situ machine tool inspection systems for drivetrain components. This should include (i) an evaluation of the accuracy of machine tool measuring stations for fast and flexible in-line measurements, and (ii) an assessment of the feasibility of developing self-calibration methods for rotary axis calibration.
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (accredited laboratories, instrument manufacturers), standards developing organisations (e.g. ISO TC 213 and ISO TC 60) and end users (the automotive and wind 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 projects NEW06 TraCIM, IND62 TIM and ENG56 DriveTrain 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 to the project.

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 automotive and wind 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.