EMPIR Call 2020 – Fundamental, Industry and Normative

Selected Research Topic number: **SRT-i19**
Version: 1.0

Title: Metrology for Emerging Wireless Technologies

Abstract

The European telecommunications industry plays a crucial role in development of emerging wireless technologies. Therefore, there is a need to develop the metrology to underpin the emerging wireless technologies such as the Internet of Things (IoT), 5G (fifth generation) and 6G (sixth generation) in order to give EU industries and academia a competitive advantage on the world stage. While standardisation and definition processes are ongoing for emerging wireless technologies, the key challenges are the lack of accurate, fast, low-cost, and traceable methods for the verification of new radio (NR) high-volume products. This has highlighted the need for new system-level measurements and their industrial adoption. The goal is to establish realistic and cost-effective traceable metrology for the IoT, intelligent antennas, over-the-air (OTA) tests of multiple-input-multiple-output (MIMO)/ massive MIMO, and millimetre-wave (mm-wave) wireless channel.

Keywords

IoT; 5G; 6G; new radio; mm-wave; intelligent antennas; MIMO; OTA testing; RF; wireless telecommunications.

Background to the Metrological Challenges

The digital economy such as high bandwidth mobile communication is an essential tool for wealth creation in Europe. Connectivity is becoming more reliable and is offering EU citizens a higher capacity to connect with over 8.9 billion mobile subscriptions by 2022. However, the challenge for communication networks is to scale up to meet these requirements and to provide new kinds of elaborate machine-to-machine systems and applications (e.g. autonomous vehicles, tracking/locating, big data, smart cities, etc.) using emerging wireless technologies such as IoT, 5G and automotive.

Furthermore, the addition of MIMO capability in 4G (fourth generation) has driven the need to develop testing methods for OTA systems in order to accurately evaluate emerging wireless system performance in realistic scenarios. In particular, for mm-wave band, the antenna and RF circuitry are highly integrated, i.e. without RF connection ports for conducted testing OTA is the only measurement method possible. Intelligent antenna systems can offer beam reconfigurability and smart connection functionality, but their practical evaluation presents significant cost and time issues. Operating emerging wireless technologies at a higher RF such as mm-wave and quasi-THz is a route to higher data bandwidth. Moreover, the recent use of graphene to intelligent antenna with frequency aging ability has supported its application to THz bands. However, their traceability, propagation channel, interference characterisation (especially for sparse multipath) and system-level testing present new challenges in a real-world environment.

Massive MIMO and mm-wave MIMO systems have been identified as a key element for addressing high data demands required for 5G and future communications. In the EU, 5G beamforming massive MIMO base stations that operates at sub-6 GHz and mm-waves are currently being real-world trialled, and several candidate methods are currently being considered. OTA testing for small MIMO capable terminals are also currently ongoing but there is currently no clear NR MIMO OTA test metrology that can handle Orthogonal frequency-division multiple access scheduling in time, frequency and space domain at the same time for the evaluation of the realistic wireless performance of base station and user equipment.

With the industrial adoption of multi-user MIMO (MU-MIMO), massive MIMO beamforming, beam reconfigurable intelligent antennas, and mm-wave in emerging wireless systems, industries, research communities and standardisation bodies are now facing new measurement challenges in NR OTA verification testing of products that meet desired performance parameters for fulfilling the diverse technological requirements. The time-burden of using existing RF exposure assessment methods applicable to specific absorption rate (SAR) and power density (PD) defined in IEC/IEEE International Standards needs to be addressed, especially, for high-volume beam reconfigurable product verifications. In addition, there is a lack of accurate, fast, low-cost, and traceable verification methods for NR high-volume products. Despite some key concepts being discussed for production verification, current test methods and equipment remained undefined and there is no underpinning metrology to support their development.

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 emerging wireless technologies.

The specific objectives are

1. To develop cost-effective NR OTA metrology to accurately evaluate device performance in realistic scenarios. This includes the development and verification of IoT ready methods that qualifies the measurement and quantifies the associated uncertainties for MU-MIMO and massive-MIMO systems in sub-6 GHz and mm-wave bands.
2. To develop time-efficient methodology for intelligent antennas measurement in order to reduce cost and time of testing small- and large-scale array antenna systems at sub-6 GHz and mm-wave bands with beam reconfigurable and smart connectivity capabilities. In particular, to develop real-time intelligent array antenna testbed and cost-effective traceable test methods for advanced software defined radios.
3. To develop methodology and characterise radio propagation channel and wireless coexistence for wide-bandwidth communications. This includes the characterisation of radio propagation channel up to sub-THz and wireless coexistence interferences between IoT, Vehicle-to-Everything (V2X), 5G, and emerging wireless systems.
4. To develop traceable and efficient RF exposure assessment methods for SAR and PD to address public health concern on using NR. This includes the use of advanced methods such as machine learning and statistical approaches to reduce cost, time and human compliance tests at sub-6 GHz and mm-wave bands applicable to versatile emerging wireless systems.
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain, standards developing organisations (ETSI and CEN) and end users (telecommunication industries, autonomous vehicles industries, big data and smart city stakeholders).

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 IND51 MORSE and EMPIR projects 14IND10 MET5G and 18SIP02 5GRFEX 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 telecommunications and electrical 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.