PhD THESIS

WIDE BAND ARRAYS AT SUB-MILLIMETER BANDS

- **Laboratory**
  - Institut d'Électronique et de Télécommunications de Rennes (**IETR**), UMR CNRS 6164. Rennes, France. www.ietr.fr
    - Département 'Antennes et Dispositifs Hyperfréquences' – Equipe BEAMS 'BEam Antennas up to Mm and Sub-mm waves'.

- **Doctoral school**: MathSTIC (https://ed-mathstic.u-bretagneloire.fr/)

- **Keywords**
  Connected arrays, wideband antennas.

- **State of the art**

  Connected arrays of slots and dipoles have become the technology of choice for compact, low profile, wideband and wide scanning antennas [1], [2]. The principle of operation consists in creating a continuous current distribution over the radiating aperture, avoiding resonances and reducing impedance variations at the array elements over very wide frequency and scan ranges. Such a concept has taken also different forms as Planar Ultra-wideband Modular Array (PUMA) [3], connected arrays of slots or dipoles [4] backed by a ground plane for unidirectional radiation and Continuous Transverse Stub (CTS) arrays [5]. The antenna stack-up may require several metallic layers (>4) [3] or separated circuits mechanically assembled [6]. These arrays can achieve record performance, with 5:1 impedance bandwidth with a scan range up to ±70° [6]. The band and visible range are improved by replacing the backing reflector with a stack-up of frequency selective surfaces (FSS) [7] or by loading the radiating aperture with Wide Angle Impedance Matching (WAIM) layers [8]. Anisotropic artificial dielectrics [9] have been also proposed to ease the fabrication in Printed Circuit Board (PCB) and avoid mechanical assembling but require more than 10 metallic layers. Recently, [10] has presented for the first time a 3×3 connected array of dipoles covering all allocated 5G bands in USA from 27.5 up to 72 GHz with a field of view of ±45°. Its limited scan range is due to packaging issues, confirming that fabrication and system architecture are key for such arrays. IETR has recently proposed CTS arrays links in the V- [11] and E-bands [12]. In D-band, a connected arrays in polystrata technology has been recently proposed with 4096 radiating elements [13].

- **Main goals**

  The PhD project addresses three major goals:

  ⇒ To propose a Green's function approach for the analysis of connected arrays at sub-millimetre bands taking into account technology constraints for the fabrication of such arrays. Losses, active reflection coefficient and scanning capabilities should be assessed.

  ⇒ To investigate the scanning capability and suitability of such antennas for next multi-band radiometers in the sub-millimetre bands.

  ⇒ To prototype and validate experimentally the numerical results with advanced technology as for example diffusion bounding of thin laminate plates and silicon micro machining.

- **Location and supervision**

  The PhD project will be held at the IETR, Rennes in the framework of a collaboration with the French Space Agency (CNES). The main supervisor of the PhD student will be Mauro ETTORRE IETR, CRCN CNRS

(mauro.ettorre@univ-rennes1.fr), David GONZALEZ-OVEJERO IETR, CRCN CNRS and Ronan SAULEAU, IETR, Professor. The student will be co-advised by Baptiste PALACIN from CNES. During the PhD program, the candidate may spend some time in the premises of CNES.

- **Candidate profile**

  The PhD candidate should hold a MSc degree M2R in electrical engineering, physics or an equivalent title recognized by the doctoral school MATISSE. In particular, he should master electromagnetic theory, physics, mathematics, and circuit analysis. A good level of spoken and written English is required.

- **Application**

  Interested candidate should send a detailed CV and motivation letter by email to Mauro ETTORRE (mauro.ettorre@univ-rennes1.fr)

- **Examples of references**

[1] L. Shi, et al., "High-Efficiency and Wideband Aperiodic Array of Uniformly-Excited Slotted Waveguide Antennas, Designed through Compressive Sensing," IEEE TAP, 2019.

[2] L. Shi, et al., "High-Efficiency and Wideband Aperiodic Array of Uniformly-Excited Slotted Waveguide Antennas, Designed through Compressive Sensing," IEEE TAP, 2019.

[3] S.S. Holland and M. N. Vouvakis, "The Planar Ultra-wideband Modular Antenna (PUMA) Array," IEEE TAP, Jan. 2012.

[4] D. Cavallo, et al., "Connected-slot array with artificial dielectrics: a 6 to 15 GHz dual-pol wide-scan prototype," IEEE TAP, Jun. 2018.

[5] W. W. Milroy, "The continuous transverse stub (CTS) array: basic theory, experiment, and application," in Proc. APS., Sep. 1991.

[6] E. Yetisir, et al., "Ultra wideband array with 70° scanning using FSS superstrate," IEEE TAP, Oct. 2016.

[7] M. Pasian, S. Monni, A. Neto, M. Ettorre, and G. Gerini, "Frequency selective surfaces for extended bandwidth backing reflector functions," IEEE TAP, Jan. 2010.

[8] C. Yepes, et al., "Angularly stable frequency selective surface combined with a wide-scan phased array," IEEE TAP, Feb. 2018.

[9] W. H. Syed, et al., "Wideband, wide-scan planar array of connected slots loaded with artificial dielectric superstrates," IEEE TAP, Feb. 2016.

[10] M.H. Novak, et al., "Ultra-wideband phased array for milli-meter-wave ISM and 5G Bands, realized in PCB," IEEE TAP, 2018.

[11] F. Foglia Manzillo, M. Smierzchalski, L. Le Coq, M. Ettorre, et. al, "A wide-angle scanning switched-beam antenna system in LTCC technology with high beam crossing levels for V-band communications," IEEE TAP, Jan. 2019.

[12] T. Potelon, M. Ettorre, L. Le Coq, T. Bateman, J. Francey, and R. Sauleau, "Reconfigurable CTS antenna fully integrated in PCB technology for 5G backhaul applications," forthcoming in IEEE TAP, 2019.

[13] J. W. Jordan et al., "Monolithically fabricated 4096-element, PolyStrata broadband D-band array demonstrator," 2019 IEEE MTT-S IMS.