PROJECT MAELSTROM

Modern approaches to enhanced electromagnetic sensing through Orbital Angular Momentum radar

MAELSTROM project addresses the exploratory assessment of vortex (orbital angular momentum, OAM) radar concepts for defence-oriented sensing applications. The project aims to evaluate whether structured electromagnetic wavefronts carrying angular momentum can provide measurable advantages over conventional beamforming techniques in selected operational contexts, without assuming their replacement of established radar architectures. The focus is placed on realistic radar use cases relevant to ISTAR, seeker-like tracking, and target discrimination, where angular information, robustness at low signal-to-noise ratio, or additional motion features may be beneficial.

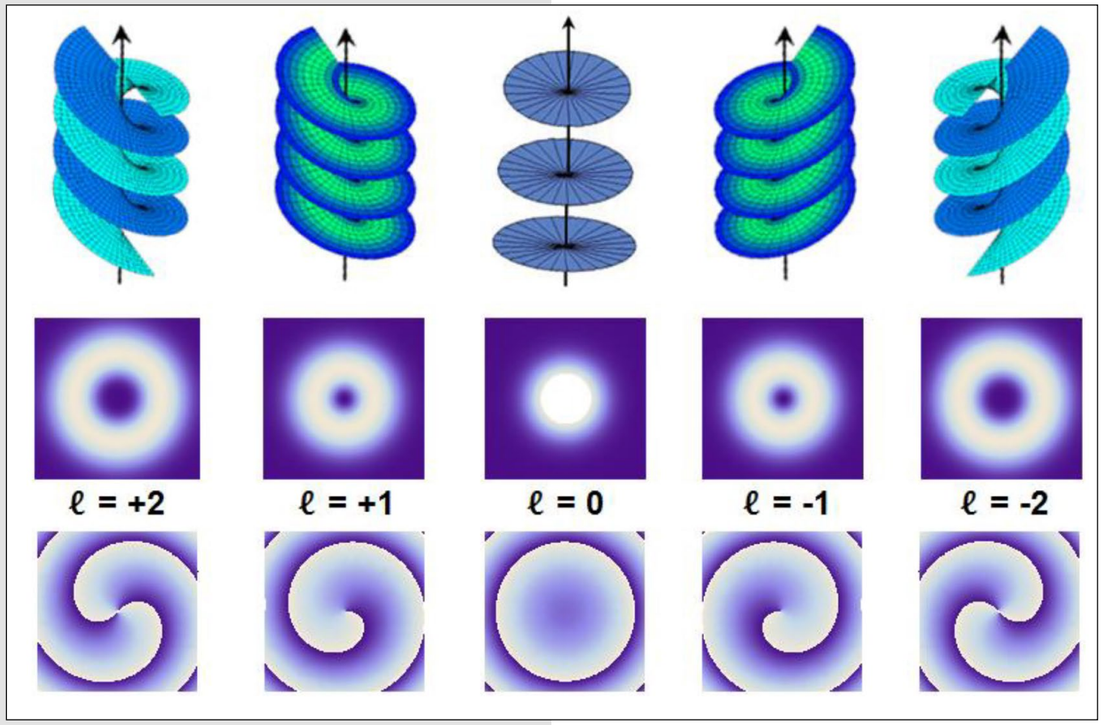
Within MAELSTROM, an extensive analysis of the international state of the art is combined with a structured consultation of stakeholders and end users from the defence community. This process supports the identification of operational scenarios, user needs, and technical constraints that are critical for the practical adoption of vortex radar concepts. The project investigates detection and tracking in challenging geometries, angular separation of closely spaced targets, and the exploitation of rotational motion signatures, with particular attention to the limits imposed by array geometry, calibration, and mode purity.

The outcome of the study is a consolidated set of user requirements, system-level considerations, and technology gaps, together with a realistic assessment of the current technological readiness level. MAELSTROM provides guidance on where vortex radar techniques may complement conventional solutions, clarifies their limitations, and outlines research directions necessary to progress towards operationally relevant demonstrations.

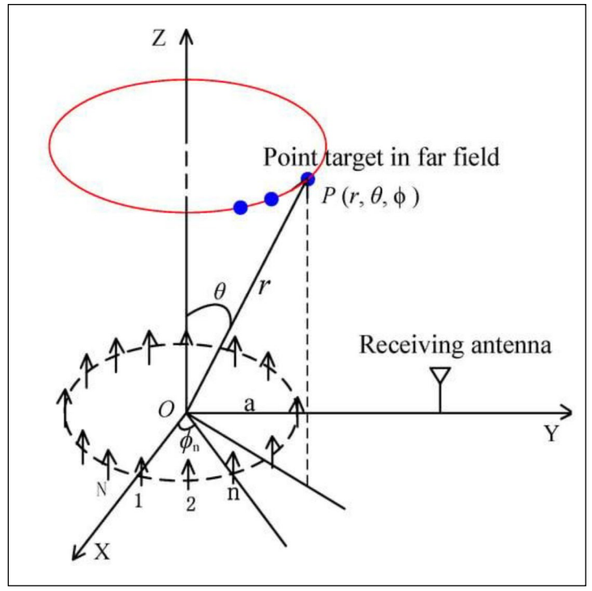
Keywords: Vortex radar, orbital angular momentum, beamforming.

MAELSTROM

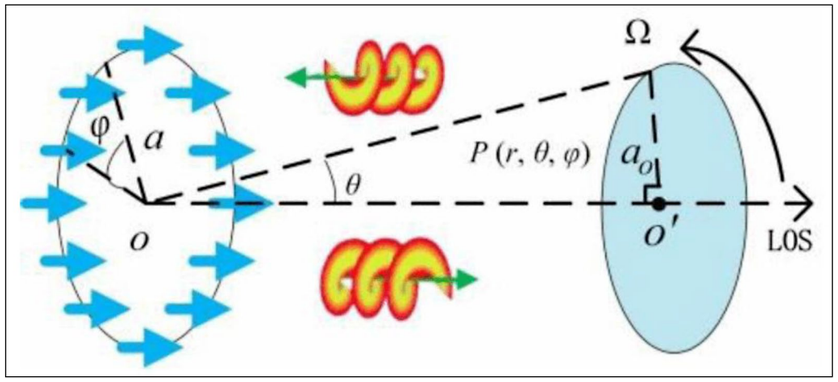
Technical Sheet
Funding institution:
EDA
Project partners
Fondazione Links, Warsaw University of Technology (WUT)
Project duration
March 2025 - ongoing
Involved countries
Italy, Poland



(a) Wavefront, amplitude and phase diagrams of a vortex wave depending on mode (RAI - Centro Ricerche e Innovazione Tecnologica (CRIT), "Progetti di ricerca e innovazione", available online at http://www.crit.rai.it/)



(b) UCA (Uniform circular Array) for OAM beamforming (from Yuan, T.; Wang, H.; Cheng, Y.; Qin, Y. Electromagnetic Vortex-Based Radar Imaging Using a Single Receiving Antenna: Theory and Experimental Results. Sensors 2017, 17)



(c) Vortex radar for rotational Doppler detection (from Z. Zhou, Y. Cheng, K. Liu, H. Wang and Y. Qin, "Rotational Doppler Resolution of Spinning Target Detection Based on OAM Beams," in IEEE Sensors Letters, vol. 3, no. 3, pp. 1-4, March 2019.