

1) Title of the tutorial:

RADAR, PHASED-ARRAYS, METAMATERIALS, STEALTH, ANTI-STEALTH, ULTRA-WIDEBAND, COGNITIVE-ADAPTIVITY, 5G, MIMO – BASICS, ADVANCES AND BREAKTHROUGHS

2) Instructors name and affiliation:

Dr. Eli Brookner: Raytheon Co. (Retired)

3) TUTORIAL SUMMARY:

BASICS: Active Electronic Scanned Arrays (AESAs). **RECENT SYSTEM DEVELOPMENTS:** Patriot upgrade; New AMDR AESA, 30X sensitivity of AEGIS. **LOW COST AESAs** using COTS. **EXTREME MMIC:** Whole 256 element phased array on chip at 60 GHz for future 5G and car radars. **DIGITAL BEAM FORMING (DBF):** mixer-less and reconfigurable; **MOORE'S LAW:** Future continuation of: via Spintronics, Memristor, Graphene, Quantum Computing. **LOW COST RADARS:** For cars, cell phones and smart wrist watches. **Ultra-Wideband (UWB) Radar.**

METAMATERIALS: for low cost 2-D Electronically Steered Antennas for satellites, cell towers, cars. UAV radars; Stealthing by absorption and by cloaking; Army conformal whip antenna replacement. **WIDEBAND LOW PROFILE ANTENNA:** 20:1 bandwidth.

MIMO (MULTIPLE INPUT MULTIPLE OUTPUT): Explained in simple physical terms instead of with heavy math. Performance, waveforms, signal processing load, ability to handle jamming. Contrary to what is claimed MIMO array radars do not provide orders of magnitude better resolution and accuracy than conventional array radars. Should not provide better GMTI. Applications presented.

COGNITIVE ADAPTIVE ARRAY PROCESSING (CAAP): Applied to barrage, hot clutter and repeater jamming for conventional and MIMO systems. Enabled by DBF. Tremendous advantages over classical methods. Results derived through simple physical explanation rather than heavy math that which does not give one physical insight into adaptive nulling. Show how CAAP re SMI reduces by **several orders of magnitude** the: 1) number of training sample needed, 2) the size of the interference matrix to be inverted, and 3) the amount by which the adapted sidelobes are degraded. Using CAAP show that MIMO does not provide better rejection of barrage, repeater or hot-clutter jammers than conventional array radars.

NEW TECHNOLOGY: HOLOGRAPHIC RADAR RADAR; QUANTUM RADAR; LOW COST PRINTED MICRTECHNOLLOWAVE ELECTRONICS; ELECTRICAL AND OPTICAL SIGNALS ON SAME CHIP. BIODEGRADABLE ARRAYS OF TRANSISTORS OR LEDs: Imbedded under skin. **NEW POLARIZATIONS -- OAMs (Orbital Angular Momentum).**

4) INTENDED AUDIENCE: Directed toward those unfamiliar and familiar with phased array radars. The phased array basics is at a level for those not familiar with subject and covers subjects that experienced would gain from. The breakthroughs and future trends material is aimed at all levels of attendees. Have lectured around the world on the subject successfully to college students, professors, practicing engineers and scientists of all backgrounds.

5) PREREQUISITES: First three years of bachelor's degree in electrical engineering or equivalent.