Phased Arrays for the New Millenium

Dr. Eli Brookner, Raytheon Systems Company

Tutorial Material: The Following Book Given Out FREE to Registered Attendees: Practical Phased-Array Antenna Systems, Dr. Eli Brookner, Editor, LexBook, 282 Marrett Road, Lexington, MA 02421 (formerly published by Artech House and still available from them), 1991, list price $96 in USA. Also given out free will be extensive course notes and paper reprints.

Course Overview: Phased arrays have seen a phenomenal growth in the last three decades. With the growing need for phased arrays for radar and communication systems (like the DD-X, F-22, JSF and Milstar), phased arrays are on the threshold of even more extensive use around the world. These accomplishments together with future trends will be covered:

- Passive phased arrays -- PATRIOT, COBRA DANE, AEGIS, ARTHUR, EMPAR, ARABEL, RAFALE RADANT;
- Discrete solid-state active phased arrays -- Swedish Erieye, Israeli Phalcon airborne early-warning system and Tactical Ballistic Missile Defense systems, PAVE PAWS, SMARTELLO, MARTELLO;
- Integrated-circuit, solid-state MMIC active phased arrays like the L-Band cellular-satellite IRIDIUM, Swedish ASEA, Japanese FSX, European COBR:\, Dutch APAR, European AMSAR, British MESAR-2 and SAMPS:\, and USA F-22, F-18, JSF, THAAD, SPY-3, MEADS systems;
- State-of-the-art of active array T/R modules -- MMIC and discrete; Time-delay steering;
- Narrow-band and Octave-bandwidth arrays; Single- and Multiple-Beam Array Systems;
- Digital Beam Forming (SMART-L, and --S; Discoverer-II); Sophisticated adaptive array algorithms and hardware like: 1) Space-Time Adaptive Processing (STAP), 2) Sidelobe C canceller with 63 degrees of freedom in a compact disc package, 3) Adaptive Nulling for jammer and clutter cancellation with massively parallel systolic arrays using Givens, Gram-Schmidt and Householder Algorithms, 4) Adaptive-Adaptive Array Processing; A/D’s can now sample at RF frequencies with no down conversion, e.g., at UHF 3 GHz, 8 bit A/D at room temperature; Phenomenal advances in signal processing speed and memory will make advanced algorithms feasible -- by 2015, 600 GFLOPS on 14” X 12” card, 64 Gbits on a chip, by 2010 3 TIPS on TMS320 chip; Ultra-Low Sidelobe antennas; Research to reduce cost and complexity by use of: 1) row-column Ferroelectric Lens antennas; 2) Continuous Transverse Stub (CTS) Antennas, 3) 95 GHz Reflectarray using two 4” MMIC wafers, 4) Micro-Electro-Mechanical Semiconductor (MEMS) Phase Shifters; Arrays that Electronically Scan Optical Beams; Multi-User (Radar, Communications, ESM, ECM) Shared-Aperture Antennas (AMRFS), Wideband-Antennas (ASAP: C-band to Ku-band; RECAP); Covered also: (1) Array Fundamentals: Phase and Time-Delay Steering, Grating Lobes, T-space (sine-space), Array Thinning, Blindness Phenomenon; (2) Array Errors: Effect on sidelobe level and directivity; (3) System Considerations: Beam shape and packing losses, sequential detection, array bandwidth and pulse distortion; (4) Element Types: Waveguide, dipole, microstrip, notch; bandwidth, cost, power handling considerations; (5) Array Feeds: Corporate, Butler, Blass, Serial, Lopez; Rotman; (6) Limited-Scanned Arrays: Fundamental Minimum number of Elements Theorem and its realizations; examples; use of spatial filters.
**Who Should Attend:** This tutorial is intended for engineers not familiar with phased-array antennas as well as the antenna specialist who wants to learn about other aspects of phased-array antenna systems, especially the latest developments and future trends.

**Short biography of Dr. Eli Brookner**

Dr. Eli Brookner is a Principal Fellow at the Raytheon Company where he has worked on the COBRA DANE, PAVE PAWS, BMEWS, COBRA JUDY, THAAD (formerly GBR), ASTOR, SPY-3, ASDE-X, Space-Based Radar, RADARSAT-2, Teledesic, and next generation IRIDIUM phased array programs, among others. He has published four books, the most recent being Tracking and Kalman Filtering Made Easy, John Wiley and Sons, Inc., 1998. His previous three books were Radar Technology (1977), Aspects of Modern Radar (1988), and Practical Phased Array Antenna Systems (1991), all published by LexBook (also available from original publisher Artech House). He has taught his radar course to over 8,000 around the world. He is a Fellow of the IEEE, AIAA and MSS. He was awarded the IEEE 2003 Warren White Award for Excellence in Radar Engineering “For Significant Advances in Development and Education of Phased Array Radars”.

![Image of phased-array antenna system](practical_phased_array_antenna_system.png)

![Image of Dr. Eli Brookner](eli_brookner.png)