

**TITLE:**

Electronic Scanned Array (ESA) Design

**TUTORIAL TOPIC:**

Electronic Scanned Arrays have expanded far beyond their initial defense applications in the mid-20th century into scientific, commercial and consumer markets. This proliferation is a consequence of enormous cost reductions driven by high volume production for consumer products, notably wireless communications, both voice and data, as well as personal computing.

The scientific theory and design approaches for ESAs were discovered and developed almost concurrently with the discovery of radio waves and development of communications applications. Initial application of ESAs required large budgets available only to governments but costs gradually diminished with the growth of the industrial base for components and manufacturing technology. With ESA costs no longer a dominant consideration, their substantial performance benefits make them increasingly popular.

The objective of this tutorial is to provide an introduction to the theory and application of electronic scanned arrays. The tutorial will discuss array theory, design principles and approaches, practical design considerations and exemplary applications, primarily in the field of radar. Numerical examples using Matlab will illustrate performance of specific designs.

**INTENDED AUDIENCE:**

Microwave engineers and managers.

**LEARNING OUTCOMES**

Participants will gain an understanding of the current theory and practice of ESAs applied to radar and communications.

**SUGGESTED PREREQUISITES**

The intended audience will have a general knowledge of radar principles.

**PRESENTER BIOGRAPHY**

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Mr. Williams has worked on Electronic Scanned Arrays since 1980. He worked on a number of radar systems and managed several T/R module, array development and

test programs during his employment at TRW, Hughes Aircraft, Raytheon Corporation and The Aerospace Corporation over the course of 40 years. He is the author of "ESA Design", to be published in 2020 by the SciTech imprint of the IET. He received his bachelor's degree from the California Institute of Technology and a master's degree from the University of California, both in physics. He holds two patents in the field.

## **SCHEDULE**

### Introduction and system applications

The presentation will describe the general design principles of aperture antennas applied to the specific case of ESA design. System applications will be discussed to set the framework for requirements allocation and flowdown. The relative merits of ESA and reflector antennas as well as ESA feeds for reflectors will be discussed

### Antenna attributes and figures of merit

Important ESA design issues will be described including:

- array partitioning and subarrays
- lattice tradeoffs
- feed design
- sidelobe causes and mitigation
- bandwidth
- mutual coupling
- errors and tolerances
- thinned arrays
- grating lobes
- beam steering

### Beam shape analysis and synthesis

Schelkunoff representation, Woodward-Lawson synthesis, beam broadening

### Practical design considerations and design process

ESA performance is constrained by the availability and limitations of specific components. The presentation will discuss the contribution of radiating elements, T/R modules, monolithic microwave integrated circuits (MMICs), microwave distribution and packaging to performance goals including tradeoffs to meet size, weight, power and thermal dissipation constraints.

### Operational and proposed examples

Recent radar satellite designs will be described to illustrate actual performance and design choices. Requirements, design alternatives and tradeoffs for a conceptual L-band antenna will be presented

## **PREVIOUS VENUES**

I have presented the tutorial several times as follows.

Tutorial Proposal for 2020 IEEE International Radar Conference  
 Electronic Scanned Array (ESA) Design  
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Date	Venue	Topics	Partici- pants
May 8, 2009	IEEE Radar Conference Pasadena, CA, USA	Electronic Scanned Array Design	30
October 15, 2010	IEEE Phased Array Conference Waltham, Massachusetts	Electronic Scanned Array Design	35
October 11, 2013	European Radar Conference Nuremberg, Germany	Electronic Scanned Array Design	25
October 10, 2014	European Radar Conference Rome Italy	Multibeam Antennas and Beamforming Networks/ Electronic Scanned Array Design	25
May 10, 2015	IEEE International Radar Conference	Electronic Scanned Array Design	25
October 7, 2016	European Radar Conference, London, England	Electronic Scanned Array Design	25
May 6, 2017	IEEE Radar Conference Seattle, WA, USA	Electronic Scanned Array Design	20
April 23, 2018	IEEE Radar Conference Oklahoma City, OK	Electronic Scanned Array Design	20
September 23, 2019	IET Radar Conference, Toulon France	Electronic Scanned Array Design	tbd