Ultra Wide Band Surveillance Radar

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Syllabus: This tutorial introduces the history and developments of multimode radar for air to ground surveillance. It is intended for a wide range of background from advanced undergraduates up to and including business and government program managers. The tutorial was developed for the 2018 IEEE Radar Conference in Boston, and it will have been given at the 2019 International Radar Conference in Toulon France. In Boston there were over 20 attendees, primarily due to the new material and some previously unpublished results on a multibeam radar. As a result of this 2018 tutorial, a new text book is in final draft for IET Publishing (but not in time for the 2020 IEEE International Radar Conference).

Description: Ultra Wide Band Surveillance Radar is an emerging technology for detecting and characterizing targets and cultural features for military and geosciences applications. It is essential to have fine range and cross-range resolution to characterize objects near and under severe clutter. This Tutorial is divided into five parts.

- **The Early History of Battlefield Surveillance Radar:** Battlefield surveillance from manned and unmanned aircraft, along with early experiments in fixed and moving target detection and foliage penetration are covered. There were some very interesting developments in radar technology that enabled our ability to detect fixed and moving objects in dense clutter. Examples of airborne phased array antennas and UWB radars will be summarized.
    - Battlefield Surveillance Radar History: GMTI and SAR
    - Early Battlefield Surveillance Systems: Ground Based and Airborne
    - Motivation for Tactical FOPEN SAR: First Implementation of UWB Radar
- **Surveillance Radar Modes**: Early radars recognized the need for multi-mode surveillance. Detection of fixed and moving targets were required to sense the position and movement of man-made objects and cultural clutter. As the success of early radars advanced; there were requirements for more resolution for characterization of the objects. Radar modes include

    - Radar waveform characteristics
    - Surveillance Radar Testbeds: MASR and HOWLS
    - Battle Field Surveillance Radar Modes: Frequency agility; Displaced Phase Center Antenna; Doppler Beam Sharpening; GMTI; SAR; Along Track Interferometry
- **UWB Phased Array Antenna:** Electronically scanned antennas are widely used for surveillance of large areas. Wideband waveforms place a significant demand on the ESA design to maintain gain and sidelobe characteristics. Design of ESA systems with time delay steering and digital beamforming will be described. Details of the development of UWB antennas include:
    - Electronic Scanned Antennas
    - Passive Phased Array Antennas: HOWLS, Multibeam Radar
    - Active Electronic Scanned Antenna: MIMIC Design; Time Delay Beamforming
    - Digital Beamforming and Equalization techniques
- **UWB Synthetic Aperture Radar (SAR):** A brief description of several UWB surveillance SAR systems will be provided, along with illustrations of the SAR image and fixed object detection capability. Techniques developed for ultra-wideband and ultra-wide-angle image formation will be presented. Topics include:
    - UWB SAR Characteristics
    - Wide Collection Angles and Range Migration
    - Image Formation: Back Projection and Range Migration Algorithms
    - Motion Compensation
- **UWB Ground Moving Target Indication:** Space time adaptive processing (STAP) has been used for over 20 years for detecting and tracking moving targets in clutter. As the resolution is improved for target characterization, the limits of STAP are tested. This section will discuss two approaches for increasing the bandwidth and maintaining geolocation accuracy: wideband STAP and Along Track Interferometry. System applications include:
    - Moving target detection from airborne moving platform
    - Space Time Adaptive Processing – UWB waveform impact
    - Along Track Interferometry for high resolution moving target detection
- **New research in Multi-mode Ultra-Wideband Radar**, with the design of both SAR and moving target indication (MTI) FOPEN systems. The last section of the tutorial will illustrate new technologies that have promise for future multimode operation: simultaneous SAR and GMTI in a multichannel radar. The applications and research on multi-mode, multi-channel processing will be given for:
    - Multi-beam Modular Survivable Radar: an early testbed for advanced radar mode applications
    - UWB multimode radar technology: Frequency jump burst, simultaneous SAR and GMTI operation; frequency agility for detection

Lecturer Biography: Dr Mark E Davis has over 50 years' experience in Radar technology and systems development. He has held senior management positions in the Defense Advanced Research Projects Agency (DARPA), Air Force Research Laboratory, and General Electric Aerospace. At DARPA, he was the program manager on both the foliage penetration (FOPEN) radar advanced development program and the GeoSAR foliage penetration mapping radar. Dr Davis wrote the text: "Foliage Penetration Radar – Detection and Characterization of Objects Under Trees", published by Scitech Raleigh NC in April 2011.

His education includes a PhD in Physics from The Ohio State University, and Bachelor and Master's Degrees in Electrical Engineering from Syracuse University. He is a Life Fellow of both the IEEE and Military Sensing Symposia, and a member of IEEE Aerospace Electronics Systems Society Board of Governors, past VP Conferences, and past-Chair the Radar Systems Panel. He is the 2011 recipient of the AESS Warren D White Award for Excellence in Radar Engineering, and the 2018 IEEE Dennis J. Pickard Medal for Radar Technologies and Applications.