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INTELLIGENCE & INFORMATION WARFARE DIRECTORATE

Presented by:

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CERDEC
US ARMY – RDECOM

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Army Phased Array RADAR Overview

MPAR Symposium II

17-19 November 2009

National Weather Center, Oklahoma University, Norman, OK

THE OVERALL CLASSIFICATION OF THIS BRIEFING IS UNCLASSIFIED

RADAR at CERDEC

- **Ground Based**
  - Counterfire
  - Air Surveillance
  - Ground Surveillance
  - Force Protection
- **Airborne**
  - SAR
  - GMTI/AMTI

RADAR Technology at CERDEC

- **Phased Arrays**
- **Digital Arrays**
- **Data Exploitation**
- **Advanced Signal Processing** (e.g. STAP, MIMO)
- **Advanced Signal Processors**
- **VHF to THz**

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Design Drivers and Constraints

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- **Requirements**
  - Operational Needs flow down to System Specifications
- **Platform or Mobility/Transportability**
  - Size, Weight and Power (SWaP)
- **Reliability/Maintainability**
  - Modularity, Minimize Single Point Failures
- **Cost/Affordability**
  - Unit and Life Cycle

RADAR Antenna Technology at Army Research Laboratory

- **Computational electromagnetics**
- **In-situ antenna design & analysis**
- **Application Examples:**
  - Body worn antennas
  - Rotman lens
  - Wafer level antenna
  - Phased arrays with integrated MEMS devices
  - Collision avoidance radar
  - Metamaterials

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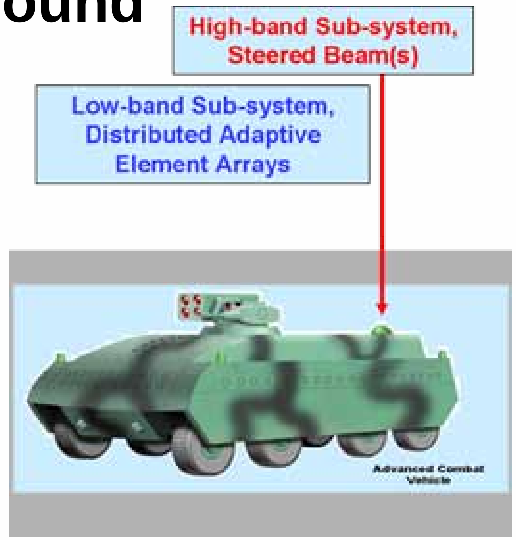
Antenna Modeling

ARL

- **CEM "Toolkit" requires expert users**
  - EM Picasso (MoM 2.5D) – modeling of planar antennas (e.g., patch arrays)
  - XFDTD (FDTD) – broadband modeling of 3-D structures (e.g., spiral)
  - HFSS (FEM) – modeling of 3-D structures (e.g., horn antennas)
  - FEKO & GEMACS (3-D MoM/FMM)
- **Ground plane models required for most Army applications**
- **In-situ antenna simulations – model the effects of structures, platforms, and the human body over lossy ground**
  - The radiation pattern of the antenna
  - The in-situ antenna impedance (bandwidth)
  - Co-site mitigation (multiple antennas or vehicles)
  - EMI/EMC and RAD HAZ issues
  - Low observables and signature management
- **HPC systems are required at high frequency**



Antenna Design Considerations

- **Antenna development for military applications is a collaborative process that involves DoD labs, universities and industry**
- **Antenna has to be designed with platform and environment in mind**
- **In-situ antenna design & analysis are essential to successful development**
- **New simulation tools are still needed for new frontiers, such as metamaterials and nano-designs**
- **Fully integrated, adaptive designs have been at the forefront of antenna research and development**
- **Wideband, low profile, high efficiency, polarization diversity and low cost are still requirements**

Phased Array RADAR at CERDEC

SOMISR II

- UHF building penetration radar
- Operated stationary for MTD and moving for SAR

SOMISR II Antenna

§ Antenna: Ultra wideband linear array of Vivaldi elements

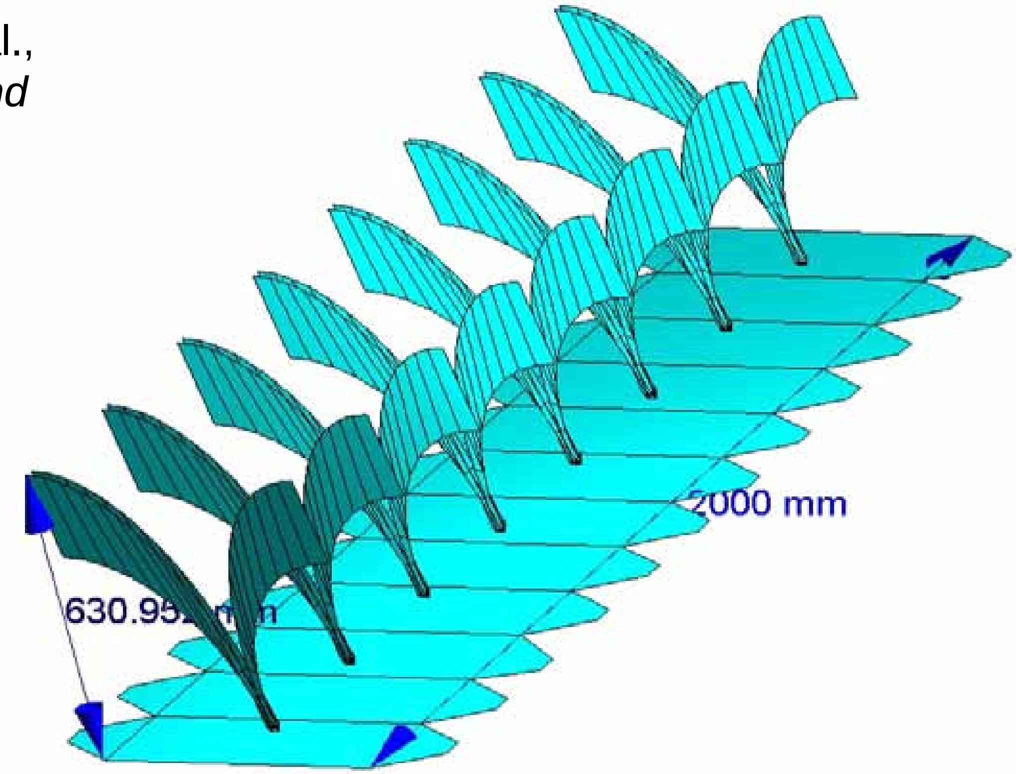
- Lightweight, relatively low cost, ~2 x ½m
- Six active elements, two dummy elements, no grating lobes
- Single transmitter would be switched between two end elements
- Six coherent UHF digital receivers, one at each active element
- Total FOV 60° digitally beamformed to eight beams of 7.1°

§ MIMO-inspired ping-pong type transmitter and digital beamformer

- Creates an effective virtual receive aperture
- Improves azimuth accuracy performance equivalent to conventional array twice the width
- Allowed for reduced size/weight
- Eight simultaneously formed receive beams

SOMISR II Eight-Element Array with Back Plane Plate Extensions

- **Vivaldi type flaired notch:** variant of the Balanced Antipodal Vivaldi [Langley, et. al., *IEE Proceedings-Microwave Antennas and Propagation*, Vol. 143, No. 2, April 1996]
- **Three layers of conductor:** upper and lower flair together, middle flairs in opposite direction; layers separated with low dielectric foam
- Naturally fed with stripline or coax or other unbalanced line
- Very wide bandwidth achieved with scaled “standard” design but that resulted in undesirably large element
- Single-element design required substantial additional modification when arrayed to remove resonance introduced by mutual coupling



FOPEN Reconnaissance, Surveillance, Tracking and Engagement Radar (FORESTER)

Objective: Persistent FOPEN GMTI radar surveillance to deny dismounted troops the ability to maneuver under foliage

Description:

- UHF GMTI/SAR radar to detect and track moving personnel and vehicles hidden or obscured by foliage.
- System is designed for the A160 Hummingbird (helicopter UAV)

Capabilities:

- Detect moving dismounts and vehicles under foliage
- Synthetic Aperture Radar mode
- Electronically steer beam to search a 90 degree sector
- Real-time onboard processing

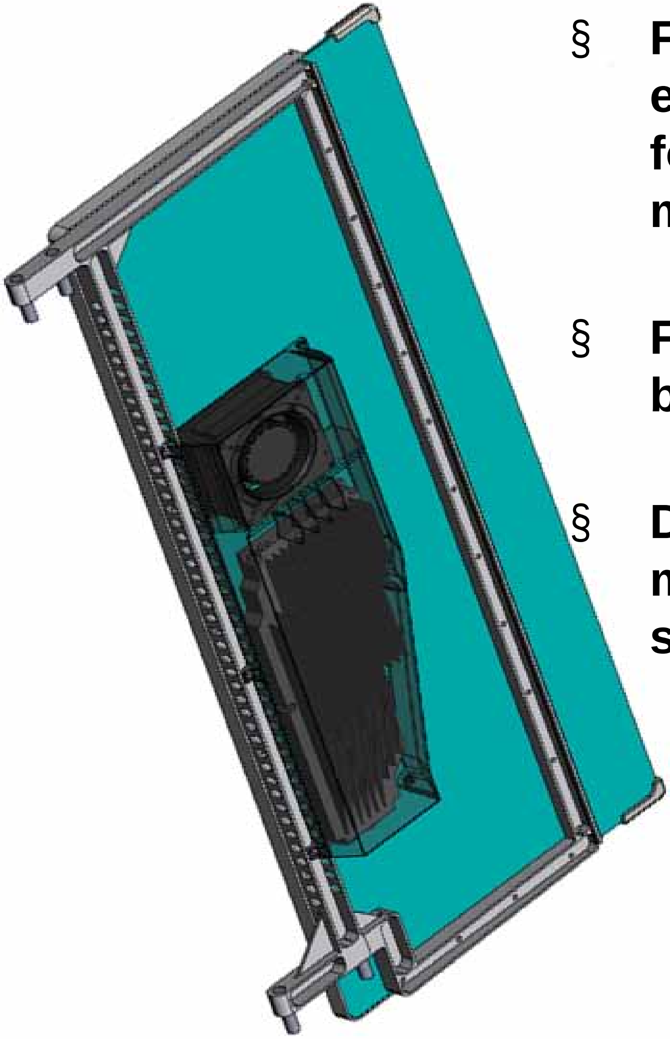
Status:

- Completed FORESTER/Black Hawk testing
- Completed FORESTER/ A160T testing

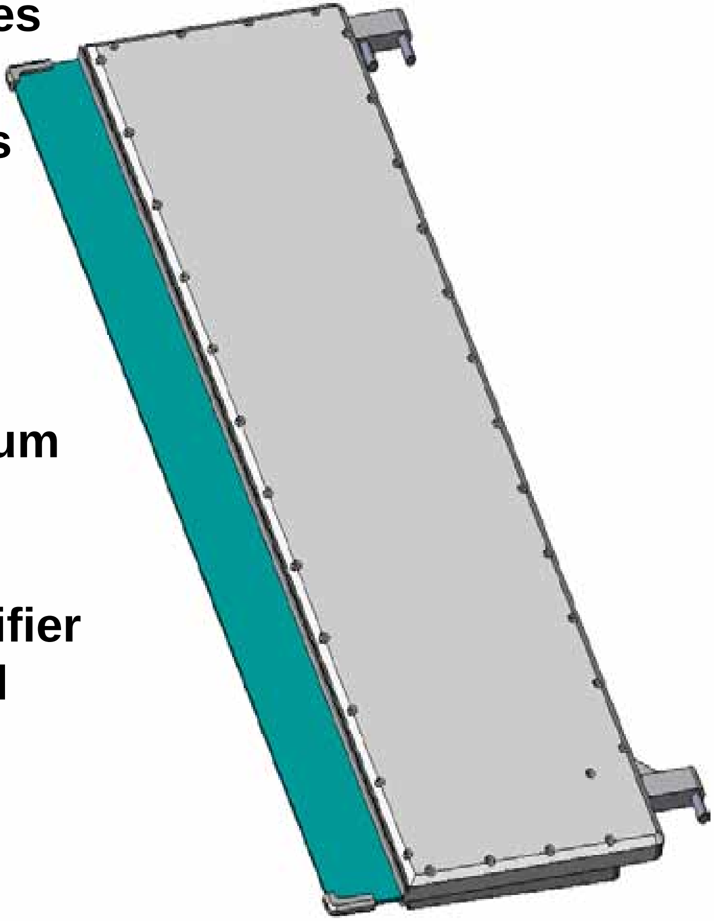
LCMR (V)3

- **L-Band**
- **Cylindrical Array**
  - Electronically scanned in azimuth – "Wullenweber" architecture
  - Dual fixed receive beams in elevation
- **Dual receive elevation beams (each with delta azimuth)**
- **Receive elevation beams formed with Blass Matrix**

LCMR (V)3 Antenna Column



- Linear array of six dipoles
- Forms two simultaneous elevation receive beams for amplitude only monopulse
- Forms single transmit sum beam
- Dual output power amplifier module provides several stages of amplification



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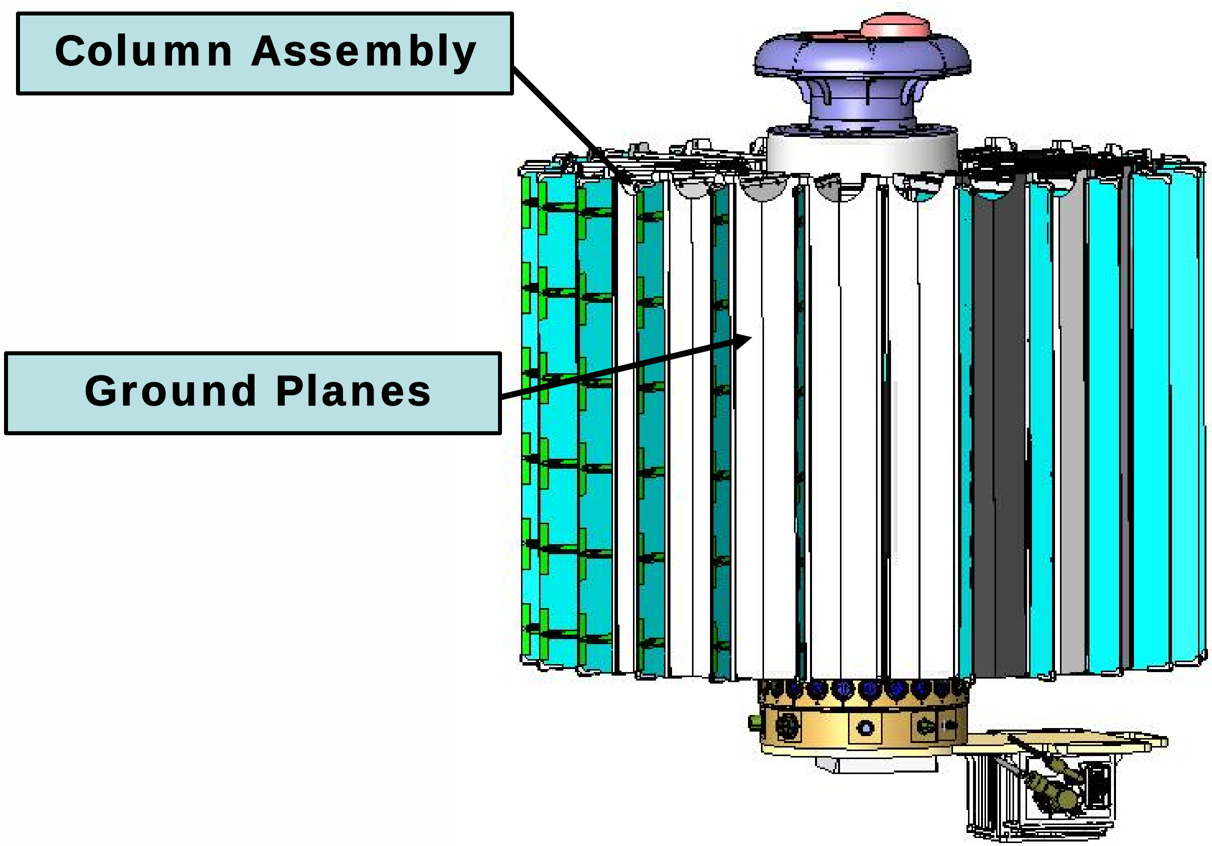
LCMR (V)3 Array



Array is comprised of 24 antenna columns (144 elements) arranged in a cylinder configuration. 8 columns used together to form a beam

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Multi-Mission Radar (MMR)

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- **Ground based radar for**
  - Air Surveillance
  - Counter Battery
  - Fire Control
  - Air Traffic Control
- **S-Band**
- **Planar Array**
  - Element level T/R
  - Phase steering in azimuth and elevation (+/- 45 degrees azimuth and +/-33 degrees elevation)
  - Rotates 360 degrees mechanically at up to 30rpm
  - Analog beamforming
    - Single transmit Sum beam
    - Three stacked beams in elevation each with delta azimuth

MMR

MMR system with Radome removed

MMR Octapak laying against the array face

MMR Octapak

Enhanced AN/TPQ-36 (EQ36)

- C-130 Transportable; Highly-Mobile
- Q-36/37 Performance in Small Footprint
- Soldier “Friendly” for Protection & Ergonomics
- 72-Hour Operation with Mission Essential Configuration
- IFPC Compatible
- Linked to AFATDS & FAADC2

Operations Control Shelter (OCS)

Mission Essential Group (MEG)

- Detect, Classify, Track Incoming Projectiles Mortars, Artillery (Cannon), Rockets
- 90˚ and 360˚ Capable
- Emplacement – 5 Minutes, Displacement – 2 Minutes; Auto Levels and Self-Align
- Miltope Laptop Control - Remote Control Display Unit (1 KM Range)

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Low-Risk Solution

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Existing Radars

AN/TPQ-36

AN/TPQ-37

The Army's Successful Solution

Highly Capable

TPQ-36 and 37 Performance in a Small Footprint

- Solid-State
- Electronic Steering 90º AZ. 65º EL
- Mechanical 360º Azimuth Rotator
- Flexible Radar Resource Management, Waveforms, and Processing

Significantly Upgrades Army Counterfire Target Acquisition Capability

- Range and Accuracy
- Operate in Severe Clutter
- High Probability of Location (>90%)
- Modern, Modular Design
- 360º Counterfire
- HMMWV-Based

Ruggedized, Producible, Supportable

Prototype Re-Use

- Radar System Design
- CTA Algorithm
- Antenna RF Architecture
- Digital Signal Processor Architecture

- Antenna Structure Optimized for Producibility
- Platform Optimized for Ease of Emplacement
- Signal Processor Optimized for Maintainability and Ruggedization
- Automated Leveling

The Army's EQ-36

Antenna Transceiver Group (ATG)

90º and 360º CTA

Pedestal Electronics Easy To Access and Replace

Antenna Group Levels Easily and Quickly Using Automated Leveling

Automatic ATG Leveling

Operations Control Shelter

Interoperable with Army Fire Control Systems

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Army Digital Array Radar Program (Army DAR)

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- Develop the technology and production building blocks for Digital Array Radars
- Develop a generic platform on which future advanced, low cost radars will be built
- Devise techniques for low cost integration of the active components with radiating panel
- Utilize efficient technologies to minimize power and thermal overhead
- Use modern digital transceiver technology for system for system-wide flexibility

Digital arrays offer significant improvements in the detection and tracking of challenging targets and overall radar system flexibility

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