CIMMS Accomplishments in Radar Engineering

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CIMMS 40th Anniversary Celebration
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Aren’t engineers cool?

“Engineering is the creative application of science, mathematical methods, and empirical evidence to the innovation, design, construction, operation and maintenance of structures, machines, materials, devices, systems, processes, and organizations for the benefit of humankind.”

-Wikipedia
Weather Radar Engineering

• **Radar Engineering** R&D areas

  – **Software**
    - Software infrastructure
    - Signal processing techniques

  – **Hardware**
    - Radar systems
    - Radar technologies
Some numbers

- **Doppler Weather Radar R&D** theme added in 1996
  - Evidence of radar R&D predates 1996
  - Recast as **Weather Radar R&D** in 2011

- **CIMMS employees make up 70% of NSSL’s Radar Division**
  - 14 out of 18 engineers in RRDD are CIMMS employees
  - The **Advanced Radar Techniques** team is 100% CIMMS engineers
Characteristics of Echoes from Alternately Polarized Transmission

by

M. Sachidananda

Cooperative Institute for Mesoscale Meteorological Studies
University of Oklahoma

and

D.S. Zrnic

National Severe Storms Laboratory
ERL, NOAA

July 1986

Cooperative Institute for Mesoscale Meteorological Studies
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Figure 6. Spectra of separated H and V samples for the same data as in fig. 4.
WSR-88D Open Systems

- Interoperability
- Portability
- Open standards
WSR-88D Open Systems

ORPG (1996)

ORDA (1996)

OPUP (1997)
• Radar signals are **messy**!
• Users need **clean** radar data
Signal Processing Examples

Getting Better Velocity Data

Staggered PRT Mode

Filtering Echoes from the Ground

Filtering with WET and CLEAN-AP

- Reflectivity
- Velocity
- Differential Reflectivity
- Correlation Coefficient
Research to Operations

**Research**
- Systematic Phase Coding (SZ-2) 2007
- Super Resolution 2008
- Coherency-Based Thresholding (CBT) 2014
- Radial-by-Radial Noise Estimator 2014
- Staggered PRT
- CLEAN-AP Ground Clutter Filter
- Weather Environment Thresholding (WET)
- Range Oversampling
- Hybrid-Scan Estimator (HSE)
- Improved DP Variable Estimators
- Wind Turbine Clutter Mitigation
- Polarimetric Spectral Densities
- Interference Filters

**Transition**

**Operations**

WSR-88D
CIMMS has a rich history of contributions related to the design, implementation, calibration, and enhancement of weather radar systems.
Phased Array Radar at NSSL

The National Weather Radar Testbed Norman, OK

From 2003 through 2016 the legacy NWRT PAR supported demonstrations of unique capabilities

Reflectivity at 0.5º - 20 May 2013 Moore, OK tornado

Rapid Updates

Conventional

Adaptive Scanning

Multifunction

Reflectivity at 0.5º plus aircraft tracks

courtesy of P. Heinselman (NSSL)

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An upgrade for the NWRT

- Advanced signal processing
- Adaptive weather observations
- Multifunction
- Modern technology
- Active array
- Dual polarization

The Advanced Technology Demonstrator has been developed over the last 5 years with funding from NOAA and the FAA (~$38M). CIMMS collaborates with government, industry, and other university organizations.
**Radar System Simulations**

1. **Define the Radar Architecture and Initial Scanning Configuration**
   - Reflector
   - Planar PAR
   - Cylindrical PAR
   - 4-faced PAR

2. **Select the Case**
   - **NCEI Archived Data**
     - Dual-Polarization
     - Wide variety of cases
     - Data processed with advanced DSP techniques
     - Publicly available
   - **Convective**
     - Data from the WSR-88D in Omaha, NE on 05/07/2015 (02:02:27Z)
   - **Stratiform**
     - Data from the WSR-88D in Grand Rapids, MI on 12/13/2017 (22:48:53Z)

3. **Run the Command and Control Loop**
   - Consecutive scans of Original Radar Data
   - Consecutive scans of Simulated Radar Data

   **Command and Control Simulator**
   - Temporal interpolation
   - SPARC Simulator
   - I/Q Data
   - DSP
   - Scan
   - Adaptive Scanning
   - Adaptive Scan
The next revolution is coming!
The next 40 years

• Operational use of **phased array radars**
  - Address technology obsolescence
  - Improve weather surveillance

• Filling **observation gaps**
  - Retrieve meteorological information from radar data to improve warnings and forecasts
  - Use hybrid observing-system networks to improve quality, availability, and coverage