Observations and Understanding

Phased Array Radar R&D Overview

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PAR Observations Improve Forecasts And Warnings

Grand Challenge to ensure NOAA has the best radar tools available to accomplish its mission

- Investigation of PAR and its abilities to provide the future weather radar observations requires NSSL to
  - Develop and evaluate cutting edge radar system technologies
  - Understand their application to weather radar operations
  - Inform NOAA’s acquisition decisions for the replacement of the WSR-88D network

OAR Strategic Plan (2020-2026)

GOAL 3

Make Forecasts Better
- Improve predictions
- Save lives and property

3.1 Develop interdisciplinary Earth system models
3.2 Design tools to forecast high-impact weather
  - Increase relevancy of forecasts
  - Improve understandability of observations
  - Better communicate the uncertainty

3.3 Transition science that meets users’ current and future needs
PAR R&D Funding History

- **SPY-1A Installation**
- **SPY-1A Improvements**
- **Meteorological Studies with SPY-1A Data**
- **Dual Polarization Panel Development**
- **Small-Scale Demo Development (CPPAR / TPD)**
- **ATD Development and Calibration Activities**

Does not include initial investment of $24M by non-NOAA entities to establish SPY-1A system in Norman

Includes ~$80M since the last NSSL Science Review
Leading the Way: Dual Polarization PAR

• Developed the most sophisticated S-band, dual polarization PAR Advanced Technology Demonstrator (ATD)
  • Design and development: 2015-2018
  • Installation begun: July 2018
  • First RF test: November 2018
  • Testing & Evaluation: 2019-2020
  • Preliminary calibration report: November 2020
  • Completed Systems Operational Test: April 2021

• Many research activities being done for the first time
  • Pioneering dual polarization calibration processes
Calibration Infrastructure

**Challenge:** The most significant risk for dual-pol phased array radar is in calibration tolerances.

**Strategy:** Build in as many tools as possible to take measurements. Our main tool is the calibration tower.
The Challenge of PAR Calibration

Polarimetric radars require precise characterization of radar beams

- The quality of weather observations depends on our ability to account for the radar system

PAR electronic steering changes radar beams

- Pointing direction, beam shape, polarization orientation

Calibration of a dish antenna = characterize 1 beam
Calibration of a PAR antenna = characterize 1,000s of beams
Research Documentation (2015-2021)

- 4 Congressional Reports
  - Numerous briefings
- 44 formal publications concerning “phased array”
  - Technical applications or performance
  - Phenomenon studies
  - Forecaster use and evaluations
  - Programmatic or overview
  - Modeling applications
- 9 NSSL technical reports
  - Sharing information with collaborators
Forecaster Use and Evaluation Studies Of Rapid-Update PAR Data

**Does radar update time matter?**
- Involved participation of 30 NWS forecasters
- Forecasters saw various update times
  - 1, 2, or 5-min of single-pol data
- Warnings issued for severe weather hazards (tornado, hail, high winds)

**Answer == Yes!**
- Improved all tornado warning metrics
  - Lead time, Probability of Detection, False Alarm Ratio
- Increased confidence in warning decision

**Now looking at rapid update dual polarization data from KOUN & ATD**
The Challenge of PAR System Design

PARs come in many *flavors*

- **Architecture** and **form factor** are key characteristics
- Each have their own benefits based on their technical capabilities and risks or complexities

Spent much of the last 15 years looking at a Multifunction PAR

- Dual-use presented additional technical difficulties and increased costs
- A rotating array was not compatible with multi-agency concept of operations

PAR designs must consider trade-offs between cost and capabilities

- Any *concept of operations* meeting NWS requirements must be compatible with the capabilities/performance of the radar system
Weather Radar Follow-On Plan

• Consolidated Appropriations Act of 2019 requested NOAA’s weather radar follow-on transition-to-operations plan

• Key Elements ...
  • Sustain and enhance NEXRAD through current expected service life (2035)
  • Conduct PAR R&D to reduce technical risk and inform future acquisition
  • Protect NEXRAD spectrum
  • Organize for success
PAR R&D Next Steps

• Gain knowledge from ATD research
  • Development of calibration tools suitable for an operational platform
  • Meteorological studies of rapid update dual polarization observations

• Gain information from other technology demonstrators
  • Funded all-digital PAR development at OU Advanced Radar Research Center (ARRC) and Massachusetts Institute of Technology Lincoln Laboratory (MIT/LL)

• Continue research as outlined in *Weather Radar Follow-On Plan* …
  • Develop additional technology demonstrators to further reduce risk
  • Work with NWS to establish collaborative R&D and acquisition planning
Questions for the PAR panel?