

# An Overview of the Shared Polarimetric Atmospheric Imaging Radar (PAIR)

Tian-You Yu<sup>1,2,3</sup>, Jorge L. Salazar<sup>1,3</sup>, David Schwartzmann<sup>1,2,3</sup>, Caleb Fulton<sup>1,3</sup>, Robert D. Palmer<sup>1,2,3,4</sup>, Mark Yeary<sup>1,3</sup>, and Howard B. Bluestein<sup>2</sup>

<sup>1</sup>School of Electrical and Computer Engineering, University of Oklahoma, Norman, OK, U.S.A.

<sup>2</sup>School of Meteorology, University of Oklahoma, Norman, OK, U.S.A.

<sup>3</sup>Advanced Radar Research Center, University of Oklahoma, Norman, OK, U.S.A.

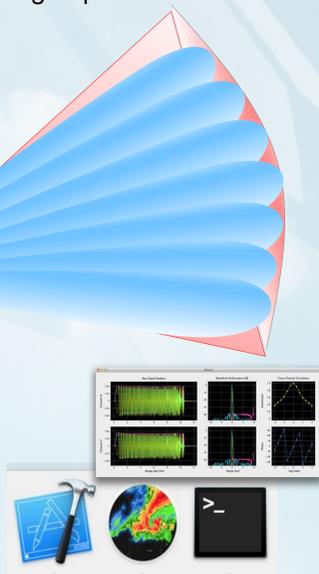
<sup>4</sup>College of Atmospheric and Geographic Sciences, University of Oklahoma, Norman, OK, U.S.A.

## Abstract

This paper presents the development of a mobile C-band polarimetric atmospheric imaging radar (PAIR), sponsored by the National Science Foundation. The architecture of the PAIR offers a unique flexibility of scanning capabilities and an unprecedentedly fast update time of polarimetric observations. An imaging radar transmits a wider beam and simultaneously produces multiple narrow receiving beams through digital beamforming (DBF), which leads to significant reduction of update time. Moreover, DBF allows radar beams to be shaped adaptively for better suppression of ground clutter, interference, etc., and provides improved weather observations. The idea of an imaging radar has been demonstrated and verified by the Atmospheric Imaging Radar (AIR), developed at the Advanced Radar Research Center (ARRC), the University of Oklahoma, which is an X-band mobile radar with single polarization. The development of PAIR leverages on the lessons learned from the development and deployment of the AIR and other radar systems at the ARRC, and improves reliability, maintainability, ease-of-use, safety and fast deployment in the field, etc.

## Highlights and Specifications

- Mobile, C-band, Polarimetric Imaging radar
- Digital beamforming and e-scan in elevation for ultra-high update time (360°x20° in 6-10 s)
- E-scan pencil or spoiled beam in elevation
- Polarization dual-linear (STST, ATSR)
- High sensitivity (-2.9 dBZ @ 10 km)
- Data will be available via ARRC's radarhub

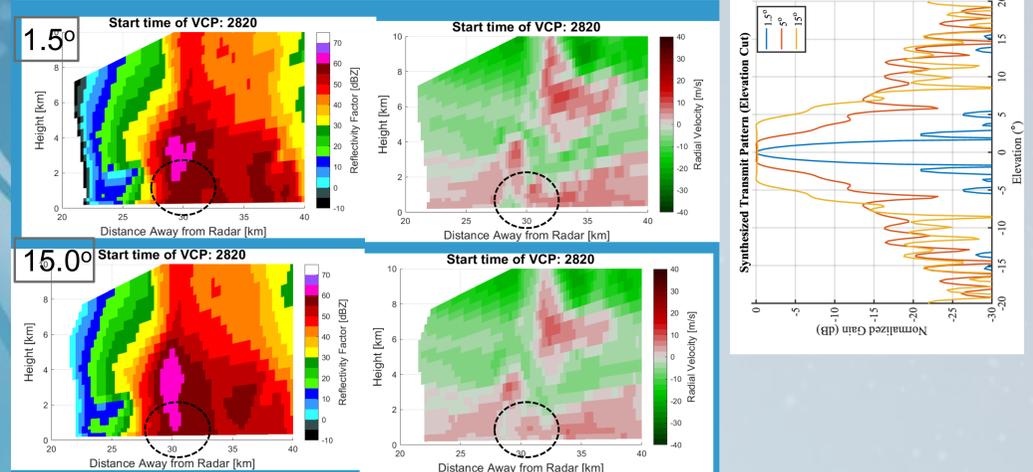


System Performance Overview (2.2m Target Aperture)	
Operating Frequency Range	5.35-5.45 GHz
Element Polarization	Dual-Linear, RHCP, LHCP
Transmit Waveform Type	LFM/NLFM
Transmit Power (Single Element)	5.0 W (Single-Pol)
Transmit Pulse Width	33.0 μs (100μs MAX)
Max Transmit Duty Cycle	20.0 %
Max Transmit Waveform Bandwidth	50 MHz
Element Spacing (Horizontal x Vertical)	0.50 x 0.50 λ at 5.552 GHz
Radiator Panel Size (Elements)	8 x 8 (64) elements
Total Number of Panels (50% Truncate)	10 x 10 (76) panels
Total Number of Radiating Elements	4864 elements
Maximum Elevation Scan Angle	45.0 deg
Horizontal Aperture	2.16 m (7.09 ft)
Vertical Aperture	2.16 m (7.09 ft)
Radiating Element Gain	6.0 dBi
Array Gain (10log <sub>10</sub> N)	36.87 dB
Total Assumed SNR Losses	Transmit: 15.25 dB (Includes Spoil) Receive: 5.00 dB (Includes NF)
Min Beamwidth (Azimuth x Elevation)	1.50 x 1.50 deg at 0-deg El
(1.18xUniform Excitation Beamwidth)	1.50 x 2.12 deg at 45-deg El
Estimated Sensitivity (1 Pulse)	Weather: -2.9 dBZ @ 10.0 km Hard Target: 9.93E-06 m <sup>2</sup> @ 10.0 km

## Calibration and Simulation



### Impacts of spoiled beam on downburst signatures



## Summary

The overarching goal of this project is to design, develop, integrate and commission a mobile C-band polarimetric atmospheric imaging radar (PAIR) that will be shared by communities. The imaging radar exploits the floodlight concept to achieve unprecedented temporal resolution. PAIR will be capable of providing a volumetric (360°x20°) dual-pol measurements in 6-10 seconds. The PAIR team and collaborators have shown strong interests in applying PAIR to studies of tornadoes, hurricanes, cloud electrification, etc. It is planned to perform initial field test and verification in spring of 2026.



This work is partially supported by the National Science Foundation through AGS-1532140. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the authors and do not necessarily reflect those of the National Science Foundation.

