

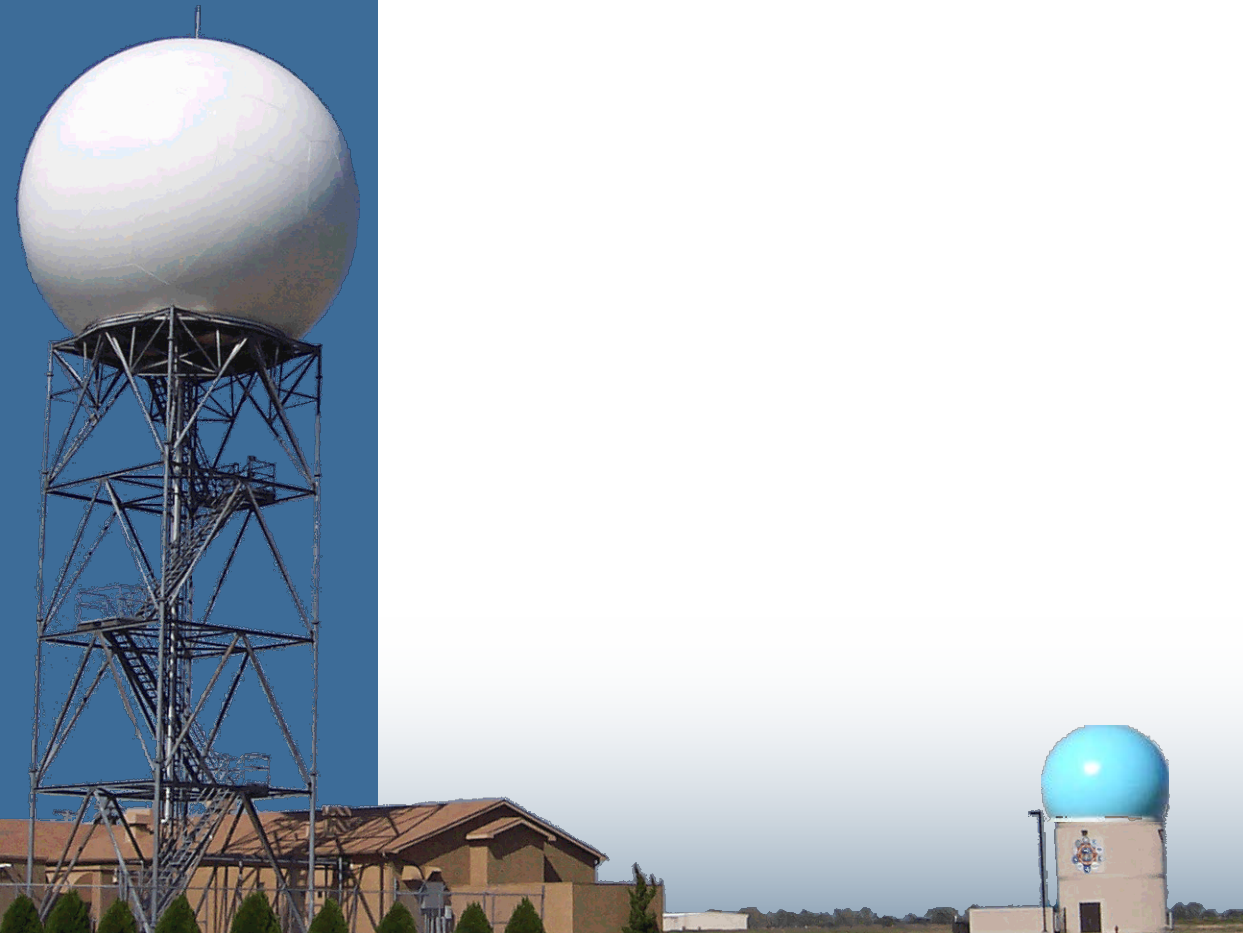
CIMMS Accomplishments in Radar Engineering

Sebastián Torres

Sr. Research Scientist

CIMMS/The University of Oklahoma
and National Severe Storms Laboratory/NOAA

CIMMS 40th Anniversary Celebration
November 15th, 2018 - Norman, OK



- **Radar Engineering R&D areas**

- **Software**

- Software infrastructure
- Signal processing techniques

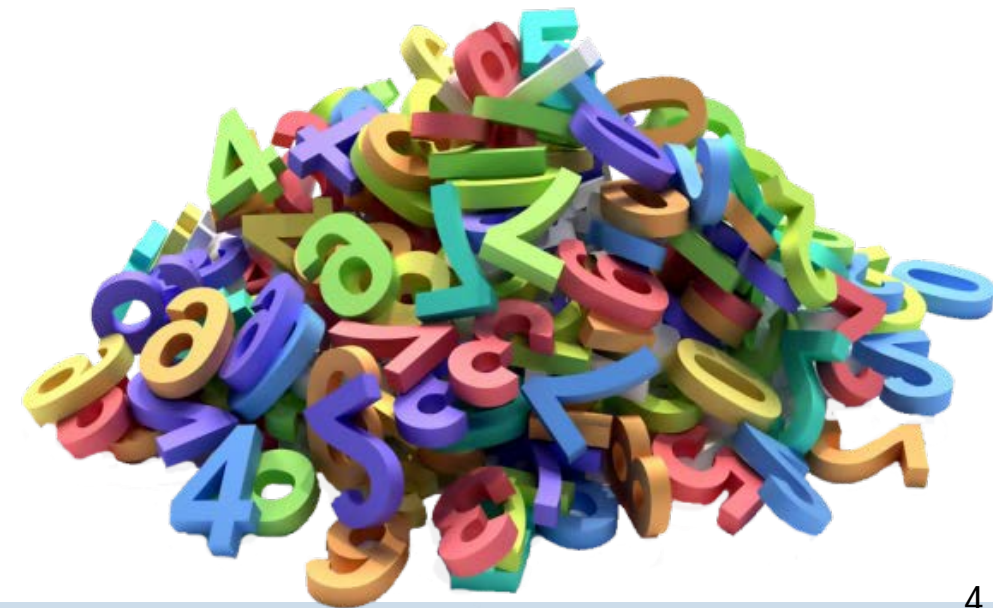
- **Hardware**

- 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



CIMMS first (?) contribution

CIMMS Report No. 71

Characteristics of Echoes from Alternately Polarized Transmission

by

M. Sachidananda

Cooperative Institute for Mesoscale Meteorological Studies

University of Oklahoma

and

D.S. Zrnić

National Severe Storms Laboratory

ERL, NOAA

July 1986

Cooperative Institute for Mesoscale Meteorological Studies

401 East Boyd, Norman, Oklahoma 73019

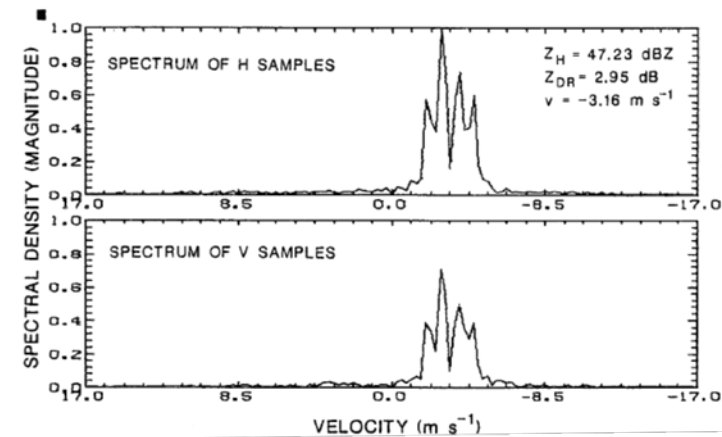


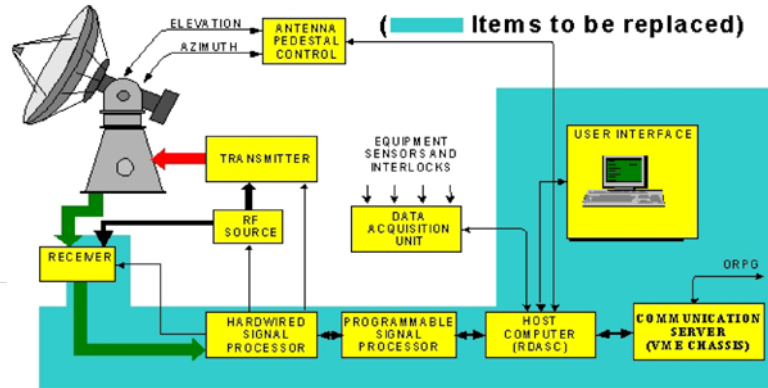
Figure 6. Spectra of separated H and V samples for the same data as in fig. 4.

WSR-88D Open Systems

- Interoperability
- Portability
- Open standards

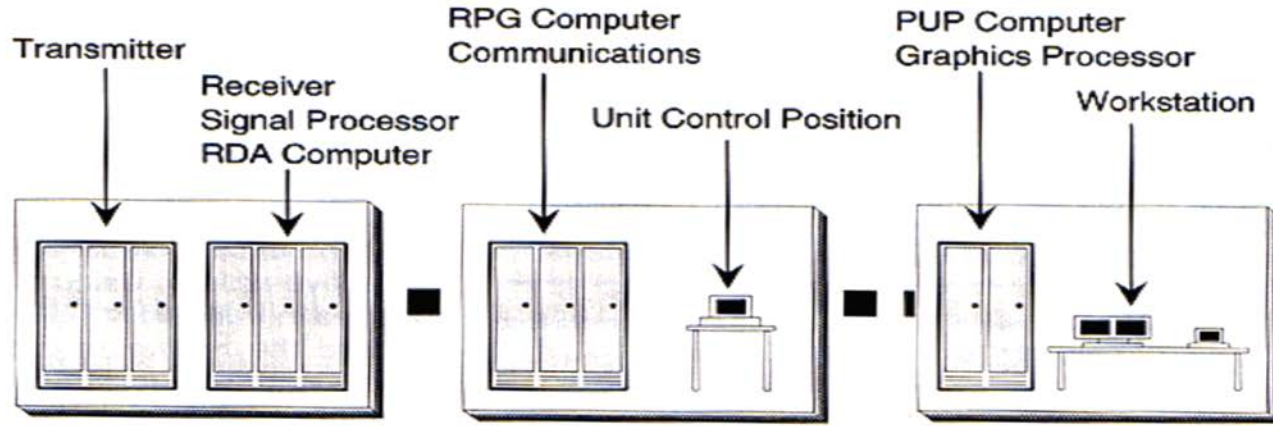
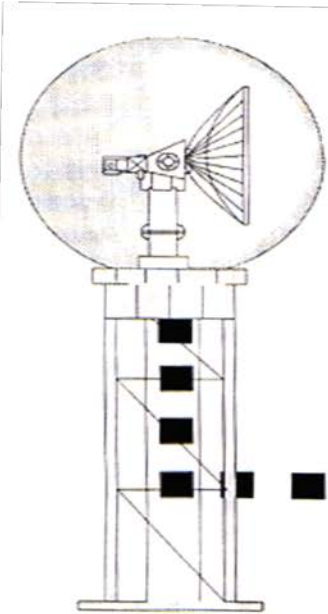


WSR-88D Open Systems



ORPG
(1996)

ORDA
(1996)



RDA
Radar
Data
Acquisition

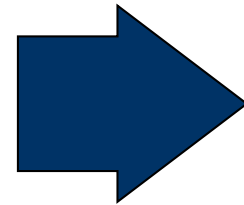
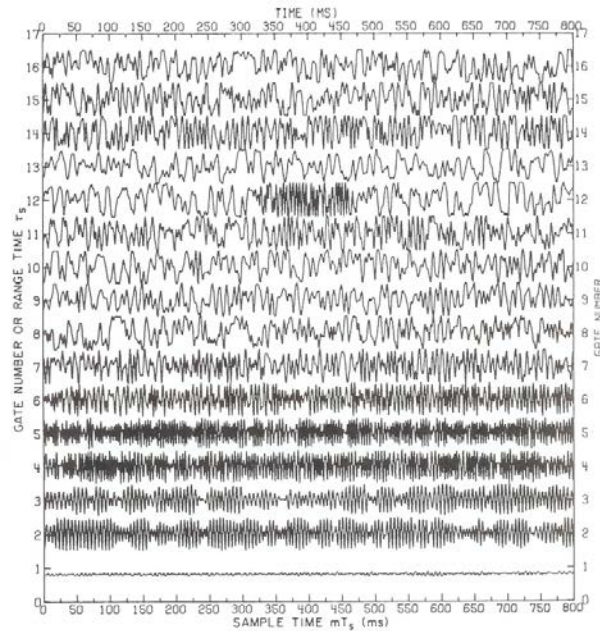
RPG
Radar
Product
Generator

PUP
Principal
User
Processor

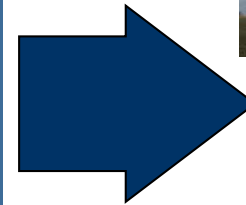
OPUP
(1997)

Signal Processing Techniques

Radar signals



Weather
Radar
Signal
Processing



- Radar signals are **messy!**
- Users need **clean** radar data

Geeky signal
processing superhero

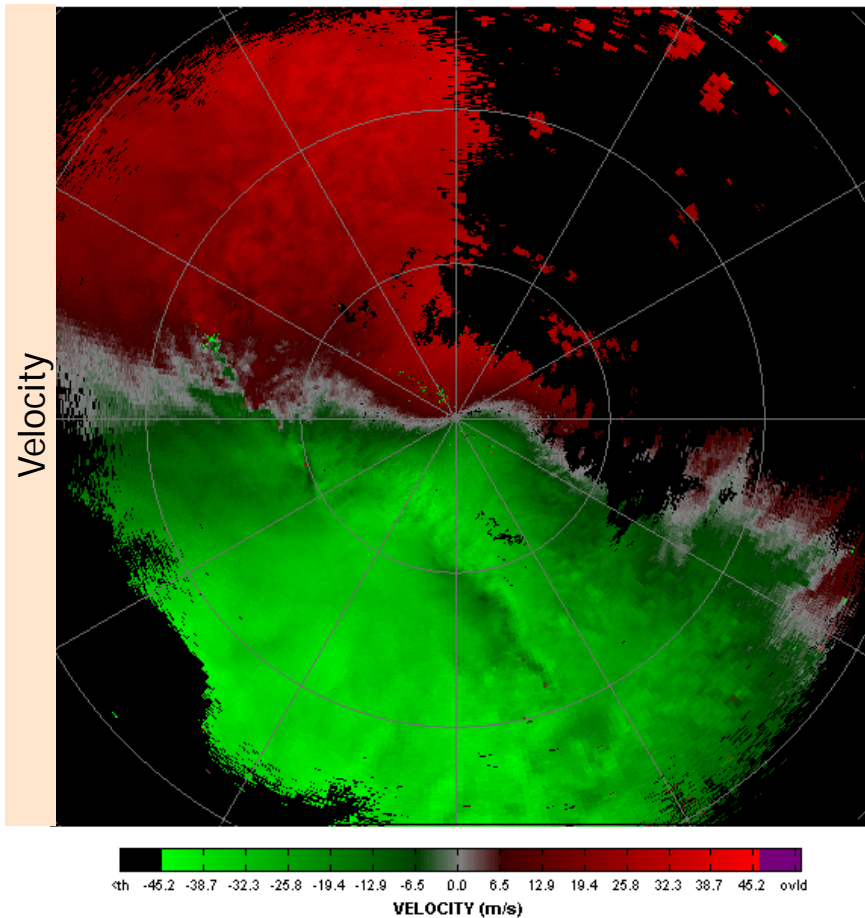


Signal Processing Examples

Getting Better Velocity Data

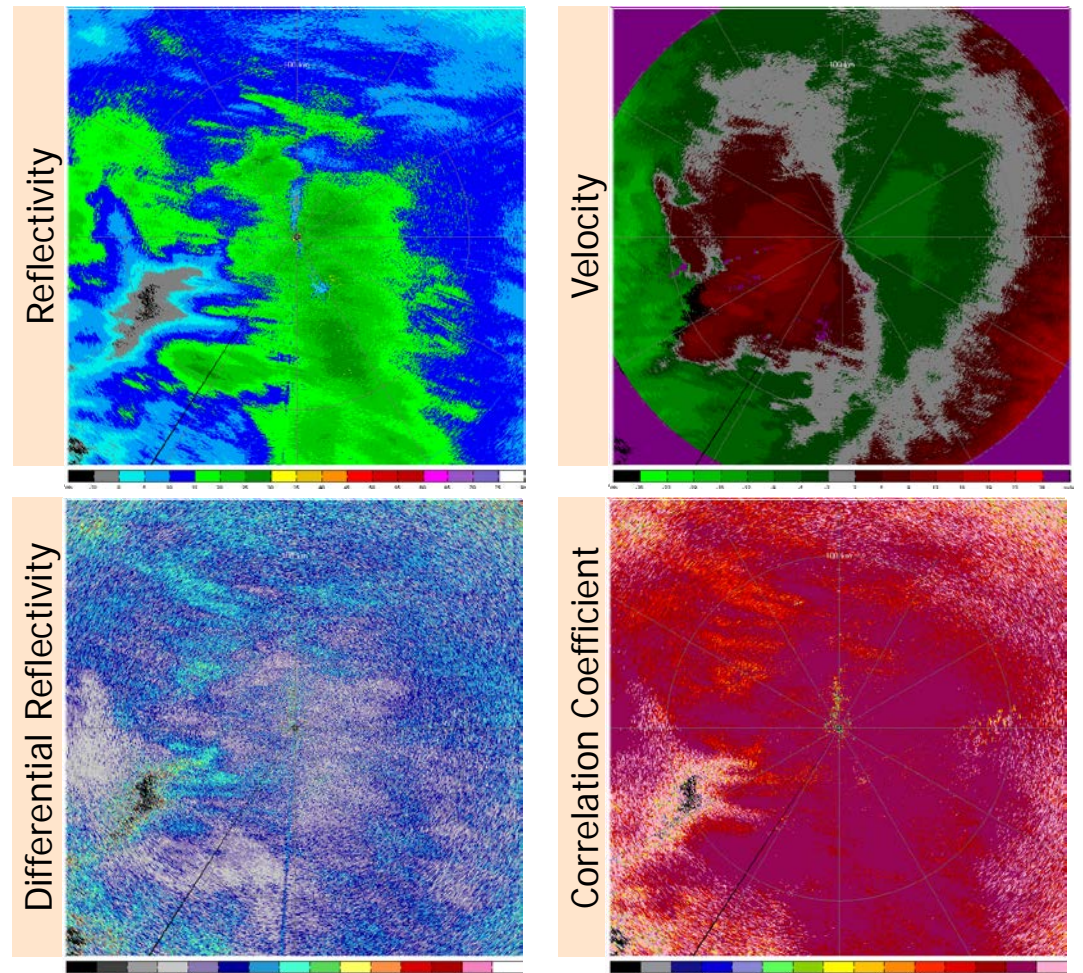
Staggered PRT Mode

04 Mar 2004 20:42Z - VCP 48 (Cut #11, 2.4 deg)



Filtering Echoes from the Ground

Filtering with WET and CLEAN-AP



Research to Operations

Research

Transition

Operations

Signal Processing Techniques

- 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

WSR-88D



Radar Systems



KOUN
(1996)



NWRT
(2003)



NOXP
(2007)



TPD
(2015)

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

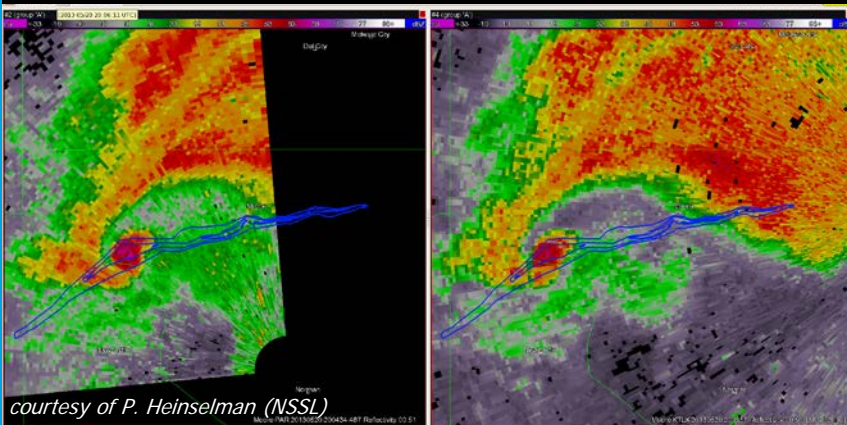


Rapid Updates

Reflectivity at 0.5° – 20 May 2013 Moore, OK tornado

PAR

Conventional

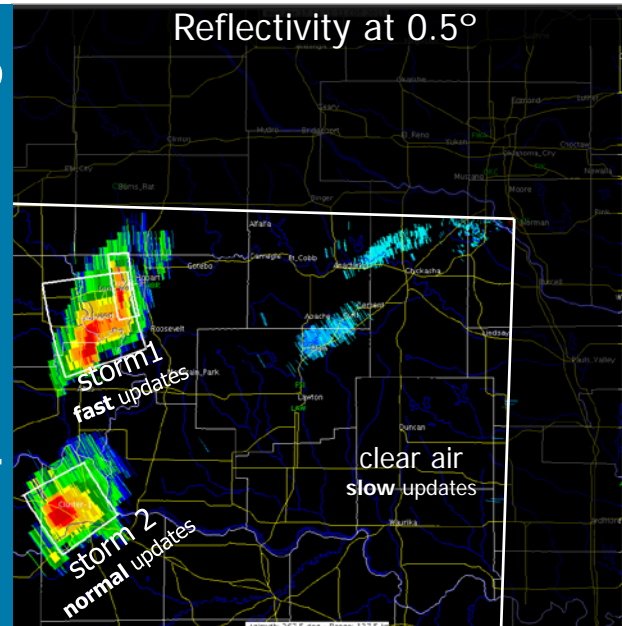


1.2-min updates

4.2-min updates

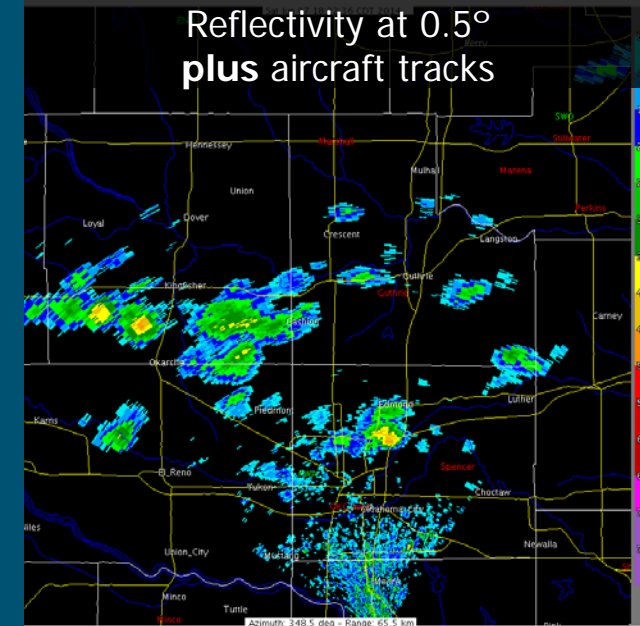
Adaptive Scanning

Reflectivity at 0.5°

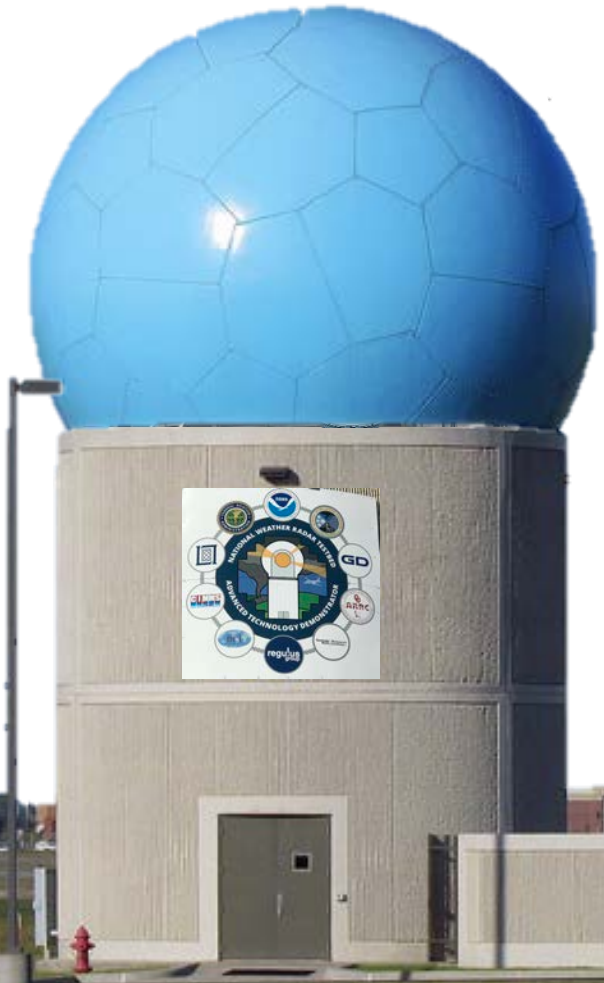


Multifunction

Reflectivity at 0.5°
plus aircraft tracks



An upgrade for the NWRT



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

The **A**dvanced **T**echnology **D**emonstrator 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

Antenna Patterns

Spatial Sampling

Temporal Sampling

Dwell type
M, PRTs
P2P phase coding

Waveforms

Dual Polarization Transmission

Single polarization (H or V)
Simultaneous (SHV)
Alternate (AHV)

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

National WSR-88D Doppler Radar Sites
National Centers for Environmental Information

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

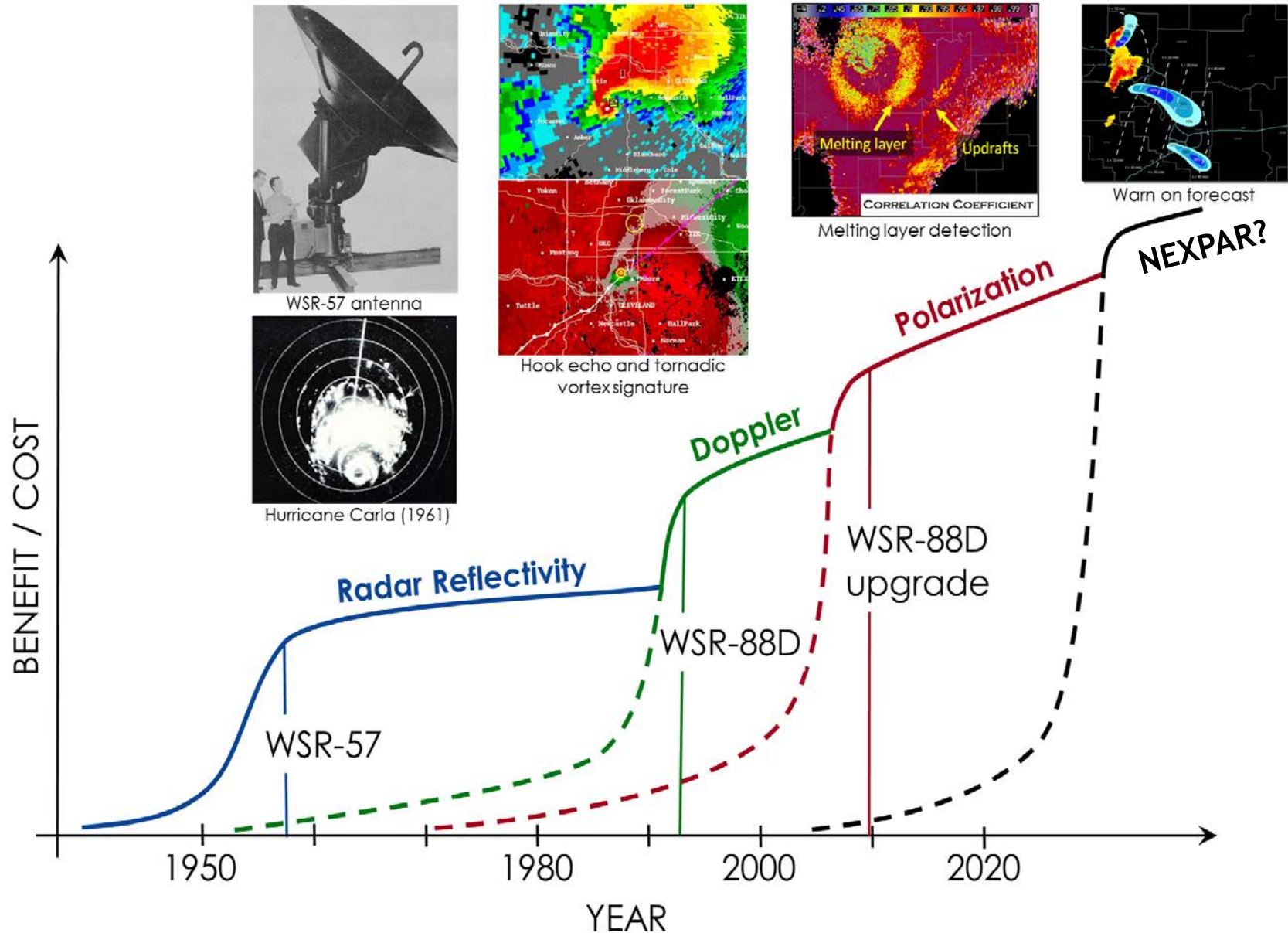
Command and Control Simulator

```

graph LR
    Scan((Scan)) --> TI[Temporal interpolation]
    TI --> SPARC[SPARC Simulator *]
    SPARC --> IQ((I/Q Data))
    IQ --> DSP[DSP]
    DSP --> AS((Adaptive Scan))
    AS --> AScan[Adaptive Scanning]
    AScan --> Scan
            
```

Consecutive scans of **Simulated** Radar Data

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

The perfect
partnership to save
lives and property

