National Weather Radar Testbed Research & Development

Presentation
for the

**2nd MPAR Symposium
Technology Innovation & Development**

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Behind the Scenes

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B. Ballard

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John Havlicek

Nannette Kalani, Jim Olivo

Jim Melody, Les Lemon, Bob Blasewitz

More Behind the Scenes

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Chris Curtis, Rick Adams, John Thompson, Dave Priegnitz, Dan Suppes, Kevin Manross

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Additional Collaborators

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Spanky Kirsch

Points/Questions – 1ˢᵗ Symposium

- Dual-Polarization – Multiple Frequencies
- Antenna Design
- Visualization
- Automated Adapted Scanning
- Decision Theory
- Indirection

What is the difference between a Phased Array and Conventional Radar?

Conventional radar is White

PAR is Blue

National Weather Radar Testbed (NWRT) Milestones

Sept 2003

NWRT became operational

May 2004

Completed Engineering checkout phase

May 2006

Environmental Processor upgraded to a Matrix PC w/ new 7 terabyte RAID
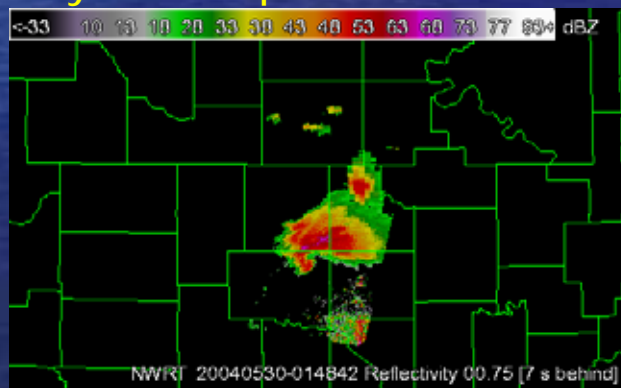
August 2007

EP upgraded Matrix PC – 150 times faster (Dual 3 GHz Processors with 10 Gb Backbone) w/ new 12 terabyte RAID
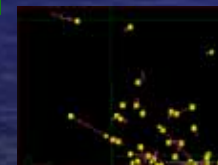
Winter 2006 - Spring 2007

User Interface improved along with addition of internet power control systems

May 2004 - present

NWRT 20040530-014842 Reflectivity 00.75 [7 s behind]

Data collection for Research (Limited data 2005 & 2006, poor storm seasons)

Fall 2008 - present

Improved Data Quality & added Adaptive Scanning and Track Processor

NWRT Accomplishments 2008 - 2009

- Dual-Polarized Fractional Sub-Array
  - Worked continued with Basic Commerce Industries on design criteria
    - Beam Width
    - Effects of Radome
    - Radiating Element design
      - 30 db cross-pol isolation
    - Design trade-offs

Conventional Radar   Dual-Polarization Radar

- Monopulse Port Activation
  - Using Azimuth Difference Port for Interferometry Studies
  - Full port activation accomplished
- Multi-Channel Receiver Suite (OU NSF Proposal)
  - Hardware is integrated with the NWRT and is being tested
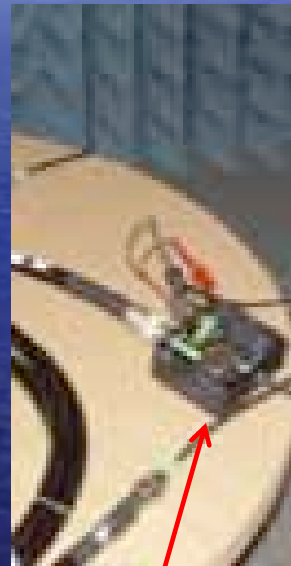
Multi- Receiver System

$x_3(nT_s)$ $x_4(nT_s)$

$x_5(nT_s)$

$X_0(nT_s)$

$x_1(nT_s)$ $x_2(nT_s)$

$x_6(nT_s)$
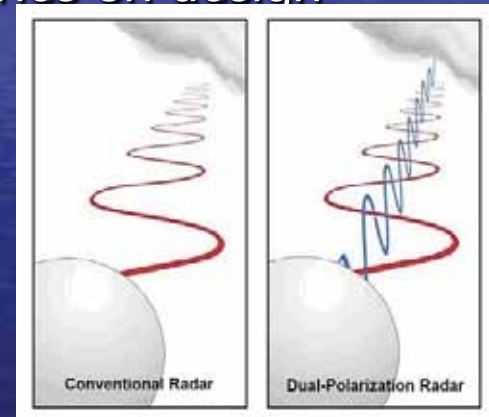
eight downconverters
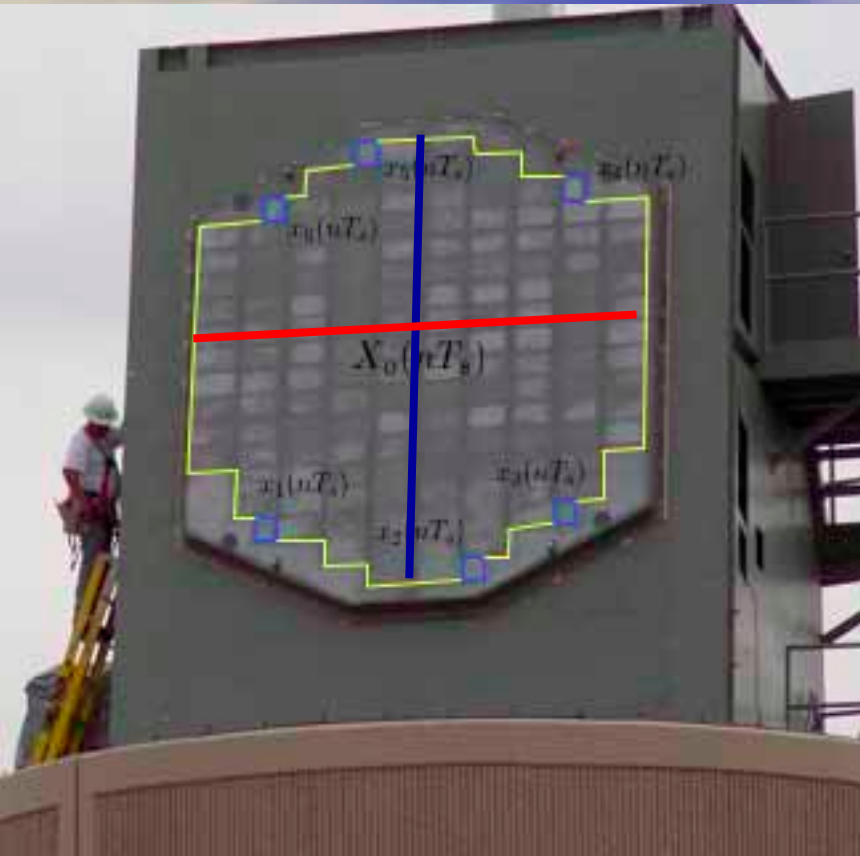
eight LNA's

1 - Az Diff
1 - El Diff   Monopulse

6 – Clutter Channels

Courtesy of Mark Yeary

Installed rack w/ digital receivers

NWRT Accomplishments 2008 -2009

- Modification to Real Time Controller (RTC)
  - Mv 5500 work is awaiting a resolution of operating system and application software issues.
  - Established messages handling between RTC and the Digital Signal Processor (DSP) in preparation for Adaptive Scanning
- Improved NWRT Data Quality - 2008
  - Ground Clutter filter
  - Range/Velocity de-aliasing
  - DC-bias removal
- Digital Signal Processor upgrades
  - Spectral processing
  - Staggered Pulse Repetition Time (PRT)
  - Automatic ground clutter detection and removal
  - Interference filter

NWRT Accomplishments

- ## Scanning Strategy Assessments - 2008
  - Ran Spring Phased Array Radar Experiment – Scanning Strategies produced 1-min volumetric updates and 30 second updates at 0.5 deg. tilt
  - Data Collection
    - 16 supercells, 7 tornadic
    - 13 MCSs, 1 tornadic
    - 13 Pulse storms (microbursts, weak and strong)
    - 7 Scattered storms
  - Obtained forecaster evaluations on the utility of PAR data for improving warnings
  - Obtained an assessment of radar needs for the NWS and broadcast Meteorologists
    - High-temporal sampling
    - Reliable, clean & accurate data
    - Consistent low-altitude information
    - Ability to distinguish precip type, size and intensity
  - Completed a preliminary comparative analysis of the temporal evolution of a long lived tornadic supercell (24 May 2008)

NWRT Accomplishments

- Scanning Strategy Assessments - 2009
  - Ran ADAPTS
    - Adaptive DSP Algorithm for PAR Timely Scans
    - First implementation of adaptive scanning of phased array weather radar
  - Ran PARISE
    - Phased Array Radar Innovative Sensing Experiment
    - Forecaster evaluation of operational Utility of PAR technology
  - Supported VORTEX-2
  - Three high-temporal resolution scanning strategies tested
  - Data Collection
    - 5 supercells, 2 tornadic
    - 4 MCSs, 1 tornadic , 2 with Severe Winds
    - 7 Pulse storms (microbursts, weak and strong)
    - 3 Scattered storms
- Improved Radar User Interface
- Wind Retrievals using PAR data

Adaptive Scanning

Conventional scanning

Everywhere
Sequential
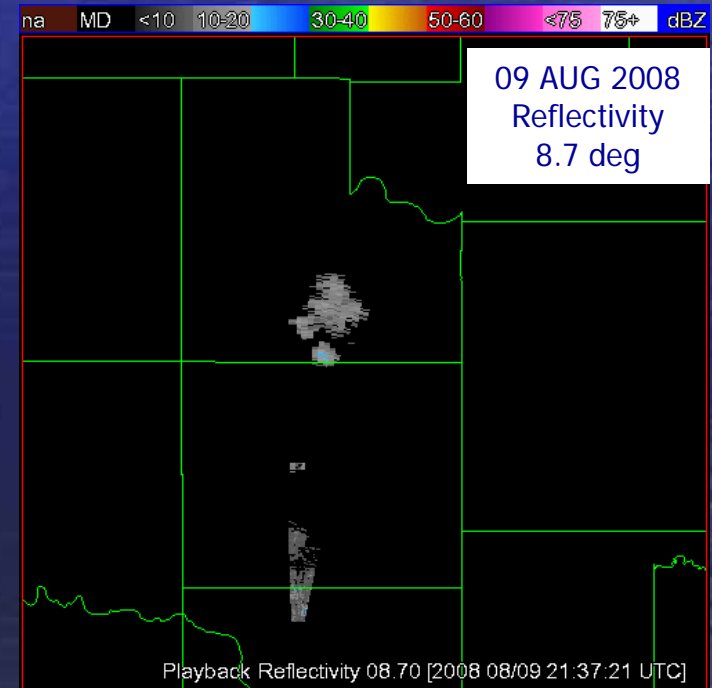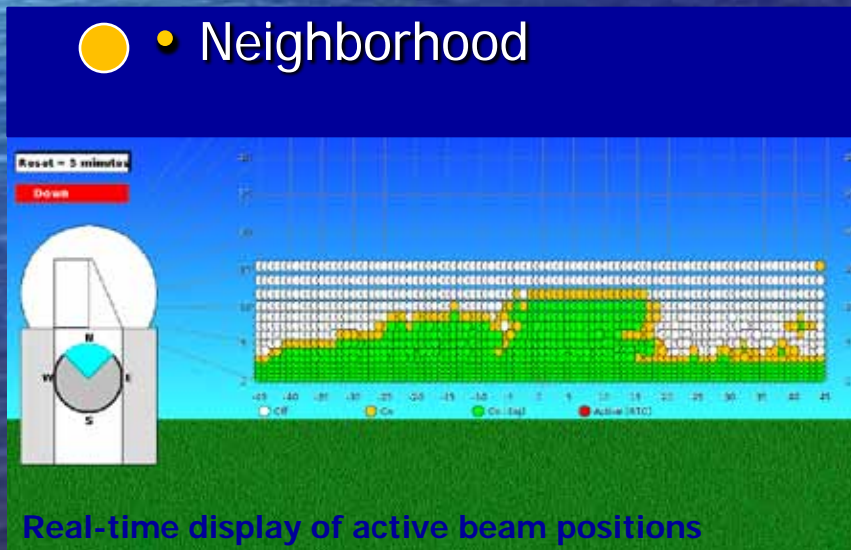
Adaptive scanning

Areas of interest only
Arbitrary

Goal: Faster Updates

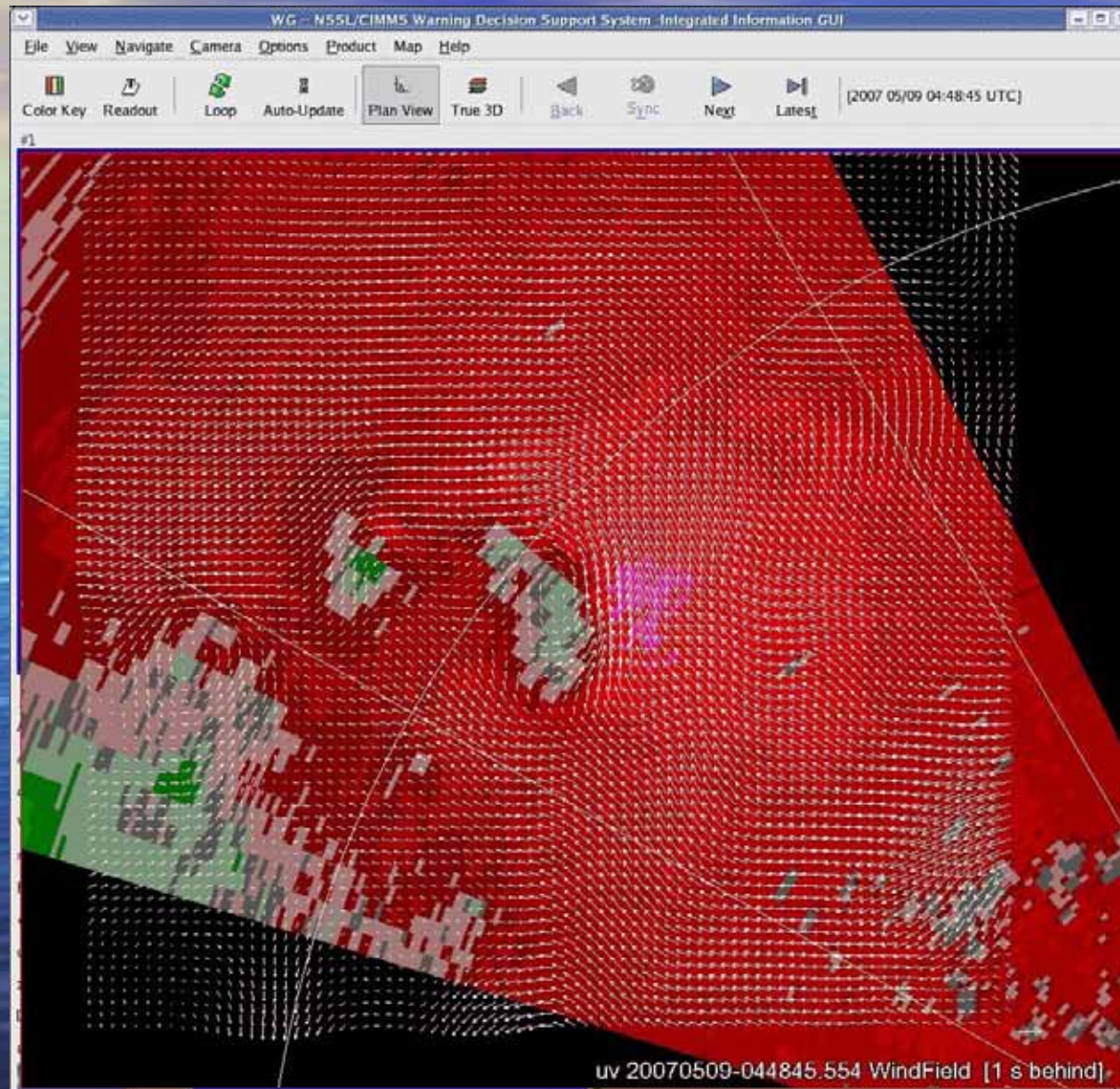*Courtesy of Chris Curtis*

ADAPTS

- Adaptive DSP Algorithm for PAR Timely Scans
  - Beam positions are classified as **active** or **inactive**
    - Only **active** beam positions are scanned
    - Full volume scans are scheduled periodically
  - Active beam positions meet one or more criteria
    - Elevation angle
    - Continuity and coverage
    - Neighborhood

Real-time display of active beam positions

09 AUG 2008
Reflectivity
8.7 deg

Playback Reflectivity 08.70 [2008 08/09 21:37:21 UTC]

Wind retrieval on conical surface

NWRT 20070509

81x81pts
500mX500m
Moving Frame
U=2m/s
V=11m/s

Phase Array radar

Courtesy of Qin Xu
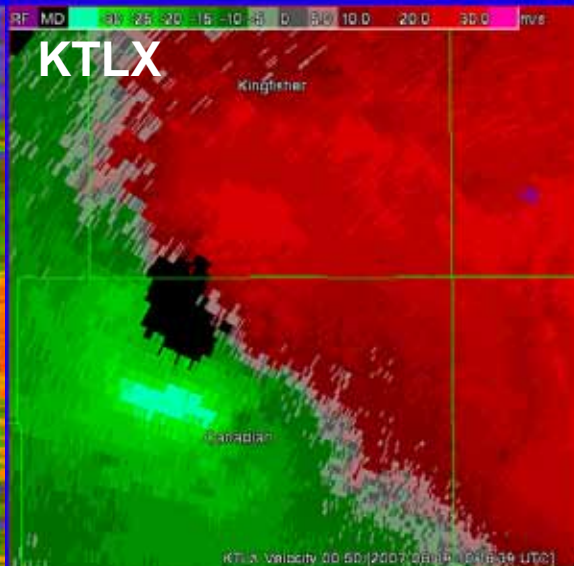
Tropical Storm Erin: Eyewall
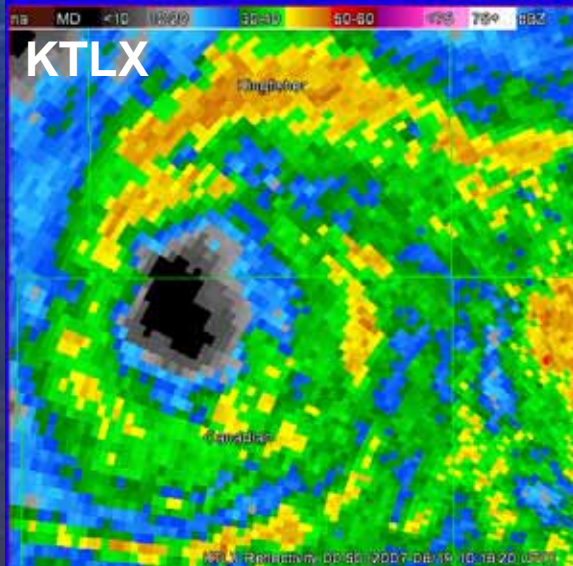

19 August 2007
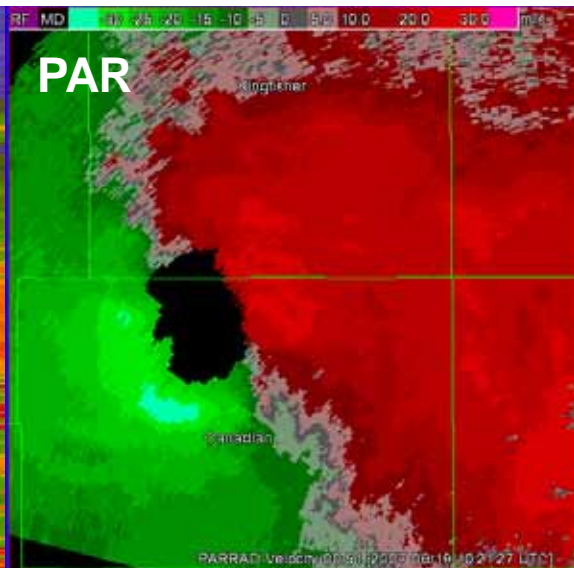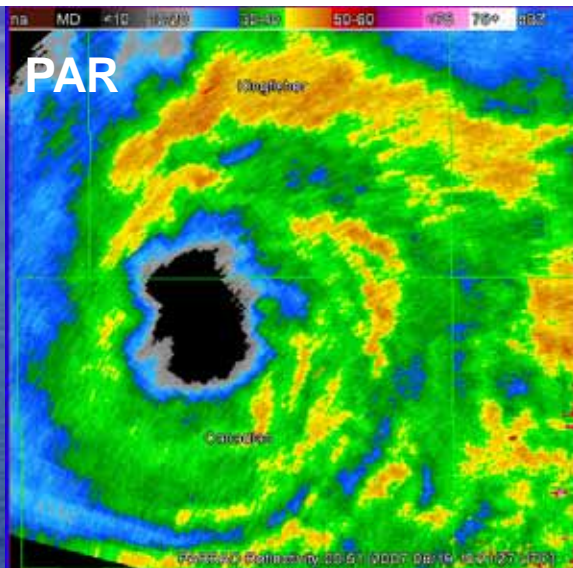
PAR
VCP 12 BMX
60° sector
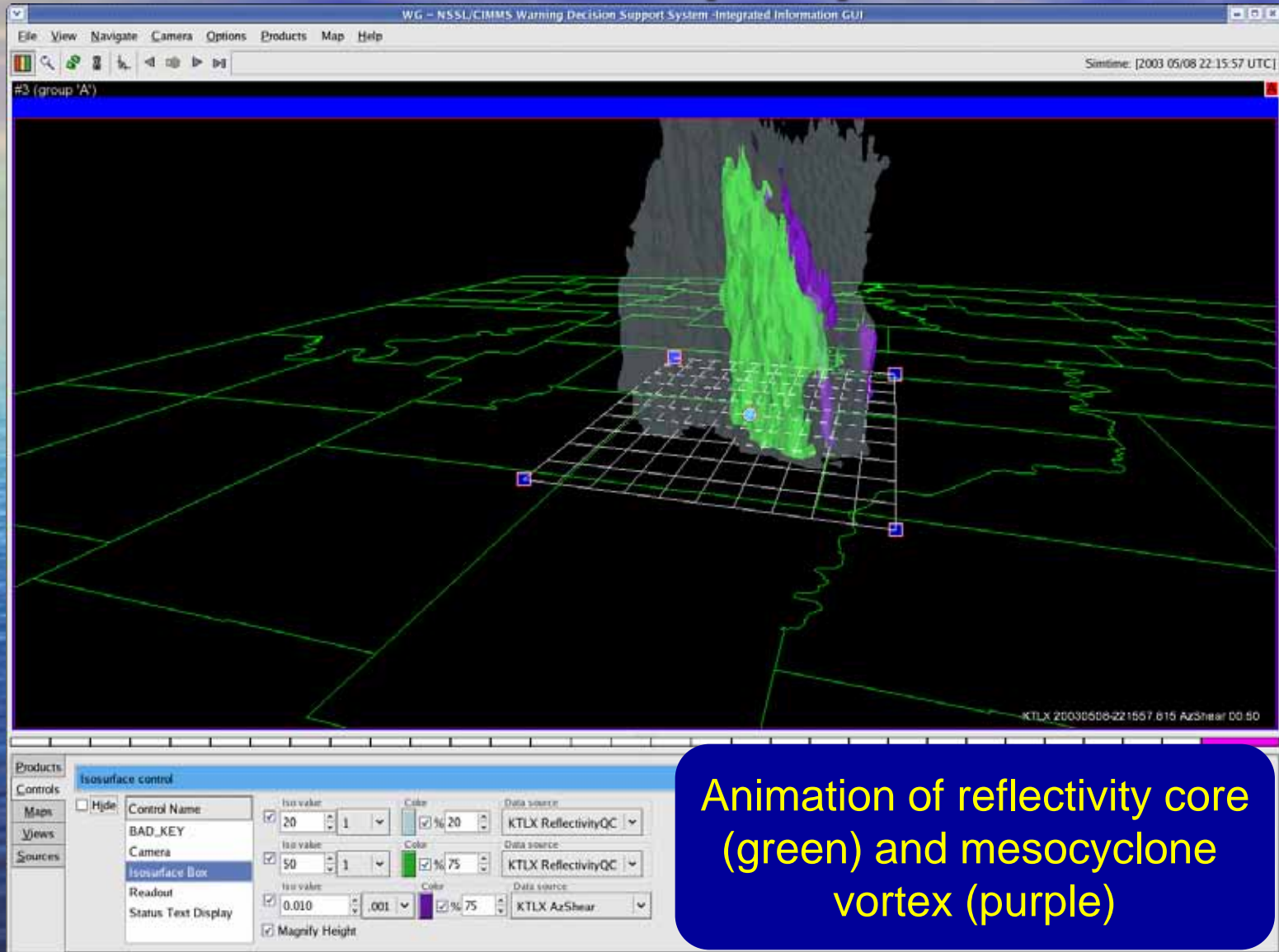
0.5° oversampling
in azimuth

Images ~ **43 s**

WSR-88D
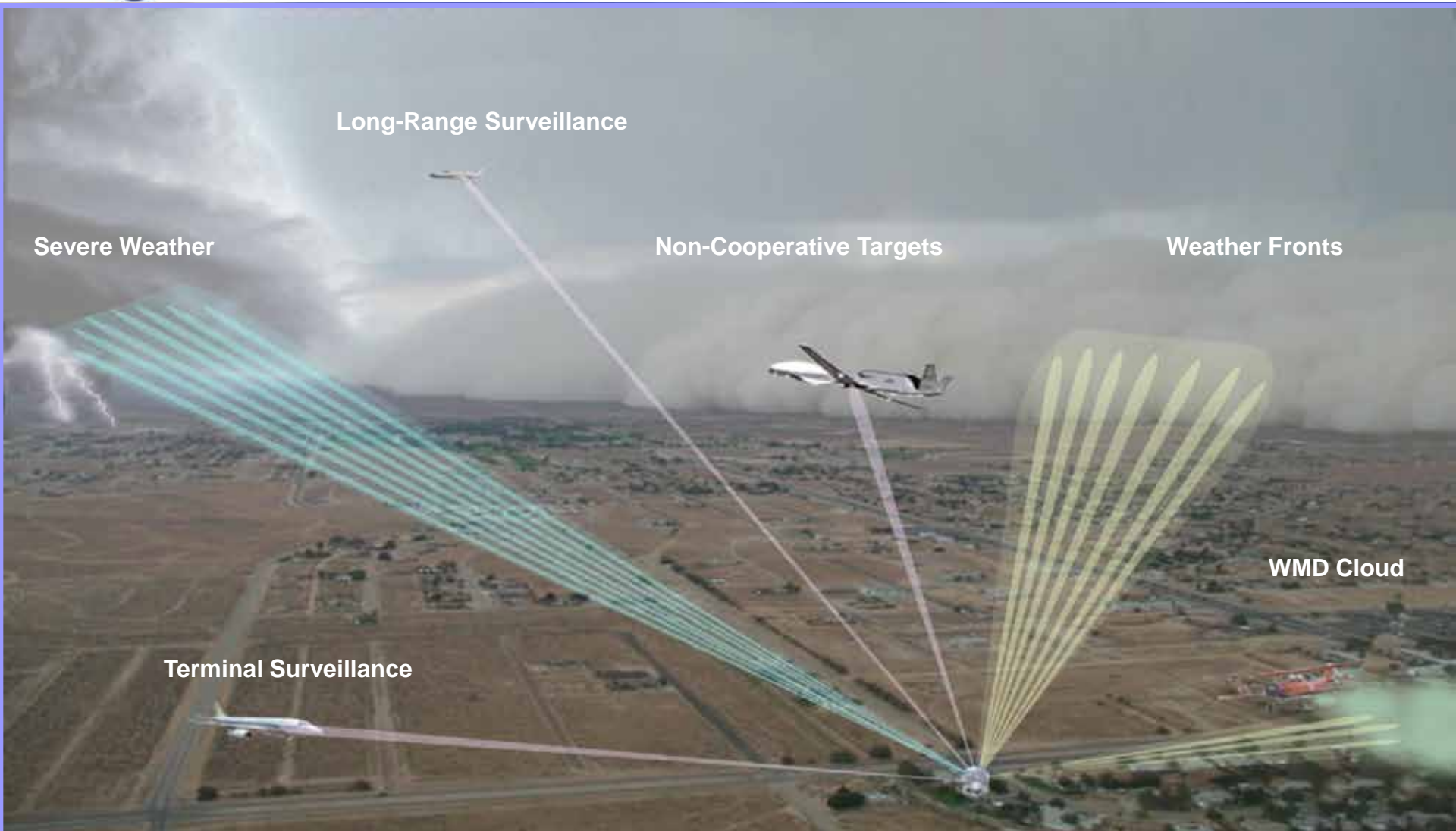VCP 12
Images ~ **4.1 min**
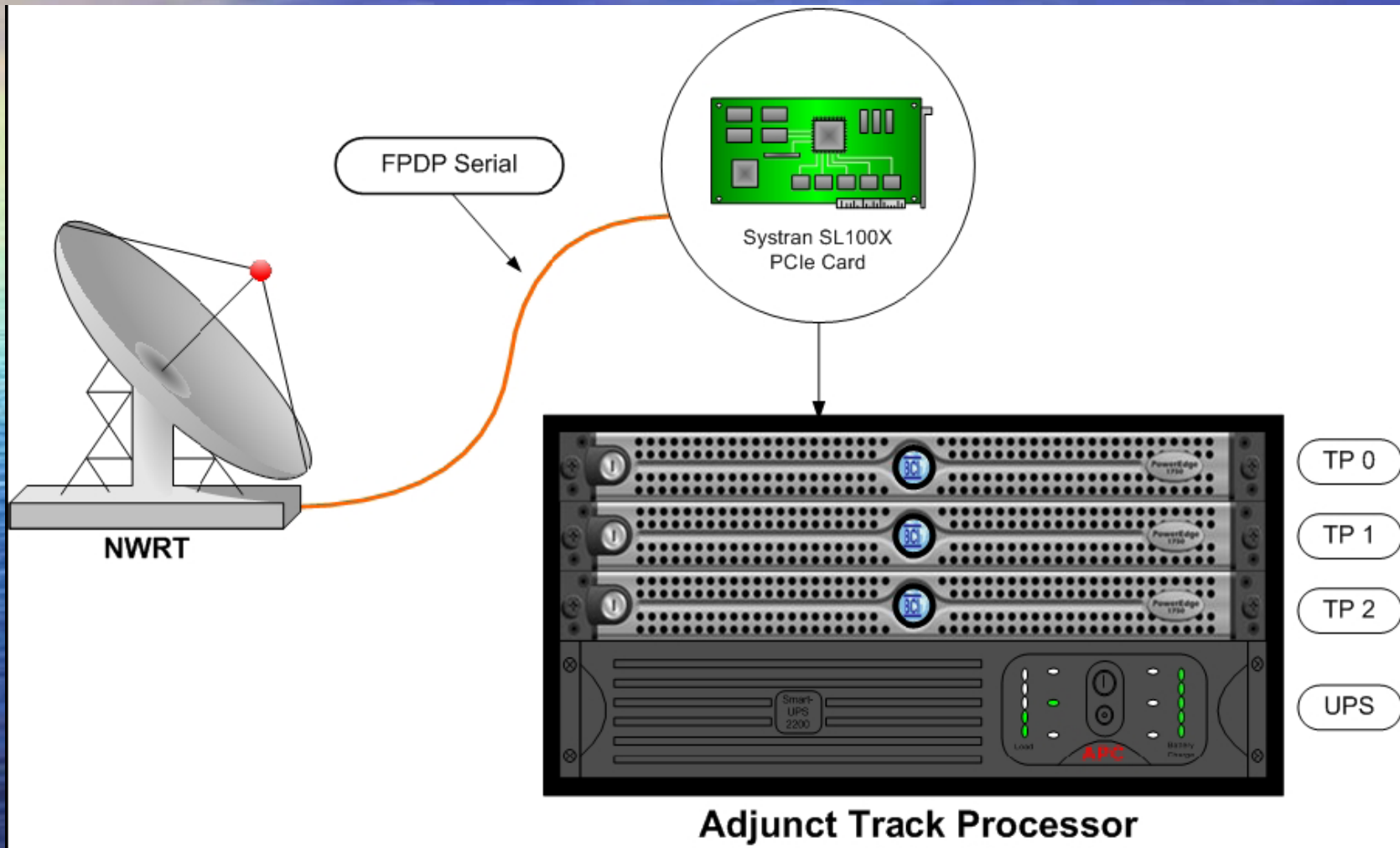
3D Isosurface Display

Animation of reflectivity core (green) and mesocyclone vortex (purple)

Multi-Function Phased Array Radar (MPAR) Concept

Adjunct Track Processor (ATP)

FPDP Serial

Systran SL100X
PCIe Card

NWRT

TP 0

TP 1

TP 2

UPS

Adjunct Track Processor

Progress being Made, But Still a long way to go.

- Dual-Polarization – Multiple Frequencies
- Multi-Function
- Antenna Design
- Visualization
- Automated Adapted Scanning
- Decision Theory
- Hope Ray Kurzweil

Questions?

THANK YOU