7.2 UPDATE ON THE NATIONAL WEATHER RADAR TESTBED (PHASED-ARRAY)

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1. INTRODUCTION

The National Weather Radar Testbed (NWRT) has now been available for research for over two years. Located in Norman, Oklahoma, this 10-cm phased array radar is used for studying and developing faster and more accurate warning, analysis and forecast techniques for severe and hazardous weather along with testing multifunction capabilities such as aircraft tracking and wind profiling. As reported at several American Meteorological Society conferences, (Forsyth, 2002, 2003, 2005, 2006, 2007), the NWRT was developed by a government/university/ industry team consisting of the National Oceanic and Atmospheric Administration's (NOAA) National Severe Storms Laboratory (NSSL), the Tri-Agencies' (Department of Commerce, Defense & Transportation) Radar Operations Center (ROC), the United States Navy's Office of Naval Research, Lockheed Martin Corporation, the University of Oklahoma's (OU) Electrical and Computer Engineering Department and School of Meteorology, the Oklahoma State Regents for Higher Education, the Federal Aviation Administration's (FAA) William J. Hughes Technical Center and Basic Commerce and Industries, Inc.. The NWRT uses a converted Navy SPY-1A phased array antenna system, thus providing the first phased array radar available on a full-time basis to the meteorological research community and for testing of the concept of a Multi-mission Phased Array Radar (MPAR) system.

In this paper, we will describe the current system status along with planned upgrades, an overview of the 2007 experiments and data sets collected so far in the 2007 season. In addition, we will discuss our progress on making the NWRT available as a national facility.

2. Current Status

The NWRT became operational in September 2003 and completed its engineering checkout phase in May 2004. Data were collected from one tornadic storm in 2004, with only a few data sets collected in both the 2005 and 2006 storm seasons due to the limited amount of severe weather in Oklahoma.

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The Environmental Processor (EP) has been upgraded to a Matrix PC version with all processes formerly performed by the EP now running on one processor in the Matrix PC version. A new RAID system (7 terabytes) now allows us to collect several days of I&Q data along with the moment data. Data to be saved is then copied off the RAID to cheap USB storage devices.

Many changes have been made to improve the User Interface. These changes have improved our ability to use the system and determine error codes more easily (Priegnitz, 2006, 2007). Several internet power control systems have been added to reduce the amount of time required to travel to the facility to reboot various components. All of these devices are controlled by the User Interface.

3. Planned Upgrades and Research

We are currently working on a new and improved version of the Matrix PC. The system will consist of 6 nodes using dual 3 GHz processors with a 10 gigabyte/sec ethernet backbone. This increased capability is required to implement oversampling and whitening algorithms on the system. We have also added a switch to support data collection for a transverse wind algorithm (Zhang and Doviak, 2007), but plan to implement a multi-receiver system to support this task along with mono-pulse tracking.

In addition, we are looking at building a dual polarized sub-array to investigate the dual polarization characteristics of such an array We are also working on modifying the Real Time Controller (RTC) in order to implement adaptive scanning (Priegnitz, 2007). Adaptive scanning will allow analysis algorithms to control the scanning functions of the radar and thus increase the efficiency in identifying severe weather.

An additional hardware upgrade will include an Uninterruptible Power Source for the NWRT. This will allow power transfers from commercial to generator and back without human intervention. Also, this will smooth out many of the power clichés that requires a reset of the power converter (240 volts, 60 Hz to 400 volts, 450 Hz).

In addition to hardware upgrades, we are continually improving our ability to display the fast scan data (Lakshmanan, 2007) and process it with various detection algorithms. An additional area of research is the use of decision aids that will be required when using the fast scan data received from the phased array radar systems.

4. Summary of 2007 projects

Several projects are in place for the 2007 spring data collection season ranging from adaptive scanning to oversampling. A summary follows:

a. Adaptive scanning and Radar Client Interface (RCI). Using phased array technology, a user has the capability to rapidly scan targets of interest as well as perform the traditional volume scan. The RCI and Real Time Controller software can be modified to satisfy these capabilities, but currently this is done in a manual mode. In the future, we would like this to be automated to the point that an algorithm could decide its own optimum scan strategy.

b. Data Collection. We are continuing to collect data on targets of opportunity and have a goal of collecting at least one event for each weather phenomena for comparison purposes and further development.

c. Techniques Development. Collect data to support research on staggered PRT, beam multiplexing and ground clutter cancellation.

d. Oversampling and Whitening. Collect snapshots of weather and clear-air data to support testing of signal processing techniques under development.

e. Severe weather warning decision making R&D. Support the Hazardous Weather Testbed warning scale activities and provide information to NWS HQ.

f. NWS pre-proof-of-concept experiment. On potentially high-impact severe weather days, provide data to NWS by running the NWRT and displaying data in the Hazardous Weather Testbed.

g. Algorithm work. Develop storm interrogation and warning guidance applications that take advantage of high temporal sampling of potentially severe storms.

h. Refractivity Fields. Retrieve refractivity fields (~moisture) using rapid update of NWRT. Implement real-time version using average I&Q and WDSS-II and compare to refractivity fields from KTLX.

i. Transverse wind. Implement and test the concept of weather radar interferometry using a switched receiver to alternately sample sum and difference signals.

j. Tracking Aircraft. Using the NWRT to detect aircraft.

k. SMART-R validation & assimilation. Use both SMART-Rs to collect coordinated data sets with MPAR setting up two dual-Doppler networks in OKC area. Coordinate SMART radars to collect data to be used for verification of NWRT data in assimilation experiments and NWRT cross-beam winds

l. Multiple projects. Compare NWRT to WSR-88D baseline, experimental data and mobile radar data.

m. Collect data for comparison to Lidar and X-band radar system. In addition, collect data for comparison to the mobile X-Band phased array system.

Many of these projects are reported on in this conference.

5. National Facility

As part of a Memorandum of Understanding between NOAA, Navy, FAA and OU, the NWRT is now a national facility allowing access to the broader research community for use in testing and advancing our understanding using phased array radar. To implement this national facility, a new user interface was developed to allow the operation of the NWRT from anywhere there is a network connection. Also, a NWRT Assessment Panel has been formed to evaluate and regulate the use of the NWRT. Current members are Jeff Kimpel and Doug Forsyth (NOAA), Jim Williams and Bill Benner (FAA), Ron Ferek and Scott Sandgathe (Navy) and Mark Yeary and Robert Palmer (OU). Details on how to apply for use of the NWRT are located on our web site: http://www.nssl.noaa.gov/research/radar/nwrt_use.php

The intent is to charge only for costs exceeding basic NWRT support costs.

6. Data Collection (Nov 06 – May 07)

Date	Radar Status	Moment	IQ	Weather / Comments
11/30/06	Snow Collection	4 hrs	6.6 gbs	via Laptop at home
12/01/06	Snow Collection			Archive
1/12/07	Ice Storm/ Thunder Sleet			
1/13/07	Ice Storm			
1/20/07	Ice Storm			
1/27/07	Snow			
1/29/07	Antenna Pattern Collection			
1/30/07	Antenna Pattern Collection			
1/31/07	Snow			
2/01/07	Snow & Ice			
2/15/07	Snow			
2/20/07	Azimuth Difference Collect		4.9 gbs	
2/21/07	Elevation Difference Collect		4.9 gbs	
2/23/07	Thunderstorms			

3/11/07	Thunderstorms			
3/12/07	Fog			
3/14/07	Wind Field Collection		20 gbs	With Chris Curtis
3/15/07	Wind Field Collection		40 gbs	With Chris Curtis
3/26/07	Rain			
3/27/07	Rain			
3/29/07	Thunderstorms & TVS	2 hrs		
3/30/07	Thunderstorms & TVS	4 hrs	61.4 gbs	
4/10/07	Hail & TVS	2 hrs		
4/13/07	Thunderstorms South		6 gbs	
4/17/07	Rain			
4/24/07	Thunderstorms & Hail	108 mbs	2.2 gbs	
4/30/07	Thunderstorms & Hail			
5/01/07	Thunderstorms	68 mbs	1 gbs	
5/02/07	Thunderstorms			
5/03/07	Thunderstorms	3.321 gbs		
5/04/07	Thunderstorms & TVS	17 mbs	600 mbs	Split cells NW
5/05/07	Hail & TVS			Out of range
5/06/07	Thunderstorms & TVS		20 gbs	Red River & Seminole
5/07/07	Thunderstorms	5 hrs	10 gbs	
5/08/07	Thunderstorms & TVS		115 gbs	El Reno
5/09/07	Thunderstorms		48 gbs	Funnel Cloud recorded
5/10/07	Thunderstorms			
5/11/07	Thunderstorms			
5/15/07	DARE Deployment	5 hrs	60 gbs	Cells to West with SMART-Rs
5/21/07	DARE Deployment	5.5 hrs		Cells NW moving SE
5/24/07	DARE & Balloon Deployment	5 hrs	224 gbs	Sqall line WSW
5/30/07	DARE & Balloon Deployment	2.5 hrs	53 gbs	Squall line W mvg rapidly SE
6/01/07	DARE & Balloon Deployment	3 hrs	41 gbs	MCS NW mvg SE

Table 1. Summary of Data Collection for 2007. Moment data (Reflectivity, Mean Velocity, and Spectrum Width). I/Q data are raw data collected before moments are calculated. (DARE = Data Assimilation Resolution Experiment, gbs = giga-bytes, mbs = Mega-bytes, MCS = Mesoscale Convective System, mvg = moving, TVS = Tornadic Vortex Signature)

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