# The National Weather Radar Testbed (Phased-Array)

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## 1. Introduction

The WSR-88D has been in the field now for over 12 years and it is time to look at what additional technology might be applied to improving this important forecast and warning tool. The National Oceanic and Atmospheric Administration's National Severe Storms Laboratory (NSSL) has combined efforts with the United States Navy's Office of Naval Research, Lockheed Martin Corporation, the University of Oklahoma's Electrical Engineering Department and School of Meteorology, the Oklahoma State Regents for Higher Education, the National Weather Service's Radar Operational Center and the Federal Aviation Administration's Technical Center to build a $25 million national phased array radar testbed in Norman, Oklahoma. This system will be used as a radar meteorological research testbed serving the needs of the atmospheric research community.

In this paper, we briefly describe the potential benefits of such a testbed and its components and capabilities that will be available for use in the spring of 2003.

## 2. Benefits

***The National Weather Radar Testbed will benefit meteorological researchers and forecasters, the Navy, the FAA, and the public.***

The primary tool for the detection and warning of severe storms is the weather radar. The United States has upgraded its weather radar capabilities over the last ten years by implementing Doppler technology and by providing data automation using the WSR-88D. Although this is a great improvement over previous radars, these radars can take between five and six minutes to scan a partial storm volume. Tornadoes, convective storms and hazardous wind shears develop very rapidly and for such events, a rapid scanning radar is essential to improve the warning lead times.

Conventional single-beam, mechanically scanned radars cannot achieve the requirement for a faster update rate and volumetric coverage with a spatial resolution of less then one kilometer. Phased array radars provide this ability. We estimate that a phased array radar system could provide volumetric update rates of less than one minute and combined with improved algorithms, could increase lead times for

warnings of hazardous weather to 22 minutes. This is an increase of 10 minutes over the current WSR-88D radar systems. These increased warning times will reduce injuries and loss of life so often associated with hazardous weather.

The National Weather Radar Testbed (NWRT) will be the first phased array radar facility available on a full-time basis to the radar meteorological research community. Based on a SPY-1A antenna provided by the Navy, the testbed has the capability to perform rapid update scans of a volume. Benefits of a rapid scanning phased radar system are summarized below:

**Public:**

- ✓ Increased lead time for tornado warnings
- ✓ Increased lead time for flood warnings
- ✓ Improved aviation safety

**Weather Researchers and Forecasters:**

- ✓ Improved understanding of storm dynamics and initiation
- ✓ Improved initialization of numerical models
- ✓ Improved real time algorithms for detection of hazardous weather
- ✓ Improved detection of tornadoes, microbursts, wind gusts, and other small scale phenomena

**FAA:**

- ✓ More timely and accurate weather information
- ✓ Increased warning lead time for wind shear hazards
- ✓ Increased lead time for wind shifts
- ✓ Dual-use for tracking aircraft and weather features

**Navy:**

- ✓ Initialization of on-scene weather prediction models
- ✓ Improved clutter characterization and elimination - Earlier detection of small cross-section targets
- ✓ Real time observation of weather for tactical planning
- ✓ Retrival of propagation characteristics in the environment

## 3. Advancements in Weather Radar Technology

***The National Weather Radar Testbed provides the upgrade path to the future of weather radar technology.***

Use of phased array radar for weather sensing is expected to provide numerous benefits to the radar meteorological community. These include:

- ♦rapid update of developing events, leading to increased warning time for hazardous weather events such as tornadoes, wind shears, wind gusts, and floods
- ♦tailoring of radar scan patterns to match local obstructions, leading to lower elevation scans and improved rainfall rate estimates
- ♦improved ground clutter cancellation due to reduction in spectral spreading
- ♦rapid update of developing weather events through adaptive scanning

The NSSL is continually investigating new ways to improve the performance of weather radars for the detection and warning of hazardous weather. The NWRT will allow the NSSL along with researchers nationwide to investigate the use of phased array radars as applied to the detection of weather

phenomena. Investigations will be conducted in several areas including meteorological research, radar design and algorithm development. Areas of study include:

**Meteorological Research**:

- Convective Storms
- Turbulent Flow
- Vortex dominated flows
- Mapping lightning channels
- Model initialization with rapid update data
- Spatial/temporal resolution tradeoffs
- Single-Doppler velocity retrieval

**Radar Design**:

- Advanced Scan Techniques
- Waveform Studies
- Clutter Mapping and Cancellation
- Phased Array Design Tradeoffs

**Algorithm Development**:

- Adaptive Scan
- Hazardous Weather Recognition
- Forecasting and Nowcasting Algorithms
- Determination of the vector wind field

One of the ways the NWRT creates improvements in our weather observation system is by using the rapid and variable scan capability of the radar to increase our understanding of the storm dynamics. This information can then be used to improve the scanning strategies of the WSR-88D's and to develop new detection algorithms. This will improve the National Weather Service's ability to detect and provide warnings of impending severe weather.

## 4. Objectives

The primary objectives of the National Weather Radar Testbed (NWRT) are:

- To support meteorological research into the evolution of hazardous weather events resulting in an enhanced capability to detect and predict severe weather
- To obtain rapid update data for initialization of numerical models that will improve forecasting and nowcasting capability
- To demonstrate the effectiveness of a phased array radar in providing longer lead time for severe storm warnings.
- To provide more timely and accurate weather information to the Air Traffic community
- To be a research testbed leading to the development of improved/new weather radars for the 21st century

The primary advantage of a phased array radar for meteorology is its capability to obtain very rapid update data that improves the meteorologists ability to issue improved warnings and forecasts of hazardous weather.

The NWRT provides the research community with a tool to investigate how to use rapid scanning radars to improve our warning and forecast operations. The better temporal resolution of the data will allow researchers to enhance their conceptual models of storms and to improve their detection algorithms. With the help of the FAA, we will also investigate the dual-use of the radar for tracking aircraft and weather simultaneously.

## 5. System Components

The National Weather Radar Testbed (NWRT) will include a SPY-1A antenna and beamsteering controller and a WSR-88D (NEXRAD) transmitter provided by the National Weather Service. A COTS based environmental processor for the NWRT is being designed and built by Lockheed Martin under a contract with the University of Oklahoma. The rest of the system and integration, installation and testing is being accomplished by Lockheed Martin under a separate contract with the Navy. The components that comprise the NWRT include:

**NAVY:**
★AN/SPY-1A Antenna
★AN/SPY-1A Beam Programmer

**NOAA/NWS:**
★WSR-88D Transmitter

**University of Oklahoma:**
★Environmental Processor (EP)

**Lockheed Martin:**
★Receiver/Exciter
★PAR Testbed Controller
★Enclosure, Pedestal & Radome

**NOAA/NSSL:**
★Infrastructure support for the Architectural Facility (Enclosure, Pedestal & Radome)
★User Facility

The antenna, pedestal and system components for analog signal generation and processing are located in the pedestal building/Architectural Facility. After A/D conversion is performed by the digital receiver, the digital data is sent via fiber optic link to the control building/User Facility. The control building houses the EP that consists of the digital signal processor (DSP), weather data processor (WDP), and the data recording and archive devices. The user interface software, radar control display, and the radar scheduler are also housed in the control building located a maximum of 300 meters from the pedestal building.

## 7. Schedule

The current schedule will result in the system being built this fall with integration and testing occurring next spring and summer at the Lockheed Martin facility in Moorestown, New Jersey. The system will then be installed on the north campus of the University of Oklahoma near the NSSL in Norman, Oklahoma during the fall 2002. The NWRT will then be tested and ready for operations during the spring 2003.

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