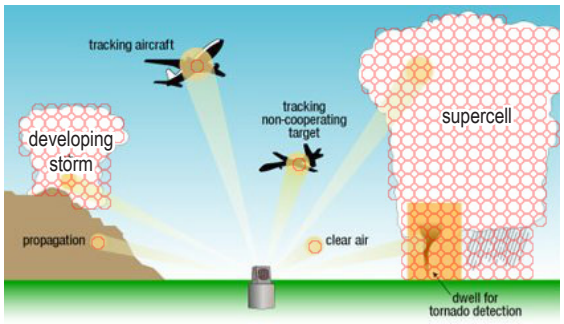
NOAA National Severe Storms Laboratory

Multi-function Phased Array Radar

The National Weather Radar Testbed (NWRT) Multi-function Phased Array Radar (MPAR) program is a NOAA/FAA initiative to combine the operational radar functions of several national networks and have them served by a single radar system for aircraft and weather surveillance. NSSL successfully led the effort to repurpose a 1970s vintage U.S. Navy surveillance phased array radar and adapt it for weather. Now, because the NWRT/PAR system is based on military technology that is several decades old, the MPAR program is researching and developing more modern technology.

A multi-function radar

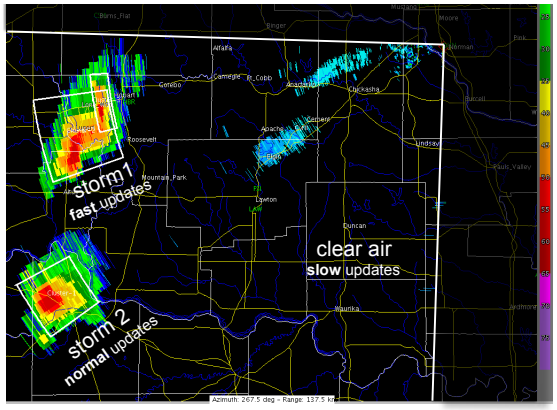
Various federal agencies operate radar networks (including ~350 aircraft tracking radars and ~200 weather radars) that will eventually need to be replaced. These ~550 single-function radars could be replaced with approximately 365 multi-function radars. Combining the operational requirements of these several radar systems with a single technology solution would result in an estimated savings to the nation of $4.8 billion in acquisition and maintenance costs. The agencies would have access to data from all 365 radars rather than just their own, more than doubling the number of radars available for use by the National Weather Service (NWS) for its weather mission requirements.



The Multi-function Phased Array Radar program (MPAR) is investigating whether a single radar system can perform both aircraft and weather surveillance.

Electronic steering and adaptive scans

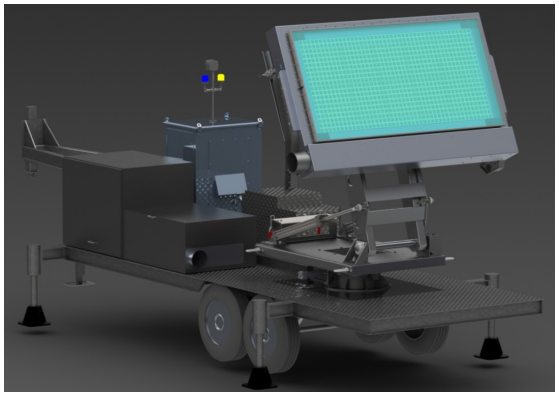
The antenna of a phased array radar can be a stationary flat or cylindrical panel, unlike the rotating antenna dish on current weather radars. These dishes require 4-5 minutes to mechanically rotate and tilt upwards as they sample the atmosphere around the radar. In contrast, the phased array radar has no moving parts so it can scan the entire sky in less than a minute. Operators can also steer its beams electronically to skip areas of clear air, or scan storms vertically, resulting in more information over areas of severe weather.



The ability to control where the radar needs to scan saves time.

Testing other PAR configurations

Phased array radars may be configured in many different geometries. The MPAR program has funded the development of a small-scale engineering technology demonstration system with a planar array that will be evaluated in 2015. Engineers will evaluate dual-polarization performance, calibration techniques, and develop scanning strategies for this new configuration.



Computer drawing of a 10-panel demonstrator.

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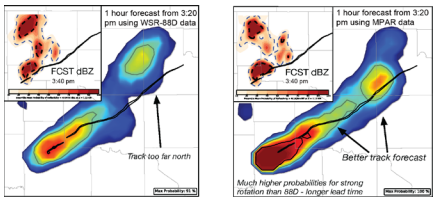
Warn-on-Forecast

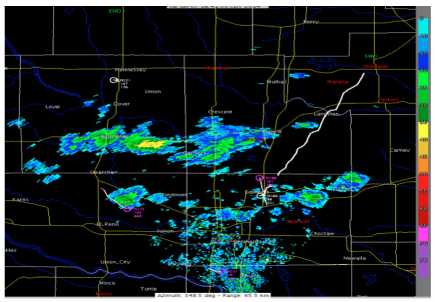
NOAA's Warn-on Forecast research project, led by NSSL, requires rapidly updating radar data such as data available from phased array radars to create computer forecasts that accurately predict when and where severe weather will occur in the next hour. The rapid update of phased array radars will provide better information for the forecast models and result in better forecast products. Scientists believe these models will eventually be able to predict the probability that severe weather will hit communities up to an hour in advance.



The Warn-on-Forecast project will need rapidly updating phased array radar data to accomplish its goal.

New software

New scanning strategies and techniques are installed and tested each spring and fall to minimize the amount of time MPAR takes to scan a storm without losing data quality. In spring, 2014, engineers successfully tested aircraft detection and tracking algorithms that were robust in the presence of weather and ground clutter. They also tested adaptive scheduling of weather and aviation functions using interlaced scans, and integrated radar data displays that show both aircraft and weather information.



Researchers are testing phased array radar aircraft tracking capabilities. Aircraft routes are indicated by white lines.

Tornado warning decisions

In a recent experiment, forecasters from nine NWS offices used rapid-scan PAR data to issue tornado warnings on two tornadic and two non-tornadic archived supercell cases. Verification of the tornadic cases revealed that forecasters using PAR data provided a mean tornado lead-time of 20.1 minutes, exceeding the current 13 minute national mean tornado lead-times using current NWS radars. Forecasters reported that the rapid update of PAR data helped them diagnose and track velocity signatures more efficiently.

Advanced Technology Demonstrator

NSSL and FAA are currently planning the construction of an Advanced Technology Demonstrator to replace the aging and obsolete SPY-1A phased array antenna within the NWRT. This Advanced Technology Demonstrator (NWRT/ATD) will be a single-face planar array capable of demonstrating multi-function operation using modern, dual-polarization technology, and allow the MPAR program to perform the analysis necessary to make key investment decisions.

Research Partnerships

Federal, private, state and academic groups are partnering to develop MPAR technology. Participants include NOAA NSSL and National Weather Service Radar Operations Center; the Federal Aviation Administration; Lockheed Martin, Raytheon, Northrup Grumman, Ball Aerospace, and Saab Sensis; the Department of Defense; University of Oklahoma's School of Meteorology, School of Electrical and Computer Engineering, and Advanced Radar Research Center; Oklahoma State Regents for Higher Education; Basic Commerce and Industries; Massachusetts Institute of Technology/Lincoln Laboratory, Georgia Tech Research Institute, and the Office of the Federal Coordinator for Meteorology.

Benefits of MPAR include:

- Improvements in detection and warning of high-impact, severe weather.
- Tornado warning lead-times extended from the current 13 minutes to 20 minutes, and false alarm rates reduced substantially from the current 75 percent.
- Better national radar coverage through partnership and reuse of MPAR radars at other agency locations
- The capability to track aircraft not responding to air traffic control in U.S. airspace to benefit homeland security and commercial aviation.
- Estimated $4.8 billion in savings to the taxpayer: $1.8 billion with single radars having multi-function capability, $3 billion in life-cycle costs projected over 30 years.

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