

National Oceanic and Atmospheric Administration
Multi-function Phased Array Radar Program:
Dual Polarization Technology and Inter-agency Coordination Activities
FY 2016 Report to Congress

The House Report (114-130) accompanying the Consolidated Appropriations Act, 2016 (P.L. 114-113), included the following language,

“The Committee encourages [National Oceanic and Atmospheric Administration] NOAA to facilitate a full evaluation of a dual-polarization [Multi-function Phased Array Radar] MPAR system and submit a report to the Committee within 180 days of enactment of this Act. The Committee encourages NOAA and [Federal Aviation Administration] FAA to work with the Office of Management and Budget (OMB) and the Office of Science and Technology Policy (OSTP) to develop a long term multi-year funding strategy to ensure the MPAR program is adequately resourced in future years.”

The Senate Report (114-66) accompanying the Consolidated Appropriations Act, 2016 (P.L. 114-113), included the following language,

“The Committee directs NOAA to maintain its leadership role for MPAR research and development [R&D] and to establish an interagency committee, including the FAA and other stakeholders, to formulate key requirements for a comprehensive development and acquisition strategy. Not later than 45 days after enactment of this act, NOAA shall provide a plan detailing how such key requirements would be achieved.”

This report responds to the Committees’ requests.

Introduction

The NOAA National Severe Storms Laboratory (NSSL) and the FAA have been conducting R&D on the MPAR concept for over 13 years. Much of this R&D is described in the Fiscal Year (FY) 2014 *Multi-Function Phased Array Radar and Cylindrical Polarized Phased Array Radar*¹ Report to Congress. Many of NOAA’s MPAR R&D activities have been directed at implementing dual polarization on phased array radar technology. This work continues in FY 2017, as described in this report, with the evaluation of dual polarization performance of small-scale engineering demonstrators and the continued development of medium-scale dual polarization planar phased array radar.

With FAA, NOAA is actively engaged in a leadership role for MPAR R&D, including coordination with other relevant Federal agencies. Until late FY 2015, FAA and NOAA were the only agencies actively involved in the development of the MPAR concept, and were following a timeline based on the FAA acquisition process (described in the FY 2015 *NOAA Multifunction Phased Array Radar Program Milestones* Report to Congress²). The Department

¹ http://www.nssl.noaa.gov/publications/mpar_reports/FY14_MPAR_CPPAR_Congressional_Report.pdf

² http://www.nssl.noaa.gov/publications/mpar_reports/FY15_MPAR_Program_Report_to_Congress.pdf

of Defense (DoD) and the Department of Homeland Security (DHS) have now joined NOAA and FAA in an effort to determine if evolving radar system technology could potentially allow the agencies to consolidate the functions of current air traffic control, weather, and homeland defense/security surveillance systems. The involvement of all four agencies responsible for the various Federal radar networks is viewed as a positive step, as the business case for MPAR is stronger if more agencies participate. Sharing the non-recurring engineering & development costs among multiple agencies and sharing the costs of deployed radars among the multiple agencies should reduce the overall cost of the program through economies of scale when compared to each agency developing their own radar.

This report describes the NOAA MPAR Program's ongoing dual polarization technology development and evaluations as well as the ongoing inter-agency coordination activities, including an updated timeline.

Dual Polarization Phased Array Radar Technology Development and Evaluation

The MPAR program has previously supported the development of two small-scale dual polarization phased array radars. The University of Oklahoma's Advanced Radar Research Center has developed the Cylindrical Polarized Phased Array Radar (CPPAR). The Massachusetts Institute of Technology Lincoln Laboratory (MIT/LL) has developed a planar polarized phased array radar Ten-Panel Demonstrator (TPD). NOAA and the FAA are currently developing the dual polarization Advanced Technology Demonstrator (ATD) planar phased array radar based on a new generation of the MIT/LL panel design. The ATD will replace the aging and limited capability National Weather Radar Testbed Phased Array Radar currently used by NSSL for research.

The TPD and CPPAR systems were developed to test and demonstrate certain capabilities and technologies associated with dual polarization technology on phased array radar. Both systems have similar size and power, but have significantly different operating capabilities. Planar and cylindrical array geometries each have their own advantages and disadvantages (see FY 2014 MPAR report to Congress for more details) and operate differently. Planar arrays scan electronically by changing the phase (or timing) of the individual transmitters to direct the beam to a given location. Cylindrical phased array radars steer the beam in azimuth (side to side) by selectively turning on columns (within a sector or quadrant) so that the radar beam points in a desired direction perpendicular to the cylinder.

Dual polarization phased array radars are a relatively new development, and weather radars require an exacting standard with regards to dual polarization performance. It is essential for dual polarization phased array radars to maintain electronic isolation between the horizontal and vertical channels while scanning electronically in both azimuth (side to side) and elevation (up and down) directions (see FY 2014 MPAR report to Congress for more details). NOAA has just begun evaluating the polarization performance and calibration of the TPD and CPPAR demonstration systems in preparation for the eventual evaluation of the larger scale ATD. These fundamental evaluations must be completed before the ATD technology can be used, in research mode, for dual polarization weather observations. Based on the current schedule, the ATD technology is slated to be available for demonstration in late FY 2018.

Both the TPD and CPPAR demonstrators have identified unique challenges with respect to dual polarization array calibration and weather calibration for phased array radars. Many lessons learned have been identified and applied to the ATD development activities and support infrastructure for the ATD facility. One of the lessons learned is that it is important to quantify performance and calibration in a controlled environment (i.e. a nearfield anechoic, or echo free, chamber) before attempting to make performance and calibration measurements in an operational environment. The controlled environment measurements of the ATD will be of tremendous benefit in determining if initial operational measurements are consistent with expected performance.

The evaluations done to quantify TPD and CPPAR calibration measurements have also led to a change for an improved calibration process of the ATD. The TPD and CPPAR measurements are being facilitated by temporary calibration equipment which require significant setup and takedown activities. Because calibration tests are crucial to the evaluation of the radar, a permanent calibration tower will be integrated with the ATD. This new facility will allow routine and on-demand polarization and calibration measurements for the ATD. The calibration tower should be installed by mid-FY 2017 prior to the integration and testing of the ATD system.

Interagency Activities - Spectrum Efficient National Surveillance Radar Program

Interagency efforts and coordination for a national radar solution have been influenced by recent legislation and Administrative policy regarding spectrum use.

The Commercial Spectrum Enhancement Act (2004), as amended, created the Spectrum Relocation Fund (SRF) to provide a funding mechanism for Federal agencies to recover costs associated with transitioning use of assigned federal spectrum from exclusive Federal use to exclusive nonfederal use, or shared Federal and nonfederal use. A 2010 Presidential Memorandum³ directed that executive departments, agencies, and offices collaborate with the Federal Communications Commission (FCC) to make available a total of 500 MHz of Federal and nonfederal spectrum over the next 10 years, suitable for both mobile and fixed wireless broadband use. In late FY 2015, the agencies (FAA, NOAA, DoD, and DHS) began discussing a multi-agency program to assess the possibility of combining the various agency radar networks into a common network. Under the Commercial Spectrum Enhancement Act the SRF could only fund cost recovery after the spectrum had been auctioned and could not fund the substantial R&D necessary to consolidate radar functions within a common radar system.

Last year, Congress passed the Spectrum Pipeline Act of 2015 (hereafter SPA15) as part of the Bipartisan Budget Act (P. L. 114-74). The SPA15 provides \$500 million from the SRF to be made available to agencies for R&D and planning activities that increases the probability of reallocating or sharing spectrum for commercial broadband use.

In response to the opportunity created through SPA15, NOAA, FAA, DoD, and DHS are formulating a program to assess the feasibility of consolidating and/or relocating long-range and short-range air surveillance and weather radar networks, which currently operate in different

³ <https://www.whitehouse.gov/the-press-office/presidential-memorandum-unleashing-wireless-broadband-revolution>

parts of the spectrum, into a smaller footprint of the spectrum. This cross-agency program is called the Spectrum Efficient National Surveillance Radar (SENSR) program. The SENSR program will investigate the possibility of consolidating the various Federal radar networks into a common system (or system of systems) to use less of the spectrum while performing the necessary functions to meet agency requirements. The MPAR concept is a potential solution for the SENSR program. SENSR is a new interagency effort which is being coordinated with ongoing NOAA and FAA MPAR R&D activities.

As a first step, the agencies have collaborated and developed a Spectrum Pipeline Plan to explore the SENSR concept and request SENSR funding from the SRF via the authorities specified in SPA15. A final plan was signed by all agencies and approved by a Technical Panel (consisting of representatives from OMB, the National Telecommunications and Information Administration, and the Federal Communications Commission) in January 2017. OMB has delivered the Spectrum Pipeline Plan to Congress for review before the Technical Panel releases the SENSR funding.

Through the SENSR Program, the agencies have developed and proposed a three phase approach and corresponding timeline for activities leading up to a radar system acquisition. This timeline is mandated by SPA15 which states that the Technical Panel must consider whether the activities conducted with the payment will increase the probability of relocation from or sharing of Federal spectrum, and facilitate an auction intended to occur not later than eight years after the payment. This three-phased approach and timeline has replaced the timeline previously guiding the NOAA MPAR Program's R&D efforts, which was based on the FAA acquisition process (described in the FY 2015 MPAR Report).

A summary timeline is shown in Figure 1 along with some of the major activities conducted during each phase.

Phase One:

The first phase of the SENSR plan is a Feasibility Study, to be conducted in FY 2017 and 2018. Each of the four participating agencies is contributing its expertise to the feasibility study. The Feasibility Study consists of requirements definition, development of an integrated concept of operations, a market survey, an analysis of alternative solutions, and some additional R&D activities. NOAA will conduct R&D activities to answer the remaining science questions concerning the technical challenges of an MPAR solution. R&D during this phase will be supported through both MPAR Program funds and SENSR funding to meet the established timeline. The remainder of NOAA's SENSR funding will support National Weather Service (NWS) analysis and planning activities to support the interagency program. The Feasibility Study will examine command and control concepts to determine any risks posed to each agency's mission, including risks associated with combining the multi-agency network of radars into a single frequency band. The agencies will use the outcome of the Feasibility Study activities to determine the best path forward. Phase One also includes establishing a Joint Program Office (JPO) to coordinate activities and resolve conflicts among the participating agencies.

Phase Two:

If the feasibility study concludes that the program is viable, the agencies plan to begin a System Maturation Phase (FY 2019 - 2021) consisting of vendor demonstrations of existing capabilities and possibly new development. Anywhere from two to four vendors could be selected for the vendor demonstrations/evaluations in phase two.

Phase Three:

Phase three would begin with the agencies down-selecting to one (or possibly two) vendor(s) who would be awarded a contract to develop their final design and build a prototype. The agencies would perform their evaluations on the prototype(s) and jointly make an acquisition decision. This phase needs to begin (and all agencies need to commit to the spectrum auction) by early FY 2022 in order to facilitate an auction in FY 2024.

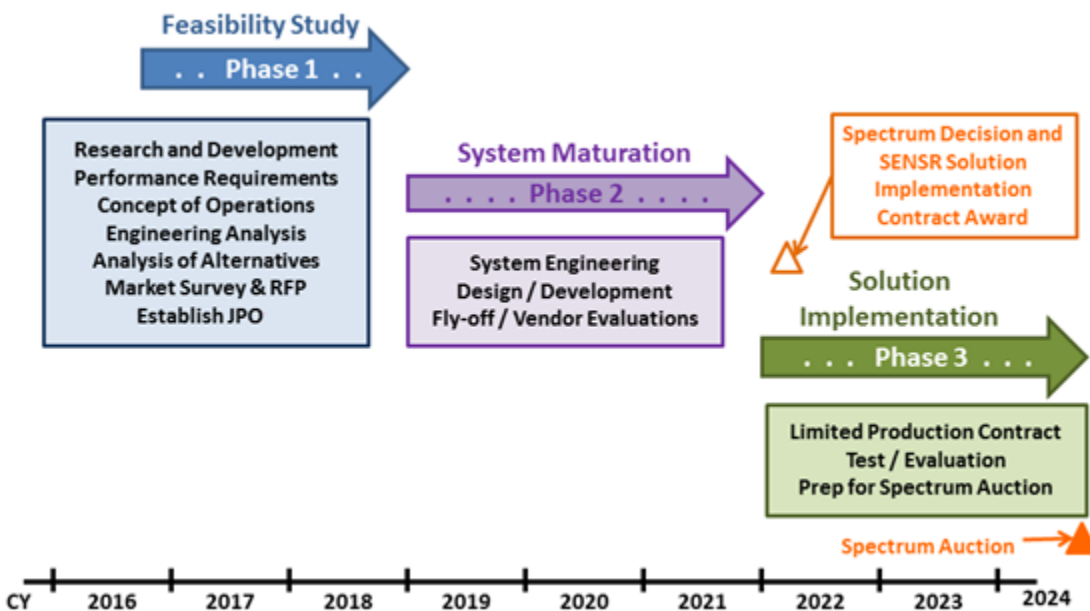


Figure 1: A summary timeline of the phases and activities of the SENSr program necessary to meet the spectrum auction date specified in SPA15.

The plan laid out above for SENSr activities forms the basis of a potential acquisition strategy, but the details of a comprehensive development and acquisition strategy will be dependent on the outcome of the Feasibility Study. The planned inter-agency activities will include the formation of a SENSr Joint Program Office (JPO) that will coordinate future activities and a senior-level Executive Steering Group (ESG) consisting of representatives from each agency to make decisions going forward. The SENSr JPO will be formed once the agencies have secured the necessary funding for the Feasibility Study and an inter-agency Memorandum of Agreement (currently under development) has been signed. The JPO and ESG will be augmented by a multi-agency Government Engineering Team of program managers and technical staff representing agency stakeholders. The JPO will determine the final SENSr timeline and

milestones, which will supersede the previous FAA acquisition milestones as well as the draft plan laid out here.

Previous MPAR R&D has been focused on the concept of how a single multifunction radar design could potentially meet all the mission requirements of multiple agencies. Integrating all the radar functions into a single radar introduces technical complexities and cost implications. The SENSR R&D funds are crucial to NOAA's understanding of how NWS operational performance requirements would be met by MPAR or any other alternative suggested by SENSR. The SENSR Feasibility Study may determine that (given the implementation time frame associated with SPA15) a bifurcated network of weather surveillance radars and aircraft detection radars (or some other alternative solution) may be necessary to meet the requirements of multiple agencies and the spectrum auction mandate of SPA15. This approach would likely be less efficient than an MPAR solution and may require a larger number of radars and the possibility of multiple maintenance and logistics organizations to support the network. Additionally, each approach carries risks of having insufficient spectrum to support all radar operations using a single target band of spectrum.

Conclusion

NOAA continues to evaluate the calibration and dual polarization performance of phased array radar technologies. This evaluation will continue through the integration and demonstration of the ATD and beyond. The ATD system will continue to serve as a testbed for dual polarization phased array radar in support of SENSR program objectives and severe storm research at NSSL. Upon completion of the SENSR Feasibility Study and following the evaluation and demonstration of the ATD, the technical challenge of implementing dual polarization with phased array radar technology will be better understood.

The FAA and NOAA have over a decade of experience conducting R&D in the areas of dual polarization phased array radar technology, significantly furthering the maturation of the MPAR concept. Current MPAR program funds are necessary to complete the ongoing development of the ATD, all-digital design studies, and to support meteorological studies of dual polarization phased array radar. NOAA's SENSR funding will augment the R&D activities to support the accelerated timeline of the SENSR program and provide support for NWS analysis and planning activities.

The multi-agency SENSR program is a strategic shift in that DoD and DHS are now collaborating with FAA and NOAA on a SENSR plan and a portion of SPA15 funding can now be requested for the Feasibility Studies prior to the commitment of the sale of Spectrum. The SENSR plan is being finalized for signature by the agencies which will initiate Phase 1 and the Feasibility Study, if approved by the Technical Panel. Phase 1 includes establishment of a JPO to coordinate future collaborations and make strategic decisions.

List of Acronyms

ATD	Advanced Technology Demonstrator
CPPAR	Cylindrical Polarized Phased Array Radar
DHS	Department of Homeland Security
DoD	Department of Defense
ESG	Executive Steering Group
FAA	Federal Aviation Administration
FY	Fiscal Year
JPO	Joint Program Office
MIT/LL	Massachusetts Institute of Technology Lincoln Laboratory
MPAR	Multi-function Phased Array Radar
NOAA	National Oceanic and Atmospheric Administration
NSSL	National Severe Storms Laboratory
NWS	National Weather Service
OMB	Office of Management and Budget
OSTP	Office of Science and Technology Policy
R&D	Research and Development
SENSR	Spectrum Efficient National Surveillance Radar
SPA15	Spectrum Pipeline Act of 2015
SRF	Spectrum Relocation Fund
TPD	Ten-Panel Demonstrator