National Oceanic and Atmospheric Administration
Multifunction Phased Array Radar Program Milestones

The House Report (113-448) accompanying the Consolidated and Further Continuing Appropriations Act, 2015, included the following language,

"NOAA shall provide a report no later than 180 days after enactment of this Act regarding timeframes for determining the operational feasibility of MPAR [Multifunction Phased Array Radar], to include yearly costs and schedule milestones. NOAA shall consult with its government and academic research partners in developing this report."

This report responds to the Committee's request.

Introduction

Multifunction Phased Array Radar (MPAR) is an ambitious concept for the future of radar in the United States. If implemented for operational use, MPAR would replace a variety of present radar systems with a single, advanced radar design. There are approximately 629 radars of varying design used by multiple Federal agencies, primarily the Department of Defense (DoD), the Federal Aviation Administration (FAA), the Department of Homeland Security, and the National Oceanic and Atmospheric Administration (NOAA). Phased array radar technology is the only known technology available that could possibly meet the combined requirements of all the existing radar systems and possible evolutionary requirements throughout its lifecycle.

NOAA and FAA Research and Development (R&D) activities over the past 12 years have identified three key challenges in MPAR's development: cost, dual polarization, and multi-function operation. The Fiscal Year (FY) 2014 *Multi-Function Phased Array Radar and Cylindrical Polarized Phased Array Radar*[1] Report to Congress details these challenges and the NOAA and FAA R&D to address them.

Historically, the development and transition of new radar technology into operations requires 20-25 years. For example, Doppler weather radar was first demonstrated in the early 1970s, but was not deployed as part of NOAA's operational weather radar system (WSR-88D) until the early 1990s. The development of dual polarization on phased array radar technology is substantially more complex than the development of Doppler, but necessary to meet the multi-function requirements of MPAR. The lengthy engineering design/development/test cycles of the MPAR program are also necessary to ensure that operational performance requirements are met. Despite these challenges, progress is developing on schedule within the appropriated funds for the program.

In addition to R&D, NOAA and FAA are discussing the potential for a joint acquisition of phased array radar technology for operational use. At this time, neither agency has made a decision to procure or deploy MPAR, but are jointly investigating cost/benefit estimates. In addition, the National Weather Service (NWS) has already compiled its radar requirements and

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

also identified new requirements that could lead to the implementation of phased array radar technology.

Historical Interagency Collaborations and Program Milestones

The four main Federal agencies that operate the current radar networks have been collaborating and engaged on the discussion of combining radar systems across agencies for multi-use purposes since 2003. In 2003, the National Weather Radar Testbed/Phased Array Radar (NWRT/PAR) was established at the National Severe Storms Laboratory (NSSL) in Norman, Oklahoma, through a collaboration of Federal agencies and other partners. This NWRT/PAR system is based on a military SPY-1A[2] antenna, which has been used over the past 12 years to study how phased array radar could improve weather research and observations of severe storms.

In 2006, the Joint Action Group for Phased Array Radar Project (JAG/PARP) published the *Federal Research and Development Needs and Priorities for Phased Array Radar (FCM-R25-2006).*[3] One of the recommendations of the JAG/PARP in the FCM-R25-2006 report was to establish an interagency MPAR Working Group (WG/MPAR) within the Office of the Federal Coordinator for Meteorological Services and Supporting Research to coordinate and report on the R&D activities of participating agencies in implementing an MPAR risk-reduction program. The WG/MPAR includes representatives from NOAA, FAA, DoD, and DHS and has continued to meet two to three times per year to discuss MPAR R&D activities that NOAA and FAA have conducted. In addition, this report included a nine-year MPAR R&D plan and estimated the cost of these activities at $215 million. Approximately $92 million has been spent on MPAR R&D activities between NOAA ($63 million) and FAA ($29 million) from FY 2007 through FY 2015.

The MPAR: NOAA and FAA Spend Plan report to Congress required through the Consolidated and Continuing Appropriations Act, 2015 (previously released to Congress) details MPAR development activities through FY 2018. An updated spend plan is included in Appendix A.

FAA Acquisition Program and Milestones

The FAA's process to replace their radar networks drives the timeline for future MPAR program activities. The goal of FAA's NextGen Surveillance and Weather Radar Capability (NSWRC) program is to replace the FAA's Terminal Doppler Weather Radar (TDWR) and Airport Surveillance Radar (ASR) systems that perform weather and aircraft tracking in the airport terminal area, respectively. MPAR is one of three possible solutions the FAA is considering. Of the three technologies under consideration, MPAR is the only technology that could potentially meet FAA needs of a multi-function weather surveillance and aircraft tracking radar. NOAA and FAA are conducting R&D to inform the FAA's decision-making process and to ensure the technologies necessary for MPAR are sufficiently tested and can be implemented in a costeffective way.

[2] Army Navy Joint Electronics Type Designation System / **S** - Water (surface ship), **P** - Radar, **Y** - Surveillance (target detecting and tracking) and Control (fire control and/or air control), model number **1A.** The SPY-1A antenna is a passive electronically scanned array that was developed in the 1970's as part of the Aegis Combat System deployed aboard U.S. Navy ships. The SPY-1A phased array technology was developed to detect and track airborne threats.

[3] Available online at http://www.ofcm.gov/r25-mpar/fcm-r25.htm.

The following program milestones are from the NextGen Surveillance and Weather Radar Capability (NSWRC) program. Each milestone includes information on NOAA's R&D efforts towards meeting these milestones and the potential for a joint NOAA-FAA acquisition program. The FAA timeline is driving decision milestones and all dates listed below are tentative and subject to FAA modification.

This figure shows the major milestones and activities of the FAA acquisition process. The investment decision milestones of the NSWRC relate to the FAA acquisition process only. NOAA is partnering with FAA, however, to perform a similar analysis from a joint-agency perspective.

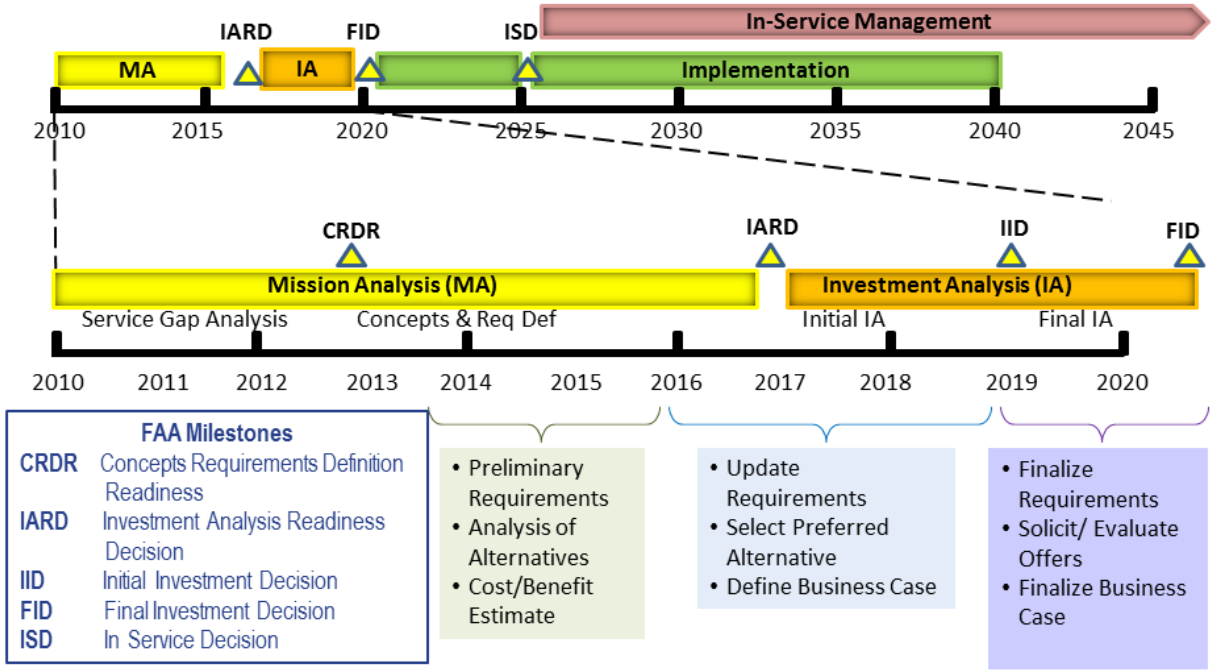

Figure 1: Key milestones and activities of the FAA NSWRC acquisition program.

A) Investment Analysis Readiness Decision (IARD) December 2016: The FAA has compiled their preliminary requirements for the replacement of the TDWR and ASR systems. The FAA has identified several alternative solutions. During the IARD, three alternatives will be formally selected for the follow-on investment analysis phase. MPAR is expected to be one of the three alternatives selected.

<u>Related R&D Efforts</u>

Several studies and technology development activities have been and continue to be conducted to determine if sufficient risk reduction has been accomplished to warrant including MPAR in the three alternatives that are selected for the follow-on investment analysis phase. NOAA's National Severe Storms Laboratory (NSSL), in Norman, Oklahoma has funded the development of two small-scale dual polarization phased array radar demonstrators leading up to IARD. The two demonstrators consist of one 10-panel planar array (jointly funded with FAA) and one partial cylindrical array (jointly funded

with the University of Oklahoma). Evaluation of these systems began in 2015 and will continue through 2016 and should provide information on polarization performance and calibration procedures that will inform upcoming key agency decisions.

B) Initial Investment Decision (IID) December 2018: Following the IARD, the FAA will enter the Initial Investment Analysis period. During this period, the three alternatives will be further investigated, including refining requirements to meet the agency's combined weather and aircraft surveillance needs and developing a business case for each alternative. At IID, the preferred alternative will be selected. Preliminary cost estimates indicate that an MPAR system only makes economic sense if multiple agencies participate, therefore, for MPAR to be selected, the FAA would need a firm commitment from at least one other agency to join an MPAR development program. The requirements and business case developed during the Initial Investment Analysis period for MPAR would represent all participating agencies. If MPAR is selected at the IID under a multi-agency scenario, then a Joint Program Office for MPAR (JPOM) would likely be formed to lead the effort on behalf of the participating agencies.

Related R&D efforts

Prior to the IID, NOAA is working to provide a demonstration of MPAR-capable technology via an Advanced Technology Demonstrator (ATD), which would prove the viability of the MPAR concept. The ATD, with a dual polarized *active array*[4] antenna, will eventually replace the current NWRT SPY-1A phased array radar antenna at NSSL. The ATD will demonstrate the capability of an electronically scanned array radar to collect dual polarization weather data, and provide a proof-of-concept platform to evaluate multi-functionality for both weather and air surveillance. It will also demonstrate critical calibration processes for large arrays, allow for the evaluation of cost alternatives and tradeoffs, and serve as a future R&D asset for NSSL for further MPAR pathfinding activities. NOAA and FAA have begun planning and executing the ATD[5] project, and are jointly sharing costs of the program.

C) Final Investment Decision (FID) December 2020: If MPAR is selected as the preferred alternative, requirements will be finalized based on input from the participating agencies. The JPOM will solicit offers from industry vendors to design and develop MPAR pre-production (i.e., first article; prototype) systems. The vendors would be free to submit any MPAR design (e.g., multi-face planar array, faceted-cylindrical array, or rotating planar array) that meets all participating agency MPAR requirements. NOAA and the FAA have made MPAR research investments in dual polarization capabilities, planar and cylindrical designs, scanning strategies, and all-digital architectures. These investments should provide the necessary background and support to enable industry vendors to offer

[4] The current NWRT SPY-1A system is based on older *passive* phased array radar technology that has limited capability compared to the newer active phased array radar technology. Passive array radar has a single high-power transmitter whose energy is distributed to all the elements on the array antenna, whereas active array radar has a low-power transmit/receive chip located at each element in the array. Active array architecture gives the radar the ability to perform advanced beamforming and shaping to improve performance and functionality.

[5] The ATD is being designed to use currently available components with as little re-engineering as possible to reduce risk to the schedule and budget. A production MPAR would likely use advanced technology available at the time of production.

proposals that are the most cost effective and supportive of the Federal Government's requirements. The JPOM will evaluate proposals and award pre-production contracts to one or two vendors. The details of an acquisition strategy cannot be finalized until there is greater certainty on how the actual procurement will be conducted.

D) Solution Implementation Phase from December 2020 to December 2025: Following the FID, the winning vendor(s) would design and develop a pre-production MPAR and the JPOM would then conduct a test and evaluation of the prototype(s).

E) In Service Decision (ISD) December 2025: Following the test and evaluation of the MPAR prototype, the participating agencies would determine if requirements are being met. This decision will determine the ultimate feasibility of the MPAR concept to meet each agency's mission requirements. If so, the vendor would be awarded a production contract and deployment of MPAR would begin.

MPAR Budget Planning

The *MPAR: NOAA and FAA Spend Plan* report to Congress required through the Consolidated and Continuing Appropriations Act, 2015 details development activities through FY 2018, which correspond with MPAR R&D activities leading to the NSWRC IID. The major expenditure during this period is the development and integration of the Advanced Technology Demonstrator (ATD). For FY 2014 through FY 2018, NOAA plans to spend more than $65 million toward MPAR-related R&D activities.

Conclusion

The FAA and NOAA have been collaborating on MPAR R&D and have been jointly funding projects of mutual interest. The FAA and NOAA have conducted R&D in the areas of dual polarization phased array radar technology and maturation of the MPAR concept of operation. The joint FAA and NOAA MPAR R&D will culminate with the development of a dual polarization ATD with advanced operational features that would likely be required to meet MPAR operational requirements.

Although not as actively engaged, DoD and DHS have been monitoring the MPAR R&D activities through their participation in interagency groups and through other briefings and presentations from FAA and NOAA.

The MPAR program is currently in the R&D phase, however, analysis of the feasibility and affordability of an MPAR deployment will depend on the final set of government requirements agreed upon by the participating agencies. Any preformed or preconceived technical solution or implementation to meet performance objectives is premature. The establishment of a JPOM would signify the transition from a R&D program to a joint-agency acquisition program. The JPOM would then determine interagency performance requirements, the concept of operations, network topography, and cost sharing methods among the participating agencies.

Appendix A – Updated Joint Spending Plan

Combined NOAA and FAA investments in MPAR research and development activities FY 2014-2018*

Tentative
NOAA and FAA Spend Plan
In Millions of Dollars

Activity	FY 2014 Spend Plan	FY 2015 Spend Plan	FY 2016 Spend Plan	FY 2017 President's Budget	FY 2018 Projected	Total FY14-18
Advanced Technology Demonstrator	NOAA $ 3.900	NOAA $ 3.900	NOAA $ 3.900	NOAA $ 3.900	NOAA $ 3.900	NOAA $ 19.500
	FAA $ 4.000	FAA $ 4.000	FAA $ 1.500	FAA $ 1.500	FAA $ 2.000	FAA $ 13.000
	Sub-Total $ 7.900	Sub-Total $ 7.900	Sub-Total $ 5.400	Sub-Total $ 5.400	Sub-Total $ 5.900	Sub-Total *$ 32.500*
10-Panel Engineering Demonstration	NOAA $ 1.300	NOAA $ 0.650	NOAA	NOAA	NOAA	NOAA $ 1.950
	FAA	FAA $ 0.500	FAA	FAA	FAA	FAA $ 0.500
	Sub-Total $ 1.300	Sub-Total $ 1.150	Sub-Total $ -	Sub-Total $ -	Sub-Total $ -	Sub-Total *$ 2.450*
Industry Studies	NOAA	NOAA $ 0.650	NOAA	NOAA	NOAA	NOAA $ 0.650
	FAA	FAA $ 0.500	FAA	FAA	FAA	FAA $ 0.500
	Sub-Total $ -	Sub-Total $ 1.150	Sub-Total $ -	Sub-Total $ -	Sub-Total $ -	Sub-Total *$ 1.150*
Academic Grants	NOAA $ 2.730	NOAA $ 3.900	NOAA $ 3.250	NOAA $ 3.250	NOAA $ 3.250	NOAA $ 16.380
	FAA	FAA	FAA	FAA	FAA	FAA $ -
	Sub-Total $ 2.730	Sub-Total $ 3.900	Sub-Total $ 3.250	Sub-Total $ 3.250	Sub-Total $ 3.250	Sub-Total *$ 16.380*
Cooperative Institute Support	NOAA $ 3.250	NOAA $ 3.100	NOAA $ 3.846	NOAA $ 3.900	NOAA $ 3.900	NOAA $ 17.996
	FAA	FAA	FAA	FAA	FAA	FAA $ -
	Sub-Total $ 3.250	Sub-Total $ 3.100	Sub-Total $ 3.846	Sub-Total $ 3.900	Sub-Total $ 3.900	Sub-Total *$ 17.996*
Contractor Support	NOAA	NOAA	NOAA	NOAA	NOAA	NOAA $ -
	FAA $ 2.000	FAA $ 1.230	FAA $ 0.500	FAA $ 0.500	FAA $ 0.500	FAA $ 4.730
	Sub-Total $ 2.000	Sub-Total $ 1.230	Sub-Total $ 0.500	Sub-Total $ 0.500	Sub-Total $ 0.500	Sub-Total *$ 4.730*
Investment Analysis	NOAA	NOAA	NOAA $ 0.650	NOAA $ 0.650	NOAA $ 0.650	NOAA $ 1.950
	FAA $ 2.000	FAA $ 0.300	FAA	FAA $ 5.000	FAA $ 1.500	FAA $ 8.800
	Sub-Total $ 2.000	Sub-Total $ 0.300	Sub-Total $ 0.650	Sub-Total $ 5.650	Sub-Total $ 2.150	Sub-Total *$ 10.750*
NWRT/PAR and Other Miscellaneous Program Costs	NOAA $ 1.800	NOAA $ 1.300	NOAA $ 1.458	NOAA $ 1.458	NOAA $ 1.458	NOAA $ 7.474
	FAA	FAA	FAA	FAA	FAA	FAA $ -
	Sub-Total $ 1.800	Sub-Total $ 1.300	Sub-Total $ 1.458	Sub-Total $ 1.458	Sub-Total $ 1.458	Sub-Total *$ 7.474*
Yearly Total	NOAA $ 12.980	NOAA $ 13.500	NOAA $ 13.104	NOAA $ 13.158	NOAA $ 13.158	NOAA $ 65.900
	FAA $ 8.000	FAA $ 6.530	FAA $ 2.000	FAA $ 7.000	FAA $ 4.000	FAA $ 27.530
	Sub-Total $ 20.980	Sub-Total $ 20.030	Sub-Total $ 15.104	Sub-Total $ 20.158	Sub-Total $ 17.158	**Total *$ 93.430***

*The Joint Spend plan is contingent upon the availability of funds. In addition, changes may occur as MPAR research progresses. In May 2016, NOAA funding amounts were updated for FY 2016, 0217, and 2018. The FY 2016 Spend Plan amounts for NOAA assume that the Working Capital Fund reprogramming is approved.

Each of the NOAA investment activities include funds which support facilities, information technology, and other infrastructure and management. The FAA funds provided through the NextGen Office of Portfolio Management and Technology Development are applied in their entirety to organizations that provide direct support to the MPAR R&D effort.

Appendix B

List of Acronyms

ASR	Airport Surveillance Radar
ATD	Advanced Technology Demonstrator
DHS	Department of Homeland Security
DoD	Department of Defense
FAA	Federal Aviation Administration
FID	Final Investment Decision
FY	Fiscal Year
IARD	Investment Analysis Readiness Decision
IID	Initial Investment Decision
ISD	In Service Decision
JAG/PARP	Joint Action Group / Phased Array Radar Project
JPOM	Joint Program Office for MPAR
MPAR	Multifunction Phased Array Radar
NOAA	National Oceanic and Atmospheric Administration
NSSL	National Severe Storms Laboratory
NSWRC	NextGen Surveillance and Weather Radar Capability
NWRT/PAR	National Weather Radar Testbed/ Phased Array Radar
OFCM	Office of the Federal Coordinator for Meteorological Services and Supporting Research
R&D	Research and Development
RF	Radio Frequency
SLEP	Service Life Extension Program
TDWR	Terminal Doppler Weather Radar
WG/MPAR	MPAR Working Group
WSR-88D	Weather Surveillance Radar – 1988 Doppler