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AMDR Competition: The USA's Next Dual-Band Radar

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The US Navy's Dual-Band Radar that equips its forthcoming 14,500t Zumwalt class "destroyers" and Gerald R. Ford class super-carriers replaces several different radars with a single back-end. Pairing Raytheon's X-band SPY-3 with Lockheed Martin's S-band VSR in this way allows fewer radar antennas, faster response time, faster adaptation to new situations, one-step upgrades to the radar suite as a whole, and better utilization of the ship's power, electronics, and bandwidth.

Rather than using the existing Dual-Band Radar design in new ships, the "Air and Missile Defense Radar" (AMDR) aims to fulfill future CG (X)/ DG-51 Flight III cruiser needs through a new competition. The winner will actually have 2 deployment opportunities, one of which could be far bigger than the DBR's:

AMDR: Opportunities and Challenges

As the DDG-1000 platform ends at 3 ships, the US Navy confronts a need for more dual-band naval radars on 2 fronts. One is the follow-on CG (X) cruiser, which has no concept design in place and has now been delayed even further by recent Pentagon decisions. It, and the "Future Surface Combatant," were both proposed for cancellation in the FY 2011 defense budget, but AMDR is expected to continue as the radar for the DDG-51 Flight III Arleigh Burke Class, which the Navy aims to buy from FY 2016 to FY 2022 or even FY 2031.

Rather than extending or modifying the existing Dual Band Radar combination used on its DDG-1000 Zumwalt Class, the "Air and Missile Defense Radar" (AMDR) aimed to fulfill these need through a re-opened competition. The resulting radar will have 3 components:

- The AMDR-X radar will provide horizon search, precision tracing, missile communications, and final illumination guidance to targets.
- The AMDR-S radar will provide wide-area volume search, tracking, Ballistic Missile Defense (BMD) discrimination, and missile communications. While CG (X) and its DDG-51 Flight III replacement are both "blue water" ships, requirements do call for defense against very low observable/very low flyer (VLO/VLF) threats in heavy land, sea, and rain clutter, where S-band has some advantages.
- The back-end Radar Suite Controller (RSC) will perform all coordination, ensuring that the radars work well together.

The contractors are designing radar systems with hardware and software modularity, future technology, insertion, and open architectures. The lack of a CG (X) design forced some flexibility all by itself, and the initial specification added that it's "designed to be scalable to accommodate current and future mission requirements for multiple platforms." With the shift to DDG-51 Flight III ships as the focus for both AMDR and the future US Navy, that specification becomes especially important.

That requirement for adjustable size is the key to AMDR's larger opportunity. If the adjustments can be taken far enough, it could give the Navy an opportunity to add or retrofit AMDR to some of its 60+ serving Arleigh Burke Class ships, DDG-1000 Zumwalt Class destroyers, or later carriers of the CVN-78 Gerald R. Ford Class.

The bad news is that any retrofit, or even installation in new "DDG-51 Flight III" variants, will be more complicated than it appears.

The visible face of a naval radar is only the tip of the iceberg. Most of its weight and space comes from its need for 2 things: power, and cooling. More powerful radars usually need more power to drive them, which can tax the limited 7.5 MW capacity an older ship like the DDG-51 Flight I/II/IIAs. More power also means more cooling much of the time. Power storage, power conversion, and cooling require weight and space. All of which are usually in short supply on a warship. Even if that space exists, the additional equipment and antennas must be installed without unduly affecting the ship's balance and center of gravity, and hence its seakeeping abilities.

In 2009, the US Congressional Research Services' "Navy DDG-1000 and DDG-51 Destroyer Programs: Background, Oversight Issues, and Options for Congress" report update (#RL32109) explained the potential impact:

"Multiple industry sources have briefed CRS on their proposals for modifying the DDG-51 design to include an active-array radar with greater capability than the SPY-1. If the DDG-51 hull is not lengthened, then modifying the DDG-51 design to include an improved radar would require removing the 5-inch gun to make space and weight available for additional equipment needed to support operations with the improved radar. Lengthening the hull might provide enough additional space and weight capacity to permit the 5-inch gun to be retained.75 Supporting equipment to be installed would include an additional electrical generator and additional cooling equipment.76 The best location for the generator might be in one of the ship's two helicopter hangar spots, which would reduce the ship's helicopter hangar capacity from two helicopters to one."

An October 2008 report from the right-wing Heritage Foundation draws on other sources to note that weight shifts can also create issues:

"...SPY-1E [active array] radar could affect the stability of the upgraded Arleigh Burkes because the radar's phased-array panels weigh more than the panels of the earlier SPY-1 radar, which it will replace. While the SPY-1E's weight is concentrated more in the panels, freeing more space below deck,[78] this greater weight would be added to the ship's superstructure.

Combined with the DDG-51's relatively narrow hull width and short length, this could cause stability problems, particularly when sailing in rough weather."

Obviously, those kinds of trades are less than ideal, but they may be necessary. Whether, how many, and which trades end being necessary, may well depend on which contender's design is chosen for AMDR.

AMDR: The Contenders

Lockheed Martin steps into the competition with several strengths to draw on. Their AN/SPY-1 S-band radar is the main radar used by the US Navy's current high-end ships, the DDG-51 Arleigh Burke class destroyers and CG-47 Ticonderoga class cruisers. Lockheed Martin also makes the AEGIS combat systems that equips these ships, and supplies the advanced VSR S-band radar used in the new Dual Band Radar installations on board Zumwalt and Ford class ships. This strong S-band experience, and status as the supplier of the combat system that any DDG-51 fitting would have to integrate with, gives them leverage at multiple points.

Nor are they devoid of X-band or ballistic missile defense experience. Their L-Band AN/TPS-59 long range radar has been used in missile intercept tests, and is the only long range 3D Radar in the Marine Air-Ground Task Force. It's related to the AN/TPS-117, which is in widespread service with over 16 countries. The Patriot missile's successor MEADS system's MFCR radar will integrate an active array dual-band set of X-band and UHF modules via a common processor for data and signal processing.

Raytheon goes into AMDR with experience developing the existing Dual-Band Radar's Radar Suite Controller and SPY-3 X-band radar, along with the dual X/S band system that will equip the Cobra Judy (USNS Observation Island) Replacement vessel used to track missile launches and tests around the world. Phased array radars for wide-area air and ballistic missile defense are another strong point. Raytheon builds the AN/TPY-2 X-band radar used by the land-based THAAD missile system, the 280 foot high X-band array on the floating SBX missile defense radar, and the large land-based ballistic missile Upgraded Early Warning Systems like the AN/FPS-108 Cobra Dane and AN/FPS-115 PAVE PAWS. On the S-band side, the firm builds the S-band transmitters for Lockheed's SPY-1 radar. Unsurprisingly, Raytheon personnel who talked to us said that:

"... leveraging concepts, hardware, algorithms and software from our family of radars provides a level of effectiveness, reliability and affordability to our proposed AMDR solution…. The challenge for all the competitors will be to deliver a modular design. The requirements demand that the design be scalable without significant redesign…. A high power active radar system requires significant space not only for the arrays themselves but also for the power and cooling equipment needed to support its operation. Finding space for additional generators and HVAC plants can be quite challenging for a backfit application. That is why power efficiency is a premium for these systems."

Northrop Grumman was a less obvious contender, despite its enviable record making advanced AESA and phased array radars for use on aircraft of all types and sizes, and land-based systems like the US Marines' Ground/Air Task Oriented Radar (G/ATOR).

In subsequent discussions, he stressed that Northrop Grumman has shipboard radar experience, too. They're the prime contractor for the AN/SPQ-9B track-while-scan X-band radar, the SPS-74 used to detect submarine periscopes, and navigation radars. On a less visible note, the firm has been working under several CRAD programs from 2005 to the present, targeted at technology demonstrations, system risk reduction, and advanced integration techniques for advanced S-band shipboard radars. They also have a partnership with Australia's CEA Technologies, which is developing an advanced X-band (CEAMOUNT) and S-band (CEAFAR) radar set for Australia's ANZAC class frigate upgrade.

What does this team see as important?

"The ability to scale up to a potential future cruiser or down to a DDG-51 variant is fundamental to the Northrop Grumman radar architecture. Size, weight and power (SWaP) of the radar system are the key drivers…. Minimizing the radar impact is key to an affordable surface combatant solution. We are focused on not just the radar technology, but to minimize the ship impact while allowing for scalable growth in the future. We are working closely with various elements in the Navy to address the ship impact of large AESA radars on the entire ship."

AMDR: Contracts and Key Events

June 7/11: Raytheon announces that it has conducted a system requirements review (SRR) for AMDR Phase II beginning May 17/11. Notably, their release does not describe it as successful, offering only the less categorical claim that the "Navy's feedback throughout the review was favorable," and pointing out that the firm "matured its design ahead of schedule, surpassing customer expectations."

Raytheon is currently developing a technology demonstrator for AMDR's S-band radar and radar suite controller, and the firm demonstrated hardware from that pilot array during the review. The SRR also included Raytheon's understanding of AMDR's requirements, how its design and architecture meets those requirements, and Raytheon's its analysis of those requirements, including cost and performance trade studies. A System Functional Review will be held later in 2011.

May 19/11: Raytheon announces that it has produced the first group of S-band transmit/receive (T/R) modules for the U.S. Navy's AMDR program.

Sept 30/10: US Naval Sea Systems Command in Washington Navy Yard, DC solicits bids via the Federal Business Opportunities website, receives 3 offers, and issues 3 technology development contracts for the AMDR S-band radar and its radar suite controller (RSC). AMDR-S will provide volume search, tracking, ballistic missile defense discrimination and missile communications. The RSC will perform all coordination actions to ensure that both radars work

together. This approach dovetails with the Pentagon's focus on competitive prototypes, as a way of reducing long-term risks of failed development and cost overruns.

Raytheon Integrated Defense Systems in Sudbury, MA received a $112.3 million fixed-price incentive (firm target) contract. Work will be performed in Sudbury, MA (81%), Fairfax, VA (18.3%), and New York, NY (0.7%), and is expected to be complete by September 2012 (N00024-10-C-5340). See also Raytheon.

Lockheed Martin Mission Systems and Sensors in Moorestown, NJ receives a $119.2 million fixed-price incentive (firm target) contract. Work will be performed in Moorestown, NJ (86.2%); Clearwater, FL (5.5%); Fairfax, VA (3.5%); New Brighton, MN (2.5%); Clearfield, UT (1.3%); and Huntsville, AL (1%), and is expected to be complete by September 2012 (N00024-10-C-5358). See also Lockheed Martin.

Northrop Grumman Electronic Systems in Linthicum Heights, MD receives a $120 million fixed-price incentive (firm target) contract. This contract is incrementally funded, with $38.4 million placed on the contract at the time of award. Work will be performed in Linthicum Heights, MD (99.4%), and Arvonia, VA (0.6%), and is expected to be complete by September 2012 (N00024-10-C-5359). See also Northrop Grumman.

Aug 10/10: An opinion from the Information Dissemination article Happy Thoughts and DDG-1000:

"I love Chris, and I don't think anyone in the Navy deserved their star more than Jim Syring… but this Navy Times article is just a bit too much happy half-the-story for me. Here is how half the story gets told…. The real reason the Navy is dropping the VSR on DDG-1000 is because the Navy intends to put… AMDR on the DDG-1000… because the timeline works out. The thing is the Navy can't actually say this because there is no official AMDR program yet and the DDG-1000 isn't supposed to be a ballistic missile defense ship – remember? This story in Navy Times is what it is because when it comes to US Navy shipbuilding, the Navy under CNO Roughead is never completely honest with the American people about what the Navy is doing. Sorry if the truth hurts."

June 2/10: As expected, the Pentagon this week certifies that the DDG-1000 destroyer program is vital to national security, and must not be terminated, despite R&D loaded per-ship cost increases that put it over Nunn-McCurdy's legislated limit. There will be at least one important change, however: the S-band SPY-4 Volume Search Radar will be deleted from the DDG-1000's DBR.

Performance has met expectations, but cost increases reportedly forced the Navy into a cost/benefot decision. The Navy would not release numbers, but reports indicate possible savings of $100-200 million for each of the planned 3 ships. The X-band SPY-3 has reportedly exceeded technical expectations, and will receive upgrades to give it better volume search capability. The move will save weight and space by removing SPY-4 aperture, power, and cooling systems, and may create an opportunity for Raytheon's SPY-3 to be upgraded for ballistic missile defense – or replaced by the winner of the BMD-capable AMDR dual-band radar competition.

The full DBR will be retained on the USS Gerald R. Ford [CVN 78] aircraft carrier, as the SPY-4 replaces 2 air search radars and will be the primary air traffic control radar. No decision has been made for CVN 79 onward, however, and AMDR's potential scalability may make it attractive there as well. Gannett's Navy Times | US DoD.

Feb 26/10: The US Congressional Research Service lays out what remains of AMDR's opportunity, in an updated report. From "Navy DDG-51 and DDG-1000 Destroyer Programs: Background and Issues for Congress" :

"The Navy's FY2011 budget submission calls for procuring two DDG-51s in FY2011 and six more in FY2012-FY2015. The two DDG-51s that the Navy wants to procure in FY2011 received $577.2 million in FY2010 advance procurement funding. The Navy's proposed FY2011 budget requests another $2,922.2 million in procurement funding for the two ships, so as to complete their estimated combined procurement cost of $3,499.2 million. The Navy's proposed FY2011 budget also requests $48.0 million in advance procurement funding for the one DDG-51 that the Navy wants to procure in FY2012, and $186.3 million in procurement funding for DDG-1000 program-completion costs. The Navy's FY2011 budget also proposes terminating the Navy's planned CG (X) cruiser program as unaffordable. Rather than starting to procure CG (X)s around FY2017, as the Navy had previously envisaged, the Navy is proposing to build an improved version of the DDG-51, called the Flight III version, starting in FY2016. Navy plans thus call for procuring the current version of the DDG-51, called the Flight IIA version, in FY2010-FY2015, followed by procurement of Flight III DDG-51s starting in FY2016. Navy plans appear to call for procuring Flight III DDG- 51s through at least FY2022, and perhaps until FY2031. Flight III DDG-51s are to carry a smaller version of the new Air and Missile Defense Radar (AMDR) that was to be carried by the CG (X). The Navy's proposed FY2011 budget requests $228.4 million in research and development funding for the AMDR. Detailed design work on the Flight III DDG-51 reportedly is to begin in FY2012 or FY2013. Issues for Congress for FY2011 include the following:"

June 26/09: The Naval Sea Systems Command in Washington, DC issues 3 firm fixed-price contracts, covering initial concept studies for the (AMDR) S-band and Radar Suite Controller (RSC) only. Deliverables will include the S-band and radar suite controller conceptual design, systems engineering studies and analyses, and a technology development plan. This contract was competitively procured via the Federal Business Opportunities and Navy Electronic Commerce Online websites, with 3 offers received.

Northrop Grumman receives a $10 million contract. Work will be performed in Linthicum Heights, MD, and is expected to be complete by December 2009 (N00024-09-C-5398). See also NGC's July 28/09 release.

Lockheed Martin Maritime Systems and Sensors in Moorestown, NJ, receives a $10 million contract. Work will be performed in Moorestown, NJ, and is expected to be complete by December 2009 (N00024-09-C-5312). See also Lockheed Martin's July 14/09 release.

Raytheon Integrated Defense Systems in Sudbury, MA receives a $9.9 million contract. Work will be performed in Sudbury, MA (94%); Fairfax, VA (4%); Bath, ME (3%); Andover, MA

(3%); Tewksbury, MA (3%); and East Syracuse, NY (2%), and is expected to be complete by December 2009 (N00024-09-C-5313). See also Raytheon's Aug 3/09 release.

Additional Readings

- US Congressional Research Services' "Navy DDG-1000 and DDG-51 Destroyer Programs: Background, Oversight Issues, and Options for Congress. Also explains the Future Surface Combatant option.
- GlobalSecurity.org – Solid State SPY Radar/ Air and Missile Defense Radar (AMDR)/ Air & Missile Defense Radar (A&MD Radar)/ Next-Generation Maritime Air & Missile Defense/ Multi-Function Advanced Active Phased-Array Radar
- Military & Aerospace Electronics (June 29/09) – Next-generation missile defense radar systems for Navy warships is goal of new study contracts
- Defense News (Feb 2/09) – New Destroyer Emerges in U.S. Plans: Options Mulled As DDG 1000 Hits $6 Billion. Includes AMDR coverage.
- DID Spotlight – The US Navy's Dual Band Radars. Covers the SPY-3/VSR combination aboard the new DDG-1000 Zumwalt class destroyers and CVN-78 Gerald R. Ford class aircraft carriers.