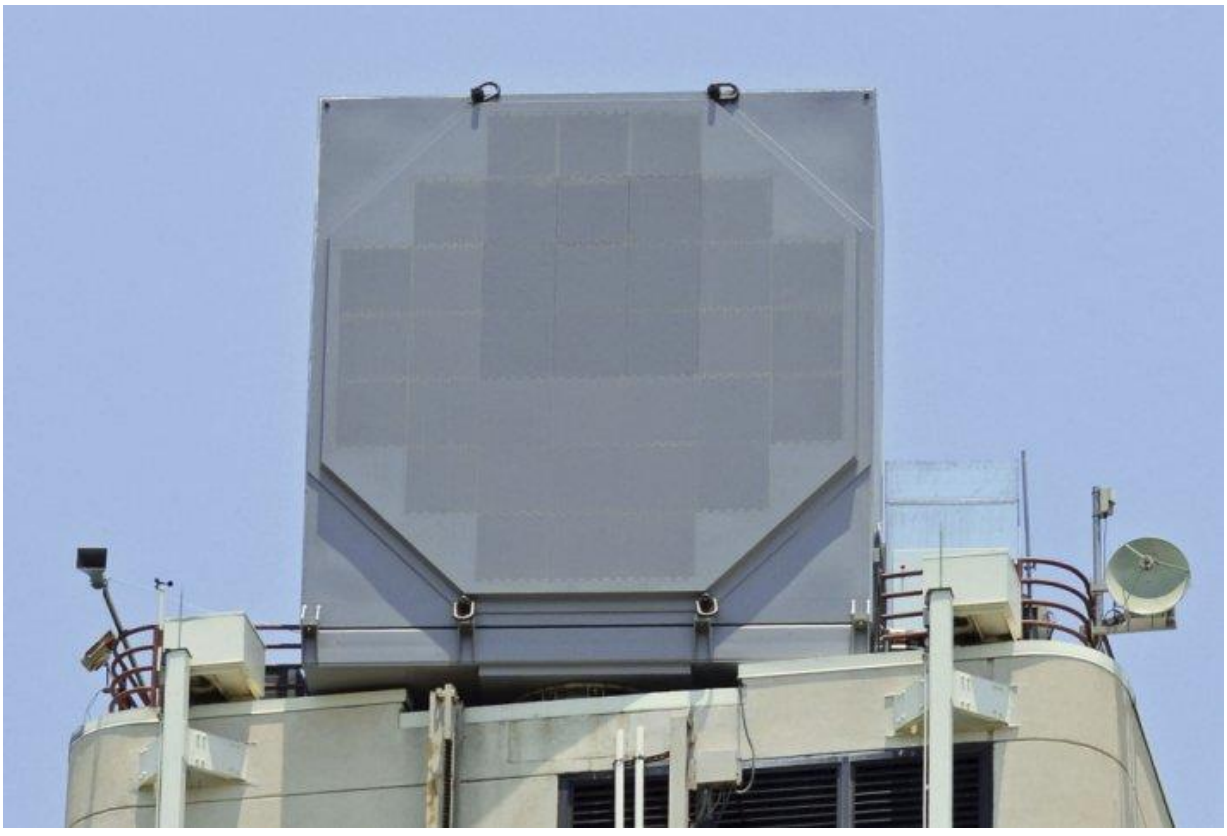
Jane's Defence Weekly

Beneath the skin: US Navy DDG 51 Flight III guided missile destroyer

The US Navy's DDG 51 Flight III guided missile destroyer has now entered the detailed design stage. *Richard Scott* examines how this new variant, designed to take the new AN/SPY-6(V) Air and Missile Defense Radar to sea, will differ from the current Flight IIA design

Beginning procurement in fiscal year (FY) 2016, the US Navy's (USN's) next-generation DDG 51 Flight III guided missile destroyer will, from the outside, resemble its antecedent. Under the skin, however, there will be some significant changes in order that the hull, mechanical and electrical (HM&E) systems, and the Aegis combat system, can support a new Air and Missile Defense Radar (AMDR) intended to confer the Flight III ships with an unmatched integrated air and missile defence (IAMD) capability.



Raytheon built a full-size, partially populated AMDR array as part of the programme's technology development phase. (Raytheon)

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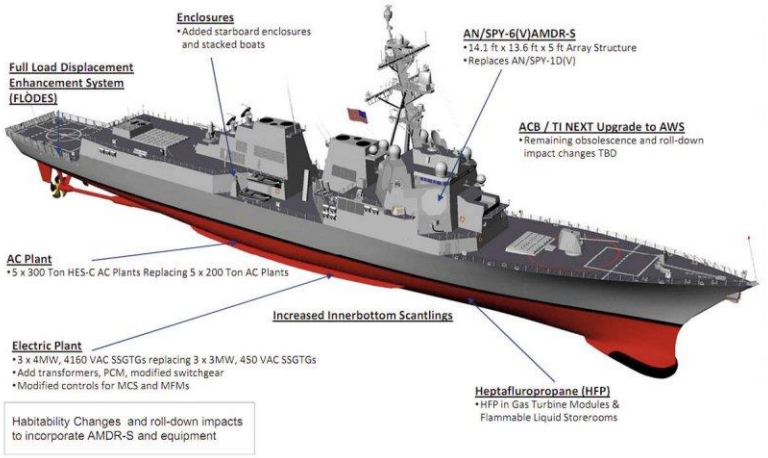
In development by Raytheon Integrated Defense Systems under the designation AN/SPY-6(V), the AMDR is the de facto successor to the AN/SPY-1(V) family of S-band radars associated with the Aegis weapon system since its inception. Yet while the DDG 51 Flight III deckhouse and array structure will appear

relatively unchanged from the current Flight IIA design, the solid-state, open-architecture technology embodied within the S-band AMDR will be a full two generations removed from that in SPY-1.



DDG 51 Flight III core design changes. (NAVSEA)

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The new AN/SPY-6(V) AMDR antenna array (right) will be slightly larger than the current AN/SPY-1D(V) aperture. (NAVSEA)

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Detail design

DDG 124, the first of a planned 33 DDG 51 Flight III destroyers, is scheduled to achieve initial operating capability (IOC) in 2023. "For a ship that probably won't start construction until sometime in [fiscal year] FY 2017, we've got a good two/two-and-a-half years' detailed design project in front of us," Captain Mark

Vandroff, DDG 51 shipbuilding programme manager (PMS 400D) in NAVSEA's PEO Ships, briefed at the Surface Navy Association annual symposium in Arlington, Virginia, in January this year. "And for the amount of work change we have going, that's about right."

Three mantras characterise the Flight III design and development effort: minimum change, minimum risk, and maximum re-use.

"We know what we need to do," said Capt Vandroff. "We need to get a SPY +15 dB radar onto a DDG 51 hull and deliver it to the fleet. Every other one of those requirements after that, some of them might be nice but we might say, 'I'm not taking that stuff today. I'm going to do something else. I'm going to keep the risk low.' So the only technology that's getting on [Flight III] is something that's already ripe and ready right now."

DDG 51 Flight III preliminary design development started in May 2012 and in the last 18 months the Flight III programme has come through a series of key review events, said Capt Vandroff. "We conducted Gate 4/5 and Configuration Steering Board in March 2014, approving the Core Flight III ECPs [engineering change proposals]," he said.

"The under secretary of defence for acquisition, technology, and logistics subsequently issued an acquisition decision memorandum in June last year to allow the release of RfPs [requests for proposals] for Flight III detail design development. The Flight III capabilities development document was validated by the Joint Requirements Oversight Council on 28 October 2014, with the Flight III preliminary design also completed that month."

Flight III detail design was initiated in December 2014. A preliminary design review is scheduled for July 2015 and contract awards for the ECPs to be introduced are planned for 2016.

In February Huntington Ingalls Industries and Bath Iron Works each received USD13 million contract modifications for lead yard services to support the Flight III upgrade design effort, along with procurement of design vendor furnished information.

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Powering up

Attendant to the introduction of AMDR is the need for increased ship service power and cooling. Five 200-ton air-conditioning (AC) plants installed on the Flight IIA will be replaced with five 300-ton high-efficiency small-capacity units. "We need more cooling so I take *York* 's existing 200-ton AC plans and we upgrade to 300 tons just like was already being planned to be used for the next big-deck amphibs," said Capt Vandroff.

A new electrical plant is one of the key changes embodied in DDG 51 Flight III. (NAVSEA)

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The Flight III electrical plant architecture is being substantially re-engineered to meet higher ship power demand. Three Rolls-Royce MT5S HE+ 4MW 4160 V gas turbine generators will replace the three AG9140 3MW 450 V sets installed on the current Flight IIA. New transformers, power conversion modules, and modified switchgear will also be added, along with modified controls for the machinery control system and the multifunction monitors.

According to Capt Vandroff, development risk has been kept in check by the widespread re-use of existing machinery and systems. "When I needed electrical power, my friends in PMS 320 [NAVSEA's Electric Ships Office], they said 'Yes, we've got a generator for you. We'll get you a power conversion module. They're already out there, you don't have to invent something new.'

"That reduces our R&D [research and development] cost. You take a look at my budget and you will see that we are really tightening our purse strings for so much procurement. That's always been our philosophy on Flight III. We've got one new thing we are inventing [AMDR]; everything else is what's out there.

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No hybrid drive

While the USN is currently advancing plans to introduce hybrid electric drive (HED) on its DDG 51 Flight IIA guided missile destroyers, this modification is not being taken forward on Flight III at this stage.

The future USS John Finn (DDG 113) is launched from the Huntington Ingalls Industries shipyard in Pascagoula, Mississippi, on 28 March. John Finn will be the USN's 35th DDG 51 Flight IIA destroyer. The Flight III design will further evolve from this baseline. (US Navy)

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The HED backfit programme, planned for implementation on 36 DDG 51 Flight IIA destroyers, forms part of a wider initiative to improve fuel efficiency across the US surface fleet. Each Flight IIA ship is fitted with four GE LM2500-30 gas turbine prime movers, totalling 74.6 MW for a maximum speed in excess of 30 kt. Yet the ships spend most of their time at speeds below 14 kt: a part-load regime in which the simple-cycle LM2500 performs far less efficiently.

However, the DDG 51 ships are also fitted with three Rolls-Royce AG9140 gas turbine generator sets rated at 3 MW apiece for supporting the combat system, ship's services, and 'hotel' load. At any given time two gensets are normally online, producing 6 MW, although less than half of this (2.7 MW) is actually used. The HED system is therefore aimed at harnessing the excess 3.3 MW for power propulsion, enabling the DDG 51's crew to turn off one or more propulsion gas turbines and allow more efficient operation of the existing gas turbine generators.

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AMDR DEVELOPMENT ADVANCES THROUGH CRITICAL DESIGN REVIEW

The USN had originally planned to equip the new DDG 51 Flight III destroyer with a dual-band AMDR suite consisting of a four-face S-band radar (AMDR-S) for volume search, a three-face X-band radar (AMDR-X) for horizon search, and a radar suite controller (RSC) to provide S- and X-band radar resource management, co-ordination, and interface to the Aegis combat system.

However, in April 2012 the USN gave notice that the AMDR-X programme was being delayed and revealed that the first 12 DDG 51 Flight III ships would instead be equipped with the existing mechanically scanning

AN/SPQ-9B X-band horizon search radar. Follow-on ships will integrate a non-developmental AMDR-X radar.

After evaluating bids from Lockheed Martin, Northrop Grumman, and Raytheon, NAVSEA in October 2013 awarded Raytheon Integrated Defense Systems a USD385.7 million engineering and manufacturing development (EMD) contract to undertake the design, development, integration, test, and delivery of the S-band AN/SPY-6(V) AMDR and the associated RSC over a 45-month period.
The start of EMD was delayed by a protest from Lockheed Martin - the longtime Aegis radar incumbent - questioning the navy's evaluation process. However, the protest was withdrawn in early January 2014 and Raytheon's stop-work order was then rescinded.

Employing full digital beamforming, the AN/SPY-6(V) will have more than double the range of the SPY-1, support efficient and precise search and tracking using multibeam operation, and provide robust BMD detection and discrimination. Fundamental to this leap in performance is the use of Gallium Nitride (GaN) semi-conductor technology. Technology maturation efforts under way since the early 2000s have given confidence that GaN transmit/receive devices - offering major power, efficiency and performance improvements over the Gallium Arsenide modules hitherto used in multifunction radars - can deliver from the standpoints of both performance and producibility.

During the earlier technology development (TD) phase of the AMDR programme, Raytheon built a 14.1 ft full-sized array, including the signal- and data-processing back-end, to demonstrate the design, capability, and scalability of the radar, and to prove outfitting within a DDG 51 Flight III deck house (including mechanical interface, cabling, piping, and maintenance elements). The array was partially populated with a small group of radar modular assemblies (RMAs) containing more than 1,000 GaN transmit/receive modules, meeting TD phase requirements. According to Raytheon, many of the technology risks associated with AMDR were retired in the TD phase.

A series of design reviews have been conducted since the start of EMD, culminating with a successful critical design review (CDR) in April 2015.

"The system CDR is the latest in the series of major program milestones executed exactly on schedule," said Capt Doug Small, major programme manager for above water sensors in the Naval Sea Systems Command's (NAVSEA's) Program Executive Office (PEO) Integrated Weapon Systems. "Completion of this review demonstrates that the technical and design maturity of the system is exactly where it needs to be for Flight III DDG 51."

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