

Aegis Modernization Program

Executive Summary

- The Navy is modernizing the Aegis Weapon System (AWS) installed on Baseline 3 USS *Ticonderoga* (CG 47)-class cruisers and Flight I USS *Arleigh Burke* (DDG 51) destroyers to the AWS Advanced Capability Build (ACB)-12 (Baseline 9A and 9C, respectively). New construction Flight IIA DDGs, beginning with USS *John Finn* (DDG 113), will be equipped with Baseline 9C as well.
- Baseline 9A cruiser operational testing began in FY15 and continued through FY16. Baseline 9C destroyer operational testing began in FY16. Neither variant has completed all planned events. In particular, no live-firing events intended to demonstrate surface warfare performance have been executed on any Baseline 9 variant. Additionally, air defense events against supersonic sea-skimming anti-ship cruise missile surrogates have been deferred for reasons including GQM-163A aerial target availability, schedule constraints, and weather.
- In FY16, the SECDEF directed the Navy to fund long-lead items for an Aegis Self-Defense Test Ship (SDTS) to be used for testing of Aegis ACB-20, DDG 51 Flight III, the Air and Missile Defense Radar (AMDR, a.k.a., AN/SPY-6), and Evolved SeaSparrow Missile (ESSM) Block II, and to produce Test and Evaluation Master Plan (TEMP) updates outlining the intended use of the test ship. The Navy has complied with the funding portion of the directive, but has not complied with the remainder of the direction to provide the TEMP or integrated test plan for Aegis ACB-20 and DDG 51 Flight III. Additionally, the Navy has not funded the remainder of the installation/integration cost for the test ship or the remaining test resources to conduct the self-defense testing for ACB-20/DDG 51 Flight III.
- Testing completed to date is insufficient to make a determination of operational effectiveness or suitability for Aegis Baseline 9A or 9C.
- The lack of an adequate modeling and simulation (M&S) suite of the Aegis Combat System (ACS), as well as the lack of an Aegis-equipped SDTS where the ship's full self-defense kill chain can be tested, precludes assessment of the Baseline 9 Probability of Raid Annihilation requirement self-defense mission.
- The Navy will not fully assess Aegis Integrated Air and Missile Defense (IAMD) until a validated M&S test bed is developed and validated. The test bed is planned to be available by FY20, but there is no agreed upon strategy to validate the model to support assessment of the close-in, self-defense battlespace.
- Navy Integrated Fire Control – Counter Air (NIFC-CA) From-the-Sea (FTS) Increment I became a fielded capability in 2015 and fully integrated as a tactical option in fleet air defense. Future testing of the ACB-16 and ACB-20 Aegis



Modernizations and Standard Missile-6 (SM-6) will evaluate the NIFC-CA FTS Increment II capability.

System

- The Navy's Aegis Modernization program provides updated technology and systems for existing Aegis-guided missile cruisers and destroyers. This planned, phased program provides similar technology and systems for new construction destroyers.
- The AWS integrates the following components:
 - AWS AN/SPY-1 three-dimensional (range, altitude, and azimuth) multi-function radar
 - AN/SQQ-89 undersea warfare suite that includes the AN/SQS-53 sonar, SQR-19 passive towed sonar array (DDGs 51 through 78, CGs 52 through 73), and the SH-60B or MH-60R helicopter (DDGs 79 Flight IIA and newer have a hangar to allow the ship to carry and maintain its own helicopter)
 - Close-In Weapon System
 - A 5-inch diameter gun
 - Harpoon anti-ship cruise missiles (DDGs 51 through 78, CGs 52 through 73)
 - Vertical Launch System that can launch Tomahawk land attack missiles, Standard surface-to-air missiles, ESSMs, and Vertical Launch Anti-Submarine Rocket missiles
- The Navy is upgrading the AWS on USS *Ticonderoga* (CG 47)-class cruisers and Flight I USS *Arleigh Burke* destroyers to Baseline 9A and 9C, respectfully. Baseline 9 will provide the following new capabilities:
 - Full SM-6 integration
 - IAMD, to include simultaneous air defense and ballistic missile defense missions on Aegis destroyers equipped with the new Multi-Mission Signal Processor
 - NIFC-CA FTS capability

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- Starting with USS *John Finn* (DDG 113), the AWS on new construction Aegis-guided missile destroyers is Baseline 9C.

Mission

The Joint Force Commander/Strike Group Commander employs AWS-equipped DDG 51-guided missile destroyers and CG 47-guided missile cruisers to conduct:

- Area and self-defense anti-air warfare in defense of the Strike Group
- Anti-surface warfare and anti-submarine warfare
- Strike warfare, when armed with Tomahawk missiles
- IAMD to include simultaneous offensive and defensive warfare operations

- Operations independently or in concert with Carrier or Expeditionary Strike Groups and with other joint or coalition partners

Major Contractors

- General Dynamics Marine Systems Bath Iron Works – Bath, Maine
- Huntington Ingalls Industries (formerly Northrop Grumman Shipbuilding) – Pascagoula, Mississippi
- Lockheed Martin Maritime Systems and Sensors – Moorestown, New Jersey

Activity

- The Navy continued Baseline 9A operational testing in December 2015, but weather and schedule constraints prevented execution of a majority of the planned events. Uncompleted events include a combined surface warfare and air defense firing scenario and a combined supersonic sea-skimming and subsonic sea-skimming anti-ship missile raid. The Navy currently has not re-scheduled these events.
- The Navy began at-sea operational testing of Baseline 9C in March 2016. Two of three planned air defense scenarios were executed, with one of the scenarios executed twice due to execution difficulties. A multi-mission firing scenario combining air defense and surface warfare could not be conducted because of ship system problems and uncooperative weather. Additional surface warfare tracking exercises also remain unexecuted.
- The Baseline 9C testing in March 2016 included operational testing in the undersea warfare area in conjunction with AN/SQQ-89 testing. The undersea warfare testing included exercises against USS *Cheyenne* (SSN 773).
- The Navy planned to conduct Baseline 9C manned aircraft raids in late FY16, but was unable to schedule needed supporting assets. A planned live-firing event including both supersonic and subsonic anti-ship cruise missile surrogates was deferred prior to the start of the March 2016 testing due to GQM-163 aerial target availability.
- Remaining Baseline 9C operational testing, including previously unexecuted events, deferred events, a maintenance demonstration, and cybersecurity testing are planned to occur in FY17.
- The Navy conducted all operational testing in accordance with the DOT&E-approved test plans.
- In February 2016, the SECDEF directed the Navy to acquire long-lead items needed for an Aegis and AMDR SDTS required for conducting adequate self-defense operational testing for DDG 51 Flight III, Aegis ACB-20, AMDR (also known as AN/SPY-6), and ESSM Block II. The Navy complied with this direction by budgeting for a single face of the AMDR to be procured. However, the Navy has not

budgeted for the needed Aegis Combat System or the test resources to support the self-defense operational testing for DDG 51 Flight III. The Navy also was directed to update the Aegis/Flight III, AMDR, and ESSM TEMPs, to include the Aegis SDTS and self-defense test events; the Navy has not complied with this direction.

- The Navy is developing an M&S suite that can supplement live testing and facilitate a robust statistical evaluation of air defense performance for DDG 51 Flight III ships after an Aegis-equipped SDTS is available in FY23. As part of the overall M&S development effort, the Navy plans to make limited use of the suite for operational testing of the ACB-16 (Baseline 9C2) in FY22.
- NIFC-CA FTS Increment I became a fielded capability in 2015 after completing developmental testing and is now fully integrated as a tactical option in fleet air defense. Future testing of the ACB-16 and ACB-20 Aegis Modernizations and SM-6 will evaluate the NIFC-CA FTS Increment II capability.
- In September 2016, at White Sands Missile Range, New Mexico, the Navy and Marine Corps successfully conducted a NIFC-CA FTS Increment I demonstration event using an F-35 Lightning II as a targeting source for the Aegis Baseline 9 Desert Ship test configuration and the SM-6. This demonstration was part of developmental testing and did not represent a fleet operational configuration of the ACS or the communications path that would be needed. The demonstration used a non-tactical engineering computer software build in the Aegis Desert Ship test site – itself not fully representative of the ACS – interfaced to a datalink gateway that could receive the F-35 Multifunction Advanced Data Link (MADL) and port track data from the aircraft sensor to the AWS. Using this track data, an SM-6 was initialized and launched at an MQM-107 unmanned target drone.

Assessment

- Baseline 9A and 9C testing completed to date was not sufficient to support an assessment of operational effectiveness or suitability prior the FY15 USS *Normandy* and USS *Benfold*

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- deployments. In accordance with Section 231 of the National Defense Authorization Act for FY08, DOT&E submitted Early Fielding Reports for each baseline. The 12 live flight tests events on Baseline 9A and 9C ships to date suggest that area air defense performance against single subsonic and supersonic high-diving targets is consistent with historical performance against comparable threats, but is not necessarily operationally relevant. The Navy has not yet demonstrated performance against more stressing presentations during operational testing. Operational testing, to include more stressing presentations, is planned to continue through FY17.
- The Navy will not fully assess Aegis IAMD until an AWS M&S test bed is developed and validated. The test bed is under development and is planned to be available by FY20; however, there is no agreed upon strategy to validate the model to support assessment of the close-in, self-defense battlespace. A limited Baseline 9C IAMD operational assessment suggests that DDGs can simultaneously support limited air defense and ballistic missile defense missions, within overall radar resource constraints. This assessment is supported by a single successful live firing event, managed by the Missile Defense Agency, which included simultaneous live firing of SM-2 and SM-3 missiles against threat representative targets in an IAMD engagement.
 - Although not presented for operational testing, the Baseline 9A surface warfare performance, specifically to counter high-speed surface threats in littoral waters, as demonstrated during developmental testing, indicated no improvements over previous Aegis baseline operational test results. For both Baseline 9A and 9C, these results indicate that AWS does not fully meet desired surface warfare performance levels.
 - As appropriate, and until the full capability may be operationally tested, DOT&E will provide periodic capability assessments to inform Navy and OSD leadership, as well as Congress, on the progress of T&E of the IAMD mission area.
 - Until an Aegis-equipped SDTS is available for testing, it is neither possible to characterize the self-defense capabilities of the Aegis cruisers and destroyers, nor possible to accredit an M&S suite to determine if the ships satisfy their Probability of Raid Annihilation requirements.
 - The Navy's NIFC-CA FTS Increment I test events conducted to date were sufficient to demonstrate basic capability; however, these demonstrations were not conducted under operationally realistic conditions or against aerial targets representative of modern threats. Additionally, the scenarios conducted were not sufficiently challenging to demonstrate the NIFC-CA FTS requirements defined in the Navy's September 2012 NIFC-CA FTS Testing Capability Definition Letter. DOT&E will assess and report NIFC-CA FTS (Increment II) performance as part of the FY18-23 ACB-16 and ACB-20 Aegis Modernization operational testing and SM-6 FOT&E.
 - The Navy's combined Baseline 9 and SM-6 FOT&E test events to date have been successful with no SM-6 integration issues revealed.
 - The Navy's Aegis Baseline 9A cybersecurity testing revealed significant problems, which are classified. The nature of these problems is such that they could pose significant risk to the cybersecurity. Details can be found in DOT&E's Early Fielding Report dated July 2015.
 - Changes made to the radar software presented unexpected problems during the initial phase of the Aegis cruiser at-sea operational test. The Navy is addressing these problems and remaining cruiser and destroyer operational testing will provide opportunities to confirm these items have been mitigated.
 - During both integrated and operational test events, instability of the Aegis operator consoles adversely affected the conduct of test events. The Navy is addressing these problems and remaining cruiser and destroyer operational testing will provide opportunities to confirm these items have been mitigated.
 - Aegis Baseline 9C has incorporated software changes to address performance against certain stressing air defense threat presentations; however, these changes proved ineffective during developmental testing.
 - The Navy conducted under-sea warfare (USW) testing on Aegis Baseline 9C utilizing USS *Cheyenne* (SSN 773) as a live, reactive threat surrogate. This testing was more operationally realistic than previously reported USW testing that utilized non-reactive threat simulators. Analysis of test results is ongoing. DOT&E will report on USW mission effectiveness in the final Aegis Baseline 9 operational test report.
 - In September 2016, at White Sands Missile Range, New Mexico, the Navy and Marine Corps successfully conducted a NIFC-CA FTS Increment I demonstration event using an F-35 Lightning II as a targeting source to allow the ACS (partial) installed at the Desert Ship test facility, WSMR New Mexico, to engage an aerial target with the SM-6. The configuration of the F-35 and the Desert Ship was not operationally representative, nor was the communications path that would be needed replicated for the test. This demonstration was part of developmental testing and did not represent a fleet operational configuration of the ACS. The demonstration used a non-tactical engineering computer software build in the Aegis Desert Ship test site – itself not fully representative of the ACS – interfaced to a datalink gateway that could receive the F-35 MADL and port track data from the aircraft sensor to the AWS. Using this track data, an SM-6 successfully engaged an MQM-107 unmanned target drone. This demonstration was conducted as a proof of concept to show that the NIFC-CA FTS Increment I capability could utilize additional airborne sensors to provide fire control quality data to the AWS. In the context of the event, this objective was met; however, this demonstration should not be construed as an operational capability.

Recommendations

- Status of Previous Recommendations. The Navy has not addressed the following previous recommendations from FY14. The Navy still needs to:
 1. Continue to improve Aegis ships' capability to counter high-speed surface threats in littoral waters.
 2. Synchronize future baseline operational testing and reporting with intended ship-deployment schedules to ensure that testing and reporting are completed prior to deployment.
 3. Provide the necessary funding to support the procurement of an advanced air and missile defense radar and Aegis-equipped SDTS that are needed to support Aegis Modernization, advanced AMDR DDG 51 Flight III, and ESSM Block 2 operational testing.
 4. For Baseline 9A, develop and deploy necessary cybersecurity corrective actions and verify correction with a follow-on operational cybersecurity test.
- FY16 Recommendations. The Navy should:
 1. Complete the planned FOT&E events as detailed in the approved test plan as soon as practical.
 2. Produce an integrated test strategy and capture that in the TEMPs to be approved by DOT&E for the DDG 51 Flight III, AMDR, Aegis Modernization, and ESSM Block 2 programs as soon as possible.
 3. Include planning for NIFC-CA FTS Increment II and NIFC-Collateral (CC) testing in future updates to the Aegis Modernization ACB-16 and ACB-20 and SM-6 TEMPs.