DDG 51 Flight III Destroyer/Air and Missile Defense Radar (AMDR)/Aegis Modernization

Executive Summary

- On May 22, 2013, DOT&E disapproved the Air and Missile Defense Radar (AMDR) Test and Evaluation Master Plan (TEMP) because the proposed operational test approach did not adequately assess the capability of that radar to support the DDG 51 Flight III Destroyer's self-defense mission.
  - Safety restrictions preclude realistic testing on manned ships in this region of the battlespace. Consequently, an unmanned test ship equipped with an AMDR and an Aegis DDG 51 Flight III Destroyer Combat System is required for adequate operational testing and assessment of the AMDR and DDG 51 Flight III Destroyer's self-defense capabilities.
  - This approach is similar to the Self-Defense Test Ship (SDTS) currently used for testing the self-defense capabilities of ships equipped with Ship Self-Defense System (SSDS)-based combat systems
- On August 9, 2013, DOT&E disapproved the Aegis Modernization TEMP because the proposed operational testing did not provide the credible modeling and simulation (M&S) effort needed to fully assess the DDG 51's combat system self-defense capability, nor a means to validate the M&S (i.e., an unmanned SDTS equipped with an AMDR and the DDG 51 Flight III Combat System).

System

- The DDG 51 Flight III Destroyer is a combatant ship equipped with the:
  - AMDR three-dimensional (range, altitude, and azimuth) multi-function radar
  - AN/SQQ-89 Undersea Warfare suite that includes the AN/SQS-53 sonar
  - MH-60R helicopter
  - Close-In Weapon System
  - Five-inch diameter gun
  - Vertical Launch System that can launch Tomahawk, Standard (SM-2, -3, and -6), and Evolved SeaSparrow Missiles (ESSMs)
- The Navy is developing the AMDR to provide simultaneous sensor support of integrated air and missile defense (IAMD) and air defense (including self-defense) missions. IAMD and air defense require extended detection ranges and increased radar sensitivity against advanced threats with high speeds and long interceptor fly out times. The three AMDR major components are:
  - The AMDR S-band radar (AMDR-S) will provide search, track, cueing, missile discrimination, air defense Non-Cooperative Target Recognition, S-band missile communications, surveillance capability for ship self-defense and area air defense, and S-band kill-assessment support functions.
  - The AMDR X-band radar (AMDR-X) will provide horizon and surface search capabilities in addition to navigation and periscope detection/discrimination functions. The Navy is delaying development of the AMDR-X. The AN/SPQ-9B X-band radar will provide these functions in the interim.
  - The Radar Suite Controller will provide the open interface with the ship combat system.
- The Aegis Combat System is an integrated naval weapons system that uses computers and radars to form an advanced command and decision, and a weapon control system to track and guide weapons to destroy enemy targets.
  - The Navy's Aegis Modernization program is a planned, phased program that provides updated technology and combat systems for existing Aegis-guided missile cruisers (CG 47) and destroyers (DDG 51) as well as the DDG 51 Flight III Destroyers.
  - The Aegis Modernization program will provide an improved Advanced Capability Build combat system variant for the DDG 51 Flight III Destroyers equipped with the AMDR.

Mission

- The Navy will use the DDG 51 Flight III Destroyer equipped with the Aegis Modernization program and AMDR to provide joint battlespace threat awareness and defense capability to counter current and future threats in support of joint forces ashore and afloat.

- The Navy will use the AMDR-S/Radar Suite Controller with the AN/SPQ-9B and the Aegis Modernization Program to support the following DDG 51 Flight III Destroyer missions:
  - Support area air defense (to include self-defense) to counter advanced air and cruise missile threats and increase ship survivability
  - Detect, track, discriminate, and provide missile engagement support (including kill assessment) to counter ballistic missile threats
  - Support surface surveillance, precision tracking, and missile and gun engagements to counter surface threats
  - Support Undersea Warfare with periscope detection and discrimination
  - Detect and track enemy artillery projectiles to support combat system localization of land-battery launch positions by the DDG 51 Flight III Combat System
  - Detect and track own-ship gun projectiles in support of surface warfare and naval surface fire support

Major Contractors
- DDG 51 Destroyer
  - General Dynamics Marine Systems Bath Iron Works – Bath, Maine
  - Huntington Ingalls Industries, Ingalls Shipbuilding Division – Pascagoula, Mississippi
- AMDR
  - Raytheon – Sudbury, Massachusetts
- Aegis Modernization Program
  - Lockheed Martin Marine Systems and Sensors – Moorestown, New Jersey

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Activity
- DOT&E issued two classified memoranda to USD(AT&L) (February 25 and May 5, 2013) in preparation for the AMDR Milestone B decision. Both memoranda highlighted severe shortfalls in the operational test plans in the AMDR and DDG 51 Flight III ship self-defense test arena and stressed the requirement for an unmanned SDTS equipped with the AMDR and DDG 51 Flight III Combat System for adequate operational testing of the radar and ship's combat system self-defense capability.
- DOT&E disapproved the AMDR TEMP on May 22, 2013, because the proposed operational test approach did not adequately assess the capability of the AMDR to support the DDG 51 Flight III Destroyer's self-defense mission.
- DOT&E disapproved the Aegis Modernization TEMP on August 9, 2013, because the proposed operational testing did not provide a credible M&S effort needed to fully assess the ship's combat system self-defense capability nor a means to validate the M&S (i.e., an unmanned SDTS equipped with an AMDR and the DDG 51 Flight III Combat System).

Assessment
- The operational test programs for the AMDR, Aegis Modernization, and DDG 51 Flight III Destroyer programs are not adequate to fully assess their self-defense capabilities in addition to being inadequate to test the following Navy-approved AMDR and DDG 51 Flight III requirements.
  - The AMDR Capability Development Document describes AMDR's IAMD mission, which requires AMDR to support simultaneous defense against multiple ballistic missile threats and multiple advanced anti-ship cruise missile (ASCM) threats. The Capability Development Document also includes an AMDR minimum track range Key Performance Parameter.
  - The DDG 51 Flight III Destroyer has a survivability requirement directly tied to meeting a self-defense requirement threshold against ASCMs described in the Navy's Surface Ship Theater Air and Missile Defense Assessment document of July 2008. It clearly states that area defense will not defeat all the threats, thereby demonstrating that area air defense will not completely attrite all ASCM raids and that individual ships must be capable of defeating ASCM leakers in the self-defense zone.
- Conduct of operational testing with threat-representative ASCM surrogates in the close-in, self-defense battlespace using manned ships is not possible since current Navy test range safety restrictions preclude testing on manned ships in this region because targets and debris from intercepts will pose an unacceptable risk to personnel at ranges where some of the engagements will take place.
  - In addition to stand-off ranges (on the order of 2 to 5 nautical miles for subsonic and supersonic surrogates, respectively), safety restrictions require that supersonic ASCM targets not be flown directly at a manned ship, but at some cross-range offset (approximately 1 nautical mile), which unacceptably degrades the operational realism of the test.
  - Similar range safety restrictions will preclude testing the AMDR minimum track range requirement against supersonic, sea-skimming ASCM threat-representative surrogates at the land-based AMDR test site at the Pacific Missile Range Facility.
- Due to the inherent complexity and safety limitations, live testing (without an SDTS) cannot provide sufficient data to assess the self-defense capabilities of the AMDR and the DDG 51 Flight III Destroyer.
  - M&S will therefore play a major role in determining those capabilities. However, per public law, M&S cannot be the only contributor to the assessment; realistic operational test results are required.

  - M&S can support an operational evaluation, but must be accredited not only with manned test ship testing, but also through end-to-end testing against operationally realistic targets equipped with an ADMR and the DDG 51 Flight III Destroyer Combat System in the close-in, self-defense battlespace.
  - The extent to which the Navy can use M&S to assess AMDR and DDG 51 Flight III's self-defense capability depends critically on whether the M&S can be rigorously accredited for operational testing.
  - Side-by-side comparison between credible live fire test results and M&S test results form the basis for M&S accreditation. Without an Aegis SDTS, there will not be a way to gather the operationally realistic live fire test data needed for comparison to accredit the M&S.
- The Air Warfare/Ship Self Defense Enterprise M&S accreditation paradigm being used in the test programs for LHA-6, Littoral Combat Ship (LCS), DDG 1000, LPD-17, LSD-41/49, and CVN-78 ship classes was approved by the Navy and DOT&E in 2005. It is based on live fire events conducted on manned ships and an SDTS, as well as M&S events conducted in the same configuration.
  - The live firings conducted in the close-in, self-defense battlespace can only be accomplished with an SDTS due to the range safety restrictions on testing with manned ships.
  - For the AMDR and DDG 51 Flight III, the paradigm will be the same; whatever end-to end M&S tool is developed must be accredited for use in operational testing by comparing live fire results in the close-in battlespace to simulated events in the close-in battlespace.
  - Those live fire events can only be conducted on an SDTS equipped with the AMDR and the DDG 51 Flight III Destroyer Combat System. DOT&E considers that paradigm to be the credible template for application by the AMDR and DDG 51 Flight III Destroyer operational test programs.
- The Navy currently models the Aegis Weapon System (AWS) with Lockheed Martin's Multi-Target Effectiveness Determined under Simulation by Aegis (MEDUSA) M&S tool.
  - MEDUSA encompasses several components of the AWS including the SPY-1 radar, Command and Decision, and Weapon Control System. MEDUSA models AWS performance down to the system specification and the Navy considers it a high-fidelity simulation of AWS.
  - However, it is not a tactical code model; so, its fidelity is ultimately limited to how closely the specification corresponds to the Aegis tactical code (i.e., the specification is how the system is supposed to work while the tactical code is how the system actually works). This adds to the need for realistic live fire shots to support validation efforts.
  - By comparison, the Air Warfare/Ship Self Defense Enterprise M&S test bed used for assessing USS *San Antonio*'s (LPD-17) self-defense capabilities used re-hosted SSDS Mk 2 tactical code.
- Recent test events highlight the limitations of specification models like MEDUSA. During Aegis Advanced Capability Build 08 testing in 2011, five AWS software errors were found during live fire events and tracking exercises.
  - Three software errors contributed to a failed SM-2 engagement, one to a failed ESSM engagement, and one to several failed simulated engagements during tracking exercises.
  - Since these problems involved software coding errors, it is unlikely that a specification model like MEDUSA (which assumes no software errors in tactical code) would account for such issues and hence it would overestimate the combat system's capability.
- Since Aegis employs ESSM in the close-in, self-defense battlespace, understanding ESSM's performance is critical to understanding the self-defense capabilities of the DDG 51 Flight III Destroyer.
  - Past DOT&E Annual Reports have stated that the ESSM's operational effectiveness has not been determined. The Navy has not taken action to adequately test the ESSM's operational effectiveness.
  - Specifically, because safety limitations preclude ESSM firing in the close-in self-defense battlespace, there are very little test data available concerning ESSM's performance, as installed on Aegis ships, against supersonic ASCM surrogates.
  - Any data available regarding ESSM's performance against supersonic ASCM surrogates are from an SSDS- based combat system configuration, using a completely different guidance mode or one that is supported by a different radar suite.
- The cost of building and operating an Aegis SDTS is small when compared to the total cost of the AMDR development/ procurement and the eventual cost of the 22 (plus) DDG 51 Flight III ships that are planned for acquisition ($55+ Billion). Even smaller is the cost of the SDTS compared to the cost of the ships that the DDG 51 Flight III Destroyer is expected to protect (~$450 Billion in new ship construction over the next 30 years).
  - If DDG 51 Flight III Destroyers are unable to defend themselves, these other ships are placed at greater risk.
  - Moreover, the SDTS is not a one-time investment for only the AMDR/DDG 51 Flight III IOT&E, as it would be available for other testing that cannot be conducted with manned ships (e.g., the ESSM Block 2) and as the combat system capabilities are improved.

Recommendations

- Status of Previous Recommendations. There are no previous recommendations.
- FY13 Recommendations. The Navy should:
  1. Program and fund an SDTS equipped with the AMDR and DDG 51 Flight III Combat System in time for the AMDR/DDG 51 Flight III Destroyer IOT&E.
  2. Modify the AMDR, Aegis Modernization, and DDG 51 Flight III TEMPs to include a phase of IOT&E using an

SDTS equipped with the AMDR and DDG 51 Flight III Combat System.

3. Modify the AMDR, Aegis Modernization, and DDG 51 Flight III TEMPs to include a credible M&S effort that will enable a full assessment of the AMDR and DDG 51 Flight III Combat System's self-defense capabilities.