

AGM-88E Advanced Anti-Radiation Guided Missile (AARGM) Program

Executive Summary

- The Navy completed testing, including some testing with the operational test agency, of the AGM-88E Advanced Anti-Radiation Guided Missile (AARGM) Block 1 in March 2017 and fielded the system in July 2017.
- AARGM Block 1 is a software-only upgrade addressing deferred capabilities and deficiencies discovered in FY12 during IOT&E.
- AARGM Block 1 software demonstrated some improved capabilities over the previous Block 0 software, but still demonstrated shortfalls in key areas of reliability and accuracy.
- Navy test squadrons VX-31 and VX-9 conducted Block 1 integrated testing beginning in 4QFY14 and ending after DOT&E rescinded test approval in 3QFY16. VX-31 and VX-9 continued limited testing of Block 1 as a developmental test assist in order to characterize the system.
- In FY17, VX-31 completed the final three of eight live fire test events. Of the eight live fire events, six were successful engagements and two were unsuccessful because the missiles did not impact anything of tactical significance. The analysis of the two unsuccessful events revealed classified deficiencies.
- AARGM Block 1 is not operationally suitable, having failed to satisfy two Capability Production Document (CPD)-defined reliability requirements in addition to demonstrating a decline in reliability compared to Block 0.
- Testing during the period was not adequate to provide an evaluation of operational effectiveness or survivability.
- Cybersecurity testing was conducted in accordance with the approved test plan but the test strategy proved ineffective for assessing AARGM's survivability against cyber-attacks. The Navy released Block 1 software in July 2017 without completing operational testing and without adequately addressing the performance and software stability problems discovered during Block 1 testing.
- The AARGM Extended Range (ER) variant is currently based on Block 1 software capabilities, which will require additional work to correct the accuracy, reliability, and software deficiencies to be effective against advanced threats.

System

- The Navy designed AARGM to improve the effectiveness of the legacy AGM-88B/C High-Speed Anti Radiation Missile (HARM) against fixed and relocatable radar and communication sites, particularly those that shut down in order to counter anti-radiation missiles.
- The seeker is optimized to passively detect and guide on radio frequency emissions from a radar site then transition to an



- active Millimeter Wave terminal radar to detect and track air defense unit elements.
- AARGM incorporates digital Anti-Radiation Homing, a GPS, Millimeter Wave guidance, and a Weapon Impact Assessment transmitter.
 - Anti-Radiation Homing improvements include an increased field of view and increased detection range compared to HARM.
 - The GPS allows position accuracy in location and time.
 - The Weapons Impact Assessment capability allows transmission of a real-time hit assessment via a national broadcast data system.
 - The Millimeter Wave radar technology allows target discrimination and guidance during the terminal flight phase.
 - The weapon uses an internal GPS and Inertial Navigation System with mission planning data to establish Missile Impact Zones and Missile Avoidance Zones in an effort to reduce fratricide.
- The Navy employs AARGM on all variants of the F/A-18 aircraft.
- The Navy intended for AARGM Block 1 to deliver Full Operational Capability, including Block 0 capability improvements and software changes to provide deferred capabilities and address deficiencies identified during IOT&E.

Mission

Commanders are intended to use AARGM-equipped aircraft to conduct pre-planned, on-call, and time-sensitive reactive anti-radiation targeting in order to suppress, degrade, and destroy radio frequency-enabled surface-to-air missile defense systems regardless of whether the systems continue radiating or shut down.

Major Contractor

Orbital/Alliant Techsystems – Northridge, California

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Activity

- In June 2015, DOT&E approved the AARGM FOT&E test plan developed by the Program Office and the Navy's Operational Test and Evaluation Force (OPTEVFOR). The test plan was adequate to address the testing of deferred capabilities and deficiencies discovered during developmental test and IOT&E.
- In January 2016, DOT&E issued a memorandum describing problems with AARGM's performance (in particular, Guidance/Navigation Computer anomalies), poor reliability, and multiple software stability problems during integrated testing. In June 2016, DOT&E rescinded approval of the AARGM FOT&E Test Plan because the Navy had taken no significant actions to address these concerns and because integrated testing revealed additional problems.
- At a Gate 6 review, conducted August 2, 2016, the Navy decided to continue test and evaluation as a developmental test assist in order to field Block 1 software. OPTEVFOR and DOT&E attended all remaining test events to observe system performance.
- Navy test squadrons VX-31 and VX-9 completed test items from the Integrated Evaluation Framework as a developmental test assist from 3QFY16 to 2QFY17 at Naval Air Weapons Station China Lake, California, and Naval Base Ventura County, Point Mugu, California.
- The program developed and delivered software versions R2.1, R2.2, R2.2.1, R2.2.2, and R2.2.3 to address some of the deficiencies discovered during testing. R2.2.3 is the current version of Block 1 software but was only evaluated for 24.00 hours of the 234.09 hour test.
- In total, the AARGM Block 1 FOT&E and developmental test assist periods consisted of 32 sorties and 234.09 flight hours consisting of 222 captive carry runs and 8 live fire events.
- In FY17, VX-31 completed the final three of eight live fire test events. Of the eight live fire events, six were successful engagements and two were unsuccessful because the missiles did not impact anything of tactical significance. The analysis of the two unsuccessful events revealed classified deficiencies.
- The test team and OPTEVFOR observed 12 system of systems operational mission failures (OMFs) during 234.09 flight hours, resulting in a system of systems reliability of 19.50 hours Mean Time Between Operational Mission Failures (MTBOMF). This did not satisfy the CPD-defined requirement of greater than or equal to 28.00 hours.
- The test team and OPTEVFOR observed 7 OMFs during 234.09 flight hours, resulting in a system under test reliability of 33.40 hours MTBOMF. This did not satisfy the CPD-defined requirement of greater than or equal to 72.00 hours.
- OPTEVFOR did not conduct vulnerability scanning or penetration testing. The cybersecurity data consist of subject matter opinion and exploration of possibilities, with very little actual operational testing. The remaining cybersecurity test points were limited to interviews with AARGM operators and maintainers.
- In June 2017, OPTEVOR released a letter of observation providing operationally relevant observations of AARGM Block 1 performance during the FOT&E and developmental test assist periods. In July 2017, the Navy fielded Block 1 software and began retrofitting Block 1 software into all Block 0 AARGM.
- The Navy is negotiating a contract with Orbital/Alliant Techsystems to address the overall system reliability shortfalls.
- The Navy's FY16 budget included funding for an AARGM-ER variant that utilizes the existing guidance system and warhead of the AGM-88E with a solid integrated rocket motor to increase range. Development funding will last until 2020.
- In FY17, the Navy contracted with Orbital/Alliant Techsystems to identify near-term risks associated with the thermal protection properties of the current nose cone and seeker design if the rocket motor were redesigned to extend missile range. Results are expected in early FY18.

Assessment

- The operational testing of AARGM Block 1 was adequate to support an evaluation of operational suitability but was not adequate to support an evaluation of operational effectiveness or survivability.
- The Navy evaluated the current version of Block 1 software for only 24.0 hours of the 234.09 hour test. This led to a lack of operationally relevant data to make conclusions on effectiveness and survivability with an acceptable level of statistical confidence.
- AARGM Block 1 software demonstrated improved capabilities over the previous Block 0 software version but also demonstrated effectiveness shortfalls in key capabilities of reliability and accuracy. The details of the improvements and deficiencies are discussed in the classified "AGM-88E Advanced Anti-Radiation Guided Missile FOT&E Report," released in September 2017.
- Detailed analysis of the two live fire failures is classified, but the failures do affect weapon accuracy and performance. The Program Office made adjustments to correct the problems but did not verify the effectiveness of the corrections with additional live fire events before fielding Block 1. Based on known guidance logic, AARGM will likely be ineffective against advanced surface-to-air missile threat systems, particularly in an Anti-Access and Area Denial (A2AD) environment.
- AARGM Block 1 is not operationally suitable. AARGM Block 1 did not satisfy two CPD-defined reliability requirements. AARGM Block 1 demonstrated a slight decline in reliability compared to Block 0, which failed to satisfy reliability requirements during IOT&E but was suitable with a Verification of Correction of Deficiencies period in FY12. The operational effects of poor reliability are decreased availability of training missiles for fleet users and increased maintenance man-hours troubleshooting the missile and associated aircraft systems.

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- The Navy attempted to streamline the AARGM Block 1 FOT&E test design by conducting developmental and operational testing simultaneously in a prolonged integrated test phase. There was no dedicated developmental testing designed into the original test plan. In retrospect and for future AARGM-ER testing, a dedicated developmental test phase is recommended for a weapon system software upgrade of this magnitude. This allows for a dedicated period of problem discovery and correction to take place prior to beginning operational testing with an operationally representative configuration.
 - Cybersecurity testing was inadequate to assess AARGM survivability against cyber-attacks.
 - The Navy released Block 1 software in July 2017 without completing operational testing and without adequately addressing performance and software stability problems discovered during Block 1 testing.
 - Block 1 performance provides limited employment capability against advanced threat surface-to-air radar systems. AARGM-ER will use Block 1 software, which will require additional work to correct the accuracy, reliability, and software deficiencies to be effective against advanced threats.
1. Submit an updated operational test plan for DOT&E approval to correct the accuracy, reliability, and software deficiencies discovered during previous Block 1 testing prior to fleet release.
 2. Assess current and future Navy and Marine Corps doctrine to counter advanced threat surface-to-air missile systems, particularly in an A2AD environment, taking into account the classified problems discovered during previous testing.
 3. Improve seeker performance against advanced threat surface-to-air radar systems prior to investing time, money, and resources in extending the current system's range in an AGM-88E AARGM ER concept.
- FY17 Recommendations. The Navy should:
 1. Conduct dedicated developmental testing prior to further operational testing to ensure the operational test asset performance is stable and is production representative.
 2. Conduct a cybersecurity Adversarial Assessment of AARGM and supporting systems, including AARGM employment from weapons storage and loading, mission planning, and aircraft employment.

Recommendations

- Status of Previous Recommendations. The Navy still needs to address the following previous recommendations:

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