ARLEIGH BURKE (DDG-51) CLASS GUIDED MISSILE DESTROYER WITH THE AN/SPY-1D RADAR

Navy ACAT IC Program

Total Number of Systems:	58
Total Program Cost (TY$):	$55,807.6M
Average Unit Cost (TY$):	$962.2M
Full-rate production:	1QFY87

Prime Contractor

Bath Iron Works (Shipbuilder)
Ingalls Shipbuilding, Inc. (Shipbuilder)
Lockheed Martin (AEGIS Weapon System)

SYSTEM DESCRIPTION & CONTRIBUTION TO JOINT VISION 2020

The ARLEIGH BURKE (DDG 51) class of multi-mission, guided missile, and battle force capable destroyers form the core of the Navy's surface combatant force for the 1990s and beyond. These ships are designed for forward presence and are capable of ***precision engagement*** of targets ashore, ***full-dimensional protection*** of joint and allied forces, and ***dominant maneuver*** while operating at sea and in the littorals. As described in the section on the Navy Area Theater Ballistic Missile Defense, planned upgrades to the AEGIS Weapon System and Standard Missile will also give DDG 51 a ballistic missile defense capability. DDG 51's armament includes a mix of 90 missiles to support its missions, housed in two MK-41 vertical launch systems. The ship uses a computer-controlled machinery control system and an up-rated LM 2500 gas turbine propulsion system to provide a maximum speed of at least 30 knots. The AEGIS Weapon System (AWS), which includes the SPY-1D radar and vertically launched SM-2 surface-to-air missiles, provides DDG 51's area defense anti-air warfare capability. The Phalanx close-in

weapons system, along with the SM-2 missiles and gun, provides self-defense against anti-ship missiles. For Anti-Submarine Warfare (ASW), DDG 51 uses the SQQ-89 surface ASW combat system, the LAMPS MK III ASW helicopter, over-the-side torpedoes, and vertically launched ASW standoff weapons. DDG 51 also employs TOMAHAWK and HARPOON missiles, and has a 5-inch gun for anti-surface and strike warfare missions. The DDG 51 AEGIS Combat System is the integration of the AWS, the SQQ-89, and the ship's anti-surface, strike warfare and self-defense systems.

DDG 51s are being constructed in flights to incorporate technological advancements during construction. Flight II, authorized in FY92, incorporates improvements to the SPY radar and communications systems and adds active electronic countermeasures. Flight IIA, authorized in FY94, adds hangar facilities to accommodate two helicopters, removes HARPOON and the AN/SQR-19 towed array sonar system, replaces Phalanx with the Evolved Sea Sparrow Missile, and upgrades the 5-inch gun to add the capability of firing extended range guided munitions. FOT&E of a Flight IIA ship will occur in FY02.

The SPY-1D radar system is the multi-function, phased-array, three-dimensional (range, altitude, and bearing) radar that conducts search, automatic detection, and tracking of air and surface targets. The SPY-1D also provides mid-course guidance for the SM-2 missile. SPY-1D is a variant of the SPY-1B radar system on later TICONDEROGA (CG 47) class cruisers tailored for a destroyer-sized ship. The AN/SPY-1D(V), intended for installation in later Flight IIA ships, is an improved system with better performance against targets in clutter, additional moving target indicator wave forms, and greater ability to counter deceptive electronic attack measures.

BACKGROUND INFORMATION

The DDG 51 program has undergone continuing OT&E since inception. DOT&E's FY91 report contains a complete summary of the eleven periods of testing prior to commissioning of the lead ship, along with assessments and a discussion of significant deficiencies. The results of the first at-sea testing of the Flight I ship, conducted in DDG 51, were detailed in DOT&E's FY92 report. The results of subsequent FOT&E to reexamine ASW effectiveness and the effectiveness and suitability of the Gun Weapon System were reported in DOT&E's FY94 and FY96 reports. The Flight I LFT&E Program, which included a 1994 Shock Trial and a 1995 Total Ship Survivability Trial, is complete.

The AN/SPY-1D(V) underwent the first phase of OT in FY96. The test was conducted at the Aegis land-based test site at Moorestown, NJ, and examined performance of the radar engineering development model against simulated and actual targets in both clear and electronic attack conditions. SPY-1D(V) demonstrated better low altitude detection and performance in clutter than the operational SPY-1D radar. Based on these results, COMOPTEVFOR found the improved radar potentially operationally effective and suitable and recommended continued development. The Navy authorized LRIP in January 1997 and plans to install SPY-1D(V) in DDG 91 and later ships.

TEST & EVALUATION ACTIVITY

During October 1999, Phase I of Flight II FOT&E (OT-IIID1), was conducted in conjunction with DDG 75 Combat System Ship Qualification Trials (CSSQT) at the Atlantic Fleet Weapons Training Facility. The principal objective of this phase of testing was to spot-check the ship's effectiveness in areas most likely affected by introduction of the AEGIS Baseline 5.3.7 computer programs and other Flight II changes. Test events emphasized air defense and included tracking of manned aircraft and

unmanned target drones in a variety of ECM environments, Standard Missile (SM)-2 engagements, and a gun engagement against a high-speed maneuvering surface target. This period was used as an opportunity to verify that selected deficiencies identified in earlier testing had been corrected.

AEGIS Baseline 5.3.7 underwent joint interoperability certification in November 1999. Following an abbreviated period of observation marked by test-related connectivity, testbed configuration, and crypto equipment difficulties, the Joint Interoperability Test Command (JITC) declared the evaluation an incomplete test. In response to a Joint Staff request, the Navy completed the joint interoperability evaluation in November 2000.

Phase II of Flight II FOT&E (OT-IIID2) was completed during a ten-day period in March 2000 while the USS GEORGE WASHINGTON (CVN 73) battle group was conducting its Composite Training Unit Exercise in the Gulf of Mexico. This was the first systematic operational test of DDG 51 class interoperability with other carrier battle group units. It afforded an opportunity for an in-depth examination of the interoperability among the AEGIS Baseline 5.3.7 combat system in DDG 75, earlier AEGIS baselines installed in cruisers and destroyers, and other combat systems found in the ships and aircraft of today's carrier battle groups. Test scenarios once again focused on air defense exercises. Selected aspects of DDG 51 Flight II operational suitability were also evaluated during this phase of testing.

FOT&E of AN/SPY-1D was conducted concurrently with DDG 51 Flight II FOT&E to evaluate the effectiveness of computer program modifications and the newly-added Track Initiation Processor and provide an updated assessment of the radar's operational suitability.

Throughout the year, DOT&E participated in a series of Test and Evaluation Working Groups chartered to develop plans for DT and OT of the Flight IIA ship (DT/OT-IIIE). Early risk-reduction DT began during DDG 79 and DDG 80 CSSQTs scheduled September-December 2000. Work on the TEMP revision required to support Flight IIA and AN/SPY-1D(V) testing is also underway.

DOT&E received the Navy's DDG 51 Flight I Mission Keeping Design Level Assessment in December 1999. After reviewing this report, DOT&E requested additional information on the Navy's plan for implementation of the recommended design changes in both existing and future ships. To date, not all of the requested information has been provided. DOT&E plans to submit its independent LFT&E assessment of the DDG 51 Flight I ship in FY01.

As part of the LFT&E survivability assessment for the Flight II and IIA ships, the Navy and DOT&E worked together to review the primary damage analysis results and select 15 hits for secondary damage (e.g., fire, smoke, flooding) analysis. With DOT&E participation, this list was pared to 6 significant hits for damage scenario-based engineering analysis and selection of four hits for the January 2001 Total Ship Survivability Trial (TSST) in DDG 79. DOT&E participated in ship checks for the selected scenarios as well as initial checks of the drill guides.

The Navy is completing preparations for a Flight IIA Shock Trial to be conducted during FY01. In late FY00, after the Program Manager had submitted a request for an additional $4.9M for the Shock Trial, DOT&E learned the Navy Comptroller had frozen all DDG 81 Shock Trial funds. DOT&E requested SECNAV take action to restore the funding for this singularly important trial (and those funds have been restored.)

In October 1999, the Program Executive Officer, Theater Surface Combatants, approved a plan to accredit all modeling and simulation used for assessing ship vulnerability. As a result of this effort,

the Navy and DOT&E is gaining new insight into the many models and simulations used for assessing ship vulnerability. In particular, questions concerning the credibility of the Total Mine Simulation System prompted the Program Manager to conduct a mine susceptibility trial in August 2000. This trial, which was observed by DOT&E, will provide data to support an analysis of the ship's susceptibility to selected mine threats and accreditation of the modeling and simulation. In August 2000, the DDG 51 LFT&E Accreditation Review Panel met for the first time to consider accreditation of the Naval Research Laboratory's Radar Target Signature model and CRUISE Missiles missile engagement model. The accreditation of several other models is in progress.

TEST & EVALUATION ASSESSMENT

In keeping with the department's efforts to achieve efficiencies by combining operational testing with DT and training events whenever possible, DDG 51 Flight II FOT&E (OT-IIID) was overlaid onto a collage of such events. In addition to the obvious economies, this approach fostered a close working relationship between the OT and DT communities and allowed the OTA to capitalize on the depth of the AEGIS technical community. In retrospect, however, this collaboration resulted in combined DT/OT that was heavily weighted toward technical objectives. This diminished the "top-down" focus, operational realism and tactical spontaneity usually associated with OT. Although the test ships were operated and maintained by Navy crews, technicians were on hand during CSSQT events to support the operators, and the operators were briefed on DT/OT scenarios in advance. These circumstances do not measurably detract from our ability to evaluate the performance of the SPY-1D radar and other DDG 51 combat systems, but they limit our ability to assess the crew's ability to employ the combat system effectively when faced with the uncertainties and ambiguities that characterize the operational environment.

The primary objective of FOT&E was to evaluate the impact of the changes introduced in the Flight II configuration and AEGIS Baseline 5.3.7 computer program on the ship's operational effectiveness and operational suitability. That objective was not fully achieved. The contribution of the AN/SRS-1(V) Combat Direction Finding system and the Global Command and Control System could not be evaluated because they were not certified ready for OT. Lack of a suitable target precluded evaluation of the effectiveness of the active ECM features of the AN/SLQ-32(V)3. While we continue to assess the SPY-1D radar to be effective and suitable, the test did not provide any quantitative basis for evaluation of the contribution of the new Track Initiation Processor.

Although FOT&E lacked the discriminating power needed to measure the improvement in effectiveness resulting from Flight II upgrades, it provided substantial evidence that the changes did not degrade effectiveness or suitability. It also provided evidence that the Baseline 5.3.7 computer program is stable and devoid of significant deficiencies.

Although examined extensively as part of the LFT&E susceptibility analyses, DDG 51's ability to defeat anti-ship missiles with soft-kill measures has not been evaluated during operational testing because the Navy does not have accredited targets.

Battle Group interoperability testing conducted in FY00 as part of Phase II of OT-IID Flight II FOT&E, established an important performance baseline in an area where there are currently no quantitative performance requirements. Although the AEGIS Baseline 5.3.7 combat system has fewer interoperability problems than earlier baselines, testing highlighted several issues that can degrade situational awareness including the need for an improved contact identification capability and the need more effective training of ship's crew in the use of Link 4A and Tactical Data Link management.

DDG 51 FOT&E did not address the ship's undersea warfare capability since Flight II changes had no impact on that area. However, operational testing of the AN/SQQ-89(V)6 Surface Undersea Warfare Combat System with Torpedo Alertment Upgrade conducted in DDG 78 (a Flight II ship) showed that the DDG 51 class is still at a disadvantage in a one on one encounter with a submarine. A detailed discussion of these test results is provided in the Integrated Surface Ship ASW Combat System (AN/SQQ-89) section of this report.

DDG 75 demonstrated the capability to defeat a single high-speed, maneuvering surface target simulating the patrol boat threat during OT-IIID. Burst patterns from 15 percent of the projectiles fired by the ship's 5-inch gun mount were considered target hits and another 24 percent were counted as near misses. Since the crew was fully alerted in this event, we are unable to assess whether comparable results could be achieved in a tactically realistic scenario. Additional testing to examine the ship's effectiveness against multiple surface targets is planned for future FOT&E.

Gun Weapon System effectiveness against slow-moving aircraft and helicopters remains unresolved pending allocation of suitable targets. Projectile tracking, which might enhance the ship's effectiveness against surface threats and shore batteries, has not yet been implemented for fleet use. DOT&E is reviewing the OTA determination that most of the deficiencies noted in earlier Gun Weapon System testing have been corrected. Gun reliability, which was unsatisfactory in earlier test results, was not re-examined during OT-IIID. Operational effectiveness and suitability of the new Mk 34 Mod 1 Gun Weapon System and the longer range Mk 45 Mod 4 Gun Mount will be evaluated during Flight IIA FOT&E.

From an LFT&E perspective, the Navy is not using the shock trial results to maximum advantage. For example, finite element modeling would provide a more reliable method of extrapolating shock trial results beyond the limits of testing. For Flight IIA, the Navy began a physics-based Shock Trial Simulation Project, which consisted of finite element modeling of the full ship to make pre-shock trial predictions. However, the project was canceled in early FY00 when it became clear that the project would not be completed in time to support the DDG 81 Shock Trial.

Since the shock trial is conducted at less than design level, it should not be relied upon as the sole basis for shock qualification of major equipment and systems. Currently, there is no planned or funded component shock qualification program for the upgraded 5-inch gun being installed in the Flight IIA ships beginning with DDG 81. In January 1999, DOT&E asked the Assistant Secretary of the Navy, Research, Development and Acquisition, to address this concern.

CONCLUSIONS, RECOMMENDATIONS AND LESSONS LEARNED

The long and continuing Operational Test program associated with the DDG 51 has been very effective. The AEGIS program office conducts an aggressive program of ship system testing to explore the boundaries of DDG 51 performance, identify deficiencies, and develop enhancements to hardware and computer programs. This program office was an early proponent of combined DT/OT and fully supports efforts to achieve efficiencies through combining testing and training wherever possible. Although such combined events have largely been successful in the past, operational testers need to exercise greater control over test planning to ensure that future tests adequately address the salient OT objectives and incorporate more operational realism.

Flight I and Flight II DDG 51 class ships and the AN/SPY-1D radar are assessed to be operationally effective and operationally suitable. Some aspects of ship performance warrant improvement and/or additional testing. Although DDG 51 has demonstrated a robust hard-kill capability against most air threats, effectiveness against remaining identified threats should be examined as soon as the appropriate missiles and targets can be made available. Targets suitable for testing soft-kill effectiveness should be developed to complete the assessment of DDG 51 air defense effectiveness and support testing of other ship classes.

DDG 51's capability to defend against attacks from fast patrol boats has not received the level of attention warranted by the threat. Future testing should examine the ship's capability to counter realistic surface threats using all available weapons. The Gun Weapon System's effectiveness against light aircraft and helicopters should be evaluated during Flight IIA FOT&E. The ship's ability to defeat torpedoes should be re-tested as soon as technical developments warrant.

The Navy's investment in robust interoperability testing is already paying dividends. This effort has provided the first quantitative evaluation of unit and battle group situational awareness, and has established an interoperability baseline for the DDG 51 class. Testing has surfaced AEGIS system performance issues as well as inter-platform operability problems. Track correlation, ship gridlock, and target identification should receive special emphasis in light of deficiencies noted in OT-IIID. The wealth of test data will help point the way to problem resolution. Testing has also highlighted fleet training and doctrine shortfalls. The focus on interoperability must be sustained in future operational testing to evaluate Joint interoperability and assess the efficacy of computer program modifications made to address OT-IIID deficiencies.

DOT&E is concerned that funding for a second phase of land-based AN/SPY-1D(V) testing during FY03 may not be adequate to conduct a test that will provide the requisite risk-reduction.