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AEGIS: NEWEST LINE OF NAVY DEFENSE

TICONDEROGA (CG-47) is the first ship in a new class of U.S. Navy guided missile cruisers that will carry the AEGIS Weapon System, the most advanced air defense system in the world today. The ships are intended to provide the primary surface protection for our aircraft carrier battle groups well into the 21st century. In addition to CG-47, YORKTOWN (CG-48) is in construction, and CG-49 and CG-50 are contracted and will commence construction shortly. AEGIS cruisers are multi-mission ships and are highly effective in a variety of missions including antiair warfare, antisubmarine warfare, antiship warfare, strike warfare including bombardment of shore positions, escort to military and merchant ship convoys, amphibious assault support, surveillance and trailing of hostile ships, blockage, and search and rescue at sea.

INTRODUCTION

The guided missile cruiser TICONDEROGA (CG-47) (Fig. 1) is the first of a projected class of 24 U.S. Navy warships that will provide antiair warfare (AAW) defense for U.S. Navy Aircraft Carrier Battle Groups through the end of the 20th century and beyond. TICONDEROGA is armed with the AEGIS Combat System, which possesses an unprecedented AAW combat capability and will provide effective defense against known and projected air attacks. The AEGIS Combat System (Fig. 2) comprises all the elements used to perform the three basic functions of all warships — detection, control, and engagement — for the three types of warfare — antiair, antisubmarine, and antisurface.

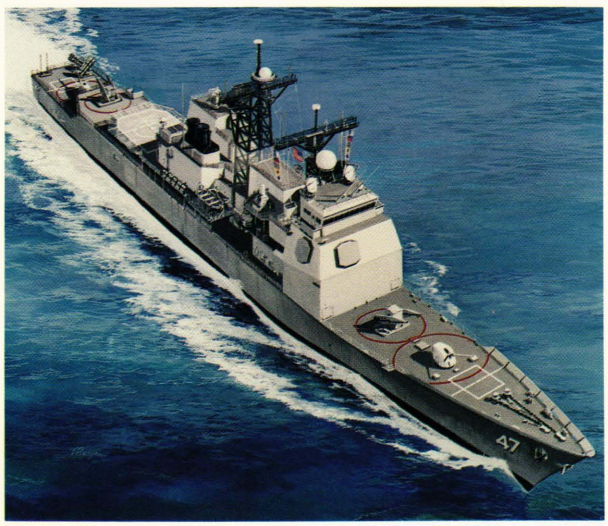


Figure 1 — TICONDEROGA (CG-47) is the lead ship of a class of 24 warships planned to form the bulwark of antiair warfare defense for U.S. Navy Battle Groups into the 21st century.

The essence of the AEGIS Combat System is the Mk 7 Weapon System — the AAW system — shown in Fig. 3. This system is composed of eight elements: weapons control, fire control, and missile launching systems; STANDARD Missiles; the AN/SPY-1A radar; an operational readiness test system; a command and decision system; and a display system. The key to the Weapon System's capability is the SPY-1A Radar System. It is a multifunction three-dimensional (range, altitude, and bearing) weapon-control radar system that permits the engagement of air and surface targets from detection through interception without operator intervention. SPY-1A searches preassigned volumes in space, automatically detects targets, and initiates tracks. It is the primary air and surface radar system for TICONDEROGA.

The most distinctive characteristic of the SPY-1A Radar System is its four-sided stationary array antenna. This enables the radar system to achieve its three-dimensional radar coverage within a volumetric hemisphere symmetrically located with the ship at its center. Pulsed radar beams (Fig. 4) are radiated from the four faces of the antenna system in a predetermined time sequence (adaptive to natural or man-made electromagnetic environments) to support the radar functions of search, track, and missile guidance. Only one such pulsed beam exists at any instant, and each beam is electronically steered. Thus, the fundamental attribute of the radar system is apparent. This characteristic allows rapid, unlimited angular coverage, achievable only because SPY-1A is inherently free of the physical limitations resident in all mechanically scanned radar antenna systems. The SPY-1A evolved from earlier developments in radar technology.

The development of the AEGIS Mk 7 Weapon System can be traced back to the establishment of the Advanced Surface Missile System (ASMS) in the early 1960's and, before that, to 1957 when APL formu-

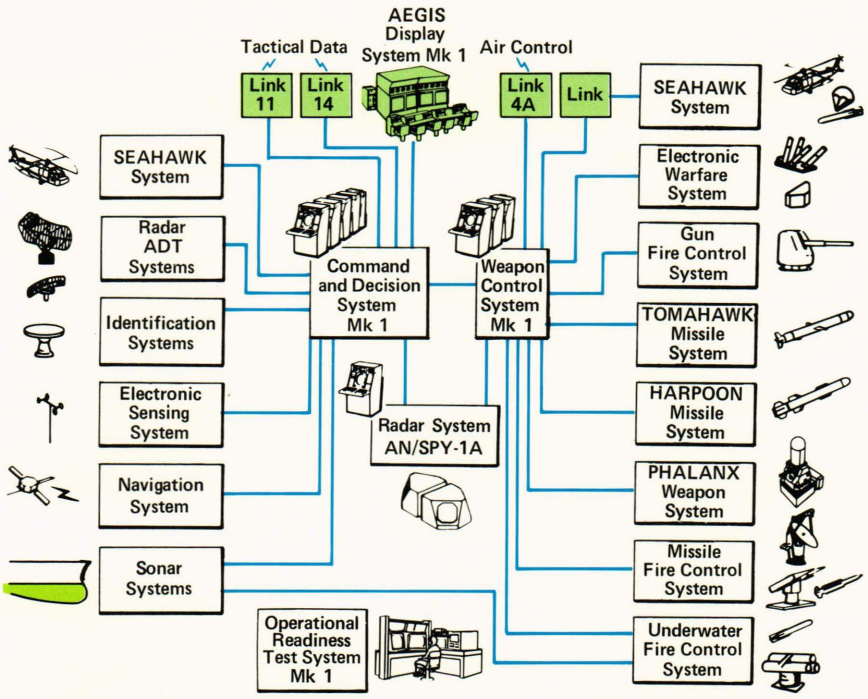


Figure 2 — The major elements of the AEGIS Combat System perform the basic functions of detection, control, and engagement in antiair, antisubmarine, and antisurface warfare.

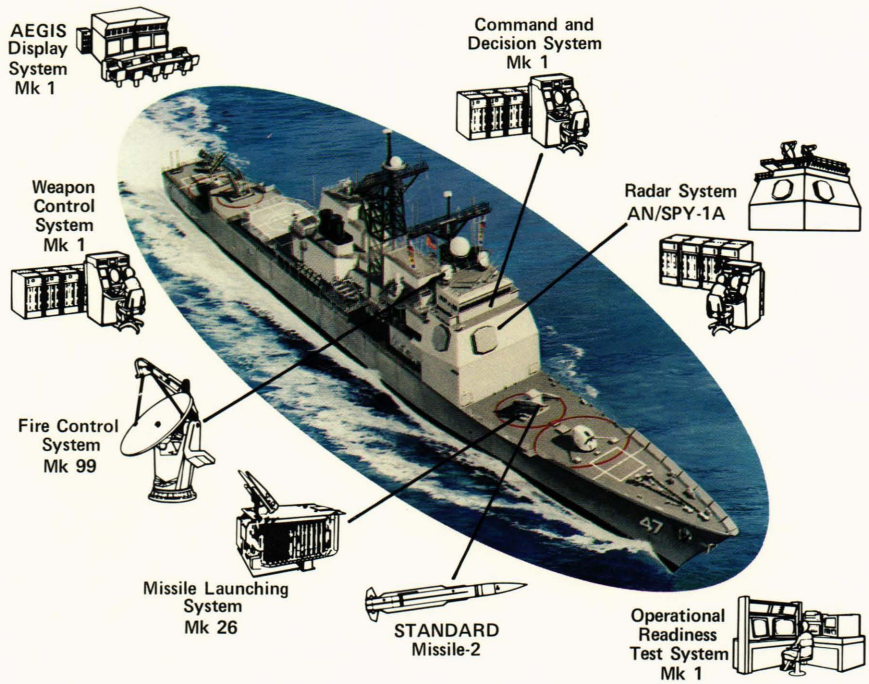


Figure 3 — Eight major elements comprise the AEGIS Mk 7 Weapon System in TICONDEROGA (CG-47).

lated the basic concepts and techniques for an integrated missile weapon system based on a radar system with an electronically steered beam of radar energy. The TYPHON Program emerged from this work, and, in 1959, APL and Westinghouse initiated system development. The article by J. D. Flanagan and W. N. Sweet describes the history of missile system definition and refinement that led to the development of AEGIS.

Navy antiair warfare fundamentals have remained constant over the past quarter century. The AEGIS "Cornerstones" of today are:

- Fast reaction time
- High firepower
- Electronic countermeasures and clutter resistance
- High availability
- Area coverage

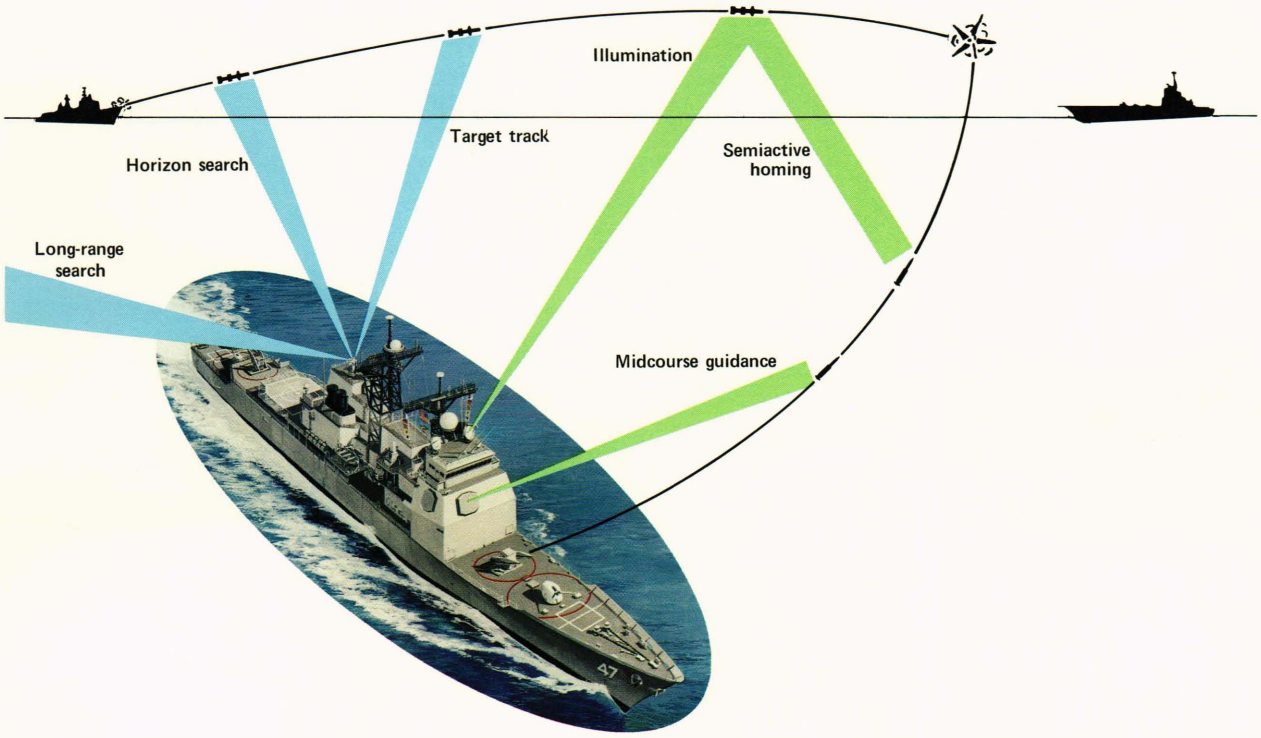


Figure 4 — The AN/SPY-1A radar is a multifunction three-dimensional weapon control radar system that supports the engagement of air and surface targets from detection through interception. The operational sequence of events is illustrated here.

These can be identified in the 1959 TYPHON Weapon System Requirements. Defense in depth and the need for complementary long- and medium-range AAW missiles to achieve it continue to be vital elements of Naval planning.

ENGINEERING DEVELOPMENT

The RCA Missile and Surface Radar Division, Moorestown, N. J., was awarded the contract for the design and development of AEGIS Mk 7 Engineering Development Model 1 (EDM-1) in December 1969. The Critical Design Review was completed in early 1972; in the spring of 1973, the SPY-1 Radar System was installed and was tracking live targets at the Land-Based Test Site (Fig. 5). For two days in November 1973, the system was operated and maintained by sailors in an operational test called "FAST CRUISE." Then EDM-1 was disassembled and flown to the Long Beach Naval Shipyard in California. It was installed in USS NORTON SOUND, a converted World War II seaplane tender now used as the Navy's floating "proving ground" for the development of shipboard combat systems (Fig. 6).

SPY-1 began operating and tracking air targets over the Pacific Ocean 126 days later. STANDARD Missiles (the ammunition currently used by the Fleet) were loaded into the magazines of the Mk 26 Guided Missile Launching System, and on May 16, 1974, AEGIS EDM-1 automatically detected, tracked, engaged, and successfully intercepted two drone aircraft targets, physically striking the second target. In

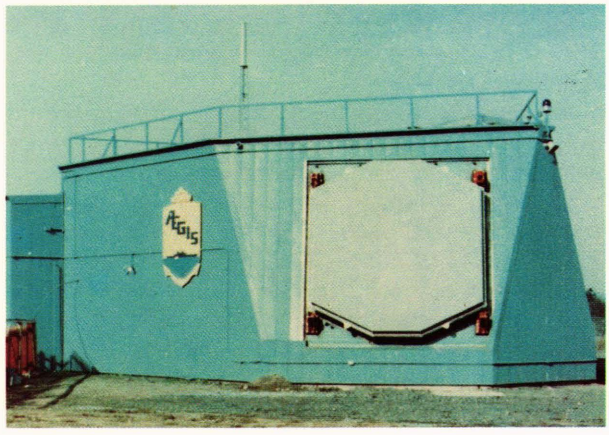


Figure 5 — The Land-Based Test Site was erected at RCA Moorestown to evaluate the performance of AEGIS Engineering Development Model 1.

the six years since that initial engagement, AEGIS in NORTON SOUND has engaged more than 50 targets with STANDARD Missiles (SM-1 and SM-2) with an extraordinary success rate. The highest performance targets in all domains that the test and evaluation community could bring to bear against AEGIS have all, without exception, been successfully engaged and intercepted.

Concurrent with test operations in NORTON SOUND, engineering development continued at the contractor's facility. The Combat System Engineering Development Site was conceived, designed, con-

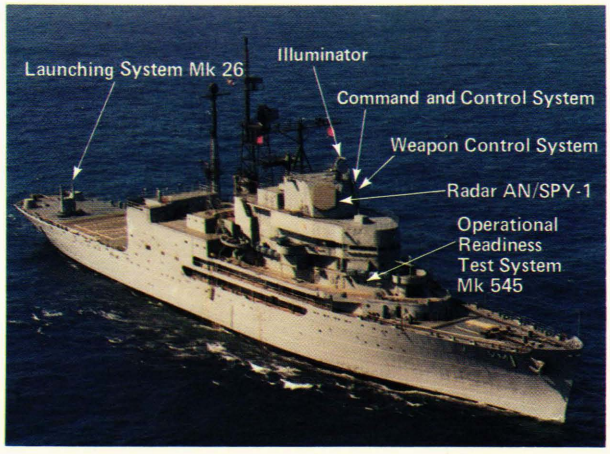
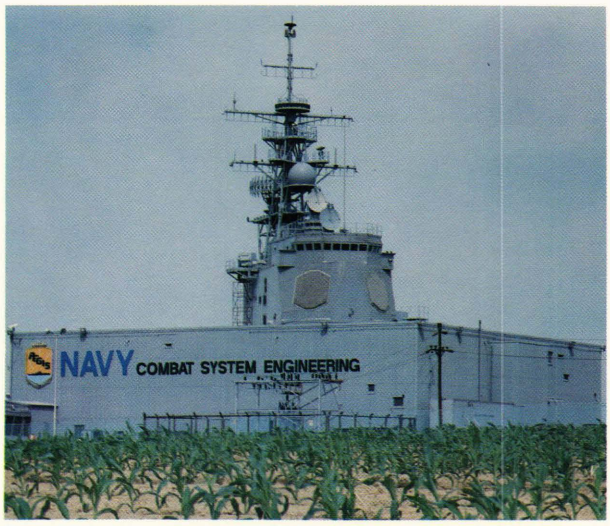


Figure 6 — AEGIS Engineering Development Model 1 was installed in USS NORTON SOUND, where extensive tests and evaluations of the weapon system have been conducted since 1974.



Courtesy RCA Moorestown

Figure 7 — The Combat System Engineering Development Site at RCA Moorestown is a three-story building with a replica of a ship superstructure on top. It is used for system integration, computer program and interface validation, and TICONDEROGA crew training.

structed, and finally commissioned as a U.S. Navy facility on Armed Forces Day, May 21, 1977 (Fig. 7). There, with some selective element simulators, AEGIS was installed for system integration, computer program and interface validation, and TICONDEROGA crew training. The site has a unique structural configuration, appearing to be a warship superstructure looming up out of a New Jersey cornfield. In fact, the site is a three-story building with an actual replica of the superstructure of the planned (but delayed) AEGIS Nuclear Powered Cruiser (CGN-42) on top, with combat system elements in place and operating.

Manned by sailors with contractor support, the site has been the scene of progressively more comprehensive testing as the combat system development moves toward completion. In February 1981, the Commander of the Operational Test and Evaluation Force (COMOPTEVFOR) of the U.S. Navy conducted an intensive three-day exercise. The COMOPTEVFOR final report of this exercise documented the superb results and recommended continued production of the AEGIS Weapon System. This exercise was the last in a long series of combat system tests to be conducted prior to combat system installation in TICONDEROGA.

AEGIS SHIP EVOLUTION

In 1977, recognizing the scope of the overall program, the Navy consolidated into a single project the responsibility for AEGIS ships from design, development, engineering, and acquisition through lifetime support; and for the design and production of the AEGIS Combat System. Rear Admiral Wayne E. Meyer, who had been the AEGIS Weapon System Project Manager since 1970, was appointed the AEGIS Shipbuilding Project Manager.

TICONDEROGA and the AEGIS Nuclear Powered Cruiser emerged from a decade of intense debate within the Navy and the Department of Defense. This debate centered on the projected missions of the Navy as foreseen by policy makers and the meaning of those projections in terms of numbers and types of surface combatants.

In the latter half of the 1960's, during AEGIS Advanced Development, APL was part of an effort to establish a long-term shipbuilding program consisting of three generic destroyer-type ships: DX, DXG, and DXGN. (The Navy notation D is for destroyer, X is a destroyer subcategory denoting size, G means guided-missile-capable, and N means nuclear powered.) A fundamental premise of the program was that these ships, although varying widely in mission capability, would be characterized by an optimal degree of commonality and modularity, thus having profound effects on logistics, training, and manpower throughout the surface Navy.

The AEGIS System was initially intended for the first ship of the DXGN type, which, by 1969, had evolved into the USS VIRGINIA (CGN-38) class. The CGN-38 class was then designed from a structures and displacement point of view. Schedule considerations for both programs (CGN-38 and AEGIS) caused the Navy to redirect the AEGIS System to a later ship of the CGN-38 class. Finally, it was concluded that AEGIS System development and the CGN-38 construction program were entirely mismatched, and the attempts to merge the two were abandoned. However, preliminary design of a nuclear powered AEGIS cruiser was completed, and it is identified today as CGN-42 (Fig. 8). At least three other candidate ships were considered for AEGIS in the 1970's: a single-purpose guided missile destroyer, a nuclear powered strike cruiser, and a converted nuclear powered cruiser.

In 1975, the Secretary of Defense directed that the AEGIS System be planned for installation in a new

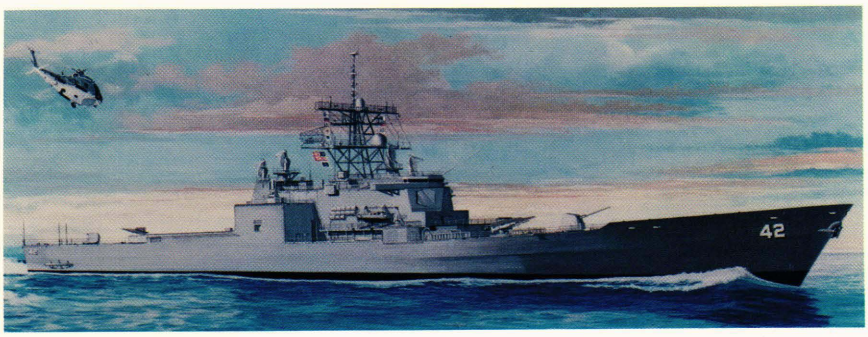


Figure 8 — A nuclear powered AEGIS cruiser, CGN-42, has been designed. Construction has not yet been authorized by Congress.

Figure 9 — CG-47 was "floated off" on April 25, 1981, at Ingalls Shipbuilding Division.

Figure 10 — The CG-47 was christened "TICONDEROGA" on May 16, 1981.

class of destroyer then denoted as DDG-47 (now CG-47). This ship was to be a derivative of the proven SPRUANCE (DDG-963) class destroyer whose basic hull propulsion system and machinery were to be employed. Congress authorized the design and construction of the DDG-47 in 1977. The report of Secretary of Defense Harold Brown to Congress on January 25, 1979 stated: "When deployed in the mid-1980's, the DDG-47s [now CG-47] will become the linchpin of the area Anti-Air Warfare (AAW) defense of our major Naval task forces." The shipbuilding program includes 10 CG-47's in Fiscal Years 1980 to 1984.

AEGIS SHIP PRODUCTION

As AEGIS Combat System development and engineering was proceeding at the Combat System Engineering Development Site, the AEGIS Shipbuilding Project was preparing for warship production. Upon completion of preliminary design work, production contracts were awarded in 1978 by the Navy to RCA and to Ingalls Shipbuilding Division of Litton Industries (Pascagoula, Miss.) for the AEGIS Combat System and the first CG-47 class ship, subsequently named TICONDEROGA. Fabrication of TICONDEROGA was started on July 25, 1979. Six months later, the keel was laid at Ingalls on the west bank of the Pascagoula River. The ship was "floated off" on April 25, 1981 (Fig. 9) and christened by Mrs. Nancy Reagan on May 16, 1981 (Fig. 10).

Recognizing the interdependence of the Combat System and the ship structure and the need to assemble and test in an environment that includes specific operating space arrangements, the AEGIS Shipbuilding Project specified the construction of a Production Test Center at RCA Moorestown. All production equipment and computer programs are being installed and checked out *as a system* prior to installation in TICONDEROGA, thereby obviating the extremely difficult task of integrating the system for the first time *after* ship installation. The AEGIS Shipbuilding Project is unique in this respect, and results to date demonstrate that the use of the Production Test Center will more than fulfill the intended objective.

FLEET INTRODUCTION OF AEGIS

As the 1970's were the decade of AEGIS engineering, the 1980's will be the decade of AEGIS production. Construction of all 24 ships will begin in the 1980's.

In view of the imminent introduction of this new warship class into the operational Fleet, the Navy is dedicating substantial resources toward assuring that, upon its introduction, the groundwork will have been done to allow exploitation of its unique capabilities. The AEGIS System enables the CG-47 to be used as the basic element of a Navy Aircraft Carrier Battle Group containing an unprecedented degree of antiair warfare capability.

AEGIS UPGRADE

APL has been involved in AEGIS development since the program's inception. The articles that follow describe much of this early work, notably the ASMS Program and the development of the Advanced Multi-Function Array Radar.

What of the future? The projected threat is intensifying in all dimensions. Targets are faster and smaller, fly higher, and dive more steeply while being supported by ever-more-powerful radar jamming aircraft. The AEGIS Shipbuilding Project, in recognition of the increasing threat and in view of surging technological progress, has initiated an Upgrade Program aimed at assuring the continued effectiveness of the AEGIS Combat System.

An Upgrade Radar System identified as AN/SPY-1B is now in engineering development. Analysis projections conclude that SPY-1B will support an effectiveness (targets destroyed) improvement against the projected future threat of at least a factor of two.

Beyond SPY-1B, APL is working on preliminary programs to define the parametric boundaries of even-higher-performance guided missile weapon systems that will be required to support an effective AAW defense on into the foreseeable future.