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TERRIER/TARTAR: PACING THE THREAT

Before the introduction of guided-missile-equipped ships that used TERRIER and TARTAR Missiles for antiair warfare, APL was heavily involved in the initial development and continuing modernization of both the guided missiles and their related ship systems. The TERRIER and TARTAR ships, which now use STANDARD Missiles, will continue to be upgraded until they are phased out. These upgrading programs involve a strong, continuing commitment by APL.

EARLY GUIDED MISSILE SYSTEMS

The use of guided missiles for Fleet air defense began with the recommissioning of USS BOSTON in November 1955. USS BOSTON, a World War II heavy cruiser of the BALTIMORE class, was converted to accommodate a two-launcher TERRIER Missile battery during 1955 (Fig. 1). Her sister ship, USS CANBERRA, was converted and recommissioned on June 15, 1956. USS GALVESTON, a World War II light cruiser of the CLEVELAND class, was converted to employ TALOS Missiles and was recommissioned in May 1958, becoming the first TALOS guided missile ship. By 1960, the United States Guided Missile Shipbuilding Program was well under way with eight operational cruisers: three TALOS and five TERRIER. Three more heavy cruisers were converted to TALOS capability, and the first guided missile cruiser, USS LONG BEACH — armed with both TALOS and TERRIER Missiles — was under construction. Additionally, the first of a guided missile frigate class, USS DEWEY, was commissioned in December 1959, and the first of a class of guided missile destroyers, USS CHARLES F. ADAMS, was commissioned in September 1960 (Fig. 2).

These first guided missile systems were direct replacements for gun systems. The associated radars and fire control systems were close derivations of antiair warfare gun systems. The threat was the aircraft of that era, which carried bombs, torpedos, and guns. Although electronic countermeasures were known, little consideration was given to that facet of antiair warfare. Radar detections were made by operators observing video displays. Targets were tracked with grease pencil marks on the face of the display, until they were within the range of the fire control radars. During this process, targets were identified as hostile, friendly, or unknown.

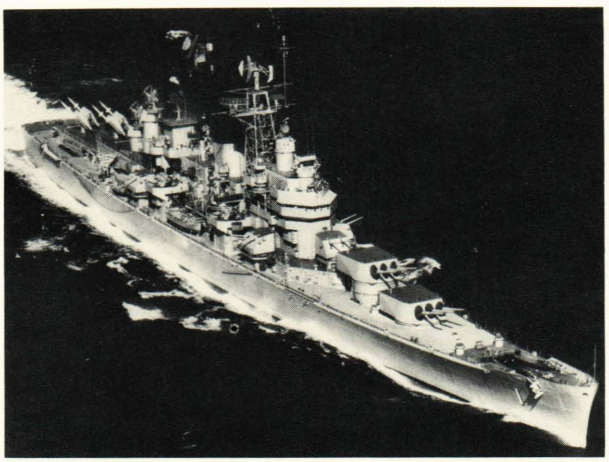

Figure 1 — USS BOSTON, the first United States guided missile cruiser, was a converted World War II heavy cruiser of the BALTIMORE class that was recommissioned in 1955. Armed with two TERRIER batteries, USS BOSTON is identified as the first operational guided missile ship although USS MISSISSIPPI (battleship) and USS GYATT (destroyer) were outfitted as prototype systems in 1952 and 1954, respectively.

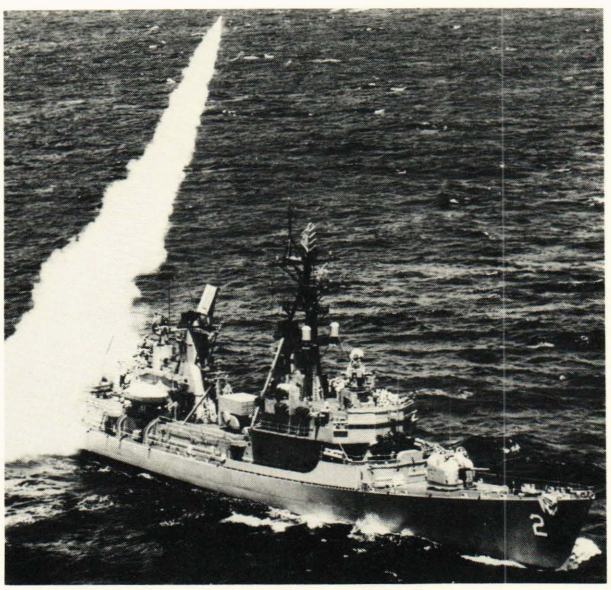

Figure 2 — USS CHARLES F. ADAMS was the first United States guided missile destroyer employing the TARTAR Missile System. USS CHARLES F. ADAMS and USS DEWEY were the first newly constructed ships specifically designed and constructed to be guided missile ships. USS DEWEY was commissioned in 1959 and USS CHARLES F. ADAMS in 1960.

When a hostile target was within engagement range, it was designated to a fire control radar that searched until it acquired the target, after which it tracked the target. When in track, target parameters (range, elevation angle, and bearing angle) were continuously measured and sent to the fire control computer. The computer, using these data, determined when the target would come within range of the guided missile and signalled the launch of the missile into a radar guidance beam that was collocated with the fire control tracking radar beam and steered by the fire control computer. A radar receiver in the missile picked up the guidance beam signals, converted them into steering information, and rode the beam to the target. The missiles were equipped with warheads and proximity, as well as contact, fuzes These early TERRIER and TALOS Missiles had ranges of about 10 and 50 nautical miles, respectively.

These systems were quite effective for their time as long as the threat aircraft were not too fast, not too numerous, and did not utilize very sophisticated countermeasures and countertactics. However, as system capabilities and limitations were stressed and as technology progressed, the guided missile systems have been improved and have become more effective.

TALOS/TERRIER/TARTAR EVOLUTION

During the years between 1955 and 1960, evaluations of TALOS and TERRIER systems were conducted. One of the weaknesses noted was the difficulty of a beamriding missile in operating against low-altitude targets. This difficulty was caused by a multipath phenomenon; i.e., when the fire control radar tracked a target close to the surface of the ocean (100 feet or less), a part of the radar beam was reflected off the ocean to the target and then back to the radar antenna and receiver. This doubly reflected energy caused the radar to produce inaccurate measurements of the target parameters and resulted in incorrect launch computations and rough beamriding. To aid in the alleviation of this situation, the capture beam was power modulated to reduce power on the water, but the ultimate solution to this problem was utilization of semiactive homing in which target track data are filtered to provide predicted intercept conditions, and equipping the missile with a space-stabilized seeker antenna and receiver. The missile is first launched in the direction of the predicted intercept. Then the seeker acquires and tracks radar energy reflected from the target and homes on it to intercept.

Semiactive homing was first implemented in the TALOS system with a pulsed-radar tracking beam. Although pulse tracking was effective, it was determined that a continuous-wave illuminating beam would allow discrimination between moving targets and clutter caused by the Doppler shift of the reflected radar frequency energy and would eliminate the effects of low-altitude multipath returns. At the same time, solid-fuel rocket technology had progressed so that an integral dual-thrust rocket motor permitted use of a missile smaller than TERRIER, which uses a tandem booster. The resulting missile was developed and was named TARTAR. By 1968, the United States had over 60 guided missile ships: six TALOS cruisers, one TALOS/TERRIER nuclear cruiser, 18 TERRIER frigates, two TERRIER nuclear frigates, three aircraft carriers armed with TERRIER, 23 TARTAR destroyers, six TARTAR converted destroyers, and six TARTAR destroyer escorts.

TERRIER MODERNIZATION PROGRAM

In the early 1960's, there were two versions of the TERRIER Fire Control System. One, the Mk 73, was characterized by a large AN/SPQ-5 Fire Control Radar that used a zone-plate lens antenna structure that was an adaptation of the TALOS AN/SPG-49. The other was the Mk 76 Fire Control System with a lightweight AN/SPG-55B Fire Control Radar. When the semiactive homing version of the TERRIER Missile was introduced, it was decided to standardize the fire control systems in 31 TERRIER ships. In 1968, the TERRIER Modernization Program saw its first ship, USS LEAHY, recommissioned. Concomitant with the standardization of the fire control system was the replacement of the three-dimensional search radar with the newer, more capable AN/SPS-48 and the inclusion of the digital Naval Tactical Data System[1] and its integral Mk 11 Weapon Direction System. By 1974, all TERRIER ships had a modernized, standard combat system configuration (Fig. 3).

When problems arose during Fleet introduction of TERRIER, TARTAR, and TALOS guided missile ships, the Navy appointed a Special Navy Task Force for Surface Missile Systems headed by Rear Admiral Eli T. Reich. In July 1963, he formed an Ad Hoc Surface Missile Systems Technical Planning Group, which later became known as Technical Planning Group I. This group, headed by Captain R. K. Irvine, Technical Director of the Special Navy Task Force, included members of APL and of key industrial organizations selected on the basis of their background and expertise. Technical Planning Group I, with heavy participation by APL, reviewed all aspects of TERRIER, TARTAR, and TALOS guided missile systems and produced a plan, "Technical Plan for the Surface Missile Systems" (November 1963), which guided system developments through the 1960's. One of their first actions was the identification of APL, in May 1962, as Technical Direction and System Integration Agent for TERRIER, TARTAR, and TALOS Systems. Another element of that plan recommended that a development support facility be established at APL. In 1964, a complete TERRIER Mk 76 Fire Control System, consisting of the AN/SPG-55B Fire Control Radar and the Mk 119 Fire Control Computer, was installed in APL's Building 40 and has remained there to this day. A partial TARTAR Fire Control System, consisting of the antenna and receiving components of the AN/SPG-51 Fire Control Radar, was installed in 1967. Dubbed the AN/SPG-51X, it was used to explore

Figure 3 — USS WAINWRIGHT was commissioned in 1966. It was the first all up guided missile frigate, later redesignated as a cruiser, in the combat system configuration that served as the prototype for the TERRIER Modernization Program: AN/SPS-48 Three-Dimensional Air Search Radar, Mk 11 Weapon Direction System, and AN/SPG-55B Fire Control Radars. By 1974, all 31 TERRIER ships were of the modernized configuration.

special counter-countermeasures improvements. Additionally, Technical Planning Group I recognized the need for a new-generation guided missile weapon system; the Advanced Surface Missile Systems Study of 1965 led to the AEGIS system.

THE GROWING THREAT

Terrier/Tartar Countermeasures Improvements

In 1968, the Navy recognized that the threat was becoming more sophisticated and increasing in both numbers and capability. Additionally, the exploding technology of digital electronics applications to tactical military systems had matured sufficiently to permit significant redesigns of weapon systems. Surface Missile Systems Technical Planning Group II was chartered to provide a technical plan for the support of improvements to the guided missile Fleet. This group included representation from the Office of the Chief of Naval Operations, the Naval Material Command, the Naval Sea Systems Command, the Naval Ship Weapon Systems Engineering Station, APL, and Vitro Laboratories. Their report, issued in December 1968, included detailed information on, and an analysis of, the threat; the requirements, capabilities, and limitations of the current TERRIER and TARTAR systems; and the derivations of requirements for improvements. Highlighted was the emergence of the antiship missile. The report also laid out a technical plan through which the improvements could be achieved. It was recognized that TERRIER and TARTAR ships, while unable to achieve AEGIS capability, could still be made to cope with the threat of the 1970's through further improvements, including increased countermeasures resistance.

Improvements to TERRIER systems, as a result, were centered around their counter-countermeasures capabilities and their ability to engage surface- and subsurface-launched antiship missiles. Because of the numbers of ships involved (31) and the nature of the improvements (functional, physical, and economic), they were packaged as functional modules. These modules were designed so that they could be implemented singly or in concert, with the exception of the baseline system, which was a conversion from an analog fire control computer to a standard Navy general-purpose digital computer. This conversion module was called the Digital Fire Control System. Three other modules were identified: Track Module, Continuous Wave Module, and Counter-Countermeasures Module. The Track Module provided for the inclusion of digital phase-coded pulse compression to the primary tracking element of the AN/SPG-55B Fire Control Radar. This allowed high-resolution tracking and improvements in clutter and countermeasures. The Continuous Wave Module provided a receiving system adjunct to the Continuous Wave Illuminator. This added a redundant tracking capability with a special ability to track targets in heavy chaff, in weather clutter, and over land. It also provided gains in countermeasures resistance by virtue of the two-band redundant tracking capability of having two radars on one pedestal. The Counter-Countermeasures Module added improved operator consoles and displays and implemented special circuitry and operating modes to further enhance the counter-countermeasures capability of the Fire Control Radar.

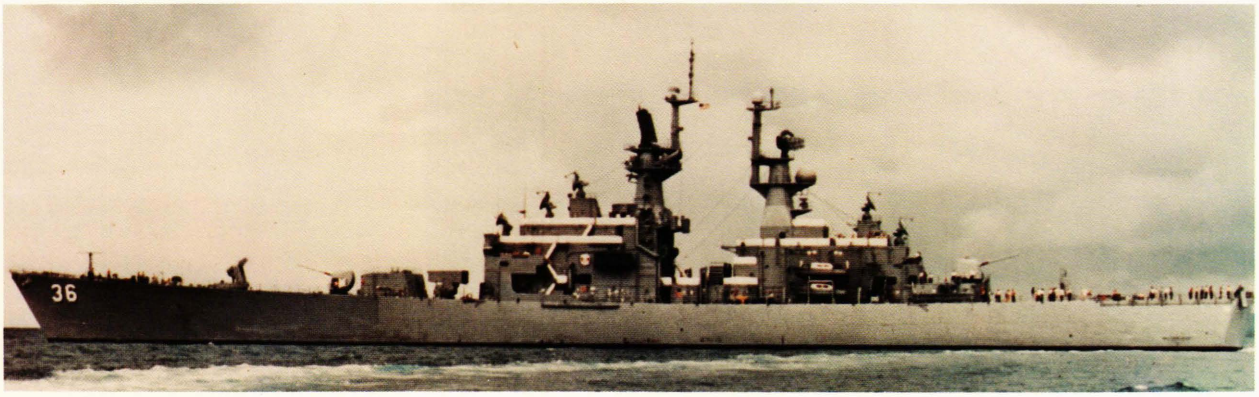

Figure 4 — USS CALIFORNIA was the first guided missile nuclear powered cruiser armed with the TARTAR-D Missile System. This system is the interim system prior to deployment of AEGIS. There are two of this class and four of the USS VIRGINIA class. All are armed with the STANDARD Missile.

At the same time, the TARTAR Fire Control System was being converted to the use of the standard Navy digital computer. The pulse-Doppler tracking radar segment of the AN/SPG-51 Fire Control Radar was changed significantly by increasing its power, incorporating frequency agility and digital control, and installing a new antenna with better sidelobe structure and reliability. This conversion was built into the fire control systems of the newly constructed nuclear cruisers, the CGN-36/38 class, and was called TARTAR-D (Fig. 4).

Automatic Detection and Threat Processing

The Surface Missile Systems Technical Planning Group II also highlighted a reaction time problem. Because of the speed of the antiship missiles, conventional procedures that call for sequential and manual operations (detection, target entry, track updating, evaluation, identification, decision to engage, and target engagement) would not allow viable engagements. Threat-responsive procedures were introduced in which the systems perform parallel and automatic or semiautomatic functional processing to reduce reaction times.

Radar data from the Tonkin Gulf during the Vietnamese conflict demonstrated that, although the search radars operated as designed, local environments and large numbers of air targets precluded timely detection, identification, and subsequent engagement of many targets. APL entered into a development program that ultimately led to two significant advances toward solving the target detection and tracking problem. The first was the development of an adaptive thresholding technique applied to the radar video signal. The technique eliminates the clutter in each beam that would otherwise obscure targets in other beams when the composite video was displayed. The second was the conversion of the processed video to digital form so that target data could be processed in a digital computer. Target detection and tracking can then be done by the computer rather than by an operator using manual techniques. These improvements were applied to the two search radars of the DDG TARTAR ships, the AN/SPS-52 and the AN/SPS-40, and provided integrated automatic detection and tracking. This system, the AN/SYS-1, is now in production and is being installed in the TARTAR DDG upgraded ships. A later version, AN/SYS-2, is being installed in TERRIER ships and TARTAR nuclear cruisers using AN/SPS-48 and AN/SPS-49 radars.

Introduction of STANDARD Missile

In 1972, the missile being developed for AEGIS, the STANDARD Missile-2, had progressed to where it was appropriate to consider its utility for improving TERRIER ships in firepower and range. Through the use of an onboard inertial reference unit, the STANDARD Missile-2 (Extended Range) can be launched and flown through an up-and-over, maximum lift/drag trajectory and can achieve double the typical range. Terminal homing is then accomplished similar to STANDARD Missile-1. Firepower is increased by this means. This improved system capability was implemented under the technical direction of APL through system modifications that were designed, fabricated, and tested at the APL Land-Based Test Site and then taken to USS WAINWRIGHT in 1976 for at-sea testing. Further system integration testing was done at the Fleet Combat Direction Systems Support Activity (Land-Based Test Site) at Dam Neck, Va., as well as at APL , with final operational testing on USS MAHAN in 1978. This guided missile cruiser STANDARD Missile-2 system is in production and currently is installed in two TERRIER ships.

New Threat Upgrade Program

In 1974, the Office of the Assistant Secretary of Defense for Research and Engineering identified a potentially increasing threat, typified by the Backfire bomber (Fig. 5), and directed that a study be performed to determine if TERRIER and TARTAR ships could be further improved to provide increased capabilities. APL, assisted by the intelligence community and several Navy contractors and laboratories, per-

Courtesy Royal Swedish Air Force

Figure 5 — Backfire aircraft: this aircraft and its cruise missiles are typical of potential threats to U.S. forces.

formed a comprehensive assessment of the threat, including an examination of many probable scenarios with countermeasures; determined TERRIER and TARTAR capabilities and limitations against the threat; and reviewed available technologies in propulsion, guidance, ordnance, and radar to shape a total improvement program. The proposed program was presented to the Navy in 1976, and approval to proceed was given. That program, called New Threat Upgrade, is under way and will be applied to the 31 TERRIER ships and the 10 newest TARTAR ships. Key elements in this program are being carried out by a Navy industrial team led by APL as both Technical Direction Agent and System Integration Agent.

NOTE

[1]The Naval Tactical Data System employs computers, displays, and digital data links that share track and identification tasks among Battle Group elements.