CHARLES L. ROE

THE NATO SEASPARROW SURFACE MISSILE SYSTEM

The NATO Seasparrow Project has seen twenty-three successful years of international cooperation and owes much of its success to the leadership of the NATO Seasparrow Project Steering Committee and the NATO Seasparrow Project Office, and to the capable support of the international team of laboratories and industry. Today's NATO Seasparrow Surface Missile System provides the navies of the free world with a quick-reaction, self-defense capability of proven effectiveness against a wide spectrum of threats, including steep-diving and low-altitude aircraft and cruise missiles.

INTRODUCTION

Twenty-three years ago, a unique memorandum of understanding was signed by four NATO countries (Denmark, Italy, Norway, and the United States) to form a consortium whose objective was to develop and produce a state-of-the-art, shipborne, self-defense system to counter the threat posed to their navies by anti-ship weapons.[1] This system is the NATO Seasparrow Surface Missile System (NSSMS). Since its inception, the consortium has grown to include thirteen member nations—Australia, Belgium, Canada, Denmark, Germany, Greece, Italy, The Netherlands, Norway, Portugal, Spain, Turkey, and the United States (see Fig. 1). The NATO Seasparrow is also aboard ships of Japan.

PROGRAM INITIATION

It is a well-known adage in ships' anti-missile defense that you try to "kill the archer, not the arrow." Long-range engagement systems, such as Harpoon and Standard Missile of the Aegis and New Threat Upgrade combat systems and the combat air patrol, are employed in the outer air battle to destroy or disable the launch platforms of anti-ship missiles. In the present day, naval warfare analysts and engagement assessment specialists project that coordinated attacks may be made from multiple launch platforms along multiple axes and that these attacks may come from surface, subsurface, and air platforms, as well as from land-based sites in support of near-land operations. Large numbers of attackers may be expected to overwhelm long-range weapons. Layered-defense concepts have thus been developed wherein long-range weapons are used for counterstrikes against attackers, and attackers that survive those weapons are engaged by successive layers of mid-range, self-defense, and terminal-defense weapons.[2]

Figure 1. This spread of flags for the NATO Seasparrow Consortium nations has grown from the four signatories of the original memorandum of understanding to those representing the current thirteen participants.

As early as 1966, the U.S. Navy, working with APL, had developed requirements for a short-range missile system (the future NSSMS) for self-defense against the recognized anti-ship missile threat. To place this system in perspective, the self-defense operating regime is the region extending from approximately 20 nmi (the radar horizon for low-flying aircraft) to within a mile or so of the ship. Such a short-range missile system was proposed to the NATO Conference of National Armaments Directors to be a NATO cooperative venture to meet the needs of other NATO navies as well as those of the U.S. Navy. The sinking of the Israeli destroyer *Elath* in 1967 by an anti-ship missile provided further impetus to the program, and agreement was reached between the four charter member nations for a cooperative development of the NSSMS.

The memorandum of understanding for the NSSMS project defined the technical program, the initial development, and the follow-on production phases. This document was signed by Denmark, Italy, Norway, and the United States in 1968. Belgium and The Netherlands joined the consortium in 1970, and Germany joined in 1977. Canada and Greece joined the consortium in 1982, Turkey in 1986, Portugal in 1988, and Australia in 1990. Spain became the thirteenth member, signing the memorandum of understanding for accession in 1991.

The memorandum of understanding also established the NATO Seasparrow Project Steering Committee (NSPSC), which sets program policy, critically reviews program progress, and renders fiscal and technical direction. Rear Admiral J. T. Hood, USN, is the current chairman of the NSPSC. Program management is provided by the NATO Seasparrow Project Office (NSPO) in Washington, D.C., under the policy direction of the NSPSC. Captain J. Scott Beachy, USN, is the Project Manager. National Deputies are assigned to the office by the member nations.

A three-year development program was initiated to include design, fabrication, testing, and evaluation of three engineering developmental models. Maximum use was made of existing technology and existing hardware (including the Sparrow missile) to minimize the risks to performance, schedule, and cost. The Raytheon Company was awarded a prime contract for development of the NSSMS in September 1969 (Fig. 2). The NSSMS developmental costs were rigorously held within the contract price. The technology transfer accomplished by using the existing Sparrow missile design significantly reduced project costs and provided NATO standardization and interoperability.

The prime contract for the production phase was awarded in August 1973.[3] Intensive planning, coordination, and implementation efforts were set in motion for what was the first multinational production venture of this magnitude, again headed by the Raytheon Company. Parts of the system were required to be purchased and manufactured in Europe, but the value of the orders had to be within the constraints imposed by the balance of payments provision of the memorandum of understanding. Since this initial procurement, vendors from other member nations have continued to supply various parts of the system. The cooperative production programs and sharing of technology have resulted in minimum cost and maximum efficiency in weapons system production.

After undergoing land-based performance demonstration testing, one of the engineering models was installed on the USS *Downes* (DE-1070) for shipboard testing. A contractor demonstration test conducted in early 1972 produced 80% successful intercepts within the specified missile performance envelope. A U.S. Navy technical evaluation conducted in mid-1972 produced similar results. The U.S. Navy operational evaluation was completed successfully in April 1973. Tests conducted aboard a Norwegian frigate in far northern environments provided additional evidence of the system's effectiveness.

Figure 2. Rear Admiral Mark W. Woods, Commander of the Naval Ordnance Systems Command (and now Assistant to the Director at APL), signs the NATO Seasparrow development contract in October 1969. Representatives from other Navy offices, consortium governments, and the Raytheon Company observe the event.

The first production NSSMS was installed aboard the Norwegian ship KNM *Trondheim* in mid-1975. A system was also delivered to Dam Neck, Virginia, to use in training U.S. Navy personnel in the operation and maintenance of the NSSMS. The number of deployed systems has grown to eighty-seven systems on fifty-nine U.S. Navy ships and fifty-three systems on fifty-three ships of the other consortium navies. In the next five years, an additional thirty-seven consortium ships will receive the NSSMS, many with vertical launching systems.[4]

THE SYSTEM

The NSSMS has a computer complex that processes targets that are either assigned from an external designation source or detected by its own fire-control radar. The radar also illuminates the target for the missile and serves as the target-tracking radar. An NSSMS battery comprises one or two fire-control radar directors, a computer, and a launcher. Ship installations vary from a single director battery up to three dual-director batteries for some nuclear-powered aircraft carriers. A low-light-level television subsystem on the director enables positive target-kill assessment and assists in manual target acquisition and tracking.

The U.S. fire control system, the Mk 91, is also used by Norway, Denmark, and Italy. Eight countries use the "Dutch" system manufactured in part by Hollandse Signaalapparaten. The Australian navy uses a fire-control system developed by the Bofors Company of Sweden.

The NSSMS trainable launcher accommodates eight Seasparrow missiles. These are Sparrow AIM-7 (A signifies air-launched) missiles that are modified with folding wings and clipped tail fins for sea-launch applications. The Seasparrow RIM-7M (R signifies surface-launched) is now the most widely deployed RIM-7 variant on consortium ships. The RIM-7P, with improved low-altitude intercept capability, recently successfully completed Navy operational testing and went into production in late 1990. The RIM-7M missile can be modified to the RIM-7P configuration. Versions of the RIM-7M that can be launched vertically have also been developed for consortium use. Firings of Seasparrow from the Mk 29 trainable launcher and the Mk 48 Vertical Launching System are shown in Figures 3 and 4, respectively.

For most U.S. applications, a capable external designation source is provided by the Mk 23 Target Acquisition System (TAS).[5] The combination of the TAS and the NSSMS provides an effective self-contained, self-defense, surface missile system that has been given the nomenclature AN/SWY-1. The TAS is a combination of a dual-mode radar (with IFF [identification, friend or foe]) and a digital processor that provides automatic detection, tracking,

Figure 3. A NATO Seasparrow missile being launched from the Mk 29 trainable launcher on the USS *Merrill* (DD-976) during an exercise. Thirty-one ships of this class are outfitted with the NATO Seasparrow Surface Missile System.

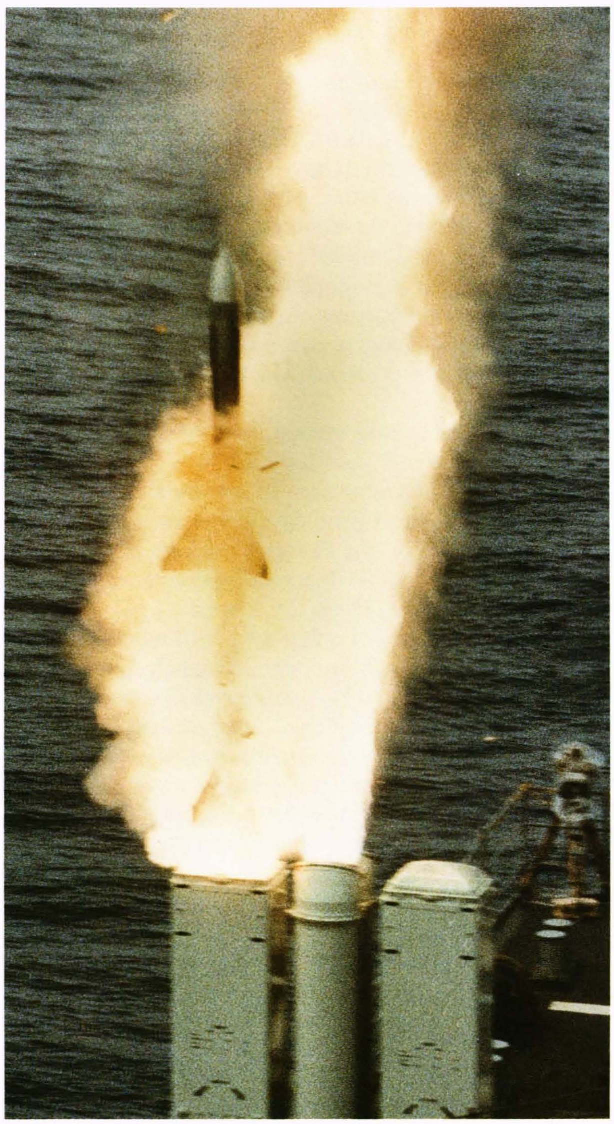

Figure 4. A NATO Seasparrow missile being launched from the Mk 48 Guided Missile Vertical Launching System on the USS *Briscoe* (DD-977) during at-sea tests.

threat evaluation, and weapon-control information to the NSSMS.

ENGAGEMENT SEQUENCE

An NSSMS engagement begins when an external designation source such as the Mk 23 TAS (or NSSMS itself) detects a target.[6] The designation is sent to the NSSMS computer, and the system is put into action. When given the target designation (which can be as little information as an approximate bearing), the director will move to the desired azimuth and begin an appropriate scan, the transmitter will radiate, and the acquisition process will begin, all under control of the system computer. When the target is detected, the director is stopped, the ranging and angle-tracking modulations are turned on, and tracking begins. If the target signal fades during track, the computer will coast the system in range, bearing, and elevation until the target signal returns.

During track, the time of missile flight to the target is computed. If the target course will bring it within range at some future time, the operator is alerted that the target will be engageable. If it is within range, he is alerted that the target is engageable. Two engagement-range contours are available; operations doctrine determines which one will be used.

Shortly before a target becomes engageable, the launcher is automatically assigned to the appropriate fire-control radar. It is aimed at the predicted intercept point and adjusted for the optimum trajectory, and the necessary missile orders are continuously calculated and provided. In the automatic mode, a salvo is fired when the target becomes engageable. During the firing sequence, the rocket motor is armed; the missile self-tests, tunes to the illuminator frequency, and reports that it is ready; and the motor is ignited. In the semiautomatic mode, all operations are identical, except that the fire command is issued by the Firing Officer. Figure 5 shows a Seasparrow launch from a U.S. Navy aircraft carrier.

Figure 5. A NATO Seasparrow RIM-7M missile being fired from the USS *Abraham Lincoln* (CVN-72) in January 1990. All aircraft carriers are provided with Seasparrows.

The shipboard system provides continuous wave target illumination for missile homing. The Seasparrow missile is a boost–sustain–glide missile that employs semiactive homing guidance. It is propelled by a solid-propellant rocket motor and carries a highly explosive fragmentation-type warhead. Warhead fuzing is accomplished by an active proximity fuze or a contact detonator.

On the Firing Officer's display, the predicted intercept point for the first salvo will blink, and the latest predicted intercept point continues to be calculated and displayed, should a second salvo be desired (Fig. 6). The radar operator, watching and listening to the target return, is alerted to the predicted intercept. He assesses the success of the intercept and advises the Firing Officer, who can either terminate the launcher assignment or fire a second salvo. The success or failure of the engagement is also reported to the external designation source, which can order a reengagement.

SYSTEM EFFECTIVENESS

As anti-ship missile threats have become more difficult to engage (because they are faster, are more stealthy [by reason of lower radar cross section or passive homing], can fly lower or dive steeply onto their targets, or can perform complex terminal maneuvers), the NSSMS has evolved to meet the challenge.[7] Improvements to the fire-control system, missile, and sensor have enabled the NSSMS to keep apace of the threat. Better integration of the system with other elements of the ship combat system has provided decreased reaction time and increased overall effectiveness. More capable use has been made of low-light-level television to assist operations, the missile has evolved to perform better in electronic countermeasures environments and against very low altitude sea-skimming threats, and tactics have been developed and promulgated to the fleet to provide guidance for optimal setup and operation of the NSSMS for various operational and environmental conditions.

Figure 6. The Firing Officer (background) and Radar Set Console Operator (foreground) of the NATO Seasparrow Surface Missile System exercise positive control over Seasparrow engagements, and interact with automatic processes to make weapon direction and engagement decisions.

Today's NSSMS offers an automatic, fast-reaction, designate-to-launch sequence, including flexible-volume search and automatic detection of air-to-surface threats. The system provides electronic counter-countermeasures and all-weather operation, with eight missiles in constant readiness for rapid fire from each installed launcher (with vertical launching systems, this number may increase). The system's reliability, maintainability, and availability are reflected in its high mean time between failures and low mean time to repair. A broad spectrum of casualty backup modes is available. The NSSMS has been proven effective against all threat types, including pop-up threats; very low altitude threats; and high, diving threats.

Enhanced reliability, maintainability, and availability of the NSSMS have resulted from an NSPO program that analyzes firings to increase operator proficiency and from the ability to employ the system successfully under all battle conditions. The NSPO has participated in the planning of firing events to optimize operator training and data collection on system performance while testing the extremes of the operating envelope. The results from such firing events are used to build a system database from which tactical doctrine can be developed, and to verify simulations that analyze system performance under conditions that are difficult to test.

During the past three years, the U.S. Navy and German Navy have participated in joint firing exercises at the Atlantic Fleet Weapons Test Facility. These exercises assess fleet self-defense combat-system readiness, identify and correct weaknesses in tactics, and assess the ability of the two navies to conduct coordinated engagements. The NSPO also uses these opportunities to evaluate sensor and system improvements in an at-sea environment. It is expected that other NATO partners will participate in the exercises in the future.

APL CONTRIBUTIONS

The Applied Physics Laboratory has been closely associated with the NSSMS program since its inception, initially defining the system requirements and acting over the years in its role as technical advisor to NSPO. In several instances, APL has acted on NSPO's behalf to direct the technical efforts of the various design agents responsible for hardware and software developmental activities. In 1983, APL undertook an NSSMS upgrade study, in which the effectiveness of the system on all consortium ships was assessed and recommendations were made for upgrades. Similarly, in 1985, APL participated in a Naval Sea Systems Command (NAVSEA) self-defense assessment study (widely known as the Kuesters study) to analyze the Navy's self-defense needs and shortfalls and to recommend corrective action.

At NAVSEA's request, APL chaired a Seasparrow Availability Review Council to address reliability, maintainability, and availability problems. The Council led to an ongoing activity that has resulted in dramatic improvements in the problem areas.

Additional activities at APL have addressed the computer programs of the external designation sources (TAS and Combat Direction System) and interface changes to facilitate the exchange of data for better integration and complementary employment of the NSSMS with other combat-system elements. The Laboratory investigated monopulse and other electronic counter-countermeasures improvements to the missile and to the fire-control system, and led an effort to develop a flood illuminator to improve the system's firepower by illuminating an engagement sector. The Laboratory also led a program to address and correct deficiencies in the system identified during the RIM-7M operational evaluation testing.

The Applied Physics Laboratory is currently supporting NSPO in long-range planning efforts to upgrade the NSSMS to meet the fleet's self-defense needs. In anticipation of threat, countermeasures, and operational evolution, APL is working to ensure system compatibility with new developments and technologies and to align NSSMS goals with other Navy planning efforts. When these upgrades require studies and analyses to determine their contribution to firepower and reaction time, APL will perform them.

FUTURE PLANS

The outlook for the NSSMS seems especially bright. Twenty-three years of cooperative international development and testing have yielded a self-defense missile system not only capable of dealing with today's sophisticated threats, but one that is being honed to defeat the threats of tomorrow. Several programs are already in place to continue the improvements in NSSMS operation against the next generation of anti-ship missiles, which will present targets that are increasingly difficult to detect, to track, and to kill. There is little doubt that the NSSMS will be up to the challenge. The Laboratory is working with NSPO to continue to improve the NSSMS in cooperation with other members of the consortium to provide a continued, effective, self-defense capability to be used when ships find it necessary to "kill the arrow."

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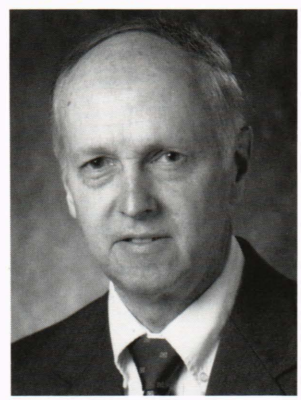
THE AUTHOR



CHARLES L. ROE is the project manager for NATO Seasparrow Combat Systems in APL's Fleet Systems Department. He holds a B.S. in computer science from The University of Maryland and an M.S. in technical management from The Johns Hopkins University. Employed at APL since 1957, he has been involved in self-defense programs, including NATO Seasparrow, the Rolling Airframe Missile Guided Missile Weapon System, and the Phalanx Close-In Weapon System. He has been particularly active in combat system integration to attain improvements in self-defense for the fleet. His most recent efforts have been directed at upgrades and evolution of existing systems to meet the challenges of the 1990s.