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EVOLUTION OF THE TALOS MISSILE

In 1945, the Bumblebee Program began work directed toward determining the feasibility of building a supersonic guided missile. It was to be ramjet propelled and guided by radar. Because the state of the required technology was then very limited, many problems needed solutions. This article is an overview of the work done to bring the Talos missile into the Navy's arsenal.

At the beginning of World War II, the principal threat to Allied surface ships was from dive-bombing or torpedo-carrying aircraft, with speeds on the order of 250 knots. The airplanes had to make a long, slow, straight-in approach rather close to the target in order to deliver their weapons. This put them in positions where antiaircraft gunfire was quite effective and attrition rates were high.

With the advent of proximity-fuzed antiaircraft shells in 1943, enemy planes were even less able to mount conventional attacks without incurring unacceptable losses. However, it was foreseeable that this advantage of defense over attack would not long continue. As high-performance turbojet and rocket engines became available, and with the advent of radio-guided bombs, it was evident that small, high-speed, air-launched missiles might become a threat to ships whose antiaircraft shells had insufficient range to prevent enemy airplanes from launching such missiles.

A solution to this dilemma was to provide ships with defensive weapons of such range, accuracy, and speed that attacking airplanes would be unable to approach near enough to launch antiship missiles. In the fall of 1944, responding to an inquiry by the Bureau of Ordnance (BuOrd) regarding the feasibility and time scale of such a development, APL proposed a program for a supersonic, radar-guided, ramjet-propelled missile, launched by a solid propellant booster rocket and carrying a payload of about 600 pounds of explosives. It was suggested that, in a period of two to three years and with an expenditure of 10 to 20 million dollars, an initial version of such a "chaser missile" could be produced or, conversely, that proof could be provided that such devices could not be built. It was also proposed that such a development should be sharply focused on the specific objective of developing a supersonic guided missile and be carried out by a closely integrated team responsible for the solution of the overall problem. The anticipated time scale foresaw limited military use in the latter stages of World War II.

In December 1944, the Chief of Naval Operations, Admiral E. J. King, directed BuOrd to proceed with the development of such a missile on an urgent basis. The other Navy bureaus were to give all possible support and assistance.

On January 11, 1945, Admiral G. F. Hussey, Jr., the Chief of BuOrd, assigned the following task to the Applied Physics Laboratory:

> Task "F" — A comprehensive research and development program shall be undertaken, embracing all technical activities necessary to the development of one or more types of rocket-launched, jet-propelled, guided, antiaircraft missiles. The desired performance characteristics are to be defined in consultation with the Bureau of Ordnance as the work progresses, in accordance with the objective of obtaining a weapon of useful military characteristics in the shortest feasible time.
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> This program shall include pertinent basic research, investigations and experiments, and the design, fabrication and testing of such missiles, their component parts, and supplementary equipment. Alternative modes of promising technical approach are to be pressed either singly or simultaneously, as deemed most effective for the rapid development of a useful weapon. The work shall include cooperation and joint activity, as may be feasible, with those groups in the Armed Services and other agencies which are actively concerned with the development, testing, production and use of similar or related missiles for the United States Government. The work also may include, on request of the Bureau of Ordnance, supervision and guidance of the technical work under other Navy contracts which may be assigned work related to this Task.
>
> The Bureau of Ordnance does not expect by this request and in the immediate future to obtain an ideal or

> ultimate antiaircraft weapon, and is aware that the actual results of these efforts cannot be guaranteed or accurately predicted. The Bureau believes, nevertheless, that an immediate attack must be made on this problem, and expects that this will result at the best in the production of an advanced antiaircraft weapon which may be available in the latter stages of this war, and at the least in considerable valuable progress in research and development on jet propulsion techniques, self-guided techniques, and other technical matters of great importance to the future of ordnance.

This was the beginning of the "Bumblebee" program, the development of the technology necessary to build a supersonic surface-to-air guided missile. The key problems were the development of a ramjet engine, supersonic maneuvering, a guidance system that directed the missile to the vicinity of the target, and a warhead that would explode at the appropriate instant.

The program consisted of a family of direct Navy contracts with universities and industry under the integrating technical direction of APL. Initially, industry and APL collaborated in the R&D effort. With the passage of time, industry's role changed from co-developer to that of missile contractor. Bendix Aviation Corp., Mishawaka, Ind., assumed this role for the Talos missile. To maintain the continuity between R&D and production, the engineering program at Bendix was under the technical direction of APL.

INITIAL GOALS

Initial goals were to intercept an airplane target at a horizontal range of 10 nautical miles and 30,000 feet altitude and with a shooting accuracy of 2 mils (2 feet per 1000 feet of target range). Large warhead weights (300 to 600 pounds) were required to achieve kill probabilities of 0.3 to 0.6. This, in turn, meant that a large and fast guided missile was needed to deliver such warheads effectively. Subsonic turbojets were too slow to achieve such intercepts with high-speed targets. Rockets had not been developed at that time to reach such distances. The choice of ramjet propulsion was dictated primarily by the required range and the possibility of extending it by minor alterations in missile geometry, as was done later. Powered flight right up to target intercept was the goal.

EARLY BUMBLEBEE MISSILE DEVELOPMENTS

The development of the Bumblebee missile required ground and flight tests with a variety of test vehicles, each designed to investigate or verify the operation of a specific missile subsystem. These were the following: (a) launching test vehicles that evaluated the performance of the large solid-fuel booster rockets; (b) burner test vehicles to study ramjet engine performance; (c) subsonic control test vehicles that tested radar beamriding; (d) supersonic test vehicles (STV) for the study of guidance and control during supersonic flight; and (e) the XPM, a prototype ramjet-propelled guided missile that incorporated all previous developments. The relationships between these developments are shown in Fig. 1.

STV-3 test vehicles, the most complex of the rocket-propelled test vehicles, were launched by a booster rocket and sustained in supersonic speed by a small solid-fuel rocket. As the first successful supersonic beamriding missiles ever to be flown, they were recognized by both the Navy and APL to have potential as a short-range antiaircraft missile if the telemetry section were replaced with a fuze and warhead. APL accepted responsibility for developing a prototype missile from this test vehicle. The missile was named Terrier.

RATIONALE OF THE TALOS DESIGN

Since the small Terrier missile was to cover short-range antiair targets and was expected to be deployed much sooner than the ramjet-propelled version of the Bumblebee missile (to be known as Talos), goals for the large missile were extended. Maximum range was increased to 50 nautical miles or more, and a terminal homing guidance requirement was generated.

As early work on Task F began to develop confidence that a ramjet missile would be successfully developed, an appropriate name for this missile was sought. From Bulfinch's *Age of Fable*, the name Talos was selected. Talos was a demigod who watched over and guarded the island of Crete. He was made of brass and was reputed to fly through the air at such terrific speed that he became red hot. His method of dealing with his enemies was to clasp them tightly to his breast, turning them to cinders at once. Talos was approved as the name for the new ramjet missile by BuOrd and by the Guided Missiles Subcommittee of the Aeronautical Board on January 5, 1948.

Beamriding for midcourse guidance was an obvious choice, based on successful experience in development of the STV-3. Even though the maximum range requirement of Talos precluded the missile from traveling on a direct line-of-sight trajectory from launch to target (because of excessive fuel consumption on such a flight path at low altitude), it was realized that a guidance beam could be programmed in elevation so that a missile riding along its axis could be made to follow a fuel-conserving trajectory. Beamriding also offered the possibility of simultaneously guiding several missiles with a single guidance beam.

Since beamriding guidance could not provide sufficient accuracy for precise intercepts at ranges of 50 to 100 nautical miles, a terminal guidance phase with a semiactive target seeker was envisaged. The interferometer seeker proved to be the most accurate among the surface-to-air missile seekers of the Navy.

Development of the missile along the above lines led to the pilot line production of the First Tactical Talos missile (SAM-N-6b) shown in Fig. 2. This configuration was flown in 1952, and the First Tactical

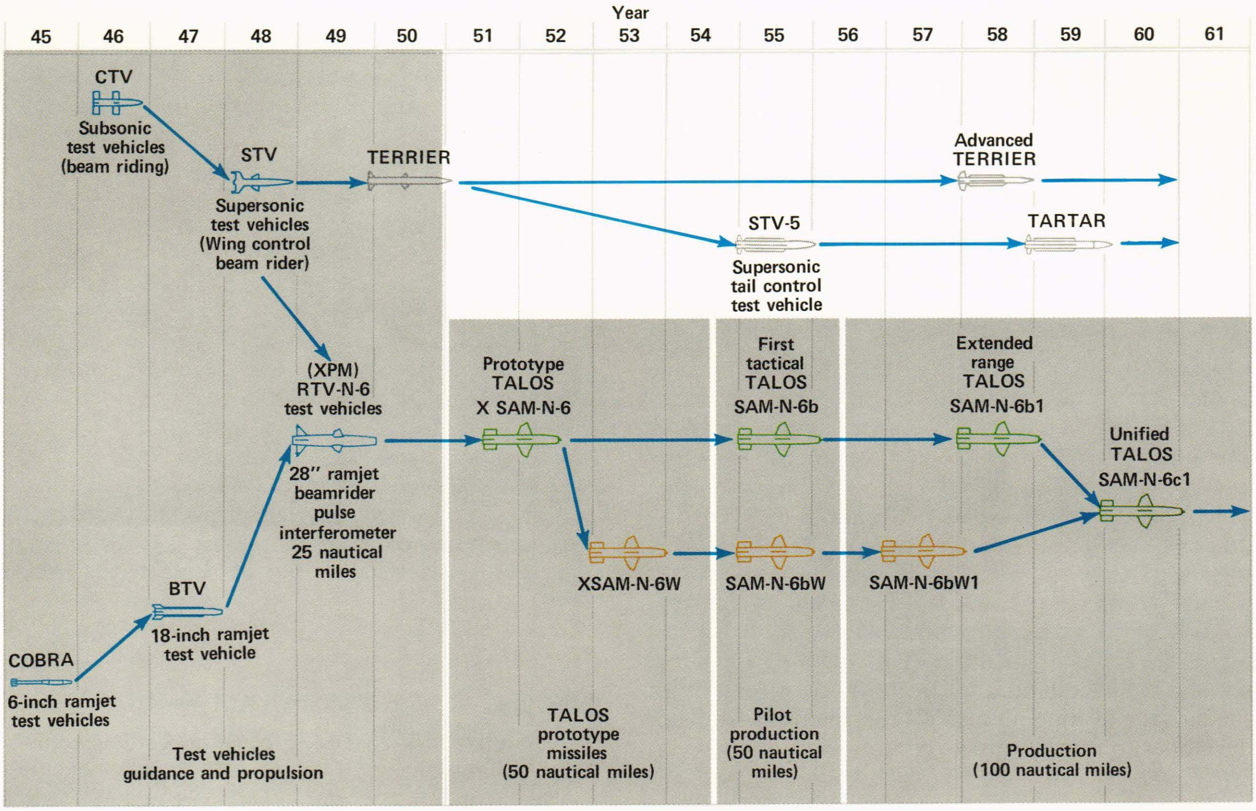

Figure 1 — The evolution of Talos started with the development of Bumblebee test vehicles to investigate operation of missile subsystems and ended with the production of the Unified Talos missile. Bumblebee test vehicles also led to the Terrier and Tartar missile programs.

Talos missile was introduced into the Fleet in May 1958, with the recommissioning of USS *Galveston* (CLG-3). The principal time-determining factor in introducing Talos to the Fleet was ship conversion, a four-year task, following a decision to proceed on a satisfactory missile design.

RATIONALE OF THE TALOS W DESIGN

Analysis of the basic capabilities of the Talos semiactive interferometer homing system included a study of guidance accuracy under conditions where the missile could simultaneously receive microwave energy reflected from two or more aircraft flying in formation. It showed that, for target separations of a few hundred feet, the missile would have a large miss distance. The Talos weapon system was therefore vulnerable to simple tactics that could be used by a well-informed attacker.

A solution to this vulnerability was seen when it became known that a small nuclear bomb was being developed (in 1951) for use by fighter-bomber aircraft. Since this bomb had a smaller diameter than the Talos missile, it was feasible to adapt it as a warhead for Talos.

Talos W, capable of carrying a nuclear warhead, would be guided all the way to the target by the beamrider system used for Talos midcourse guidance. The accuracy of this system at maximum range and the basic need to force large separation distances for attacking aircraft required the kill radius for the warhead to be 1000 to 2000 feet. Estimates of warhead effectiveness showed that gust loading would generally be the kill mechanism at longest range, but that both overpressure and thermal radiation could produce significant effects.

The large value for tolerable miss distance for Talos W translated into a relatively low missile maneuver requirement. As a result of the more forward location of the center of gravity, which increased the missile's dynamic stability, the Talos W maneuver capability was diminished relative to Talos but remained adequate to meet the system requirement.

All aerodynamic surfaces, the combustion chamber, exit nozzle, fuel tank, fuel controls, and the actuators for wing control of Talos W were identical with those of prototype Talos. A modified front end, with an enlarged inner body, was necessary to accommodate the nuclear warhead.

When the Talos W missile development was initiated, it was decided to develop a new beamrider receiver, beacon transponder, and control system electronics. The microwave frequency for the Talos W beamrider and beacon was in the 5 to 6 gigahertz band intended for the tactical Talos weapon system rather than the 9 to 10 gigahertz band then being used in the prototype Talos flight testing. Electronic packaging compatibility between Talos and Talos W was attained in later production missiles.

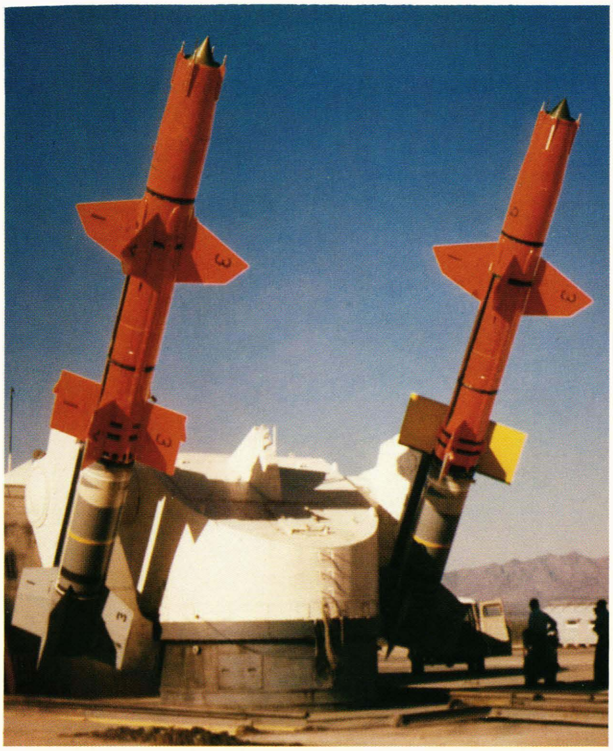

Figure 2 — The First Tactical Talos missiles (SAM-N-6b) are shown on the launcher at White Sands Missile Range. Introduced into the Fleet in May 1958, Talos had a 50-nautical-mile range that employed midcourse beamriding and semiactive pulse homing.

Development along the above lines led to the first successful flight test of a prototype in 1953 (Fig. 3). This was accomplished in 18 months from initiation of hardware design to this first flight. Tactical missile (SAM-N-6bW) production followed the initial 12 prototype missiles. Early in its development, Talos W was seen as a possible new weapon for land defenses and a little later as a possible first anti-ICBM weapon. These possibilities motivated programs to use Talos for the defense of the continental United States.

TALOS CONFIGURATIONS

Capabilities of the missile were enhanced by a succession of configuration variations of Talos (see Fig. 4 and Table 1) beyond First Tactical Talos (identified as SAM-N-6b and SAM-N-6bW). The development program, known as Extended Range Talos (identified as SAM-N-6b1 and SAM-N-6bW1), encompassed a reoptimization of missile flight capabilities for the separate conventional and nuclear versions of Talos. A further development, known as Unified Talos (SAM-N-6c1), took advantage of electronic miniaturization, which made it feasible to package all the electronics of the homing system within the space available for electronics in the nuclear missile. This made it possible to design a single Talos missile configuration for either conventional or nuclear warheads.

Figure 3 — The first Talos W missile was successfully flight tested in December 1953 at White Sands Missile Range.

Extended Range Talos (SAM-N-6b1 and SAM-N-6bW1)

Exploitation of the full-range capability inherent in the ramjet engine was expedited by the interest of the Air Force in the use of Talos for defense of Strategic Air Command bases against rocket-launched missiles. The development of a 100-nautical-mile Talos took place in the 1950's, with the first Fleet firing taking place in 1961.

This development began in 1953 with studies carried out by the missile airframe contractor and APL looking at a possible redesign of the Talos missiles (prototype and W versions) to achieve higher performance. As the analysis proceeded, the improved performance was defined as an increase of the altitude ceiling from 60,000 to 70,000 feet and of the range under optimum conditions from 50 to 100 nautical miles.

The more efficient design of these missiles (greater maneuverability, lower maneuver-induced drag, and greater engine thrust and efficiency) resulted in a higher operating ceiling, the capability to engage faster and more maneuverable targets, and tolerance of greater levels of residual low-frequency angular motion of the guidance beam due to imperfect beam stabilization. Greater missile speed was a factor in obtaining this increase in efficiency and also a decrease in the weapon system tie-up time for any one engagement, with an increase in weapon system firepower.

Modifications to achieve the improved performance were:

1. Increased flight speed at high altitude from 2000 to 2400 feet per second;
2. Increased missile tail fin span and increased speed, providing greater maneuverability, high-

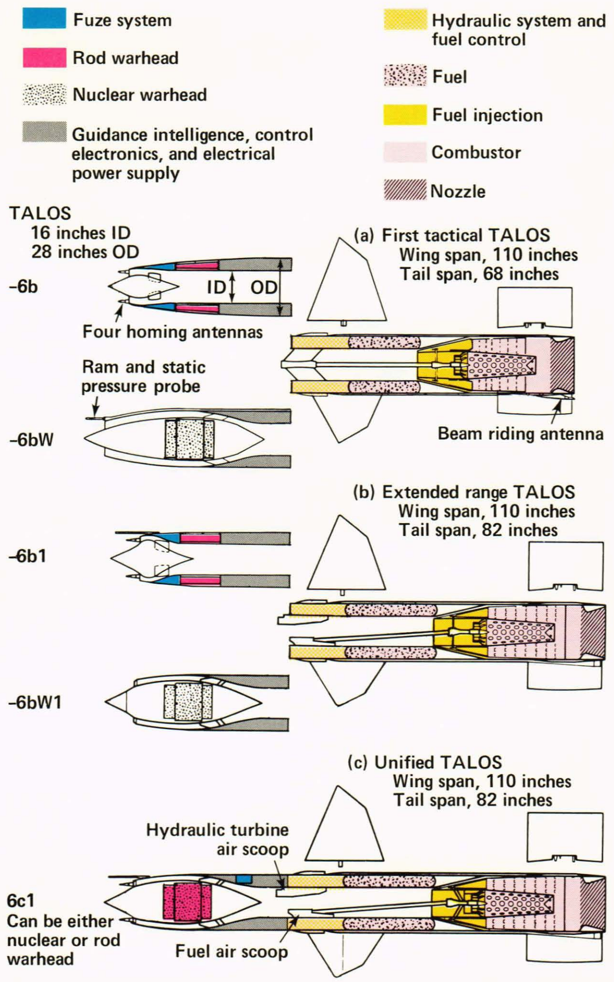

Figure 4 — The Talos configurations can be divided into three classifications: First Tactical Talos, Extended Range Talos, and Unified Talos. (a) The First Tactical Talos employed beamrider midcourse guidance and semiactive pulse homing for terminal guidance. The warhead was annular and surrounded the diffuser. The nuclear version required a special front end. (b) The Extended Range Talos was achieved by enlarging the fuel tank, redesigning the combustor, and improving the aerodynamic efficiency. Air turbine scoops for the fuel and hydraulic systems were placed on the wall of the diffuser. Separate warhead sections were required. (c) The Unified Talos configuration was basically the nuclear version of the Extended Range Talos with a solid-state continuous wave seeker added. The inner body normally contained a rod warhead, but it could also accommodate a nuclear warhead. All subsequent versions of Talos were obtained by exchanging subsystem modules on the basic configuration.

er lift-to-drag ratio, and more linear aerodynamic characteristics;

3. Lengthened fuel tank, providing about 20% more fuel capacity;
4. Six-inch lengthening of the combustion chamber, giving greater combustion efficiency at high altitudes;
5. Double-cone engine inlet, resulting in greater thrust margins at high altitudes;
6. A more powerful booster, providing adequate launch speed for these heavier missiles.

Unified Talos (SAM-N-6c1)

Still unsolved at this stage of development were two problems that forced the next development step. Low-altitude target intercepts were precluded because of excessive sea clutter. Also, the use of two missile types (carrying either nuclear or high-explosive warheads) posed logistic problems and required a determination of the number of each type to be allocated to a ship. In a nonnuclear war situation, vital stowage would be taken up by missiles that would never be launched.

The solution to this dilemma lay in providing interchangeable warheads so that any missile aboard ship could be equipped at will with either a high-explosive or a nuclear warhead. To accomplish this, it was necessary to develop a high-explosive rod warhead to be packaged in the inner-body space occupied by the nuclear warhead and to find space in the SAM-N-6bW1 design for a target seeker and fuze in addition to the beamrider. Fortunately, since a shift from pulse seeker to continuous wave seeker was required to permit low-altitude intercepts, it was possible to meet the space demands simultaneously by developing this new seeker with space-conserving solid-state devices.

Studies carried out in 1956 established the feasibility of adding interferometer homing to the SAM-N-6bW1 missile. This configuration provided the Talos weapon system with missiles that could be used with either a conventional or a nuclear warhead.

The Unified Talos (SAM-N-6c1) was essentially a SAM-N-6bW1 with an alternative, interchangeable, high-explosive warhead and a solid-state continuous wave seeker. The modular construction of this missile provided invaluable versatility. All subsequent versions of the Talos missile were obtained by simply exchanging subsystem modules in this basic SAM-N-6c1 airframe.

Flight testing of the XSAM-N-6c1 configuration began in June 1959. Production of missiles for ship deployment began in the early 1960's.

Talos Antiradiation Missile (RGM-8H)

The need for an antiradiation missile became evident early in the Vietnam conflict, and work was started in 1965 to develop a missile that would passively home on a radar installation. The system and missile requirements were quickly defined and implemented. Successful demonstrations of the system occurred at White Sands Missile Range during 1967, and this was followed by deployment of antiradiation missiles on USS *Long Beach* in 1968.

While specific details of combat applications cannot be released, the radiation-seeking capability was demonstrated by the fact that shore batteries were silenced by missiles fired from ships located in the Gulf of Tonkin. The target discrimination capabilities of Talos also permitted long-range kills of MiG aircraft over land. The long-range intercept capacity limited the enemy air tactics whenever a Talos ship was present. An opportunity to use the surface-to-surface capability did not occur.

Table 1 — Missile designations.

Description	Designations Former	Designations Current *
Talos prototype, 50-nautical-mile range	XSAM-N-6	None
Talos prototype, 50-nautical-mile range	XSAM-N-6a	None
Nuclear warhead Talos prototype	XSAM-N-6aW	None
First Tactical Talos	SAM-N-6b	RIM-8A
First Tactical Talos W (nuclear)	SAM-N-6bW	RIM-8B
Extended Range Talos, 100-nautical-mile range, modular packaging	SAM-N-6b1	RIM-8C
Extended Range Talos W (nuclear)	SAM-N-6bW1	RIM-8D
Modified RIM-8D, first CW seeker	SAM-N-6b1-CW	RIM-8F
Unified Talos, CW seeker, solid-state electronics and an interchangeable high-explosive or nuclear warhead	SAM-N-6c1	RIM-8E
Antiship capability and guidance improvements		RIM-8G
Antiradiation missile, 120-nautical-mile range		RGM-8H
Unified Talos (final version). Improved seeker, electronic counter-countermeasures, chaff rejection, multiple target discrimination, 130-nautical-mile range (dimer fuel), low-altitude fuzing		RIM-8J

*Missile designations as revised by the Department of Defense in 1963.

THE END OF AN ERA

From the commissioning of USS *Galveston* in May 1958 to the decommissioning of USS *Oklahoma City* in September 1980, Talos missiles protected the Fleet for 22 years. Eventually, the time came to consider their retirement, for several reasons. First, although their one-to-one capability to engage planes at long range was clearly demonstrated and has never been matched, it required the exclusive dedication of a midcourse guidance beam for essentially the full flight time of the missile. This degraded defensive capabilities against multiple azimuth attacks. Second, long-range target identification problems had to be solved before the long-range missile capability was really usable in a congested battle environment. Third, Talos missiles required relatively large launchers and occupied considerable storage space. Fourth, maintenance of the aging Talos ships was expensive. Fifth, new weapon systems using smaller missiles and capable of handling many targets simultaneously had been developed and were available for the threats of the 1980's.

Thus, with the decommissioning of USS *Oklahoma City* the Talos missile deployment came to an end. Yet the technology that was developed and the concepts it engendered continue to exercise an influence over much of modern missilery. Many of the operational missiles in the Fleet today reflect the proud parentage of Talos. We hope they will serve as long and as well.