

REGULUS MISSILE HISTORIC CONTEXT ADDITION

BRIEF CHRONOLOGY OF EVENTS

1933

- Germany begins study into use of pilotless aircraft, yielding two prototypes, the V-1 and V-2 missiles.

1944

- In June 1944, the Germans initiate V-1 attacks on England.
- U.S. Army engineers “reverse-engineer” and test-fly a copy of the V-1.
- Production of American version of V-1 (designated JB-2) begins; 2,000 ordered.

1945

- In April, the Navy initiates testing of the JB-2 and designates it the K UW-1 “Loon”.
- American production of JB-2 ends in August.

1946

- In June, the BuAer specifications were sent to 18 companies interested in pursuing missile and rocket technologies and willing to participate in a design competition at Edwards Air Force Base in California.

1947

- In February, the first submarine launch of a Loon takes place.
- In May, the Air Force awarded Martin a contract for its turbojet-powered, subsonic Matador missile. The Navy saw this action as a threat to its guided missile program and asked BuAer to speed up the selection process in its design competition.
- In August, BuAer selected Chance Vought Aircraft and its Regulus missile as the Navy’s first guided missile manufacturing program because of its affordability, recoverability, and ability to be launched from land, surface vessels, and submarines.

1948

- On 17 December, Vought delivered 10 production models to the Navy that were immediately tested at Edwards Air Force Base.

1949

- Due to budgetary constraints, the Department of Defense was forced to consolidate funding into one guided missile program. The Air Force's Matador and Navy's Regulus missiles entered a competition at Edwards Air Force Base in which the Regulus won.

1950

- Flight-testing on the 10 Regulus I fleet test vehicles began 12 February 1950 at Edwards Air Force Base, using recoverable prototypes. This process took two years.

1952

- In December, Chance Vought began design efforts on the successor to the Regulus I.

1953

- Chance Vought begins full-scale production on the Regulus I, beginning with recoverable fleet test vehicles and continuing with the tactical missile variant.
- On 15 July, the first submarine launch of a Regulus occurred aboard the USS Tunny.
- The Navy signs a development contract with Chance Vought on the Regulus II.

1954

- Navy begins fleet operation testing of the Regulus missile at the Marine Corps Auxiliary Air Station in Mojave, California. Fleet operation testing required 146 launches from the ground, surface ships, and submarines.
- Chance Vought began manufacture efforts & initial flight-testing on prototypes of the Regulus II.

1956

- In June, the Navy successfully completed fleet operation testing of the Regulus I, which meant that the missile was qualified for operational use aboard surface ships and submarines.
- On 6 February, a Regulus II test vehicle made its first flight at Edwards Air Force Base.

1958

- The Navy cancelled the Regulus II missile program in favor of the Polaris missile.

1959

- In January, Chance Vought phased out production of the Regulus I following delivery of the 514th production model.

1964

- Regulus I operations ended in July, culminating in 16 years of use by the Navy and more than 1,000 launches.

INTRODUCTION

The concept of the cruise missile was conceived during the First World War. German researchers explored the use of pilotless aircraft to deliver ordnance to a particular target, but the project never resulted in a successful prototype. Adolf Hitler resumed research and development into missiles when he was elected Chancellor of Germany in 1933. Hitler's missile program was far more ambitious than the World War I efforts and can be linked to the Chancellor's fascination for exotic weaponry, especially rockets and nuclear technology. Germany's missile program during World War II resulted in two successful designs: the V-1 and V-2 missiles (www.vectorsite.tripod.com; www.mit.edu/people/zimmerman).

EARLY HISTORY OF MISSILES, 1939-1945

The German V-1 rocket was the first practical cruise missile. It resembled an unmanned airplane rather than a modern-day missile. Powered by a device known as a pulse-jet engine, the V-1 used a cycling flutter valve to regulate the air and fuel mixture following launch into the air from a ground-based catapult system. Once launched, the German military had no control mechanism for the missile. Course control was achieved through combination of a magnetic compass and an air-driven gyroscope. The V-1 reached speeds of between 200 and 400 miles per hour and often attained ranges of 150 miles. A highly simplified barometric altimeter located in the front portion of the missile body controlled its altitude. The missile contained a small propeller that activated the onboard warhead after a specified number of rotations. As the missile approached the target zone, the control vanes were inactivated and a rear-mounted spoiler deployed, which sent the missile down towards its target. This downward action interrupted fuel supply to the flutter valve, causing the pulse-jet engine to stop and the weapon to crash and detonate.



Figure 8-46. The V-1 in England.

The V-1 was not a reliable weapon due to problems with its Argus As-109 propulsion and rudimentary guidance systems. Nevertheless, between June 1944 and March 1945, the Germans launched over 18,000 V-1 missiles against London and Antwerp, with about 2,400 impacting each city (Figure 8-46). British fatalities from V-1 attacks were calculated at 6,139 – three times the number killed by the later V-2 ballistic missiles (Encyclopedia Britannica 1994-2001: 1; www.mit.edu/people/zimmerman; www.spaceline.org/history).

AMERICAN MISSILE DEVELOPMENT, 1944-1947

Three weeks after German V-1 missiles struck England on June 13, 1944, American engineers began the “reverse-engineering” on America’s first unmanned guided missile. A working model of the V-1 was fired at Wright Field, Ohio just seventeen days after Army engineers received damaged components salvaged from English crash sites. Initial tests of the weapon took place at Muroc Army Air Base (now Edwards AFB), California, and contracts were let for the production of 2,000 weapons, to be designated JB-2 (Jet Bomb-2). While superficially resembling the V-1, the JB-2 incorporated improved guidance systems using airborne and shipborne radars, radio control, and human operators, all of which gave these missiles much greater accuracy than the German weapon. Although it was never used operationally in World War II, by the war’s end some 1,400 had been delivered. The Navy adopted the JB-2, designating it the KUV-1 “Loon” (www.customizedsvcsmgmt.com/MACE/History.htm; www.cdiss.org/cmhist.htm).

Initially, the Navy intended to deploy the Loon on aircraft carriers but in early 1946 began exploring the feasibility of submarine deployment as well. The first submarine launch took place from the USS Cusk (SS-348) in February 1947. The Carbonero (SS-337) joined the tests several months later and acted as the control and tracking station. The Navy was so impressed with the possibilities of this new weapon that it ordered testing continue through 1949. The continued testing was intended to develop and refine terminal guidance procedures and tactical concepts for the Regulus, a missile then under development by Chance Vought Aircraft (www.nasm.si.edu/nasm/dsh/artifacts/RM-Loon.htm).

The early success of the JB-2 and Loon testing resulted in increased funding for research and development of an American-designed weapon system. The department of the Navy was determined to be the first military branch to create an unmanned strategic bombardment weapon capable of carrying a nuclear warhead. In the postwar defense appropriations battles, Air Force proponents argued that long-range bombers and nuclear weapons made the traditional role of the Navy obsolete. Because Air Force bombers could now operate from European airfields well within range of Soviet targets, they argued, carrier aviation seemed superfluous. To reaffirm its role as a superior defense force, the Navy needed a nuclear weapon delivery system to break the Air Force's monopoly on this new weapon. Navy developers saw this opportunity in a seaborne missile program. Of course the Air Force was simultaneously engaged in missile development, which resulted in an unofficial, interdepartmental race for missile supremacy.

The Regulus was one of several programs under concurrent development by the United States military in the late 1940s to provide medium- and long-range nuclear-armed cruise missiles. By the late 1950s, several of these systems were in operational service, including the Air Force's medium-range Matador and Mace, long-range Snark, and the Navy's sea-launched Regulus. Other systems, such as North American's Navaho, never reached production due to technical problems (www.cdiss.org/cmhist2.htm; www.fas.org/nuke/guide/usa/icbm/sm-64.htm).

By the end of 1945, advancements in electronic technology greatly improved research into rockets and missiles that served to separate German designs from postwar models. The Navy tasked the Bureau of Aeronautics (BuAer) to expand its missile program from primarily analysis and research and into development of a combat-ready prototype. This next generation of Naval missiles utilized new electronics with proven research. BuAer formed a study committee, headed by Commander Grayson Merrill, to review the status of American, English, and German guided missiles. The committee submitted a 69 page report on 15 December 1945 entitled "Study of Requirements for Pilotless Aircraft for Fleet Use in 1950". The report resulted in a set of design criteria most likely to produce a successful guided missile. The Department of the Navy considered guided missiles the future of the armed forces and felt that a design competition was the best method to get American aircraft companies involved in the early development of this type of weapon system. BuAer distributed the design criteria to 18 of the nation's leading aircraft companies, of

which only 12 chose to participate. Subsequently, BuAer dispersed approximately \$5 million for each of its 12 design contracts (Stumpf 1996: 20).



Figure 8-48. The Matador.

In May 1947, the Army Air Force awarded the Glenn L. Martin Company a contract for its turbojet-powered, subsonic missile, which later became known as the Matador (Figure 8-48). The Navy was much further behind schedule in choosing a company to manufacture a prototype and saw the selection of Martin as a threat to its role in guided missile technology. Consequently, the Navy ordered BuAer to immediately select one of the 12 companies involved in the design competition. By August, BuAer completed a review on the status of all contrac-

tors involved in the guided missile development competition and assessed which company had the most plausible design. BuAer selected a design by Chance Vought Aircraft.

CHANCE VOUGHT AIRCRAFT WINS THE GUIDED MISSILE COMPETITION

As one of America's first aircraft designers and manufacturers, Chance Vought Aircraft set many of aviation's earliest records, including the first airplane to take-off and land on a carrier in 1922. The company manufactured for the Allies throughout World War II, producing such famed aircraft as the F4U Corsair, OS2U Kingfisher, and the SB2U Vindicator. Chance Vought Aircraft began its research into missiles in October 1943 after first hearing of Germany's pilotless aircraft program. The company was one of the 12 aircraft manufacturers that responded to the guided missile competition initiated by BuAer in 1945. The Navy offered the company the design specifications and Vought was tasked to develop a design plan that conformed to these standards:

- The missile had to carry a 3,000-pound nuclear warhead to a maximum range of 500 nautical miles at Mach .85 with a CEP of .5 percent of the range;
- The vehicle had to be at least 30 feet in length, 10 feet in span, 4 feet in diameter; and,
- The vehicle had to weigh between 10,000 and 12,000 pounds.

Because Chance Vought Aircraft had a design in development for nearly two years that was based roughly on these guidelines, the company had an advantage over other firms competing for BuAer

contracts. Furthermore, Vought's longstanding manufacturing history with the United States military afforded the company an additional edge. Vought knew how the military operated, its performance requirements, and that the armed forces often favored cost-effective manufacturing programs (www.voughtaircraft.com; www.fas.org).

In 1945, Vought submitted to BuAer a guided missile design, called the P/A VI (Figure 8-49). Vought's design was conventional, meaning it looked like a small jet aircraft. The model closely resembled aircraft designs that the Navy liked and had purchased. The missile's similarity to an aircraft meant that it could be manufactured with existing aircraft components and tooling equipment, machinery, and practices. Vought's missile was sleek, tubular, and utilized the same engine as the Air Force's Matador – the Allison J-33 engine. This power plant had a proven flight record and was already used in early jet aircraft designs by several different manufacturers, including the Glenn L. Martin Company. The aforementioned advantages made Chance Vought's design the most likely to enter manufacturing quickly, but more importantly, it was the most affordable. The defining characteristic in the missile's affordability was that the test version was recoverable and reusable. The P/A VI test models had landing gear and a parabrake that enabled most vehicles to be recovered and reused during test flight operations. This recoverability feature greatly reduced the cost of flight tests and development. Consequently, BuAer awarded Chance Vought Aircraft a manufacturing contract in early 1946 for one guided missile prototype (www.voughtaircraft.com; www.fas.org).

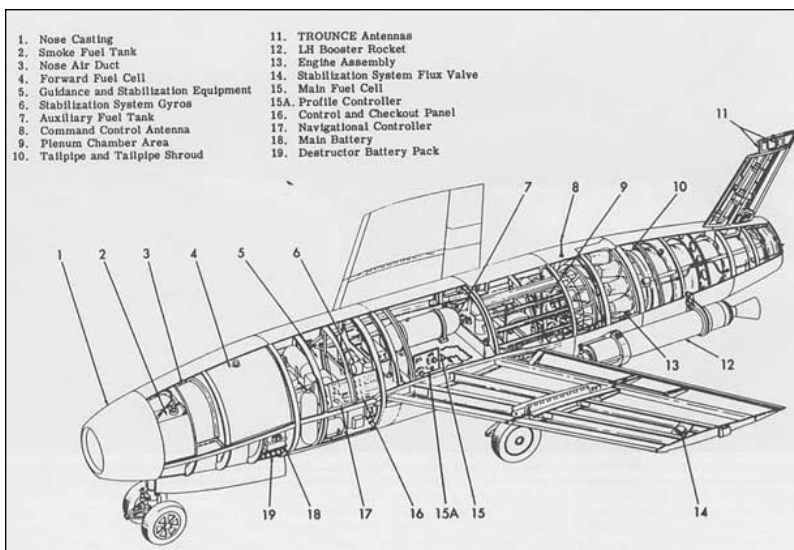


Figure 8-49. The P/A VI.

INTEGRATED CULTURAL RESOURCES MANAGEMENT PLAN

Short History of Significant Missile Development

<i>Name</i>	<i>Year</i>	<i>Specifications</i>	<i>Significant Design Features</i>	<i>Historical Information</i>
German V-1 Missile	1938 - 1945	Powered by German pulse jet engine	Resembled an unmanned airplane rather than missile	Predecessor of Regulus I and today's cruise missile
German V-2 Missile	1938 - 1945	Powered by German pulse jet engine	Resembled an unmanned airplane rather than missile	Direct ancestor of the inter-continental ballistic missile
Martin/Matador Martin Mace	1946 - 1970	Powered by an Allison J-33 with 5,200 pounds thrust Range of 690 nautical miles Traveled 650 miles per hour	Mid-sized pilotless aircraft Launched by a solid fuel booster rockets Radio guided Armed with a high-explosive or W-28 nuclear warhead	1,000 Matadors manufactured Air Force deployed the weapon to West Germany, Florida and Taiwan Matador entered into DoD competition and lost to Vought's Regulus I
Chance Vought Regulus I	1947 - 1964	Powered by an Allison J-33 with 4,600 pounds thrust Range of 500 nautical miles Traveled at subsonic speeds	Cigar-shaped Launched by 2 solid fuel booster rockets Radio control Armed with a W-5 or W-27 nuclear warhead Recoverable test vehicles	514 Regulus I manufactured for use service - wide Five submarines designed around the Regulus I Carried aboard 10 aircraft carriers and 4 cruisers
North American Navaho/Triton	1950 - 1957	Powered by a Wright RJ-47 ramjet engine with 40,000 pounds thrust Reached altitudes of 90,000 ft. Traveled at Mach 2.05	Launched vertically by large liquid-fueled rocket booster, which set a World's Speed Record	10 prototypes made and paralleled the Navy's Polaris Program cost \$880 million Work on the Navaho/Triton considered significant to modern ICBM development

Table 8-12. Concise history of guided missile development.

INTEGRATED CULTURAL RESOURCES MANAGEMENT PLAN

Short History of Significant Missile Development				
<i>Name</i>	<i>Year</i>	<i>Specifications</i>	<i>Significant Design Features</i>	<i>Historical Information</i>
Chance Vought Regulus II Missile	1953 - 1958	Launched by solid-fuel rocket booster Range of 1,150 nautical miles Traveled at Mach 2	Canard-configured Air-breathing cruise system Armed with a 2,920-pound W-27 nuclear warhead	Only 20 Regulus II made, but did see operational use Not as prolific as the Regulus I, but an interim weapon until completion of the Polaris
North American Hound Dog Missile	1957 - mid 1970s	Powered by a Pratt & Whitney J52-P-3 jet engine with 7,500 pounds thrust Range of 805 miles at altitude Traveled at Mach 2.1	Launched from a B-52, equipped with INS star tracker guidance systems Armed with a W-28 nuclear warhead	Arguably one of the most successful missile program, replacing almost all other programs service - wide Used to disrupt Soviet defenses and clear path for the B-52
Boeing AGM-69/ SRAM Missile	late 1960s - 1990	Launched by a dual-thrust solid-fuel rocket motor Range of 100 miles Traveled at Mach 3	Simple sleek, spike design Launched from a B-52 & B-1, equipped with INS star tracker guidance systems Armed with a W-80 nuclear warhead	Influenced by the Hound Dog Offered in four different semi-ballistic flight modes Prolific weapon and used service - wide
Lockheed - Martin Polaris Fleet Ballistic Missile	1955 - 1990	Launched by solid-fuel rocket, both underwater & surface Range of 1,200-2,500 nautical miles Manufactured in solid steel motor casing	Air-breathing cruise system Armed with a 600 kt W47-Y1 Mod 1 fission-fusion-fission warhead, which is nearly 43 times the power of the Hiroshima explosion Operated inertia guidance	Navy's successor to Regulus I & II missile programs Manufactured in 3 versions First missile ever successfully launched from underwater Prominently used in the last 3 decades of Cold War

Table 8-12 (continued). Concise history of guided missile development.



Figure 8-50. Hensley Field at NAS Dallas.

On 3 October 1947, Vought submitted its preliminary proposal to BuAer for the cost of fabricating one test vehicle. In Vought's proposal, the company stated its primary goal was the quick production of "...a flight test vehicle that differed as little as possible from the tactical vehicle". Vought estimated it would cost \$4,997,309 for one prototype, referred to in the proposal as the Regulus Missile.

Vought's Regulus missile was to be powered by the Allison J-33 jet engine. Vought relied on existing and successful designs in order to reduce delays and engineering time on engine development and trouble-shooting. BuAer accepted Vought's design and cost estimate. On 17 November 1947, BuAer and Chance Vought Aircraft signed a Contract of Intent, number No(a) 9450 for the manufacture of one Regulus prototype (Stumpf 1996: 21).

Chance Vought began initial work on the Regulus prototype at its Stratford, Connecticut manufacturing plant. At the time, the company was moving its corporate headquarters and entire manufacturing operations to a Navy-owned manufacturing complex in Dallas, Texas. Following World War II, the Navy gained stewardship of 11 industrial plants dedicated to aircraft, missile, and engine development and manufacturing. Due to several factors – the most important of which was national security – the Department of the Navy was intent on distributing essential military manufacturers from congested, vulnerable coastal areas to inland states. Chance Vought was one of the Navy's prime manufacturers and the Dallas plant was new, modern, and significantly larger than the Stratford plant.

Members of the Dallas City Chamber of Commerce traveled to the Stratford plant and met with Vought officials. The visitors encouraged the company to move to Dallas by describing the area's excellent year-round flying weather, affordable housing, well-trained labor pool, and diminutive tax burden. The Navy also persuaded Vought to

move to Dallas by offering them use of Hensley Field at NAS Dallas, located immediately east of the main manufacturing plants and hangars (Figure 8-50). Finally, the Navy offered a lease on the Dallas Plant of \$1 per year so long as Vought manufactured products for the armed forces. Vought agreed to the lease and carried out the move to Dallas in incremental phases that took 14 months to complete. Throughout the transition, Vought continued to manufacture the F4U Corsair and the F6U Pirate jet aircraft as well as development of the Regulus missile prototype (www.voughtaircraft.com).

CHANCE VOUGHT MOVES TO DALLAS, TEXAS

Prior to the move, the Department of the Navy invested \$12.4 million to renovate Facility 6, the main manufacturing plant at NIRAP Dallas. The Navy funds also expanded existing buildings and structures as well as provided monies for new construction. Vought invested nearly \$9 million in this expansion. Overall, the renovation and expansion at NIRAP Dallas provided the company enough space to meet productive commitments, reduce company backlog, and increase research and development capabilities (www.voughtaircraft.com).

Facility 6 received four newly constructed internal processing areas as part of the expansion effort. One the processing areas was dedicated to the manufacture of jet aircraft and another dedicated entirely to the Regulus missile (Figure 8-51). According to former employees at the plant, the Regulus manufacturing space was a high security area where employees wore special badges for clearance into manufacturing and production. Along the west end of Facility 6, the Navy built and installed equipment for a Metallite Processing Department. Vought created and patented Metallite during World War II and used the product on the wings of jet aircraft and the Regulus missile. The Metallite Processing

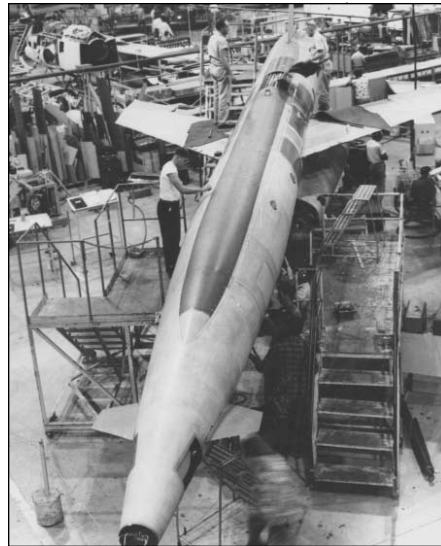


Figure 8-51. Regulus manufacture.

Department was centrally located between the jet and missile manufacturing spaces. Vought relied heavily on aluminum, steel, metal, and other lightweight alloys for most aircraft and missile skins and frames. The final processing area was devoted to heat treatment of both steel and aluminum, and for the anodizing, dichromate, and

other metal- working requirements (Barksdale 1958: 19; Analysis of Leasehold Improvement nd: 1; Chance Vought News 30 September 1948: 4).

Facility 49, a 129,000-square-foot building, was the largest project undertaken during the Vought expansion at NIRAP Dallas (Figure 8-52). This building cost \$1.6 million to construct and accommodated a new Engineering Department and Laboratory. Chance Vought Aircraft utilized Facility 49 in the design of all its products, from aircraft to missiles and rockets (Chance Vought News 30 September 1948: 4).



Figure 8-52. Facility 49.

VOUGHT RESUMES REGULUS WORK AT NIRAP DALLAS

In April 1948, Chance Vought Aircraft completed its move to Naval Industrial Reserve Aircraft Plant (NIRAP) Dallas. Vought immediately resumed the engineering phase of the Regulus missile prototype. Vought submitted a proposal to BuAer detailing the specifics of the manufacturing and testing phases. The plan submitted to BuAer covered all items that the company would deliver to the Navy under

its 1947 contract valued at approximately \$4.9 million:

- Fabrication of one Regulus Flight Test Article, complete in all details and ready for flight testing upon delivery to the Navy;
- Instrumentation of the Flight Test Article;
- Fabrication of the launcher;
- Fabrication of a mock-up;
- Fabrication of the Beacon Guidance System; and,
- Fabrication of ten test missiles and airborne Beacon Guidance units.

On 1 June 1948, Vought informed the Navy that it could produce 30 Regulus test missiles for the amount originally allocated. The fabrication and testing phase of the project was to occur in the company's new and modern plant. NIRAP Dallas' production capabilities enabled the company to consolidate Regulus manufacturing and testing in one single location, which further reduced manufacturing costs

and permitted the company to fabricate 29 additional models (Figure 8-54). By 17 December 1948, Vought delivered the first 10 Regulus production models (Stumpf 1996: 21).

VOUGHT FACES AN EARLY CHALLENGE IN THE REGULUS PROGRAM

In November 1949, qualification tests began in Dallas, which consisted of vehicle fabrication quality. The next phase of testing was airborne and ground radio command control, which occurred at Naval Air Station Chincoteague, Virginia. Radio testing was completed in a month and the Regulus Project Team returned to Dallas to prepare for field operations. Upon the team's return, Vought learned that budgetary constraints forced the Pentagon to re-focus its funding into guided missiles. At the time, the Pentagon was simultaneously funding the Navy's Regulus and the Air Force's Matador missile projects. The Matador and the Regulus were similar – both powered by the Allison J-33 and both in fabrication stages. The Pentagon decided that the two programs would be combined into a single program that would save the Department of the Defense a significant amount of money. The Pentagon recommended an interservice competition between the two missiles, with the winner placed under the cognizance of the Navy. The winning missile was to then be used by both branches of the Armed Forces (Stumpf 1996: 21-22).

The Pentagon convened a joint Research & Development Board to study and compare the Matador and the Regulus programs. Most observers at the time considered the Matador to be about a year ahead of the Regulus in fabrication, but the Navy argued that it could not be adapted for fleet use. Regulus advocates pointed to its simpler guidance system, which required only two submarines and one aircraft to control the missile, as compared with the Matador, which required three submarines. Also, the Matador's single booster had to be fitted to the missile after it was on the launcher while, in contrast, the Regulus was stowed with its two boosters attached. In addition, Chance Vought built a recoverable version of the missile, which saved approximately \$400,000 per test launch. Recoverability meant that Vought's missile was cheaper to use. This also meant that in comparison to the Regulus, the Matador would require more money, men, and machinery (www.fas.org).



Figure 8-54. Production of the Regulus II.

The Research & Development Board selected the Regulus program and consolidated funding in guided missile development with the Navy for the next few years. The selection of the Regulus settled the interservice competition between the Navy and Air Force that began during World War II. The Navy developed a way to deliver a more powerful warhead via a lightweight missile launched from a submarine, seagoing vessel, or land. The Regulus victory seemed to confirm the Navy's return to importance within the armed forces. "It now found itself with a modern weapons system with which to play in the big game" (www.users.erols.com; www.fas.org).



Figure 8-55. Edwards Air Force Base.

The Navy's victory was short-lived and the Regulus Project Team was back to work. BuAer quickly turned its attention to completing the flight-testing phase, which began in February 1950. Flight-testing was a joint effort between Chance Vought and the Navy and occurred incrementally over a two-year period. The Navy planned to test and fine-tune the missile at Edwards Air Force Base, California, using the recoverable prototypes (Stumpf 1996: 21). Testing the missile at NIRAP Dallas would cause

unnecessary and unwarranted attention. The dry lakebeds at Edwards afforded Vought the necessary room for evaluating the missile as well as extreme privacy (Figure 8-55). Once the missile's initial flight characteristics and recoverability were proven at Edwards, the Navy then tested the missile at Pt. Mugu, California and nearby San Nicolas Island (Stumpf 1996: 30).

REGULUS HISTORY DURING THE COLD WAR PERIOD, 1950-1989

The Regulus/Matador guided missile consolidation placed additional pressures on Chance Vought Aircraft's manufacturing facilities. The company now had to produce nearly double the amount of guided missiles, enough for both the Navy and the Air Force as well as in three variants:

- The Fleet Test Vehicle, later renamed the flight training or fleet training missile;

- The Tactical Missile, which came equipped with removable landing gear, additional fuel capacity, and a either a W-5 or W-27 nuclear warhead; and,
- The Target Drone, which was nearly identical to the Fleet Test Vehicle, but differed in the telemetry for target mass indication and had greater fuel capacity.

Each Regulus version had identical dimensions and launching requirements, using two Jet Assisted Take-off solid fuel booster rockets (Table 8-13). In all, the Pentagon wanted over 500 production models (Stumpf 1996: 24).

NIRAP DALLAS EXPANDS TO MEET NEW PRODUCTION DEMANDS

From 1950-1955, Chance Vought received expanded Regulus production orders on top of increased orders for its jet aircraft. The Korean conflict placed demands on Vought that its existing facilities simply could not accommodate. Vought needed new workers to meet its contractual requirements on the Cutlass and Corsair jet aircraft and the Regulus missile. In addition to hiring new employees during the Korean War, Vought needed additional manufacturing space at NIRAP Dallas. In late 1951, Chance Vought announced a \$4 million expansion program that it called the Spring Building Program in company newsletters and local newspapers. The expansion included construction of new buildings, upgrading existing NIRAP Dallas facilities, and adding new parking lots to accommodate elevated employment levels (Executive Order 11724 Installation Survey Report 1974: 5).

Regulus I Design Features		
<i>Specifications</i>	<i>English</i>	<i>Metric</i>
Wingspan	21 feet	6.4 meters
Length	34 feet 4 inches	10.5 meters
Speed	subsonic	subsonic
Range	500 miles	800 kilometers
Total Weight	14, 520 pounds	6,000 kilograms
<i>Source:</i> www.vectorsite.tripod.com		

Table 8-13. Design specifications of the Regulus I.



Figure 8-55. Facility 95.

Chance Vought submitted its construction request to the Navy. After examining the specifications of the proposed expansion, the Navy agreed to supply Vought land for new construction as well as contribute some funds for plant and building renovations. Since construction occurred on Navy-owned lands, work was approved and supervised by the Bureau of Yards & Docks, 8th Naval District, located in New Orleans, Louisiana. In some of the cases, the Bureau of Yards & Docks

supplied the architectural drawings, but independent contractors carried out at least half of the design work. Vought constructed several facilities for use in fabrication of both jet aircraft and missiles. Facility 94, a research, design, and structures test lab for the Regulus missile, was one of the first new buildings constructed as part of Vought's Spring Building Program. The company utilized the space to verify the structural stability of production missiles as well as aid Vought in developing new technologies. Along with Facility 94, Vought constructed five additional buildings – Facilities 95, 97, 102, 103, and 106. The first two supported the Regulus exclusively while the other served jet aircraft operations.

Construction on Facility 95, the Regulus test cell building, began in 1953 and was in early 1954 (Figure 8-55). Test cells consist of both the power and control mechanisms for guided missiles and can be either self-contained rocket motors or air-breathing jet engines. The equipment and machinery installed at Facility 95 was capable of testing both types of engines as well as the outside booster charges from tube launchers. On 18 June 1953, Vought broke ground on Facility 97, a \$1.7 million guided missile hangar to store and test the Regulus



Figure 8-56. Facility 97.

(Figure 8-56). The nearly 70,000-square-foot hangar contained a high bay area, electronics test area, and storage space, as well as offices and workrooms. Vought used Facility 97 primarily to check and ground test the Regulus prior to its delivery to the west coast for flight operations (Chance Vought News June 1953: 1-2). Regulus missiles leaving Facility 6 were transported to Facility 97 for installation of electrical systems, internal components, as well as final testing operations. Following final component testing, the Regulus missile was moved to nearby Facility 95 for engine simulation, testing, and clearance. Vought used Facility 95's test cells to simulate engine start-up, take-off, climb, cruise, and let-down (Chance Vought News June 1953: 1).



Figure 8-57. Regulus missile.

Once all systems were tested and cleared, the Regulus missiles were moved to Facility 93, the Shipping and Manufacturing Building, for delivery to the navy. Vought utilized Facility 93's manufacturing space to fabricate special shipping containers for the Regulus because it needed to be shipped intact with no assembly required. The large, cylindrical metal containers held one missile and came equipped with tethers that stabilized the missile during shipping. The tethers prevented shifting and damage to delicate electrical components. Facility 93 employees folded the missile's wings, loaded one Regulus missile into a shipping container, and then attached the tethers (Figure 8-57). Vought transported the containers via flatbed, commercial trucking lines from Dallas to military testing ranges in Southern California (Figure 8-58).

During construction of the Regulus-dedicated buildings – Facilities 94, 95, and 97 – the Navy and Vought completed testing of the initial prototypes in California. Flight-testing resulted in the first successful



Figure 8-58. Shipping the Regulus missile.

launch of a missile from a submarine. On 15 July 1953, the Navy launched a Regulus missile from the deck of the USS Tunny in the Pacific and landed at San Nicolas Island airfield near coastal California. During this same year, the Regulus was repeatedly launched from surface ships. The Navy believed that the Regulus enhanced the usefulness of its Cruisers by extending the vessels' offensive range and mission capabilities. Following completion of both flight-testing and construction at NIRAP Dallas, the Department of the Navy gave Vought permission to begin full-scale manufacturing on the Regulus (www.fas.org; Stumpf 1996: 48).

FLEET TESTING AND USE OF THE REGULUS MISSILE

In January 1954 – and following 46 successful launches of the Regulus – the Chief of Naval Operations decided that the Regulus must undergo the most rigorous form of testing to determine if the missile was ready to enter fleet operations. Chance Vought's newly expanded facilities at NIRAP Dallas enabled the company to deliver additional production models of the Regulus for use in fleet testing. They Navy planned to launch the extra missiles during combat training exercises that tested the operational usefulness of the Regulus. Fleet operational testing began in August 1954 and was completed in June 1956. The training schedule required 146 missile launches from the ground as well as aboard surface ships and submarines.

Just prior to fleet testing, Chance Vought hosted several weeks of training at NIRAP Dallas where ten Naval engineers learned about the Regulus missile's major subsystems and detailed knowledge of Regulus production and assembly. Vought believed the training helped naval engineers to deal with unanticipated problems during operational testing and better explain and describe problems with company engineers. Upon graduation from the conference, the Navy deployed the engineers to each Regulus support unit with the task of monitoring fleet operational testing. The success of the NIRAP Dallas conference led to repeat training sessions in which Chance Vought updated Naval personnel on changes and modifications in the engineering and manufacturing processes of the Regulus (Stumpf 1996: 48-49).

The Navy conducted the great bulk of fleet operations testing at the Marine Corps Auxiliary Air Station (MCAAS) in Mojave, California. Edwards Air Force Base was the Navy's first choice for testing, but the installation's already overburdened training schedules made MCAAS Mojave a good alternative. Near Edwards Air Force Base, MCAAS Mojave was isolated far in the southern California desert

and afforded the level of privacy necessitated for the secret missile program. In addition, MCAAS was close to Naval Ordnance Test Station China Lake and the Inyokern nuclear warhead test area, where additional Regulus testing occurred. Fleet training also took place from the aircraft carrier USS John Hancock, deployed in the Western Pacific, as well as aboard the USS Lexington, USS Bon Homme Richard, and the Norfolk-based USS Randolph (Figure 8-59; Stumpf 1996: 49, 54).



Figure 8-59. Regulus fleet training.

The results of the fleet operational testing were incredibly favorable to Chance Vought, earning the prestigious “highly reliable” rating by the Navy. Of 146 launches of the Regulus tactical missiles, 82% were considered successful. Tactical missiles – the ones the Navy used in deployment from land, vessel, and submarine – were awarded a 91% reliability rating (Stumpf 1996: 53-54, 74; www.fas.org; www.collinsmuseum.com; www.vectorsite.tripod.com).

The success of the initial Regulus program led to a successor missile called the Regulus II (Figure 8-61). Development on this program began at NIRAP Dallas in 1954, but was cancelled a few years later. The Navy determined that this second program was not a significant improvement on its predecessor, primarily because it could not be launched from a submerged submarine. The Polaris ballistic nuclear missile, which was in development, could launch a nuclear warhead from underwater. The Navy considered the Polaris, not the Regulus II, as the long-term future of Naval missiles. Termination of Vought’s Regulus II program saved the Navy \$100 million and these funds were immediately diverted to the Polaris program (Stumpf 1996: 53-54, 74; www.fas.org; www.collinsmuseum.com; www.vectorsite.tripod.com).

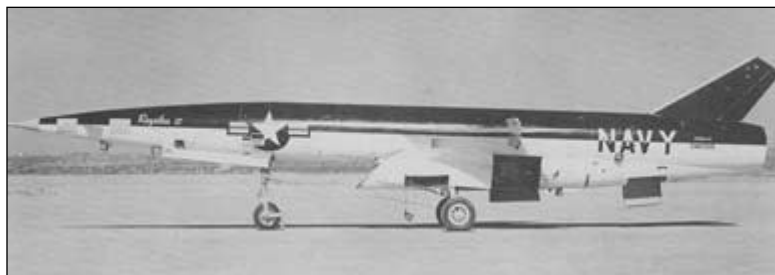


Figure 8-61. The Regulus II missile.

It took nearly a decade for the Polaris to be operationally ready, so the Navy continued to support, purchase, and utilize the Regulus I as an interim program. From 1954 to January 1959, Chance Vought manufactured 514 Regulus I tactical missiles. All of these missiles were manufactured at NIRAP Dallas, (now known as NWIRP Dallas). Even though production ended in 1959, the missile remained in service until August 1964. Admiral Zumwalt called the cancellation of the Regulus I as the “single worst decision about weapons [the Navy] made during my years of service.” (www.fas.org). For 16 years, the Regulus served aboard specially designed submarines, a variety of surface ships, and from the ground (Stumpf 1996: 58; www.vectorsite.tripod.com).

NAVAL VESSELS AND DEPLOYMENTS ASSOCIATED WITH THE REGULUS MISSILE

For nearly a decade, the Navy extensively used the Regulus I aboard sea-going vessels and submarines (Table 8-14). The Regulus were launched from sea-going vessels by means of a mobile catapult system, which required a minimum amount of mechanical work and installation. The first operational deployment of a Regulus I aboard a sea-going vessel occurred in 1955 and onboard the cruiser USS Los Angeles (CA-135) and later aboard three additional Baltimore Class cruisers – the USS Helena (CA-75), USS Macon (CA-132), and the USS Toledo (CA-133). Each of the four heavy cruisers carried three Regulus I missiles and one catapult launching system. The Regulus I was used in support of Western Pacific patrol routes from 1955-1961 in which American vessels monitored Soviet Naval movements (www.collinsmuseum.com).

In late 1955, the Navy configured a total of ten aircraft carriers to support the Regulus I missile. Of the ten carriers fitted for Regulus I operations, only six actually carried out deployments with the weapon. In general, aircraft carriers supported 4-6 Regulus I missiles and multiple catapult launching systems; therefore, the configuration of aircraft carriers was a more complicated process than with cruisers. Configuration required installation of new power and instrumentation lines from the below-deck storage area to the carrier deck, where the missiles were launched. The first operational warship to launch a Regulus I missile was the USS Princeton (CV-37). The USS Randolph (CV-15) was the first aircraft carrier to be deployed abroad with Regulus I missiles. The USS Randolph, along with the USS Shangri-La (CV-38), the USS Lexington (CV-16), and the USS Ticonderoga (CV-14), were all deployed to the Mediterranean for NATO training exercises (Figure 8-62).

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Naval Vessels Associated with the Regulus Missile				
	<i>Name of Ship</i>	<i>Designation</i>	<i>Service Dates</i>	<i>Historical Notes</i>
Heavy Cruisers	USS Los Angeles	CA-135	1955 - 1961	<ul style="list-style-type: none"> · Carried 3 Regulus Missiles · Used for Operational Patrols in the Pacific · Carried 3 Regulus Missiles · Used for Operational Patrols in the Pacific · Carried 3 Regulus Missiles · Used for Operational Patrols in the Pacific · Carried 3 Regulus Missiles · Used for Operational Patrols in the Pacific
	USS Helena	CA-75	1956 - 1960	
	USS Macon	CA-132	1956 - 1958	
	USS Toledo	CA-133	1956 - 1959	
Aircraft Carriers	USS John Hancock	CV-19	1955	<ul style="list-style-type: none"> · Involved extensively with operational training & development of the Regulus RAM Missile · Site of the first launch from a warship · First aircraft carrier to be deployed with Regulus · Deployed to Mediterranean for NATO training · Conducted only one test launch · Deployed to Mediterranean for NATO training · Deployed to Mediterranean for NATO training · Deployed to Mediterranean for NATO training · Participated in two demonstration launches
	USS Princeton	CV-37	unknown	
	USS Randolph	CV-15	unknown	
	USS Franklin D. Roosevelt	CVA-42	unknown	
	USS Lexington	CV-16	unknown	
	USS Shangri-La	CV-38	unknown	
	USS Ticonderoga	CV-14	unknown	
	USS Saratoga	CVA-60	unknown	

Table 8-14. Naval vessels associated with the Regulus I missile.

The USS John Hancock (CV-19) was the most heavily involved aircraft carrier in both the testing and deployment of the Regulus I missile. It was deployed with each version of the Regulus I, the most noteworthy of which was the Regulus Assault Mission concept, or RAM missile, the first of its kind. Part of the 7th Fleet Operations division, the USS Hancock carried Regulus I missiles on deployments in Hawaii, Japan, the Philippines, Taiwan, Laos, and on Soviet patrols in the South China Seas. The USS Hancock also tested the Regulus II missile near San Diego, prior to its cancellation in favor of the Polaris missile (www.collinsmuseum.com; www.navyhistory.com).



Figure 8-62. NATO training exercises in the Mediterranean.

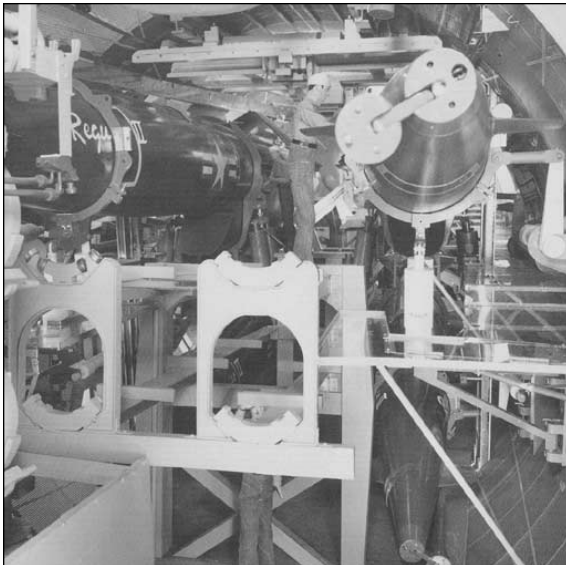


Figure 8-63. Carrying methods for the Regulus.

The Regulus missile was the first nuclear weapon capable of launch from a submarine – a feat that took the Soviet Union more than a decade after the Regulus to achieve. Regulus submarine launches were a much more complicated process than vessel or land-based launches. Submarines carried the Regulus missiles in a two-round hangar mounted on the exterior body of the ship (Figures 8-63). The ship surfaced and then sailors removed the weapon from the hangar compartment and loaded it onto the catapult launching system. The entire launch sequence took approximately 15 minutes to complete. The Navy selected five diesel-powered, World War II-era

submarines to be specially retrofitted with a Regulus hangar compartment and launching protocol (Figure 8-64). In the early 1950s, the Navy dry-docked the USS Cusk (SSG-348), USS Tunny (SSG-282), USS Barbero (SSG-577), USS Grayback (SSG-574), and the USS Growler (SSG- 517) to install instrumentation, wiring, the hangar compartment, and an exterior catapult launching system (Table 8-15). With the modifications, each submarine supported between two and four missiles (www.vectorsite.tripod.com; www.collinsmuseum.com).

The Navy completed alterations to the diesel-powered submarines in 1956. Subsequently, the submarines were re-designated SSG class and placed in service with the Pearl Harbor Submarine Force Family (Figure 8-65). In October 1959, the USS Cusk, USS Tunny, USS Barbero, USS Grayback, and the USS Growler made their first missions as part of a top secret program called Regulus Deterrent Patrols. The details of these missions are still largely classified nearly four decades after the program ended. According to veterans of the deterrent missions, these submarines traveled through the Arctic and into Soviet waters and the South China Sea, enabling the Navy to monitor Soviet submarine and naval operations. Oral histories also indicate that these ships carried Regulus missiles directly to Russia's coast. The five aforementioned submarines made a total of 40 patrols over a five year period (www.users.erols.com; www.scs.wsu.edu; www.vector-site.tripod.com; www.collinsmuseum.com);).



Figure 8-64. Regulus-launching mechanism on the U.S.S. Growler.

Concurrent with the SSG program was a move by the Department of the Navy to develop and manufacture nuclear-powered submarines, referred to as the SSG(N) program. Work on the SSG(N) class submarines began at the same time as diesel-powered submarines were retrofitted for Regulus Deterrent Patrols. The first SSG(N) class submarine was the USS Halibut (SSG(N)- 587). Manufactured

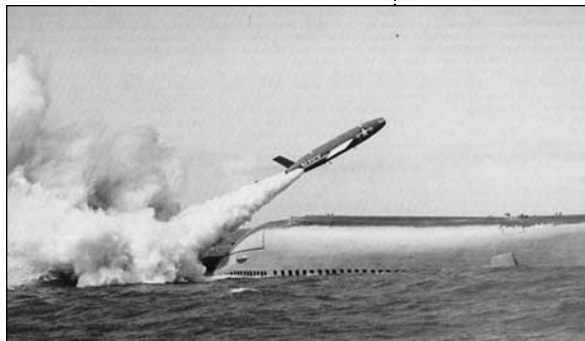


Figure 8-65. SSG-class submarine during a missile launch.

at Mare Island Naval Shipyard in Vallejo, California, the USS Halibut was commissioned in January 1960. The Halibut was not only the Navy's first nuclear-powered submarine, but it was also the first submarine designed and manufactured from keel up to launch guided missiles. Designed to carry the Regulus I missile, the Halibut's main deck was taller than other submarines to provide a dry "flight-deck" for loading the missile onto the catapult and launched (Figure 8-66). The loading mechanism was completely automated with hydraulic powered machinery that brought the Regulus from the hangar compartment and up to the deck (www.geocities.com; www.users.erols.com; www.scs.wsu.edu).



Figure 8-66. USS Halibut with flight deck.

On 11 March 1960, the USS Halibut sailed to Hawaii to join the Pearl Harbor Submarine Force Family. During its first year of operation, the Navy used the Halibut for worldwide demonstrations of the U.S. nuclear capabilities in locations such as Australia, Southeast Asia, and locations throughout the western Pacific. In

April 1961, the USS Halibut began Regulus Deterrent Patrols as part of Pacific Fleet operations. From 1961-1964 the USS Halibut made an unknown number of deterrent patrols in classified locations. Unlike diesel-powered submarines, the Halibut was capable of making extended, submerged missile deterrent patrols, possibly up to six months per mission. Prior to the Halibut, lengthy, covert missions were impossible for both the U.S. and the Russians. In 1965, the USS Halibut returned to the Mare Island Naval Shipyard to be reconfigured for use with the Polaris Missile (www.geocities.com; www.users.erols.com).

SIGNIFICANCE OF THE REGULUS MISSILES

At the end of World War II, the crux of the United States military's massive nuclear retaliation depended solely on the Air Force, which greatly limited the strategic capabilities of the armed forces – military leaders could only deliver a nuclear bomb to areas accessible by heavy bomber aircraft. The advent of guided missiles changed military planning because they provided strategists an opportunity to deliver thermonuclear weapons directly upon enemy territory, regardless of the location and its accessibility. In this post-war environment, the Navy found itself in a uniquely important position, especially after it combined its guided missile programs with a modern, strong fleet of vessels and submarines. The development, acceptance, and operational readiness of the Regulus missile reinstated the Navy's position within the armed forces and placed it on equal footing with the Air Force in terms of strategic and wartime planning. For a decade, the Navy had the only guided missile capable of delivering a nuclear warhead anywhere in the world in a matter of days. Not even the Soviet Union had a comparable weapon system. In this sense, Chance Vought's Regulus I missile was a true product of the Cold

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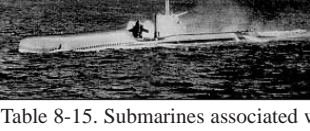
Submarines Associated with the Regulus Missile				
<i>Photo</i>	<i>Name of Ship</i>	<i>Type of Vessel</i>	<i>Service Dates</i>	<i>Historical Notes</i>
	USS Halibut SSGN-587	Nuclear-powered, designed specifically around Regulus	1961 - 1964	· First ever guided missile nuclear sub · Capable of long-range, submerged Regulus Deterrent Patrols, independent of support vessels
	USS Cusk SSG-348	World War II diesel- powered submarine converted for Regulus	1961 - 1964	· First submarine to launch a guided missile · Served as a missile guidance sub- marine
	USS Tunny SSG-282	World War II diesel- powered submarine converted for Regulus	1961 - 1964	· Participated in Regulus Deterrent Patrols with support of other naval vessels
	USS Barbero	World War II diesel- powered submarine converted for Regulus	1961 - 1964	· Participated in Regulus Deterrent Patrols with support of other naval vessels
	USS Grayback SSG-574	Diesel-powered submarine built for Regulus Missile	1961 - 1964	· Participated in Regulus Deterrent Patrols with support of other naval vessels
	USS Growler SSG-577	Diesel-powered submarine built for Regulus Missile	1961 - 1964	· Participated in Regulus Deterrent Patrols with support of other naval vessels

Table 8-15. Submarines associated with Regulus I.

War – conceived during a time in which the United States military was looking for a powerful deterrent to Soviet and communist expansion worldwide. Even though the Regulus was not the most technologically advanced of guided missiles, it was a proven design, affordable, recoverable, and capable of launch from land, ship, or submarine. Furthermore, the Navy designed, constructed, and commissioned a submarine (USS Halibut) around the Regulus in an effort to maximize the usefulness of the weapon. The Halibut's operations were top secret and are classified even today. These characteristics made Chance Vought's Regulus missile important to Cold War policies and practices and valuable to the government of the United States of America (www.collinsmuseum.com/regulus; www.scs.wsu.edu; www.fas.org; www.users.erols.com).