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Level II Documentation of Space Launch Complex 5 at Vandenberg Air Force Base, California

Julie L. Webster, Susan I. Enscore, and Martin J. Stupich

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Construction Engineering Research Laboratory

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Level II Documentation of Space Launch Complex 5 at Vandenberg Air Force Base, California

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Final report

Prepared for Operationally Responsive Space Office
3548 Aberdeen Avenue SE
Kirtland AFB, NM 87117

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Abstract: This report represents Historic American Engineering Record (HAER) Level II documentation of Space Launch Complex 5 (SLC-5), Vandenberg Air Force Base (VAFB), California. SLC-5 is one of approximately 70 VAFB facilities and complexes that have been determined eligible for listing on the National Register of Historic Places (NRHP). Five buildings at SLC-5 are eligible for the NRHP under "Cold War Criterion A" as a result of their historic role in supporting missions of exceptional importance during the Cold War. These facilities are also eligible under "Cold War Criterion D" as a result of SLC-5's distinctive launch technology that had been relatively unchanged since the early 1960s.

Preface

This study was conducted for the Operationally Responsive Space Office at Kirtland Air Force Base, Albuquerque, NM, under Project Order Number F2KTAN8255J001, “Vandenberg SLC-5 HAER Documentation.” The technical monitor was Dr. Mark R. Franz of the Operationally Responsive Space Office. The field coordinator at Vandenberg Air Force Base was Dr. James Carucci, Cold War Architectural Historian, VAFB Cultural Resources Office (30 CES/CEVNC).

The work was performed by the Land and Heritage Conservation Branch (CN-C) of the Installations Division (CN), at the U.S. Army Engineer Research and Development Center – Construction Engineering Research Laboratory (ERDC-CERL) in Champaign, IL. At the time of publication, Dr. Christopher M. White was Chief, CEERD-CN-C; Ms. Michelle Hanson was Chief, CEERD-CN; and Mr. Alan Anderson was the Technical Director for Military Ranges and Lands. The Deputy Director of ERDC-CERL was Dr. Kirankumar Topudurti and the Director was Dr. Ilker Adiguzel.

COL Kevin J. Wilson was the Commander and Executive Director of ERDC, and Dr. Jeffery P. Holland was Director.

Acknowledgments

The authors gratefully acknowledged the following individuals for their contributions to this document:

- Harry Brown, Scout Ordnance Technician and Pad/Vehicle Electrician, 1972-1994.
- Dr. James Carucci, Cold War Architectural Historian, VAFB Cultural Resources Office, 30 CES/CEVNC.
- James Denton, Real Property Technician, VAFB Real Property Office, 30 CES/CECBR.
- Jeffrey Geiger, Chief, VAFB History Office, 30 SW/HO.
- Harlan L. Gurney, Blue Scout Project Officer, Launch Vehicle Directorate, Space Systems Division (1961-1963).
- Donald M. Johnson, Engineering Supervisor, VAFB Scout Operations (1976-1994).

- Larry B. Johnson, Technical Project Manager, Scout Liquid Propulsion and Controls Systems (1961-1994).
- Jim Price, Blue Scout Electrical Technician (1961-1966); Scout Electrical Technician (1981-1994).
- Donald 'Jay' Prichard, Director, Vandenberg Heritage Museum, 30 SW/MU.
- Lee Wise, Scout Fluid Systems Technician and Mechanical Supervisor (1980-1994).

About the authors

Julie L. Webster, R.A., was Project Manager for this study. She served as the ERDC-CERL project administrator and prepared architectural descriptions of the subject facilities. Ms. Webster is a Registered Architect in the State of Illinois. She has extensive experience as a technical expert and project manager for research affecting architecture on federal lands, and frequently is sought for guidance, assistance, and troubleshooting on behalf of international, federal, regional, state, and local government agencies. Among the many Cold War studies Ms. Webster has managed or made key contributions to are the *Guide to Source Material on Ballistic Missile Defense (1946–1987)* for the Missile Defense Agency; several research efforts addressing the Western and Eastern Missile Ranges at Cape Canaveral Air Force Station and Vandenberg Air Force Base respectively; and four major Cold War military publications: *To Defend and Deter: The Legacy of the United States Cold War Missile Program*; *Searching the Skies: The Legacy of the United States Cold War Defense Radar Program*; *Forging the Sword: Defense Production during the Cold War*; and *Training to Fight: Training and Education during the Cold War*.

The Project Historian was Dr. Susan Enscore, who researched and prepared the historic context for the report. Dr. Enscore has been involved in the evaluation and documentation of Cold War era Department of Defense properties since 1992. During this time, Dr. Enscore has developed Cold War era historic contexts for HABS/HAER documentation of Launch Complexes 19, 21/22, and 31/32 at Cape Canaveral, Florida. Respectively, these complexes were used for the Titan II/Gemini program, the Bull Goose and Mace missiles, and the Minuteman I, II, and III R&D programs. She also created a historic context for Hanger C at Cape Canaveral, the first permanent hangar constructed at the site. Dr. Enscore created a public outreach document for Fort Bliss chronicling the “von Braun team” during their years at that installation. This project included conducting oral history interviews with four surviving members of the rocket team. Dr. Enscore has researched and written historic contexts for use in evaluating eligibility to the National Register of Historic Places for Cold War era properties at Fort Bliss/Biggs Air Force Base, Fort Hood, Fort Leonard Wood, and Fort Riley. Dr. Enscore also participated in a project to create a history and analysis of facilities designed and constructed for Cold War-era servicewomen nationwide.

Photographer Martin Stupich produced all the current-condition, large-format, archival photographs for this document. Mr. Stupich has been providing large-format photographic documentation for the Library of Congress HABS/HAER Collection since 1980. Documentation of military sites has been an area of professional emphasis starting with Fort Stewart, Nevada, in 1981. He began documenting Cold War military artifacts in 1982 with the inclusion of his sweeping panorama of a radio and radar array atop Winnemucca Mountain, Nevada, in an exhibition of western industrial landscape at the Nevada Historical Society. Notable Cold War documentation projects include: 1983 Environmental Impact Statement documentation for an early MX Missile basing proposal in Modena, Utah; 1989 documentation of "Spook Central," Arlington Hall Station, Virginia; 1993 documentation of the Foster, Rhode Island, Nike Missile Launch Complex and Long Island (Boston Harbor) underground Nike complex; projects between 1991 and 2008 at several launch pads and support facilities at Cape Canaveral Air Force Station; and projects between 2001 and 2005 at multiple space launch complexes and radar tracking facilities at Vandenberg Air Force Base.

Introduction

Background

Space Launch Complex 5 (SLC-5) is one of about 70 Vandenberg Air Force Base (VAFB) facilities and complexes that have been determined eligible for listing on the National Register of Historic Places (NRHP). The National Historic Preservation Act (NHPA) (16 U.S.C. 470) establishes the basis for site protection and management requirements for SLC-5. Lengthy consultations between VAFB Cultural Resource Managers and the California State Historic Preservation Officer (SHPO) between 1998 and 2002 resulted in a two-party programmatic agreement that identifies historic, NRHP-eligible Cold War properties on VAFB, and lists appropriate treatment activities for their care and management. Not all facilities at SLC-5 are considered historic elements of the complex; facilities 578, 579, 580, 582, 589 (and their contents) are NRHP-eligible, but other facilities at the site are not.

Between December 2006 and 1 April 2007, all buildings at SLC-5 were vandalized. Damage consisted of broken cathode ray tube (CRT) monitors in launch control consoles, broken instrumentation readouts, broken fluorescent light tubes, punctured or dismantled walls and ceilings, smashed windows, and building contents destroyed and scattered about the facilities. The vandalism was documented by the VAFB Cultural Resources (30 CES/CEVNC) and Museum programs (30 SW/MU). These programs have digital photographs documenting pre-vandalized conditions that date to early December 2006, when the site was known to be secured. Although vandalized and degraded, SLC-5 remains an eligible NRHP property.

Since its closeout in 1994, there has been the potential to reuse all or part of the SLC-5 facility for new launch programs or to offer SLC-5 hardware to agencies elsewhere for reuse. The vandalism at SLC-5 accelerated consideration of such actions.. The Hawaii Space Flight Laboratory in Honolulu, Hawaii requested transfer of the Scout launcher to the Pacific Missile Range Facility (PMRF) located on the island of Kauai. As the new owner of the Scout launcher, the PMRF was responsible for the logistics of disassembling the launcher on site at SLC-5, removing launcher components from the site, trucking them to White Sands Missile Range for refit, and transporting them to PMRF.

An Air Force Form 813, *Environmental Impact Analysis Review Form*, was prepared to include a detailed description of the work to be accomplished at SLC-5 prior to disassembly and transfer of the launcher. This form was used as the basis for an environmental assessment plan submitted to the University of Hawaii at Manoa regarding the historic preservation requirements for the SLC-5 transfer. A Memorandum of Record was also prepared by VAFB Cultural Resources Office that summarized for the proposed transfer: (1) coordination and consultation requirements related to historic preservation law and (2) mitigation details.

Objective

The objective of this work was to provide the level of documentation required by Section 106 of the NHPA as mitigation prior to any SLC-5 Cold War-era component's reuse, demolition, or disassembly. Following a consultation with the California SHPO, it was determined that HAER documentation of SLC-5 would meet the historic preservation requirements. To ensure successful documentation, the Operationally Responsive Space Office at Kirtland Air Force Base, New Mexico, was identified as a proponent, and funds were secured for the HAER effort.

Approach

The historical research focused on the acquisition and interpretation of primary and secondary documents relating to SLC-5 missions and construction histories. Research and documentation procedures followed the standards established by the National Park Service (NPS) in their publications entitled *Secretary of the Interior's Standards and Guidelines for Architectural and Engineering Documentation* (1990), *Historic American Engineering Record Guidelines for Historical Reports* (April 2008), and *Preparing HABS/HAER/HALS Documentation for Transmittal to the Library of Congress* (14 September 2006).

Sources consulted and referenced included previous reports on VAFB Cold War-era properties, real property records, engineering drawings, books, historic records, newspaper clippings, and historic photographs. The locations for these information sources include: the offices of 30 SW/HO, 30 SW/MU, 30 CES/CEVNC, 30 CES/CECBR, and 30 CES/CECB, all at VAFB, CA; U.S. Navy Seabee Museum, Port Hueneme, CA; History Office, Space and Missile Systems Center, Los Angeles AFB, CA; National Archives and Records Administration (NARA), College Park, MD; and National Aeronautics and Space Administration (NASA) Headquarters, History Division, Washington, DC.

Graphical documentation for this project included representative current-condition exterior and interior large-format (4 x 5-inch) archival photographs of SLC-5, as well as non-restricted government drawings, trade and technical journals, vendor marketing publications, and private collection photographs. Many of these graphical sources also incorporated text or data that proved to be useful during the course of the study.

HISTORIC AMERICAN ENGINEERING RECORD

VANDENBERG AIR FORCE BASE
SPACE LAUNCH COMPLEX 5
HAER No. CA-2288

Location:	Vandenberg Air Force Base Space Launch Complex 5 Avery and Delphy Roads Lompoc Vicinity Santa Barbara County California U.S. Geological Survey (USGS) Santa Maria Quadrangle, Universal Transverse Mercator Coordinates: A–10/34.60803/120.62435 B–10/34.60739/120.62441 C–10/34.60807/120.62497 D–10/34.60783/120.62477 E–10/34.60940/120.62826
Date of Construction:	1961-1978
Engineer:	Kaiser Engineers, Oakland, California (original construction); Quinton Engineers, Ltd., Los Angeles, California (1963 modifications)
Present Owner:	U.S. Air Force (USAF)
Present Use:	Deactivated
Significance:	SLC-5 is significant for supporting important Cold War missions, specifically those associated with the Scout missile between 1962 and 1994. Scout missions have studied aerosol contamination, helped scientists map planet's magnetic and thermal fields, discovered new X-ray sources in space, studied quasars and black holes, helped prove Einstein's gravitational and relativity theories, tested different materials to determine their tolerance to reentry heat, and studied how to protect spacecraft from micrometeoroids. Additionally, NASA relied on Scout missions to focus on specific problems pertaining to the manned space programs.
Report Prepared By:	Julie L. Webster, RA, Dr. Susan I. Enscore, and Mr. Martin Stupich U.S. Army Engineer Research and Development Center (ERDC) Construction Engineering Research Laboratory (CERL) P.O. Box 9005 Champaign, IL 61826-9005
Date	September 2010

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VANDENBERG AIR FORCE BASE, SPACE LAUNCH COMPLEX 5 HAER No. CA-2288
Avery and Delphy Roads
Lompoc Vicinity
Santa Barbara County
California

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

PHOTOGRAPHS

HISTORIC AMERICAN ENGINEERING RECORD
Pacific West Region
National Park Service
U.S. Department of the Interior
1111 Jackson Street, Suite 700
Oakland, CA 94607

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HISTORICAL OVERVIEW[1]

Introduction

The aftermath of World War II and the associated geopolitical fight for supremacy between the former Soviet Union and the United States (known as the Cold War) created a scenario that brought together scientific and military technological achievements in many arenas. One of the most celebrated results of this synergism was the emergence of space flight. Decades of scientific rocketry experiments were entwined with military funding and timelines, resulting in an extraordinarily rapid growth of capability in launching and guiding missiles.

For the United States, the civilian scientific emphasis remained alive in the National Astronautics and Space Administration (NASA), created in 1958. In addition, all branches of the U.S. military establishment were involved in rocket/guided missile development to some extent. By the late 1950s, both Russia and America were launching satellites into orbit, and the sky literally became the limit for technological and weapons ambitions on both sides.

One component of the Cold War was an arms race between the United States and the former Soviet Union that entailed massive research and development programs. The programs were aimed at producing weapons systems and technologies that were increasingly lethal, but at the same time, less vulnerable to attack. Chief among these efforts was the development of long-range missile weapon systems capable of accurately delivering nuclear warheads to enemy targets thousands of miles away. Realizing the potential of these missiles to hurl things into space in addition to hurling destruction at adversaries, both governments promulgated dedicated space research programs that resulted in both manned and unmanned launches.

This chapter begins with a general discussion of the Cold War and related missile programs, a look at the history of the U.S. space program, the development of the Naval Missile Facility at Point Arguello (NMFPA), and the origin of Vandenberg Air Force Base (VAFB). A specific histo-

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[1] Much of the material in the historical overview section is taken verbatim from the history provided in Patrick Nowlan and Roy McCullough, *Cold War Properties Evaluation – Phase II: Inventory and Evaluation of Minuteman, MX Peacekeeper and Space Tracking Facilities at Vandenberg Air Force Base, California*, (Champaign, IL: USACERL, 1997) and Susan I. Enscore, et al., *Historic American Engineering Record Level II Documentation of Launch Complex 21/22, Cape Canaveral Air Force Station, Florida*, (Champaign, IL: ERDC-CERL, 2008).

ry of the Scout program, along with development and use information, architectural descriptions, and photographs of the Scout Space Launch Complex 5 (SLC-5) facilities are found in subsequent chapters.

Origins of the Cold War

The seeds of the Cold War were sown during World War II when the United States and the Soviet Union found themselves to be allies in the fight against Nazi Germany. While outwardly praising their Soviet partners, British Prime Minister Winston Churchill and U.S. President Franklin D. Roosevelt distrusted Soviet leader Joseph Stalin. Consequently, when the United States launched the Manhattan Project to develop the atomic bomb during the war, the Western leaders deliberately withheld all information about the project from the Soviets. Stalin also harbored a deep distrust toward the West, and his attitude was not improved when the Western leaders delayed opening up a second front in Europe against Germany until 1944; a second front would have substantially reduced the pressure on the Soviets, who were bearing the brunt of German aggression.

At war’s end, relations quickly deteriorated between the Soviet Union and the West as each struggled to create a post-war world based on its own political ideologies. The first major crisis in the Cold War began in June 1948 when the Soviet Union blocked access to West Berlin in an effort to consolidate control of the country that had invaded it twice. The United States, with very different post-war plans for Germany, responded to the blockade by initiating a massive airlift campaign that brought 5,000 tons of supplies daily to West Berlin. The successful airlift campaign prompted the Soviets to lift the blockade in May 1949.

The Berlin incident, however, fueled fears in the West of a war with the Soviet Union and prompted U.S. military and political leaders to begin planning for such a possibility. At the time, the Soviet Union held a substantial military advantage in conventional forces. The United States, however, was at that point the sole possessor of the atomic bomb, and U.S. leaders believed that the Soviet Union was still many years away from developing its own atomic weapon. With post-war budgetary restrictions ruling out the buildup of a massive conventional force to match that of the Soviet Union, U.S. leaders came to view nuclear weapons as a relatively inexpensive and politically acceptable means to offset the Soviet threat. Consequently, the United States began producing smaller, more powerful nuclear bombs while dramatically reducing its defense budget.

In April 1949, while the Berlin airlift operation was still underway, the United States, Canada, and ten Western European countries joined together in a military and political alliance known as the North Atlantic Treaty Organization (NATO). Greece, Turkey, and West Germany joined the ranks of NATO within the next six years. The NATO treaty provided for U.S. military assistance to Western European nations in the event of a Soviet-backed invasion. Although not explicitly stated, that assistance was understood to include the possible use of nuclear weapons.

To fulfill its NATO commitment, the United States looked to its nuclear bomber force as an affordable and effective solution. The new B-36 intercontinental bomber could threaten targets deep within the Soviet Union from bases on U.S. soil. Although the United States viewed NATO as a defensive alliance, Soviet leaders viewed NATO as an organization whose ultimate aim was to push the Soviet Union back to its pre-war position. The Soviets responded to the creation of NATO by creating an alliance of their own with the communist governments of Eastern Europe. This alliance was formalized in 1955 with the signing of the Warsaw Pact.[2]

U.S. nuclear policy in the 1950s and 1960s was greatly affected by a number of developments. The first was the Soviet detonation of a nuclear bomb in August 1949, far sooner than U.S. leaders had expected. This event ended the U.S. nuclear monopoly and provided the impetus for the United States to develop the more powerful hydrogen bomb. Only a few months after the Soviet nuclear detonation, Mao Zadong's Red Army defeated the forces of Chiang Kai-shek, the longtime ally in China of the United States. Mao established the People's Republic of China the following year. When the Soviet Union consolidated its alliance with China, it appeared as if half a billion people had joined the enemy camp. These events prompted U.S. leaders to reassess the nation's defense policies. Greatly coloring that reassessment was National Security Council (NSC) report NSC-68, which portrayed the Soviet Union as a dangerous opponent armed with nuclear weapons and bent on world domination. The report warned that the Soviet Union could have as many as 200 atomic bombs by 1954 and urged an immediate U.S. buildup of both nuclear and conventional forces.[3]

The anxiety generated by the NSC-68 report was reinforced by suspicion that the 1950 invasion of South Korea by North Korea was undertaken with Soviet approval. The invasion immediately led to the Korean War, and Congress drastically increased the U.S. defense budget, fearing that the Korean development might be a prelude to similar action in Europe.

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[2] *The Weapon of Choice: War and Peace in the Nuclear Age Series*, Program 2, videocassette, Annenberg/CPB Project, 60 min. (Boston, MA: WGBH/Boston and Central Independent Television/England in association with NHK/Japan, 1988).

[3] Ibid.

While the U.S.-dominated United Nations (U.N.) forces fought in Korea, U.S. efforts to develop a hydrogen bomb advanced rapidly. In November 1952 at Eniwetok Atoll, U.S. scientists detonated the world's first thermonuclear device, paving the way for the creation of the hydrogen bomb. The explosion was 600 times more powerful than the bomb dropped on Hiroshima. For the moment, the nuclear balance shifted back in favor of the United States. Only forty or fifty such bombs would be needed to totally destroy the Soviet Union.[4]

Advantages gained by either side throughout the Cold War tended to be short-lived, however. The Soviet Union detonated its first hydrogen bomb only ten months after the United States. With both sides possessing the hydrogen bomb, the Cold War acquired a new and much more disturbing character. For the first time, two antagonistic nations possessed the means to essentially destroy civilization on a global scale.

Although both superpowers possessed the hydrogen bomb in the early 1950s, the United States continued to maintain a strategic advantage over the Soviet Union in the form of a fleet of long-range bombers. These bombers, loaded with hydrogen bombs, could deliver their deadly payloads to Soviet targets within two hours. At that time, Soviet bombers were not yet capable of threatening the U.S. mainland. U.S. military planners used this to their advantage. They reasoned that the best deterrent to a possible Soviet nuclear attack was the threat of a devastating retaliation visited upon targets within the Soviet Union. The Air Force Strategic Air Command (SAC) was the primary instrument for this policy known as "massive retaliation." Soviet leaders, painfully aware of the U.S. strategic advantage, initiated a massive military production campaign aimed at narrowing the strategic weapons gap. It was not long before the Soviet Union was producing long-range bombers capable of reaching mainland U.S. targets with nuclear bombs.[5]

Concurrent with the effort to produce a fleet of long-range bombers, the Soviet Union also began to invest heavily in the development of long-range missiles. By the mid-1950s, the Soviet's long-range missile program began to pull ahead of U.S. efforts. In August 1957, the Soviets announced the launch of a multi-stage long-range ballistic missile that had reached a "very high,

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[4] Ibid.

[5] Ibid.

unprecedented altitude" and claimed that this accomplishment would "make it possible to reach remote areas without resorting to a strategic air force."[6]

Undeniable proof of the advanced state of the Soviet missile program came on 4 October 1957, when a Soviet rocket placed the world's first man-made satellite, Sputnik, into orbit. The Soviets quickly followed this launch with an even more impressive one. On 3 November 1957, a Soviet rocket placed the 1,120 pound satellite, Sputnik 2, into orbit carrying a live dog. This launch had tremendous strategic implications. A booster that could carry a payload of comparable weight into space would also be capable of delivering a nuclear bomb to targets within the United States. Leaders in both countries realized that such a development would effectively offset the U.S. advantage in long-range bombers. The age of the intercontinental missile had arrived.

Early U.S. Long-Range Missile Program

At the time of the Soviet's Sputnik launches, the United States was involved in its own long-range missile research and development efforts. These efforts began in earnest immediately after World War II. Although the military experimented with some crudely developed guided missiles during World War II, there had not been much interest in rocketry among U.S. military leaders until the Germans began firing their V-1 "buzz bombs" and V-2 rockets at Allied cities in the summer of 1944. Allied anti-aircraft batteries quickly learned to shoot down the slow-flying V-1. There was no defense, however, against the 3,500 mile-per-hour V-2. The German V weapons made it clear that missiles would revolutionize the future of warfare. Recognizing this, the different branches of the U.S. armed services scrambled to create their own missile programs, each hoping to gain future operational and deployment responsibility.

Immediately after World War II, the Army brought several hundred German engineers and scientists, including Dr. Wernher von Braun, to the United States during Operation Paperclip. The Army organized a team of these scientists at Fort Bliss, Texas, to conduct studies for development of long-range, surface-to-surface, guided missiles. In an effort to refine the German V-2 rocket, these scientists began helping the Army test launch captured V-2s at the adjacent White

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[6] Carl Berger and Warren S. Howard, *History of the 1st Strategic Aerospace Division and Vandenberg Air Force Base, 1957-1961*, (Vandenberg Air Force Base, California: Headquarters, 1st Strategic Aerospace Division, April 1962), 8.

Sands Proving Ground in May 1946. In 1951 the Army moved the team to the Redstone Arsenal in Huntsville, Alabama, where they began to develop the Redstone rocket.[7]

The Navy and Air Force also began their own missile programs in the 1940s. For a brief time, however, it appeared that a single, national-guided missile program might be established to eliminate duplication of effort among the services. The Army and Navy both favored such a development. But the Air Force (at that time still known as the Army Air Forces or AAF) strongly opposed such a plan.[8] AAF officials feared that a single program would jeopardize their chance of gaining sole responsibility for development and deployment of long-range guided missiles.[9] A fierce inter-service rivalry over control of guided missiles ensued as each service sought to define its role and mission. In support of its claim on the technology, Army officials argued that ground-launched missiles were basically extensions of artillery and therefore belonged to the Army's mission. In opposition, Air Force officials argued that missiles were essentially robotic or pilotless aircraft, and as such they fell under the mission of the Air Force.[10]

In an attempt to clarify the roles of each service branch and to reduce the waste resulting from a duplication of effort, Secretary of Defense Louis A. Johnson initiated a review of the nation's missile programs in 1949. The review resulted in (1) the creation of a priority list of missiles to be developed and (2) the assignment of a separate missile test range to each service branch. More importantly, the Air Force emerged from the review with "formal and exclusive" responsibility for developing long-range strategic missiles and short-range tactical missiles. Even after the review, however, the issue was still far from settled as both the Army and Navy continued to conduct missile studies that eventually progressed to the development stage.[11]

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[7] The Army began testing its Redstone rockets at Cape Canaveral, Florida in 1953. The Redstone, with a range of approximately 300 miles and capable of carrying a nuclear warhead, was employed in West Germany by U.S. troops in 1958 as part of the NATO arsenal. It was later employed as a booster during the nation's manned and unmanned space program.

[8] The National Security Act of 1947 divided the military services into the three separate departments: the Army, the Navy, and the Air Force.

[9] Jacob Neufeld, *The Development of Ballistic Missiles in the United States Air Force, 1945-1960* (Washington, D.C.: Office of Air Force History, U.S. Air Force, 1990), 50-52.

[10] Ibid., 82-93.

[11] Ibid., 55-56.

Cruise versus Ballistic Missiles

There are two basic types of long-range missiles: (1) the aerodynamic cruise (or winged) missile and (2) the more advanced ballistic missile. Cruise missiles, resembling pilotless airplanes (as the Air Force claimed they were), require oxygen to support fuel combustion and therefore, are restricted to operating within the earth's atmosphere. Ballistic missiles, however, carry their own oxygen source, enabling them to travel beyond the earth's atmosphere. Faster and more effective than cruise-type missiles, ballistic missiles travel in a long, arcing trajectory before striking their target.

The AAF first began funding long-range missile development studies in 1946. In January of that year, engineers from the Consolidated Vultee Aircraft Corporation (Convair) presented the AAF with two design proposals for a missile capable of carrying a 5,000 pound warhead over a range of between 1,500 and 5,000 miles. One design was for a cruise-type missile and the other for a ballistic missile. AAF officials awarded Convair a study contract in April 1946.[12]

Headed by the Belgian-born engineer Karel Bossart, the Convair effort became known as Project MX-774. In order to collect the necessary data, Bossart gained permission to build ten test vehicles. Funding cutbacks soon forced Bossart to abandon the cruise missile design and concentrate solely on the ballistic missile design. Bossart and his team focused their efforts on improving the structural design and performance of the German V-2 rocket, but continual funding cutbacks forced cancellation of the program in July 1947. Even though funding for the project was terminated, the AAF allowed Bossart and his team to use their remaining unexpended funds to complete and flight-test three vehicles. These flight tests, conducted November 1947–May 1948 at the White Sands Proving Ground in New Mexico, validated Bossart's design changes.[13] Later ballistic missile programs benefited from information gained during this project.

As a result of the drastic reductions in defense spending in the late 1940s, the U.S. Air Force (USAF), officially established in July 1947, had to choose between developing either cruise-type long-range missiles or ballistic long-range missiles. Air Force officials decided to pursue development of the cruise missile on grounds that this type could become operational sooner than the expected ten years necessary for development of an operational ballistic missile.[14] In the late

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[12] Ibid., 45.

[13] Ibid., 48-49.

[14] Ibid., 48.

1940s and early 1950s, the Air Force began to invest heavily in the development of the Snark and Navajo cruise missiles.

In the early 1950s, when the Korean War spurred an increase in military spending, the Air Force began to fund another long-range missile study by Convair. This study, designated Project MX-1593, later became known as Project Atlas. The Air Force began funding further studies of the Atlas ballistic missile design in fiscal year 1952. This funding, however, remained at a very low level compared with the funds allocated to the Snark and Navajo cruise missile programs.[15]

When the military services began developing long-range missiles after World War II, it quickly became apparent that the nation's existing ranges were inadequate to support missile test flights that, at times, could extend to several thousand miles. Realizing this, the Department of Defense (DoD) began searching in 1946 for an adequate site for a long-range missile proving ground.

A special selection committee eventually chose the Cape Canaveral area in Florida. The DoD established Cape Canaveral in 1950 as a long-range missile research, development, and testing facility for the joint services. This facility became one component of a missile test range that included administrative headquarters at nearby Patrick Air Force Base (AFB) and downrange tracking facilities extending in the Atlantic Ocean.[16] The Air Force, in charge of developing and administering the range, began extensive testing of its cruise-type missiles at Cape Canaveral in 1950.

Several important developments in the early 1950s significantly altered the U.S. approach to long-range missile development. Soon after the first thermonuclear device was detonated in 1952, the Atomic Energy Commission (AEC) predicted that the production of smaller nuclear warheads with tremendous destructive potential would soon be feasible. Smaller yet more powerful warheads would solve many of the problems associated with missile weight and would also eliminate the need for pinpoint accuracy. This news, combined with intelligence reports indicating the Soviet Union was making significant progress in the development of long-range missiles and in the development of its own thermonuclear warheads, prompted a reexamination of the United States' strategic missile programs.

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[15] Ibid., 241.

[16] This missile test range is known today as the Air Force Eastern Range.

The Air Force convened a panel of leading U.S. scientists in 1953 to examine the Snark, Navajo, and Atlas missile programs. Known as the Teapot Committee, the panel submitted a report in February 1954 recommending relaxation of performance requirements for long-range missiles (based on the availability of new, lightweight, high-yield thermonuclear weapons) and acceleration of the development of the Atlas intercontinental ballistic missile (ICBM).[17] These recommendations received the approval and support of high-ranking civilian and military leaders during the following months. Air Force officials, and in particular Trevor Gardner, Special Assistant for Research and Development, began to campaign vigorously to convince Congress and the President of the urgency of ICBM development. These efforts paid off when President Eisenhower assigned highest national priority to the ICBM development program in 1955. President Eisenhower also supported the Air Force in its bid to gain control of ICBM development. Although budget cuts by the Eisenhower administration in 1956–57 temporarily slowed progress toward an operational ballistic missile, the Soviet launch of the Sputnik satellites in October–November 1957 again focused U.S. attention on the ICBM program. Congress reacted by restoring national priority to the ICBM program and by increasing funds for its development.[18]

Air Force Ballistic Missile Development

Air Force officials hoped to achieve operational capability with the Atlas ICBM by the end of the 1950s. As a hedge against failure in the Atlas program, however, the Air Force initiated a second ICBM development program, designated Titan, in 1955. By 1958, the Air Force began funding the development of yet another ICBM, the Minuteman, which was to be a smaller, more effective, three-stage, solid-fueled ICBM that would be relatively inexpensive to produce.

As the pace of the Air Force ICBM program quickened, intelligence reports indicated that the Soviet Union would likely have a dangerous number of ICBMs armed with nuclear warheads operational by 1960. Fearing the United States would not be ready to match that threat, DoD officials decided that an intermediate-range ballistic missile (IRBM) should be developed and based in Europe to act as a stopgap measure until a sufficient number of U.S. ICBMs became operational. After it was concluded that an IRBM with a 1,500 mile range could be developed in a relatively short time, the Joint Chiefs of Staff granted approval in 1955 for two IRBM pro-

[17] Neufeld, *Development of Ballistic Missiles*, 99-103.

[18] Ibid., 133-135.

grams — the Air Force Thor IRBM program and the Army/Navy Jupiter IRBM program. Both programs advanced simultaneously, in direct competition with each other.[19]

In order to speed progress in its ballistic missile programs, the Air Force replaced the conventional sequential weapon system development pattern with a parallel or concurrent approach. The liquid-fueled Atlas, Titan, and Thor missiles all would share many common components thereby reducing costs and speeding development time. Concurrency allowed Air Force personnel and contractors to develop and test different missile systems and different models of the same missile within a very narrow and overlapping timeframe. Research, development, testing, and production all proceeded simultaneously. The Air Force also worked toward readying missile sites, equipment, and crews concurrently with the development of the missiles.[20]

Beginnings of the U.S. Space Program

Military research into high-altitude rockets got underway after World War II, with Army Ordnance's V-2 program (utilizing both German missiles and scientists) and field missiles including the Private, Corporal, and Sergeant. A smaller variant of the Corporal missile, called the WAC Corporal, was the first U.S. rocket designed specifically for upper atmosphere research. The most famous role of the WAC Corporal was as the first large, two-stage rocket when it was launched atop a V-2 as its booster. In 1949, this setup achieved a then-record 250 miles in altitude from a launch at White Sands Missile Range, NM.[21] This proved the viability and performance gains that could be achieved with large, multi-staged rockets.

The WAC Corporal led to the Aerobee which was originally designed to replace the dwindling supply of V-2s. The Aerobee was funded through the Office of Naval Research (ONR) and contracted to Aerojet Engineering Corporation. The Naval Research Laboratory (NRL) also wanted a successor to the A-4 for high altitude instrumentation. The first flight was in November 1947. A

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[19] Ibid., 143-148; The IRBM programs were assigned equal priority with the ICBM program in January 1956. The Jupiter program was assigned to the Air Force in 1956.

[20] Ibid., 122-23, 201.

[21] Matt Bille, et al., "History and Development of U.S. Small Launch Vehicles," in Roger D. Launius and Dennis R. Jenkins, eds, *To Reach the High Frontier: A History of U.S. Launch Vehicles* (Lexington, KY: University Press of Kentucky, 2002), 187-188.

second generation (called the Aerobee-Hi) was proposed in 1952 and began flying in 1956 carrying larger payloads.[22]

Engineer Milton Rosen of the NRL designed a single-stage guided rocket weighing about 10,000 pounds called the Viking. Fourteen of the Vikings were built from 1946–1955 incorporating major advances in technology such as high-thrust, turbine-driven pump engines, a gimbaled motor for steering, advanced orientation system, and the use of aluminum as the main structural material for greatly reduced weight.[23]

The official beginnings of the U.S. space program can be traced back to 1955, when President Eisenhower announced that the United States would launch a small, unmanned, Earth-circling, scientific satellite as part of the nation's participation in the International Geophysical Year (IGY).[24] While planning for the IGY late in 1954, the International Scientific Committee discussed satellite vehicles as a way of obtaining information about the upper atmosphere. The IGY provided a perfect opportunity for the United States to start a satellite program that would not appear to be motivated by military considerations. In reality however, U.S. military leaders were extremely interested in developing a military space program. Although the Air Force, Army, and Navy all had been conducting upper air research programs of varying magnitude, none of the services had initiated any major efforts to start a satellite program by the early 1950s.

President Eisenhower's announcement concerning the IGY prompted all three U.S. armed services to begin devising plans for a satellite program. By April, three separate plans had emerged. The first was a joint effort by the Army and Navy designated Project Orbiter. This plan called for placing a simple un-instrumented satellite into orbit utilizing an Army Redstone booster. A second plan by the Navy, eventually designated Project Vanguard, involved using a Navy Viking rocket as the first-stage of a three-stage rocket. The Air Force's plan recommended using an Atlas coupled with an Aerobee-HI second stage rocket.

Faced with these three plans, the DoD set up a special advisory group to review the proposed satellite programs and to make recommendations. Although favoring use of the Atlas, the committee eventually decided that the Navy program had the best chance of placing the most useful

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[22] Ibid., 189.

[23] Ibid.

[24] The IGY extended from July 1957 to December 1958.

satellite into orbit within the IGY without interfering with the priority of ballistic missile development. As a result, the Navy was given permission to proceed with Project Vanguard.

Even after the DoD advisory group announced their official support for the Vanguard program, the Army continued to push its own proposed satellite program. Although the proposal was continuously rejected, the Army Ballistic Missile Agency continued to claim it could launch a satellite on only four months notice. The Army's persistence would eventually pay off.

While the Soviets were successfully placing satellites into orbit, the Navy satellite program was experiencing many problems. The Vanguard launch vehicle blew up on its pad several times during a string of failed launch attempts. This was all the more embarrassing for the United States given the spectacular success of the Sputnik launches. While the Navy worked frantically to conduct a successful launch, the Army beat them to it. After the Sputnik launches, the Secretary of Defense gave approval to the Army to proceed with its satellite program. Eighty-four days later, on 31 January 1958, an Army team succeeded in placing the first U.S. artificial satellite, Explorer I, into orbit by using a modified Redstone missile known as Juno I. This historic launch occurred at Cape Canaveral Launch Complex 26. The Vanguard team finally succeeded in placing a satellite into orbit on 17 March 1958. The three-pound Vanguard I satellite, launched from Cape Canaveral, studied temperatures and upper atmosphere conditions and also revealed the earth to be slightly pear-shaped.[25]

U.S. Military Space Program

The Vanguard and Explorer launches were early efforts to place fairly primitive scientific satellites into orbit. The DoD, however, gained valuable experience in satellite launch techniques as a result of these early efforts. Eager to build upon that experience, DoD officials soon began planning the development of satellites that could be used specifically for military purposes. Although there had been interest among the armed services in developing reconnaissance satellites as far back as 1945, several obstacles delayed their development. Chief among these were the considerable technological challenges posed by achieving and maintaining orbit and the problems of data transmission.

Initially, the development of military satellites did not receive a high priority because the DoD focused its attention on the development of operational long range missiles. By the mid 1950s,

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[25] C.W. Scarboro, *Twenty Years in Space: The Story of the United States' Spaceport* (Cape Canaveral, FL: Scarboro Publications, 1969), 155.

however, when it became clear that the Soviet Union would soon have numerous operational ICBM sites posing a threat to the security of the United States, American leaders quickly realized the importance of identifying the characteristics and location of those weapon systems. On 1 March 1954, the Research and Development Corporation (RAND) produced Report R-262, Project FEEDBACK, which recommended the Air Force develop a surveillance satellite program.[26]

In response to this study, within a year the Air Force began calling for proposals from industry for the development of a photographic reconnaissance satellite. Two basic types of satellite systems were subsequently proposed. One was a "non-recoverable" radio-relay reconnaissance system in which television cameras aboard a satellite would photograph ground targets, store the imagery on tape, and then relay the images to ground receiving stations when the satellite passed close enough overhead. The second type of satellite featured a "recoverable" system in which a capsule loaded with exposed film would be ejected from its satellite and return to earth where it would then be recovered. The development plan was approved in July 1956, and the Air Force awarded the Lockheed Corporation a contract to develop both types of satellites in October 1956. The project became known as WS-117L (Weapon System-117L).[27]

By 1958, the NSC assigned highest priority status to the development of an operational reconnaissance satellite. In November of that year, the DoD announced plans for its WS-117L program, revealing that it would consist of three separate systems: DISCOVERER, SENTRY (later called SAMOS), and MIDAS. The first two were reconnaissance systems and the latter was the nation's first ballistic missile early warning satellite system. The Air Force conducted launches under these programs, using Thor and Atlas boosters coupled with various upper stages (primarily the Agena), throughout the 1960s and beyond. All of the DISCOVERER and SAMOS launches occurred at VAFB. Cape Canaveral supported the first two MIDAS launchings on 26 February and 24 May 1960.[28]

The U.S. military satellite launchings did not go unnoticed in the Soviet Union. On several occasions the Soviets complained bitterly about the satellites. In light of statements by the Soviets on the illegality of such activities and the increasingly credible threat to shoot U.S. reconnaissance satellites down, officials in the Kennedy administration decided to drastically curtail any official

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[26] William E. Burrows, *Deep Black: Space Espionage and National Security* (New York: Random House, 1986), 83; John Hilliard, written correspondence to Susan Enscore, 17 May 2008.

[27] Burrows, *Deep Black*, 84. The WS-117L project was code-named Pied Piper.

[28] Hilliard, written correspondence to Susan Enscore, 17 May 2008.

publicity concerning U.S. military satellite programs. By 1962, all military launches were classified as secret. The national reconnaissance effort continued, although henceforth it was conducted under the highest degree of official secrecy.[29] Government officials hoped that the blackout of these activities would make it much harder for the Soviets to pick out the military satellites from among the various other non-military application satellites the United States was launching.[30] In addition, the President John F. Kennedy's administration hoped that if the Soviet Union was not unnecessarily embarrassed in front of the other nations of the world, Soviet officials would not complain as loudly about U.S. satellite reconnaissance activity.[31]

By the mid 1960s, reconnaissance satellites were yielding a regular supply of photographs to officials in the military services and the Central Intelligence Agency (CIA), allowing them to stay up to date with the latest Soviet military developments. By revealing that the Soviets did not have as many ICBMs deployed as U.S. officials had previously thought, reconnaissance satellite photographs were greatly responsible for dispelling fears of the much publicized "missile gap."[32] Reconnaissance satellites also proved invaluable for monitoring compliance with international arms treaties such as the 1963 Nuclear Test Ban Treaty and the 1972 Strategic Arms Limitation Treaty (SALT I).[33]

The United States has also launched other types of satellites that have military applications. These include defense communication, weather, and navigational satellite systems. Some of the important non-reconnaissance military satellite launches of the late 1960s and 1970s included the Initial Defense Satellite Communication System (IDSCS) and the Defense Satellite Communications System (DSCS II and DSCS III), the Tactical Communications Satellite system (TACSAT

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[29] After the launch of SAMOS 5 in December 1961, officials would no longer even admit the existence of the SAMOS project; Jeffrey T. Richelson, *The United States' Secret Eyes in Space: The U.S. Keyhole Spy Satellite Program* (New York: Harper & Row, 1990), 53.

[30] Richelson, *Secret Eyes in Space,* 65.

[31] Burrows, *Deep Black*, 142.

[32] President Kennedy used the "missile gap" argument as a campaign issue in the presidential election of 1960. He charged that the Soviet Union was gaining a strategic advantage over the United States in ICBMs. In 1961, photographs recovered from the DISCOVERER satellites reduced the estimate of Soviet ICBMs from the hundreds previously thought to ten to twenty-five, thereby dispelling the missile gap notion (Richelson, *Secret Eyes in Space*, 349).

[33] The Nuclear Test Ban Treaty, signed by the United States, Great Britain and the Soviet Union, prohibited nuclear testing in the atmosphere, in space, and under water.

I), the Fleet Satellite Communications system (FLATSATCOM), the Defense Meteorological Satellite Program (DMSP), and the NAVSTAR Global Positioning System (GPS) program. Most of the above satellites have been launched from Florida's Cape Canaveral or the adjacent Kennedy Space Center. The DMSP, as well as numerous early navigational satellites, have been launched from complexes at VAFB.

The military space program played a crucial role in the nation's strategic efforts during the Cold War. Satellites have kept the United States abreast of the qualitative and quantitative characteristics of the weapons systems deployed by potential adversaries. This has helped leaders within the U.S. government more accurately assess potential threats to the national security and has guided them in their policy deliberations. Perhaps more importantly, the military space program made a significant contribution to the maintenance of international stability, particularly between the two nuclear superpowers of the Cold War era. Arms control resolutions and treaties would have carried little weight had there not been satellites capable of accurately monitoring the degree of compliance among the signatory nations. In addition, by virtually eliminating the possibility of a surprise attack on the United States, reconnaissance satellites have dramatically reduced the possibility that any nation might be tempted to launch such an attack.

U.S. Unmanned Civilian Space Program

Besides spawning the nation's military space program, the early Explorer and Vanguard launches signaled the beginning of the U.S. civilian space science program as well. From these pioneering scientific launches evolved programs to study the earth, the solar system, interplanetary space, the Moon, other planets and their moons, the galaxy, and ultimately, the universe. Besides enormously expanding our pool of scientific knowledge, these efforts greatly contributed to the nation's effort to send men safely to the Moon and back. Information gained from the various U.S. space science programs also has been applied toward practical ends, resulting in numerous application satellite programs, as described below.

The National Aeronautics and Space Act that became law on 1 October 1958 established the National Aeronautics and Space Administration (NASA) as the primary U.S. space agency responsible for developing and carrying out a civilian national space program. NASA was created with the expressed intent that its space program be directed toward peaceful pursuits. The new civilian agency was to carry out aeronautical and space activities except those associated with defense, which were the responsibility of the DoD. In anticipation of conflicts between NASA and the

DoD, provisions were made for mediation between the two via the President and a newly formed National Aeronautics and Space Council.[34]

In August of 1961, NASA and the DoD chose a section of Merritt Island, FL as the launch center for the Manned Lunar Landing Program. This would become the site of the John F. Kennedy Space Center, owned and operated by NASA. Almost immediately, NASA initiated a National Launch Vehicle Program aimed at eliminating the proliferation and duplication of orbital launch vehicles. Consequently, five launch vehicle families evolved. These included the Scout (NASA), the Thor (Air Force) which eventually evolved into the Delta, the Atlas (Air Force), the Titan (Air Force), and the Saturn (NASA) vehicles. Separate complexes at Cape Canaveral supported developmental launchings of these space boosters. The successful launch vehicle program enabled NASA and the DoD to turn to each other for launch services whenever a certain payload better fit the other agency's launch vehicle, regardless of who sponsored the launch vehicle.[35]

NASA's civilian unmanned space program consisted of both science and application satellite and space vehicle programs. Throughout most of the 1960s, these programs were under the direction of the NASA Office of Space Science and Applications. A reorganization within NASA in 1972 resulted in separation of the science and application satellite programs, with each being given its own office headed by an associate administrator.[36]

Many of the missions in NASA's space science program have been directly related to physics and astronomy. Although some of these missions have been sub-orbital, involving sounding rockets and balloons, and others have traveled as far as the Moon, the majority of NASA's physics and astronomy missions have been Earth orbital. The orbital missions have been especially rewarding to scientists because they allow measurements to be taken of phenomena well above the reach of sounding rockets or balloons. Orbital missions also have helped revolutionize astronomy by placing telescopes above the distortion caused by atmospheric turbulence and electromagnetic, infrared, and short-wave radiation.[37] Explorer spacecraft and several more complex orbiting observatories, such as the Orbiting Solar Observatory (OSO), the Orbiting Astronomical Observatory (OAO), the Orbiting Geophysical Observatory (OGO) and the High Energy Astron-

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[34] Richelson, *Secret Eyes in Space,* 52.

[35] "Master Plan of the Cape Canaveral Missile Test Annex," (Pan American World Airways, Inc., 1971), 184.

[36] Ibid., 718.

[37] Ibid., 721.

omy Observatory (HEAO), provide NASA with its principal means of conducting long-term automated investigations of the Earth, interplanetary space in close proximity to the Earth, Sun-Earth relationships, and astronomical studies of the Sun, stars, and galaxies.[38] Explorer missions, many of them undertaken with a significant degree of international cooperation, have been launched from both Cape Canaveral and VAFB using a variety of launch vehicles. Launches in the Explorer series began in 1958 and have continued into the 1990s. NASA launched most of its orbiting observatories from Cape Canaveral complexes in the 1960s and 1970s; a few OGOs were launched from VAFB from 1965–1969.[39]

Besides purely scientific programs, the U.S. unmanned space program has also encompassed a multitude of application satellite programs. Too numerous to list here in detail, these application programs included communication satellites, meteorological satellites, earth resources and environmental monitoring satellites, ocean sensing satellites, geodynamic satellites, and navigation satellites. Application satellites have had a tremendous impact on modern life because they have linked together remote areas of the earth, exerted a lasting impact on the growth and application of the science of meteorology, and provided numerous new ways to examine and map the Earth and its oceans.[40] Also, there has always been a close correlation between civilian and military application satellites, especially for communications, weather, and geodetics. Application satellites characterized as "military" often provide useful information to the civilian sector while "civilian" satellites, in turn, often furnish important information to the military as well.[41] Because of this, the U.S. application satellite programs, combined with the nation's space science programs, have revolutionized the way we see our world and the way in which we live in it.

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[38] Ibid., 723.

[39] Hilliard, written correspondence to Susan Enscore, 17 May 2008.

[40] For information on specific civilian application satellite programs see "United States Civilian Space Programs: Volume II, Application Satellites" prepared for the Subcommittee on Space Science Applications of the Committee on Science and Technology, U.S. House of Representatives, 98th Congress, 1st session, May 1983.

[41] For example, the Department of Defense's DMSP satellites regularly provide weather data to the National Oceanic and Atmospheric Administration (NOAA). Conversely, in March 1984, NOAA's Landsat 4 earth resources satellite helped Department of Defense officials detect a Soviet ballistic missile-firing submarine testing equipment designed to smash through Arctic ice prior to underwater missile launch.

U.S. Naval Missile Facility Point Arguello

In June 1957, the northern half of the Army's World War II era Camp Cooke was acquired by the Air Force. In May 1958, the southerly 20,000 acres became the U.S. Naval Missile Facility, Point Arguello (NMFPA), making it the largest single piece of land in the Pacific Missile Range (PMR). This gave the Navy a missile facility equivalent to the Air Force's Cape Canaveral and the Army's White Sands Proving Grounds. The new facility was commissioned on 10 May 1958. It was given the primary mission of maintaining and operating facilities in addition to supporting operations of the Pacific Missile Range, including control and tracking for launches.[42]

The Pacific Missile Range in California consisted of three sites: (1) Point Arguello, (2) the Naval Missile Center located 100 miles south at Point Mugu (which controlled both the range and the NMFPA), and (3) an ocean test strip 500 miles long paralleling the California coast and extending 250 miles out to sea (Figure 1).[43] A buffer area between the southern end of Point Arguello and inland of the Point was later obtained through the purchase of the Sudden Ranch property to the south of the new missile facility. A formal announcement of the new facility was made in April 1960 with a press release in major newspapers that described the $33 million installation as "the nation's newest rocket base."[44] At that time, the naval personnel strength of the NMFPA was 300, plus 150 supporting contract personnel. The management contract for the missile facility was signed with Federal Electric Corporation of Paramus, New Jersey in April 1958.[45]

Preliminary construction at the NMFPA included a road network and a set of essential facilities. The original buildings were constructed under contract NBy-19386 by AL-CO Company, Inc., Los Angeles, California. The contract was dated 27 June 1958, and provided $961,452 for construction. With the inclusion of a change order for $1,820,291, the total cost for the initial con-

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[42] SECNAV Notice 5450, in vertical file, California - Point Mugu History 1959-1960, at U.S. Navy CEC/Seabee Museum, Port Hueneme, California (Washington, DC: Department of the Navy, 21 May 1959).

[43] The range would eventually encompass observation posts stretching across the Pacific Ocean to Eniwetok and Kwajalein Islands."DoD Space Facility: The Pacific Missile Range," *The Navy Civil Engineer*, April 1963, 14, Vertical File: California - Lompoc - Point Arguello Missile Facility at U.S. Navy CEC/Seabee Museum, Port Hueneme, California.

[44] "New Rocket Base Unveiled by Navy," *Navy Press*, 4 April 1960, in vertical file: California - Lompoc - Point Arguello Missile Facility, at U.S. Navy CEC/Seabee Museum, Port Hueneme, California.

[45] Ibid.

struction was $2,781,723. The appropriation for the construction was under 17X1205 MCON. Plans and specifications were prepared by the Public Works Office, 11th Naval District, San Diego, California. The field work started 31 July 1958, and the work was completed by 18 December 1959.[46] This rapid schedule was due to the work being conducted under a forced-draft emergency program. The following buildings were constructed under this appropriation and contract: Range Operations Building, Remote Radar Building, Telemetry Receiver Building, Radio Receiver Building, F.I.C. Building, HF-VHF Transmitter Building, and UHF Transmitter Building.[47]

Construction on the first major missile and satellite launching complex at NMFPA was completed by 1 June 1960, and consisted of two Atlas launch towers, blockhouse, and associated facilities. The complex was built by the Bureau of Yards and Docks for the Air Force Samos and Midas satellite programs.[48] Also in June 1960, two construction contracts totaling more than $2 million were awarded. The larger of the two ($1,883,939) was for construction of a public works shop, ordnance assembly building, launch site assembly building, missile assembly building, fire station, and marine detachment building. The Fred A. Arnold Company of Los Angeles, California undertook the work with an expected completion of late summer 1961. A smaller contract ($193,000) was awarded to the Robert W. King firm of North Hollywood, California for technical support facilities at Launch Complex 1.[49]

A Mercury tracking station was established at Point Arguello in February 1962, and was first utilized for John Glenn's Mercury/Atlas (MA-6) orbital flight on 20 February 1962. The capsule

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[46] "Historical Report for Fiscal Year 1960 of the Naval Missile Facility, Point Arguello, California," in vertical file: California -Lompoc - Point Arguello Missile Facility, at U.S. Navy CEC/Seabee Museum, Port Hueneme, California; "Contract Record Report - Construction of Various Buildings," in vertical File: California - Lompoc - Point Arguello Missile Facility, at U.S. Navy CEC/Seabee Museum, Port Hueneme, California.

[47] "Contract Record Report - Construction of Various Buildings," Vertical File: California - Lompoc - Point Arguello Missile Facility, U.S. Navy CEC/Seabee Museum, Port Hueneme, California.

[48] "Civil Engineer Corps Weekly Report,", in vertical file: California - Lompoc - Point Arguello Missile Facility, at U.S. Navy CEC/Seabee Museum, Port Hueneme, California. (Washington, DC: Department of the Navy, 2 June 1960), 1.

[49] "New Facilities Set For Point Arguello," *Navy Times*, 2 July 1960, in vertical file: California - Lompoc - Point Arguello Missile Facility, at U.S. Navy CEC/Seabee Museum, Port Hueneme, California.

was tracked with radars and telemetry, and the data was transmitted to NASA's Goddard Space Flight Center in Maryland, then to the Mercury Control Center at Cape Canaveral, Florida.[50]

Although administered independently, the NMFPA and VAFB were closely linked from the beginning. The Air Force conducted extensive space launch programs at Point Arguello (from Navy-built complexes) while NMFPA personnel had access to many of the facilities at VAFB, including its housing resources.[51] Intentionally, no barracks, housing, or recreational buildings were constructed at NMFPA, since these types of facilities were felt to create additional safety concerns that could negatively impact operations goals.[52] As a result, the NMFPA personnel lived to the north at VAFB. The relationship worked both ways, as VAFB was a tenant at NMFPA. In addition, the Navy provided command and control until 1964 for all launches from VAFB and the NMFPA.

This coordination made it somewhat easier logistically when on 21 November 1963, the DoD announced plans to consolidate ICBM and satellite test ranges under the single management of the Air Force.[53] As a result, the DoD ordered the Navy to transfer the real estate and logistic support functions of the NMFPA to the Air Force, and the activity was disestablished as of 1 July 1964.[54] When the Navy completed the transfer on that date, the former NMFPA was incorporated into VAFB and became known as South VAFB. The transfer actually occurred in two phases, with the NMFPA first in 1964. On 1 February 1965, the Pacific Missile Range assets were trans-

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[50] Jeffrey Geiger and Jan Kays, *Vandenberg 1958-2008*, (Vandenberg Air Force Base: 30th Space Wing, 2008), 12. The same service was provided for the Gemini and Apollo manned missions.

[51] Warren S. Howard, *History of the 1st Strategic Aerospace Division and Vandenberg Air Force Base*, *1962-63*, (Vandenberg Air Force Base, California: Historical Division, Directorate of Information, 1st Strategic Aerospace Division, February 1964), 21.

[52] "New Rocket Base Unveiled by Navy," *Navy Press*, 4 April 1960, in vertical file: California - Lompoc - Point Arguello Missile Facility, at U.S. Navy CEC/Seabee Museum, Port Hueneme, California.

[53] The day following this announcement, President John F. Kennedy mentioned in several speeches the need for the United States to be technologically advanced and "second to none" in defense and in space. These were among his last public remarks as he was assassinated later that day (22 November 1963) in Dallas, TX.

[54] Geiger and Kays, *Vandenberg 1958-2008*, 15; *SECNAV Notice 5450*, in vertical file: California - Lompoc - Point Arguello Missile Facility, at U.S. Navy CEC/Seabee Museum, Port Hueneme, California, (Washington, DC: Department of the Navy, 19 May 1964).

ferred to the Air Force Western Test Range (AFWTR) which took responsibility for the intercontinental ballistic missile and space vehicle support functions.[55]

Establishment of Vandenberg Air Force Base

When the Atlas and Thor programs received top national priority, the Air Force initiated the construction of launch complexes in preparation for the research and development portion of those programs. As research and development facilities, the complexes constructed at Cape Canaveral did not resemble the type of operational launch complexes that would be practical at field missile bases. Operational launch facilities needed to be less vulnerable to enemy attack while at the same time allowing for a quick launch reaction time. Since research and development facilities were not designed for this purpose, the Air Force began in 1956 to search for a site where missiles and their supporting ground equipment could be developed and tested under favorable operational conditions. The Air Force also wanted a base where missile combat and maintenance crews could be trained. A special site selection board evaluated nearly 200 sites before recommending Camp Cooke in June 1956.

Camp Cooke, used by the Army during World War II to train armored, infantry, anti-aircraft artillery, combat engineer, and ordnance units, was an ideal location for an operational missile testing installation. Its advantages included its size, remoteness, year-round fair weather, access to an ocean for use as a test range, proximity to the aerospace industry of southern California, and its existing military infrastructure.[56] Camp Cooke also had another important feature. Its unique geographic siting is the only location in the United States that offers a direct and safe flight path for polar-orbiting satellites. This had important implications for the U.S. military space program as most surveillance and reconnaissance satellites require a polar flight path to provide optimum coverage of the earth.

In 1957, the Secretary of Defense directed the Army to transfer the northern 65,000 acres of Camp Cooke to the Air Force. The Air Force subsequently redesignated Camp Cooke as Cooke

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[55] Geiger and Kays, *Vandenberg 1958-2008*, 16.

[56] Versar, Inc., *A Historical Significance Assessment and Effects Determination of Space Launch Complex 3, Vandenberg Air Force Base, California*, (Columbia, Maryland: Versar, Inc., 1992), 3-12.

Air Force Base. The Army transferred the remaining southern portion of the former Camp Cooke to the Navy in 1958.[57]

The mission of the new west coast missile facility was to provide training for ballistic missile units, support operational weapon system testing, and serve as a temporary operational ICBM base until others became operational. Supporting space launches was a secondary mission of the installation.[58] The Air Force's Air Research and Development Command (ARDC) and Strategic Air Command (SAC) shared responsibility for conducting ballistic missile and space launches.

ARDC, later known as Air Force Systems Command (AFSC), initially managed Cooke Air Force Base. ARDC established the 392nd Air Base Group in April 1957. In the following months, the Air Force activated the 704th Strategic Missile Wing and 1st Missile Division and assigned them to Cooke Air Force Base. The 1st Missile Division, later renamed the 1st Strategic Aerospace Division (1Strad), was responsible for training missile launch crews, supporting test launches, and maintaining tactical ballistic missile capabilities. When SAC took over as base host in January 1958, it acquired the three ARDC base organizations.

Later that year, the Air Force Ballistic Missile Division (AFBMD), a division of ARDC, established a field office at Cooke Air Force Base. The AFBMD eventually evolved into the 6565th Test Wing (Ballistic Missiles and Space Systems), which supported ballistic missile test launches and the space program.[59]

Ground-breaking activities at the new missile center began in May 1957. The Air Force committed over $178 million for initial improvements to the installation. Over $120 million went toward the construction of launch complexes while more than $32 million was spent on repairs and modifications to base support buildings and an airfield.[60]

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[57] Geiger and Kays, *Vandenberg 1958-2008*, 5-6.

[58] William S. Reed, "Vandenberg Trains USAF Missile Crews," *Aviation Week*, 26 October 1959, 69.

[59] Dames & Moore, Inc., *Request for Determination of Eligibility. Atlas 576 G, Vandenberg Air Force Base, California*, (Austin, TX: Dames & Moore, Inc., 1993), 4; Jeffrey Geiger, *The Heritage of Vandenberg Air Force Base*, (Vandenberg Air Force Base, California: 30th Space Wing History Office, n.d.).

[60] Versar, *Historical Significance Assessments and Effects Determination*, 3-13.

The Army Corps of Engineers was the supervising construction agency responsible for converting the former Camp Cooke into a modern missile and space center. The Corps of Engineers worked closely with the AFBMD at Inglewood, California, and with civilian contractors, to rapidly complete missile and support facilities at the new Cooke Air Force Base.[61] Initial construction at what is now referred to as North VAFB included seven Thor pads and six Atlas pads. By mid 1966, the Corps of Engineers had overseen the construction of eleven Atlas pads, four Titan I silos, three Titan II silos, and fourteen Minuteman silos at North VAFB (Figure 2).

As Cooke Air Force Base prepared for its new mission, the Air Force decided to rename the installation in honor of General Hoyt S. Vandenberg. General Vandenberg had been an early proponent of aerospace readiness and had served as the Air Force's second Chief of Staff. Since his death in 1954, the Air Force had been waiting for the opening of a base sufficiently important to bear his name. Formal dedication ceremonies held on 5 October 1958, officially redesignated the installation as Vandenberg Air Force Base.[62]

VAFB increased in size by 20,000 acres in 1964 when the Navy transferred the Naval Missile Facility at Point Arguello (NMFPA) to the Air Force, which became known as South VAFB. At the time of the transfer, the Air Force also assumed responsibility for the Pacific Missile Range, renaming it the Western Test Range.[63] South VAFB itself increased in size by approximately 15,000 acres in 1968 with the Sudden Ranch purchase.[64]

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[61] The Corps of Engineers was responsible for the 'brick and mortar" part of the launch complexes at VAFB (e.g., the construction of gantries, silos, and other technical facilities). Individual contractors and, in some cases, Air Force personnel installed the instrumentation at new launch facilities.

[62] Berger and Howard, *History of the 1st Strategic Aerospace Division*, 13.

[63] The organizational arrangement of the Western Test Range (WTR) changed several times over the years. In 1970 the WTR was inactivated and its function absorbed by the newly created Space and Missile Test Center (SAMTEC). The 6595th Aerospace Test Wing (ATW) was assigned to SAMTEC. SAMTEC and the 6595th were subsequently inactivated in 1979 with some elements of the 6595th reassigned to the newly created Western Space and Missile Center (WSMC). Several other command and name changes occurred over the next few years. Today the range is known as the Western Range (ITT Federal Services Corporation, *Landbased Instrumentation Handbook*. 30th Range Squadron, Vandenberg Air Force Base, 1994, 1-3, 4).

[64] Dames & Moore, Inc., *Request for Determination of Eligibility*. Atlas 576 G, 5.

THE SCOUT PROGRAM

The increasing success rates of the first decade of post-war rocketry research inspired scientists and engineers to design and plan satellite launch systems. The desire for a quick, reliable, and cost effective launch vehicle would eventually become reality with the Scout program. Designed for light payloads delivered to both probe and orbital trajectories, the Scout program had its conceptual beginnings in 1956 at the Pilotless Aircraft Research Division (PARD) of National Advisory Committee for Aeronautics (NACA) at the Langley Aeronautical Laboratory in Maryland.

The engineers at PARD had been utilizing rockets to gather aeronautical data useful in supersonic aircraft and rocket nose cone design, including high-velocity performance and material heating.[65] Langley had a research facility on Wallops Island, off the Virginia coast, where these rockets had been launched for years. With the 1955 announcement by the IGY organizers pushing for the first launch of an artificial satellite, and the subsequent installation of satellite launch programs in the United States and the Soviet Union, the idea of launching satellites seemed appropriate and possible to a core group of four PARD engineers at Wallops Island. Pooling their previous experience launching multi-stage rockets, and research on solid-fuel rockets, William E. Stoney, Jr., Robert O. Piland, Max Faget, and Joseph G. Thibodaux, Jr. began discussing ways to launch a light-weight payload into orbit.[66]

By 1957, they were investigating the ability of a solid-fueled, four-stage vehicle composed of existing motors to reach orbital velocity with a small payload. Although NACA informed the group in early 1958 that the launch capability provided by the Jupiter C, Vanguard, and Thor-Able were sufficient and their launch vehicle was not needed, this position abruptly changed.[67] As plans for the much larger, more ambitious NASA organization began to shape up, NACA Headquarters requested a Space Technology Program for the new agency from Langley. The March 1958 request was fulfilled on 15 May with a report that included the PARD rocket as a program component. Intended for "the investigation of manned space flight and reentry prob-

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[65] J.D. Hunley, *U.S. Space-Launch Vehicle Technology: Viking to Space Shuttle*, (Gainesville: University of Florida Press, 2008), 128; Matt Bille, et al., *History and Development of U.S. Small Launch Vehicles*,", 204; James R. Hansen, *Spaceflight Revolution: NASA Langley Research Center from Sputnik to Apollo*, (Washington, DC: National Aeronautics and Space Administration, 1995), 197.

[66] Hansen, *Spaceflight Revolution*, 197-198.

[67] Hunley, *U.S. Space-Launch Vehicle Technology*, 128-129.

lems," the report promoted the booster as a means to launch small recoverable payloads into orbit and stated a quick development period costing $4 million.[68]

Early Launch Vehicle Design

Optimistic of approval for the program, Langley officials had asked for a research authorization on 6 May, and provided specific objectives of "the investigation of a four-stage solid-fuel satellite system capable of launching a 150-pound satellite in a 500-mile orbit."[69] Approval and first developmental funding (from NASA's Office of Space Flight Development) resulted in five contracts by early 1959 for Scout system components.[70] The contractors and their products/characteristics are listed below and in Table 1.[71]

(1) Aerojet General Corporation, Sacramento, CA
1st Stage: Algol I or Aerojet Senior motor (combination of Jupiter Senior and Polaris)

(2) Thiokol Company (Redstone Division), Huntsville, AL
2nd Stage: Castor I motor (derived from the Sergeant)

(3) Hercules' Allegany Ballistics Laboratory (ABL), Hercules Powder Company, Cumberland, MD
3rd Stage: Antares I or X254 (enlarged X248 motor) 4th Stage: Altair I or X248

(4) Minneapolis-Honeywell, Minneapolis, MN
Guidance and Control System

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[68] Hansen, *Spaceflight Revolution*, 199.

[69] Ibid.

[70] William Stoney (the first Scout project manager) named the vehicle "Scout" to show an association with the contemporary Explorer satellites. Only later was the name made into an acronym for "Solid Controlled Orbital Utility Test System" (Hansen, *Spaceflight Revolution*, 200, 202).

[71] Hunley, *U.S. Space-Launch Vehicle Technology*, 129-132; Hansen, *Spaceflight Revolution*, 200-201. NASA renamed each motor for a star (Bille, et al., "History and Development of U.S. Small Launch Vehicles," 205).

(5) Chance Vought Corporation, Dallas, TX
Airframe and Launcher

Table 1. Characteristics of Various Stages of the Initial Scout Vehicle.

Motor Designation			Ignition Weight (lb)	Thrust (lb)	Burn Time (sec)	Diameter incl. Outer Fairing (in.)	Length (ft)
Stage	Manufacturer	NASA					
1	Aerojet-Senior	Algol	23,600	103,000	40	40.0	30.8
2	Thiokol-XM-33-20-4	Castor	9,600	62,000	27	31.0	20.7
3	ABL-X-254	Antar-es	2,700	13,600	39	30.6	11.1
4	ABL-X-258-A5	Altair	525	2,800	38	25.7	8.3

Source: Jack Posner, "Technical Report R-97: Considerations Affecting Satellite and Space Probe Research with Emphasis on the "Scout" as a Launch Vehicle," (Washington, D.C.: NASA, 1961).

All motors for the booster were solid-fueled, and this was one of the most innovative aspects of the Scout program because it was the first totally solid-fuel satellite launch vehicle in operational service. Solid-fuel rockets were not new, and they had distinct advantages in ease of propellant storage and pre-launch preparation, and a relatively simple design compared to liquid-fueled rockets. The big drawback to performance was the amount of energy they produced; their use was precluded when large amounts of thrust were needed. In the late 1940s and 1950s, significant progress was made to increase the energy output of solid-fueled rockets. Work by the Thiokol Company produced the Army's Hermes A-2, and work with the Jet Propulsion Laboratory (JPL) produced a more powerful Sergeant motor which in a smaller version was used as upper stages for both Juno and Jupiter. Thiokol later used the same technology to great success in the Minuteman family of ICBMs and produced development solid-fuel motors for the Navy's Polaris missile.[72]

The use of existing motors (or upgraded versions) resulted in a quick design and production period for the initial booster, and the contractors began delivering components by early 1960 (Figure 3). The stages were joined together by the Chance Vought Corporation airframe transition sections which contained "ignition, guidance and attitude controls, spin-up motors, and separation systems."[73] The Minneapolis-Honeywell guidance system used a "strapped-down inertial reference package with miniature integrating rate gyros detecting deviations from the pro-

[72] Bille et al., "History and Development of U.S. Small Launch Vehicles," 201, 204.

[73] Hansen, *Spaceflight Revolution*, 201.

grammed path and initiating error signals proportional to the variances in pitch, yaw, and roll."[74] The guidance and control system was housed in a transition section between the third and forth stages. The system allowed pitch angle control to be set for specific launch requirements. This supplemented the Scout's ability to utilize a launch position up to 20 degrees from vertical.[75] First-stage control came primarily from jet vanes in the rocket exhaust, with some additional control from four fins with control surfaces on the tips. For the second and third stages, hydrogen peroxide-powered motors provided control over pitch, roll, and yaw. The 90 percent hydrogen peroxide fuel for these motors was provided by a compressed nitrogen feed. When needed, hydrogen peroxide was released through four valves. A silver catalyst reacted with the hydrogen peroxide turning it to steam, thus providing the thrust necessary to initiate any course corrections. The fourth stage contained small motors to provide enough spin for stability, and was released from the third stage by a set of explosive bolts and springs.[76]

The airframe and launcher contract to Chance Vought Corporation initially provided the launcher and four airframes at a fixed price cost of $1,069,300. Follow-on contracts also eventually resulted in Chance Vought quickly becoming the contractor (under Langley Research Center management) responsible for running Scout systems management and motor procurement programs.[77] This partnership was particularly successful, and continued with a high degree of cooperation until January 1991, when the Scout program transferred from Langley to Goddard Space Flight Center, and commercial Scout production passed to LTV Corporation (formerly Ling-Temco-Vought).[78] Airframe sections were made primarily of thin aluminum skins with internal stiffening or a fiberglass material, as opposed to standard convention of heavy magnesium sections.[79] This saved considerable weight, resulting in cost savings during transport and launch.

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[74] Hunley, *U.S. Space-Launch Vehicle Technology*, 131.

[75] Ibid.

[76] Hunley, *U.S. Space-Launch Vehicle Technology*, 131, 135; Patrick Nowlan, et.al., *Cold War Properties Evaluation - Phase I: Inventory and Evaluation of Launch Complexes and Related Facilities at Vandenberg Air Force Base, California*, (Champaign, IL: U.S. Army Construction Engineering Research Laboratories, 1996), 160.

[77] Hunley, *U.S. Space-Launch Vehicle Technology*, 132.

[78] Hansen, *Spaceflight Revolution*, 203; Hunley, *U.S. Space-Launch Vehicle Technology*, 132. LTV became the new corporate name in 1991 for the former Chance Vought.

[79] Hunley, *U.S. Space-Launch Vehicle Technology*, 133.

Scout Program Developments

A formal Scout Project Group was established at Langley in February 1960, with nine people reporting to the newly established NASA Office of Launch Vehicle Programs.[80] The project quickly took off, with over 200 Langley personnel employed on Scout by 1962. The Scout program grew to become the main activity at the Wallops Island facility. The first launch was scheduled for October 1959, but developmental problems with the X254 third-stage motor and delays in testing the airframe, heat shields, and reaction control system pushed back the launch date. Anxious to get launch testing underway, NASA and Langley agreed that a partial or "Cub" Scout could be launched to gather data. The unofficial (and therefore, not listed) test on 18 April 1960 utilized live first and third stages, dummy second and fourth stages, and no control system. The results, predictably, were not positive with a structural failure and loss of the heat shield.[81]

Problems were corrected and the first of nine developmental flights occurred on 1 July 1960 at the Wallops Flight Facility (WFF). The full configuration Scout (named ST-1 for Scout Test 1) was expected to launch a Langley-designed 193-pound payload containing measurement instruments. After an eleven-hour countdown, the first-stage motor performed as expected, but the tracking radar reported a problem with the vehicle going significantly off course. As a result, the safety officer was forced to keep the fourth stage from firing and when the radar signal proved false, the stage could not be ignited. As with any new program, however, good starts are very important, and the launch was classified a success, as the fourth stage technically did not fail and some radiation experiment data were obtained.[82]

A truer measure of success arrived with the launch of ST-2 on 4 October 1960. On a probe trajectory, carrying an Air Force Special Weapons Center radiation payload, the Scout flew 5,800 miles downrange. The next launch (ST-3) attempted to put a payload into orbit, but had a motor failure. ST-4 on 16 February became the first entirely solid-propellant launch vehicle to orbit a payload and the first orbital flight from WFF. That payload, designated Explorer 9, was an inflatable sphere for measuring atmospheric density.[83] The Explorer 9 payload was indicative of NASA's attitude toward the Scout - although the first nine flights were considered tests, they

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[80] Hansen, *Spaceflight Revolution*, 202. By the time it peaked in 1965, the core project team had 55 members.

[81] Hansen, *Spaceflight Revolution*, 205.

[82] Hansen, *Spaceflight Revolution*, 209; Hunley, *U.S. Space-Launch Vehicle Technology*, 134.

[83] Hunley, *U.S. Space-Launch Vehicle Technology*, 134.

were given operational payloads to make the most of success. Three types of missions were identified for the Scout: “placing small satellites into orbit, making high-velocity reentry studies and testing heat-resistant materials, and launching high-altitude and space probes.”[84]

The remaining test flights were a mixture of two failures and three successes, with one of the successes being ST-8 which gathered data on reentry heating which was subsequently used in the manned space program. On 29 March 1962, ST-9 successfully tested the Antares II motor, signifying a shift from the original configuration (designated X-1) to the second or X-2 version. The new third-stage motor provided more thrust, thereby increasing payload capacity. This happened with every iteration of the vehicle (see Table 2). Version changes over time largely resulted from improved motors; the basic design of the Scout remained nearly constant (see Table 3).

Table 2. Growth in Scout Orbital Capabilities.

Year	Vehicle Designation	Payload Capability in Pounds* (*in a 300-nautical mile circular orbit)		
		Easterly	Polar	Equatorial
1960	X-1	131	99	n/a
1962	X-2	168	130	n/a
1963	X-3	193	149	n/a
1964	X-4	228	177	n/a
1965	A-1	268	208	n/a
1966	B-1	315	255	332
1972	D-1	408	327	436
1974	F-1	425	344	448
1979	G-1	458	367	486

Source: “100 Scout Launches: 1960-1979,” Booklet for 100th Launch Celebration, Williamsburg, 27 July 1979, from the collection of Harry Brown, Lompoc, California.

Table 3. Scout Vehicle Evolution.

Designation / Year Introduced	Stage 1	Stage 2	Stage 3	Stage 4
X-1 / 1960	Algol 1C	Castor I	Antares I	Altair I
X-2 / 1962	Algol 1D	Castor I	Antares II	Altair I
X-3 / 1963	Algol IIA	Castor I	Antares II	Altair I
X-4 / 1964	Algol IIB	Castor I	Antares II	Altair II
A-1 / 1965	Algol IIB	Castor II	Antares II	Altair II

[84] Hansen, *Spaceflight Revolution*, 210.

Designation / Year Introduced	**Stage 1**	**Stage 2**	**Stage 3**	**Stage 4**
B-1 / 1965	Algol IIB	Castor IIA	Antares IIA	Altair IIIA
D-1 / 1972	Algol IIIA	Castor IIA	Antares IIA	Altair IIIA
F-1 / 1974	Algol IIIA	Castor IIA	Antares IIB	Altair IIIA
G-1 / 1979	Algol IIIA	Castor IIA	Antares IIIA	Altair IIIA

Source: "100 Scout Launches: 1960-1979," Booklet for 100th Launch Celebration, Williamsburg, 27 July 1979, from the collection of Harry Brown, Lompoc, California.

The increases in payload capability and motor performance were accomplished by design to require minimal change to the other vehicle components. This process served to keep modification costs down, to preserve systems that were functioning successfully, and to reduce impacts to mission timelines.[85]

Growing Pains and Program-Wide Review

The fledgling Scout program was on a tight time frame with launches following each other as rapidly as possible. With any new system, time pressure tends to exacerbate other problems. Within a few years, failures were outnumbering successful launches. A number of problems with electrical system components prompted modifications resulting in an ignition system upgrade, an improved heat shield design, and a refurbished wiring system by December 1962.[86] Concerns with performance were allayed slightly with a series of successful launches, but then, a spectacular failure at Wallops on 20 July 1963 forced management to realize that the program needed to be reevaluated. During that failed flight, the Algol IIA first stage was engulfed in flames within the first five seconds of the flight, due to a burn-through of the first stage nozzle. The vehicle reached approximately 300 feet elevation before disintegrating and showering the launch area with flaming debris.[87]

In the aftermath of that failure, NASA halted all Scout launches and began a formal investigation. The review committee focused not only on the ill-fated S-110 flight, but also on the program as a whole including all failures and Scout subsystems. Results indicated different causes

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[85] L. R. Foster and R. G. Urash, "The Scout Launch Vehicle Program," in *The Year of the Shuttle: Proceedings of the Eighteenth Space Congress,* (Cocoa Beach, FL: Canaveral Council of Technical Societies, 1981), 6-50.

[86] Hunley, *U.S. Space-Launch Vehicle Technology*, 146.

[87] Hansen, *Spaceflight Revolution*, 211.

for each failure, leading to the conclusion that the entire program needed to be rethought and improved. One of the primary problems was a lack of common practices and procedures among the various players regarding handling of the vehicles. For example, assembly checkout lines used different equipment and procedures at LTV Corporation's Dallas plant, at Wallops, and at VAFB (both on the ground and in the launchers).[88] There was a distinct need for standardization across various areas of the program.

In a determined shift from speed to reliability for the Scout program, a stringent quality control system was put in place. A fourteen-month effort to improve reliability involved personnel from NASA, LTV, and the Air Force. LTV began procuring the motors directly instead of through NASA, then assembled the launch vehicles, and sent them complete to the launch sites. Teams composed of manufacturing and launch personnel accompanied the vehicles. For existing vehicles, a program to recertify all twenty-seven in stock began when the Scouts returned to the LTV plant where they were disassembled and inspected, refurbished, and recertified. Manuals and specifications were written that standardized equipment and procedures. Steps then were taken to insure compliance with new methods.[89]

The program review and vehicle recertification program led to a vastly improved Scout operational management situation that was reflected by a jump in mission success rates. Beginning with the first post-review launch on 19 December 1963, the next three years saw twenty-six launches with only one failure. Groundwork for the Scout's well-deserved reputation for reliability and success was laid in response to early program failures, and that reputation continued to increase throughout the life of the program.

The use of existing hardware and determined efforts to keep the technology as simple as possible continued throughout the program. The Scout utilized technology that remained basically unchanged since the late 1950s. The vehicle's heat shield and fins were insulated with cork, and its guidance system used simple gyros that could not be reprogrammed after launch (most modern boosters are guided by computers). NASA considered developing a computerized guidance system for the Scout in the 1970s but since the Scout performed so well already, it was deemed not to be worth the effort. Even the Scout launch preparation techniques, though strictly standard-

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[88] Ibid., 213.

[89] Hansen, *Spaceflight Revolution*, 214-215; Hunley, *U.S. Space-Launch Vehicle Technology*, 149.

ized, remained relatively primitive compared to the pre-launch activities for other space boosters; the procedures utilized tried and true tools such as oscilloscopes and even vacuum tubes.[90]

This reliability encouraged other users to procure Scouts. By the mid 1970s, ninety-two Scouts had been launched, with fifty-four paid for by NASA. The second largest user was the U.S. Navy which bought nineteen Scouts, followed by the U.S. Air Force which funded fourteen. The remaining five were purchased by the Atomic Energy Commission or various European agencies.[91]

Permanent Scout Launch Sites

As stated earlier, the original launch site for the Scout vehicle was at the NASA Wallops Flight Center, Wallops Island. Launched due east, the Wallops facility originally provided orbital inclinations only between 37.7 degrees and 51.5 degrees, due to range safety limitations. The launch shelter was similar to the building at VAFB, but the launcher itself was originally a different design. Instead of assembling the vehicle components horizontally, the initial system at Wallops Island required the Scout to be assembled vertically by crane (Figure 4 and Figure 5). The launcher was a more substantial structure that wrapped around the Scout to provide the necessary work platforms for the component integration. Sometime during 1964–1966, the system in effect at VAFB was installed at Wallops Island, leading to identical launchers and assembly procedures. The last Scout launch from Wallops Island was 12 December 1985.

To meet a NASA and DoD need for polar trajectory launches, a second Scout launch complex was completed at NMFPA in 1962 (Figure 6). Subsequently, that site became part of VAFB in 1964. The site's location enabled launches to achieve both polar and sun-synchronous orbits and provided an inclination range of 75.5–146 degrees. DoD involvement in the Scout program increased with the availability of the NMFPA/VAFB launch site. The number of military payloads increased, particularly Air Force and Navy satellites. VAFB personnel of the 6595th Aerospace Test Wing (ATW) conducted the early launches, from receiving the launcher components to running the countdown in the blockhouse (Figure 7). Several NASA and Vought personnel supplemented the Air Force team, providing liaison with their organizations' offices and with the Wallops Vought launch crew.[92] The VAFB site was utilized for Scout launches through May 1994.

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[90] Joseph A. Harriss, "Get 'em Up Scout," *Air & Space*, March 1989, 84.

[91] Hunley, *U.S. Space-Launch Vehicle Technology*, 149.

[92] Foster and Urash, "The Scout Launch Vehicle Program," 6-49.

In order to have a site capable of placing a satellite in near-equatorial orbit, NASA Langley provided Scout launch vehicles, beginning in April 1967, for use on an Italian launch platform located off the Kenyan coast in a place called Ngwana Bay. Utilizing this location provided the Scout with an inclination range of 2.9–38.5 degrees. This international effort was part of a cooperative agreement between the United States and Italy, with the concept originating at the Italian Centro Ricerche Aerospaziali of the University of Rome. Italian Space Agency personnel served as the launch crew, in cooperation with NASA. The launch facility, known as San Marco, consisted of two large mobile platforms, one for the blockhouse and operations, and one for the launcher (Figure 8 and Figure 9). The platforms were converted from oil rigs. The Italian space program launching the Scout from the San Marco platforms was very popular in Italy, even being blessed by Pope Paul VI, who called it an "example of international cooperation for the progress of science."[93] A total of nine Scout launches provided equatorial orbits for Italian, British, and American spacecraft measuring radiation, x-rays, and atmospheric elements.[94] Payloads were launched from the platform for the U.S., Italian, and the United Kingdom. Most of the San Marco launches were in the early 1970s. The final San Marco facility Scout launch occurred on 25 March 1988 after a long period of inactivity; the most recent previous launch had been 15 October 1974.[95]

The availability of the three spatially distinct launch sites provided Scout with a unique capability. Except for a few narrow bands, any orbital inclination was available to Scout users by selecting the appropriate launch site. In addition, the vehicle itself could be maneuvered several degrees in the yaw plane to provide additional inclination coverage. Combined with the vehicle's capability for either orbital, probe, or re-entry trajectories, the Scout offered customers with small payloads a truly wide variety of options.

Scientific Achievements of the Scout Program

The payloads carried aloft by the launch vehicle expanded knowledge in many fields of scientific endeavor. Some of the more prominent missions included atmospheric density studies, investigation of the Van Allen belts, and an exploration of Einstein's theory of relativity. The Scout vehicle often was utilized for placing satellites in orbit, serving the needs of NASA, the DoD, and

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[93] Harriss, "Get 'em Up Scout," 84.

[94] Hansen, *Spaceflight Revolution*, 217; Foster and Urash, "The Scout Launch Vehicle Program," 6-50.

[95] "Farewell, Scout," *Missileer* (Special Edition), 26 May 1994, 8-9.

some commercial interests. Communication and navigation satellites were among the most numerous of the Scout-launched orbiting hardware.[96]

Discoveries were made when Scout missions found new x-ray sources and quasars. A particularly noteworthy discovery was confirmation of the existence of black holes, made by the Small Astronomy Satellite series. Other missions investigated the effects of aerosol contamination of the atmosphere and mapped the Earth's magnetic field.[97]

Transit satellites placed into orbit by the Scout for the Navy were a series of navigation satellites that initially provided submarines with precise longitude and latitude readings to accurately aim their submarine-launched ballistic missiles. Eventually, Transit satellite data became available to anyone who could purchase the relatively inexpensive equipment needed to receive the data. More than 80,000 users worldwide, including numerous military and civilian ocean-going vessels, took advantage of the Transit satellites' ability to give a precise fix anywhere in the world.[98] Additionally, the Transit satellites were utilized to provide accurate location data for off-shore oil exploration before drilling began.[99]

Scout missions played a role in several NASA programs, including the manned space program. Measurements were taken of phenomena that could impact spacecraft, such as micrometeoroids. Several reentry tests were invaluable in determining the heat resistance of various materials. There was even one live payload; two bullfrogs were orbited by a Scout for experiments hoping to understand the causes of space sickness. All of these missions contributed to the success of the Mercury, Gemini, and Apollo programs.[100]

There were also Scout launches for the European Space Agency.[101] In addition to its work for NASA and DoD, the Scout system is also lauded for ushering in an international approach to small launch systems. Over its 33 years, the Scout was utilized to launch 23 satellites for foreign countries, including Japan, the United Kingdom, Germany, France, Netherlands, and Italy

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[96] Hansen, *Spaceflight Revolution*, 216.

[97] Foster and Urash, "The Scout Launch Vehicle Program," 6-50.

[98] "Rocket for All Reasons," *Air & Space*, February/March 1989, 82.

[99] Foster and Urash, "The Scout Launch Vehicle Program," 6-50.

[100]Ibid.

[101]Hansen, *Spaceflight Revolution*, 216.

(Figure 10 and Figure 11). The Scout was also used by the European Space Research Organization. Launches with payloads for these international users took place from all three Scout launch areas, VAFB, WFF, and the San Marco platform.[102]

In the case of San Marco launches, U.S. Scout advisors would travel to the launch site. Prior to this, however, personnel from the payload-owning country would come to U.S. launch sites to assist with the launches. The 15 December 1964 launch of the San Marco I satellite marked the first time that a NASA launch had been conducted by a team composed of foreign nationals. For that launch, the Wallops Island launch team consisted of seventy-five Italians that had been trained by NASA in the United States.

Closeout of the Scout Program

After several decades of successful service, the Scout program was threatened with obsolescence as plans for the Space Shuttle (formally known as the Space Transportation System, or STS) expanded in the late 1970s and early 1980s. This new system was proposed for all launch activities to eliminate the need for expendable launch systems. DoD also planned to utilize the Shuttle for launching most of its satellites. As a result, Scout launches nearly ceased in the early 1980s, and at one point, it was intended that the last Scout launch should take place in 1983. The Shuttle program, however, was experiencing budget delays and Scout launches continued. After the tragic Space Shuttle Challenger disaster in January 1986, NASA and the Department of Defense decided to maintain a mixed fleet of expendable space boosters to complement its Space Shuttle fleet.[103]

There was simultaneously a push across the government to downsize and to put certain activities into private hands. The Reagan administration desired to commercialize space activities in this way. Several agencies, including NASA and the Defense Advanced Research Project Agency (DARPA), began accepting proposals in the late 1980s from companies that could provide launch vehicles for small scientific and application satellite missions.[104] The LTV Corporation hoped Scout launches would continue to be used for small payload missions through the 1990s. Historically, the Scout did not have much competition for these types of launches. Several companies, however, began developing small boosters to compete with the Scout. Newly-developed

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[102] Bille, et al., "History and Development of U.S. Small Launch Vehicles," 205.

[103] Nowlan, et.al, *Cold War Properties Evaluation - Phase I: Inventory and Evaluation*, 131.

[104] Hansen, *Spaceflight Revolution*, 219.

space vehicles, such as the Orbital Sciences Corporation's air-launched Pegasus, offered higher launch capacities at less cost. The Pegasus was a successful entry into the field, and, at the time of this report, continues to place small payloads into low earth orbit.

Despite a plan to develop a new Scout vehicle with a heavier payload capacity (designated Eagle Scout or Scout 2), the Scout program fell victim to the combined challenges of a newly competitive light space booster market and a simultaneous decrease in DoD and NASA funding. Plans were drawn up for phasing out the program, beginning with management of the Scout program being transferred from NASA Langley to NASA Goddard on 1 January 1991. This was part of a larger NASA reorganization and consolidation of launch vehicle contracts. Signaling the end of the program, the final Scout launched from VAFB on 8 May 1994 (Figure 12) (see Appendix A for a complete list of Scout launches and missions). By this time, an enviable record of 104 successes out of 118 launches for the NASA Scout insured its place as "a government-driven version for rockets of Henry Ford's mass production…a launch vehicle that was as reliable for a trip to space as an automobile was for a trip to town."[105]

Blue Scout

The Air Force was interested very early in the Scout program, as it would provide a useful launch vehicle for Air Force missions. Negotiations had begun with NACA and continued with NASA, resulting in a memorandum of understanding on 31 October 1958. Under the terms of the agreement, NASA would provide Scout boosters for DoD purposes, with some military modifications done by the Air Force. Officially, the Air Force Scout program was called the Hyper Environmental Test System (HETS) or System 609A. Informally, it became known as the Blue Scout Program (for Air Force blue), and the vehicle varieties that emerged from this program were known as the Blue Scout family of launch vehicles (Figure 13). Management for this joint program rested with a new NASA–Air Force Scout Coordinating Committee, which assigned primary Blue Scout development to the Air Force Ballistic Missile Division.[106]

The first order from the Air Force was for ten (reduced to nine) Blue Scouts, acquired by amending NASA contracts. The prime contractor for the NASA Scout was LTV, but the Blue Scout prime contractor was Ford Aeronutronics. Concurrently with the NASA launches, the Blue Scout

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[105] Hansen, *Spaceflight Revolution*, 219.

[106] Oversight was transferred to the Space Systems Division on 1 April 1961 (Hunley, *U.S. Space-Launch Vehicle Technology*, 144).

underwent developmental testing in 1960 and 1961.[107] The Blue Scout program then moved on to the operational phase. Prior to 1970, Air Force personnel were responsible for launching Blue Scouts. On 10 January 1970, an agreement was signed between DoD and NASA that provided for NASA to contract for both NASA and DoD Scout launches from VAFB.[108] Although most launches occurred in the early and mid 1960s, the Air Force continued to fly Blue Scouts into the 1970s.

Modifications for the Air Force version included thicker walls and more mounting studs for the third and fourth stages to support heavier payloads.[109] These changes resulted in a set of different configurations named Blue Scout I, Blue Scout 2, and Blue Scout Junior. These launch vehicles underwent developmental testing primarily at Cape Canaveral.

Blue Scout Junior led the way and was mostly a four-stage (sometimes three-stage depending on the mission) vehicle with the NASA Scout Castor I as the first stage, Antares I as the second stage, an Aerojet Alcor as third stage, and a fourth stage powered by a Naval Ordnance Test Station (NOTS) model 100A motor. When used as a three-stage vehicle, the fourth stage simply was omitted. There was no guidance and control system, instead utilizing fins on the lower stages and spin-stabilization on the upper stages. The initial test flight from Complex 18, Cape Canaveral on 21 September 1960 accomplished most objectives, but the payload did not function. The second launch failed when it exploded sixty-two seconds into flight.[110] Overall, twenty-five Blue Scout Juniors were launched from WFF, VAFB/NMFPA, and Cape Canaveral, all on suborbital flights (Figure 14).

By May 1961, discussions were occurring between NASA and the Air Force to have joint facilities at NMFPA/VAFB for Scout and Blue Scout operations.[111] Eleven Scout Juniors were fired from VAFB/NMFPA, all but one from Point Arguello Launch Complex A (PALC-A) from 4 De-

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[107] Hunley, *U.S. Space-Launch Vehicle Technology*, 139; “Scout,” http://www.astronautix.com/lvs/scout.htm.

[108] Hunley, *U.S. Space-Launch Vehicle Technology*, 144.

[109] Ibid., 139.

[110] Hunley, *U.S. Space-Launch Vehicle Technology*, 139, 141-142.

[111] U.S. Air Force, Blue Scout Directorate, “Blue Scout Chronology, 1956-1961,” in vertical file: Blue Scout Chronology, at USAF Missile and Space Center Headquarters History Office, Los Angeles, California, entry 5 May 1961.

cember 1961 to 21 December 1964. The exception was a launch on 17 December 1963 from launch pad 4300-C (Building 1681).[112]

The developmental flights at Cape Canaveral were launched by personnel of the 6555th Test Wing, and the VAFB launches were conducted by members of the 6595th ATW.[113] When the last one was fired on 24 November 1970, the launch vehicle had an 88 percent success rate. Differences between the Blue Scout Junior and the larger Scout, coupled with the nearly exclusive Air Force use of the Junior version led to a 1962 decision by NASA and the Air Force that Blue Scout Juniors would be procured by the Air Force directly through Chance Vought. The first direct order under this process was for seven Blue Scout Juniors.[114]

One of the more important early missions for the Blue Scout program was testing and operationalizing of SAC's Emergency Rocket Communications System (ERCS). The ERCS program (codename Project Beanstalk) was an effort to ensure communication capability for transmitting command and control messages to SAC's manned bomber fleet during defense emergency situations. The ERCS system was produced by Allied Signal Aerospace Communications Systems, and contained two ultrahigh frequency (UHF) transmitters launched high into the atmosphere. The transmitters "carried prerecorded force execution messages that were transmitted to all units within line-of-sight of a rocket's apogee."[115] Also known as Air Force Program 279L, the Blue Scout Junior vehicle was used for the interim launch vehicle, until the Minuteman II missile could be utilized for this purpose. Testing on a Blue Scout Junior ERCS launch was initiated on 31 May 1962, and by July 1963, the Blue Scout Junior ERCS was operational with three launch sites in Nebraska. By October 1967, the Minuteman II missile was utilized for the ERCS program, and the Blue Scout Junior ERCS sites were then inactivated.[116]

In addition to the ERCS program, Blue Scout Junior vehicles carried payloads designed for a variety of scientific and military uses including radiation and magnetosphere probes, ion and

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[112] Donald Prichard, electronic correspondence to Susan Enscore, 10 February 2009.

[113] With the exception of the first Blue Scout Junior flight from NMFPA on 4 December 1961, this was conducted by personnel from the 6555th Space Test Wing, Patrick AFB, Florida.

[114] Hunley, *U.S. Space-Launch Vehicle Technology*, 142.

[115] "Scout," http://www.astronautix.com/lvs/scout.htm.

[116] "Scout," http://www.astronautix.com/lvs/scout.htm; "Allied Signal Emergency Rocket Communication System," http://www.hill.af.mil/library/factsheets/factsheet.asp?id=5710.

scramjet engine testing, studies of vehicle reentry communication loss, and ultraviolet astronomy observations.[117]

The second configuration in the Blue Scout family was the Blue Scout 1, a three-stage vehicle using the Algol 1B, Castor 1A, and Antares 1A for propulsion. After a successful first launch from Cape Canaveral on 7 January 1961, two other flights followed over the next fifteen months; both were failures, and no other Blue Scout 1 boosters were launched. Known mission objectives for the Blue Scout 1 launches were a group of experiments for ARDC and the testing of ionization effects during reentry on vehicle radio transmissions.[118]

The final version of the system was the Blue Scout 2, a four-stage configuration utilizing the Algol 1B, Castor 1A, Antares 1A, and the Altair 1A. There were most likely only three Blue Scout 2 flights at Cape Canaveral — 3 March, 12 April, and 1 November 1961. The last of these three flights utilized the Blue Scout 2 to launch a payload into orbit as a test of the Project Mercury tracking and communications system. Unfortunately, a wiring error resulted in having to destroy the Blue Scout 2 in flight, and the Blue Scout development program ended at that point, with operational launches beginning. There is some indication that later Blue Scout 2s were launched, and the Air Force procurement of Scout vehicles continued through 1976. There seems to have been a gradual lessening of the differences between the two Scout programs, both in management and in technology. NASA and the Air Force agreed in 1970 that NASA would do all the contracting for Scout launches at VAFB, even though the DoD use of Scout vehicles would continue.[119]

DEVELOPMENT AND USE OF SLC-5

Space Launch Complex 5 (SLC-5) is located near Honda Canyon along South VAFB's Coast Road (Figure 15). This NASA-funded complex was constructed from 1961–1962. During its thirty-two years of operation, the area today known as SLC-5 hosted seventy-five launches. Three different types of vehicles rose into the skies from the two launch pads, carrying a diverse array of experiments, equipment, and satellites. By far, the major use and primary mission of SLC-5 was to support the NASA/DoD Scout Four-Stage Launch Vehicle and related payloads, although U.S. Air Force (USAF) Blue Scouts and probe rockets, including the NIKE-Aerobee,

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[117] Hunley, *U.S. Space-Launch Vehicle Technology*, 142.

[118] Ibid., 142-144.

[119] Hunley, *U.S. Space-Launch Vehicle Technology*, 144-145.

were also launched from the site. The smaller Probe complex was designated Point Arguello Launch Complex C (or PALC-C), and the Scout complex as PALC-D. On 1 July 1966, VAFB changed the identification system resulting in PALC-C becoming Probe Launch Complex C (PLC-C) and PALC-D becoming Space Launch Complex-5 (SLC-5).[120] Following closeout of the minor Probe launch program, PLC-C was redesignated as part of SLC-5 and fully dedicated to Scout launches. The 69 Scout launches from SLC-5 produced one of the highest success rates of missile launches at VAFB (87 percent). The success rate for all launches of the Scout family or rockets worldwide was 85 percent. SLC-5 launched its final Scout rocket on 8 May 1994.

A relatively small number of facilities were needed to support the launching of Scout missiles. Table 4 provides a list of the on-site facilities, along with original designation numbers if different from the present. Historically significant buildings remaining at SLC-5, and documented in this re-port are: Launch Control Building (#589), Terminal Building (#580b), Mobile Checkout Shelter (#580a), Operations Support Building (#582), Motor Building (#579), and Cosmodyne Shelter (#578).

A second set of off-site, but related facilities were located approximately six miles north of SLC-5 along Coast Road (Table 5). These facilities were used for mating, testing and balancing missile components prior to delivering them to the complex.[121] When the NMFPA transferred to VAFB, the Scout buildings that had been constructed by NASA were transferred to NASA ownership. NASA returned those same buildings to the Air Force on 30 June 1994 at the end of the Scout program.[122]

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[120] The SLCs at VAFB were numbered north to south, and if an SLC had two pads, they were designated West or East Pad. "Change in Space Launch Complex Identification System," in archive file: Boosters - Gen #2, USAF Missile and Space Center Headquarters History Office, Los Angeles, California.

[121] The focus of this report is the National Register-eligible elements of SLC-5. Therefore supporting facilities offsite are not covered in-depth, even though they were an integral part of SLC-5 use history.

[122] Memorandum from Commander, Air Force Western Test Range, Vandenberg AFB, CA re: NASA facilities at Point Arguello, CA, 12 June 1964, RG 8, Box 40, File: Detailed Inventory of Naval Shore Facilities, Real Property Data 3.

Table 4. Buildings constructed at SLC-5.

Building Name	Building Number (old or alternate) current	Construction Date	Current Area (in square feet)
Scout Launch Control Building (or blockhouse)	(514) 589	1962	3,506
Scout Launch Control Diesel Generator Building	590	1961	117
Scout Launch Pad	(515) 580	1962	n/a
Mobile Checkout Shelter	(580a) 580	1962	approx. 3,667; not listed as real property
Terminal Building	(580b) 580	1962	unknown
Motor Building	(580c) 579*	1964	approx. 156; not listed as real property
Air Conditioning Building	(580d) 583	1977	360
Scout Operations Support Building	(516) 582	1961	4,000
Cosmodyne Shelter	578	1978	216
Machine Maintenance Shop	584	1968	2,400
Sentry House	unknown; not listed as real property	unknown; not listed as real property	unknown; not listed as real property
Meteorological Tower	585	1962	n/a

Table 5. Scout facilities located off-site at VAFB.

Building Name	Building Number (old) current	Construction Date
NASA Hangar	836	1961
Hydrogen Peroxide Storage Facility	561	1959
Scout Payload Checkout and Assembly	(517) 596	1962
Spin Test Building	(61) 995	1961
Spin Test Blockhouse	(62) 996	1961
Spin Test Operations	(63) 997	1965
Ordnance Assembly Building/ Scout Systems Checkout	(76) 960	1963 (property record database says 1962; annual histories say 1963)
Scout Ordnance Checkout Facility	970	1968
Equipment Storage/Parts Supply Building	988	1963 (property record database says 1961; annual histories say 1963)

*informal designation

Original Construction

Initial development of the current SLC-5 site did not include provisions for a Scout launch program; all efforts were focused on a new Navy Probe program located at the western end of the site. Before construction was completed, however, the east end of the site was assigned to NASA for a western launch base for the Scout launch vehicle, and construction of that complex was begun as well. Both complexes were completed at roughly the same time; therefore, both are considered original construction. A description of the site, as explained in the *Navy Times* on 31 March 1962:[123]

> One of the complexes was built for the National Aeronautics and Space Administration's Scout Program. It will be used for launching various payloads into polar orbit for NASA, Navy and Air Force space programs. This is the first major launch complex to be constructed for NASA on the Pacific Missile Range.
>
> The other pad, called a multipurpose launch complex, will be for launching high altitude rockets of various types up to 150,000 pounds of thrust. It will be under management control of the Navy but will be made available to range users desiring to conduct space research tests on the Pacific Missile Range.
>
> To keep construction costs at a minimum, the two facilities were erected 1200 feet apart so that one launch control center could serve countdown operations from both pads. The control center is beneath the multi-purpose pad.

The multipurpose launch complex, also known as the Probe Launch Complex, consisted of a blockhouse/launch control center and a launch pad above and behind the blockhouse.[124] The single blockhouse/launch control center was also near the Scout launch pad and served both programs. A Military Construction Navy (MCON) project for the Probe Launch Facility was approved in early 1961.

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[123] "NASA, Navy Launch Pads Near Completion at Mugu," *Navy Times*, 31 March 1962, M15, in vertical file: California - Lompoc - Point Arguello Missile Facility, at U.S. Navy CEC/Seabee Museum, Port Hueneme, California.

[124] This facility is also referred to in the Naval Shore Facility inventory for 1964 as the "LC C Launch Pad-Control Bldg" ("Detailed Inventory of Naval Shore Facilities Real Property Data Vol. III," 8 December 1964, RG 8: Periodicals and Publications, Box 40: P-Books; Publications, File: RG12 P Books P-164 Budocks: data, Seabee Museum, Port Hueneme, California).

On 7 June, a construction contract (NBy34230) for $170,000 was awarded to Electro Steel Structures, Inc., and Western Erectors Inc.[125] The concrete pad and blockhouse project was placed on an emergency or rushed status, something very common at the time because the military was under pressure to develop rockets, missiles, and satellites quickly.[126] Construction began that month on the Probe Launch Facility located on the north rim of Honda Canyon (Figure 16). The launch pad, along with the blockhouse floor and walls were poured by 27 October.[127] Prior to construction completion, the design was amended to include a Scout control room, creating a dual purpose launch control center.[128] Construction was completed by 18 May 1962 (Figure 17and Figure 18). Six days later, a six-bay console containing panels for the pad safety officer was acquired for the blockhouse's launch distribution center.[129] A Launch Control Diesel Generator Building, completed in 1961, was located a small distance away from the southwest corner of the blockhouse.

On 17 May, NMFPA received three gun mounts salvaged from Navy vessels for modification into missile launchers. Two were 5"/38-caliber single gun mounts, and one was a twin mount (also 5"/38-caliber). The single mounts were modified for launching HASP and TERRIER-class vehicles. Major modifications turned the twin mount into an ARGO D-8-class launcher for the new Probe Complex.[130]

The Range Operations Department, Range Development Department, and the Technical Support Directorate jointly designed and fabricated the launcher. It was designed to launch missiles weighing up to 20,000 pounds. The modifications were completed that fall, and the "PMR Probe

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[125] The same source (on another page) gives the contract amount as $191,000. The given figure was used due to the presence of supporting information, such as the contract number. Arthur Menken, *History of the Pacific Missile Range and the Naval Missile Center: 1 January 1961 to 31 December 1961*, (Point Mugu, CA: Pacific Missile Range, 1962), 132, 134, 349-350.

[126] Menken, *History of the Pacific Missile Range and the Naval Missile Center: 1 January 1961 to 31 December 1961*, 353.

[127] Ibid., 175, 353.

[128] It is not known when the design was amended, but the annual Navy histories for the PMR do not mention Scout facility construction until early in the second half of 1961, when the Probe Complex was well underway.

[129] Menken, *History of the Pacific Missile Range: 1 January 1962 to 31 December 1962*, (Point Mugu, CA: Pacific Missile Range, 1963) 152, 284.

[130] The ARGO D-8 was a research rocket also known as the Journeyman.

Launcher" was installed at the Probe Complex in November 1962 (Figure 19 and Figure 20). Although the remotely controlled launcher was ready, integrating it into the blockhouse command system took a while longer because permanent power and communication facilities at the launch complex were not yet completed.[131] As it turned out, the power and communication cabling was not installed to the gun mount launcher until sometime in the last half of 1963. The launcher's tenure was short-lived, however, due to the turnover of NMFPA facilities to VAFB on 1 July 1964. Intended for Navy use in a new probe launch complex at San Nicolas Island, the launcher was removed from PALC-C on 27 August 1964.[132] No record could be found in the research for this report that documented any launchings from the Probe Launch Complex (PALC-C) in the 1960s.[133] According to one Air Force source, the rooftop launch pad was not used after construction due to potential interference with the nearby Scout complex, but served as a space probe booster launch pad beginning 29 June 1971.[134] Another Air Force source states that the blockhouse/launch pad facility was used for Nike-Aerobee and Paiute-Tomahawk rockets between 1971 and 1975.[135]

The second and larger complex was constructed for the NASA Scout pro-gram, with a mission of launching "various payloads into polar orbit for NASA, Navy, and Air Force space programs."[136] The Scout facility at NMFPA was the first major launch complex constructed for NASA on the Pacific Missile Range.

Concepts for the Scout Launch Complex at VAFB began to take shape on 18 May 1961. On that date a conference was held by NASA Launch Operations Directorate and PMR officials to discuss design criteria for the complex. By 9 June, preliminary design criteria had been received,

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[131] Menken, *History of the Pacific Missile Range: 1 January 1962 to 31 December 1962*, 149-150, 186.

[132] Arthur Menken, *History of the Pacific Missile Range: 1 January 1964 to 31 December 1964* (Point Mugu, CA: Pacific Missile Range, 1965) 81, 191.

[133] There were Journeyman missile launches at VAFB during this period. They occurred at PALC-A, also sometimes referred to as a probe launch area.

[134] "Vandenberg Launcher Status and History," VAFB: 1Strad/HO 1 Mar 1978, Vertical File: Vandenberg AFB (PMR/TWR), NASA HQ History Office, Washington, DC.

[135] David L. Skinner, "United States Missile Ranges: Origins and History," *Spaceflight*, March 1978, 102, in vertical file: Vandenberg AFB (PMR/WTR), NASA HQ History Office, Washington, DC.

[136] "NASA, Navy Launch Pads Near Completion at Mugu," *Navy Times*, 31 March 1962.

and a follow on conference was held 13 June to review siting and installation design criteria. An estimated cost of $326,300 for the complex was determined. Funding for the complex fell under a larger appropriation for $2,145,541 that included a Technical Programs Warehouse and a Range Safety Test Communication Plant as well as the NASA Scout complex.[137]

Architectural and engineering services for the Scout Launch facility were provided by Kaiser Engineers of Oakland, California. The Navy contract (NBy-36757) was signed on 31 July 1961 for services at a cost of $12,348. In addition to the major components of the site, the contract was amended 18 September 1961 to include “design of communications and control cables, cable terminals, trenches and covered cableways for the facility.”[138] Designs were also requested for utilities and utility trenches in the launch pad, and a parking lot. The cost increase for the additional design effort was $2,960.

The project was considered urgent, in part to support the Mercury program, and therefore, normal contracting processes of letting the project out for bids were replaced with authorization for the Navy to negotiate a contract directly with a reliable contractor. Captain Hickey led a selection board that met in San Diego and basically completed the negotiations in one day. The Scout Launch Facility construction contract (NBy37954) was let in August 1961 to Electro Steel Structures, Inc. & Western Erectors, Inc. at a cost of $270,213.[139]

By 15 September 1961, construction began with grading activities. The NASA-funded construction proceeded quickly and on schedule. A large percentage of the work was done by the end of 1961, and was quickly completed the following spring (Figure 21 and Figure 22). The official acceptance date of the complex was 7 May 1962, but this belies the fact that the site was operational earlier, with the first Scout launch on 26 April 1962. The complex was situated approximately 1,200 feet northeast of the Probe Complex blockhouse and launch pad, sharing the block-

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[137] Menken, *History of the Pacific Missile Range and the Naval Missile Center: 1 January 1961 to 31 December 1961*, 134, 285.

[138] “Contract No. NBy-36757,” in Record Group 12, Box 374: Bureau of Yards and Docks, NBy Contracts, File: NBy-36757, at U.S. Navy CEC/Seabee Museum, Port Hueneme, California. (San Diego, CA: Southwest Division, Bureau of Yards and Docks, 1961)

[139] Menken, *History of the Pacific Missile Range: 1 January 1962 to 31 December 1962*, 287. (This source material did not list a first name for Hickey.)

house and control center (see Figure 6).[140] New construction included the launch pad and the mobile shelter covering the pad, a terminal building next to the shelter for cable connections, and an operations support building near the launch pad.

Ancillary Construction and Modifications at SLC-5

In late 1961, NASA and the PMR developed a proposal for a television (TV) system for the Probe Launch Complex. A contract (NBy42285) for installation of a closed circuit television system and an operational announcing system at the Probe and Scout launch facilities was awarded to Thompson Electric Co. at a cost of $18,355. The systems were operational by October 1962 (Figure 23). The TV system was made up of three cameras that were used interchangeably on seven pedestals installed in the area, thereby covering both complexes. Camera images were displayed on monitors in the shared blockhouse.[141]

To support pre-launch and early post-launch range safety requirements, a dual AN/FRW-2 (500 watt) van for communication was installed near the Scout launch pad on 17 May 1962. This equipment was necessary because the topography near the SLC-5 launch pad didn't allow the use of the more standard VAFB command destruct transmitters (CDT).[142]

Another project that benefited both complexes was a 200-foot meteorological tower installed between the two complexes on 17 May 1962 (Figure 24). The tower contained AN/UMQ-5 wind speed and direction systems at three levels to provide wind data required for launch operations directly to the blockhouse. Designated as Facility 585, the tower was demolished on 9 January 2003, nearly a decade after the last launch from SLC-5 (Figure 25).[143] This meteorological facility for PALC-C and PALC-D also utilized M-33 radar for obtaining ballistic winds during over-

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[140] Menken, *History of the Pacific Missile Range: 1 January 1961 to 31 December 1961*, 132,285,353; Menken, *History of the Pacific Missile Range: 1 January 1962 to 31 December 1962, 186, 269.*

[141] Menken, *History of the Pacific Missile Range: 1 January 1961 to 31 December 1961*, 176; Menken, *History of the Pacific Missile Range: 1 January 1962 to 31 December 1962*, 274, 289.

[142] Menken, *History of the Pacific Missile Range: 1 January 1962 to 31 December 1962*, 146–147.

[143] James Denton, VAFB Real Property Office, electronic correspondence to Susan Enscore, 16 April 2004; Menken, *History of the Pacific Missile Range: 1 January 1962 to 31 December 1962*, 150.

cast conditions. The radar data and information from the launch complex's theodolites were fed into a ballistic van (located off-site but nearby). There was also a mobile AN/GMD Rawinsonde System balloon and an inflation shelter for gathering upper atmosphere data. This meteorological facility was in place by 6 December 1962.[144]

NASA submitted a list of required modifications for PALC-D to PMR in August 1962, only a few months after the complex became operational.[145] The request included an addition to the blockhouse, an addition to the Operations Support Building, pavement repair, erosion control, and security fencing.[146] Plans and specifications were completed by Quinton Engineers, Ltd. of Los Angeles, California in 1962. The $132,200 construction contract (NBy47446) was awarded on 6 May 1963 to Collins & Fletcher Company, of Lompoc, California. The contract was completed in December 1963.[147]

Also in 1963, plans were prepared for heating the Scout Mobile Checkout Shelter. Installation began that year, with the $26,075 contract (NBy54998) awarded to Double Electric Co. in September 1963. In December 1963, Collins & Fletcher Company was given a $14,500 contract (NBy55062) to provide a shelter for the winches that pulled the Checkout Shelter away from the launcher, and complete some small "alterations to Scout."[148] A voice communication system was designed, fabricated, and installed at the Scout complex by the NMFPA Technical Support Directorate's Engineering Department in 1964. The system was used during launches of NASA satellites and Scout vehicles.[149]

By 1964, PALC-D was essentially in the configuration that it would retain until 2009 (Figure 26, Figure 27, and Figure 28). There were some minor additions and modifications, however. In addition to the buildings already discussed, there was a small sentry house located on the road be-

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[144] Menken, *History of the Pacific Missile Range: 1 January 1962 to 31 December 1962*, 165.

[145] Note that by this time the entire area was beginning to be referred to as Scout Complex, or Launch Complex D.

[146] Menken, *History of the Pacific Missile Range: 1 January 1962 to 31 December 1962*, 158.

[147] Menken, *History of the Pacific Missile Range: 1 January 1962 to 31 December 1962*, 121; Menken, *History of the Pacific Missile Range: 1 January 1963 to 31 December 1963*, 260.

[148] Menken, *History of the Pacific Missile Range: 1 January 1963 to 31 December 1963*, 101, 278.

[149] Menken, *History of the Pacific Missile Range: 1 January 1964 to 31 December 1964*, 155.

tween the blockhouse and the launch pad. It is unknown when the structure was built.[150] The terminal building was expanded to the west in 1966, and the Mobile Shelter received an addition in 1976.[151] The need to stick to launch schedules resulted in a funding request for the placement of additional floodlights at the launch pad in early March 1967. Before the floodlights were installed, the method of lighting the launcher and launch area consisted of four searchlights that were furnished and manned by either employees of the Douglas Aircraft Company or the 4300th Support Squadron (SAC). This was unsatisfactory because personnel were not always available, and the carbon elements in the searchlights had a life span of about 40 minutes, resulting in a need to change them in close physical proximity to launch-ready Scouts. The contract went to Eckert's Electric, Inc., of Lompoc, California on 31 May 1967 and the work was accomplished by the following February at a cost of $18,040.[152]

Only a few other buildings were added over the years. A machine maintenance shop was added in 1968 for on-site fabrication of small parts and simple repairs. In 1977, the Air Conditioning Building provided housing for a new system of cooling the Scout, and a shelter for the Cosmodyne unit was provided in 1978.

Scout Support Buildings Located Off-Site

NASA had been assigned facility space at NMFPA as early as March 1961 for support of the Scout program, among other NASA activities at the installation. New facilities such as PALC-D were created with NASA funding, as were several off-site facilities to support the Scout program. NASA funds were also used to modify existing buildings to meet the needs of the new program. The NASA Hangar (Building #836) was modified for the Scout program by 1962.[153] As several components/systems of the Scout launcher required the use of hydrogen peroxide, a remote stor-

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[150] The sentry house was manned only when there was a launch vehicle on the pad (Donald Johnson, electronic correspondence to Julie Webster, 14 August 2009).

[151] Architect/Engineer work for the mobile shelter addition was done by Stearns-Roger, Inc. (now a subsidiary of Raytheon Company), which also performed this task for an electric/battery shop and exterior shed addition for compressors to the Operations Support Building. In addition, they built the Cosmodyne shelter.

[152] "Work Orders," Vertical File, Real Property Office, Vandenberg Air Force Base, California.

[153] Menken, *History of the Pacific Missile Range: 1 January 1961 to 31 December 1961*, 132, 261, 274.

age facility (#561) was constructed in 1959, for use by the Scout program. The facility was located east of SLC-5 on Honda Canyon Road.

Of the new support buildings, the Ordnance Assembly Building (OAB; #960) was constructed August 1962–July 1963. The OAB is located approximately six miles north of SLC-5, along the coast road. Designed by Quinton Engineers Ltd., of Los Angeles, California, it was built under contract NBy 43457-962753-5428-195545 by Electro Steel Structures, Inc., and Western Erectors, Inc. Originally designated as a Missile Assembly Test Building, the facility was utilized for motor inspection, buildup, and check out of both the Blue Scout Junior and the NASA Scout.[154] The main aspect of the building was a large bay for holding and moving the Scout components. The building contained a series of consoles used to electronically test the missile components, including the Continuity and Electrical test set for checking out the ordinance on the Scout missile. There were also consoles for the Command Destruct test set, the Radar Beacon test set, the Guidance test set and the Telemetry test set. A dedicated Ordnance Checkout Facility (#970) for the Scout program was completed in 1968 and located adjacent to the OAB.

A Payload Checkout and Assembly Building (#596) was completed and accepted on 7 August 1962. This facility was owned by the Air Force and used to process Air Force and Navy spacecraft; NASA spacecraft were normally processed in Building 836 (NASA hangar). Both of these buildings were used for processing Scout payloads, among others. Also designed and constructed on an accelerated schedule, the 4,000-square-foot building was sited to have visual and line-of-sight access to PALC-D. Near the building, a permanent meteorological van parking area was installed for on-site support of Scout operations.[155] That same year, plans were completed and a contract awarded for a Components Storage Building (#988), with construction completed in 1963.[156]

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[154] Menken, *History of the Pacific Missile Range: 1 January 1961 to 31 December 1961*, 132, 261, 274; “Real Property Accountable Record Facility 960,” Real Property Office, Vandenberg Air Force Base, California; James E. Hartness, CDR and W.C. Forma, LTJG, “Point Arguello Missile Facility in California Gets New, Model Ordnance Assembly Building,” *The Navy Civil Engineer*, June 1964, 8.

[155] Menken, *History of the Pacific Missile Range: 1 January 1962 to 31 December 1962*, 70, 120–121, 195; Menken, *History of the Pacific Missile Range: 1 January 1964 to 31 December 1964*, 95.

[156] Menken, *History of the Pacific Missile Range: 1 January 1963 to 31 December 1963*, 101.

A group of three structures for balancing the Scout fourth stage and the payload were constructed about one-half mile east of Coast Road in the northwestern-most section of South VAFB. This facility contains the equipment and checkout gear used to “spin balance” the Scout’s fourth stage and its satellite to enable them to achieve and maintain the proper orbit. The first two buildings in the group were constructed in 1961 under contract DA-04-353-NASA-61. The primary structure was the Spin Test Building (#995) that contained the equipment and checkout gear used to “spin balance” the Scout’s forth stage and its payload to enable them to achieve and maintain the proper orbit. The control and operations for the spin test building were carried out from a blockhouse (#996) approximately 60 feet to the north, also known as the Missile (MSL)/Space Research Test building, and by the mid-1970s, as the “Spin Test Control Room (Scout).” The sturdy, earth-covered building contained an operator control console, display monitors, and communication equipment. The spin test facility became operational in 1962.[157]

The Operations Support building (#997) for the Spin Test facility was constructed in 1965 under contract DA-04-353-ENG-NASA-61. That same year, it was transferred from NASA to the Air Force with a cost at that time of $58,395. The construction plans were created by Quinton Engineers, Ltd. of Los Angeles, California in November 1964 in conjunction with the U. S. Army Corps of Engineers, Los Angeles District office. The building was used for storage and minor repairs.[158]

Probe/Multi-Purpose Launch Pad

Although the Probe Launch Complex was completed by 1962, it was nearly a decade before it was utilized for a rocket launch. The original configuration was modified to support different rockets, and on 29 June 1971, a Nike-Aerobee sounding rocket took off from PALC-C. Three other Air Force flights followed, with the last on 11 October 1972 (Table 6).[159] It is likely these are the only Nike-Aerobee flights from VAFB. This combination rocket consisted of a Nike

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[157] LTV Missiles and Electronics Group, *Ground Support Equipment Manual: NASA/DoD Scout Vehicle S-208 and Subsequent*” vol. II, (Hampton, Virginia: NASA Langley Research Center, 1990), 2-89 - 2-90; “Real Property Accountable Record Facility 996,” Real Property Office, Vandenberg Air Force Base, California; Menken, *History of the Pacific Missile Range: 1 January 1962 to 31 December 1962*, 186.

[158] “Real Property Accountable Record Facility 997,” Real Property Office, Vandenberg Air Force Base, California.

[159] Utilized for gathering data on the upper atmosphere, sounding rockets have suborbital trajectories, and are mostly unguided. Upper atmosphere studies are known as aeronomy.

booster and an Aerobee sounding rocket. The liquid-fueled Aerojet-General Aerobee was originally a U.S. Navy rocket developed directly after WWII, and was the "first purpose-designed American high-altitude sounding rocket."[160] By 1947, all U.S. military services were utilizing it, and many variations of the Aerobee rocket were developed, one being the Nike-Aerobee. Technically, this rocket was developed from the Aerobee 150A with that rocket's small booster replaced with a Nike booster, thus becoming the Aerobee 170 (Nike-Aerobee). The combination vehicle was approximately 40 feet long and 1.4 feet in diameter (Figure 29).

Testing on the new combination began on 16 September 1968, and the first all-up flight on 26 October was a success. Used until 1983, 138 Aerobee 170s were launched, primarily by NASA, but also by the U.S. Navy and the U.S. Air Force. The solid-fueled Nike booster enabled the Aerobee 170 to reach an average altitude of 125 miles, carrying a payload consisting of scientific instrumentation. The vehicle was launched from a 100-plus foot tall tower at a nearly vertical attitude. The Nike-Aerobee launches carried scientific equipment for gathering data on infrared sensor technology in a project named Chaser, and all but the third were successful.[161]

Table 6. Nike-Aerobee and Paiute-Tomahawk Launches from SLC-5.

Date	Vehicle	Pad/Silo	Comments
1971 JUN 29	Nike/Aerobee	PALC-C	AFSC launch. Chaser1. Infrared sensor technology.
1971 NOV 23	Nike/Aerobee	PALC-C	AFSC launch. Chaser 2. Infrared sensor technology.
1972 JUN 20	Nike/Aerobee	PALC-C	AFSC launch. Chaser. Infrared sensor technology. (Failure)
1972 OCT 11	Nike/Aerobee	PALC-C	AFSC launch. Chaser. Infrared sensor technology.
1975 AUG 14	Paiute Tomahawk	PLC-C	AFSC/CRL launch. Escape I. Aeronomy mission.
1975 DEC 10	Ute Tomahawk	PLC-C	AFSC/CRL launch. Escape II. Aeronomy mission.

Source: Brian Webb, "Vandenberg AFB Launch History," March 7, 2009, http://www.spacearchive.info/vafblog.htm (accessed Nov. 2009); Mark Wade, "Vandenberg PLC-C," http://www.astronautix.com/sites/vangplcc.htm (accessed Nov. 2009).

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[160] Andreas Parsch, "Aerobee," in *Appendix 4: Undesignated Vehicles* of *Directory of U.S. Military Rockets and Missiles*, , 2004, http://www.designation-systems.net/dusrm/app4/aerobee.html (accessed Nov. 2009).

[161] Parsch, "Aerobee"; Mark Wade, "Aerobee 170," *Encyclopedia Astronautica*, http://www.astronautix.com/lvs/aerobee.htm (accessed Nov. 2009).

The only other launches from the Probe Complex were for the Tomahawk sounding rocket (see Table 6). Two versions were fired from the complex: Ute Tomahawk and Piute Tomahawk. The two shots were the only launchings of these sounding rocket types at VAFB. The two launches from the Probe Complex comprised a research program called Escape, with the shots noted chronologically as Escape I and Escape II. The program was used to gather upper atmosphere data, and both shots were successful.[162]

The Tomahawk sounding rocket was originally a single-stage rocket with a Thiokol motor, developed for use by Sandia in their work for the Atomic Energy Agency. The solid-fueled rocket flew from 1963 till 1995, gathering data on the upper atmosphere, usually as an upper stage component. The Ute Tomahawk used a Tomahawk second stage boosted by a Thiokol Ute motor-powered solid propellant first stage. This particular Tomahawk variant flew from November 1971 to January 1976, and had an average apogee of 140 miles. Its cousin, the Paiute Tomahawk, consisted of a more powerful Thiokol Ute motor with the same Tomahawk upper stage. The greater thrust enabled the Piute Tomahawk to reach an apogee of 210 miles.

Scout Launch Pad

Of 118 Scout launches conducted at the three program launch sites, 69 of these were conducted at PALC-D/SLC-5, VAFB. The SLC-5 launch statistics document an 87 percent overall success rate and a 95 percent success rate after June 1964. Preparation for these launches involved facilities at SLC-5, off-site facilities, and transportation between the two (Figure 30).

Launch procedure

LTV Corporation built the Scouts in Dallas, after receiving components from the manufacturers, and performed detailed check-out procedures on assembled vehicles (with unfueled motors). During the check-out in Dallas, all vehicle sections were examined for completeness, condition, and compliance with any deficiencies corrected when discovered. Detailed logs of tests performed and results gathered were created and a copy sent with the vehicle to the launch base.[163] Payload configuration specifications were sent to LTV Dallas, where heat shield, transition sections, and fourth stage separation modifications were performed when necessary. Also at this

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[162] Mark Wade, "Tomahawk," *Encyclopedia Astronautica*, http://www.astronautix.com/lvs/tomandia.htm (accessed Nov. 2009)

[163] The test logs were one result of the program review in 1963, which created extremely detailed step-by-step procedures for the Scout life cycle from fabrication to post-launch.

stage, drawings were prepared that identified all payload/vehicle and payload/ground support equipment (GSE) interfaces required for a specific launch. Pre-flight planning tasks were completed, including weight breakdowns, pitch program, calculation of optimum launch times, and final flight trajectory.[164]

At VAFB, LTV was responsible for launching the Scout and for maintaining SLC-5, Scout test facilities, and all associated GSE. Upon arrival from Dallas, the Scout vehicle was brought to the Ordnance Assembly Building (OAB) in parts (i.e. solid rocket motors, transition sections, etc.). The components were removed from their containers using a 50,000 pound bridge crane and transferred to waiting dollies. The various components were then thoroughly inspected, checked-out, and mated into one assembly. A full functional checkout of the Scout was conducted prior to delivery to the launch pad. This checkout included critical systems such as command destruct in case the missile goes off course, and the radar beacon which allowed launch technicians to determine where the missile was at all times during its flight, as well as guidance and telemetry systems (Figure 31 and Figure 32). Results had to match the ones recorded from the Dallas checkouts for the preparation process to proceed.[165]

Meanwhile, the payload was undergoing its own processes, including checkout in Building #596 and balancing in the spin test facility. The Scout fourth stage and payload were stabilized in orbit by spinning the components. In order to ensure the correct orbit was reached, the components needed to be properly balanced around their center of gravity, which was done by spinning them at different speeds to determine the center of gravity. Proper spin tests ensured the fourth stage and payload were properly aligned before mating with the lower stages of the Scout vehicle. Technicians corrected any discovered misalignment by utilizing weights.[166] After balancing, a dummy heat shield was installed to protect the fourth stage and payload until arrival at the launch pad.

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[164] NASA, "Statement of Work, Scout Systems Management, Revision A, January 1, 1986 through December 31, 1987," in vertical file: Scout: Contract/SOW, at History Office, Air Force Space and Missile Command, Los Angeles, CA. (Hampton, VA: Langley Research Center, 1985), 26-28.

[165] LTV Missiles and Electronics Group, *Ground Support Equipment Manual*, 2-6.

[166] LTV Missiles and Electronics Group, *Ground Support Equipment Manual*, 2-89 – 2-92; Donald Johnson, electronic correspondence to Julie Webster, 14 August 2009.

Operated and maintained by LTV, the spin test facility consisted of the spin test building (#995), the spin test blockhouse (#996), and an operations support building (#997). The blockhouse contained operator consoles, display monitors, and communication equipment for operating the spin test equipment. The equipment housed in the spin test building consisted of a Gisholt spin balance machine and necessary GSE to handle the Scout's fourth stage, payload, and heat shield, including a one-ton bridge crane (Figure 33). The spin balance machine consisted of "a table for mounting the component to be balanced and a suspension system, which supports the table and allows it vertical movement."[167] The components were spun, and imbalances were found through centrifugal force.

After leaving the OAB, the Scout was transferred by truck transport to SLC-5 (Figure 34). Once the vehicle reached the complex, the transporter proceeded to the launch pad/mobile checkout shelter. There, the transporter would back in, between the metal platforms and under the launcher, with the Scout in a horizontal position (Figure 35).

Any launch vehicle arriving at SLC-5 from 1962–1994 had the same basic configuration, with the most significant changes over time being more powerful motors and a larger payload container. This 1981 description of the G-1 final variant is broadly applicable to the Scout during most of its operational life:[168]

> The Scout vehicle consists of four solid propulsion rockets with interconnecting structural transition sections which provide structural continuity and also house components of various systems. Beginning at the bottom is the Base Section A. This section surrounds the Algol IIIA first stage motor nozzle and contains the hydraulically actuated first stage control system powering vanes in the exhaust and aerodynamic controls on the fin tips. Between the first stage and the Castor IIA powered second stage is Transition Section B which contains a separation diaphragm and the second stage control system, which uses hydrogen peroxide jets to provide control movements. Joining the second stage and the Antares IIIA powered third stage is Transition Section C, containing a separation diaphragm and the third stage hydrogen peroxide fueled control system. Between the third and fourth stages is Transition Section D which houses the major components of the Guidance, Ignition, Beacon, and Telemetry Systems. Mounted on the fourth

[167] LTV Missiles and Electronics Group, *Ground Support Equipment Manual*, 2-94.

[168] Foster and Urash, "The Scout Launch Vehicle Program," 6-48 – 6-49.

> stage is Transition Section E, to which the spacecraft is attached by means of a separation clamp, in addition to a payload separation ignition system and a fourth stage Telemetry System. Surrounding the Altair IIIA fourth stage and spacecraft is a heat shield to protect them from aerodynamic heating during ascent. Versatility in trajectory design and implementation is provided thru the use of an Intervalometer and a Programmer which are pre-set for specific missions. An overhead crane mounts the fourth stage and its components onto the spin mechanism. At the pre-calculated time, the Intervalometer switches selected voltage levels from the Programmer to the Pitch Gyro torquer, causing the gyro to generate an error signal subsequently nulled out by rations of the vehicle due to the action of the control system. Thus the vehicle is guided in the pitch plane while stabilized about all three axes. The fourth stage is not controlled by the guidance system but is spin stabilized during that portion of the flight. Total length of the vehicle is 23 meters (75 feet) and its weight is 21,600 KG (47,500 pounds). (See Figure 36.)

In Scout's early years, the VAFB on-site assembly and checkout differed from that at Wallops Island, because the first Scout launcher there raised the vehicle into a launch tower. As a result, much of the preparatory work at Wallops Island was done with the Scout in vertical position. The launcher at VAFB allowed this work to be done with the vehicle in a horizontal position, greatly increasing ease of access and decreasing pre-launch preparation time.[169]

Vehicle preparation and checkout took place at this stage, along with functional checks of the blockhouse, launcher, and remote fueling unit (Figure 37). The vehicle was loaded on the launcher, and electronic function checks were performed. The fourth stage, consisting of the dynamically-balanced fourth stage motor and spacecraft assembly, was installed on the launch vehicle and umbilicals connected (Figure 38). Finally, the pyrotechnic devices, flight batteries, and heat shield were installed, immediately preceding the final inspection.[170]

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[169] "New Launch site being readied at Point Arguello," *Digest*, Long Beach, California, 13 April 1962, in vertical file: California - Lompoc - Point Arguello Missile Facility, at U.S. Navy CEC/Seabee Museum, Port Hueneme, California.

[170] LTV Missiles and Electronics Group, *Administration and Vehicle Manual: NASA/DoD Scout Vehicle S-208 and Subsequent*, vol. I (Hampton, Virginia: NASA, Langley Research Center, 1990), 2-49; Donald Johnson, electronic correspondence to Julie Webster, 14 August 2009.

Once all the tests, checks, and installations were complete, and the vehicle aligned, a countdown dress rehearsal began. After a successful rehearsal, the batteries were charged, the remote fueling unit was serviced, and the Scout was ready for liftoff (Figure 39 and Figure 40). All that remained was to winch back the shelter, raise the Scout, and align it properly for the specific mission (Figure 41 and Figure 42).

Scout launches and payloads

The sixty-nine Scout launches conducted at SLC-5 were all orbital missions, mostly involving scientific or application satellites. There was a confusing amount of interplay between the NASA vehicles, Air Force (AF) vehicles, NASA payloads, Navy payloads, AF payloads, etc. For example, the first ten launches from SCL-5 were AF Blue Scouts with AF payloads, but the first NASA payload (Explorer 19) was carried on an AF Blue Scout, 19 December 1963. On 4 June 1964, a Navy satellite was launched on a NASA Scout vehicle, and 25 August 1964 marked the date of the first NASA Scout and NASA payload (Explorer 20).[171] Additionally, several Scout variations were launched from other facilities at VAFB (Table 7).

Table 7. Air Force Scout Launches from VAFB.

Date	Vehicle	Pad / Silo	Comments
1961 DEC 4	Scout Junior	PALC-A	AFSC launch
1962 APR 26	Scout	PALC-D	AFSC launch. Blue Scout I
1962 MAY 23	Scout	PALC-D	AFSC launch. Blue Scout II
1962 MAY 31	Scout Junior	PALC-A	AFSC launch. BEANSTALK 1
1962 JUL 24	Scout Junior	PALC-A	AFSC launch. BEANSTALK 2
1962 AUG 23	Scout	PALC-D	AFSC launch. Blue Scout III
1962 NOV 21	Scout Junior	PALC-A	AFSC launch. BEANSTALK 3
1962 DEC 18	Scout Junior	PALC-A	AFSC launch
1962 DEC 18	Scout	PALC-D	AFSC launch. Blue Scout IV
1963 FEB 1	Scout Junior	PALC-A	AFSC launch. BEANSTALK 4
1963 FEB 19	Scout	PALC-D	AFSC launch. Blue Scout V
1963 MAR 13	Scout Junior	PALC-A	AFSC launch. BEANSTALK 5
1963 APR 5	Scout	PALC-D	AFSC launch. Blue Scout VI
1963 APR 26	Scout	PALC-D	AFSC launch. Blue Scout VII
1963 MAY 17	Scout Junior	PALC-A	AFSC launch. BEANSTALK 6
1963 JUN 15	Scout	PALC-D	AFSC launch. Blue Scout VIII

[171] Brian Webb, “Vandenberg AFB Launch History,” http://www.spacearchive.info/vafblog.htm (accessed Nov. 2009).

Date	Vehicle	Pad / Silo	Comments
1963 SEP 27	Scout	PALC-D	AFSC launch. Blue Scout IX
1963 DEC 17	Scout Junior	4300C	SAC launch. BEANSTALK 7
1963 DEC 19	Scout	PALC-D	AFSC launch. Explorer 19 (AD-A) scientific satellite (1963-053A). Blue Scout X
1964 JUN 3	Scout	PALC-D	AFSC launch. Arrow Plant
1964 JUN 25	Scout	PALC-D	AFSC launch. Cherry Pie
1964 AUG 25	Scout	PALC-D	AFSC launch. Explorer 20 (IE-A) scientific satellite (1964-051A). Hurry Baby
1964 AUG 29	Scout Junior	PALC-A	AFSC launch. Candy Bag
1964 OCT 9	Scout	PALC-D	AFSC launch. Explorer 22 (BE-B) scientific satellite (1964-064A). Gus Goose
1964 NOV 21	Scout	PALC-D	AFSC launch. Explorer 24 (AD-B) (1964-076A) and Explorer 25 (Injun-4) (1964-076B) scientific satellites. Ima Bird
1964 DEC 21	Scout Junior	PALC-A	AFSC launch. Quaker Town
1965 DEC 6	Scout	PALC-D	AFSC launch. FR-1 (France 1) scientific satellite (1965-101A). Squeeky Hub
1965 DEC 21	Scout	PALC-D	AFSC launch. Social Circle
1966 JAN 28	Scout	PALC-D	AFSC launch. Inventory Aid
1966 MAR 25	Scout	PALC-D	AFSC launch. Best Girl
1966 APR 22	Scout	PALC-D	AFSC launch. Labrador Retriever
1966 MAY 18	Scout	PALC-D	AFSC launch. Dance Lesson
1966 AUG 4	Scout	SLC-5	AFSC launch. Rubber Mat
1966 AUG 17	Scout	SLC-5	AFSC launch. Marble Hall
1966 OCT 28	Scout	SLC-5	AFSC launch. Busy Service
1967 JAN 31	Scout	SLC-5	AFSC launch. Busy Mason
1967 APR 13	Scout	SLC-5	AFSC launch. Busy Minuteman
1967 MAY 5	Scout	SLC-5	AFSC launch. Payload was Ariel 3 (UK 3) scientific satellite (1967-042A). Busy Wife
1967 MAY 18	Scout	SLC-5	AFSC launch. Busy Ocean
1967 MAY 29	Scout	SLC-5	Unsuccessful. AFSC launch. Payload was ESRO 2A scientific satellite. Third stage malfunction prevented spacecraft from reaching orbit. Old Fad
1967 SEP 25	Scout	SLC-5	AFSC launch
1967 DEC 4	Scout	SLC-5	AFSC launch
1968 MAR 1	Scout	SLC-5	AFSC launch
1968 MAY 16	Scout	SLC-5	AFSC launch. Payload was ESRO 2B scientific satellite 1968-041A)
1968 AUG 8	Scout	SLC-5	AFSC launch
1968 OCT 3	Scout	SLC-5	AFSC launch. Payload was ESRO-I (Auro-

Date	Vehicle	Pad / Silo	Comments
			rae) scientific satellite
1969 OCT 1	Scout	SLC-5	AFSC launch. Payload was ESRO 1B (Boreas) scientific satellite (1969-083A)
1969 NOV 7	Scout	SLC-5	AFSC launch. Payload was Azur (GRS A) scientific satellite (1960-097A)
1970 AUG 27	Scout	SLC-5	AFSC launch
1971 DEC 11	Scout	SLC-5	AFSC launch. Payload was UK-4 (Ariel 4) scientific satellite
1972 SEP 2	Scout	SLC-5	AFSC launch
1975 OCT 11	Scout	SLC-5	AFSC launch. TIP-II AFSC launch. TIP-II
1975 DEC 5	Scout	SLC-5	AFSC launch. DAD-A
1976 MAY 22	Scout	SLC-5	AFSC launch
1976 SEP 1	Scout	SLC-5	AFSC launch. TIP III

Source: Brian Webb, “Vandenberg AFB Launch History,” http://www.spacearchive.info/vafblog.htm

On 26 April 1962, the first Scout launch took place from SLC-5. The Scout carried a Solar Radiation IV satellite intended to measure the hardness of solar x-rays and Lyman Alpha air-glow.[172] The launch was classified a failure when the third stage attitude control system apparently malfunctioned and the vehicle impacted in the ocean approximately 216 nautical miles downrange.[173]

An important early program utilizing SLC-5 was the Defense Meteorological Satellite Program (DMSP). This program was instituted as an interim measure for gathering knowledge of cloud cover over areas of interest until the civilian Television Infrared Observation Satellite (TIROS) program was capable of meeting this requirement. The DMSP program officially began 1 August 1960 under the authorization of the Director, National Reconnaissance Office (DNRO). Colonel Thomas Haig accepted the directorship on three conditions: “that he could use fixed-price, firm-schedule contracts; that he could select the personnel for his program office; and, that he did not have to use a civilian system engineering and technical direction (SE&TD) contractor.”[174] The Blue Scout program met his criteria, and the vehicle was used to launch five satellites in 1962

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[172] Lyman Alpha refers to the energy given off by a hydrogen electron when changing state; the release of this energy can be seen as light, or a glow in the air.

[173] Menken, *History of the Pacific Missile Range: 1 January 1962 to 31 December 1962*, 70.

[174] Mark Wade, “DMSP,” Encyclopedia Astronautica, http://www.astronautix.com/project/dmsp.htm (accessed Nov. 2009).

and 1963, with two being successful. This became the first operational satellite program for the United States that was manned entirely by Air Force military personnel.[175]

A series of launches in 1966 and 1967 utilized the Scout to orbit five satellites from SLC-5. Part of the Air Force OV3 series, these General Utility Satellites (GUS) were built by Aerojet. The solar-powered satellites gathered radiation data and studied the ionosphere.[176]

Scout launches included France's first satellite, FR-1 (launched 6 December 1965), and numerous NASA missions. Explorers 19, 20, 22, 24, 25, 39, 40 and 52 were all orbited by Scout vehicles from SLC-5 (Figure 43). Scouts launched from SLC-5 have also orbited balloon targets, used by the Air Force to test anti-satellite weapons fired from F-15 fighters.[177] On 25 March 1966, the Scout was involved in setting an unbroken record when four missiles were launched from VAFB in one day. A Titan II, Nike-Javelin, Minuteman I, and Scout all blasted off within seven hours. This launch record has been tied but never broken.[178]

The Navy's Transit navigation satellite program was one of the most successful programs carried out at SLC-5. Initially, Transit satellite data served only the Navy. Submarines used it to get precise longitude and latitude readings to accurately aim their submarine-launched ballistic missiles. As the program was expanded, NASA, Air Force, and PMR began planning launch support for Scout-boosted Transit payloads in August 1961, before the launch facilities were constructed. The first Transit launch at VAFB occurred at SLC-5 on 18 December 1962. Since then, Scout vehicles have launched a total of twenty-six such satellites (Figure 44).[179]

The final eleven Scout missions at SLC-5 involved mainly Navy Transit navigation satellite launches and Air Force anti-satellite target launches. Other payloads included the Radcal (Radar Calibration) satellite and two Strategic Defense Initiative (SDI) research payloads. Successfully placed in orbit on 25 June 1993, the Radcal satellite provided space-based calibration for over 70

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[175] Mark Wade, "Program 35," Encyclopedia Astronautica, http://www.astronautix.com/craft/proram35.htm (accessed Nov. 2009).

[176] Mark Wade, "OV3," Encyclopedia Astronautica, http://www.astronautix.com/craft/ov3.htm (accessed Nov. 2009).

[177] Nowlan, et al., *Cold War Properties Evaluation - Phase I: Inventory and Evaluation*, 130.

[178] Geiger, *Vandenberg 1958-2008*, , 18.

[179] Nowlan, et al., *Cold War Properties Evaluation - Phase I: Inventory and Evaluation*, 131; Menken, *History of the Pacific Missile Range*, 285.

C-band radars worldwide. The two DoD missions supporting SDI research, designated MSTI-1 and MSTI-2 (Miniature Seeker Technology Integration), occurred on 21 November 1992 and 8 May 1994.[180] The 8 May 1994 Scout launch, the last at SLC-5, ended an impressive run for the 36-year old Scout booster (Figure 45 and Figure 46; Table 8).

Table 8. Scout Launches from SLC-5.[181]

Flight/Vehicle Number	Date	Performance (S=success; F=failure)	Payload	Experiment
10/S-111	4/26/62	F	SOLRAD-IVB	Radiation
11/S-112	5/23/62	F	AF-1/P35-1	Military Weather Satellite
12/S-117	8/23/62	S	AF-2/P35-2	Military Weather Satellite
15/S-118	12/18/62	S	Transit-1/5A-1	Navigation
16/S-126	2/19/63	S	AF-3/P35-3	Military Weather Satellite
17/S-119	4/5/63	F	Transit-2/5A-2	Navigation
18/S-121	4/26/63	F	AF-4/P35-4	Military Weather Satellite
20/S-120	6/15/63	S	Transit-3/5A-3	Navigation
23/S-132	9/27/63	F	AF-5/P35-5	Military Weather Satellite
24/S-122R	12/19/63	S	S-56B/Explorer 19	Air density
26/S-125R	6/3/64	S	Transit-4/SC-1	Navigation
27/S-128R	6/25/64	F	CRL-2/ESRS	Cambridge Research Laboratory
30/S-134R	8/25/64	S	S-48/Explorer 20	Meteorological experiment
32/S-123RR	10/9/64	S	BE-B/Explorer 22	Electron content of ionosphere and laser tracking
34/S-135R	11/21/64	S	AD/I-B/Explorer 24	Atmospheric charged particle and air density
39/S-139R	12/6/65	S	FR-1	Study VLF in magnetosphere
40/S-140C	12/21/65	S	Transit-5	Navigation
41/S142C	1/28/66	S	Transit-6	Navigation
43/S-143C	3/25/66	S	Transit-7	Navigation
44/S-145C	4/22/66	S	OV3-1	Radiation research
45/S-146C	5/18/66	S	Transit-8	Navigation
47/S-148C	8/4/66	S	OV3-3	Radiation research
48/S-149C	8/17/66	S	Transit-9	Navigation

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180 Edward H. Kolcum, "NASA, Pentagon Chart Ambitious Unmanned Launch Vehicle Program," *Aviation Week & Space Technology*, 16 March 1992, 133.

181 This list is as complete as possible, considering there are multiple sources for launch chronology and payloads, and no two chronologies are exactly the same in every aspect. Cross-referencing provides some measure of accuracy, but authors make no claim to having a totally complete and accurate list.

Flight/Vehicle Number	Date	Performance (S=success; F=failure)	Payload	Experiment
49/S-150C	10/28/66	S	OV3-2	Radiation data
50/S-151C	1/31/67	F	OV3-5	Atmospheric measurements
51/S-154C	4/13/67	S	Transit-10	Navigation
53/S-155C	5/5/67	S	UK-3/Ariel 3	Atmospheric and radio noise
54/S-156C	5/18/67	S	Transit-11	Navigation
55/S-152C	5/29/67	F	ESRO-11	Radiation, charged particle and cosmic ray
56/S157C	9/25/67	S	Transit-12	Navigation
58/S-158C	12/4/67	S	OV3-6	Radiation
59/S-162C	3/1/68	S	Transit-13	Navigation
62/S-161C	5/16/68	S	ESRO-IIB	Charged particle, solar and cosmic X-ray
63/S-165C	8/8/68	S	AD/I-C/ Explorer 39	Air density and charged particle
65/S-167C	10/3/68	S	ESRO-IA	Ionospheric and auroral phenomena
66/S-172C	10/1/69	S	ESRO-IB	Ionospheric and auroral phenomena
67/S-169C	11/7/69	S	GRS-A/Azur	Van Allen belt, auroral and solar particle
68/S-176C	8/27/70	S	Transit-14	Navigation
78/S-183C	12/11/71	S	UK-4/Ariel 4	Interaction of charged particles in ionosphere
80/S-182C	9/2/72	S	TIP-1	Navigation
82/S-185-C	11/21/72	S	ESRO-IV	Auroral phenomena in polar regions
83/S-181C	12/16/72	S	AEROS-A	State and behavior of upper atmosphere
84/S-178C	10/29/73	S	Transit-15	Navigation
86/S-188C	3/8/74	S	X-4/Miranda	Technology for 3-axis stabilization platform
87/S-191C	6/3/74	S	Hawkeye	Neutral point region of magnetosphere
88/S-186C	7/16/74	S	AEROS-B	State and behavior of upper atmosphere
89/S-189C	8/30/74	S	ANS-A	Celestial X-ray and ultraviolet sources
92/S-195C	10/11/75	S	TIP-II	Navigation
93/S-196C	12/5/75	F	DAD	Air density studies
94/S-179CR	5/22/76	S	P76-5	Effects of ionosphere on satellite communication
96/S-197C	9/1/76	S	TIP-III	Navigation
97/S-200C	10/27/77	S	TRANSAT	Navigation and missile tracking
98/S-201C	4/26/78	S	HCMM	Provide thermal maps of earth’s surface
101/S-203C	10/30/79	S	MAGSAT	Global survey of earth’s magnetic field
102/S-192C	5/14/81	S	NOVA-I/TIP	Navigation
103/S-205C	6/27/83	S	HILAT	Plasma’s effect on radar and radio frequency
104/S-208C	10/11/84	S	NOVA-III/ TIP	Navigation
105/S-209	8/2/85	S	SOOS-1	Navigation
107/S-199	11/13/86	S	PolarBEAR	Polar communications
108/S-204	9/16/87	S	SOOS-2	Navigation
110/S-211	4/25/88	S	SOOS-3	Navigation

Flight/Vehicle Number	Date	Performance (S=success; F=failure)	Payload	Experiment
111/S-213	6/15/88	S	NOVA-II	Navigation
112/S-214	8/25/88	S	SOOS-4	Navigation
113/S-212C	5/9/90	S	MACSAT 1	Multiple access communications
114/S-216C	6/29/91	S	REX	Communications
115/S-215C	7/3/92	S	SAMPEX	Solar flare/cosmic ray data
116/S-210C	11/21/92	S	MSTI-1	Atmospheric studies
117/S-217C	6/25/93	S	RADCAL	Radar calibrations
118/S-218	5/8/94	S	MSTI-2	Tracking and earth observation studies

Sources: Loral Vought Systems, "Farewell, Scout," *Missileer*, Special Edition, May 26, 1994, 8-9; Abraham Leiss, Scout Launch Vehicle Program Final Report - Phase VI (Hampton, VA: Williamsburg West, Inc., 1982), 437-448, Mark Wade, *Encyclopedia Astronautica*, http://www.astronautix.com/lvs/scout.htm; McDowell, Jonathan, Jonathan's Space Home Page (launch records), http://www.planet4589.org/jsr.html; Peter Hunter, Dr. Jonathan McDowell, and Donald Prichard, "VAFB Launches," Manuscript, 2000; Brian Webb, "Vandenberg AFB Launch History," http://www.spacearchive.info/vafblog.htm

SLC-5 SITE DESCRIPTION

With minor alterations to the original design, the Scout program made use of the Probe launch control building (Facility 589) located just off Coast Road. All other Scout facilities were purpose-built and were situated uphill and east of the Probe complex.

To facilitate access to the uphill Scout facilities, roadways originally constructed for the Probe complex were altered and extended. A short ramp (Road E) with a larger turning radius was added to the intersection of Coast Road and Road A (the primary SLC-5 access road). Road A was extended to the southeast from the Probe complex's secondary roads (Road B and Road C) to the Scout launch pad. Access control to the uphill facilities, including a gate and sentry house, was located at the midpoint of the Road A extension at what was Avery and Delphy Roads at the time of field investigations (Figure 47). Just inside the entry point on the south side of the Road A extension was a machine maintenance shop (Facility 584). An additional secondary road, Road D, was constructed that circled north of the Scout operations support building to provide added mobility and access in the launch area. Road D also provided parking for twenty vehicles north of the operations support building; an additional ten parking spaces were located south of the building along Road A.[182] A map showing the new road construction for Scout facilities is shown in Figure 48.

Each launch pad was serviced by an independent power substation. Electrical conduit ran underground in utility ducts that were largely inaccessible except at purposefully-placed manholes and handholes. Although the two launch pads had dedicated power supplies, their communications systems were interconnected to facilitate Scout launch operations. To manage the uphill Scout facilities from the downhill Probe launch control building, a Scout control room was added to the Probe facility design. Scout communication lines ran between the control room and distant launch pad in a single channel that fluctuated between an underground cable trench and an above-grade covered cableway as site conditions required. Cabling that ran within the trenches and cableways was readily accessible along the entire length via cover plates and exposed lines. Additional site characteristics are covered in HAER reports CA-2288-A, CA-2288-B, CA-2288-C, CA-2288-D, and CA-2288-E.

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[182] Architectural/Engineering drawing set for Space Launch Complex 5, "Drawing No. 580-E-1;" "Drawing No. 580-C-1;" "Drawing No. 580-C-2." (Vandenberg AFB, CA: 30th Civil Engineering Squadron drawing vault).

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ACRONYMS AND ABBREVIATIONS

Term	**Spellout**
AAF	Army Air Force
AEC	Atomic Energy Commission
AFB	Air Force Base
AFBMD	Air Force Ballistic Missile Division
AFSC	Air Force Systems Command
AFWTR	Air Force Western Test Range; later became AFSC
ARDC	Air Research and Development Command
ATW	Aerospace Test Wing
CERL	Construction Engineering Research Laboratory
Convair	Consolidated Vultee Aircraft Corporation
DARPA	Defense Advanced Research Project Agency
DNRO	Director, National Reconnaissance Office
DoD	Department of Defense
DMSP	Defense Meteorological Satellite Program
DSCS	Defense Satellite Communications System
ERCS	Emergency Rocket Communications System
ERDC	Engineer Research and Development Center
FLATSATCOM	Fleet Satellite Communications system
GPS	Global Positioning System
GSE	ground support equipment
GUS	General Utility Satellites
HAER	Historic American Engineering Record

Term	**Spellout**
HEAO	High Energy Astronomy Observatory
HETS	Hyper Environmental Test System (official name for Blue Scout)
ICBM	intercontinental ballistic missile
IDSCS	Initial Defense Satellite Communication System
IGY	International Geophysical Year
IRBM	intermediate-range ballistic missile
JPL	Jet Propulsion Laboratory
LTV	corporation formerly known as Ling-Temco-Vought
MCON	Military Construction Navy
MSTI	Miniature Seeker Technology Integration
NACA	National Advisory Committee for Aeronautics
NARA	National Archives and Records Administration
NASA	National Aeronautics and Space Administration
NHPA	National Historic Preservation Act
NMFPA	Naval Missile Facility at Point Arguello
NOAA	National Oceanic and Atmospheric Administration
NOTS	Naval Ordnance Test Station
NPS	National Park Service
NRHP	National Register of Historic Places
NRL	Naval Research Laboratory
NSC	National Security Council
OAB	Ordnance Assembly Building
OAO	Orbiting Astronomical Observatory
OGO	Orbiting Geophysical Observatory
ONR	Office of Naval Research
OSO	Orbiting Solar Observatory
PALC-A	Point Arguello Launch Complex A
PARD	Pilotless Aircraft Research Division
PMR	Pacific Missile Range
PMRF	Pacific Missile Range Facility
Radcal	Radar calibration
RAND	Research and Development Corporation
SAC	Strategic Air Command
SALT	Strategic Arms Limitation Treaty
SAMTEC	Space and Missile Test Center
SE & TD	system engineering and technical direction
SHPO	State Historic Preservation Officer
SLC-5	Scout Space Launch Complex 5
STI	Strategic Defense Initiative
STS	Space Transportation System (now known as Space Shuttle)
TACSAT	Tactical Communications Satellite system

Term	Spellout
TIROS	Television Infrared Observation Satellite
TV	television
UHF	ultrahigh frequency
USAF	United States Air Force
VAFB	Vandenberg Air Force Base
WFF	Wallops Flight Facility
WSMC	Western Space and Missile Center
WTR	Western Test Range

HISTORIC DRAWINGS

The technical drawings used for research in this study are not available for inclusion in this document, because of the following determination:

> These drawings HAVE NOT been characterized as being released to the public domain and MAY contain EXPORT-CONTROLLED TECHNICAL DATA. Export-Controlled Technical Data is data that cannot be lawfully exported without the approval, authorization, or license under U.S. export control laws. The controlling regulations and documents are the Export Administration Regulations (EAR), the International Traffic in Arms Regulation (ITAR), and the U.S. munitions list.

Due to this stipulation, it is not possible to reproduce in this document the drawings used to gather information about the design, construction, and use of facilities at Scout Launch Complex 5, VAFB, California.

FIGURES FROM DATA SECTION

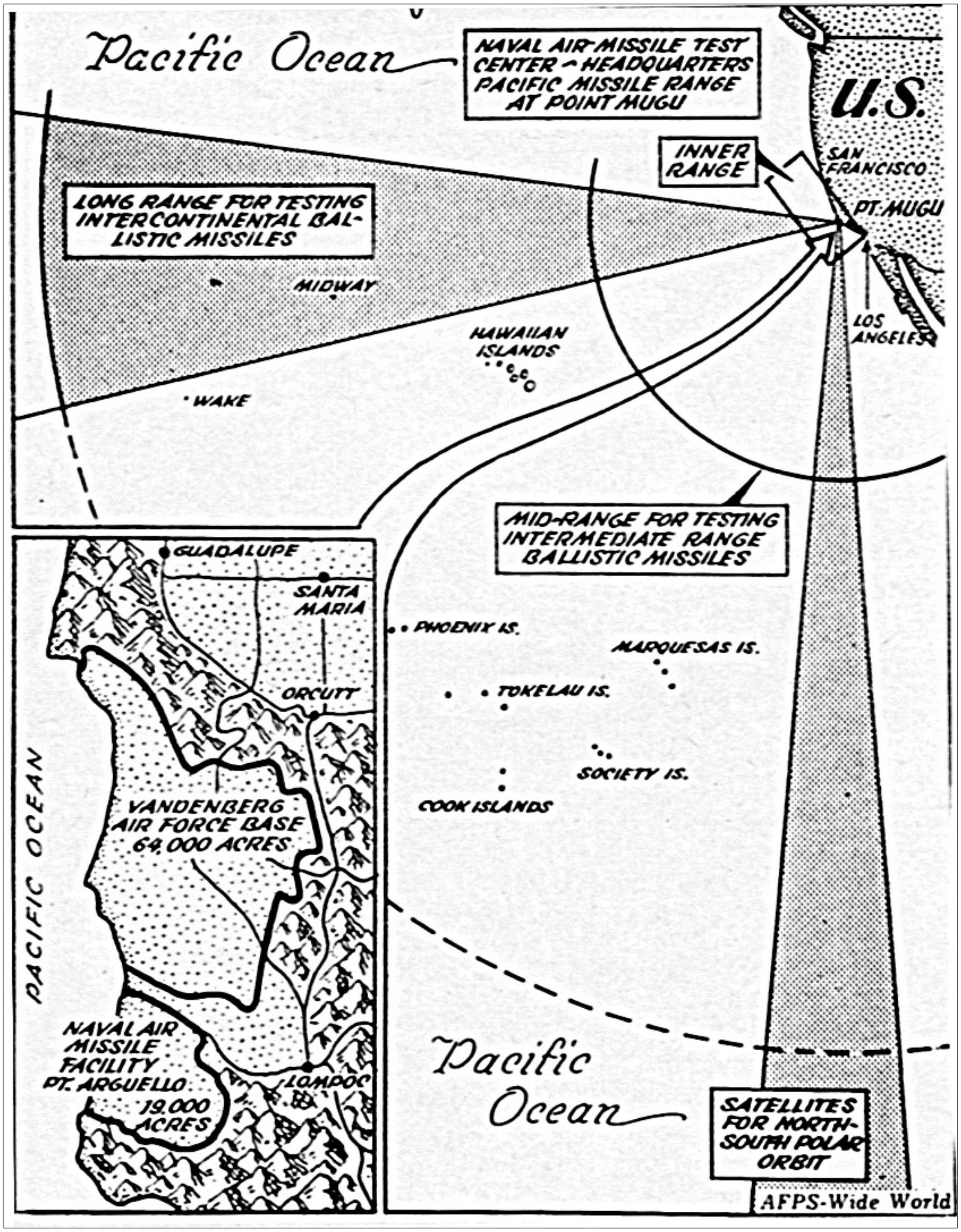

Figure 1. VAFB and NMFPA Range Map, 1959 (U.S. Navy Seabee Museum, Port Hueneme, CA).

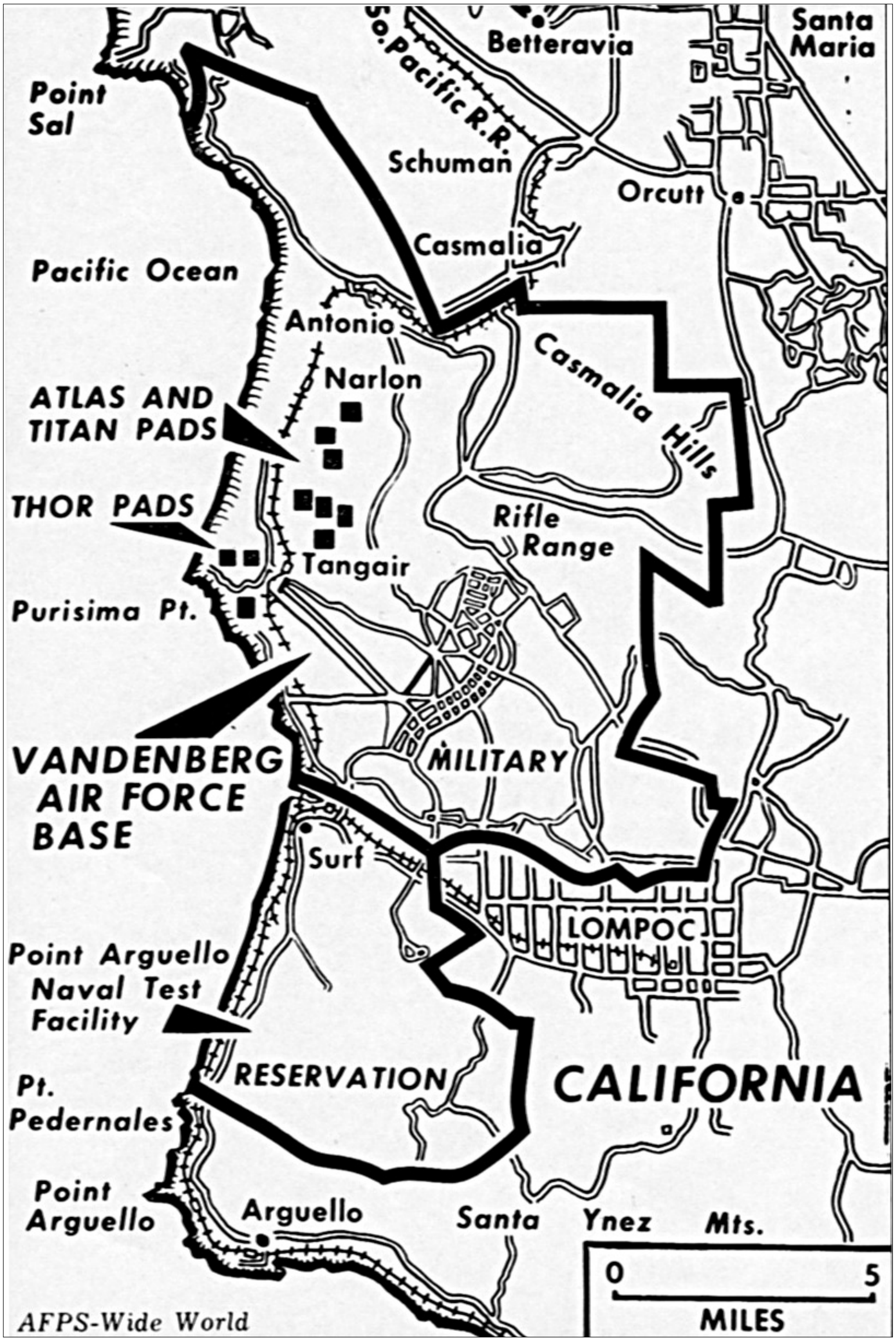

Figure 2. Early construction at VAFB, June 1959 (U.S. Navy Seabee Museum, Port Hueneme, CA).

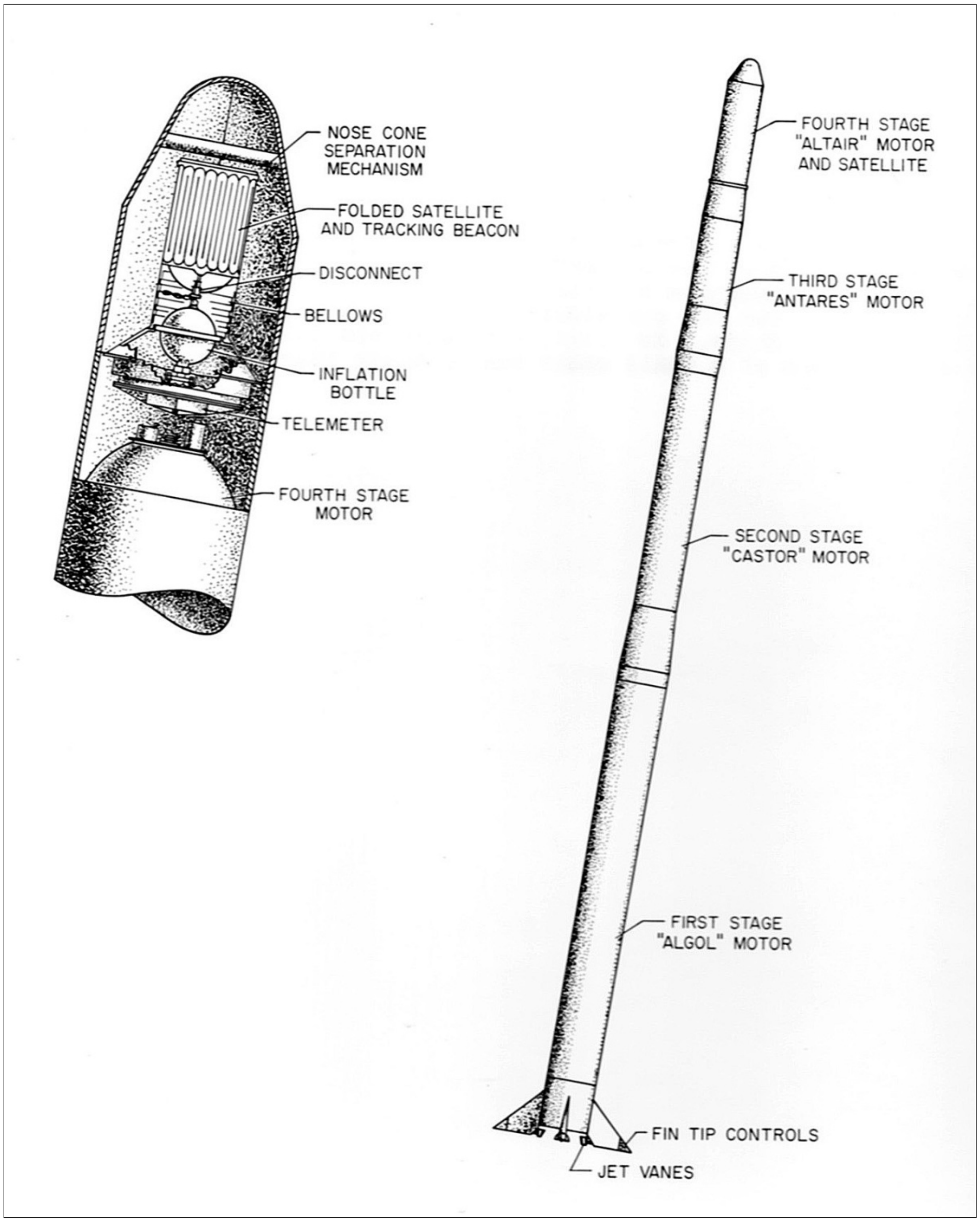

Figure 3. Original Scout Configuration, 1960 (NARA, College Park, MD).

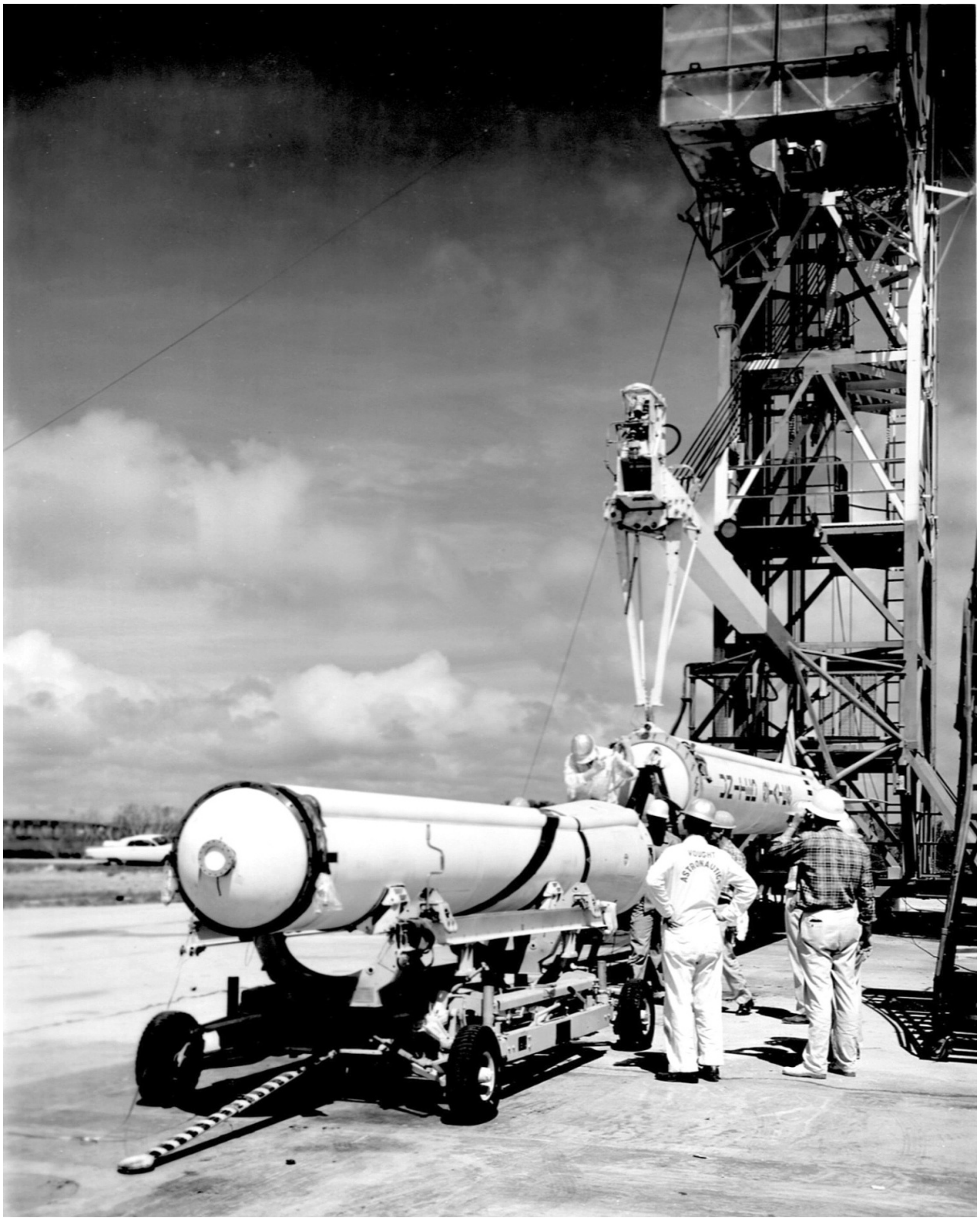

Figure 4. First and Second Stage Assembly at Wallops Island, 1960 (NARA, College Park, MD).

Figure 5. Fourth Stage Addition, 19 June 1960, Wallops Island (NARA, College Park, MD).

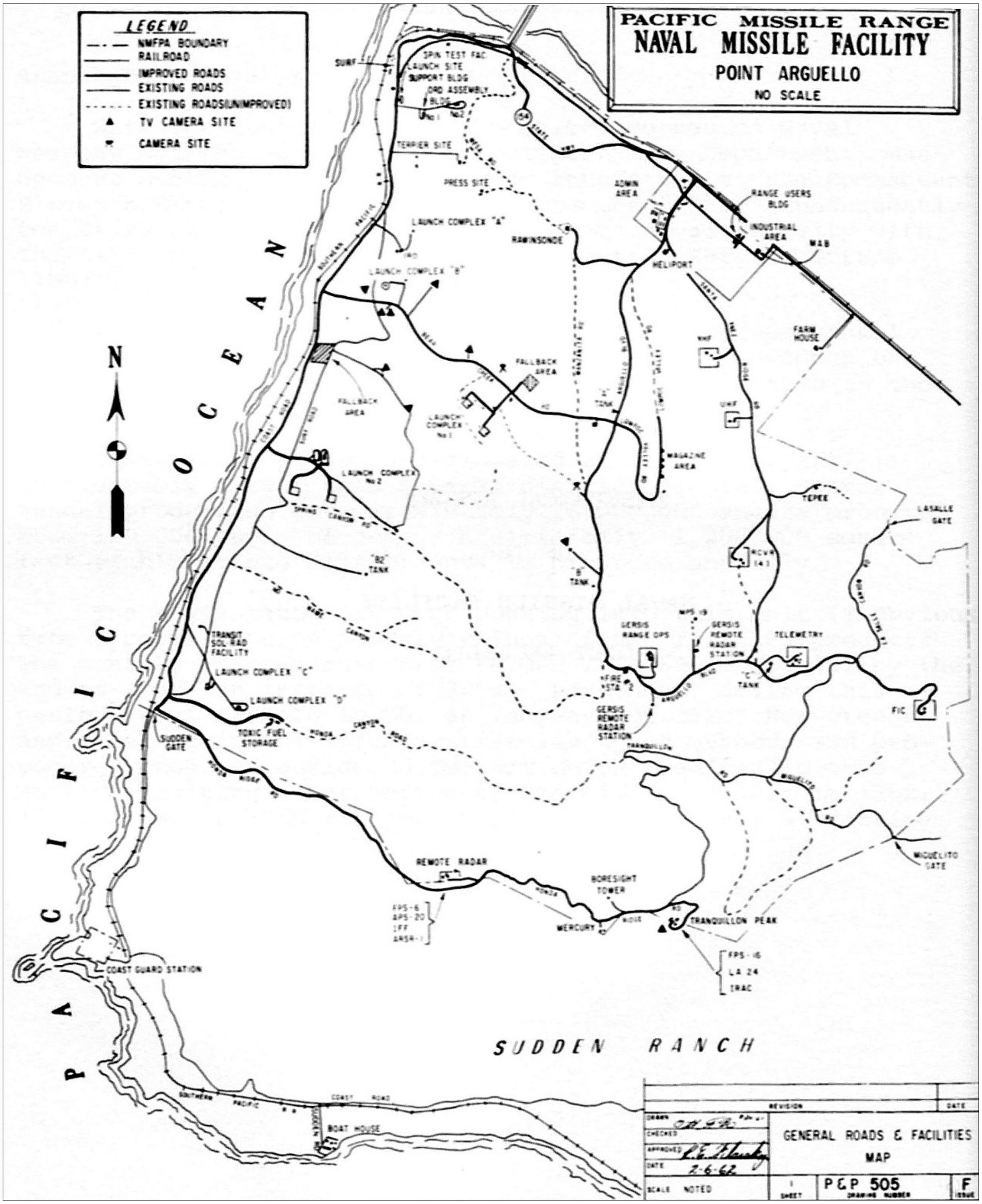

Figure 6. Map of NMFPA in 1962; Scout Complex is labeled "Launch Complex D"
(U.S. Navy Seabee Museum, Port Hueneme, CA).

Figure 7. Air Force "Blue Suit" Technicians with Scout Vehicle in mobile checkout shelter, VAFB Facility #580, 1960s (Official NASA-USAF photograph).

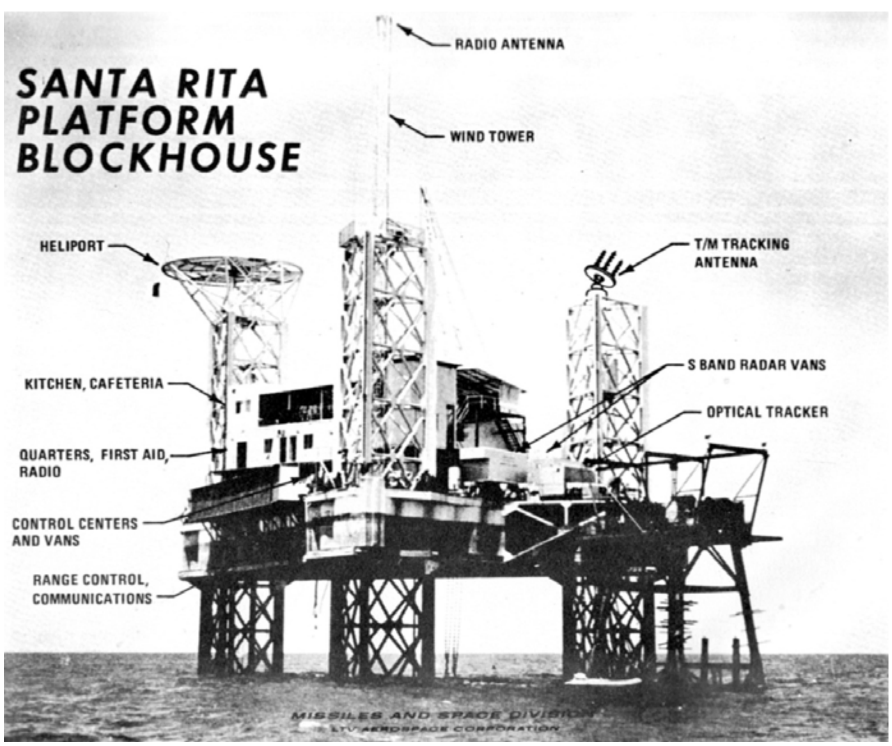

Figure 8. San Marco Facility Blockhouse, 1970s (NASA HQ, History Office, Washington, D.C.).

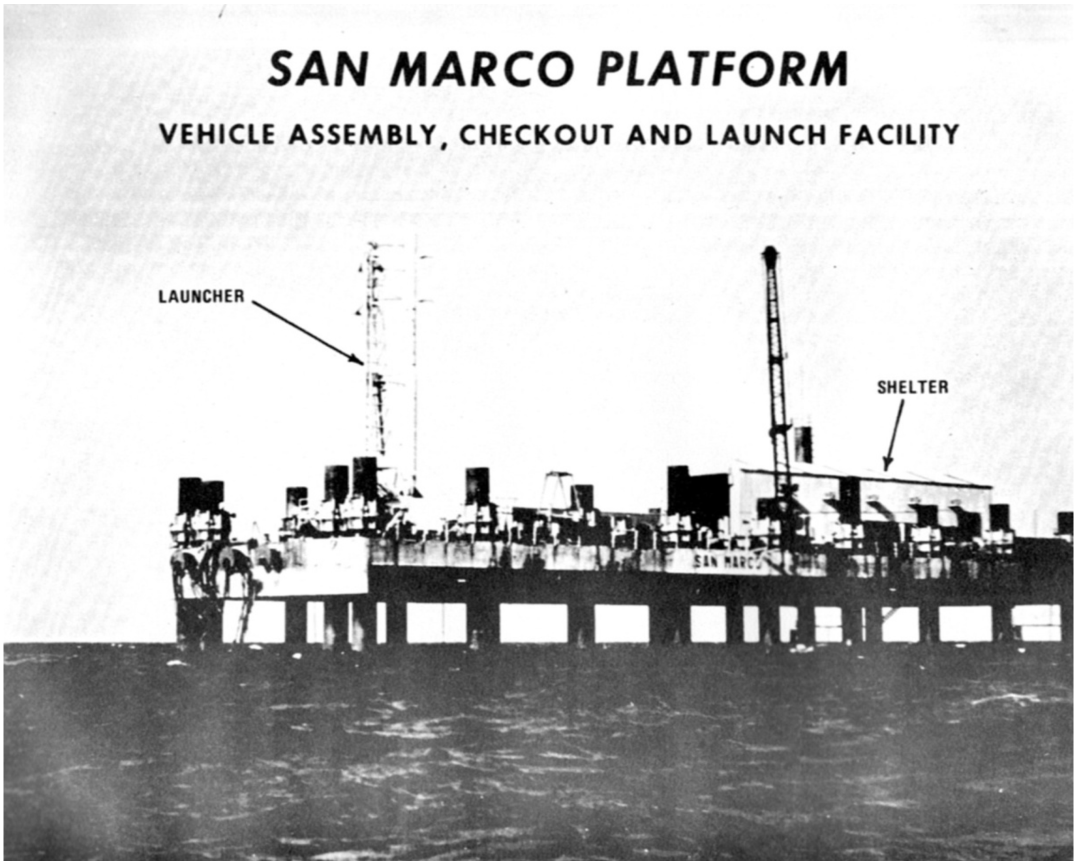

Figure 9. San Marco Launcher and Shelter, 1970s (NASA HQ, History Office, Washington, D.C.).

Figure 10. Scout carrying payload for the Netherlands, 1974 (NARA, College Park, MD).

Figure 11. UK-3 satellite being prepared for Scout launch, 1967 (NARA, College Park, MD).

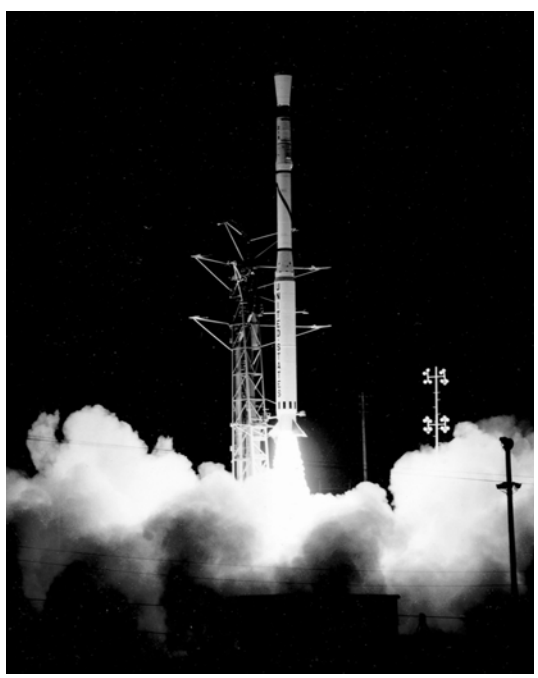

Figure 12. Last Scout launch, 8 May 1994 (History Office, Space & Missile Systems Center, Los Angeles AFB).

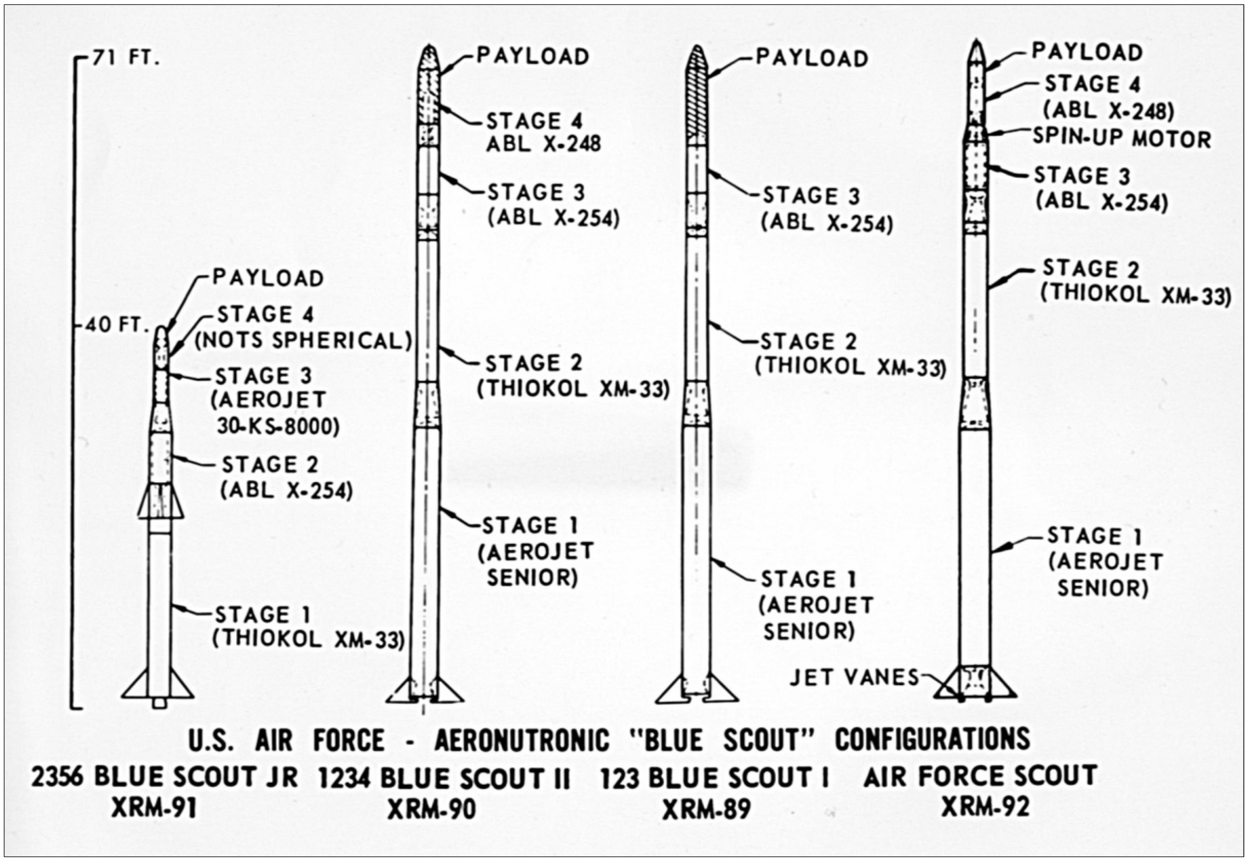

Figure 13. Air Force Blue Scout family of launch vehicles
(History Office, Space and Missile Systems Center, Los Angeles AFB).

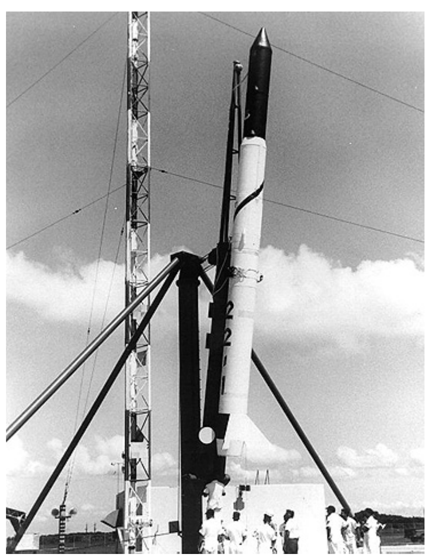

Figure 14. Blue Scout Junior at Complex 18, Cape Canaveral, 30 July 1963 (USAF).

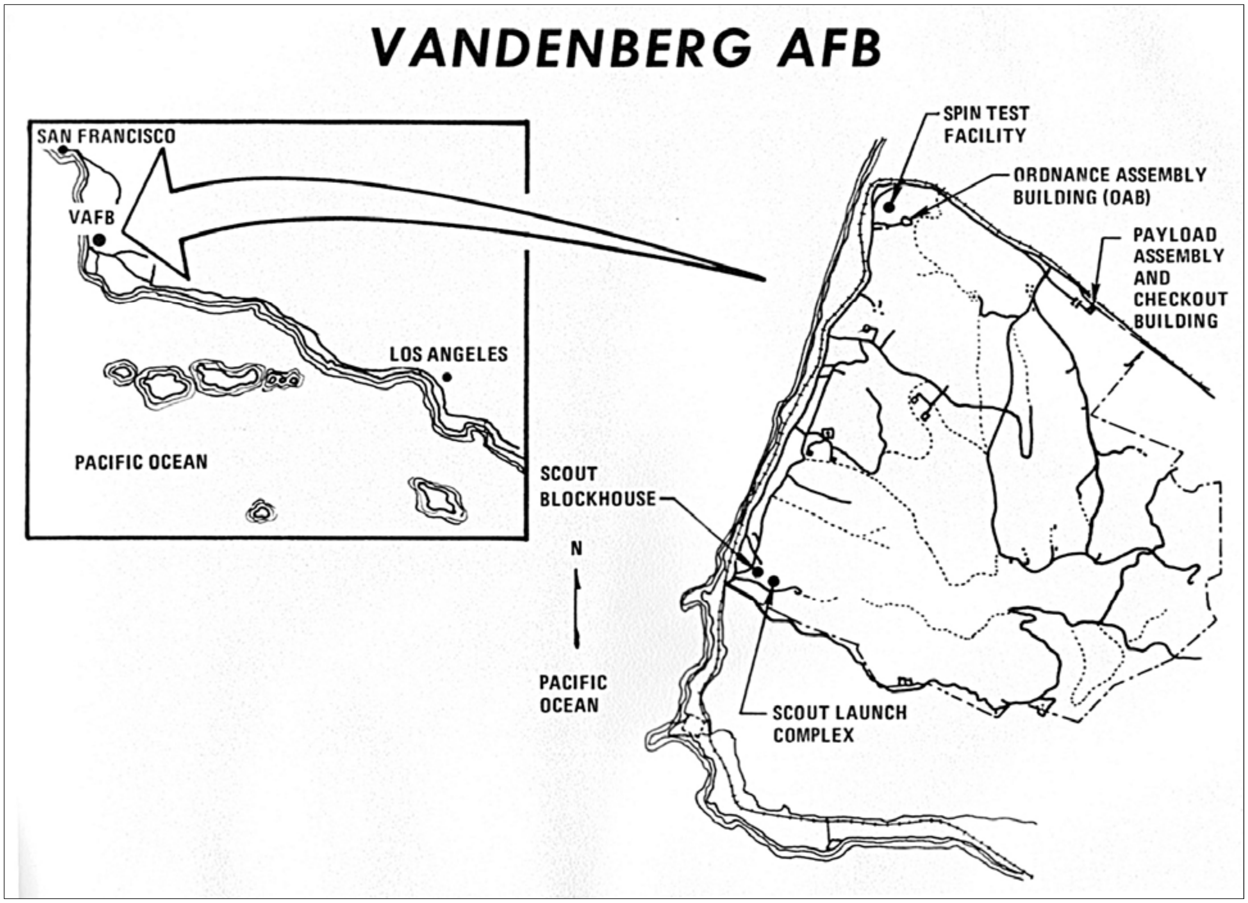

Figure 15. Scout facilities at South VAFB (NASA HQ History Office, Washington, D.C.).

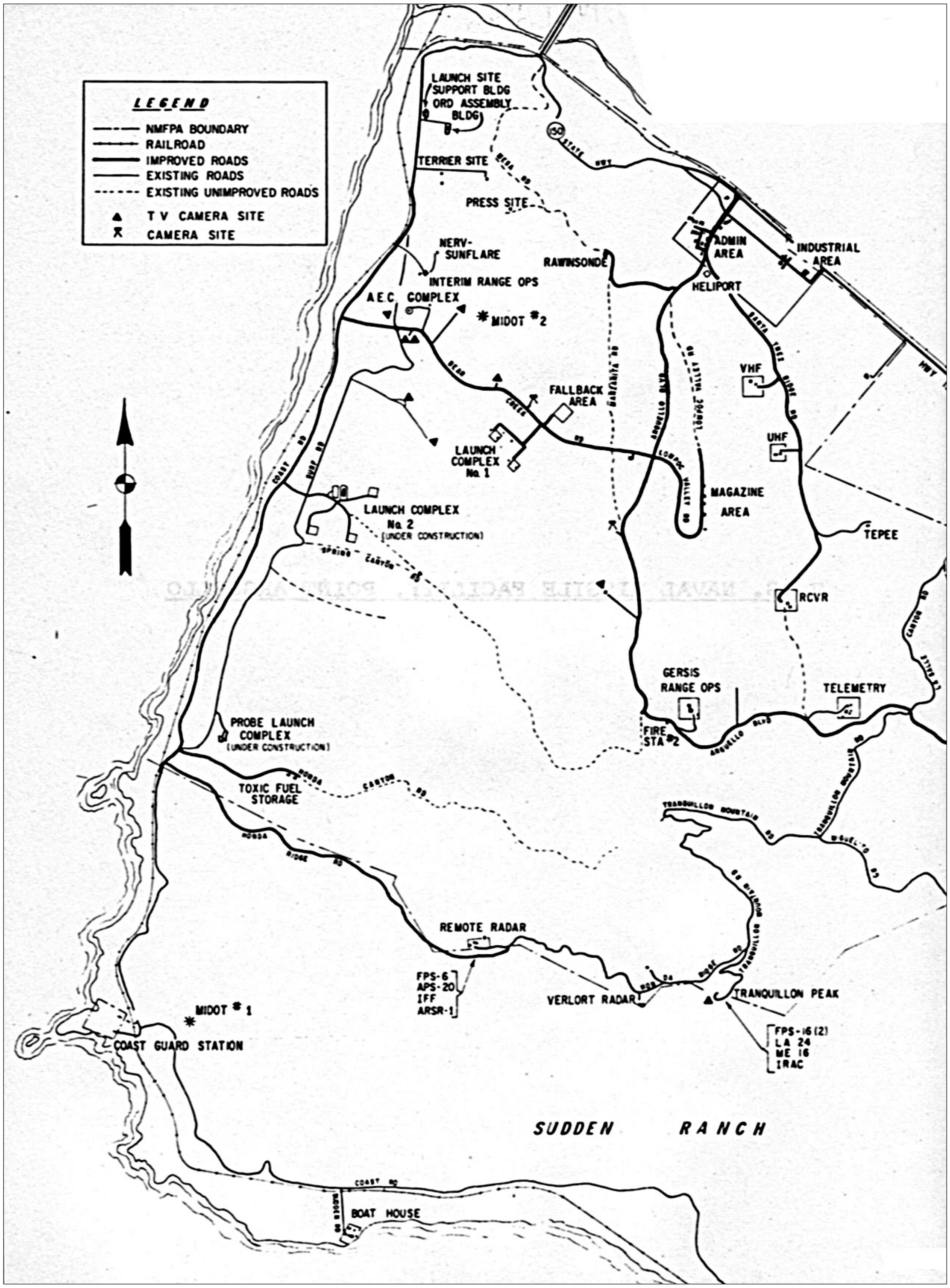

Figure 16. Location of Probe Launch Complex, Naval Missile Facility Point Arguello, 1961 (U.S. Navy Seabee Museum, Port Hueneme, CA).

Figure 17. Blockhouse construction, 1 February 1962 (Official USAF photograph).

Figure 18. Probe blockhouse nearly completed, 5 February 1962 (U.S. Navy Seabee Museum, Port Hueneme, CA).

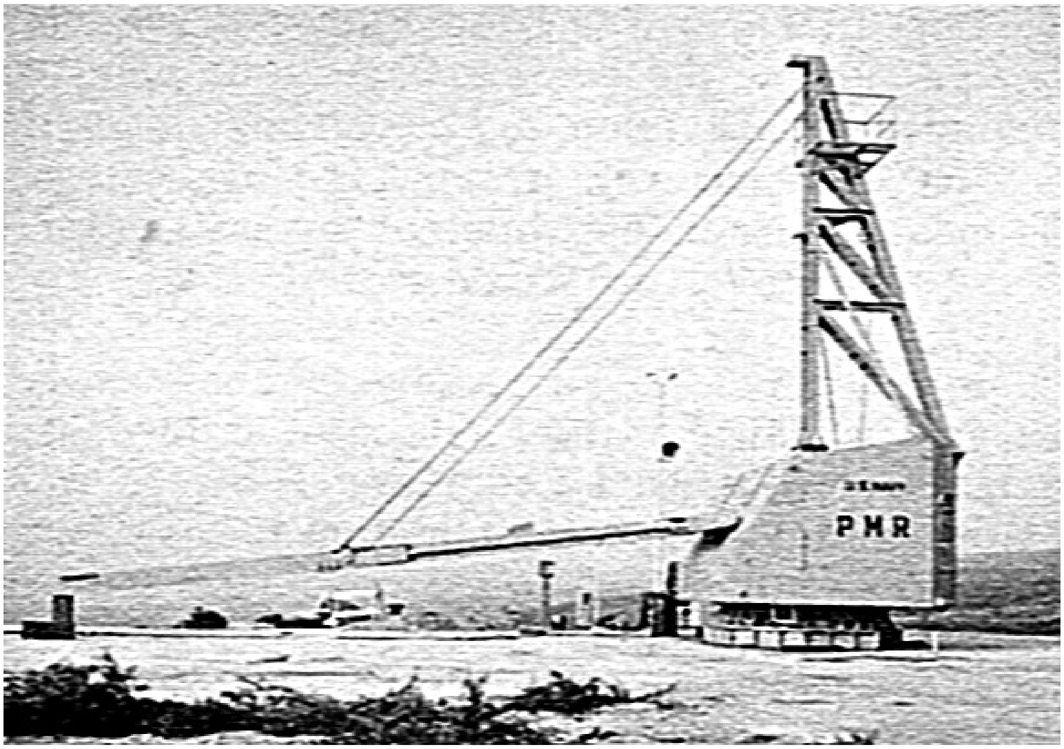

Figure 19. Probe launcher on launch pad, 1963 (U.S. Navy Seabee Museum, Port Hueneme, CA).

Figure 20. Blockhouse and probe launcher, circa 1964 (Vought Aircraft Industries).

Figure 21. SLC-5 construction showing launcher in two pieces outside mobile shelter, 9 January 1962 (Official USAF Photograph).

Figure 22. SLC-5 construction, 1 February 1962 (Official USAF Photograph).

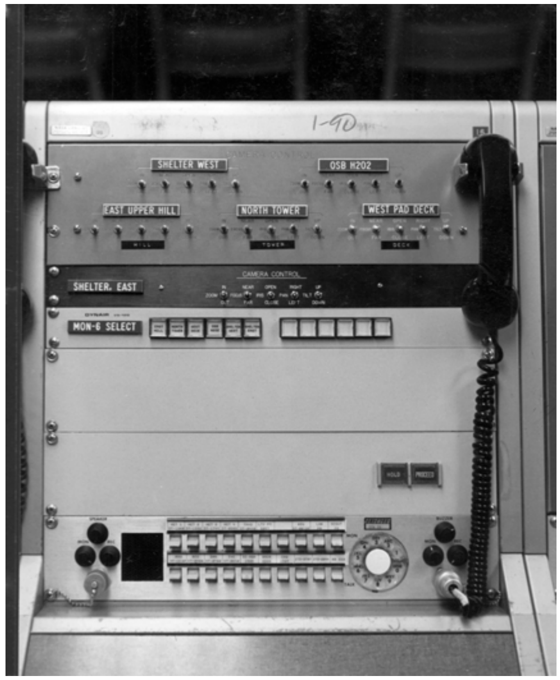

Figure 23. Camera control panel in blockhouse, VAFB Facility #589, 16 January 1990 (Collection of Jim Price).

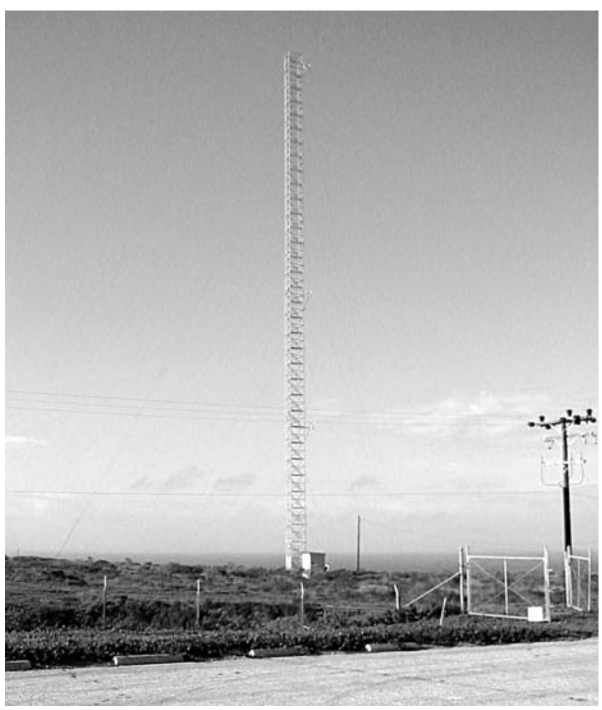

Figure 24. A 200-foot meteorological tower was installed 17 May 1962 and was located between PALC-C and PALC-D (VAFB Cultural Resources Office).

Figure 25. The meteorological tower was demolished 3 January 2003 (VAFB Cultural Resources Office).

Figure 26. Aerial view of SLC-5, 1967 (Official USAF Photograph).

Figure 27. Aerial view of SLC-5, 1979 (NASA HQ History Office, Washington, D.C.).

Figure 28. Aerial view of SLC-5, 1990 (VAFB History Office).

Figure 29. Nike-Aerobee (White Sands Missile Range Museum, Las Cruces, NM).

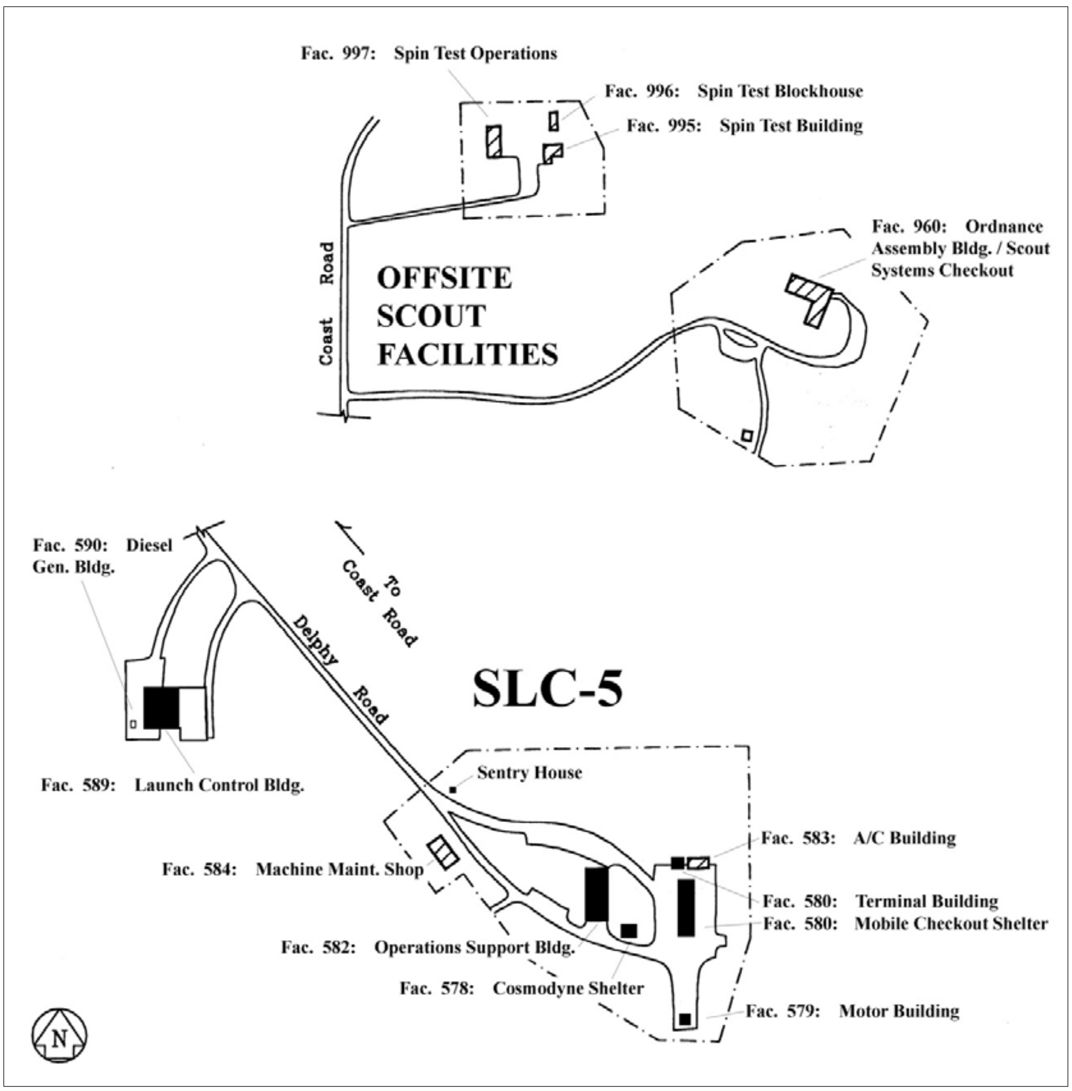

Figure 30. Scout launch facility SLC-5. (Produced by ERDC-CERL)

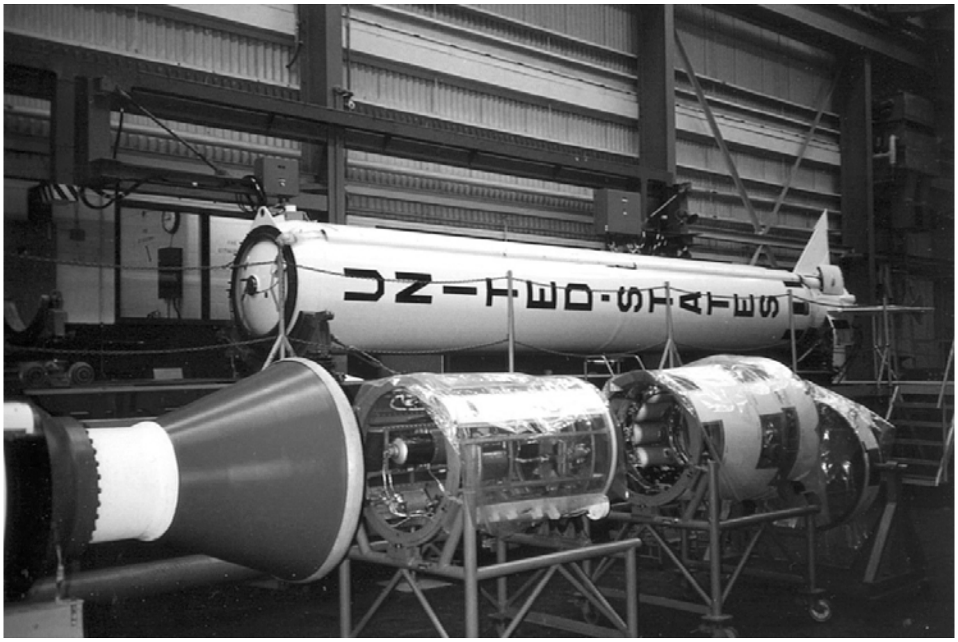

Figure 31. Work area inside the Ordnance Assembly Building, VAFB Facility #960, n.d. (Collection of Jim Price).

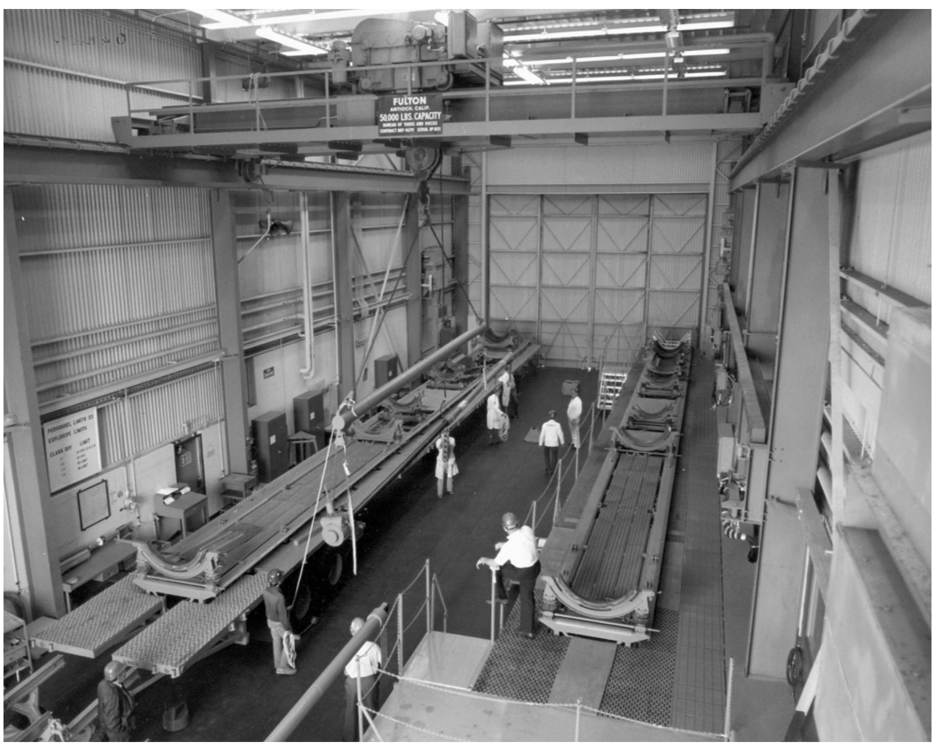

Figure 32. Interior of the Ordnance Assembly Building, VAFB Facility #960, 4 March 1986 (Official USAF Photograph).

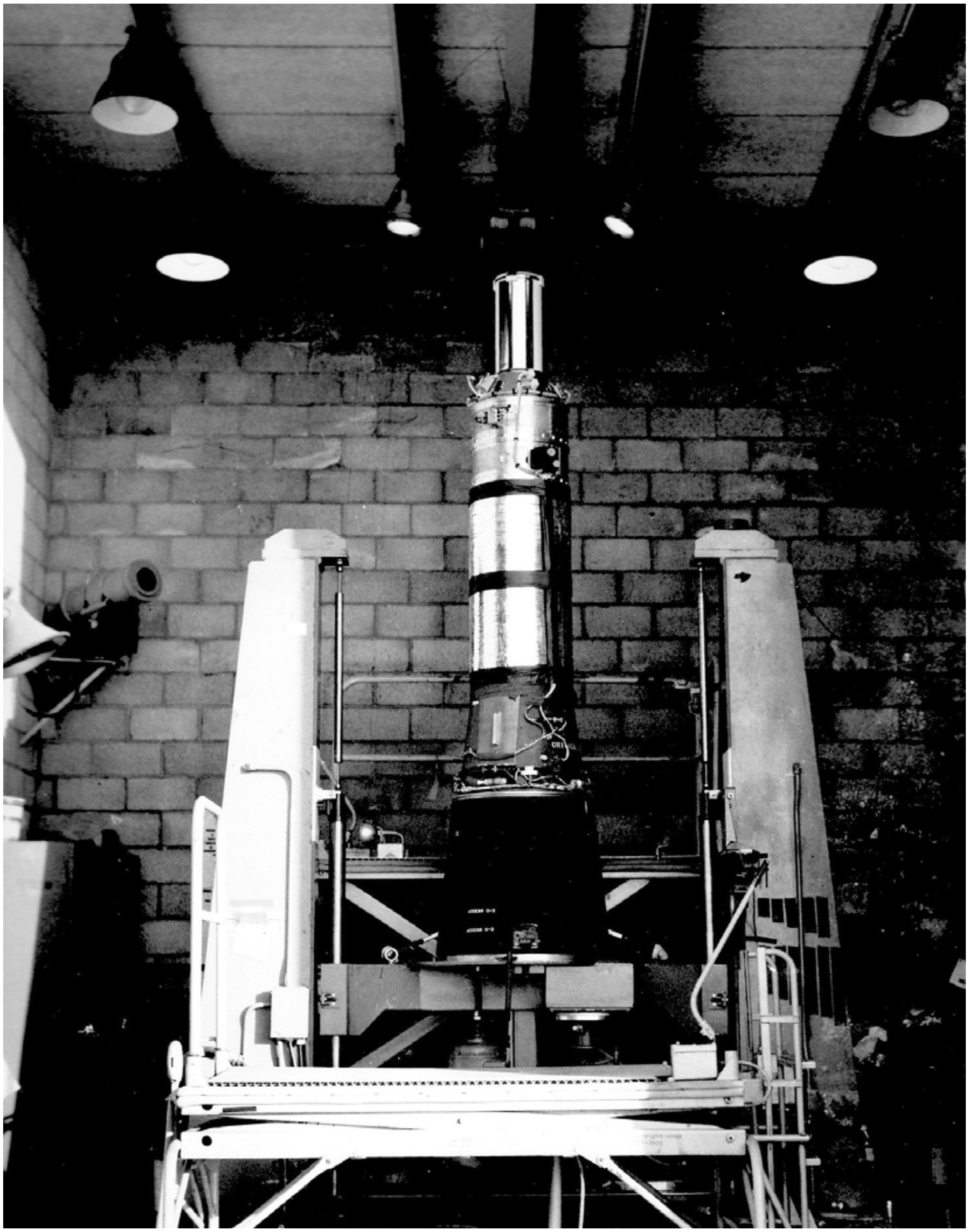

Figure 33. Explorer 19 satellite on 4th stage spin test, VAFB Facility #995, n.d. (NARA, College Park, MD).

Figure 34. Last Scout vehicle on transporter approaching SLC-5, 1994 (Collection of Jim Price).

Figure 35. Scout vehicle and transporter being placed inside mobile shelter, 1963 (NARA, College Park, MD).

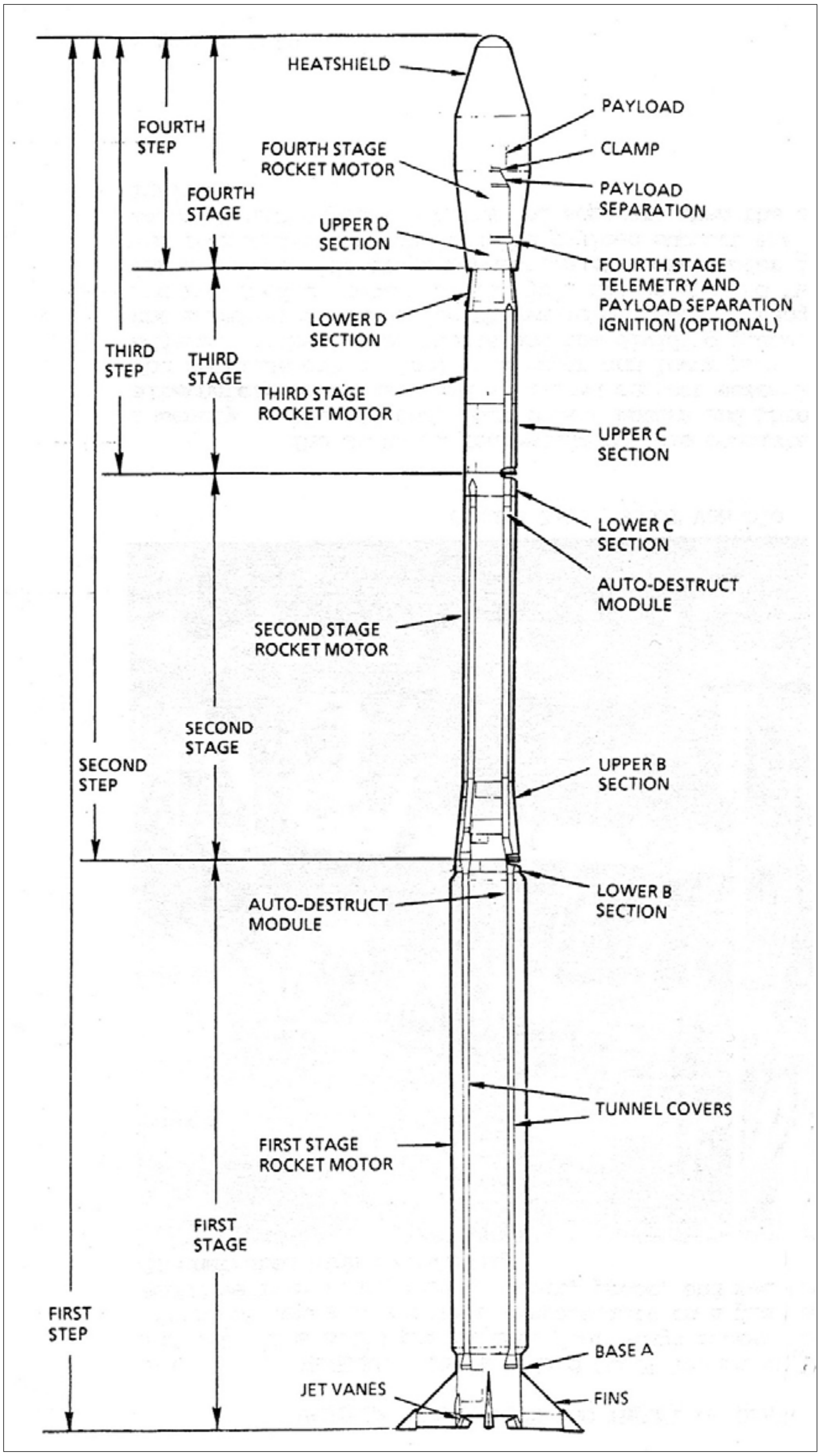

Figure 36. Standard Scout configuration
(History Office, Space and Missile Systems Center, Los Angeles AFB).

Figure 37. Scout vehicle checkout inside SLC-5 mobile checkout shelter, VAFB Facility #580, post-1982 (Official NASA-USAF Photograph).

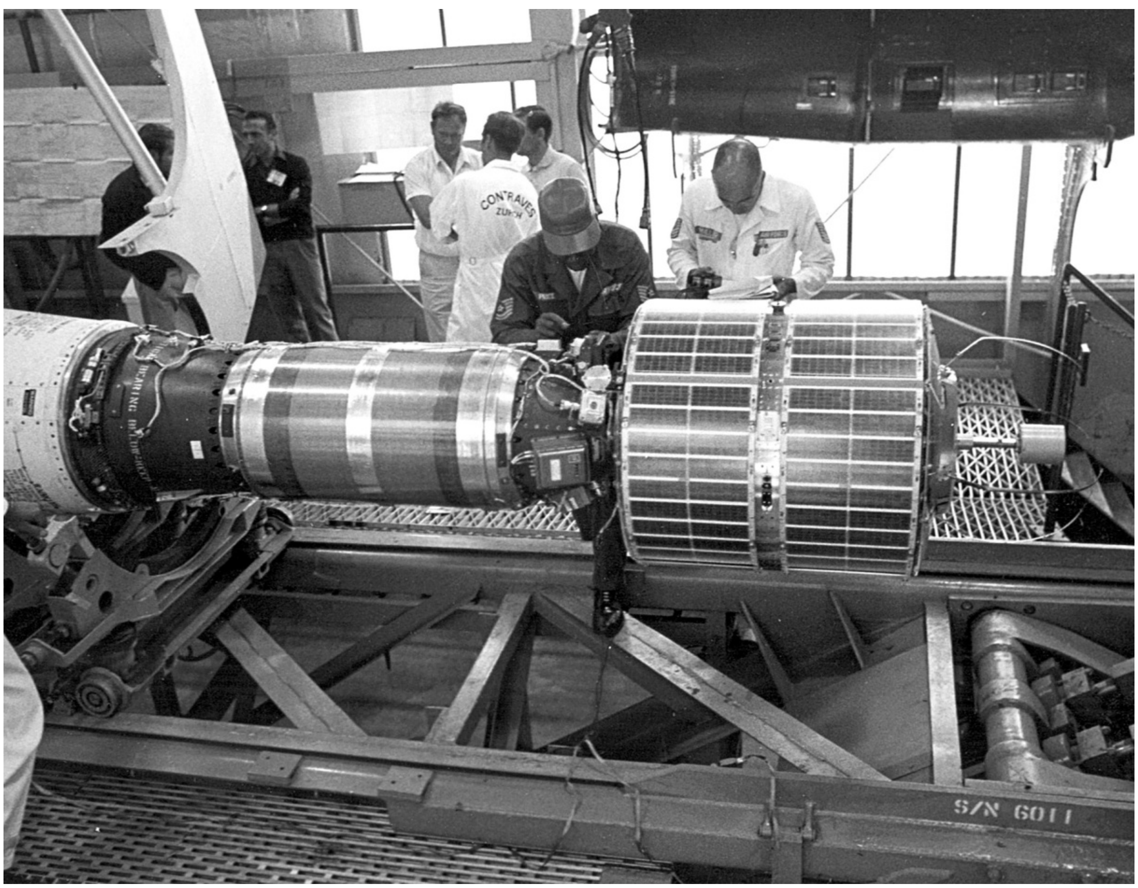

Figure 38. Payload work in SLC-5 mobile checkout shelter, VAFB Facility #580, 1967 (Official NASA-USAF Photograph).

Figure 39. Launch preparations in the SLC-5 blockhouse, VAFB Facility #589, 1963 (NARA, College Park, MD).

Figure 40. Firing panel in the SLC-5 blockhouse, VAFB Facility #580, circa 1989 (Official USAF Photograph).

Figure 41. Scout vehicle positioned in launcher with shelter removed, 1963 (NARA, College Park, MD).

Figure 42. Scout vehicle being raised in launcher for flight, n.d. (Official NASA-USAF Photograph).

Figure 43. Launch of Explorer 19 satellite on a Blue Scout vehicle at SLC-5, 19 December 1963 (History Office, Space and Missile Systems Center, Los Angeles AFB).

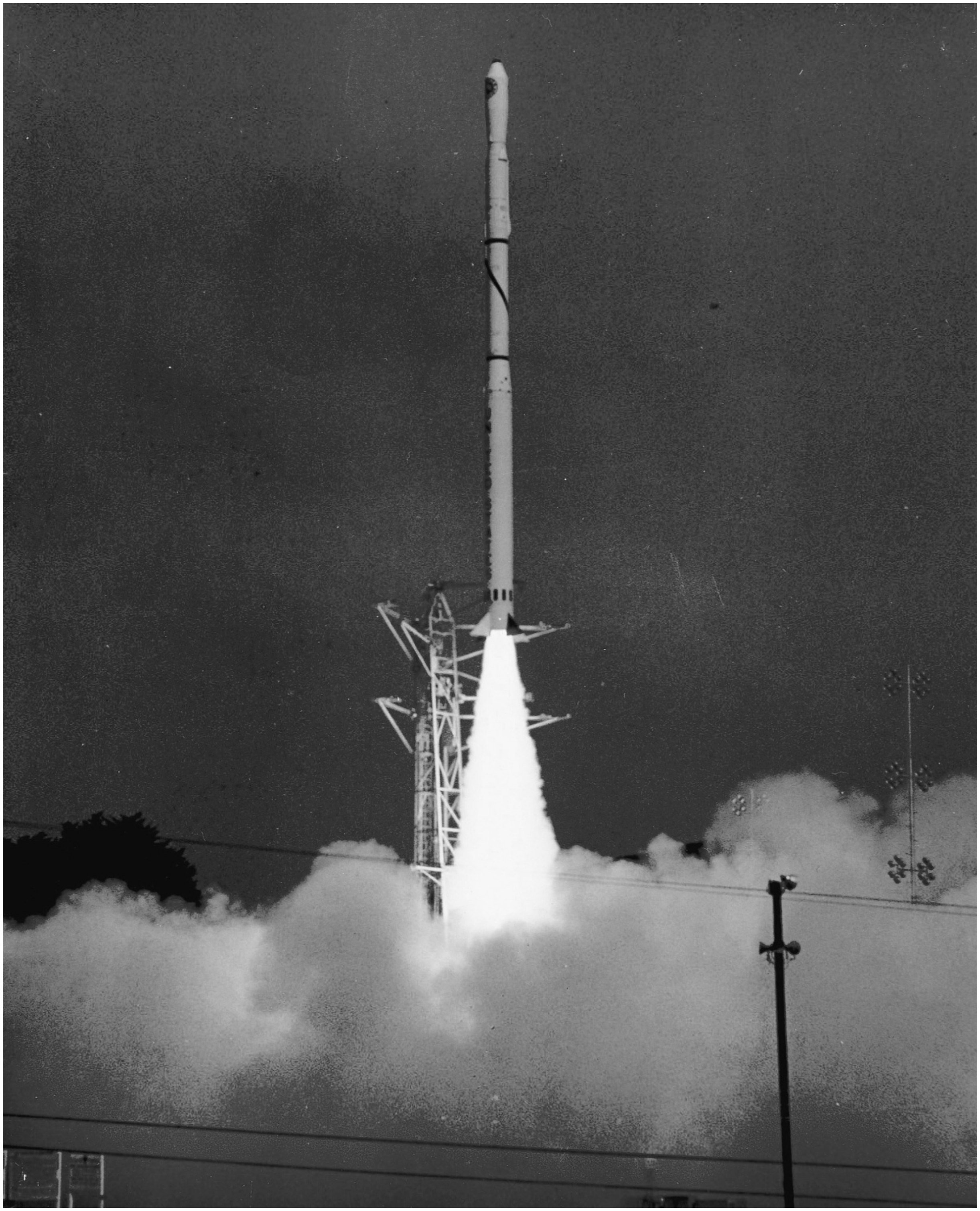

Figure 44. Launch of Transit satellite on a NASA Scout vehicle, 29 October 1973 (History Office, Space and Missile Systems Center, Los Angeles AFB).

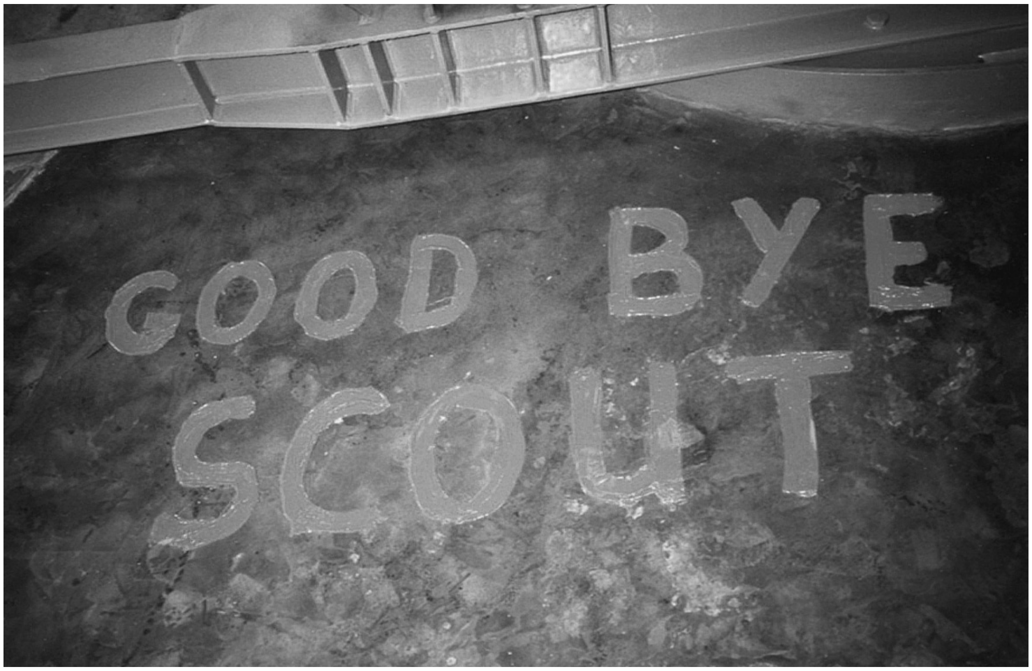

Figure 45. Farewell sign painted on the concrete inside the mobile checkout shelter (VAFB Facility #580) after the last Scout launch in 1994 (Collection of Jim Price).

Figure 46. Last Scout launch crew in 1994 (Collection of Jim Price).

Figure 47. Access control point to uphill Scout facilities in 2008 (ERDC-CERL).

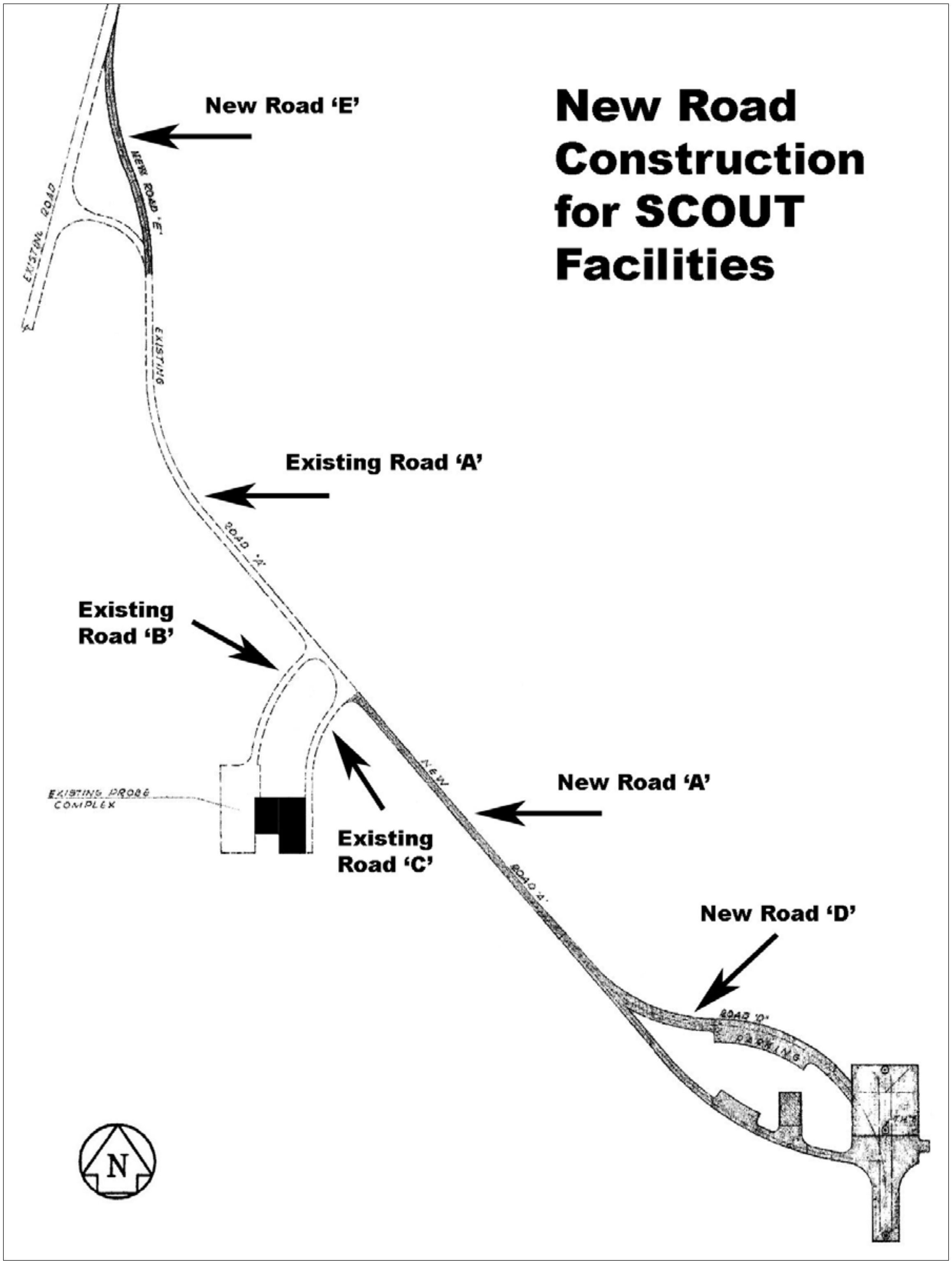

Figure 48. New road construction for Scout facilities (produced by ERDC-CERL).

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APPENDIX A: COMPLETE LIST OF SCOUT LAUNCHES

Table 9. Complete List of Scout Family Launches.[183]

Vehicle Number / Using Agency	Launch Site	Date	Mission	Performance (S=success; F=failure)	Payload	Experiment
SX-1 Cub Scout/NASA	W	4/18/60	Probe	F	R&D	Developmental flight
ST-1/NASA	W	7/1/60	Probe	S	Sim Probe	Environmental Instrumentation
D1 Blue Scout Junior/Air Force	C	9/21/60	Probe	S	HETS	Radiation Probe
ST-2/NASA	W	10/4/60	Probe	S	Radiation Probe	Environmental Instrumentation plus radiation
D2 Blue Scout Junior/Air Force	C	11/8/60	Probe	F	HETS	Radiation Probe
ST-3/NASA	W	12/4/60	Orbital	F	S-56/ Explorer 9	Air Density
D3 Blue Scout 1/Air Force	C	1/7/61	Probe	S	HETS A1-1	Radio Astronomy
ST-4/Air Force	W	2/16/61	Orbital	S	S-56A/ Explorer 9	Air Density
D4 Blue Scout 2/Air Force	C	3/3/61	Probe	S	HETS A2-1	Radiation Probe
D5 Blue Scout 2/Air Force	C	4/12/61	Probe	S	HETS A2-2	Geodetic & Radiation
D6 Blue Scout 1/Air Force	C	5/9/61	Probe	F	HETS A1-2	Radiation Probe
ST-5/NASA	W	6/30/61	Orbital	F	S-55/ Explorer 13	Micrometeoroid
0-1 Blue Scout Junior/Air Force	C	8/17/61	Probe	S	HETS Magneto-sphere	Radiation Probe

[183] This list is as complete as possible, considering there are multiple sources for launch chronology and payloads, and no two are exactly the same. Cross-referencing provides some measure of accuracy, but the author makes no claim to having a complete and totally accurate list. Launch sites: C=Cape Canaveral; W=Wallops Island; V=Vandenberg; S=San Marco.

Vehicle Number / Using Agency	Launch Site	Date	Mission	Performance (S=success; F=failure)	Payload	Experiment
ST-6/NASA	W	8/25/61	Orbital	F	S-55A/ Explorer 13	Micrometeoroid
ST-7/NASA	W	10/19/61	Probe	S	P-21	Ionosphere and Aeronomy
D8 Blue Scout 2/ NASA	C	11/1/61	Orbital	F	Mercury MS-1 (NASA payload)	Project Mercury tracking and communication
0-2 Blue Scout Junior/Air Force	V	12/4/61	Probe	S	Radiation Probe	Magnetosphere
ST-8/NASA	W	3/1/62	Reentry	S	RE-1	Reentry heating plus RAM camera pod
ST-9/NASA	W	3/29/62	Probe	S	P-21A	Ionosphere and Aeronomy
D7 Blue Scout 1/Air Force	C	4/12/62	Reentry	F	Radio Transmission	Test flight
S-111/Navy	V	4/26/62	Orbital	F	SOLRAD-IVB	Solar Radiation
S-112/Air Force	V	5/23/62	Orbital	F	AF-1/P35-1	Military Weather Satel-lite
102 Blue Scout Junior/Air Force	V	5/31/62	Probe	S	Beanstalk 1	Communications
101 Blue Scout Junior/Air Force	V	7/24/62	Probe	S	Beanstalk 2	Communications
S-117/Air Force	V	8/23/62	Orbital	S	AF-2/P35-2	Military Weather Satel-lite
S-114/NASA	W	8/31/62	Reentry	F	RE-2	Reentry heating plus boundary layer noise
s201 Blue Scout Junior/Air Force	V	11/21/62	Probe	S	Beanstalk 3	Communications
S-115/NASA	W	12/16/62	Orbital	S	S-55B/ Explorer 16	Micrometeoroid plus boundary layer noise
21-1 Blue Scout Junior/Air Force	V	12/18/62	Probe	S	Ion Engine	Test Flight
S-118/Navy	V	12/18/62	Orbital	S	Transit-1/5A-1	Navigation

Vehicle Number / Using Agency	Launch Site	Date	Mission	Performance (S=success; F=failure)	Payload	Experiment
s202 Blue Scout Junior/Air Force	V	2/1/63	Probe	S	Beanstalk 4	Communications
S-126/Air Force	V	2/19/63	Orbital	S	AF-3/P35-3	Military Weather Satellite
s203 Blue Scout Junior/Air Force	V	3/13/63	Probe	S	Beanstalk 5	Communications
S-119/Air Force	V	4/5/63	Orbital	F	Transit-2/5A-2	Navigation
S-121/Air Force	V	4/26/63	Orbital	F	AF-4/P35-4	Military Weather Satellite
s301 Blue Scout Junior/Air Force	V	5/17/63	Probe	S	Beanstalk 6	Communications
S-116/NASA	W	5/22/63	Reentry	S	RFD-1	Reentry evaluation
S-120/Navy	V	6/15/63	Orbital	S	Transit-3/5A-3	Navigation
S-113/Air Force	W	6/28/63	Orbital	S	GRS	Geophysics
S-110/NASA	W	7/20/63	Reentry	F	RE-3	Reentry heating, RAM pods and ablative materials
22-1 Blue Scout Junior/Air Force	C	7/30/63	Probe	S	CRL-1	Radio Astronomy Probe
S-132/Air Force	V	9/27/63	Orbital	F	AF-5/P35-5	Military Weather Satellite
s302 Blue Scout Junior/Air Force	V	12/17/63	Probe	S	Beanstalk 7	Communications
S-122R/NASA	V	12/19/63	Orbital	S	S-56B/ Explorer 19	Air density
22-2 Blue Scout Junior/Air Force	C	3/13/64	Probe	F	CRL-9	Magnetosphere Probe
S-127R/ UK DSIR (United Kingdom)	W	3/27/64	Orbital	S	UK-2/Ariel 2	Radio astronomy, global ozone and galactic noise
S-125R/Navy	V	6/3/64	Orbital	S	Transit-4/5C-1	Navigation
S-128R/Air Force	V	6/25/64	Orbital	F	CRL-2/ESRS	Cambridge Research Laboratory
S-124R/NASA	W	7/20/64	Probe	S	SERT	Ion engine experiment

Vehicle Number / Using Agency	Launch Site	Date	Mission	Performance (S=success; F=failure)	Payload	Experiment
S129R/NASA	W	8/18/64	Reentry	S	RE-4A	Ablative material, reentry to support Apollo
S-134R/NASA	V	8/25/64	Orbital	S	S-48/ Explorer 20	Meteorological experiment
21-2 Blue Scout Junior/Air Force	V	8/29/64	Probe	S	Ion Engine	Test Flight
S-130R/NASA	W	10/9/64	Reentry	S	RFD-2	Reentry evaluation
S-123RR/NASA	V	10/9/64	Orbital	S	BE-B/ Explorer 22	Electron content of ionosphere and laser tracking
S-133R/NASA	W	11/6/64	Orbital	S	S-55C/ Explorer 23	Micrometeoroid
S-135R/NASA	V	11/21/64	Orbital	S	AD/I-B/ Explorer 24	Atmospheric charged particle and air density
S-137R/CRS (Italy)	W	12/15/64	Orbital	S	SM-A	Atmospheric charged particle and air density
21-3 Blue Scout Junior/Air Force	V	12/21/64	Probe	F	Ion Engine	Test Flight
22-3 Blue Scout Junior/Air Force	C	1/28/65	Probe	F	CRL-309	Magnetosphere Probe
22-4 Blue Scout Junior/Air Force	C	3/30/65	Probe	S	CRL-35	Magnetosphere Probe
22-9 Blue Scout Junior/Air Force	C	4/9/65	Probe	S	AFWL-14	Magnetosphere Probe
S-136R/NASA	W	4/29/65	Orbital	S	BE-C/ Explorer 27	Ionospheric and gravitation
22-8 Blue Scout Junior/Air Force	C	5/12/65	Probe	S	CRL-335	Magnetosphere Probe
22-5 Blue Scout Junior/Air Force	C	6/9/65	Probe	S	AFWL-304	Magnetosphere Probe
S-131R/NASA	W	8/10/65	Orbital	S	SECOR	Geodetic measurements
S-138R/Navy	W	11/18/65	Orbital	S	SOLRAD-A/ Explorer 30	Solar radiation

Vehicle Number / Using Agency	Launch Site	Date	Mission	Performance (S=success; F=failure)	Payload	Experiment
S-139R/CNES (France)	V	12/6/65	Orbital	S	FR-1	Study VLF in magneto-sphere
S-140C/Navy	V	12/21/65	Orbital	S	Transit-5	Navigation
S142C/Navy	V	1/28/66	Orbital	S	Transit-6	Navigation
S141-C/NASA	W	2/9/66	Reentry	S	RE-E	Reentry materials
S-143C/Navy	V	3/25/66	Orbital	S	Transit-7	Navigation
S-145C/Air Force	V	4/22/66	Orbital	S	OV3-1	Radiation research
S-146C/Navy	V	5/18/66	Orbital	S	Transit-8	Navigation
S-147C/Air Force	W	6/10/66	Orbital	S	OV3-4	Radiation research
S-148C/Air Force	V	8/4/66	Orbital	S	OV3-3	Radiation research
S-149C/Navy	V	8/17/66	Orbital	S	Transit-9	Navigation
S-150C/Air Force	V	10/28/66	Orbital	S	OV3-2	Radiation Data
S-151C/Air Force	V	1/31/67	Orbital	F	OV3-5	Atmospheric measure-ments
S-154C/Navy	V	4/13/67	Orbital	S	Transit-10	Navigation
S-153C/CRS (Italy)	S	4/26/67	Orbital	S	SM-B	Air density, drag and ionospheric studies
S-155C/UK SRC (United Kingdom)	V	5/5/67	Orbital	S	UK-3/Ariel 3	Atmospheric and radio noise
S-156C/Navy	V	5/18/67	Orbital	S	Transit-11	Navigation
S-152C/ESRO (Euro-pean)	V	5/29/67	Orbital	F	ESRO-11	Radiation, charged parti-cle and cosmic ray
S157C/Navy	V	9/25/67	Orbital	S	Transit-12	Navigation
S-159C/NASA	W	10/19/67	Reentry	S	RAM C-A	Communications
S-158C/Air Force	V	12/4/67	Orbital	S	OV3-6	Radiation
S-162C/Navy	V	3/1/68	Orbital	S	Transit-13	Navigation
S-160C/Navy	W	3/5/68	Orbital	S	SOLRAD-B	Solar radiation
S-164C/NASA	W	4/27/68	Reentry	S	RE-F	Atmospheric entry heat-ing
S-161C/ESRO (Euro-pean)	V	5/16/68	Orbital	S	ESRO-IIB	Charged particle, solar and cosmic X-ray
S-165C/NASA	V	8/8/68	Orbital	S	AD/I-C/ Explorer 39	Air density and charged particle
S-168C/NASA	W	8/22/68	Reentry	S	RAM C-B	Communications meas-urements
S-167C/ESRO (Euro-pean)	V	10/3/68	Orbital	S	ESRO-I	Ionospheric and auroral phenomena

Vehicle Number / Using Agency	Launch Site	Date	Mission	Performance (S=success; F=failure)	Payload	Experiment
S-172C/ESRO (European)	V	10/1/69	Orbital	S	ESRO-IB	Ionospheric and auroral phenomena
S-169C/DFVLR (Federal Republic of Germany)	V	11/7/69	Orbital	S	GRS-A/Azur	Van Allen belt, auroral and solar particle
S-176C/Navy	V	8/27/70	Orbital	S	Transit-14	Navigation
S-171C/NASA	W	9/30/70	Reentry	S	RAM C-C	Communications measurements
S-174C/NASA	W	11/9/70	Orbital	S	OFO/RMS	Otolith, trapped radiation and micrometeoroid
Blue Scout Junior/Navy	W	11/25/70	Probe	S	Astronomy/ NB22.208	UV astronomy
S-175C/NASA	S	12/12/70	Orbital	S	SAS-A/ Explorer 42	Identification of galactic sources of radiation
S-173C/CRS (Italy)	S	4/24/71	Orbital	S	SM-C	Equatorial neutral particle atmosphere
S-144CR/NASA	W	6/20/71	Reentry	S	PAET	Determination of unknown planetary atmosphere
S-177C/Navy	W	7/8/71	Orbital	S	SOLRAD-C/ Explorer 44	Solar and celestial radiation
S-180C/CNES (France)	W	8/16/71	Orbital	S	CAS-A/Eole	Mapping of southern hemisphere winds
S-166CR/NASA	W	9/20/71	Probe	S	GRP-A	Features of electric and magnetic fields
S-163CR/NASA	S	11/15/71	Orbital	S	SSS-A/ Explorer 45	Charged particles of magnetosphere
S-183C/UK SRC (United Kingdom)	V	12/11/71	Orbital	S	UK-4/Ariel 4	Interaction of charged particles in ionosphere
S-184C/NASA	W	8/13/72	Orbital	S	MTS/ Explorer 46	Bumper configurations for micrometeoroid
S-182C/Navy	V	9/2/72	Orbital	S	TIP-1	Navigation
S-170CR/NASA	S	11/15/72	Orbital	S	SAS-B/ Explorer 48	Celestial Sphere Radiation sources
S-185-C/ESRO (European)	V	11/21/72	Orbital	S	ESRO-IV	Auroral phenomena in polar regions

Vehicle Number / Using Agency	Launch Site	Date	Mission	Performance (S=success; F=failure)	Payload	Experiment
S-181C/DFVLR (Federal Republic of Germany)	V	12/16/72	Orbital	S	AEROS-A	State and behavior of upper atmosphere
S-178C/Navy	V	10/29/73	Orbital	S	Transit-15	Navigation
S-190C/CRS (Italy)	S	2/18/74	Orbital	S	SM-C2	Describe equatorial neutral particle atmosphere
S-188C/RAE (United Kingdom)	V	3/8/74	Orbital	S	X-4/Miranda	Technology for 3-axis stabilization platform
S-191C/NASA	V	6/3/74	Orbital	S	Hawkeye	Neutral point region of magnetosphere
S-186C/NASA/ DFVLR (Federal Republic of Germany)	V	7/16/74	Orbital	S	AEROS-B	State and behavior of upper atmosphere
S-189C/NIVR (Netherlands)	V	8/30/74	Orbital	S	ANS-A	Celestial X-ray and ultraviolet sources
S-187C/UK SRC (United Kingdom)	S	10/15/74	Orbital	S	UK-5/Ariel 5	Locate X-ray sources in celestial sphere
S-194C/NASA	S	5/8/75	Orbital	S	SAS-C/Explorer 53	Identify sources of galactic radiation
S-195C/Navy	V	10/11/75	Orbital	S	TIP-II	Navigation
S-196C/NASA	V	12/5/75	Orbital	F	DAD	Air density studies
S-179CR/Air Force	V	5/22/76	Orbital	S	P76-5	Ionosphere effects on satellite communication
S-193C/NASA	W	6/18/76	Probe	S	GP-A	Test Einstein's gravitational and relativity theories
S-197C/Navy	V	9/1/76	Orbital	S	TIP-III	Navigation
S-200C/Navy	V	10/27/77	Orbital	S	TRANSAT	Navigation and missile tracking
S-201C/NASA	V	4/26/78	Orbital	S	HCMM	Provide thermal maps of earth's surface
S-202C/NASA	W	2/18/79	Orbital	S	SAGE	Measure stratospheric aerosols and ozone
S-198C/UK SRC (United Kingdom)	W	6/2/79	Orbital	S	UK-6/Ariel 6	Study high-energy astrophysics
S-203C/NASA	V	10/30/79	Orbital	S	MAGSAT	Global survey of earth's magnetic field

Vehicle Number / Using Agency	Launch Site	Date	Mission	Performance (S=success; F=failure)	Payload	Experiment
S-192C/Navy	V	5/14/81	Orbital	S	NOVA-I/TIP	Navigation
S-205C/Air Force	V	6/27/83	Orbital	S	HILAT	Plasma's effect on radar and radio frequency
S-208C/Navy	V	10/11/84	Orbital	S	NOVA-III/TIP	Navigation
S-209/Navy	V	8/2/85	Orbital	S	SOOS-1	Navigation
S-207C/Air Force	W	12/12/85	Orbital	S	ITV	Special Air Force (Instrumented Test Vehicle)
S-199/Air Force	V	11/13/86	Orbital	S	PolarBEAR	Polar Region Communication
S-204/Navy	V	9/16/87	Orbital	S	SOOS-2	Navigation
S-206/ASI (Italy)	S	3/25/88	Orbital	S	San Marco D/L	Drag Balance
S-211/Navy	V	4/25/88	Orbital	S	SOOS-3	Navigation
S-213/Navy	V	6/15/88	Orbital	S	NOVA-II	Navigation
S-214/Navy	V	8/25/88	Orbital	S	SOOS-4	Navigation
S-212C/DARPA	V	5/9/90	Orbital	S	MACSAT	Message relay and digital M1 & M2 communication
S-216C/Air Force	V	6/29/91	Orbital	S	REX	Communications
S-215C/NASA	V	7/3/92	Orbital	S	SAMPEX	Solar flare/cosmic ray data
S-210C/Air Force	V	11/21/92	Orbital	S	MSTI-1	Atmospheric studies
S-217C/NASA	V	6/25/93	Orbital	S	RADCAL	Radar calibrations
S-218/Air Force	V	5/8/94	Orbital	S	MSTI-2	Tracking and earth observation[184]

Sources: Loral Vought Systems, “Farewell, Scout,” Missileer, Special Edition, May 26, 1994, 8-9; “Blue Scout Chronology: 1956-1963,” in Archives File “Blue Scout Chronology,” Space and Missile Systems Center, History Office, Los Angeles AFB; Abraham Leiss, Scout Launch Vehicle Program Final Report - Phase VI (Hampton, VA: Williamsburg West, Inc., 1982), 437-448, Mark Wade, Encyclopedia Astronautica, http://www.astronautix.com/lvs/scout.htm; McDowell, Jonathan, Jonathan's Space Home Page (launch records), http://www.planet4589.org/jsr.html; Brian Webb, “Vandenberg AFB Launch History,” http://www.spacearchive.info/vafblog.htm; Peter Hunter, Dr. Jonathan McDowell, and Donald Prichard, “VAFB Launches,” Manuscript, 2000.

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[184] There were two related flights not included in this table: (1) Test of modified Scout launcher with strap-on boosters for a proposed Italian Scout follow-up program from Salto di Quirra launch complex in southeast Sardinia on March 18, 1992. Launched by the Italian Space Agency (ASI), the attempt was a failure (Mark Wade, Encyclopedia Astronautica, http://www.astronautix.com/lvs/scout.htm); (2) Scramjet test at VAFB (4300 C) on Jan 11, 1967, using a Scout first stage. The test was a partial success (Peter Hunter, Dr. Jonathan McDowell, and Donald Prichard, “VAFB Launches,” Manuscript, 2000).

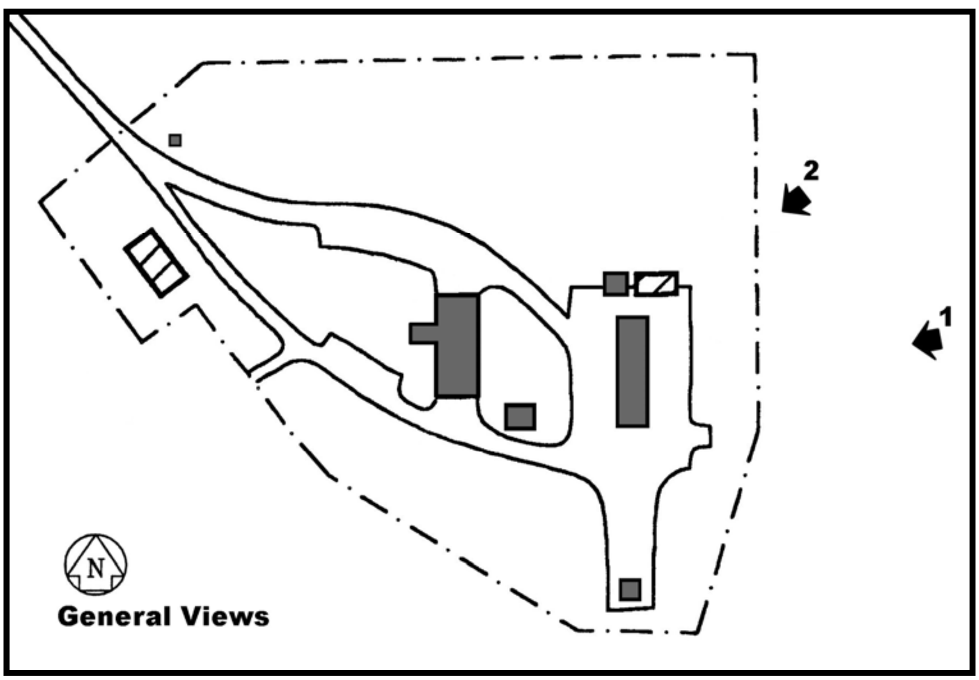
HISTORIC AMERICAN ENGINEERING RECORD

INDEX TO PHOTOGRAPHS

VANDENBERG AIR FORCE BASE HAER No. CA-2288
SPACE LAUNCH COMPLEX 5
Avery and Delphy Roads
Lompoc Vicinity
Santa Barbara County
California

Photographer: Martin Stupich, 2008
See photo key on this page.

CA-2288-1	GENERAL VIEW OF SPACE LAUNCH COMPLEX 5, VIEW EAST TO WEST
CA-2288-2	GENERAL VIEW OF SPACE LAUNCH COMPLEX 5 UPHILL FACILITIES, VIEW NORTHEAST TO SOUTHWEST



Photograph Key

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HAER NO. CA-2288-1

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HISTORIC AMERICAN ENGINEERING RECORD

VANDENBERG AIR FORCE BASE, SPACE LAUNCH COMPLEX 5
MOBILE CHECKOUT SHELTER (FACILITY No. 580)
HAER No. CA-2288-A

Location:	Vandenberg Air Force Base Space Launch Complex 5 Avery and Delphy Roads Lompoc Vicinity Santa Barbara County California U.S. Geological Survey (USGS) Santa Maria Quadrangle, Universal Transverse Mercator Coordinates: 10/34.60803/120.62435
Date of Construction:	1962
Engineer:	Kaiser Engineers, Oakland, California (original construction); Stearns-Roger Incorporated, now a subsidiary of Raytheon Company (1976 modifications)
Present Owner:	U.S. Air Force (USAF)
Present Use:	Deactivated, Demolished
Significance:	SLC-5 is significant for supporting important Cold War missions, specifically those associated with the Scout missile between 1962 and 1994. Scout missions have studied aerosol contamination, helped scientists map planet's magnetic and thermal fields, discovered new X-ray sources in space, studied quasars and black holes, helped prove Einstein's gravitational and relativity theories, tested different materials to determine their tolerance to reentry heat, and studied how to protect spacecraft from micrometeoroids. Additionally, NASA relied on Scout missions to focus on specific problems pertaining to the manned space programs.
Report Prepared By:	Julie L. Webster, RA, Dr. Susan I. Enscore, and Mr. Martin Stupich U.S. Army Engineer Research and Development Center (ERDC) Construction Engineering Research Laboratory (CERL) P.O. Box 9005 Champaign, IL 61826-9005
Date	September 2010

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VANDENBERG AIR FORCE BASE, SPACE LAUNCH COMPLEX 5, MOBILE CHECKOUT SHELTER (FACILITY No. 580)
Avery and Delphy Roads
Lompoc Vicinity
Santa Barbara County
California

HAER No. CA-2288-A

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

PHOTOGRAPHS

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Pacific West Region
National Park Service
U.S. Department of the Interior
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Oakland, CA 94607

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MOBILE CHECKOUT SHELTER AND TERMINAL BUILDING (FACILITY 580)[1]

Launch pad

The launch pad was a 120'-0" x 130'-0" x 0'-8" reinforced concrete-paved area located in the northeast corner of the Scout facility. The center portion of the pad accommodated the mobile checkout shelter, transporter, and launcher. East and west of the checkout shelter, the pad was subdivided into four equal areas with alternating contraction and dummy joints. Centered beneath the checkout shelter at the uprange end of the pad was a “launcher slab” measuring 8'-0" x 46'-0" x 3'-8". The slab was substantial to provide anchorage for the launcher. Steel blast plates were affixed to the launch pad near the slab to protect the pavement from vehicle exhaust. At the south end of the slab was the launch pad-launcher base interface. The interface featured a three-foot-deep service pit that provided utility services to the launcher via underground ducts and the pad terminal building utility trench. The center point of the service pit was also the center of rotation for the launcher and the reference point for the “bearing installation” (a series of markers on the launch pad used to set launch trajectories). Nine feet south of the service pit center was the Scout “work point;” this represented the center point for the launch vehicle when in the vertical position and the datum point for launch vehicle guidance systems.[2]

To facilitate vehicular access and other launch preparation processes, asphalt pavement extended beyond the south edge of the launch pad. The paving provided a bed for the mobile checkout

[1] According to the VAFB real property inventory, the SLC-5 pad terminal building and mobile checkout shelter were both identified as Facility 580. According to the same inventory, the motor building and air conditioning building had no formal facility designations. Informally these structures were referred to as facilities 579 and 583 respectively. For clarity purposes, this document uses the following facility designations: 580a/mobile checkout shelter, 580b/pad terminal building, 579/motor building, and 583/air conditioning building.

[2] Architectural/Engineering drawing set “Drawing No. 580-S-1” (architectural/engineering drawing sets on file with Base Planning Section (30 CES/CECB), VAFB, California.); Donald Johnson, electronic correspondence to Julie Webster, 14 August 2009; periodically the Air Force Geodetic Survey Squadron would visit SLC-5 to verify that the work point had not moved due to earthquakes and such (Donald Johnson, electronic correspondence to Julie Webster, 14 August 2009).

shelter track and winch system.[3] Asphalt turnaround areas were also provided at key locations about the pad for mobility purposes.

Mobile checkout shelter (Facility 580a)

Original building configuration

Facility 580a, the mobile checkout shelter, was a prefabricated structure erected in 1962 to protect the Scout vehicle during pre-launch operations and final checkout. In its original configuration, it was an elongated six-bay steel framed building measuring 120'-0" x 25' x 6-1/2". Its walls were 26'-0" high, and its gable peaked at 30'-2-5/16" above grade. The building was clad and roofed in corrugated galvanized steel, and featured translucent radio frequency (RF) window panel insets that served telemetry purposes and provided natural light to an otherwise windowless structure (Figure 1).[4] Interior walls were finished with ⅛-inch Masonite panels bolted over compressed fiberglass insulation. The underside of the slightly sloped gable roof was lined with fiberglass insulation held in place with galvanized chicken wire.[5]

The building featured two standard personnel doors at the northeast and southwest corners, and two motorized 20' wide x 23' high steel roll-up doors at each gable end. The large roll-up doors could be manually operated by an endless chain mechanism if necessary. Their purpose when lifted was to allow movement of the transporter in and out of the shelter and, during launches, to allow movement of the shelter to and from the launch pad. They were closed before every launch

[3] In early construction drawings, the winch was referred to as a "capstan," a nautical or railroad term.

[4] Launch vehicle telemetry signals were received in antennas located on the blockhouse and adjacent to the launch pad. These signals could not pass through the corrugated steel walls of the shelter but would transmit easily through the translucent "windows." Subsequent installation of a passive re-radiation system (see little black device above roll-up door in Figure 1) rendered these panels unnecessary for radio purposes (Donald Johnson, electronic correspondence to Julie Webster, 14 August 2009).

[5] Donald Johnson, electronic correspondence to Julie Webster, 14 August 2009; Architectural/Engineering drawing set "Drawing No. 580-A-6" and "Drawing No. 580-A-7" (architectural/engineering drawing sets on file with Base Planning Section (30 CES/CECB), VAFB, California.)

to minimize blast damage to the building interior. Occasionally, the north overhead door suffered debris damage and was repaired before the next launch.[6]

Except for the north end, much of the interior space of the mobile checkout shelter was taken up by a grated aluminum work platform 4'-9" above grade.[7] The platform was level with the bed of the transporter used to carry the launch vehicle into the shelter. The platform allowed personnel easy access to vehicle components and to various control systems located inside the shelter. Most work platform sections cantilevered from the east and west walls of the shelter. Those centered at the south end were removable to allow the transporter and dollies to move in and out of the shelter. Hatches in the work platform hinged open to provide stair access to the underside of the platform deck (Figure 2); interior stairs at the northeast and northwest corners of the platform provided uprange deck access.

The fire suppression system (painted red) was centrally located on both sides of the shelter. It used an external source of water supplied through four two-inch hoses, with two hoses per side. System use was not limited to fire suppression; it was also available for dilution in the event of a hydrogen peroxide spill. Prior to loading any fuel on the missile, these hoses were checked to ensure they were in proper working order. As a back-up safety measure when loading hydrogen peroxide onto the missile, the fire department and a pumping station were on standby at the complex for assistance. Additionally, two personnel safety showers (painted aqua) were located on each side of the shelter between the fire hoses.[8]

Also inside the shelter were a host of features necessary for launch operations. Launch vehicle stages were mated to the launcher in the horizontal position. The vehicle payload was also installed in the horizontal position. To facilitate these processes, a monorail-type lift was provided to hoist vehicle components. Telephones and adjacent work tables were centered on the east and west walls, and communications panels were located on both sides of the shelter uprange end. Additionally, the east interior elevation featured a public address system at the

[6] Nowlan, et al., *Cold War Properties Evaluation - Phase I: Inventory and Evaluation*, 155; LTV Missiles and Electronics Group—Missiles Division, *Ground Support Equipment Manual, NASA/DOD Scout Vehicle S-208* and subsequent, *NAS1-18550 Volume II*, (Hampton, Virginia: NASA Langley Research Center: 1 July 1990), 2-36.

[7] Architectural/Engineering drawing set "Drawing No. 580-A-7."

[8] Nowlan, et.al, *Cold War Properties Evaluation - Phase I: Inventory and Evaluation*, 155–156.

uprange end, and emergency lighting and a large RF window at the downrange end. General lighting, electrical service, and compressed air outlets were provided as necessary.[9]

Mobility

The checkout shelter was a mobile structure that traveled along a north-south axis between the launch pad and motor building. During launch operations, shelter positions were identified as (1) the north or uprange position and (2) the south, stowed, or downrange position. The shelter featured sixteen, twelve-inch diameter, double-flanged steel wheels to facilitate its movement on and off the pad. The wheels traveled along a track made up of paired parallel steel rails that terminated approximately 110' south of the launcher. The shelter was moved into the downrange position by means of a removable 1,000-pound-capacity tow bar assembly at the south end of the shelter near grade. It was returned to the uprange position using a retraction assembly. Both assemblies employed heavy but flexible wire tow rope.[10]

Two linear movement limit switches constrained movement of the shelter. One was located in the southwest corner of the shelter and one was positioned at the south end of the west rail. The purpose of the switches was to ensure the mobile shelter did not over-travel its rails and damage any infrastructure. They also prevented shelter movement if the launcher-end overhead door was closed (Figure 3).[11]

The shelter track was made up of two rails positioned 23'-0" apart and flanked by nine-inch concrete runner strips. The rails and strips received the shelter wheels and walls respectively. In addition to guiding the shelter downrange, the shelter rails collected water near the track and directed it offsite. Track drainage channels continued beyond the rail termini and transported

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[9] Nowlan, et.al, *Cold War Properties Evaluation - Phase I: Inventory and Evaluation*, 155; "Drawing No. 580-A-7;" "Drawing No. 580-A-6."

[10] Nowlan, et al., *Cold War Properties Evaluation - Phase I: Inventory and Evaluation*, p 154; LTV Missiles and Electronics Group, *NAS1-18550 Volume II*, 2-34; Architectural/Engineering drawing set "Drawing No. 580-S-7;" "Drawing No. 580-S-8;" "Drawing No. 580-M-1"; to ease movement of the shelter, the track was cleaned prior to shelter relocation.

[11] Limit switches located at the south end of the track were relocated northward when the motor building was constructed (Architectural/Engineering drawing set "Drawing No. 580-C-6").

runoff to angled, paved ditches beyond the motor building. These ditches emptied into an underground drain pipe that opened into a nearby ravine.[12]

Modifications to the mobile checkout shelter

In 1963, electric unit heaters were installed at the center of each structural bay on the building interior. The explosion-resistant units were controlled by four explosion-proof thermostats.[13] They were serviced by a water-tight power panel bolted to the north end of the west exterior elevation. The panel was designated "PB" and measured 6'-3" x 4'-2" x 1'6". Electrical service to the panel was provided by a portable feeder cable. The cable was spooled on a galvanized steel cable rack adjacent to the power panel enclosure at the building exterior (Figure 4). To accommodate the added electrical load of the heaters, modifications were made to the power substation west of the operations support building.[14]

In 1976, the checkout shelter was enlarged with a twenty-foot addition on its south end. The existing south end wall was reused on the addition, including its twenty-foot-wide overhead roll-up door. The existing personnel door openings were blocked with corrugated metal panels and replaced by new cantilevered entrance platforms with aluminum doors. These platforms were enclosed with corrugated metal panel walls and translucent corrugated plastic panels to match existing building components. The east platform was smaller and featured two risers; the west platform was larger and housed seven risers. On the interior, the increased floor area created by the twenty-foot addition was filled with new, raised, work platforms that matched the existing platforms in height. The existing monorail-type hoist that had been used to lift vehicle components was replaced with a new one-ton overhead bridge crane. The crane operated at the downrange end of the shelter on a pair of north-south conveyor beams and a twenty-foot east-

[12] LTV Missiles and Electronics Group, *NAS1-18550 Volume II*, 2-34 and 2-36; Architectural/Engineering drawing set "Drawing No. 580-C-6;" "Drawing No. 582-C-3;" "Drawing No. 580-C-2."

[13] Architectural/Engineering drawing set "Drawing No. 580-S-4."

[14] Architectural/Engineering drawing set "Drawing No. 580-E-5"; no cooling system was ever provided for the shelter (LTV Missiles and Electronics Group, *NAS1-18550 Volume II*, 2-36).

west bridge beam. Other crane features included a hanging push-button control station, slack tag lines for controlled hoisting operations, and taut messenger cables to support the tag line.[15]

Also in 1976, inflatable seals that ran along the underside of the east-west shelter walls were installed for environmental purposes. A compressor, series of hoses, and pneumatic solenoid valves supplied air and controlled inflation and deflation of the seals (Figure 5). A single inflation control was centered on the west wall, and four deflation controls were dispersed to each quadrant of the building. When these seals were deflated (typically for shelter movement), the building went from fully enclosed to somewhat enclosed. Rubber closure strips that ran along the bottom edge of the shelter walls remained intact to provide some enclosure.[16]

Transporter

The transporter delivered the launch vehicle to the launch site and facilitated the hook-up of vehicle components (Figure 6). During hook-up and checkout, the vehicle was supported by the transporter and the launcher. The sixty-five foot transporter, carrying numerous vehicle components, was towed to the complex by a ten-ton tractor and mated with a pair of V-shaped transporter alignment rails. The alignment rails, spaced 6'0" apart, were located between the mobile shelter track rails. They (coupled with the transporter landing gear) guided the transporter in and out of the shelter and positioned the vehicle properly with respect to the launcher (Figure 7).[17]

Once the transporter was positioned over the two alignment rails just south of the mobile shelter, its landing gear springs were locked to permit lifting of the transporter trailer onto its landing legs. The landing gear brakes were then air locked, and the front landing legs lowered to allow disconnection from the transporter tractor. The tractor was moved aside, a powered tug was attached to the front of the transporter trailer, and the rear landing legs were lowered onto the

[15] Architectural/Engineering drawing set “Drawing No. 580-A-6;” “Drawing No. 580-A-7;” “Drawing No. 580-S-10.”

[16] Architectural/Engineering drawing set “Drawing No. 580-S-8.”

[17] LTV Missiles and Electronics Group, *NAS1-18550 Volume II*, 2-39 – 2-41.

alignment rails. All landing legs were then elevated to the desired height and the transporter trailer was backed into the shelter to initiate mating to the launcher.[18]

The transporter was positioned near the launcher attach points (two support pins and split hook), and final alignment of the launch vehicle to the launcher was accomplished by chain "come-a-longs" and adjustable vehicle support dollies. The heavy steel dollies featured semicircular cradles padded with hard rubber; they moved along an elevated fixed guide rail centered on the launcher-transporter assembly. After final positioning, the transporter and dollies supported the launch vehicle from below, while the launcher supported it from above. The transporter remained in place as a secondary support for the vehicle until launch time. When the full weight of the vehicle had been transferred to the launcher, the transporter was moved downrange and stowed inside the downrange shelter.[19]

Launcher

The launcher was a steel structure that consisted of a rotating base and an adjoining cantilevered boom called a "launch beam." The launcher allowed for vehicle attachment and servicing in the horizontal position, with power changeover and flyaway at liftoff in the vertical position. From the launcher, vehicle trajectory could be directed 160–300 degrees azimuth and 70–90 degrees from horizontal.[20]

Base structure and launch beam

The base structure of the launcher was the lower main assemblage, measuring approximately 9'-0" x 29'-0"x 11'-0". It was fixed to the launch pad over the bearing installation between the mobile checkout shelter rails. Its primary functions were to accommodate the launcher ballast, support the launch beam, and house various mechanical assemblies (Figure 8), which included:[21]

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[18] Lee Wise, electronic correspondence to Julie Webster, 31 August 2009.

[19] Lee Wise, electronic correspondence to Julie Webster, 31 August 2009; LTV Missiles and Electronics Group, *NAS1-18550 Volume II,* 2-39 – 2-41.

[20] LTV Missiles and Electronics Group, *NAS1-18550 Volume II*, 2-16.

[21] Nowlan, et al., *Cold War Properties Evaluation - Phase I: Inventory and Evaluation*, 156; LTV Missiles and Electronics Group, *NAS1-18550 Volume II*, 2-16 -- 2-25.

- Launcher ballast: a concrete counterweight (measuring approximately 9'-0" x 4'-0" x 7'0") used to counterbalance the launcher (with vehicle) and minimize stress on the bearing assembly (Figure 9, left).
- Bearing assembly: a mechanism that constrained motion between the launch pad and base structure by resisting lateral loads and overturning moments applied to the launcher while rotating about the bearing centerline.
- Blast shield assembly: a cone-shaped shield that protected the downrange side of various electrical lines, junction boxes, and fluid lines from the Algol motor exhaust plume.
- Pitch drive assembly: a gear-drive system that erected the launch beam (with vehicle attached) to the requisite vertical position or pitch.
- Azimuth drive assembly: a device that positioned the launcher to the requisite horizontal position or azimuth.
- Lug assemblies: hinge points for the base structure and launch beam connection (Figure 9, right).

The launch beam assembly was the upper main tower structure measuring approximately 11'-0" x 9'-0" at its bottom, tapering to 3'-0" x 4'-0" at its top and extending 68'-0" long. It was permanently fixed to the base structure at four pin joints and was capable of being positioned from horizontal to ninety degrees (with vehicle attached). Its primary functions were to support the launch vehicle; house vehicle cooling, pneumatic, hydrogen peroxide, and nitrogen electrical control system components; accommodate the payload's environmental control system (ECS) ducting; and act as the mounting fixture for various arm assemblies. Those assemblies included:[22]

- Launch arms: supportive split hook-type device (positioned between the Scout first stage and lower B section) made up of arms that hinged outward during liftoff to clear the vehicle fin.
- B and C section umbilical arms: service arms that fed hydrogen peroxide and nitrogen to the B and C section attitude control jets.
- C and D section support arms: adjustable air motor-driven appendages with semicircular cutouts that secured the vehicle in the launcher.

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[22] LTV Missiles and Electronics Group, *NAS1-18550 Volume II*, 2-28 – 2-32; the temperate climate of the California coast rendered the third stage environmental blanket unnecessary and unused at VAFB, however it was installed nonetheless to mimic the Wallops Island setup (Donald Johnson, electronic correspondence to Julie Webster, 14 August 2009).

- D section flyaway arm: tubular arm within the D section support arm assembly that fed electrical and cooling service to the D section umbilical interface
- Payload umbilical electrical and air arms: tubular arms (adjustable for a thirty-four- or forty-two-inch heat shield) that fed electrical and compressed air cooling service to the payload and separation system interfaces
- Third stage environmental blanket: double-walled blanket installed around the Scout third stage motor case to protect it from extremely low temperatures during pre-launch operations

Launcher operation

Launcher functions relied on various utilities routed from an underground service pit, through the base structure, and to various points on the launcher. One exception was the ECS. Its eight-inch duct traveled into the shelter through a dedicated floor trench from a nearby air conditioning facility (Building 583), through the launcher base structure, and to the launch beam for providing conditioned air to the payload.[23]

When in the vertical position, the Scout was located directly over the Scout work point, 9'-0" south of the launcher service pit. The cone-shaped, half-inch-thick steel blast shield encircled this point on the downrange side to protect electrical components and fluid lines (Figure 10, left). A room temperature vulcanizing (RTV) agent resembling orange-red putty covered exposed surfaces and components within and around the work point to protect them from the blast. After each launch, areas sustaining blast damage were coated with additional RTV.[24]

The pitch drive assembly lifted the launcher into the desired vertical position in three phases. Phase one lifted the launcher in "slow mode" from horizontal to approximately four degrees above horizontal. Phase two raised the launcher from that point to a position approximately three degrees from vertical. Phase three returned the launcher to "slow mode" to set the vehicle completely vertical (although the Scout could be launched from any position within twenty degrees of vertical). The entire process took approximately four and one-half minutes, and

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[23] LTV Missiles and Electronics Group, *NAS1-18550 Volume II*, 2-24; the air conditioning building (Facility 580d—informally referred to as Facility 583) had been constructed east of the pad terminal building by 1975 (Architectural/Engineering drawing set "Drawing No. 580-C-5").

[24] Nowlan, et al., *Cold War Properties Evaluation - Phase I: Inventory and Evaluation*, 158.

various safety mechanisms existed to prevent the launcher from overshooting the vertical position.[25]

The azimuth drive assembly pivoted the launcher to the desired horizontal position by means of an electric motor and gear connection (Figure 10, right). The precise downrange direction of the launcher was set by using the bearing installation, which was made up of an azimuth ring, caliper, monument marker, and benchmarks. The uprange azimuth ring was a curved steel plate, flush-mounted to the launch pad. It passed beneath the mobile checkout shelter and featured regular markings, each representing one hundredth of a degree (Figure 11). A spring-loaded caliper, pushed down into an azimuth ring marking, indicated the current downrange direction of the launcher. A brass monument marker (also referred to as a 'guillotine') was located on the back of the launcher ballast to identify its centerline. Benchmarks in five-degree increments were arranged in two downrange semicircles about the launcher center of rotation. During final vehicle checkout and evacuation of the launch pad, the azimuth was set and verified.[26]

The launch vehicle made direct contact with the launch beam through the multiple "arms" described above. Except for the C and D section support arms, the retraction mechanisms for the arm assemblies were powered by pre-charged, high-pressure (gaseous) nitrogen (GN_2) systems known as "quick disconnects." During maintenance and checkout, disconnects were triggered from a local control station on the launcher. During "command eject" (i.e., testing), they were controlled from within the launch control building. However during "flyaway eject" (the standard mode of operation), disconnects were initiated by launch vehicle motion at liftoff.[27] Once at the desired vertical position, the two support arms released the launch vehicle. The entire weight of the vehicle was then supported from only three points: on two small base pins and at the split hook launch arms. At flyaway, when the vehicle had lifted approximately one inch from the launch pad, the umbilical retracted and the vehicle operated entirely on its own internal

[25] Ibid., 157.

[26] LTV Missiles and Electronics Group, *NAS1-18550 Volume II*, 2-25; Nowlan, et al., *Cold War Properties Evaluation - Phase I: Inventory and Evaluation*, 158.

[27] LTV Missiles and Electronics Group, *NAS1-18550 Volume II*, 2-28 – 2-32.

power. When the vehicle was approximately two inches from the launch pad, the split hook opened and the vehicle no longer had contact with the launcher.[28]

Pad Terminal Building (Facility 580b)

Original configuration

The pad terminal building, located immediately north of the mobile checkout shelter, was completed with the shelter in 1962. It housed terminal racks and cabinets that served as the distribution points for the following:[29]

- control wiring between the blockhouse and launcher/shelter
- launcher function control relays
- intercom unit
- ignition readout wiring box

The 7'-4" x 9'-4" rectangular building was constructed of concrete block walls on a poured concrete foundation. The walls were 8'-0" high and topped with a flat, reinforced concrete roof. To withstand blasts, steel reinforcing rods were inserted vertically into the concrete blocks, and the block cells were filled with concrete. Three steel-covered trenches of various depths emanated from the building. The trenches carried the electrical cabling, sensor relays, and numerous service systems extending from the building to the mobile shelter, operations support building, and blockhouse. The weight of the walls where each trench exited the terminal building was supported by trench-spanning concrete lintels.[30]

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[28] Nowlan, et al., *Cold War Properties Evaluation - Phase I: Inventory and Evaluation*, 157; to ensure proper timing and separation, three timed tests of the split hook separation were typically conducted before the missile was mated to the launcher. A split hook malfunction could severely damage the vehicle tail fin and would most likely result in the loss of the entire launch vehicle (Nowlan, et al., *Cold War Properties Evaluation - Phase I: Inventory and Evaluation*, 157).

[29] LTV Missiles and Electronics Group, *NAS1-18550 Volume II*, 2-56.

[30] Nowlan, et al., *Cold War Properties Evaluation - Phase I: Inventory and Evaluation*, 153-154; “Drawing No. 580-A-5.”

The 3'-0"-wide north-south trench serviced the launcher service pit. It contained (1) electrical cabling for the launcher and launch vehicle, (2) lines for the compressed air, gaseous nitrogen, hydrogen peroxide systems, and (3) return lines for Stage 2 and Stage 3 of the Scout launch vehicle. Launch technicians monitored the launcher and payload at all times during the mating process and launch proceedings. Numerous sensors, attached to both the launcher and payload, relayed data on the current state of the components back to the control units in the pad terminal building.[31]

The east-west double trench exited the west side of the pad terminal building. The northernmost of these trenches was 2'-0" clear in width. It lead to the launch control building and housed the site's audio-visual communications cables. On its way to the control building, it transitioned twice to a 4'-6"-high above-grade cableway. The above-grade portions were protected by a 3'-0"-wide corrugated metal shed roof that was later removed. The southernmost east-west pipe trench was 1'-6" clear in width. It lead to the operations support building and housed electrical and audio-visual conduit.[32]

Modifications to the pad terminal building

In 1966 the pad terminal building was expanded to the west to accommodate more terminal racks. With this addition, the building nearly doubled in size. New, covered, cable trenches were provided; existing trenches received new cover plates; and a second door was placed on the west elevation to facilitate personnel and equipment access.[33]

Other exterior features

Five power pedestals (designated A through E) provided electricity to the site. Uprange power receptacles included pedestal A (adjacent to the pad terminal building), pedestal B (at the center east edge of the launch pad), and pedestal C (at the south west edge of the launch pad). Pedestals D and E flanked the shelter track at mid-length to supply power to the shelter when downrange.

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[31] Nowlan, et al., *Cold War Properties Evaluation - Phase I: Inventory and Evaluation*, 153-154; "Drawing No. 580-A-5"; "Drawing No. 580-S-1."

[32] Architectural/Engineering drawing set "Drawing No. 580-A-5"; "Drawing No. 580-S-1."

[33] "Real Property Accountable Record Facility 580," Real Property Office, Vandenberg Air Force Base, California.

Power from pedestal C operated all equipment in the shelter and the heaters (at Pedestal A). Most electrical conduit ran from pedestal C to the shelter in an east-west utility trench that entered the shelter at the south end of its west elevation. To the south of pedestal C was a power rack that serviced the test communications and telephone terminal cabinets, and camera and video feeds. A bank of camera receptacles was also located at the south edge of the shelter track pavement (beyond the motor building). Originally east of the pad terminal building, power pedestal A was relocated west of that building prior to 1967. The move likely accommodated expansion of the terminal building or prior heating of the mobile checkout shelter. In addition, pedestal A was expanded in 1968 to include floodlight controls.[34]

Three Scout television camera sites were located about the launch pad. Camera sites No. 1 and No. 3 overlooked the pad on the east and north sides from the banks above. A 365'-0" conduit duct bank connected these two camera sites; handholes were located periodically along the conduit length for maintenance purposes. Camera site No. 2 was located adjacent to the pad between the mobile shelter and the operations support building. Each of the three sites featured a 5'-6" camera stand.[35]

A public address announcing system was used to keep all areas of site operations current on launch activities. Speakers for the system were located at the northwest exterior corner of the operations support building, on the roof of the operations support building, and just south of Scout camera site No. 2. Paging conduit also ran along the west edge of the mobile shelter track.[36]

Six two-bulb floodlights were initially installed at the four corners of the launch pad and at the end of the shelter track. In 1968, three additional floodlight poles were added to provide greater illumination for night launches. They were located at the northwest edge of the launch pad near the pad terminal building, at the southwest corner of the mobile shelter near the existing cable

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[34] Architectural/Engineering drawing set “Drawing No. 580-E-2”; LTV Missiles and Electronics Group, *NAS1-18550 Volume II*, 2-38; Architectural/Engineering drawing set “Drawing No. 580-E-12”; the utility trench that entered the shelter at the south end of its west elevation also contained the shelter’s water system piping (Architectural/Engineering drawing set “Drawing No. 580-C-2”).

[35] Architectural/Engineering drawing set “Drawing No. 580-E-4.”

[36] Architectural/Engineering drawing set “Drawing No. 580-E-2”; “Drawing No. 580-E-4.”

trench, and at the east uprange side of the pad approximately thirty-seven feet south of the pad corner. Each new pole featured ten six-bulb lighting clusters that provided illumination down the length of the pole. Floodlight controls were added to existing power pedestal A, and servicing conduit was laid in the cableway to the blockhouse.[37]

[37] Architectural/Engineering drawing set "Drawing No. 580-E-12," "Drawing No. 580-E-13"; "Real Property Accountable Record Facility 580."

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ACRONYMS AND ABBREVIATIONS

Term	**Spellout**
CERL	Construction Engineering Research Laboratory
DOD	Department of Defense
ECS	environmental control system
ERDC	Engineer Research and Development Center
EAR	Export Administration Regulations
GN_2	gaseous nitrogen
HAER	Historic American Engineering Record
ITAR	International Traffic in Arms Regulation
LTV	corporation formerly known as Ling-Temco-Vought
NASA	National Aeronautics and Space Administration
RF	radio frequency
RTV	room temperature vulcanizing
SLC-5	Space Launch Complex 5
USGS	United States Geological Survey
USAF	United States Air Force

Term	Spellout
VAFB	Vandenberg Air Force Base

HISTORIC DRAWINGS

The technical drawings used for research in this study are not available for inclusion in this document, because of the following determination:

> These drawings HAVE NOT been characterized as being released to the public domain and MAY contain EXPORT-CONTROLLED TECHNICAL DATA. Export-Controlled Technical Data is data that cannot be lawfully exported without the approval, authorization, or license under U.S. export control laws. The controlling regulations and documents are the Export Administration Regulations (EAR), the International Traffic in Arms Regulation (ITAR), and the U.S. munitions list.

Due to this stipulation, it is not possible to reproduce in this document the drawings used to gather information about the design, construction, and use of facilities at Scout Launch Complex 5, VAFB, California.

FIGURES FROM DATA SECTION

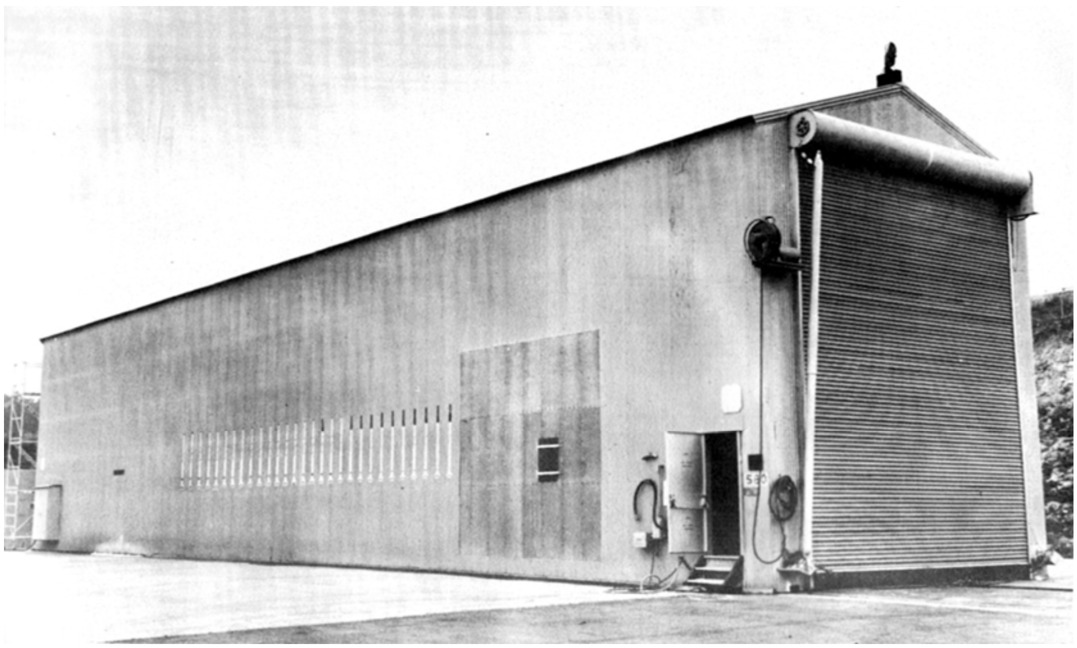


Figure 1. Pre-1976 view of the mobile checkout shelter (NASA HQ, History Office, Washington, D.C.).

Figure 2. Work platform hatch in open position, VAFB Facility #580, 2008 (ERDC-CERL).

Figure 3. Mobile checkout shelter rail, 2008 (ERDC-CERL).

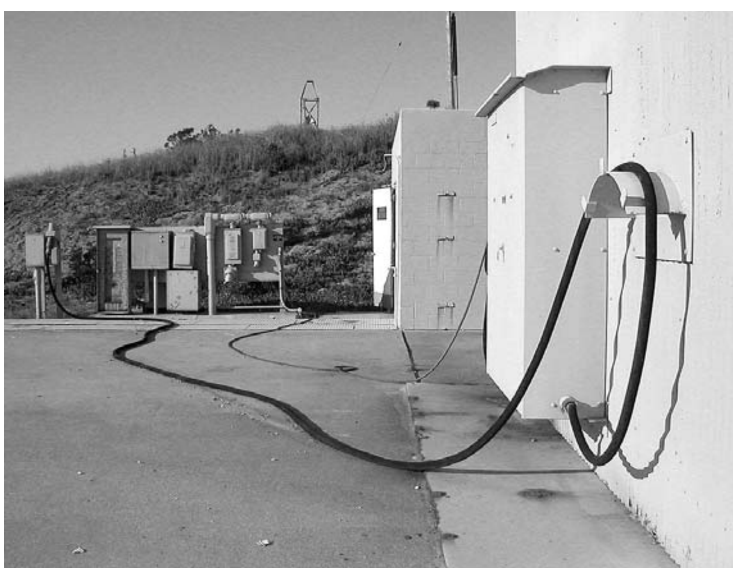


Figure 4. Water-tight power panel enclosure and spooled portable feeder cable that powered the mobile shelter electric unit heaters, 2008 (ERDC-CERL).

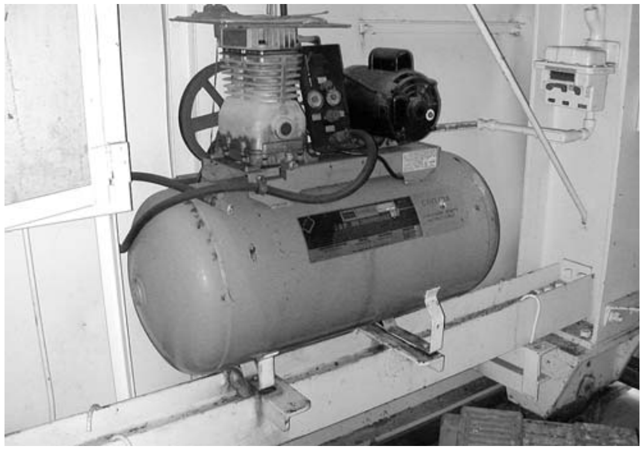


Figure 5. Compressor for inflatable seals, VAFB Facility #580, 2008 (ERDC-CERL).

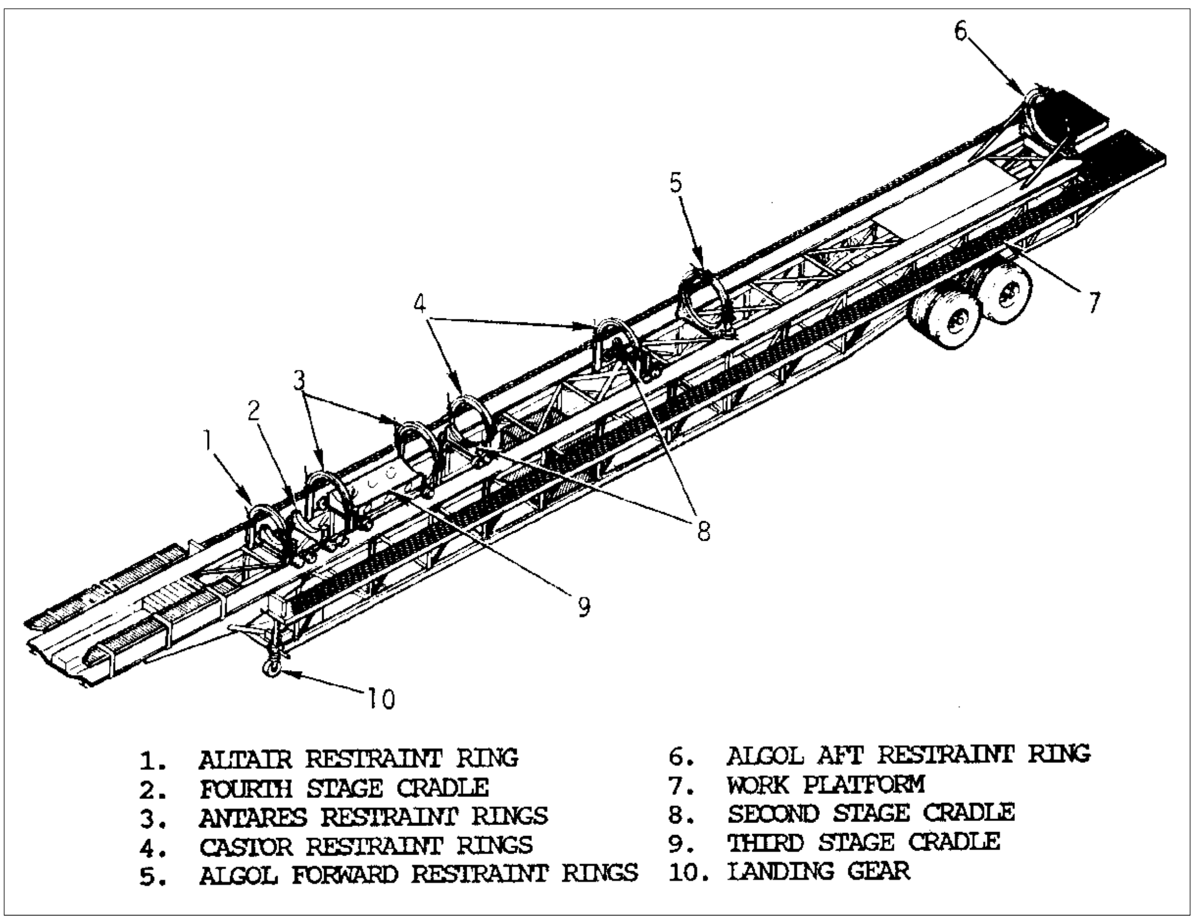


Figure 6. Diagram of transporter trailer (LTV Missiles and Electronics Group, 1990).

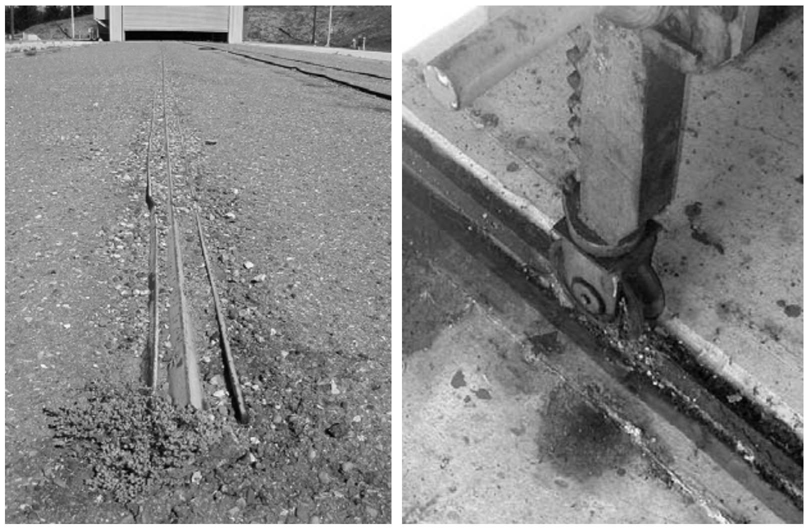
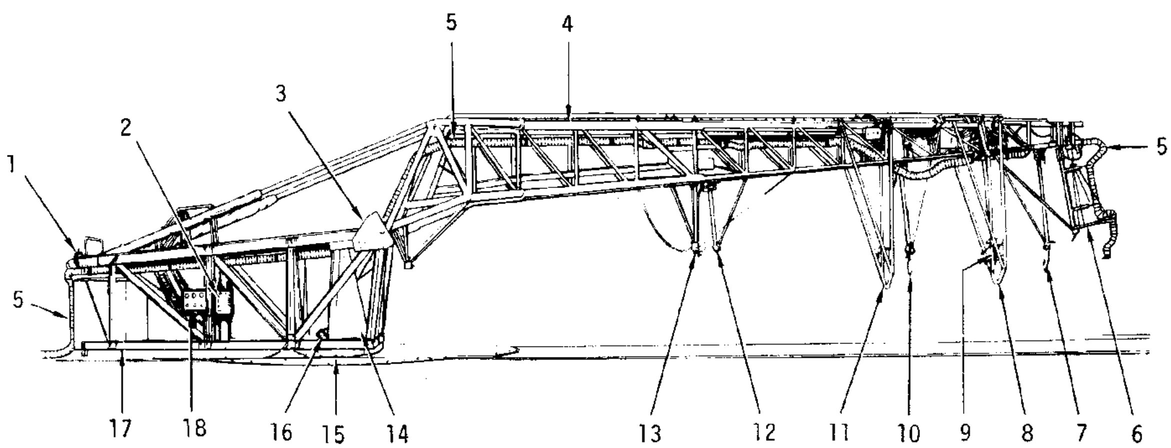


Figure 7. Transporter alignment rail and V-shaped wheels, 2008 (ERDC-CERL).



1. PITCH DRIVE ASSEMBLY
2. LAUNCHER CONTROL PANEL (SEE SHEETS 3 AND 4)
3. LUG ASSEMBLIES
4. BEAM ASSEMBLY
5. ECS DUCTING
6. ECS PAYLOAD UMBILICAL AIR ARM
7. PAYLOAD FLYAWAY ARM
8. D SECTION SUPPORT ARMS
9. D SECTION FLYAWAY ARM
10. C SECTION UMBILICAL ARM
11. C SECTION SUPPORT ARMS
12. B SECTION UMBILICAL ARM
13. LAUNCH ARMS
14. BLAST SHIELD ASSEMBLY
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16. AZIMUTH DRIVE ASSEMBLY
17. BASE STRUCTURE
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Figure 8. Diagram of launcher (LTV Missiles and Electronics Group).

Figure 9. Launcher ballast (left) and lug assemblies (right), VAFB Facility #580, 2008 (ERDC-CERL).

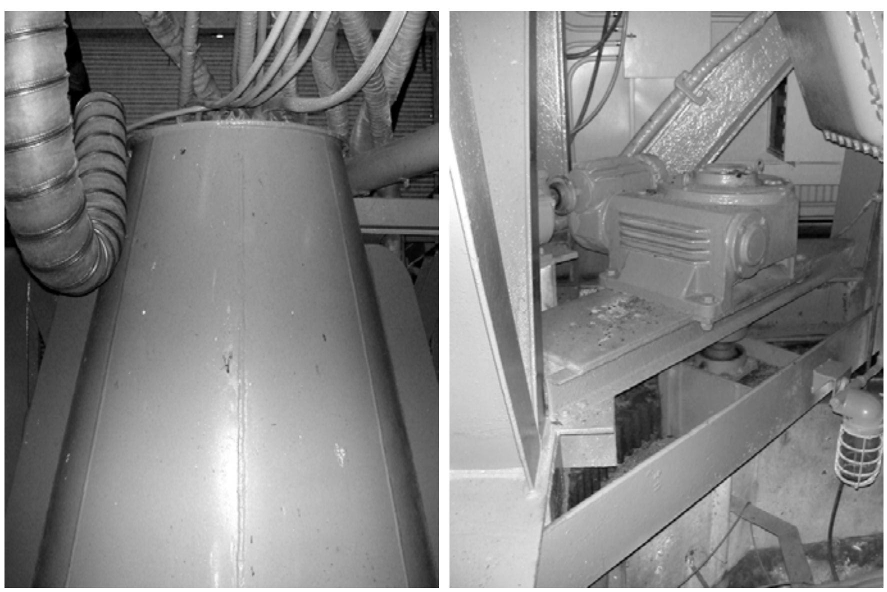

Figure 10. Blast shield assembly (left) and azimuth drive and bearing assemblies (right), VAFB Facility #580, 2008 (ERDC-CERL).

Figure 11. Portion of the azimuth ring and blast plates, 2008 (ERDC-CERL).

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Avery and Delphy Roads
Lompoc Vicinity
Santa Barbara County
California

Photographer: Martin Stupich, 2008
See photo key maps on page 3 of index to photographs.

CA-2288-A-1	EXTERIOR VIEW, MOBILE CHECKOUT SHELTER, NORTHWEST TO SOUTHEAST
CA-2288-A-2	EXTERIOR VIEW, MOBILE CHECKOUT SHELTER SOUTH OVERHEAD DOOR, VIEW SOUTH TO NORTH
CA-2288-A-3	EXTERIOR VIEW, MOBILE CHECKOUT SHELTER SOUTHWEST CANTILEVERED ENTRANCE PLATFORM, VIEW NORTHWEST TO SOUTHEAST
CA-2288-A-4	EXTERIOR VIEW, MOBILE CHECKOUT SHELTER NORTHEAST CANTILEVERED ENTRANCE PLATFORM, AZIMUTH RING, AND BLAST PLATES, VIEW NORTHEAST TO SOUTHWEST
CA-2288-A-5	EXTERIOR VIEW, MOBILE CHECKOUT SHELTER NITROGEN TANK CABINET, VIEW EAST TO WEST
CA-2288-A-6	INTERIOR VIEW, MOBILE CHECKOUT SHELTER AND LAUNCHER, VIEW SOUTH TO NORTH
CA-2288-A-7	INTERIOR VIEW, LAUNCHER BASE STRUCTURE, VIEW NORTH TO SOUTH
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CA-2288-A-9	INTERIOR VIEW, MOBILE CHECKOUT SHELTER DOUBLE FLANGED WHEELS AND TOW BAR, VIEW SOUTHWEST TO NORTHEAST

CA-2288-A-10	INTERIOR VIEW, MOBILE CHECKOUT SHELTER WORK PLATFORM UNDERSIDE AND TOW BAR, VIEW SOUTH TO NORTH
CA-2288-A-11	EXTERIOR VIEW, TERMINAL BUILDING, VIEW SOUTHWEST TO NORTHEAST
CA-2288-A-12	INTERIOR VIEW, TERMINAL BUILDING, VIEW NORTHWEST TO SOUTHEAST
CA-2288-A-13	EXTERIOR VIEW, LAUNCH PAD POWER PEDESTAL ‘C’, VIEW EAST TO WEST
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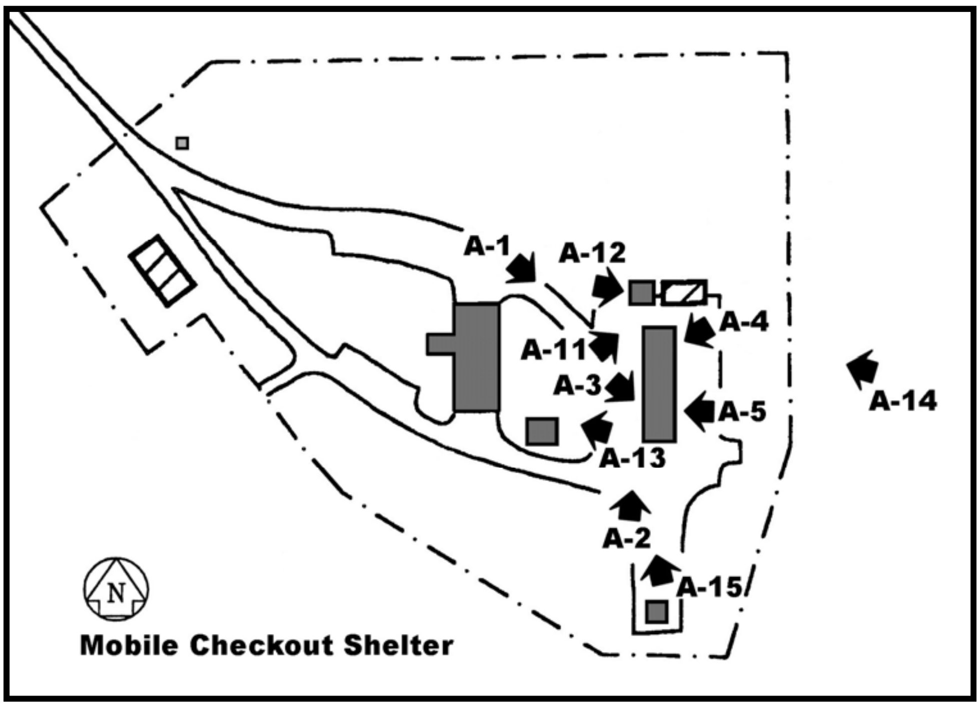
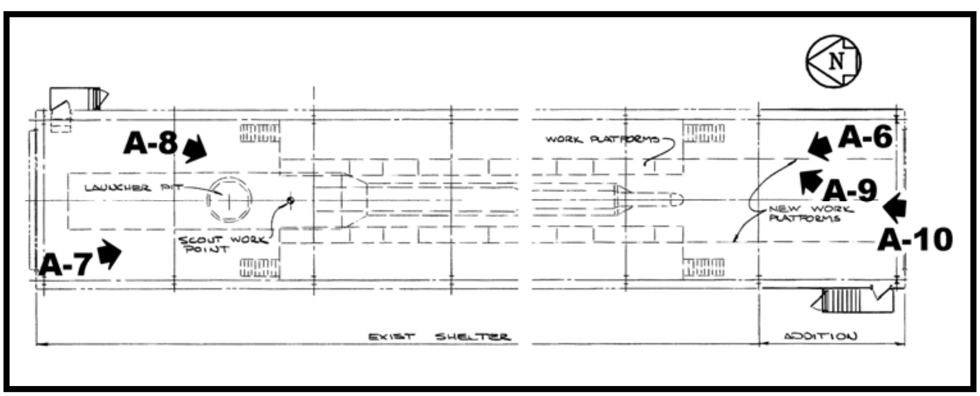
CA-2288-A-15	EXTERIOR VIEW, MOBILE CHECKOUT SHELTER RAIL AND LINEAR MOVEMENT LIMIT SWITCH, VIEW SOUTH TO NORTH





Photograph Key

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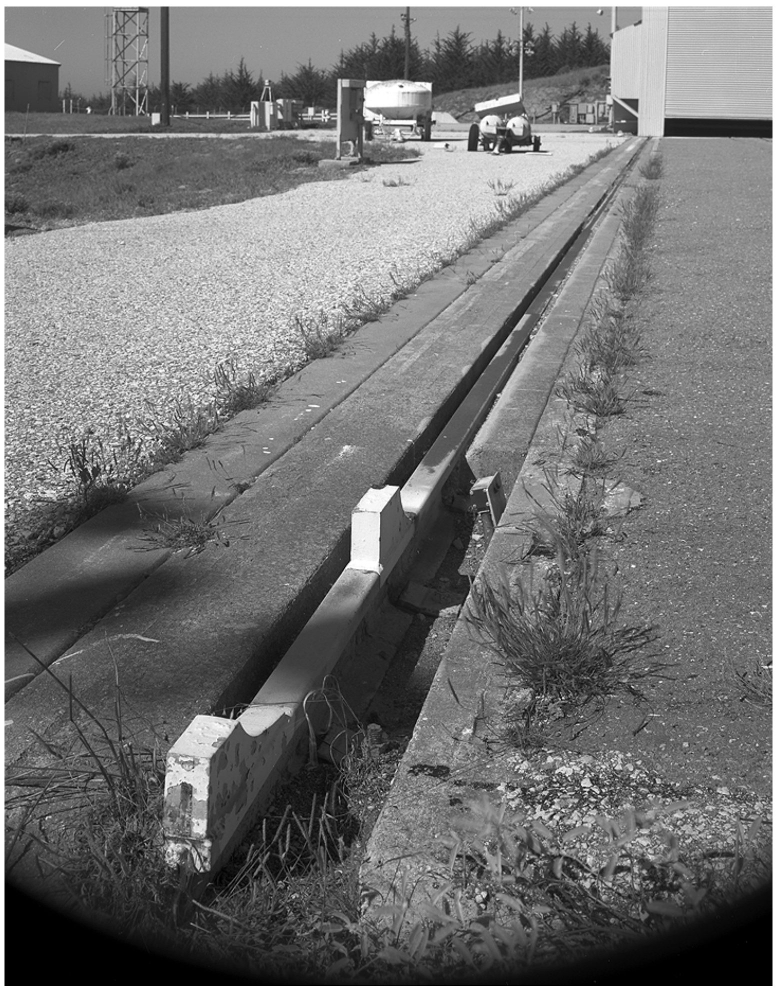

HISTORIC AMERICAN ENGINEERING RECORD

VANDENBERG AIR FORCE BASE, SPACE LAUNCH COMPLEX 5
MOTOR BUILDING (FACILITY No. 579)
HAER No. CA-2288-B

Location:	Vandenberg Air Force Base Space Launch Complex 5 Avery and Delphy Roads Lompoc Vicinity Santa Barbara County California U.S. Geological Survey (USGS) Santa Maria Quadrangle, Universal Transverse Mercator Coordinates: 10/34.60739/120.62441
Date of Construction:	Prior to 1964
Engineer:	Unknown
Present Owner:	U.S. Air Force (USAF)
Present Use:	Deactivated, Demolished
Significance:	SLC-5 is significant for supporting important Cold War missions, specifically those associated with the Scout missile between 1962 and 1994. Scout missions have studied aerosol contamination, helped scientists map planet’s magnetic and thermal fields, discovered new X-ray sources in space, studied quasars and black holes, helped prove Einstein’s gravitational and relativity theories, tested different materials to determine their tolerance to reentry heat, and studied how to protect spacecraft from micrometeoroids. Additionally, NASA relied on Scout missions to focus on specific problems pertaining to the manned space programs.
Report Prepared By:	Julie L. Webster, RA, Dr. Susan I. Enscore, and Mr. Martin Stupich U.S. Army Engineer Research and Development Center (ERDC) Construction Engineering Research Laboratory (CERL) P.O. Box 9005 Champaign, IL 61826-9005
Date:	September 2010

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VANDENBERG AIR FORCE BASE, SPACE LAUNCH COMPLEX 5, MOTOR BUILDING (FACILITY #579)
Avery and Delphy Roads
Lompoc Vicinity
Santa Barbara County
California

HAER No. CA-2288-B

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

PHOTOGRAPHS

HISTORIC AMERICAN ENGINEERING RECORD
Pacific West Region
National Park Service
U.S. Department of the Interior
1111 Jackson Street, Suite 700
Oakland, CA 94607

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MOTOR BUILDING (FACILITY 579)

In the original 1962 configuration of the launch complex, there was no motor building. Instead, an open-air winch was anchored into a concrete foundation 5'-11" south of the mobile checkout shelter track terminus. The winch relied on a ten-horsepower winch drive to power a gearbox that traded speed for torque in moving the large shelter downrange and uprange on the purpose-built track.[1]

By 1964, the winch was sheltered (Figure 1). The building was constructed on a concrete slab foundation, and walled and roofed with metal panels over a steel frame. Interior access was provided by a panelized metal personnel door on the east elevation. A manually operated overhead steel door on the north elevation provided access to the winch system. During launch preparations, the overhead door on the motor building was raised and a tow cable was attached near the south-side base of the mobile checkout shelter. The winch drive (powered both pneumatically and electrically) spooled the tow cable onto one of two cable drums that controlled the direction of shelter movement. The winch-track-shelter setup allowed the mobile checkout shelter to completely clear all launcher assemblies.[2]

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[1] Architectural/Engineering drawing set "Drawing No. 580-S-1"; Donald Johnson, electronic correspondence to Julie Webster, 14 August 2009.

[2] Nowlan, et al., *Cold War Properties Evaluation - Phase I: Inventory and Evaluation*, 155; LTV Missiles and Electronics Group, *NAS1-18550 Volume II*, 2-42.

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Architectural/Engineering drawing sets for Space Launch Complex 5. All architectural/engineering drawing sets on file with Base Planning Section (30CES/CECB), 30th Civil Engineering Squadron drawing vault, Vandenberg Air Force Base, California.

Johnson, Donald. Electronic correspondence to Julie Webster, 14 August 2009.

LTV Missiles and Electronics Group, *NAS1-18550 Volume II (of Ground Support Equipment Manual)*. Hampton, Virginia: NASA Langley Research Center, July 1990.

Nowlan, Patrick, Sheila Ellsworth, Roy McCullough, Mira Metzinger, Jim Gorski, and Andy Bonhert. *Cold War Properties Evaluation - Phase I: Inventory and Evaluation of Launch Complexes and Related Facilities at Vandenberg Air Force Base, California*. Final Report (no number). Champaign, IL: U.S. Army Construction Engineering Research Laboratory, February 1996.

ACRONYMS AND ABBREVIATIONS

Term	**Spellout**
CERL	Construction Engineering Research Laboratory
ERDC	Engineer Research and Development Center
EAR	Export Administration Regulations
HAER	Historic American Engineering Record
ITAR	International Traffic in Arms Regulation
LTV	corporation formerly known as Ling-Temco-Vought
NASA	National Aeronautics and Space Administration
SLC-5	Space Launch Complex 5
USGS	United States Geological Survey
USAF	United States Air Force
VAFB	Vandenberg Air Force Base

HISTORIC DRAWINGS

The technical drawings used for research in this study are not available for inclusion in this document, because of the following determination:

> These drawings HAVE NOT been characterized as being released to the public domain and MAY contain EXPORT-CONTROLLED TECHNICAL DATA.

> Export-Controlled Technical Data is data that cannot be lawfully exported without the approval, authorization, or license under U.S. export control laws. The controlling regulations and documents are the Export Administration Regulations (EAR), the International Traffic in Arms Regulation (ITAR), and the U.S. munitions list.

Due to this stipulation, it is not possible to reproduce in this document the drawings used to gather information about the design, construction, and use of facilities at Scout Launch Complex 5, VAFB, California.

FIGURES FROM DATA SECTION

Figure 1. Winch drive inside motor building, n.d. (Collection of Jim Price).

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HISTORIC AMERICAN ENGINEERING RECORD

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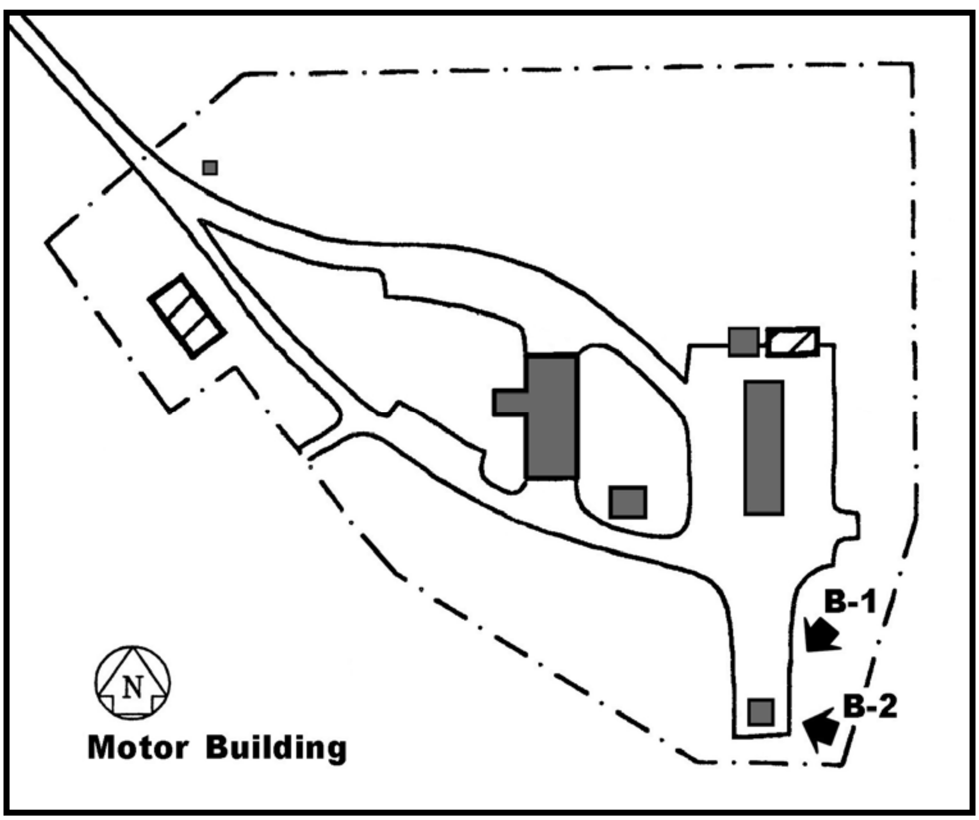
Avery and Delphy Roads
Lompoc Vicinity
Santa Barbara County
California

Photographer: Martin Stupich, 2008
See photo key map on this page.

CA-2288-B-1	EXTERIOR, MOTOR BUILDING, VIEW NORTHEAST TO SOUTHWEST
CA-2288-B-2	INTERIOR, MOTOR BUILDING WINCH, VIEW SOUTHEAST TO NORTHWEST



Photograph Key

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HISTORIC AMERICAN ENGINEERING RECORD

VANDENBERG AIR FORCE BASE, SPACE LAUNCH COMPLEX 5
OPERATIONS SUPPORT BUILDING (FACILITY #582)

HAER No. CA-2288-C

Location:	Vandenberg Air Force Base Space Launch Complex 5 Avery and Delphy Roads Lompoc Vicinity Santa Barbara County California U.S. Geological Survey (USGS) Santa Maria Quadrangle, Universal Transverse Mercator Coordinates: 10/34.60807/120.62497
Date of Construction:	1961
Engineer:	Kaiser Engineers, Oakland, California (original construction, 1975 air compressor addition); Quinton Engineers Limited, Los Angeles, California (1963-64 addition)
Present Owner:	U.S. Air Force (USAF)
Present Use:	Deactivated, Demolished
Significance:	SLC-5 is significant for supporting important Cold War missions, specifically those associated with the Scout missile between 1962 and 1994. Scout missions have studied aerosol contamination, helped scientists map planet’s magnetic and thermal fields, discovered new X-ray sources in space, studied quasars and black holes, helped prove Einstein’s gravitational and relativity theories, tested different materials to determine their tolerance to reentry heat, and studied how to protect spacecraft from micrometeoroids. Additionally, NASA relied on Scout missions to focus on specific problems pertaining to the manned space programs.
Report Prepared By:	Julie L. Webster, RA, Dr. Susan I. Enscore, and Mr. Martin Stupich U.S. Army Engineer Research and Development Center (ERDC) Construction Engineering Research Laboratory (CERL) P.O. Box 9005 Champaign, IL 61826-9005
Date	September 2010

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VANDENBERG AIR FORCE BASE, SPACE LAUNCH COMPLEX 5, OPERATIONS SUPPORT BUILDING (FACILITY #582)
Avery and Delphy Roads
Lompoc Vicinity
Santa Barbara County
California

HAER No. CA-2288-C

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

PHOTOGRAPHS

HISTORIC AMERICAN ENGINEERING RECORD
Pacific West Region
National Park Service
U.S. Department of the Interior
1111 Jackson Street, Suite 700
Oakland, CA 94607

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OPERATIONS SUPPORT BUILDING (FACILITY 582)

Original building configuration

Facility 582, the operations support building (or utility building), was part of the original 1962 construction of the launch complex. As the building's name suggests, activities inside the building supported launch operations. It housed two basic systems: (1) a compressed air distribution system that supplied compressed air to the launcher, mobile shelter, and launch pad; and (2) a hydrogen peroxide and nitrogen servicing system used to fuel and defuel the launch vehicle.[1]

In its original configuration, it was a prefabricated rigid frame steel structure measuring three, twenty-foot bays in length and forty feet wide. The former 2,400-square-foot building was clad in corrugated metal siding and featured corrugated metal sliding track doors, metal one-light personnel doors, and nine-light steel awning windows.[2] The walls were topped with a moderately sloped gable roof of corrugated metal and a series of ridge ventilators. The pre-engineered structure immediately received some interior alterations to accommodate early launch operations. These included (1) enclosure of the southeast corner to form the "fueling room" (Figure 1), (2) partitioning the entire north end with removable wood framed walls to enclose the mechanical and toilet rooms, (3) construction of a tool crib in the middle of the west wall, and (4) addition of a second personnel door west of the oversized sliding doors. The remainder of the floor plan was left open and used for storage, maintenance shop, and administrative purposes.[3]

Fueling room

Most significant of the Scout prelaunch activities was the remote fueling of the Scout launch vehicle with hydrogen peroxide (H_2O_2) fuel. Due to the volatile nature of the fuel, the remote

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[1] LTV Missiles and Electronics Group, *NAS1-18550 Volume II*, 2-54.

[2] A single, six-light steel awning window was once located at the toilet room (Architectural/Engineering drawing set "Drawing No. 582-A-1").

[3] Architectural/Engineering drawing set "Drawing No. 582-A-2"; the water heater, telephone terminal cabinet, winch starter, fire alarm control panel, and multiple power panels were located in the mechanical room.

fueling unit (RFU) was isolated from the rest of the building in the dedicated fueling room.[1] This highly specialized space measured approximately 12'-0" x 22'-0". Aluminum-sheathed wall partitions and doors, copper-free aluminum-clad piping, and stainless steel components protected the space from any explosive reactions that could occur between traditional building materials and hydrogen peroxide.[2] The room was also equipped with a portable oxygen monitor. An alarm sounded if the oxygen concentration dropped to an unsafe level. A ventilator fan in the east wall exhausted hydrogen peroxide fumes and excessive nitrogen buildup as necessary. Finally, an overheat warning system sensed dangerous temperature rises in the stored hydrogen peroxide and alarms sounded in the fueling room and blockhouse during periods of overheating.[3]

Hydrogen peroxide handling

High concentration, propellant-grade hydrogen peroxide fuel was delivered to VAFB in high-purity aluminum drums that were specially designed and fabricated for commercial shipment of concentrated H_2O_2.[4] The drums were stored at Facility 561—an elevated, covered, and grounded platform located on Honda Canyon Road—until ready for use.[5] The hydrogen peroxide was delivered to SLC-5 in the same drums and at the same concentration as received on base. Upon arrival at the launch complex, the fuel was siphoned into a 350-pound capacity stainless steel holding tank in the RFU. This was accomplished using a pump-motor-filter system located

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[1] As mentioned previously, hydrogen peroxide was carried on the second and third stages of the Scout delivery vehicle as a necessary part of the attitude control systems.

[2] Architectural/Engineering drawing set "Drawing No. 582-A-2."

[3] LTV Missiles and Electronics Group, *NAS1-18550 Volume II*, 2-54.

[4] The H_2O_2 concentration used for the majority of Scout launches was 90 percent until the supplier, FMC Industrial Chemicals, stopped production of the product. After that, an 85 percent concentration purchased from the Interox Corporation was used for the remainder of the launches (Larry Johnson, electronic correspondence to Julie Webster, 15 January 2009).

[5] Facility 561 received an H_2O_2 loading dock by 1976 ("Drawing No. 580-C-5"). A catch basin was installed under its platform in the 1980s after Air Force environmental personnel became concerned that accidental leakage of high-concentration hydrogen peroxide might harm the indigenous three-spined stickleback fish in the creek. This fish was the favorite food of the least tern, an endangered bird species believed to feed in the Honda Creek watershed. Water captured by the basin was released into Honda Creek only if it had been verified that no propellant leakage had occurred (Donald Johnson, electronic correspondence to Julie Webster, 20 January 2009).

immediately southeast of the holding tank near the floor. However, because hydrogen peroxide slowly loses concentration over time in storage, and the loss of concentration would vary from drum to drum, the H_2O_2 concentration in each drum had to be verified at the time of use. Therefore, prior to transferring the hydrogen peroxide from the drum to the RFU holding tank, launch personnel sampled the drum contents with a hydrometer to test its specific gravity (i.e., concentration and temperature).[1]

To minimize the possibility of contamination when working with the hydrogen peroxide fuel, domestic water at the site was passed through a deionization unit located in the southeast corner of the fueling room (Figure 2). This unit filtered out impurities and its deionized water was then used to flush the hydrometer, beakers, and siphoning hoses before putting the equipment into the hydrogen peroxide drums. Internal surfaces of the transfer system were also rinsed before the hydrogen peroxide was siphoned, to maintain the cleanness and integrity of the hydrogen peroxide system.[2]

Remote Fueling Unit (RFU)

The RFU was situated over an ell-shaped concrete pad containing a service basin and personnel safety shower. The hydrogen peroxide holding tank was positioned over the service basin. It rested on scales allowing technicians to determine, by weight, the precise amount of hydrogen peroxide loaded onto the Scout launch vehicle. A continuous flow of water was maintained in the service basin during launch operations so the tank could be purged of hydrogen peroxide in emergency situations. Once diluted with water, the hydrogen peroxide-water solution could be piped out to the buried leach field east of the operations support building. In circumstances where it was not possible to dump the hydrogen peroxide from the holding tank, personnel and equipment were protected from the effects of a potential explosion by a flak blanket that

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[1] Nowlan, et al., *Cold War Properties Evaluation - Phase I: Inventory and Evaluation*, 160; Larry Johnson, electronic correspondence to Julie Webster, 15 January 2009.

[2] Nowlan, et al., *Cold War Properties Evaluation - Phase I: Inventory and Evaluation*, 161; Larry Johnson, electronic correspondence to Julie Webster, 15 January 2009.

surrounded the tank. The blanket was mechanically supported from the roof structure so as not to affect fuel weight readings.[1]

The RFU also featured two integrated thick-walled spherical gaseous nitrogen tanks, approximately 34 inches in diameter. The 6,000 psi-rated tanks were pressurized remotely to approximately 3,600 psi by the cryogenic converter unit located in the Cosmodyne shelter. Their pressurized nitrogen was used (1) to pressurize the 3,000-psi nitrogen flight tanks onboard the Scout launch vehicle and (2) as a pressurant to carry hydrogen peroxide from the RFU to the Scout launch vehicle second- and third-stage reaction thrusters.[2]

A launcher nitrogen servicing panel and its bottles were attached to the north wall of the fueling room (Figure 3). The two commercial-grade storage bottles (K-sized) contained gaseous nitrogen that also was pressurized by the cryogenic converter unit. Pressure from these tanks was used to operate various devices on the Scout launcher, such as umbilical retraction and split hooks separation.[3]

A hydrogen peroxide servicing panel depicting the Scout launch vehicle was located on the west side of the RFU between the basin and shower. It featured the main RFU power switch and was used for operating the mechanical valves associated with the hydrogen peroxide fueling and gaseous nitrogen pressurization systems. It also featured a large scale for monitoring hydrogen peroxide weight. Ultimately, the hydrogen peroxide was dispensed to the launch vehicle in the

[1] Nowlan, et al., *Cold War Properties Evaluation - Phase I: Inventory and Evaluation*, 160-161; Donald Johnson, electronic correspondence to Julie Webster, 13 January 2009.

[2] Nowlan, et al., *Cold War Properties Evaluation - Phase I: Inventory and Evaluation*, 160; Donald Johnson, electronic correspondence to Julie Webster, 13 January 2009; Larry Johnson, electronic correspondence to Julie Webster, 15 January 2009.

[3] LTV Missiles and Electronics Group, *NAS1-18550 Volume II*, 2-54; Donald Johnson, electronic correspondence to Julie Webster, 13 January 2009; the term "K bottle" is a generic term used by the pressurized gas industry to describe a high pressure, steel bottle that is typically pressurized to 2,200 psig (pound-force per square inch gauge) and containing approximately 230 cubic feet of gas when expanded to ambient pressure and temperature (Donald Johnson, electronic correspondence to Julie Webster, 20 January 2009).

same concentration as it was received at SLC-5, and then fueling personnel evacuated the operations support building to a designated safe area on the far side of the remote blockhouse.[1]

The hydrogen peroxide-fueled attitude control system of the Scout vehicle was not designed to store propellant for any length of time. Hydrogen peroxide was loaded onto the vehicle approximately four hours prior to launch. It was standard practice to defuel the vehicle if the launch was delayed. Delays could be caused by weather, vehicle, or spacecraft technical problems encountered during the eight and one-half hour Scout countdown sequence. Defueling was accomplished using pressure from the onboard nitrogen flight tanks. Hydrogen peroxide offloaded from the vehicle (as well as that used to fill lines from the RFU and residual amounts left in the RFU holding tank) was diluted with large amounts of water and directed to the dedicated leach field mentioned above.[2]

Modifications to the operations support building

In 1963, two twenty-foot structural bays were added to the north side of the operations support building to provide 1,600 square feet of additional storage space. This brought the total building area up to 4,000 square feet. The new structure and roof were constructed to match the existing building. Other features (such as cladding, windows, and roof ventilators) also matched the originals. The westernmost portion of the existing removable interior wall was taken out to form a 7'-0"-wide hallway between the old and new portions of the building. A six-light, steel awning window was removed at the toilet room, and its opening expanded to accommodate a new door. An ell-shaped vision baffle was then constructed at the new door to provide toilet room privacy. The diagonal utility trench that once exited the building at the mechanical room was left in place and exposed in the addition's interior floor. Unit heaters from the blockhouse were relocated to the new operations support building storage area to provide climate control, and ceiling-mounted fluorescent fixtures were installed to provide illumination. A pair of double doors at the

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[1] Larry Johnson, electronic correspondence to Julie Webster, 15 January 2009; Donald Johnson, electronic correspondence to Julie Webster, 20 January 2009.

[2] Larry Johnson, electronic correspondence to Julie Webster, 15 January 2009; Donald Johnson, electronic correspondence to Julie Webster, 20 January 2009; this practice was acceptable and legal during the Scout Program, but no longer is allowed by State of California environmental regulations (Donald Johnson, electronic correspondence to Julie Webster, 20 January 2009).

northwest corner of the addition provided secondary egress from the building. A 10'-0" x 14'-0" concrete slab was poured outside the east wall of the addition to support a new air compressor.[1]

By 1976, the two-bay storage addition was subdivided into offices and a break area. Office space was provided for NASA, the leadmen, pad control, inspection, and blueprints (Figure 4).[2] The NASA office provided desks and phones for visiting NASA Langley Research Center (and later Goddard Spaceflight Center) personnel who represented the Scout program customer. The Scout field organization assigned one technician as Lead Electrical Technician and one as Lead Mechanical Technician. These “leadmen” supervised other technicians who performed maintenance and operations tasks. The pad control office was for the Operations Supervisor, who was responsible for scheduling and coordinating all operations at SLC-5. Both leadmen (and in turn all field technicians) reported to the Operations Supervisor. The inspection office housed the quality control inspectors and also served as storage space for all official maintenance and operations records and data files. The blueprint room contained additional program documentation files and drawings for vehicle and ground support equipment. It also housed the logbook review team, who assessed test data for errors, omissions, and anomalies. This data started with initial component acceptance testing at the Dallas, Texas, factory through final vehicle testing in the field just before a launch. Completion of this review and closure of all related action items was a constraint to launch.[3]

All office areas in the two-bay addition were framed in wood, walled with gypsum board, floored with asbestos tile, and covered by a dropped acoustical tile ceiling. Office wall heights measured approximately 10'-0" high, leaving space between the ceilings and building gable. The break area was located in the western third of the two-bay addition and was defined by partial-height modular partitions. Immediately east of the break area, “SCOUT” was spelled out in contrasting floor tiles. A narrow hallway along the wall shared by the original building and its addition provided secondary access to the toilet room.

[1] The compressor was likely removed from this slab when the west-side compressor housing addition was constructed in 1975.

[2] Facility 582 Fire Evacuation Plan, n.d.

[3] Donald Johnson, electronic correspondence to Julie Webster, 20 January 2009.

In 1975, a 15'-0" x 17'-0" compressor housing addition was constructed on the center west side of the building. This change resulted in the final T-shaped floor plan. Framed in steel, the shed addition was clad and roofed in corrugated metal to match the existing building. A circular exhaust ventilator was mounted to the high end of the shed roof, adjacent to the existing structure. The wall shared by the original building and compressor addition was an insulated gypsum-clad wood stud type with a solid core wood door leading into the main building. Two pairs of vented metal exterior doors provided access from the north and south sides of the compressor addition. On the interior, a ceiling-mounted electric heater was located in the northeast corner and two air compressors were anchored to the concrete floor slab (Figure 5).[1] The fifty-horsepower compressors were used to supply compressed air to the operations support building and to the launch pad. The compressed air was used to cool launch vehicle components, operate the launcher support arms, and supply pneumatic tools used on the pad. An air dryer system, located in the original mechanical room, was used to clean and dry this air. Drying was necessary because the cool, coastal fog of the area around VAFB frequently caused water to condense inside the compressed air lines at the site.[2]

By 1978, an electrical and battery shop addition was constructed on the building interior, adjacent to the fueling room. The electrical shop contained several work benches for the maintenance, repair, and fabrication of electrical equipment. The battery shop had a single work bench for the activation and testing of silver zinc batteries used by the Scout vehicle (Figure 6). The wood-framed addition was clad in gypsum board. In plan, the electrical shop formed an ell around the battery shop in the northeast quadrant. Access to the suite of shops was through a set of double doors on the south side or a single door on the north side; a single door provided access between the electrical and battery shops. Two interior observation windows were situated on the west wall of the electrical shop. At the same time the shops were added, a second-floor storage area was created above them for the storage of frequently used tools, equipment, and supplies. This negated the need for the original tool crib, which was dismantled. A single run of stairs and a flush door on the north side of the shops provided access to the second-floor store room. Supplies from within this room could be lowered to personnel on the first floor through a square, wall hatch on the south wall. The hatch opened onto the mechanics/fluids area west of the fueling room. The mechanics/fluids area was used to fabricate stainless steel tube assemblies

[1] Architectural/Engineering drawing set “Drawing No. 582-A-3”; “Drawing No. 582-S-3.”

[2] Donald Johnson, electronic correspondence to Julie Webster, 20 January 2009.

used extensively on the launch vehicle and ground support equipment. Machines in this area included a power tube flaring machine, tube benders, and long trays used to passivate tube assemblies for use in hydrogen peroxide systems.[1]

Other features

In addition to the attributes noted above, many safety features were installed about the operations support building. These included personnel safety showers and eye baths, supplemental water lines for dilution purposes, and a fire alarm/suppression system. Supplemental lighting systems were also available to assist with nighttime operations that included after-dark hydrogen peroxide fueling.

A jib crane was erected in 1963 at the southeast exterior corner of the operations support building for the offloading of hydrogen peroxide drums from their delivery trucks. It had a 1000-pound capacity, 10'-0"-high hook, eighty-degree swing, and nearby personnel safety shower assembly. The crane was never used because delivery trucks servicing the site were typically outfitted with safer, easy-to-use lift beds.[2]

In 1976, an existing television camera tower from SLC-4W was relocated to SLC-5. An eight-foot-square, reinforced concrete slab was constructed northeast of the operations support building. The four legs of the tower were bolted and grouted to the new slab. Cabling for the camera was provided by coring through the wall of the existing cable trench and running conduit 25'-0" up the tower. Nearby site features received minor alterations to accommodate the new tower setup.[3]

The operations support building had various utility features necessary for site operations. Its electrical transformer rested on a 6'-0" x 9'-0" concrete pad centered in a 15'-0" x 15'-0" x 7'-0" chain-link enclosure west of the building. This transformer was replaced with a new substation in

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[1] Architectural/Engineering drawing set "Drawing No. 582-A-4"; Donald Johnson, electronic correspondence to Julie Webster, 20 January 2009.

[2] Architectural/Engineering drawing set "Drawing No. 582-A-1"; Donald Johnson, electronic correspondence to Julie Webster, 20 January 2009; Donald Johnson, electronic correspondence to Julie Webster, 14 August 2009.

[3] Architectural/Engineering drawing set "Drawing No. 582-S-11."

1963 and again in 1972. The existing chain-link enclosure was enlarged to contain both the old and new transformer slabs. Northwest of the electrical transformer was the septic tank, distribution box, and drain field for the toilet room in the building. The drain field spanned most of the distance between the two support building parking lots. A two-foot-wide, covered, utility trench with cable trays ran along the east side of the building. Utility feeds from the mechanical room, battery shop, and fueling room converged in the trench, ran diagonally to the northeast, passed under the roadway, and terminated at the pad terminal building.[1] Also east of the operations support building were the Scout pad water distribution lines. Water flow was regulated by a buried valve pit northwest of the fueling room leach field. Three lines originated at the pit to provide water service to the (1) operations support building, (2) pad fire hydrant, and (3) mobile checkout shelter.[2]

[1] Architectural/Engineering drawing set “Drawing No. 580-S-2.”

[2] Architectural/Engineering drawing set “Drawing No. 580-C-2.”

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_______. Electronic correspondence to Julie Webster, 20 January 2009.

_______. Electronic correspondence to Julie Webster, 14 August 2009.

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LTV Missiles and Electronics Group, *NAS1-18550 Volume II (of Ground Support Equipment Manual)*. Hampton, Virginia: NASA Langley Research Center, July 1990.

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ACRONYMS AND ABBREVIATIONS

Term	**Spellout**
CERL	Construction Engineering Research Laboratory
ERDC	Engineer Research and Development Center
EAR	Export Administration Regulations
H_2O_2	hydrogen peroxide
HAER	Historic American Engineering Record
ITAR	International Traffic in Arms Regulation
LTV	corporation formerly known as Ling-Temco-Vought
NASA	National Aeronautics and Space Administration
PSIG	pound-force per square inch gauge
RFU	remote fueling unit
SCOUT	Solid Controlled Orbital Utility Test
SLC	Space Launch Complex
USGS	United States Geological Survey
USAF	United States Air Force
VAFB	Vandenberg Air Force Base

HISTORIC DRAWINGS

The technical drawings used for research in this study are not available for inclusion in this document, because of the following determination:

> These drawings HAVE NOT been characterized as being released to the public domain and MAY contain EXPORT-CONTROLLED TECHNICAL DATA. Export-Controlled Technical Data is data that cannot be lawfully exported without the approval, authorization, or license under U.S. export control laws. The controlling regulations and documents are the Export Administration Regulations (EAR), the International Traffic in Arms Regulation (ITAR), and the U.S. munitions list.

Due to this stipulation, it is not possible to reproduce in this document the drawings used to gather information about the design, construction, and use of facilities at Scout Launch Complex 5, VAFB, California.

FIGURES FROM DATA SECTION

Figure 1. H_2O_2 system installation in the operations support building, VAFB Facility #582, 5 February 1962 (Official U.S. Navy Photograph).

Figure 2. Fueling room deionization unit, VAFB Facility #582, 2008 (ERDC-CERL).

Figure 3. Launcher nitrogen servicing panel and bottles, VAFB Facility #582, 2008 (ERDC-CERL).

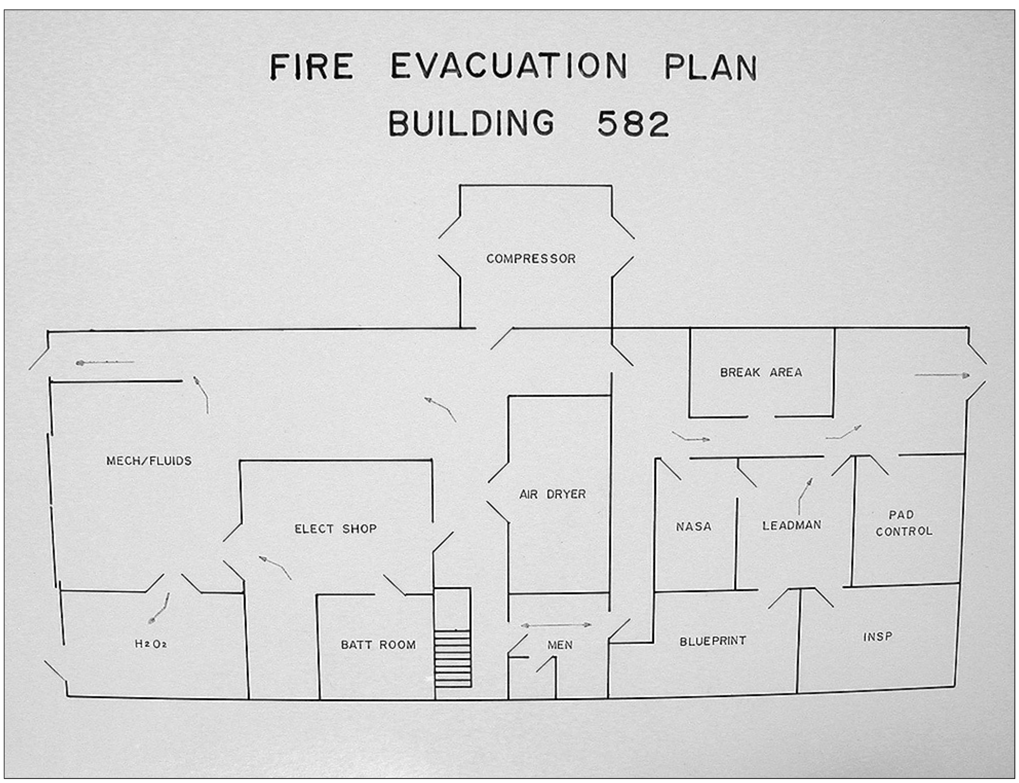


Figure 4. Fire evacuation plan showing two-bay storage addition subdivided into offices and break area, 2008 (ERDC-CERL).

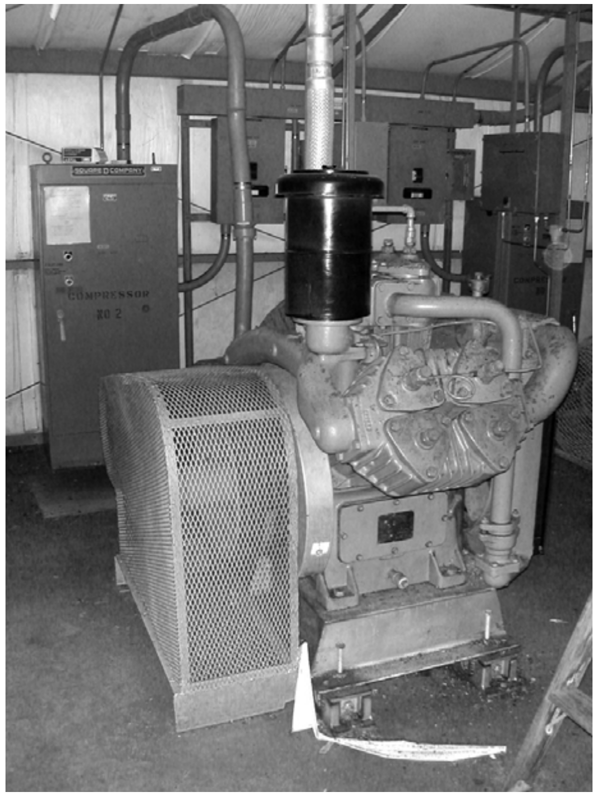


Figure 5. Air compressor in operations support building (VAFB Facility #582) compressor housing addition, 2008 (ERDC-CERL).

Figure 6. Battery-handling console in battery shop, VAFB Facility #582, circa 1990 (Collection of Jim Price).

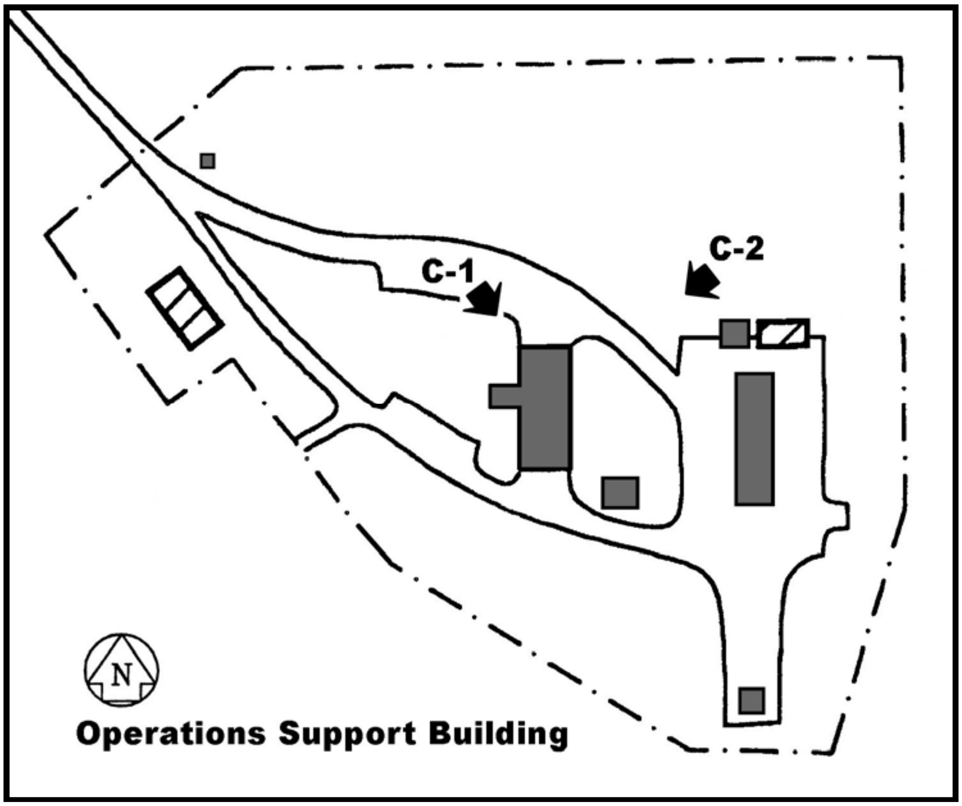
HISTORIC AMERICAN ENGINEERING RECORD
INDEX TO PHOTOGRAPHS

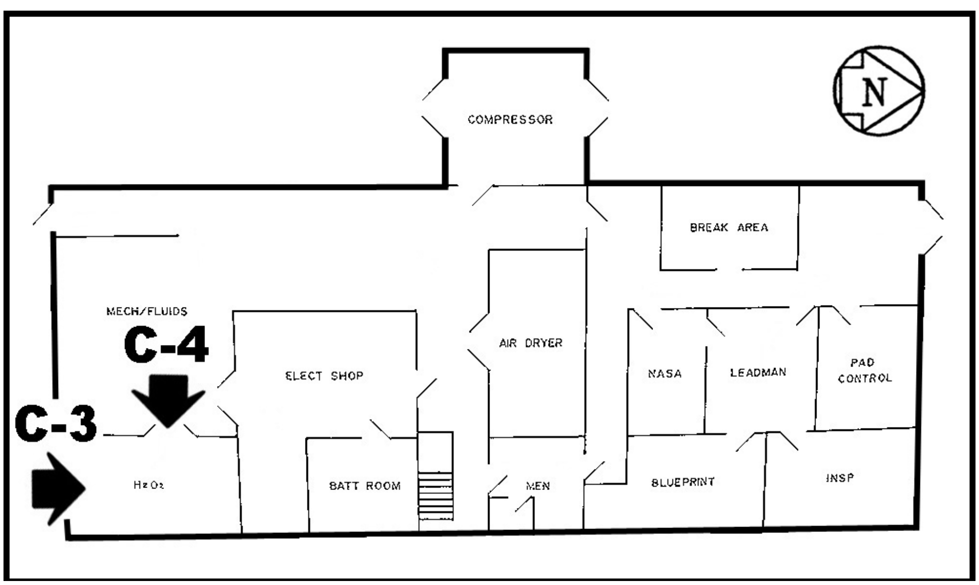
VANDENBERG AIR FORCE BASE, SPACE LAUNCH COMPLEX 5, OPERATIONS SUPPORT BUILDING (FACILITY No. 582)
Avery and Delphy Roads
Lompoc Vicinity
Santa Barbara County
California

HAER No. CA-2288-C

Photographer: Martin Stupich, 2008
See photo key maps on page 2 of index to photographs.

CA-2288-C-1	EXTERIOR, OPERATIONS SUPPORT BUILDING, VIEW NORTHWEST TO SOUTHEAST
CA-2288-C-2	EXTERIOR, OPERATIONS SUPPORT BUILDING, VIEW NORTHEAST TO SOUTHWEST
CA-2288-C-3	INTERIOR, REMOTE FUELING UNIT INSIDE OPERATIONS SUPPORT BUILDING, VIEW SOUTH TO NORTH
CA-2288-C-4	INTERIOR, REMOTE FUELING UNIT HYDROGEN PEROXIDE SERVICING PANEL, VIEW WEST TO EAST





Photograph Key

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

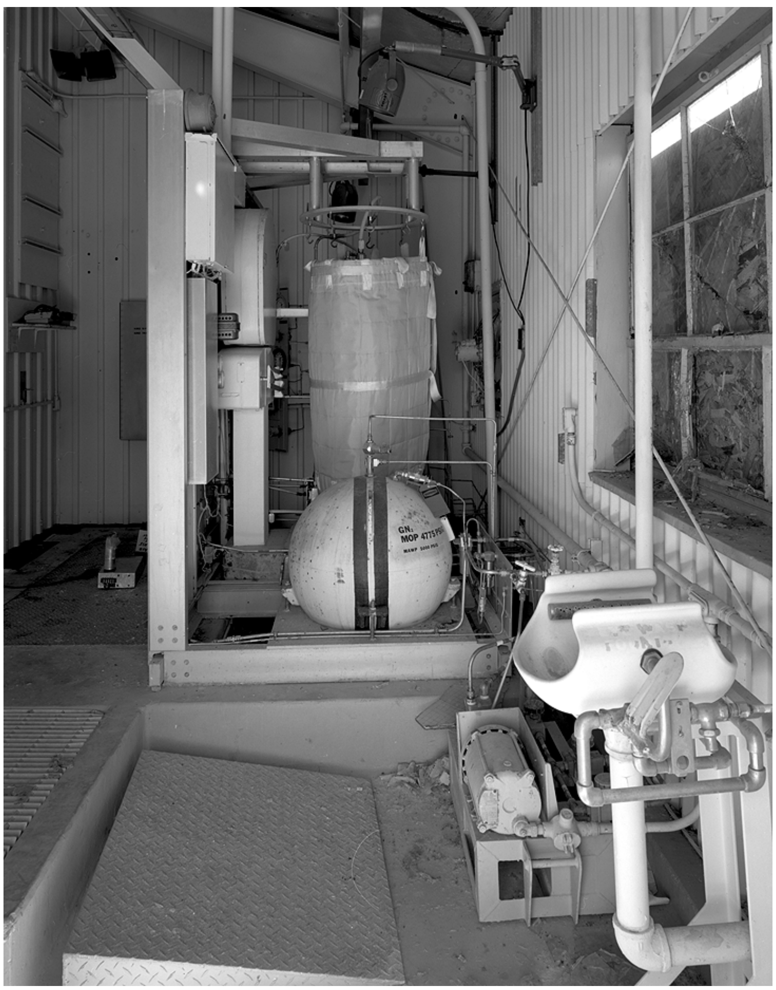
HAER No. CA-2288-C-1

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. CA-2288-C-2

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. CA-2288-C-3



HISTORIC AMERICAN ENGINEERING RECORD
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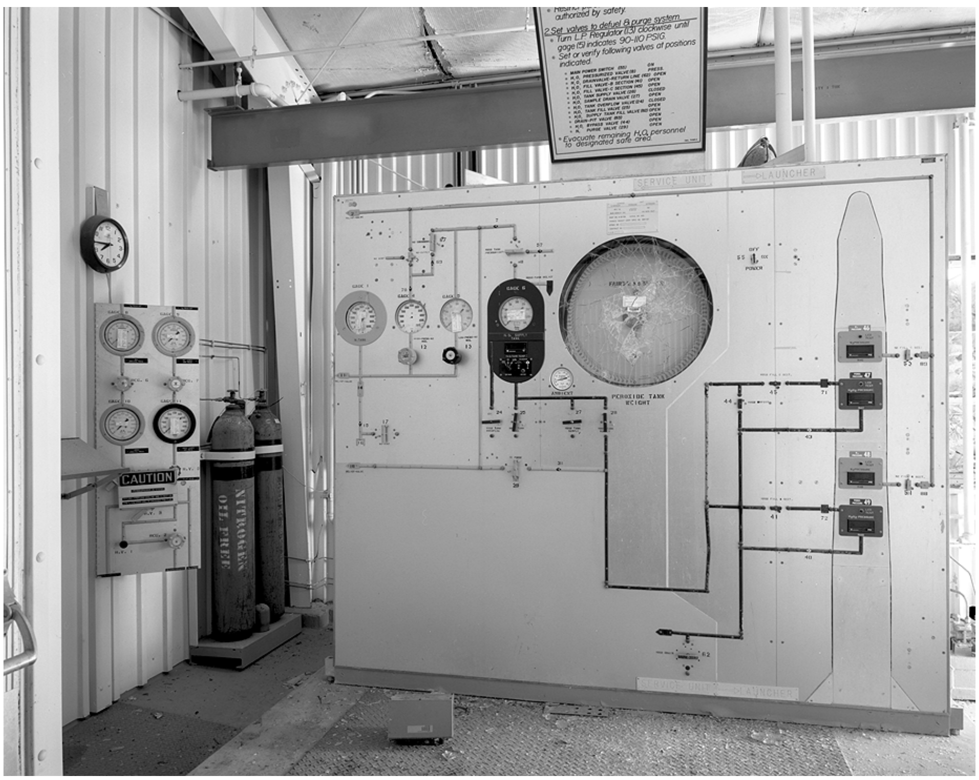
HAER No. CA-2288-C-4



HISTORIC AMERICAN ENGINEERING RECORD

VANDENBERG AIR FORCE BASE, SPACE LAUNCH COMPLEX 5
COSMODYNE SHELTER (FACILITY No. 578)
HAER No. CA-2288-D

Location:	Vandenberg Air Force Base Space Launch Complex 5 Avery and Delphy Roads Lompoc Vicinity Santa Barbara County California U.S. Geological Survey (USGS) Santa Maria Quadrangle, Universal Transverse Mercator Coordinates: 10/34.60783/120.62477
Date of Construction:	1978
Engineer:	Stearns-Roger Incorporated, now a subsidiary of Raytheon Company
Present Owner:	U.S. Air Force (USAF)
Present Use:	Deactivated, Demolished
Significance:	SLC-5 is significant for supporting important Cold War missions, specifically those associated with the Scout missile between 1962 and 1994. Scout missions have studied aerosol contamination, helped scientists map planet’s magnetic and thermal fields, discovered new X-ray sources in space, studied quasars and black holes, helped prove Einstein’s gravitational and relativity theories, tested different materials to determine their tolerance to reentry heat, and studied how to protect spacecraft from micrometeoroids. Additionally, NASA relied on Scout missions to focus on specific problems pertaining to the manned space programs.
Report Prepared By:	Julie L. Webster, RA, Dr. Susan I. Enscore, and Mr. Martin Stupich U.S. Army Engineer Research and Development Center (ERDC) Construction Engineering Research Laboratory (CERL) P.O. Box 9005 Champaign, IL 61826-9005
Date	September 2010

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VANDENBERG AIR FORCE BASE, SPACE LAUNCH COMPLEX 5, COSMODYNE SHELTER (FACILITY No. 578)
Avery and Delphy Roads
Lompoc Vicinity
Santa Barbara County
California

HAER No. CA-2288-D

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

PHOTOGRAPHS

HISTORIC AMERICAN ENGINEERING RECORD
Pacific West Region
National Park Service
U.S. Department of the Interior
1111 Jackson Street, Suite 700
Oakland, CA 94607

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COSMODYNE SHELTER (FACILITY 578)

Facility 578, the Cosmodyne shelter, was added to the site in 1978, at the same time the electric and battery shops were added to the operations support building (Figure 1). The shelter takes its name from the Cosmodyne Corporation of Seal Beach, California, producers of the cryogenic equipment used in Scout operations.

Cosmodyne cryogenic converter unit and four-ball cart

Prior to a launch (and as needed) liquid nitrogen was brought to the site in a tanker truck and offloaded into a 500-gallon Cosmodyne cryogenic converter unit. This unit stored the liquid nitrogen at negative 320 degrees Fahrenheit in a vacuum-jacketed dewar (a double-walled insulated tank designed to store very cold cryogenic fluids).[1] When various gaseous nitrogen systems needed servicing, the cryogenic unit raised the temperature of the liquid nitrogen to eighty degrees Fahrenheit, thus converting it from a liquefied state to a high-pressure, gaseous state. Cosmodyne designed the cryogenic converter to supply up to 6,000 psi gaseous nitrogen, but the pressure was down-rated to 3,600 psi for Scout systems usage. Although the Cosmodyne unit was designed to be portable, the Scout crew always used it as a stationary unit (i.e., lifted onto jack stands for stability). Eventually, the Cosmodyne shelter was built, sheltering and permanently plumbing the cryogenic converter to its nitrogen line.[2]

A vehicle known as the “four-ball cart” was used to transport nitrogen about the site. Nitrogen in the four-ball cart was pressurized to 3,600 psi by the Cosmodyne unit and then used as a clean, regulated gas source for control and function of various vehicles and ground support equipment at the site. The cart was roadworthy and towed from location to location by truck (Figure 2).[3]

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[1] Lee Wise, electronic correspondence to Julie Webster, 31 August 2009; at or near ambient atmospheric pressure, liquid nitrogen is negative 320 degrees Fahrenheit.

[2] Lee Wise, electronic correspondence to Julie Webster, 31 August 2009; Donald Johnson, electronic correspondence to Julie Webster, 13 January 2009; the cryogenic converter was permanently parked perpendicular to the overhead door.

[3] Donald Johnson, electronic correspondence to Julie Webster, 13 January 2009; gaseous nitrogen was also used to purge the dummy heat shield surrounding the payload when en route between the Spin Test Facility and the launch complex. The purged enclosure minimized the chance of foreign particles getting inside the payload (Nowlan, et al., *Cold War Properties Evaluation - Phase I: Inventory and Evaluation*, 159).

Building configuration

The Cosmodyne shelter was a rectangular one-story prefabricated building framed in metal studs and clad with metal batten seam siding. Its slightly pitched flat roof was finished with metal fascia and featured a single downspout and turbine roof ventilator. The east and west walls were vented and the south wall was largely taken up by a rolling overhead door. This door was the only means of access into the building interior. The structure rested on a reinforced concrete slab foundation with a raised edge on three of its four sides. The fourth side of the slab (containing the overhead door) was flush with a concrete apron that sloped to the surrounding asphalt pavement. A narrow precast utility trench ran to the Cosmodyne shelter from the operations support building to provide water service to the small shelter.[4] Also between the two buildings was a small bin on a post with a sign that read "Deposit switches and spark-producing items here."

The Cosmodyne shelter encompassed 216 square feet of open space. The utility trench that entered the shelter at the northwest corner fed water into the building, nitrogen out of the building, and compressed air through it. The shelter's corresponding interior features included:[5]

- water spigot low on the west wall near the utility trench opening for "cool down" operations of the Cosmodyne unit and for dilution of small, liquid nitrogen spills that routinely occurred during disconnection of the supply hose that ran between the delivery truck and the Cosmodyne unit
- nitrogen valve centrally located on the north wall to provide pressurized gaseous nitrogen to the RFU
- fill hose and hose rack on the east wall for filling mobile four-ball cart
- compressed air conduit passing through the Cosmodyne shelter (along the north wall) to the mobile checkout shelter

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[4]Architectural/Engineering drawing set "Drawing No. 578-S-1."

[5] Lee Wise, electronic correspondence to Julie Webster, 31 August 2009; "Cosmodyne Building, VAFB, Drawing No. P 321 51028" (Vought Corporation, n.d.); "cool down" operations involved flooding the Cosmodyne shelter's concrete floor with water to protect it and any nearby asphalt from damage; direct contact between the liquid nitrogen and concrete or asphalt was very destructive to those surfaces (Donald Johnson, electronic correspondence to Julie Webster, 14 August 2009) .

The interior was illuminated by two, circular, pendant light fixtures that dropped from a metal panel ceiling. An electric outlet was located at the center of the west wall. The exposed concrete floor was slightly pitched toward the overhead door opening.[6]

[6] "Cosmodyne Building, VAFB, Drawing No. P 321 51028" (Vought Corporation, n.d.); "Drawing No. 578-S-1."

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_______. Electronic correspondence to Julie Webster, 14 August 2009.

Nowlan, Patrick, Sheila Ellsworth, Roy McCullough, Mira Metzinger, Jim Gorski, and Andy Bonhert. *Cold War Properties Evaluation - Phase I: Inventory and Evaluation of Launch Complexes and Related Facilities at Vandenberg Air Force Base, California*. Final Report (no number). Champaign, IL: U.S. Army Construction Engineering Research Laboratory, February 1996.

Wise, Lee. Electronic correspondence to Julie Webster, 31 August 2009.

ACRONYMS AND ABBREVIATIONS

Term	**Spellout**
CERL	Construction Engineering Research Laboratory
ERDC	Engineer Research and Development Center
EAR	Export Administration Regulations
HAER	Historic American Engineering Record
ITAR	International Traffic in Arms Regulation
NASA	National Aeronautics and Space Administration
RFU	remote fueling unit
SLC-5	Space Launch Complex 5
USAF	United States Air Force
USGS	United States Geological Survey
VAFB	Vandenberg Air Force Base

HISTORIC DRAWINGS

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FIGURES FROM DATA SECTION

Figure 1. Cryogenic converter unit in Cosmodyne shelter, circa 1981 (Official USAF photograph).

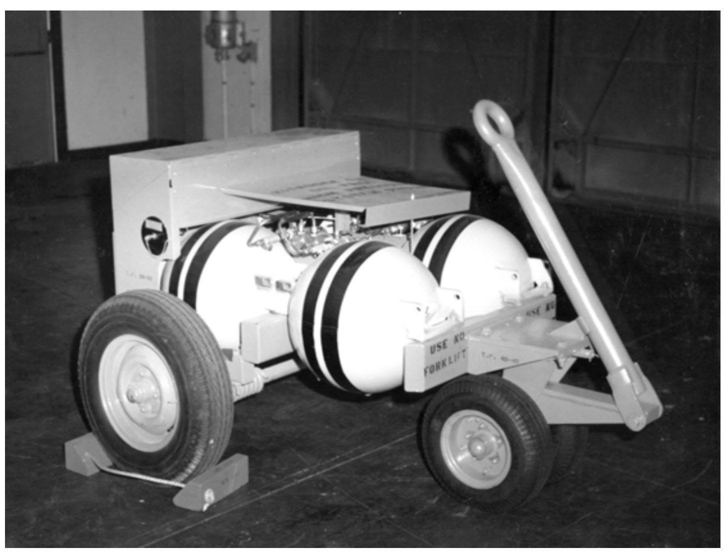

Figure 2. Four-ball cart, n.d. (Official NASA-USAF photograph).

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HISTORIC AMERICAN ENGINEERING RECORD

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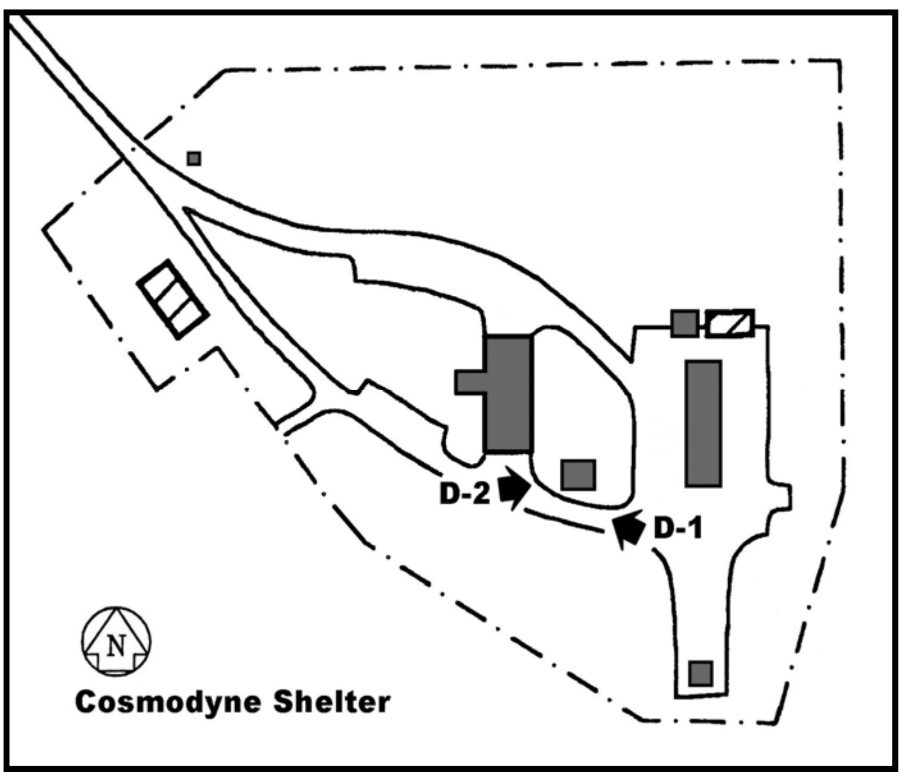
VANDENBERG AIR FORCE BASE, SPACE LAUNCH COMPLEX 5, COSMODYNE SHELTER (FACILITY No. 578) — HAER No. CA-2288-D

Avery and Delphy Roads
Lompoc Vicinity
Santa Barbara County
California

Photographer: Martin Stupich, 2008
See photograph key map on this page.

CA-2288-D-1	EXTERIOR, COSMODYNE SHELTER SOUTHWEST CORNER AND FALLEN WEST WALL, VIEW SOUTHEAST TO NORTHWEST
CA-2288-D-2	INTERIOR, CRYOGENIC CONVERTER UNIT INSIDE COSMODYNE SHELTER, VIEW WEST TO EAST



Photograph Key

HISTORIC AMERICAN ENGINEERING RECORD
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HAER No. CA-2288-D-1

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HAER No. CA-2288-D-2

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HISTORIC AMERICAN ENGINEERING RECORD

VANDENBERG AIR FORCE BASE, SPACE LAUNCH COMPLEX 5
LAUNCH CONTROL BUILDING (FACILITY 589)
HAER No. CA-2288-E

Location:	Vandenberg Air Force Base Space Launch Complex 5 Avery and Delphy Roads Lompoc Vicinity Santa Barbara County California U.S. Geological Survey (USGS) Santa Maria Quadrangle, Universal Transverse Mercator Coordinates: 10/34.60940/120.62826
Date of Construction:	1962
Engineer:	Kaiser Engineers, Oakland, California (original construction); Quinton Engineers Limited, Los Angeles, California (1963-64 addition)
Present Owner:	U.S. Air Force (USAF)
Present Use:	Deactivated, Demolished
Significance:	SLC-5 is significant for supporting important Cold War missions, specifically those associated with the Scout missile between 1962 and 1994. Scout missions have studied aerosol contamination, helped scientists map planet's magnetic and thermal fields, discovered new X-ray sources in space, studied quasars and black holes, helped prove Einstein's gravitational and relativity theories, tested different materials to determine their tolerance to reentry heat, and studied how to protect spacecraft from micrometeoroids. Additionally, NASA relied on Scout missions to focus on specific problems pertaining to the manned space programs.
Report Prepared By:	Julie L. Webster, RA, Dr. Susan I. Enscore, and Mr. Martin Stupich U.S. Army Engineer Research and Development Center (ERDC) Construction Engineering Research Laboratory (CERL) P.O. Box 9005 Champaign, IL 61826-9005
Date	September 2010

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VANDENBERG AIR FORCE BASE, SPACE LAUNCH COMPLEX 5, LAUNCH CONTROL BUILDING (FACILITY 589) HAER No. CA-2288-E
Avery and Delphy Roads
Lompoc Vicinity
Santa Barbara County
California

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Oakland, CA 94607

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LAUNCH CONTROL BUILDING (FACILITY 589)

Original building configuration

Facility 589, the launch control building or blockhouse, was part of the original 1962 SLC-5 construction. It served two primary purposes: (1) the location from which launch proceedings were controlled and monitored, and (2) the structure in which engineers, technicians, and other launch personnel were protected during launches. The one-story 2,309-square-foot building was located approximately 1,200' from the Scout launch pad. The structure was partially embedded in the sloped shoreline for protection against launch blast effects. The control building and its east wall (which extended beyond the limits of the building) acted as a retaining wall for the adjacent Probe launch pad. An exterior stairway along the north retaining wall provided access between the control building and launch pad. The building floor plan was originally ell-shaped, with a small ell projection at the southeast corner. Prior to construction completion the design was amended, and the ell was subsumed by a Scout control room addition that made the floor plan rectangular in shape.[1]

The control building structure was made up of ten-inch-thick reinforced concrete walls, a slightly thicker reinforced concrete roof, some minor concrete block walls, and an electrical grounding system throughout. The original plan had two access points, a single door each on the north and south sides of the building. The primary access was through an oversized blast door on the north elevation. Above the blast door was a 2'-6" x 5'-0" hinged air intake for building ventilation. Next to this opening was a second similar intake at the mechanical room exterior wall. These vents featured manual dampers and were protected by projecting blast covers to keep debris out of the building during topside launches. Infrequent small wall openings were located about the building exterior for additional venting.[2]

The original ell-shaped interior was divided into the following nine spaces:[3]

---

[1] Nowlan, et al., *Cold War Properties Evaluation - Phase I: Inventory and Evaluation*, 162; LTV Missiles and Electronics Group, *NAS1-18550 Volume II*, 2-46; “Drawing No. 589-E-1”; “Drawing No. 589-S-1.”

[2] Architectural/Engineering drawing set “Drawing No. 589-S-1,” “Drawing No. 589-E-1,” “Drawing No. 589-M-1.”

[3] Architectural/Engineering drawing set “Drawing No. 589-E-4,” “Drawing No. 589-A-4.”

- Room No. 1 (in the northeast corner) was the mechanical room which provided space for the air compressor and air handling fan.
- Room No. 2 (south of Room No. 1) was the launch distribution room which housed racks of technical equipment circuitry, junction boxes, and cable trays.
- Room No. 3 (south of launch distribution room) was the cable termination center. This space received the communications half of the exterior cable trench and housed the test communications mainframe, fire alarm, public address (PA) system, and telephone cabinets. Running along the east wall of Rooms 1, 2, and 3 was a compressed air line serving the launch pad.
- Room No. 4 (the southeast corner ell) was the power distribution room. This space received the power half of the exterior cable trench and contained the power panels, alternating current-to-direct current rectifier, battery, battery charger, and automatic transfer switch in case of power outages. Originally the space featured a large battery exhaust hood over the battery; this was subsequently removed.
- Room No. 5 was a central hall. This long, wide passageway ran from the north access door to the south access door for quick egress.
- Rooms 6 and 7 (the west side of the building) were Probe launch control rooms, separated only by an accordion wall partition. The rooms contained control consoles, TV monitors, and a system of floor trenches for communications cables, air supply, and power wiring. Light fixtures in the spaces were on dimmer switches to aid in the viewing of control console monitors.
- Room No. 8 (in the northwest corner) was the toilet room. This room included a lavatory, urinal, and two toilet stalls. In the hall outside the toilet room was a drinking fountain.
- Room No. 9 (inside the toilet room) was the janitor closet which featured the utility basin and water heater for the building.

The original interior as modified for the Scout program included the above spaces plus the Scout launch control room (Room No. 10) in the southwest corner (Figure 1). The addition added twenty-four feet to the west elevation and ten feet to the east elevation. The space housed range communications equipment for Scout launches and extended the existing network of floor trenches to service the additional equipment. In addition to the floor trenches, the interior featured a system of cable trays nine feet above the floor that carried communications conduit through multiple spaces.[4]

Various exterior features provided testing, safety, utility, and communications capabilities for the facility. Exterior wall-mounted lighting and power receptacles in a weatherproof terminal cabinet were located on the west elevation. The latter was used in the instrumentation van area west of the blockhouse.[5] A removable chain guard rail threaded through steel posts was mounted atop the building at the roof perimeter for personnel safety. Also on the rooftop, the northwest and southeast corners were equipped with light poles for nighttime operations. The sanitary sewer line exited the toilet room on the north side of the building. It ran north to the septic tank buried beyond the parking lot, turned northwest, and ran 417 feet to its remote distribution box and drain field. Two cable trenches with steel cover plates (one for Probe controls and one for Scout controls) exited the building on the south side. The forty-five-degree Scout trench joined the Probe trench at a distance from the building.[6]

In the original site configuration and at a distance from the control building (northwest of Road B) was a meteorology tower. Its purpose was to monitor launch-related atmospheric conditions, but as discussed previously, the tower was removed. Northwest of the control building, an eighty-foot-long, underpass-type personnel shelter was constructed in an embankment of natural material. The likely intent of the shelter was to protect personnel in the event of onsite emergencies, should they not have time to reach the blockhouse. Its orientation and location provides quick access and protection by the terrain. The structure of the shelter was 10-gauge corrugated metal piping that measured 5'-10" wide and 7'-8" high. Benches made up of two-by-

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[4] Architectural/Engineering drawing set “Drawing No. 589-S-1,” “Drawing No. 589-E-3,” “Drawing No. 589-E-2.”

[5] The Motion Picture Instrumentation Branch developed and constructed instrumentation vans that were outfitted with cameras and towed to the launch sites. Once on site, they were leveled on jacks and plugged into power and timing circuits (Arthur Menken, *History of the Pacific Missile Range*, 194).

[6] Architectural/Engineering drawing set “Drawing No. 582-E-1,” “Drawing No. 589-A-4,” “Drawing No. 589-A-2,” “Drawing No. 589-C-1,” “Drawing No. 589-E-2.”

four wooden framing members ran down both sides of the shelter length leaving a 2'-6"-wide aisle.[7]

A short distance west of the control building was a cluster of utility amenities. Among them were the diesel generator building (Building 590) and a servicing fuel tank. The building was a small, shed-roofed structure clad in corrugated metal. An oval fuel tank once sat outside the building on an anchor block, but both were removed from the site. The electrical transformer for the control building was located just north of the diesel generator building in a chain link enclosure. Like the generator fuel tank and anchor block, the chain link enclosure was later removed. Steel plate-covered communications and power manholes, measuring 216 cubic feet and 64 cubic feet respectively, were positioned north of the transformer enclosure. Concrete encased fiber ducts from these manholes ran under the parking lot to the control building. Communications ducts for the Scout control room were added prior to construction completion. These ducts ran diagonally southeast and joined the covered trench leading to the Scout launch pad.[8]

Modifications to the control building

In December 1963, an addition measuring 20'-0" x 63'-0" was completed on the west side of the launch control building, in conjunction with the expansion of the operations support building. Improvements to the building included the addition of a NASA work area (Room No. 11) and Pacific Missile Range (PMR) work area (Room No. 12) on the west elevation. The new spaces were accessible through a new west entryway that featured a three-riser stoop with removable handrails and a steel blast door. Adjacent to the door to the north was a knockout panel for electrical provisions. On the interior, both spaces included a grid of twelve- to eighteen-inch-deep floor trenches that connected to existing floor trenching. A folding partition was used to separate the two contiguous work areas (Figure 2).[9]

Other 1963 improvements included the addition of a central heating, ventilating, and air conditioning (HVAC) system and its associated ductwork. Not only did the system provide heating and cooling for the building interior, but also it reduced humidity for optimal performance of technical equipment. Manually operated vent dampers throughout the building

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[7] Architectural/Engineering drawing set “Drawing No. 589-C-1,” “Drawing No. 589-C-2.”

[8] Architectural/Engineering drawing set “Drawing No. 589-C-1,” “Drawing No. 589-E-2.”

[9] Architectural/Engineering drawing set “Drawing No. 589-A-4.”

were made automatic to function in tandem with the central HVAC system. Existing unit heaters were relocated from the control building to the operations support building.[10]

The 1963 modifications also involved shortening the central hall to gain space for restructuring the launch control rooms. Existing hall walls were removed, and new walls were built to form the new shorter hall and larger control rooms. Two steel columns (one wide-flange and one circular-pipe type) were added to support a new, oversized, wide-flange steel beam that spanned the new launch control area (Figure 3). A footing was laid beneath the new column-beam structure to support the redistributed load. Nearby, the wall separating the launch distribution center (Room No. 2) from the cable termination center (Room No. 3) was removed to create a single room. Minor interior alterations included the relocation of the accordion doors that once separated control rooms Nos. 6 and 7. The doors were moved north a short distance to skirt the new launch console setup. New carbon dioxide (CO_2) cylinders, hoses, and reels were also installed throughout the building for fire suppression. Finishes to new spaces complemented the existing interior. These included asphalt tile flooring in non-utility spaces and acoustical tiles on the ceilings and upper walls of spaces containing launch control technical equipment.[11]

Exterior modifications associated with the 1963 modifications included the relocation of electrical fixtures (e.g., lighting and receptacles) from the existing west facade to the new west facade and extension of the servicing conduit. Similarly, the westernmost television camera station and its power transformer were relocated to the west edge of the new roof. Also on the roof, additional post-and-chain guard railing was added to the existing railing to extend it around the larger roof perimeter. At grade, a new concrete slab was poured at the northwest corner to support the new air conditioner condenser.[12]

Shortly after construction completion in 1962, a seventy-foot-long splinter shield was added to the launch control building west elevation to protect it from blast debris. The steel-framed shield was topped with a protective steel plate and supported on steel pipe columns with intermittent cross-bracing. The entire shield was removed to accommodate the 1963 west addition. Upon

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[10] Architectural/Engineering drawing set “Drawing No. 589-M-2,” “Drawing No. 589-E-1.”

[11] Architectural/Engineering drawing set “Drawing No. 589-A-4.”

[12] Architectural/Engineering drawing set “Drawing No. 582-E-1,” “Drawing No. 589-A-4,” “Drawing No. 589-M-2.”

completion of the addition, four of the seven splinter shield structural bays were reattached to the new west elevation. The shield deflected blast debris for a limited number of launches, but it primarily acted as a building canopy for the instrumentation vans.[13]

After 1963, only minor alterations were made to Facility 589. The earliest project during the period was the parking lot expansion in 1964. The north edge was extended thirty-eight feet and the west edge was extended sixty-five feet.[14] Prior to the 1971 launch pad modifications (see below), a corrugated metal vestibule was added at the south entry door.[15] An antenna was added to the southwest corner of the control building some time prior to 1990.[16] Shortly thereafter, in 1990, the HVAC system was upgraded again.[17] Room No. 6 was augmented at some point in time with a raised platform and back railing, a row of consoles, and observation windows to Room No. 10. Over the years, room functions changed to meet launch program requirements. When the control building was vacated in 1994, the interior spaces were designated as follows (Figure 4):

- Room No. 1, air conditioning room (same as original)
- Room No. 2 and Room No. 3, communications room
- Room No. 4, power distribution room (same as original)
- Room No. 5, hall (same as original)
- Room No. 6, monitor console room
- Room No. 7, range sequence room
- Room No. 8, toilet room (same as original)
- Room No. 9, janitor closet (same as original)
- Room No. 10, launch control room (same as original)
- Room No. 11, microwave (M/WAVE) equipment room
- Room No. 12, briefing room

[13] Architectural/Engineering drawing set “Drawing No. 589-S-3.”

[14] Architectural/Engineering drawing set “Drawing No. 589-C-1.”

[15] Architectural/Engineering drawing set “Drawing No. SK 10490.”

[16] Architectural/Engineering drawing set “Drawing No. 589-A-2.”

[17] Architectural/Engineering drawing set “Drawing No. 589-M-3 through -7.”

Original Probe launch pad configuration

The irregularly shaped Probe launch pad was located just east and above the launch control building at an elevation of 292 feet. Its north, south, and east limits extended to the pavement edges; the west pad boundary was demarcated by a four-inch-high curb at the launch control building roof edge. The pad measured 100'-0" at its longest dimension along the east side. Its surface was scored by a series of double and triple steel launch rails. A turret-type gun mount launcher rested on the octagonal base positioned over an electrical and communications pull box pit. The pull box pit was located north of the pad center point, between two sets of triple rails. Concrete deadmen were positioned at forty-five-degree angles at the launch pad corners to provide anchorage points during missile emplacement.[18]

Perpendicular to the pad’s longest dimension, a dual communications/power trench bisected the pad at its centerline (Figure 5). It ran from the control building east wall to two offset cable vaults twenty-nine feet away. The vaults contained junction boxes that distributed power to four 2'-6" x 4'-0" x 3'-8" galvanized metal, cable stowage boxes for the pad’s 1'-6" x 2'-0" TV camera stands.[19] The north, south, and east stowage boxes were located at the pad perimeter, and their corresponding TV camera stands stood directly behind the stowage boxes a short distance away. Buried duct banks ran between the boxes and their cameras, and duct access was provided via in-ground handholes. The west stowage box and camera stand were collocated at the west edge of the launch control building.[20]

In addition to powering the TV cameras, the offset cable vaults serviced the fire alarm call box mounted to a pedestal near the northernmost camera station. Additional safety provisions were provided by the water distribution lines that ran along the north side of the launch pad. The lines included a drain valve to bleed water from the line, a standpipe for fire suppression, and a valve pit to regulate water flow.[21]

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[18] Architectural/Engineering drawing set “Drawing No. 589-C-1,” “Drawing No. 589-A-2,” “Drawing No. 580-E-11,” “Drawing No. SK 10490.”

[19] The TV camera stands varied in height to accommodate the terrain.

[20] Architectural/Engineering drawing set “Drawing No. 589-E-1,” “Drawing No. 589-E-2,” “Drawing No. 580-E-4.”

[21] Architectural/Engineering drawing set “Drawing No. 589-E-1,” “Drawing No. 589-C-1.”

Modifications to the Probe launch pad configuration

In 1971, the Probe launch pad was modified for the launch of sounding rockets. Blast protection was provided for various features within a 435-foot radius of the pad center point. This protection included construction of a blast deflector for a portion of the above-grade cableway within the specified blast radius, sand bagging of the control building roof hatches and air vents, and sand bagging of manholes and underground cable trenching from the control building to the blast deflector. Other pad-related upgrades included new post-and-chain guard rails atop the control building, a curb-like concrete dike to contain water and direct it to a runoff ditch at the northeast corner of the pad (Figure 6), two replacement light poles near the existing north and south TV camera station junction boxes, a new semi-circular launch rail laid over the original double and triple rails, and some areas of ablation protection inside the edges of the new semi-circular rail.[22] Seven-foot-high security fencing was added to the Probe facility shortly thereafter to secure the launch control building, Probe launch pad, and operationally important site features. The fencing featured chain link fabric and a 12-inch top rail barbed wire arm.[23] Prior to 1990, the westernmost TV camera cable stowage box was removed from the control building rooftop. Its servicing transformer was removed in 1990 when the roof was resurfaced with a synthetic rubber membrane.[24]

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[22] Architectural/Engineering drawing set "Drawing No. SK 10490."

[23] Architectural/Engineering drawing set "Drawing No. 589-C-3."

[24] Architectural/Engineering drawing set "Drawing No. 589-A-2."

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ACRONYMS AND ABBREVIATIONS

Term	**Spellout**
CERL	Construction Engineering Research Laboratory
CO_2	carbon dioxide
ERDC	Engineer Research and Development Center
EAR	Export Administration Regulations
HAER	Historic American Engineering Record
HVAC	heating, ventilating, and air conditioning
ITAR	International Traffic in Arms Regulation
LTV	corporation formerly known as Ling-Temco-Vought
M/WAVE	microwave
NASA	National Aeronautics and Space Administration
PMR	Pacific Missile Range
PA	public address
SLC-5	Space Launch Complex 5
TV	television
USGS	United States Geological Survey
USAF	United States Air Force
VAFB	Vandenberg Air Force Base

HISTORIC DRAWINGS

The technical drawings used for research in this study are not available for inclusion in this document, because of the following determination:

> These drawings HAVE NOT been characterized as being released to the public domain and MAY contain EXPORT-CONTROLLED TECHNICAL DATA. Export-Controlled Technical Data is data that cannot be lawfully exported without the approval, authorization, or license under U.S. export control laws. The controlling regulations and documents are the Export Administration Regulations (EAR), the International Traffic in Arms Regulation (ITAR), and the U.S. munitions list.

Due to this stipulation, it is not possible to reproduce in this document the drawings used to gather information about the design, construction, and use of facilities at Scout Launch Complex 5, VAFB, California.

FIGURES FROM DATA SECTION

Figure 1. The original Scout control room, VAFB Facility #589, circa 1962 (Official NASA-USAF Photograph).

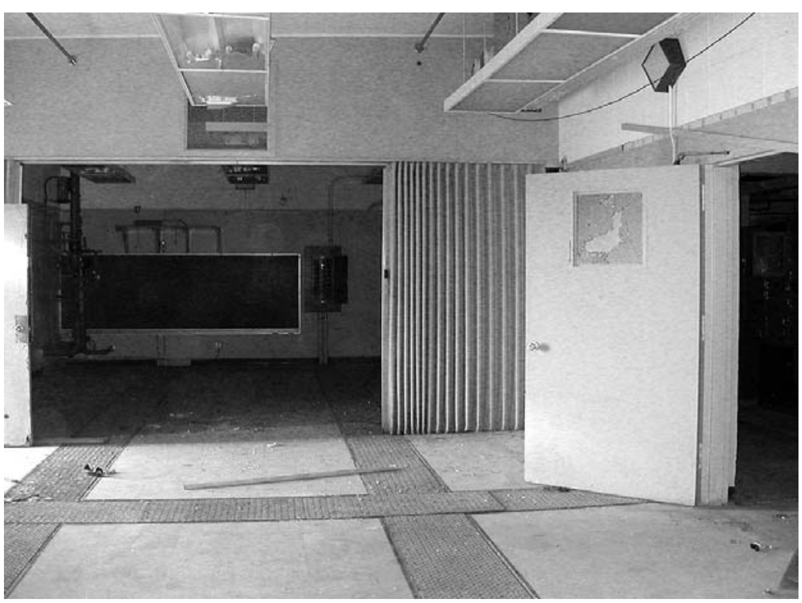

Figure 2. Blockhouse addition Rooms 11 and 12, VAFB Facility #589, 2008 (ERDC-CERL).

Figure 3. View of blockhouse control room showing new column-beam structure in background, VAFB Facility #589, circa 1994 (Official NASA-USAF Photograph).

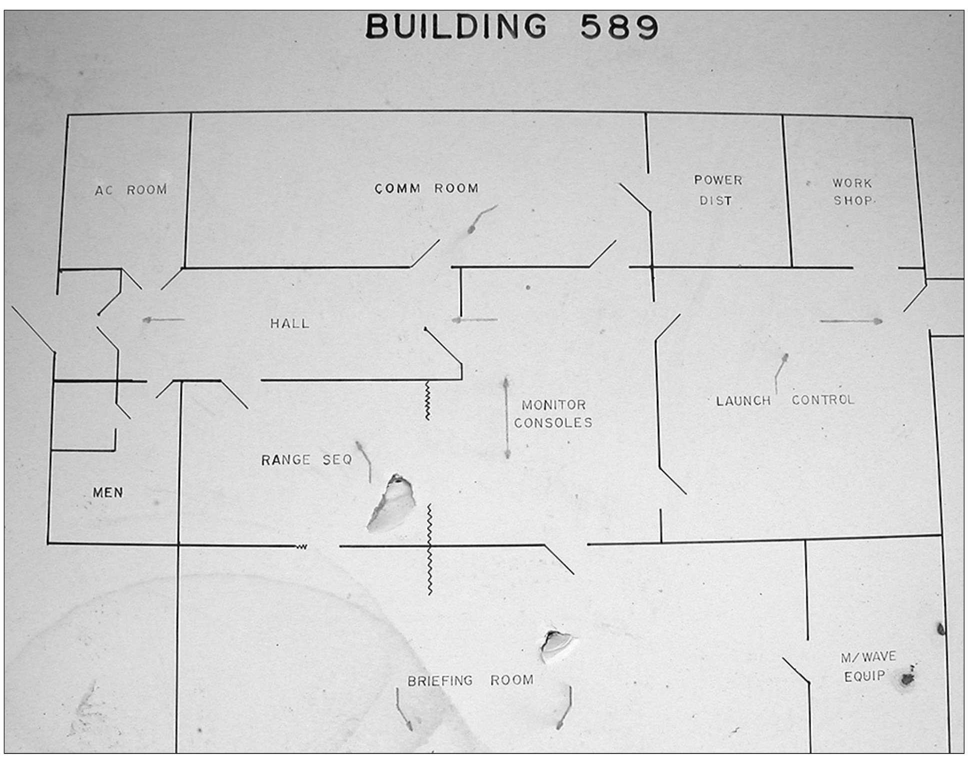

Figure 4. Blockhouse fire evacuation plan showing 1994 configuration, 2008 (ERDC-CERL).

Figure 5. Dual communications/power trench (center) and offset cable vaults (upper left) that distributed power to the pad's TV camera stations, 2008 (ERDC-CERL).

Figure 6. Concrete dike around Probe launch pad, 2008 (ERDC-CERL).

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HISTORIC AMERICAN ENGINEERING RECORD

INDEX TO PHOTOGRAPHS

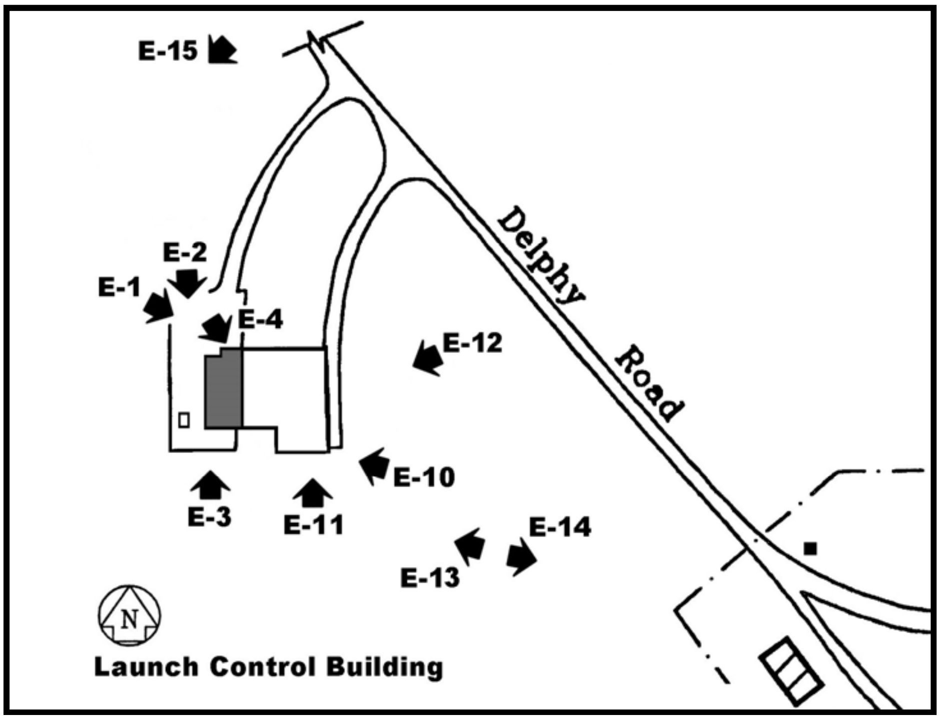
VANDENBERG AIR FORCE BASE, SPACE LAUNCH COMPLEX 5, LAUNCH CONTROL BUILDING (FACILITY No. 589) — HAER No. CA-2288-E

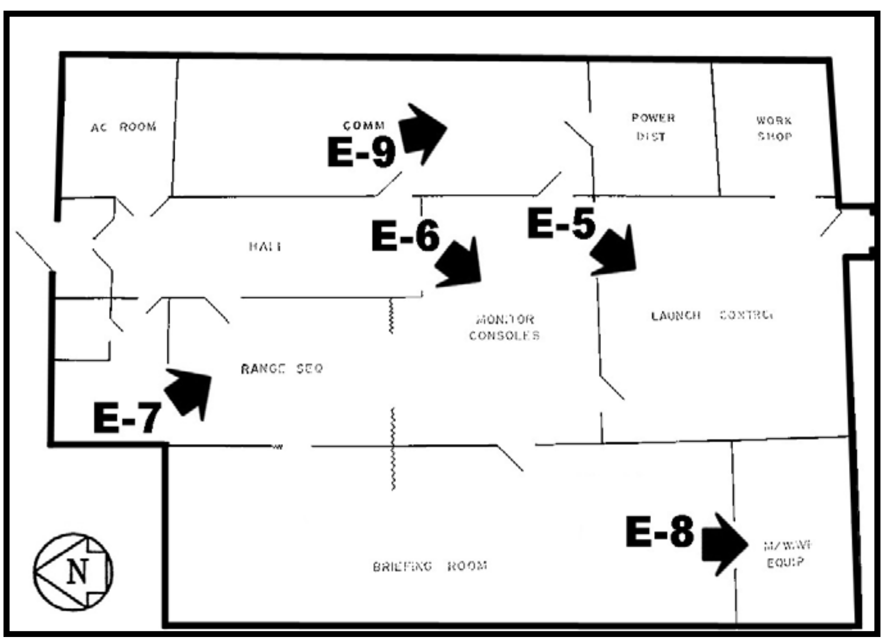
Avery and Delphy Roads
Lompoc Vicinity
Santa Barbara County
California

Photographer: Martin Stupich, 2008
See photo keys on page 3 of index to photographs.

CA-2288-E-1	EXTERIOR VIEW, LAUNCH CONTROL BUILDING, VIEW NORTHWEST TO SOUTHEAST
CA-2288-E-2	EXTERIOR VIEW, LAUNCH CONTROL BUILDING NORTH ELEVATION, VIEW NORTH TO SOUTH
CA-2288-E-3	EXTERIOR VIEW, LAUNCH CONTROL BUILDING SOUTH ELEVATION, VIEW SOUTH TO NORTH
CA-2288-E-4	EXTERIOR VIEW, LAUNCH CONTROL BUILDING BLAST DOOR AND HINGED AIR INTAKE, VIEW NORTHWEST TO SOUTHEAST
CA-2288-E-5	INTERIOR VIEW, LAUNCH CONTROL BUILDING LAUNCH CONTROL ROOM, VIEW NORTHEAST TO SOUTHWEST
CA-2288-E-6	INTERIOR VIEW, LAUNCH CONTROL BUILDING MONITOR CONSOLE ROOM, VIEW NORTHEAST TO SOUTHWEST
CA-2288-E-7	INTERIOR VIEW, LAUNCH CONTROL BUILDING RANGE SEQUENCE ROOM, VIEW NORTHWEST TO SOUTHEAST
CA-2288-E-8	INTERIOR VIEW, LAUNCH CONTROL BUILDING MICROWAVE EQUIPMENT ROOM, VIEW NORTH TO SOUTH
CA-2288-E-9	INTERIOR VIEW, LAUNCH CONTROL BUILDING COMMUNICATIONS ROOM, VIEW NORTHEAST TO SOUTHWEST

CA-2288-E-10	EXTERIOR VIEW, PROBE LAUNCH PAD, VIEW SOUTHEAST TO NORTHWEST
CA-2288-E-11	EXTERIOR VIEW, PROBE LAUNCH PAD, VIEW SOUTH TO NORTH
CA-2288-E-12	EXTERIOR VIEW, PROBE LAUNCH PAD TELEVISION CAMERA STAND, HANDHOLE, AND CABLE STOWAGE BOX, VIEW NORTHEAST TO SOUTHWEST
CA-2288-E-13	EXTERIOR VIEW, COVERED CABLE TRENCH BETWEEN LAUNCH CONTROL BUILDING AND SCOUT LAUNCH PAD, VIEW SOUTHEAST TO NORTHWEST
CA-2288-E-14	EXTERIOR VIEW, COVERED CABLE TRENCH AND ABOVE-GRADE CABLEWAY WITH BLAST PROTECTOR BETWEEN LAUNCH CONTROL BUILDING AND SCOUT LAUNCH PAD, VIEW WEST TO EAST
CA-2288-E-15	EXTERIOR VIEW, UNDERPASS-TYPE PERSONNEL SHELTER, VIEW NORTHEAST TO SOUTHWEST





Photograph Key

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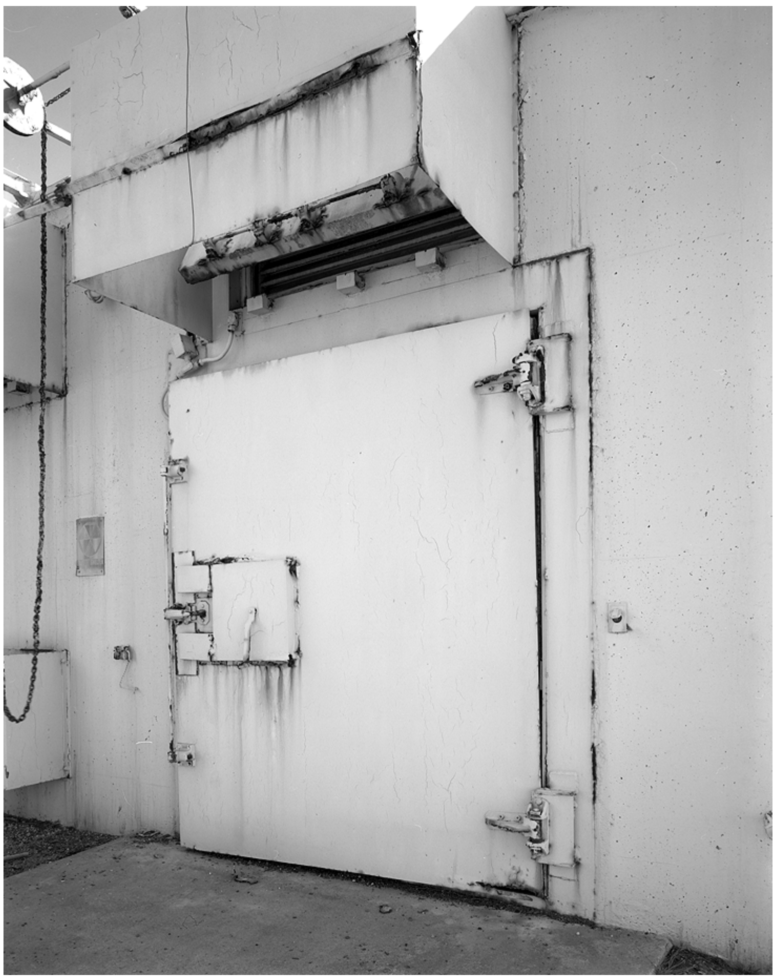

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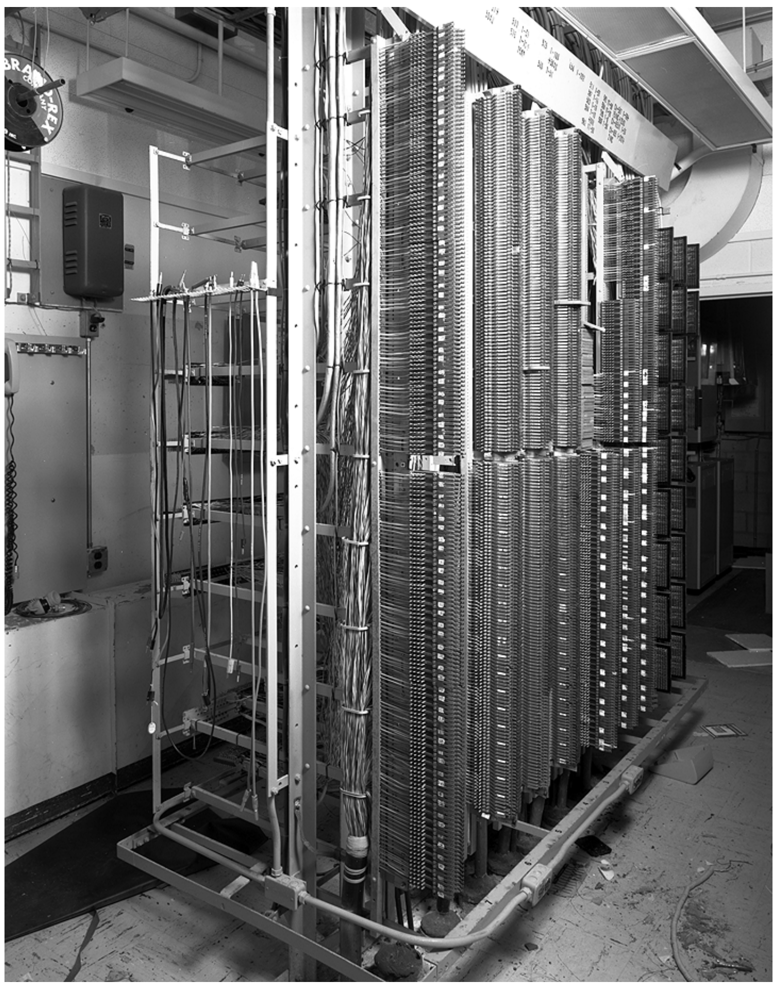

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13. SUPPLEMENTARY NOTES

14. ABSTRACT
This report represents Historic American Engineering Record (HAER) Level II documentation of Space Launch Complex 5 (SLC-5), Vandenberg Air Force Base (VAFB), California. SLC-5 is one of approximately 70 VAFB facilities and complexes that have been determined eligible for listing on the National Register of Historic Places (NRHP). Five buildings at SLC-5 are eligible for the NRHP under "Cold War Criterion A" as a result of their historic role in supporting missions of exceptional importance during the Cold War. These facilities are also eligible under "Cold War Criterion D" as a result of SLC-5's distinctive launch technology that had been relatively unchanged since the early 1960s.

15. SUBJECT TERMS
Space Launch Complex 5 (SLC-5), Vandenberg Air Force Base (VAFB), Historic American Engineering Record (HAER), National Register of Historic Places (NRHP), Cold War, missiles, cultural resources management

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