DAYS OF CHALLENGE & YEARS OF CHANGE

A TECHNICAL HISTORY OF THE PACIFIC MISSILE TEST CENTER

Approved for public release;
distribution is unlimited.

Dr. R. J. Warnagieris
Executive Director
Pacific Missile Test Center
Point Mugu, California
22 August 1989

ALS. 3. b. iii
787

DAYS OF CHALLENGE YEARS OF CHANGE

A TECHNICAL HISTORY OF THE PACIFIC MISSILE TEST CENTER

FOR SALE
BY THE SUPERINTENDENT OF DOCUMENTS, U.S. GOVERNMENT PRINTING OFFICE, WASHINGTON, D.C. 20402

ACKNOWLEDGEMENTS

In alphabetical order, the principal members of the Editorial Committee for this publication during developmental stages were Myron A. Bondelid, Ph.D.; Stanley Morganstein, Ph.D.; Stanley Opatowsky; and Elizabeth Rodriquez, Ph.D. During final review stages, the members were W. R. Hattabaugh; James R. Jensen; Willie D. Luttrell; R. J. Warnagieris, Ph.D.; Paul D. Wilson; and G. M. Wrout. The Editorial Committee and the authors would like to express their appreciation to Mr. Thad Perry (Technical Director, 1976-1982), who initiated the publication; to Mr. Kenneth Lichti (Technical Director, 1982-1985), who prosecuted the project; to Mr. W. R. Hattabaugh (Technical Director, 1985-1989), who saw it through to completion; to Dr. R. J. Warnagieris (Executive Director, 1989-present), who effected its publication; and to all the others - contributors, reviewers, and photographers - who helped to make this achievement possible.

CONTRIBUTORS

Edward Angle
C. C Andrews
Fred Ballinger
Sorrell Berman, Ph.D.
Myron A. Bondelid, Ph.D.
Jerome M. Cain
CDR Douglas W. Call, Ph.D.
Kenneth H. Coffman
Hugh Crawford
LeRoy E. Day
Robert De Violini
Burnie Dunlap
ADM Delmar S. Fahrney, Ret.
Paul J. Foster
C. G. Gerlick
Edwin M. Good
Jack Hironymous
Lloyd A. Hynds
Glenn E. Jackson
Virgil J. Ketner
Ted Kinghorn
Wesley R. Lambert
Duane A. Lea
Leslie H. Maland
Milton Marson
Jack D. Martin
James A. Means, Ph.D.
Eric Meleen
Frank Miley
W. L. (Mike) Miller
Grant E. Mills
George A. Nussear
Stanley N. Opatowsky
James R. Ordner
Victor E. Orris
James M. Perkins
Thad Perry
Robert P. Polley
Donald E. Power
R. Sam Razick
Lloyd O. Ritland
Ralph J. Roanhaus
Elizabeth Rodriquez, Ph.D.
Norman F. Rohn
Rhinnie R. Rohrback
Jay R. Scott
Jerome P. Seckel
Carroll Shullenberger
James Simpson
Arthur E. Smith
Lee V. Sorden
Charles F. Stanley
Francis H. Steptoe
H. William Stones
Donald F. Sullivan
Kenneth L. Thornton
George B. Timko
George J. Vandiver
Clifford A. Vige'
Royal Weller, Ph.D.
Maxwell White
Joe C. Wilson
Paul D. Wilson
Charles L. Zehmer

DEDICATION

To the thousands of military and civilian personnel who contributed their time, talents, and energy in making the Pacific Missile Test Center a "Center of Excellence."

EDITORIAL REVIEWERS

Sorrell Berman, Ph.D.
Myron A. Bondelid, Ph.D.
Hugh Crawford
John F. Donlan
RADM R. C. Gentz

W. R. Hattabaugh
Jack Hironymous
James R. Jensen
W. L. (Mike) Miller
R. S. Nelson

Stanley N. Opatowsky
Thad Perry
Ralph Petersen
Elizabeth Rodriquez, Ph.D.
Norman F. Rohn

Frank D. Roth
CAPT R. C. Schroeder
Jay R. Scott
Leon J. Szot
Robert J. Warnagieris, Ph.D.

PHOTOGRAPHIC CONTRIBUTORS AND REVIEWERS

Gilbert Acuna
Myron A. Bondelid, Ph.D.
Leon Bryant
Jerome M. Cain
Hugh Crawford

John Donlan
Gerald Googins
Arne J. Herleikson
James Jensen
Dean Mensa, Ph.D.

R. S. Nelson
Stanley N. Opatowsky
Celso Ovalle
Robert P. Polley
Robert B. Scott

Jerome Seckel
Richard Smith
Avice (Johnnie) Tomaszewski
Gerald Wrout
Daniel Zoll

PUBLICATIONS STAFF

Media Director .... Donald J. Fay
Book Design .... Willie O. Davis and Harry Lee

Writers and Editors .... Carl Kling, Lee Larew and Tom Winans
Production Staff .... Visual Communications Branch

TABLE OF CONTENTS

PATENTS AND TECHNICAL PAPERS

The success of the Pacific Missile Test Center (PMTC) is evidenced by its product: high-tech weaponry of the highest quality and reliability. Not so obvious is another entire area of individual and group accomplishment, an area deserving of more than just a casual mention in the pages of this technical history. Over the years the Center's scientists and engineers have made important contributions in the form of original and significant scientific papers, technical reports, and patented inventions. Because the list is so voluminous, it does not lend itself to reproduction in this text. The list, containing hundreds of such documents and patents, stands as further evidence of the momentous efforts of those who have dedicated their careers to making PMTC truly a "Center of Excellence."

October 1, 1946

August 1, 1949

June 16, 1958

January 7, 1959

April 26, 1975

Pacific Missile Test Center, Point Mugu, California, today.

PREFACE

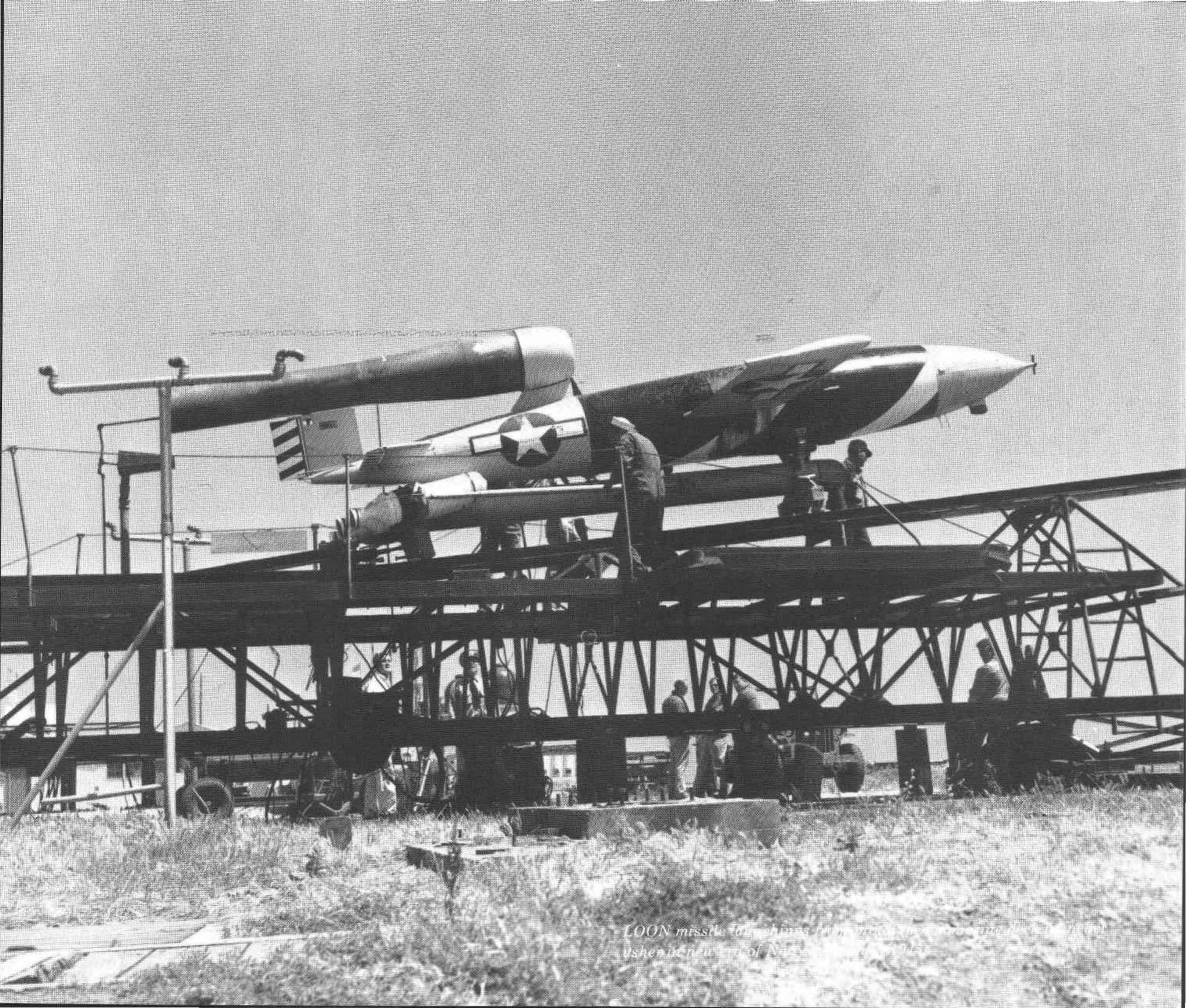
The work performed at the Pacific Missile Test Center (PMTC) has expanded through the years due both to the increasing sophistication of weapon systems and the need for even more rigorous testing. In the beginning, the problems were relatively simple and could be approached by applying general engineering principles. Now the tasks have grown so complex they require the integrated efforts of highly trained specialists in all fields of engineering, plus computer science, mathematics, physiology, psychology, microelectronics, instrumentation, and management.

In addition, testing methods have developed not only to match greater weapon complexity, but as a result of a compelling need to guarantee the effectiveness of the weapon through obtaining vast amounts of data for evaluation. Frequently, much of this data must be obtained without the destruction of a valuable weapon. Naturally, the ultimate test still remains the launch of a missile against a realistically simulated threat, but before the test by firing, everything possible must be done to ensure that the launch will answer the right questions at the right time.

Even as PMTC enters the 1980's, there is an overriding awareness that all the experience accumulated through the past three and one-half decades will be necessary to help ensure the reliability and effectiveness of new weapon systems. Also, there is a sure knowledge that present weapons and missiles will require constant improvement and updating so as to meet the potential threats posed by the adversaries of freedom-loving countries.

PMTC from its beginning has stressed the need for a highly trained core of engineers, scientists, and technicians. Furthermore, there has been a continuing emphasis on developing test and evaluation as a distinct engineering discipline. We know that in colleges, universities, and engineering schools today there are men and women preparing themselves in subjects essential to test and evaluation. To those interested in our particular field of endeavor we suggest investigating a career at Point Mugu. The following pages will give you a glimpse into what we have accomplished. We invite you to share through this history a portion of our past and hope that you may also choose to be a part of our future—a future full of promise and opportunity.

The Pacific Missile Test Center
Scientific Advisory Board



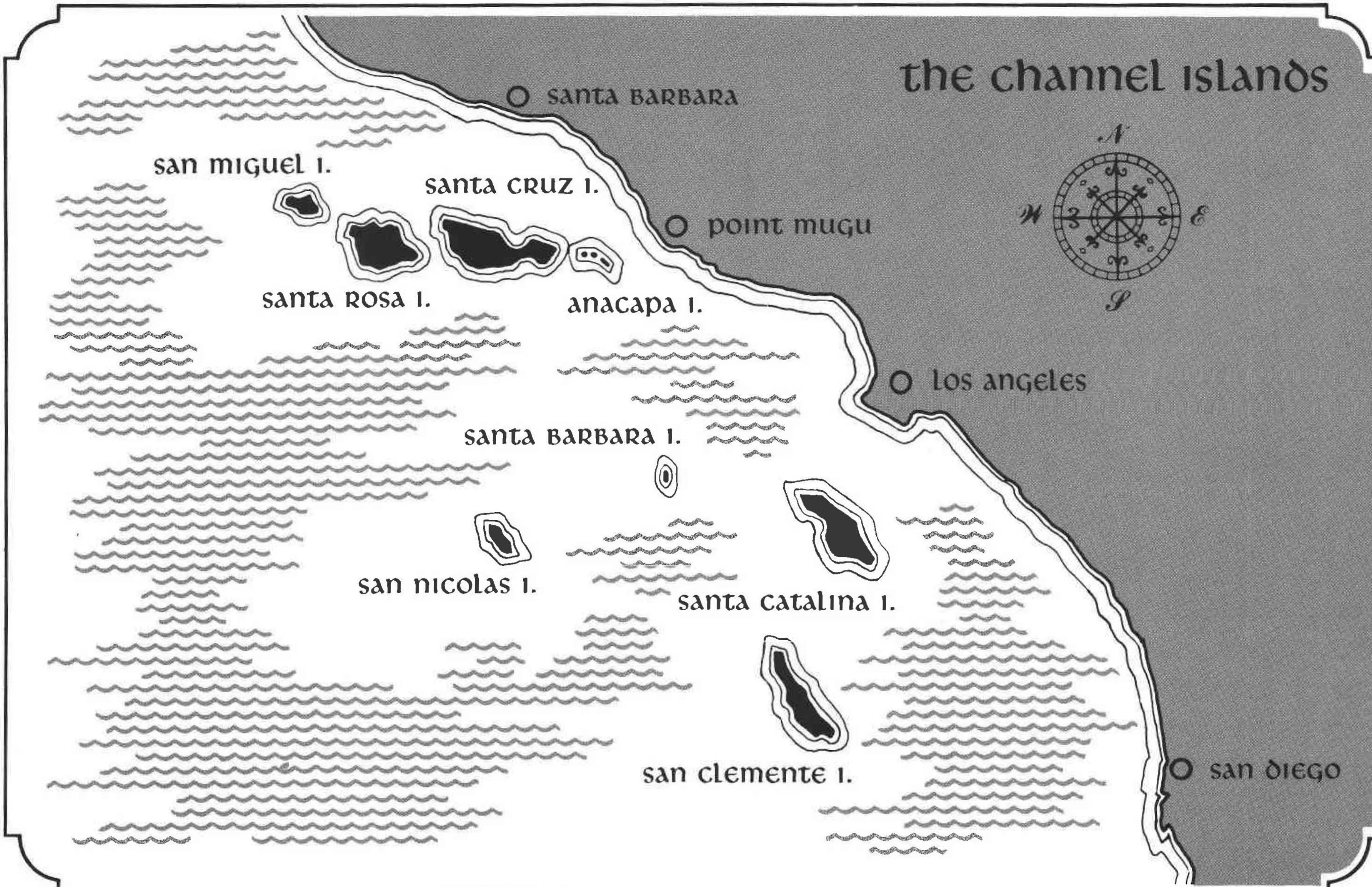
LOON missile [illegible] of N[illegible]

INTRODUCTION

Johann von Goethe once wrote, "The history of science is science itself." In a complementary manner it might be stated that the history of an organization is the *organization*; to understand the one, the other one must be understood. With this thought in mind, the following technical history has been prepared. Through it we hope to show the roots of the Pacific Missile Test Center and how our present work is built on a firm foundation of experience. The following pages contain a very generalized view of the test and evaluation effort performed here over the past thirty-five years. There are some programs which may have been inadvertently omitted and others that have been drastically abbreviated, but it is still hoped that this account will give an insight into the Pacific Missile Test Center's mission. Although over the years the names of the organizations at Point Mugu have changed, their objective has remained constant—to ensure that the missiles and weapons reaching the Fleet are effective and remain effective.

Underlying the preparation of "Days of Challenge, Years of Change" is the intent to show the scientific community, Department of Defense, Congress, and other government agencies the historical role of test and evaluation in weapon system procurement. In addition, the history will provide *industry* with a view of the part test and evaluation plays in the development process, *prospective employees* with a record of past achievements and present challenges, *present employees* with an insight into their technological heritage, *managers* with assistance in justifying expenditures for test and evaluation, the *public* with an orientation toward the work performed at Point Mugu, and the *test and evaluation community* with a means for improving present techniques and methodologies through a comprehensive review of past successes and failures.

The information contained in this book has been drawn from written technical reports, audiovisual reports, command histories, and oral interviews. Every effort has been made to substantiate the facts as they appear; however, for ease of reading, no attempt has been made to footnote the references. Instead, a listing of sources by chapters appears at the end of the volume.



The Channel Islands consist of a chain of eight major islands scattered over an area of about five thousand square miles and extending 160 miles along the Southern California Coast from northwest to southeast. Early inhabitants of these islands were Chumash Indians, who navigated the local waters in dugout canoes. The Spanish explorer Sebastian Vizcaino is generally credited with the discovery of San Nicolas Island in 1602. However, some historians credit Juan Rodriquez Cabrillo with the discovery in 1542.

PROLOGUE

The history of Point Mugu begins with the land. Over 180 million years ago the future site of the Pacific Missile Test Center was slowly forming deep beneath the sea. Volcanic eruptions occasionally disrupted the marine deposition, but through the Jurassic, Cretaceous, and into the Tertiary period the process continued until between 56 and 36 million years in the past the waters grew shallower, allowing a non-marine flood plain to form. But in geologic time solid ground was only a passing phase. Approximately 11 million years later the sea once more invaded the dry land of this area, submerging it to 15,000 feet. Again volcanoes were active and the coastline did not begin to once more emerge until the recent geologic past—one million years ago.

Geographically, Point Mugu lies on the Oxnard Plain between the extreme southern tip of the Santa Clara River mouth and the coastal termination of the Santa Monica Mountains. The area's most distinguishing feature is the 1,477-foot Laguna Peak which is visible from some distance at sea. Along with the sheltered lagoon, it is possibly one reason the Chumash Indians chose the area for a primitive harbor and named it—Mugu—*the landing place.*

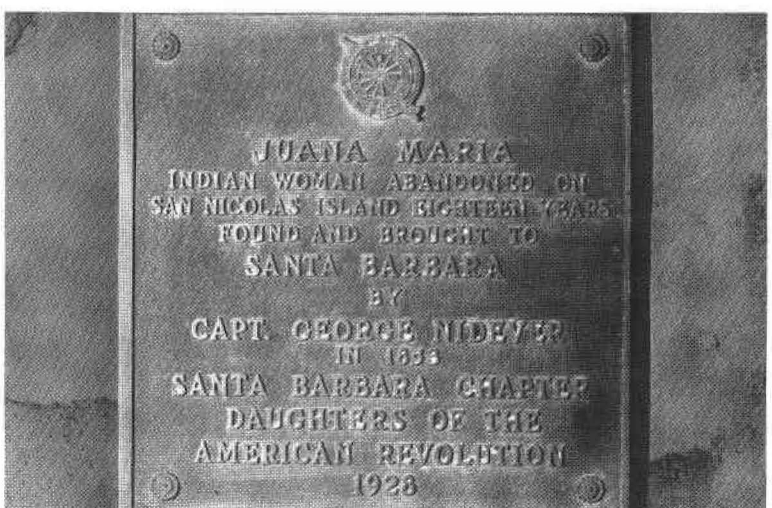
To the west and south of Point Mugu lie the Channel Islands, separated from the mainland by a curving 100-fathom deep submarine valley. Divided into two groups they are the northern or Santa Barbara group—Anacapa, Santa Cruz, Santa Rosa, and San Miguel; and approximately sixty miles south the Santa Catalina group—San Nicolas, Santa Barbara, San Clemente, and Santa Catalina. The Channel Islands are the only visible evidence of what might have been a western-most sierra, their jagged summits rising precipitously from great ocean depths.

From ancient times, Point Mugu, with its abundance of fish, game, and clams, and a protected lagoon, was the site of extensive Indian habitation. Fresh water was also plentiful, with artesian springs to be found as late as the mid-1940's. Numerous Chumash Indian villages dotted the shore, and the natives frequently sailed the Santa Barbara Channel to fish or visit neighboring islands—home of seals, sea lions, and otters. The Chumash Indian canoes, built of handhewn boards and caulked with asphaltum from the nearby hills, were so well-constructed and numerous that the early explorer Juan Cabrillo called the place El Pueblo de las Canaos—Town of the Canoes.

Juan Rodriguez Cabrillo, the first European to visit Point Mugu, was described as a sailor of "great courage and a thorough seaman." During his trip north along the Mexican and California coasts, he needed both these attributes, for his ships, the "San Salvador" and the "Victoria," were poor examples of shipbuilding even for their time. Nevertheless, Cabrillo and his men made it safely to their first landing in California at the site of the present city and harbor of San Diego. Continuing on, they sailed past the southern Channel Islands, and then it is believed they landed at Mugu Lagoon on October 10, 1542.

After staying three days, Cabrillo sailed north to explore the central California coast. Several months later, as the result of an accident, he met an untimely death, and legend has it that he is buried on one of the Channel Islands. His ships then returned to Lower California and little more was seen of the Spanish at Point Mugu until 1768 when King

Carlos II of Spain ordered that colonies—military, religious and civil—be founded in Upper California. A group of 225 men under Don Gaspar de Portola thereupon assembled in October of that same year to proceed north to the area of Monterey. After camping at the present site of Castaic, de Portola followed the Santa Clara River Valley to near the Ventura County line. He then passed to the north of Point Mugu, stopping for the night at a large rancheria or Indian settlement. One member of the party, Padre Crespi, wrote in his diary that he envisioned a mission on this "good site where nothing is lacking." Thirteen years later, Franciscan Padre Junipero Serra established that mission and called it San Buenaventura, after which the present-day city of Ventura is named.



Plaque commemorating "Juana Maria," the last of the Chumash.

Seventy-five years of Spanish and Mexican rule then followed until the tide of American expansion washed against the tiny settlement. In 1848, John Charles Fremont, explorer, soldier, and politician, arrived with a party of 62 men to gain possession of the Ventura mission for the United States.

During the remaining years of the 19th Century, history recorded very little of major interest in the area of Point Mugu; however, one interesting event did occur on San Nicolas Island, now an integral part of the Pacific Missile Test Center.

By 1835, the once numerous Indians inhabiting San Nicolas Island had been reduced to a handful by the attacks of raiding sea otter hunters and white man's diseases; therefore, the Franciscan fathers decided to remove the remnant to the mainland. During the embarkation, an Indian woman, suddenly realizing her child was missing, leaped into the water and swam back to the island. Threatening weather forced the ship to depart without her. The captain intended to return, but other commitments delayed the rescue and a month later his ship was lost at sea.

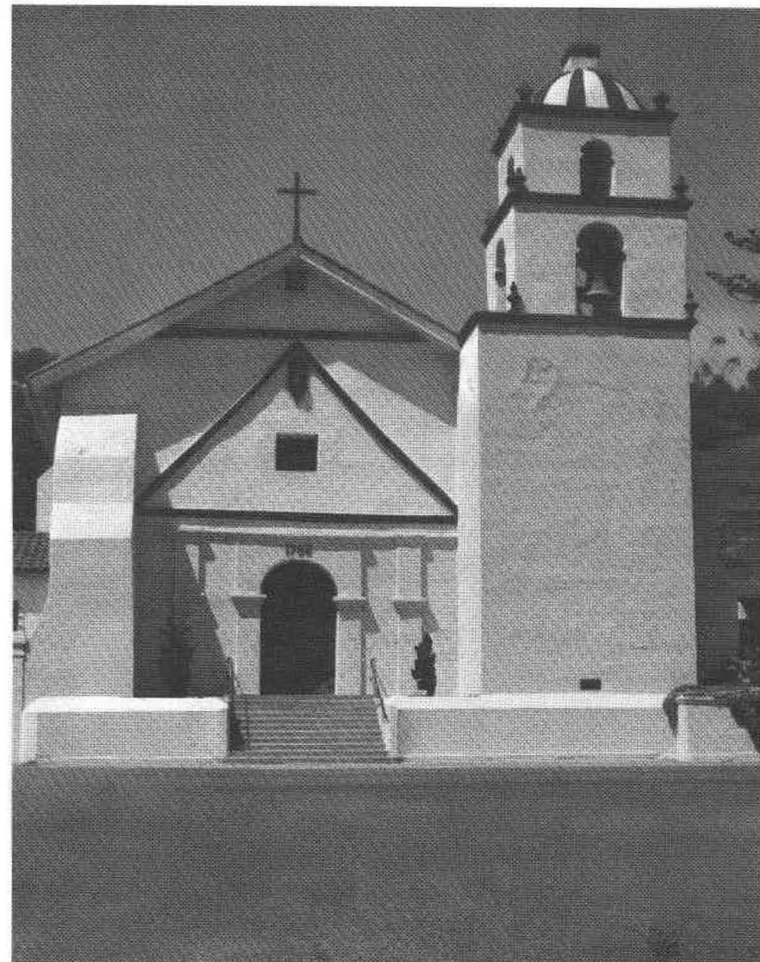
For fifteen years no one sought to find the woman, and it was assumed she had perished. Then in 1850, George Nidever and a crew of Indians were on the island hunting sea otters when one of the crewmen reported seeing a running figure. Three years later, Nidever, on another hunting expedition, spotted a basket containing a robe made of bird's plumage. An exhaustive search led the men to a grass shelter high on one of the island's peaks. There the woman, dressed in cormorant feathers, was seated. She appeared to be in excellent physical condition. There was a large supply of food in the hut, a pack of dogs trained to answer her commands was at her side, and two pet ravens were perched nearby.

When Nidever returned to the mainland he took the woman to his home, but unfortunately no island Indians remained who could speak her language. Three months after she was found, the woman, baptized Juana Maria, died, and with her died the centuries-old culture of the Chumash Indians of San Nicolas Island.

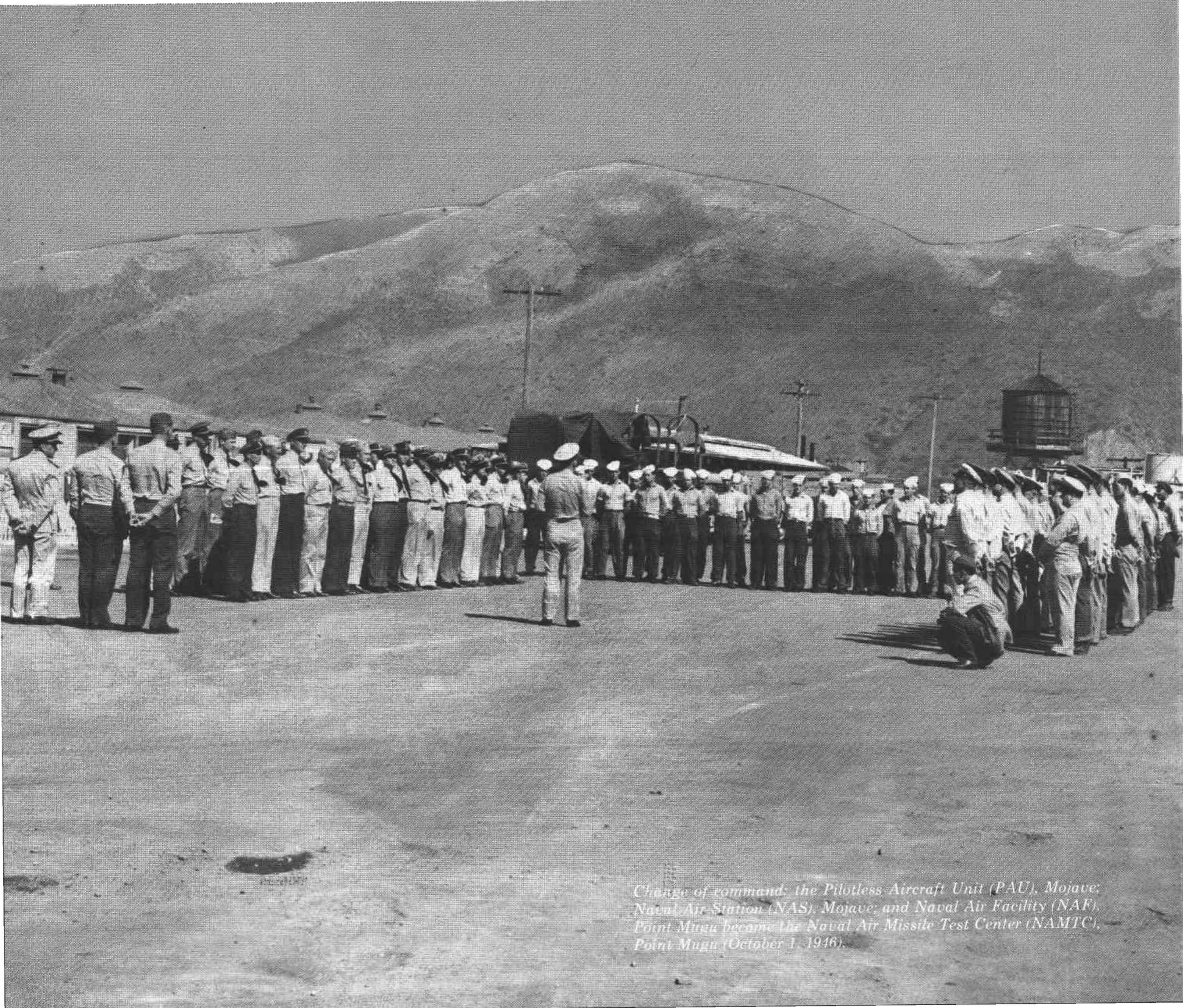
During the years following California's admission into the Union, the Ventura County area surrounding Point Mugu gradually changed from ranching to farming. The rich alluvial soil, plentiful water, and excellent climate made it possible to harvest three or four crops a year. Initially, the principal crops were barley and wheat, but later sugar beets, walnuts, and citrus were introduced. The building of the first wharf at Port Hueneme in 1871 greatly facilitated shipping the produce to Los Angeles and other ports.

One of the pioneers at Point Mugu and an early resident of Ventura County, Stan Radom, remembers duck hunting in the 1930's in the marshes that edged the lagoon and the tin-shingled, board-and-batten shacks used by a group of Japanese fishermen.

The leisurely routine of the county was abruptly shattered with the advent of World War II and the establishment of the Construction Battalion Center at Port Hueneme. The Seabees, looking for a place to train, soon turned their eyes on nearby Point Mugu with its relatively vacant beaches and marshes. A tract of land was acquired, temporary buildings erected, and a Marston mat runway laid. This then was the scene in 1946 when history began for the organization that would eventually become the Pacific Missile Test Center, Point Mugu.



San Buenaventura Mission, founded by Padre Serra.



Change of command: the Pilotless Aircraft Unit (PAU), Mojave; Naval Air Station (NAS), Mojave; and Naval Air Facility (NAF), Point Mugu become the Naval Air Missile Test Center (NAMTC), Point Mugu (October 1, 1946).

"Progress, man's distinctive mark alone."
—Robert Browning

CHAPTER 1

PIONEERING

It was the first day of October 1946.

A small group of naval officers and enlisted men gathered near a narrow wooden bridge spanning Mugu Lagoon. A hundred yards away, on the other side of a row of weathered gray temporary buildings, the blue-green Pacific surf rhythmically washed the narrow sandy beach.

A watery sun gradually dissolved the early morning mist and it appeared to be a very pleasant day at Point Mugu, located just fifty miles northwest of Los Angeles and forty miles southeast of Santa Barbara, California.

The men stood at ease in an open-ended square as Captain A. N. Perkins stepped forward to read his orders and thus in a few brief words established the Naval Air Missile Test Center (NAMTC), forerunner of the Pacific Missile Test Center (PMTC), the first Navy facility dedicated to the developmental testing of pilotless aircraft, drones, and guided missiles over an open ocean range.

When NAMTC was commissioned in 1946, pilotless aircraft and guided missiles were far from new. As far back as the 1920's the Navy had experimented with radio-controlled airplanes. After years of frustration it finally achieved success on November 15, 1937, when a radio-controlled plane took off, flew, and returned to its home base. Nine months later a very significant first was achieved when an NC-2 drone, under radio control and visual guidance, dove at the USS NEVADA.

World War II gave impetus to the Navy's interest in pilotless aircraft, and they were used extensively for naval gunnery practice and to a lesser extent as offensive weapons. However, it was the now famous or infamous V-1 buzz bombs and V-2 rockets of Nazi Germany that made the Navy and the world fully aware of the devastating potential of guided missiles.

As the men of the newly commissioned NAMTC returned to work after the brief ceremony, most were aware that the Navy had accumulated considerable experience in launching, guiding, and recovering pilotless aircraft; but they were also fully aware that the science of guided missiles was in its infancy and that they were, in a real sense, "pioneers."

NEW FRONTIER

Certainly in the mid-1940's, Point Mugu gave the appearance of a new frontier. Except for a row of Dallas huts, a few Quonset huts, a wooden water tower, and several barracks-style buildings, the area looked little different than when the Chumash Indians hunted the marshes for wild duck eggs and launched their red canoes into the cold, choppy waters of Santa Barbara Channel. Over the years, change had nearly bypassed Point Mugu.

World War II brought an abrupt end to this bucolic scene. A Japanese fishing camp was closed and later the Construction Battalion from Port Hueneme acquired a parcel of land for training. Several buildings were erected, and a 5,000-foot Marston mat runway was laid. An early historian related one interesting story regarding the runway; a rather typical account of early procurement and building practices that seems humorous today:

"When NAMTC was commissioned, an inventory

Naval missile testing at Point Mugu traced to 1944

was made of all assets. It was discovered that the 5,000-foot runway and a nearby hangar did not appear on the list. A little sleuthing revealed that an enterprising officer during the war had decided to put the training of his men to practical use. He begged surplus material so that instead of laying a section of runway and tearing it up for practice, they were able to complete the entire landing strip. Also, he had them build the hangar from used lumber."

Naval missile testing at Point Mugu can be traced back to October 1944 when the Chief of the Bureau of Aeronautics recommended that a missile test center be established. Upon return to the United States in early 1944, Captain Grayson Merrill (then Commander), after viewing first-hand the destruction wrought on Europe by German V-1 and V-2 missiles, addressed a letter through channels to the Chief of the Bureau of Aeronautics spelling out the case for establishment of a Navy missile test range. He further recommended that a board be established to determine a suitable site. Captain Merrill was destined to become the first Technical Director and the first Director of Tests of the future NAMTC, and as such, he was one of the originators of the center's test and evaluation standards and methodologies and shared in the planning and designing of the sea test range and initial laboratories.

In January 1945, the Chief of Naval Operations (CNO) concurred, and the Navy moved swiftly to further this project. Before the year was out, the first step was taken by ordering the consolidation of Navy missile activities which were scattered across the country. The Special Weapons Tactical Test and Evaluation Unit, Traverse City, Michigan, and the U.S. Navy Engineering Experiment Station, Annapolis, Maryland, were ordered to form the Pilotless Aircraft Unit (PAU) at the reactivated Naval Air Station (NAS), Mojave, California. Within a year, the PAU would become the nucleus for NAMTC.

At about the same time, the Bureau, recognizing the need to test Navy missiles over water, obtained control of a small amount of acreage at Point Mugu from the Construction Battalion Center. By November 1945, a detachment of the PAU under Commander Jack L. Shoenhair had arrived. The following month, Lieutenant Commander L. G. Lehrer reported directly from the Pacific Fleet to assume command at Point Mugu, now designated as the Naval Air Facility (NAF) with parent command at NAS Mojave.

The first construction at Point Mugu directly related to missile testing was actually completed before the establishment of the PAU. A contingent of the LOON Test Group from the Naval Air Modification Unit (NAMU), Johnsville, Pennsylvania, was at Point Mugu, and they were in a great hurry to get the LOON missile operational for use in the Pacific theater. Lieutenant Commander James Simpson, the first Guided Missile Officer, remembers:

"The LOON Launch Site was designated a Seabee training exercise to expedite construction. Hundreds of Seabees worked around the clock with bulldozers, earthmovers, dump trucks, and other equipment. They completed the entire facility in seven weeks."

Before the year was out, dead load shots consisting of 5,000 pounds of wood and steel were being made from the new McKierman Terry XM-1 catapult launcher, and even though the first launch blew the breech off the catapult, it could be said that guided missile operations were underway at the new Naval Air Missile Test Center.

SELECTION

Despite the initiation of launching activities, Point Mugu had not been officially selected as the site of a naval missile test facility. CNO had approved the plan for a missile test center in January 1945. The proposal was then submitted to higher authority and obtained the concurrence of the Joint Chiefs of Staff and President Truman. Looking to the future, the specifications called for a sea test range where both short- and long-range missiles could be launched.

A special committee surveyed 26 possible launch sites on the East, West, and Gulf Coasts and in the Caribbean. Baja California was even briefly considered. The final recommendation of Point Mugu was based on its inherent advantages: an unobstructed sea test range, offshore islands for instrumentation, generally good weather, and proximity to the aircraft industry of Southern California.

OPPOSITION

The selection of Point Mugu did not meet with universal approval from the local residents. Several ranchers raised objections, claiming a possible threat to the safety of nearby communities and that the Center would gobble up valuable farm land. Another group welcomed the Center and pointed out that most of the land involved was beachfront and salt marshes. They also emphasized the economic benefits that the Navy payroll would have on neighboring communities. Additional assurances regarding safety were given by Secretary of the Navy James V. Forrestal. When a showdown came before a Congressional committee, 77 ranchers opposed the Center while 330 ranchers and industrial and civic leaders were in favor. Any possible Congressional opposition evaporated when Admiral Chester W. Nimitz told the committee that he considered the establishment of a missile test center at Point Mugu as the Navy's number one priority project.

The CNO's letter, serial 027P601, dated 26 June 1946, as approved by the Secretary of the Navy, prescribed the basic Navy policy for development of guided missiles. Essentially, this may be summarized as follows:

> *a. The fundamental U.S. naval policy is to maintain the Navy in strength and readiness to uphold national policies and interests, and to guard the United States and its continental and overseas possessions.*
>
> *b. Further, one of the policies in support of this fundamental policy is to advance the art of naval warfare and to promote the development of naval material. It is, therefore, necessary to develop new weapons and to exploit fully all advancements in science that will contribute to the implementation of the fundamental and supporting policies. Included in the category of new weapons and advancements in science are **guided missiles including pilotless aircraft**, and the practical application of atomic energy. (Emphasis added.)*

EARLY PROBLEMS

While the commissioning of the new Center gave great impetus to the Navy's fledgling missile program, it also created some immediate concerns and problems for the men of NAMTC. It was essential that the move from Mojave to Point Mugu proceed with the loss of as little test time as possible. Consequently, a wide variety of conveyances were pressed into service. W. L. (Mike Miller) recalls one particular incident:

> *"Because we were short of trucks, they loaded a dump truck with small electrical parts and components. It arrived at Point Mugu about midday, but because everyone was busy, it had not been unloaded by late afternoon. The driver grew impatient to return to Mojave, so he backed the truck up behind one of the buildings and 'dumped' the entire load."*

Also, in the early days, nearly everything was in short supply. Lieutenant Commander Simpson related, "We obtained office furniture from nearby bases. Tools and other supplies came from wherever we could acquire them." Another early pioneer remembers that a man was detailed to forage for surplus parts using an old battered truck. He ranged as far as Sacramento.

Commander Lehrer had a vivid recollection of Point Mugu. "It seemed at first glance a sorry place and the first thing I was told upon reporting was that we were short of water." One of the two pumps was broken and the other went out the following week. A water detail brought in a supply from Port Hueneme for several weeks until the pumps were back in operation. Communications were also a problem. There were only a dozen telephones in the whole Center and only one in the test area. Messengers were dispatched for anyone receiving a call.

LOON

Despite the problems created by the move and the lack of nearly everything, testing continued at a fairly steady pace through 1946. The primary test vehicle was the JB-2 Flying Bomb (later redesignated KUW-1) or LOON. This was our version of the German V-1 buzz bomb, and the initial program was to determine the feasibility of launching the LOON from the deck of a CVE aircraft carrier.

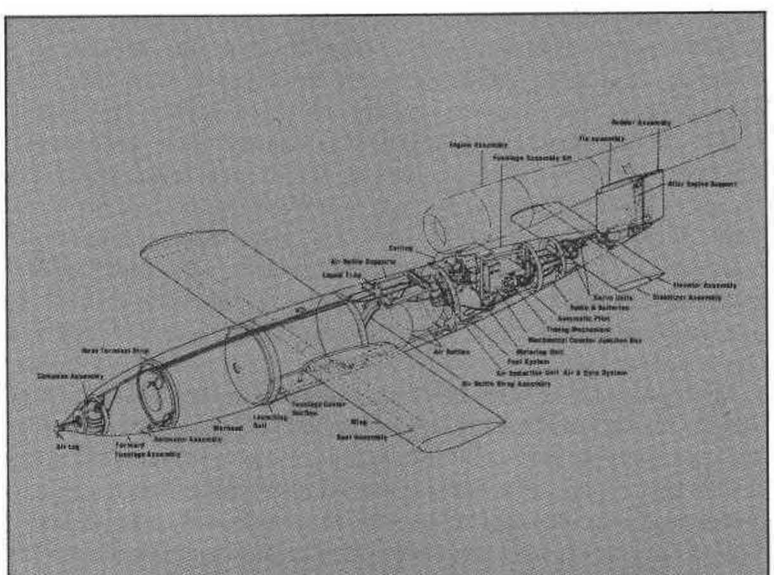
The project had been originally assigned to NAMU Johnsville, Pennsylvania, with Point Mugu designated as the experimental launch site. Later the function of the NAMU LOON Test Group was transferred to the PAU. With the establishment of NAMTC, the LOON was placed under the Projects Department and designated Project Number TED MTC PA-501.

The LOON was a pulsejet-propelled, midwing monoplane lacking ailerons, but incorporating conventional fin, rudder, stabilizers, and elevators. The design characteristics were:

Gross Weight:	5,025 lb
Wing Area:	60.7 sq ft
Wing Loading:	82.8 lb /sq ft
Span:	17 ft 8 in
Length:	27 ft 1 in
Maximum Rate of Climb:	1,000 ft /minute
Maximum Speed:	385 knots
Service Ceiling:	6,000 ft
Range:	131 nautical miles

The 22-inch diameter pulsejet engine that powered the LOON, according to Mike Miller, was a relatively simple device consisting of a tube with a spring-loaded shutter at the front. When pressure was created in the tube by combustion, the shutter was forced closed. Since the gas could not escape out the front, it was forced out the exhaust nozzle producing thrust. Pressure then decreased in the tube and the spring-loaded shutter opened to emit air. The fuel/air mixture was ignited and the cycle was repeated. The whole operation was automatic, and it was found that when the engine was properly tuned, it did not require the fuel to be pulsed. The fuel could be fed into the engine in a steady stream and when the proper air/fuel mixture was reached, ignition took place.

To propel the LOON to flying speed, the XM-1 catapult launcher was first used. The design was a slotted cylinder in which multiple powder charges were fired in sequence. The catapult was designed to launch a 5,000-pound missile at an end speed of 250 mph (217 knots) on a 150-foot run. The entire structure, designed for use aboard a CVE aircraft carrier, was made of aluminum alloy and steel and weighed thirty-three thousand pounds.



LOON missile, the U.S. version of the German V-1 buzz bomb.

In operation, the LOON was mounted on a sled which inclined the missile axis three, six, or eight degrees above the catapult axis. The sled was attached to the piston inside the catapult tube by a strength member that extended through the slot. The firing of sequential powder charges propelled the piston down the tube, accelerating the sled and missile. At the end of the run, the piston flew off into the ocean, the sled dropped away, and the missile was airborne.

The first McKierman Terry XM-1 launcher was delivered to Point Mugu in August 1945, and starting on September 5, 30 dead load shots were performed to determine operating characteristics. Lieutenant Commander J. Simpson recalled some of the early problems:

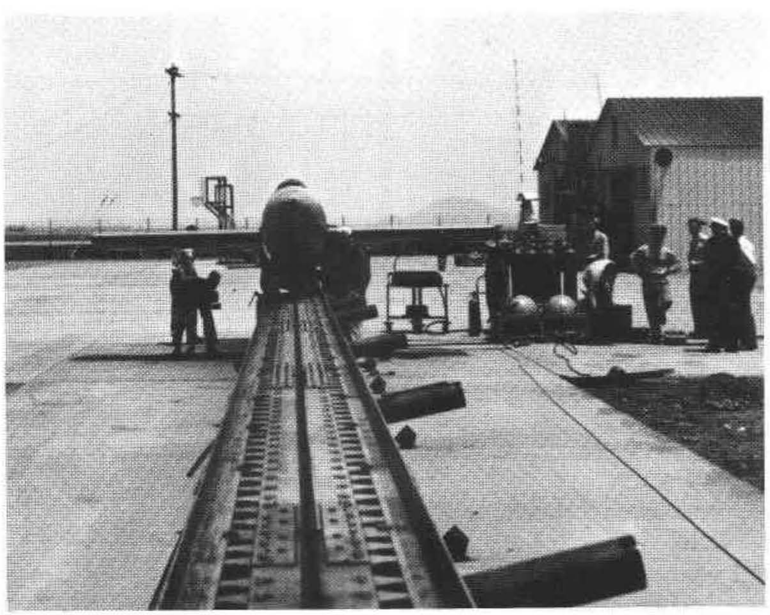
> *"At first we had sealing strip failures, powder chamber blow outs from pre-ignition, piston hook failures under stress, and other problems. Lieutenant Jean Nickels was the catapult officer. Under his expert direction, modifications to the XM-1 were made after each failure. Finally, we launched dead load shots successfully."*

The first "live firing" took place on January 7, 1946, nine months before NAMTC was commissioned. The LOON, equipped with a Compass Slave Guidance Unit and a radar radio beacon, was installed on a sled with an eight-degree inclination. The countdown commenced, the LOON's engine was started, the powder catapult was successfully fired, and the missile sped down the launcher. At the end of the run, the bird reached a speed of 225 mph and became airborne. Unfortunately, and to the great disappointment of the entire LOON launch team, the pulsejet engine had failed during acceleration on the catapult, and the missile, with a dead engine, glided for just a mile before splashing into the waves.

More than one problem plagues LOON

The next several launches did little to gladden the hearts of the missilemen at Point Mugu. The LOON's went off the catapult with regularity and with an equal regularity failed to fly. As Norm Rohn, an early engineer, put it, "We practically built a small island of missiles at the water's edge."

The causes of the monotonous failures were listed as: engine failure during acceleration, sealing strip failure causing low end speed, chase plane pilot gave only one minute warning causing low pressure to fuel tank and false start, engine not started due to catapult firing from static electricity during connection, and so forth and so on.



LOON missile ready for launch on powder catapult (1945).

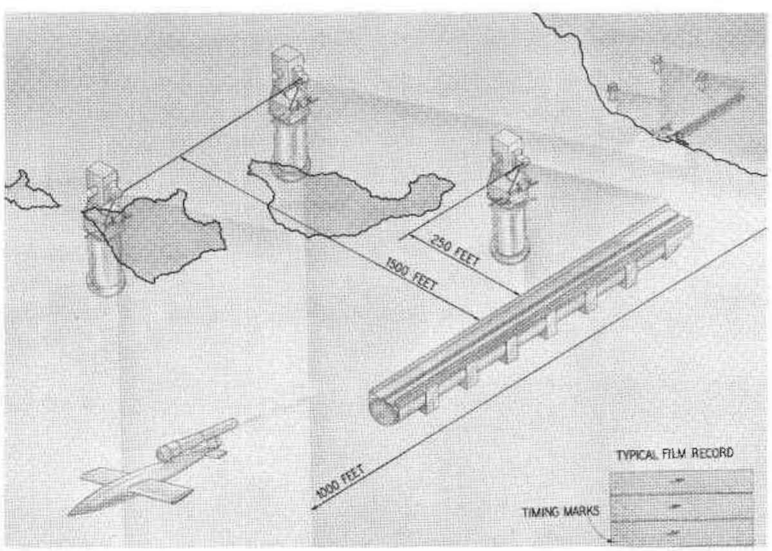
It was rapidly becoming evident to all concerned that there was more than one problem plaguing the LOON and that it would be necessary to carefully analyze each element of the launch for solutions.

The first problem tackled was the engine failures experienced on the launcher. It was determined after some study that the smoke from the powder launcher was entering the combustion chamber and producing a noncombustible mixture. Several methods of restarting the engine were tried, but none was successful. A modification of the catapult, however, eliminated this cause of engine failure.

When the LOON finally reached the point where it successfully left the launcher, a new problem emerged. Shortly after becoming airborne, the missile would take an abrupt dive. Speculations were that the engine vibration was affecting components, that the high acceleration disturbed the autopilot and the automatic control equipment, or that the catapult end blast was forcing the elevators down. To gain insight into the engine vibration factor, an ingenious vibration test was devised. A completely assembled missile, ready for launching, was suspended from a crane. The engine was run for a period of twenty minutes while control signals were given the missile and it was swung in various directions and angles of inclination. The compass and autopilot were thus tested to determine their reaction to the vibration. No effect on the action of the instruments was found using this method.

After the vibration tests, the effect of high acceleration on the components was studied using the AT-1 target drone catapult. The LOON control units were mounted backwards on the carriage of the catapult so that at the end of the run they were subjected to a deceleration equal to the acceleration they received on the XM-1 catapult. These tests revealed that the Celotex packing, used between the autopilot frame and the fuselage, was necessary to prevent actual rotation of the autopilot on its mount during launching acceleration.

Since it was known that as the catapult piston left the tube a powerful blast was exerted by the escaping gasses, it was believed that this blast might be forcing the elevators of the missile downward, causing an immediate dive. Reports from a telemetered missile showed that the elevators were going full-down immediately after launch, a fact confirmed by high-speed photography. Some attempt was made to limit the blast through modification of the catapult, but in the meantime it was demonstrated during acceleration tests that the down signal was caused by the autopilot rotating on



Typical arrangement of acceleration cameras (LOON, 1940's).

its mount. Interestingly, the first hint that the elevators might be a factor came from an outside source. The story as related by Lieutenant Commander J. Simpson is as follows:

"At an open house for the news media, a Los Angeles Times photographer somehow positioned himself at the seaward end of the launcher. A photograph he took allowed us to correct our failure. The picture appeared in the Sunday Times. Within a few minutes of its delivery, our Operations Officer, Commander E. E. Christensen (later Rear Admiral) was knocking at my door with the picture in his hand.

"We could see from the position of the LOON's elevators that the difficulty was not in balance, as had been suspected, but in the launching configuration. The LOON was designed by the Germans to be launched into the air from a hydrogen launcher. Installed at an angle of eight degrees from the horizontal, the LOON was designed to climb at an eight-degree angle of attack. The LOON was thus launched and released, by the Germans, near its correct angle of climb.

"We were launching the LOON from a horizontal launcher at six-degrees angle of attack with a two-degree correction present in the stabilizing system during launch.

"Thus the LOON was released at the end of the launcher at 220 mph in level flight, but at six degrees of up elevator. The resultant high rate of angular velocity toward the correct angle of attack caused full-down elevator and a violent dive.

"The Times photograph showed the LOON about 20 feet from the end of the launcher with full-down

elevator. Since the LOON's altitude at launch was only 20 feet above sea level, the LOON simply could not recover from the down-pitch oscillation before hitting the beach.

"The solution was simple. We fabricated and installed a pitch rate gyro caging device. The rate gyro was uncaged after the first violent angular reaction as the launching sled fell away from the LOON, and the LOON flew out of sight."

With some of the major LOON launching problems substantially behind them, the LOON team's rate of success greatly improved. However, before this an incident occurred that was well remembered by Norm Rohn:

"In those less formal times, a lady employee used to bring her small dog to work and let it run loose on the beach. One day we fired off a LOON from the XM-1 launcher and it crashed in the sand. There was a lot of smoke and dust and out of the cloud suddenly the little dog appeared, doing about 90 miles an hour down the beach."

As LOON launching became more routine, a standard operational procedure evolved. It started some time prior to launch day when the piston and sealing strip were placed in position in the catapult tube. Then on the day of the operation, the sled and missile were positioned on the launcher. While this work was in progress, search planes, in conjunction with ground stations and airborne early warning, cleared the target area of shipping. Final pre-launch checks were then made on the radio control gear, beacon, autopilot, and other internal equipment. Also, during this time, an engine test might be made.

Fifteen minutes prior to launch, the charges were placed in the powder chambers of the catapult and the firing circuit armed. The P-80 chase plane was given orders to take off. Communications checks were made and a five-minute warning sounded. At this time, the air to the LOON autopilot was turned on. A series of time marks were then exchanged between the control station and the chase plane. At the 30-second warning, the pulsejet engine was started. As the chase plane came into position, a switch was thrown to energize the firing circuit, launching the missile.

The LOON accelerated down the launcher and at the end

P-80 chase plane used in LOON tests (Mojave, Calif., 1946).

of the run separated from the sled. At this moment, the autopilot displacement gyro was uncaged, allowing the autopilot to control the missile. The flight was then turned over to the Combat Information Center (Control Station) where the missile's flight was plotted by radar and the necessary control signals transmitted. Any time after the timing clock had run down, arming the radio receiver, the missile could be dumped by radio signals. In the event the missile did not respond to the dive commands, it was dumped by a mechanical timer at a pre-set distance.

Successfully getting the bird into the air, according to Lieutenant Commander J. Simpson, was indeed "sweet," but unfortunately not the end of the problems to be solved. During practically every flight it was noted by the chase plane pilot that the control surfaces appeared to oscillate continuously, resulting in oscillations of the missile about the flight path. The LOON was behaving more like a porpoise than a bird.

Several different methods of damping the rate gyro were tested. First, the bellows on the rate gyro were replaced with dashpots obtained from aircraft turn and bank indicators. This helped decrease the oscillation to some extent, but not enough to warrant modifying succeeding missiles. Next, a launch was made with only the springs remaining on the gyros. This change was counterproductive, increasing the oscillations. Lead was then added to the leading edge of the control surfaces to balance the surfaces in an attempt to lessen their tendency to flutter. By the end of 1946, a satisfactory solution had not been found.

Another flight problem was that the missiles were consistently falling short of the target area because of engine failure. Since the value of photography had been demonstrated in solving the launching problems, it was decided to have the P-80 chase plan fly close to the LOON and take pictures from all angles. The photographs clearly showed a large fuel leak at the bottom and forward end of the fuel tank. The recovery team brought in the wreckage from one of the LOON's and the findings were verified by inspection. Lieutenant Commander J. Simpson explained the problem:

> *"The LOON was designed to be launched at about 11 g's and we were launching at about twice that. The LOON launching slot was failing under stress far beyond its designed strength. Since the point of failure was attached to the fuel tank, the failure ruptured the fuel tank. Our welders strengthened the remaining LOON launch slots during assembly."*

In the early LOON missiles, two types of guidance were used. The Compass Slave Unit, designed to control the missile throughout its flight, consisted of a control relay box which caused the compass motor to rotate the compass. Two oysters on the compass acted to give electrical energy to the slaving coils on the autopilot displacement gyro. These coils exerted a force on the gyro cradle causing it to process to a new position. With the gyro in a new position, a signal was sent to the rudder causing the missile to turn until it lined up with the compass.

In the other guidance system, called Direct Slave Control, a series of radio pulses was received by the missile and sent through the control relay box to the computer. Here they were integrated into a voltage which closed the right or left slaving coil circuit for a period of time which was directly proportional to the number of pulses received. The rate of turn had been set prior to launch so that any given degree of course change could be transmitted.

New ramp and rocket boosters used with LOON

Varying degrees of success were obtained with the two control systems, but in the only flight to reach the target area, the Direct Slave Control was in use.

On November 5, 1946, a milestone was reached when LOON missile number 38 was launched from the XM-1 catapult and completed a successful controlled flight. The missile covered a distance of 48 miles at an altitude of 2,000 feet and obeyed signals for two right turns, two left turns, and dump.

By the end of the first year, 43 LOON launches had been attempted, and although the success rate was disappointingly low, many problems had been uncovered and numerous modifications had been made to the missile and the launcher. Also, the Bureau of Aeronautics remained firmly behind the program and, just before the end of 1946, extended the program to include a study of the feasibility of rocket launching the LOON (now designated the LTV-2) from a surfaced submarine. Submarine launching occupied considerable time and attention at Point Mugu in the years that followed.

At the same time that the project was assigned to NAMTC, the Navy Yard at Mare Island was informed of the requirement for constructing a launching ramp aboard the USS CUSK. Also, NAMTC technicians traveled to the Naval Ordnance Test Station (now the Naval Weapons Center), China Lake, to obtain information on the Monsanto TIOE-1 rocket booster and also to study plans for a suitable blockhouse and control center for the LOON.

The rocket launching ramp, structured to simulate shipboard launch conditions, had an overall length of 90 feet. The first 40 feet were horizontal and corresponded to that section which would be covered by a large hangar on the submarine deck. The remaining 50 feet were inclined six degrees to the horizontal. The entire structure, when built at Point Mugu, could be oscillated in roll at amplitudes of ±5 degrees to ±15 degrees from the top dead center at periods of six seconds to 15 seconds. No provisions were made to simulate pitch or yaw.

The first test from the new ramp launcher using rocket boosters was conducted on December 2, 1946. A slight roll oscillation was experienced prior to sled separation; however, the missile climbed satisfactorily and then leveled out for a smooth glide. The range at impact was 2.5 miles. As Lieutenant Commander J. Simpson related:

> *"The rate of early booster burning sometimes caused the missile to go off the ramp at an extreme angle. However, despite this problem, the inherent excellent flying characteristics of the LOON resulted in successful launches. We found that the bird flew from almost any angle of sled release and we had no failures from any launcher rate or degree of roll or release speed."*

Summarizing the first year and a half of LOON launchings at Point Mugu, an early technical report dated July 1947 stated that the launching of this type of missile from a naval vessel was entirely feasible, the Direct Slave Guidance system developed by the Naval Research Laboratory was a practical method of radio control, and the XM-1 catapult launcher was a reliable item of service equipment.

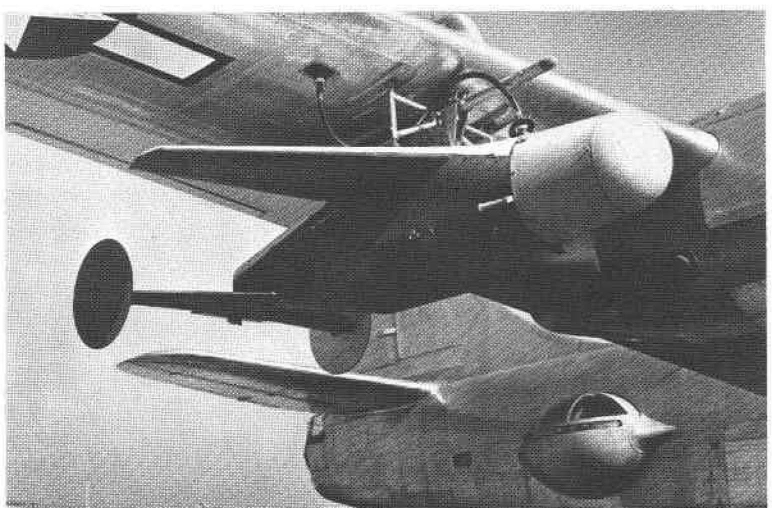
BAT

Although the LOON program was by far the most visible program during the opening days at Point Mugu, there were several other programs and projects of importance that came aboard in 1946. One of these involved modification and testing of the BAT, a World War II glide bomb that used

BAT used in "realistic" test against USS NEVADA

radar homing. The radar homing set, located in a false nose, was designed for use against marine targets in any weather suitable for flying the launch aircraft, either day or night.

The BAT program, initially assigned to PAU Mojave, and then moved to NAMTC in October 1946, would eventually involve the modification of 300 SWOD Mk 9 missiles. However, when the program first started at Point Mugu, there was considerable concern since facilities were very limited, consisting of one 20- by 40-foot Quonset hut, one modified BAT-0 missile, one BAT-1 missile, and enough test equipment to prepare them for launch. Therefore, before much work could be done, a special BAT facility was needed; tools, modification kits, and material had to be collected, and most important, personnel trained.



BAT glide bomb mounted on a Convair PB4Y "Privateer" (1945).

The facility that was finally constructed consisted of a 20- by 90-foot Quonset hut with a small adjoining auxiliary building which would be used to conduct "radar-width" adjustments. Next to the "radar-width" structure a 50-foot pole with a boom was erected. On the boom an LZ antenna was installed so that it was directly over a three-square-foot opening in the roof of the "radar-width" building. The radar head was positioned so that it was in a vertical attitude pointing through the opening. Thus the radar was capable of being offset at any desired amount in the "up-down" or "left-right" planes.

In addition to the modification work, a number of refinements to the BAT missile were undertaken and then evaluated on the Sea Test Range. Twenty BAT drops were made against a pontoon barge on which was mounted a corner reflector. The tests began on January 9 and ended February 27, 1948. The BAT's were dropped from a PB4Y plane at an altitude of 11,500 feet and a range of 9.5 miles. Many hit the barge, others missed by only a few feet, and it was concluded that if a Liberty ship had been the target, 17 of the 20 missiles would have made direct hits. Because of these excellent results, the Commanding Officer of NAMTC requested the Bureau of Aeronautics (BuAer) to make the NAMTC modifications to all BAT missiles. It was further recommended that there be a re-evaluation of the potency of the weapon in view of its proven hitting accuracy.

It was not long after these tests that a golden opportunity was presented to prove the accuracy of the BAT missile and the value of the modifications made and tested at NAMTC. The USS NEVADA was scheduled for destruction by the U.S. Fleet in the Hawaiian area and it was decided to establish the potency of the BAT in a series of drops on July 30,

1948. One week prior to the test, Heavy Patrol Squadron 13 of Fleet Air Wing 2 thoroughly tested four missiles in the air by making practice runs against surface ships operating in the area. No discrepancies were found in the missiles or the homing system.

The missiles were then loaded with 1,000-pound bombs and mounted on two PB4Y aircraft. All ground checks were satisfactory and the planes were given the signal to take off. As each plane approached the target, flight checks were made on the radar system until the BAT operator reported "locked and tracking." The lock-on was accomplished at an average of 13 miles from the target. Clearance to drop was then given.

BAT number 1, released at eight miles, 9,000 feet, and 170 knots air speed, immediately went into a 90-degree turn, struck the water and exploded on contact.

BAT number 2 experienced a normal drop-away at seven miles and an altitude of 9,000 feet. It had a good flight stability on a line to the target until at approximately one mile from the NEVADA it turned to the left, causing the point of impact to be 600 yards left and 100 yards beyond the target area.

BAT number 3 was released at 7.5 miles, 9,500 feet, and 175 knots air speed. At approximately one mile from the NEVADA, the missile dived noticeably and the point of impact was approximately 750 yards short.

BAT number 4 was released at a slightly shorter range, 6.5 miles, and a lower altitude, 8,000 feet. Drop was normal as was flight stability. The missile, however, passed over the target at approximately 600 feet and struck the water about 1,000 feet beyond the ship.

So ended the test to "prove in" a modern weapon system of high accuracy that NAMTC had given an 80 percent chance of making a direct hit. The results were particularly disappointing to the BAT personnel at Point Mugu, considering the target had been a full-size battleship. Obviously, test procedures and methods needed investigation to make them conform more closely to the real world. Speculations were that the missile failed due to the bulk of the target which actually helped defeat the radar since it gave an enormous reflecting signal that bewildered the homing set. It was further believed that the failures resulted from heavy radar interference from numerous ships and planes in the area.

P-61 aircraft with GORGON IV missile (1947).

GORGON IV

Another early program at NAMTC utilized the GORGON IV missile. In Greek mythology, the GORGON's were three sisters, one of whom, Medusa, could turn anyone looking into her eyes into stone. Thus the GORGON became synonymous with petrifying fear. Whether the designers of the weapon during World War II actually considered this is not known; however, the weapon did not reach production in time to test its terrifying effect on the enemy. Instead, it became a very valuable test vehicle, used primarily to evaluate the C-20-.85C ramjet engine.

A total of 67 captive flights and 12 free flights were made by NAMTC. The first five flights were conducted primarily to evaluate the aerodynamics of the vehicle. In this regard, GORGON IV exhibited a high degree of aerodynamic stability in both powered and unpowered flight. Durations were unfortunately limited due to equipment failures.

Two vehicles were expended in the ramjet evaluation phase. The performance of the power plant revealed that difficulties would be encountered in securing reliable operation at the designed Mach number 0.85. This could not be established as fact because of the limited number of vehicles used. In keeping with instructions, attempts to attain high subsonic speeds were curtailed before all remaining vehicles were expended. The engine was concurrently evaluated by other means, and the remaining vehicles were assigned to a program that tested the feasibility of using them as targets.

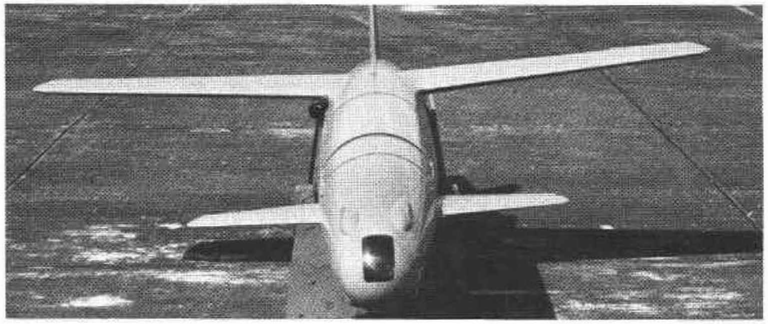
The results of the GORGON IV program at Point Mugu were at best inconclusive because of component failures that led to unreliable flights and because the number of vehicles was limited. For the same reasons, reliable operation of any one component was not demonstrated. In compliance with the BuAer's instructions, the GORGON IV program was cancelled at NAMTC. The remaining missiles were transferred to the Operational Development Force, ending a rather frustrating program at Point Mugu, as is reflected in a wry statement contained in the final report. The author says:

> *"Pilotless aircraft cannot generally be considered good substitutes for piloted aircraft as test vehicles for major components,* ***particularly*** *if the pilotless aircraft have not already demonstrated reliable operation." (Emphasis added.)*

LITTLE JOE

The KAM anti-aircraft missile, developed to counter the devastating effects of Kamakazi raids on the Pacific Fleet, was never launched from Point Mugu; however, it was tested by PAU and NAMTC personnel at Mojave and the experience gained is an important part of the NAMTC history.

Originally assigned to NAMU Johnsville, Pennsylvania, and affectionately nicknamed "Little Joe," the weapon was designed, constructed, and tested in just five weeks—an



GORGON II, a forerunner of the GORGON IV (1946).

incredibly short period of time. However, the war's end overtook "Little Joe" before the missile could be proven in combat situations.

KAM was a radio-controlled weapon that had a short range (10,000 feet) and was launched from 20-foot guide rails mounted on a 40mm gun mount. Powered by four 3.25-inch standard aircraft rocket motors and a smokeless Jet Assisted Take Off (JATO) bottle, the missile could reach speeds in excess of 350 knots.

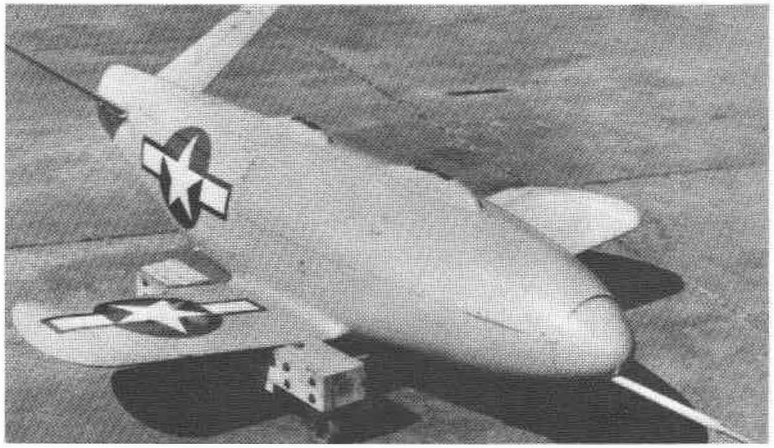
Eleven of the first 14 tests were made by the contractor and then three launches were performed at Mojave. Only in the second of these tests at Mojave did the control system operate properly. Unfortunately the flight was cut short by failure of the JATO bottle to ignite. In the third test a significant event was recorded because a new telemetry system was employed. The data returned appeared to be good, but due to the destruction of the on-board instrumentation recording equipment the results could not be verified. Nevertheless, NAMTC instrumentation engineers were encouraged and felt that the telemetry system gave promise of being very useful on the Sea Test Range.

GARGOYLE

Another weapon tested at Mojave was GARGOYLE, an air-to-surface weapon that could be considered the forerunner of BULLPUP. It had straight wings, a vee tail, and carried a 1,000-pound bomb. Designed to be launched from a dive bomber, it contained an autopilot and flare. The pilot could steer GARGOYLE up-down and left-right with a small control switch attached to his airplane control stick.

Since no telemetry was available to obtain data on GARGOYLE test flights, the bomb was removed and replaced with an airplane-type instrument panel, lights, and a gun camera packed in shock absorbing material. Lead weights were used to simulate the mass and center of gravity which would exist with the bomb installed. The target was a bullseye on the desert floor, and after impact the remains of the GARGOYLE were dug up in hope that the film in the gun camera would be undamaged. The only other data was from cameras mounted on a sandbag revetment next to the 1,000-foot diameter bullseye ring.

The first four consecutive contractor development flights were failures because in each case the GARGOYLE went into a flat spin shortly after launch. Extensive ground tests finally determined that the battery simply did not have adequate capacity and the autopilot was de-spinning. The solution was a simple one—just install a second battery in the system, wired in parallel.



GARGOYLE rocket-boosted glide bomb at NAS Mojave (1946).

The next flight was almost a complete success. The bird flew beautifully, but at the last minute the controlling pilot thought it was going to land short of the bullseye so he gave a hard "up" signal. The bird responded and flew right over the heads of observers near the target. Cameras, people, and everything went over backwards. The PAU Commanding Officer found out about the incident, and that was the last time he allowed anyone in the target area during a test. GARGOYLE gave NAMTC lots of incentive to develop better instrumentation.

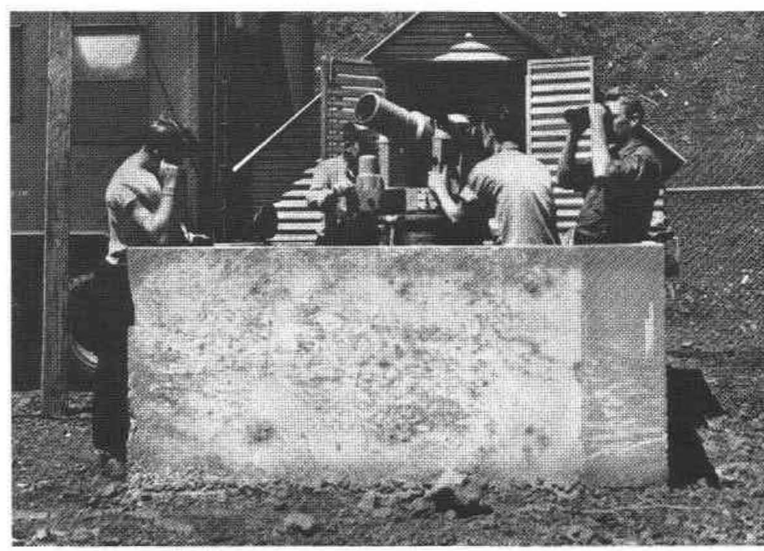
INSTRUMENTATION

One of the first attempts to gather data on a launch was recorded by an early engineer:

> *"For an important operation, seven sailors were positioned at seven strategic points. As might be expected, they returned with seven different versions of what had happened."*

Instrumentation on an open ocean range in the mid-1940's presented problems never encountered in the desert. As mentioned above, the procedure used at places such as Mojave and Inyokern (China Lake) was to rely heavily on the use of on-board cameras to photograph the missile's instrumentation panel. The cameras, mounted in hardened cases, were recovered if they survived the vehicle's crash. When launching over water, this method was obviously impractical since it was difficult to recover the missile from the ocean and the chances of sea water ruining the film were very high at that time. Consequently, NAMTC engineers pioneered in developing telemetry equipment, an early pre-eminence that has continued to the present.

The Short Range Instrumentation Project was initiated in December 1946 for the purpose of instrumenting the Sea Test Range. This very important project was the result of an earlier conference which had established the need for the instrumented range and had as its purpose procuring and installing the necessary equipment. Since optical tracking apparatus were available, it was agreed that NAMTC would provide the necessary modifications and install the Askania cine-theodolites, photographic instruments developed in Germany and "liberated" during and after World War II. BuAer directed that serious consideration be given to installing one theodolite on Anacapa Island in order to provide for successful triangulation. Arrangements were completed to prepare a limited Sea Test Range in three to six months and



Cine-theodolite station at Point Mugu Rock (1947).

plans made to obtain CNO authorization and the services of the Construction Battalion from Port Hueneme.

TARGETS

Considering that the need for target drones was a driving force in developing pilotless aircraft both before and during the Second World War, it is not surprising that several target programs were initiated very early in NAMTC's history. The first of these, the KDD-1, came to the PAU in January 1946, and subsequently the program was carried on at NAMTC.

The KDD-1 was an all-metal, midwing, aerial target powered by a McDonnell 8-inch pulsejet engine. It was designed to be a high-speed anti-aircraft target or possibly an air-to-air gunnery target. During 1946, ten additional targets were allotted for development by BuAer. These differed from the original models in that the modifications recommended by NAMTC and formerly made at Point Mugu were performed at the factory.

When the Target Drone Section was established at Point Mugu, the first step was to change the fuel system of the KDD-1 to compensate for the difference in altitude between sea level and Mojave. A maximum static thrust of 115 pounds was obtained, and then several captive flights were made to determine the optimum fuel pressures at altitudes from sea level to 10,000 feet. Also, in an attempt to increase the flight time, extensive tests were made on the receiving equipment both through static engine runs with the radio equipment operating and captive flights.

In the first test of the new receiving equipment, the target was launched from the catapult and immediately nosed over and hit the ground despite the application of full-up elevators. Fortunately, damage to the target was slight and it was launched again after moving the center of gravity aft. This takeoff resulted in the KDD-1 responding to the up-elevator and climbing safely. The flight was made to obtain rate-of-climb information, but due to the added weight of the heavier radio equipment, instrumentation, and the lead ballast added in the tail section to maintain balance, the fuel supply was not sufficient for a prolonged climb. When the fuel was exhausted, the parachute was actuated, but the hatch failed to open. The target glided in for a landing, sustaining severe damage in the process.

These early experiences were evaluated and design corrections made. Thad Perry recalls some of his experiences with early targets while he was with the Target Detachment of Globe Corporation, Aircraft Division, during the 1948 to 1951 period:

> *"The main problem was the lack of properly scaled test data for design of targets and pilotless aircraft. Each test, successful or not, added to the formerly non-existent body of engineering knowledge of high-performance targets. Propulsion, autopilots, and flight controls were all critical. It took a 'sprinkling' of National Advisory Committee for Aeronautics (NACA) wind tunnel reports and technical memoranda, assistance from the fledgling laboratory at Point Mugu headed by Commander Ralph Petersen, practical know-how of test pilots such as Mike Slowey and Lieutenant Stan Rank, and the collaboration of industrial engineers (from various companies that were resident at Point Mugu) to gain scientific and engineering confidence. We felt the turning point was reached in 1949 when the Bureau of Aeronautics awarded the first production contract*

for a jet-propelled target, the FIREFLY KD2G-2. "As the Oxnard Press Courier headlined this event, we felt American engineers were finally overtaking the state-of-the-art advantages inherited from the Germans in pilotless aircraft and missiles."

LABORATORIES

While the launch operations and flight testing were in progress on LOON, BAT, GORGON IV, LITTLE JOE, GARGOYLE and the KDD-1 target, laboratory evaluations were also initiated. Although handicapped by lack of facilities, equipment, and funds, by using innovation and improvisation these tests were often able to produce very valuable data. For example, on the KAY-1 LARK noise and vibration measurements were performed to determine their effect on electronic equipment. The data were then used to ascertain the adverse effects of the vibration and noise produced by the propulsion units.

All measurements were reduced to continuous recordings from which the noise and vibration of one propulsion unit, both propulsion units, and also the transient conditions of starting and stopping the motors could be obtained. For the measurements, the LARK missile was suspended in two lightweight cradles supported by cables. Cables were also run aft to take the thrust. Vibration pickups placed directly on the electronic equipment measured the actual modes of vibration at these units. Pickups were also placed on the aft bulkhead upon which the motor supports were attached in order to obtain data as near the propulsion units as possible while remaining relatively uninfluenced by the vibration characteristics of the airframe. Nondirectional microphones were used for noise measurements. One was suspended under the Flight Control Assembly and another in the tail immediately forward of the aft bulkhead.

Results of these measurements showed that there were no dangerous vibrations, except possibly those associated with the shock excitation produced by small explosions during motor starting. Since these were not sustained, it was felt they could be damped by shock mounting. Acoustic noise was high, but did not contribute the major component of vibration to the equipment.

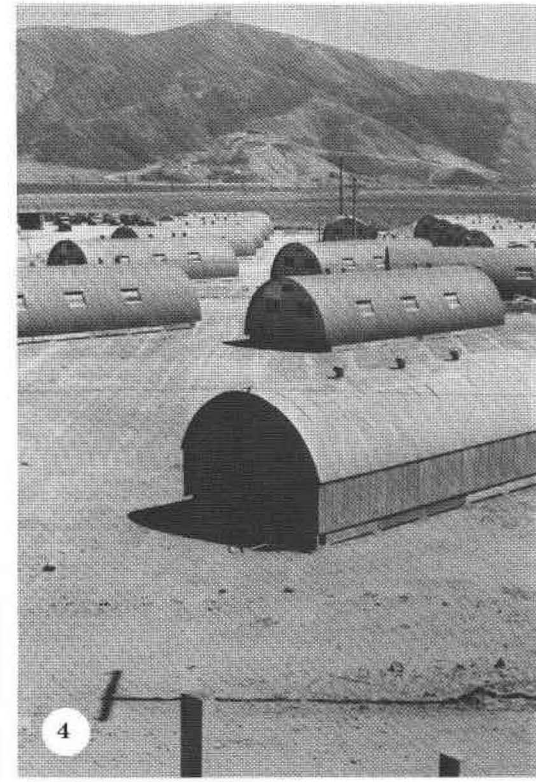
CONSTRUCTION

Facility construction during the first year at Point Mugu was very limited. An Air Engine Test Pit was completed and the test stand for hot testing the CML4N turbopump was finished. Three runs of the 220-pound motor were made to check the operation of both the rocket motor and the stand.

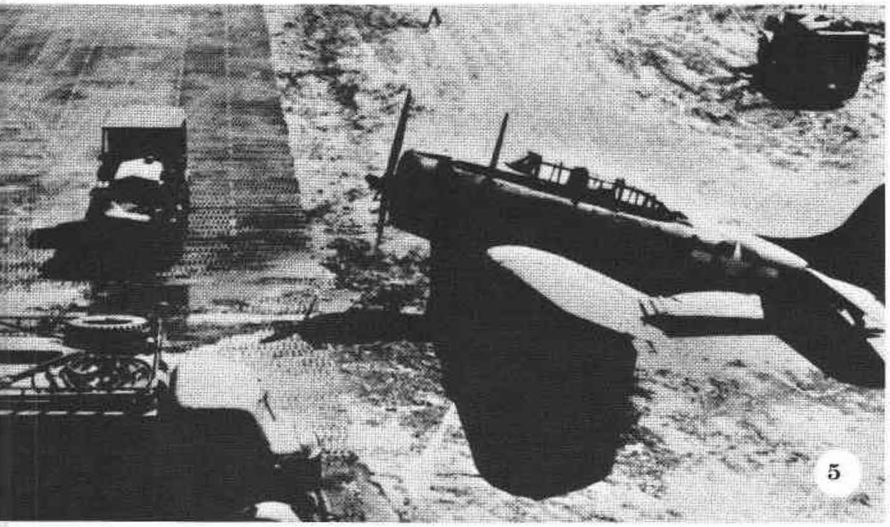
FORECAST

As the first pioneering year drew to a close, the commencement of flight testing, the commissioning of NAMTC, the construction of new facilities, and the planning for expansion helped assure that there would be a future for the Navy at Point Mugu. Technical problems appeared on a daily and sometimes hourly basis, and there was a fair share of disappointments and frustrations along with triumphs.

Perhaps the most important result of these first few months was the proof beyond all doubt that an over-the-water range at Point Mugu was feasible and would contribute greatly to the Navy's fledgling missile program. There was a spirit of adventure present and a feeling that with support from Washington, there was little in the way of missile test and evaluation that could not be accomplished.

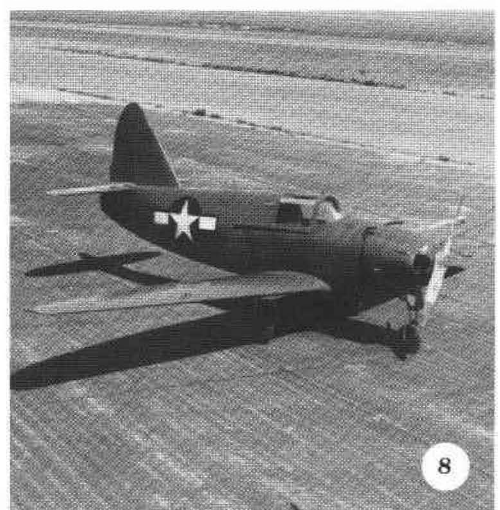


1. CAPT A. N. Perkins reading the orders that established NAMTC (1946). 2. Rocket test area on Point Mugu beach (1946). 3. When dirt roads were the norm and Point Mugu was a veritable tent city (1944). 4. A humble beginning: row after row of Quonset huts at Point Mugu (1944). 5. SBD Dauntless Dive Bomber on Point Mugu's Marston mat airstrip (mid-1940's). 6. Operations area on San Nicolas Island (1948). 7. Point Mugu airfield hangar (circa 1946). 8. Radio-controlled TD2C aircraft target. 9. Telemetering vans on site (1949).

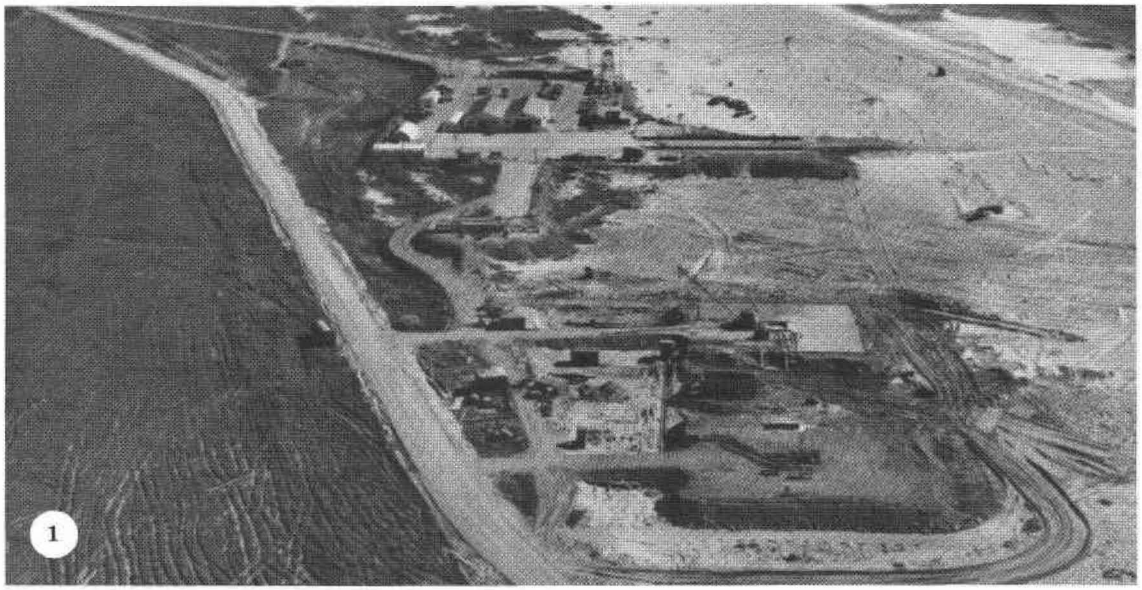

5

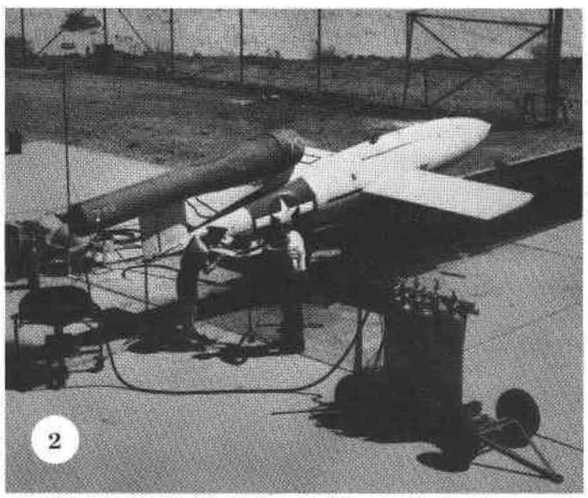

6

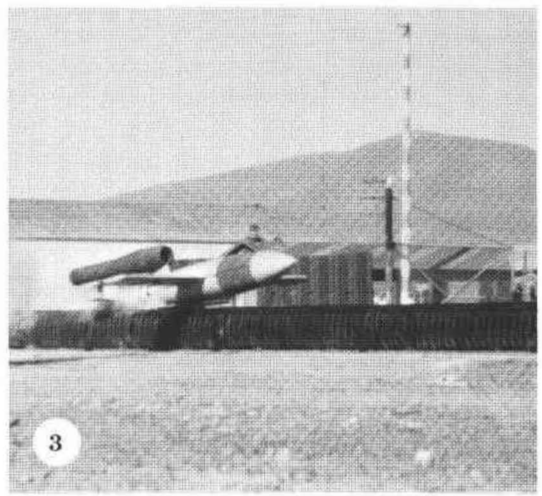
7

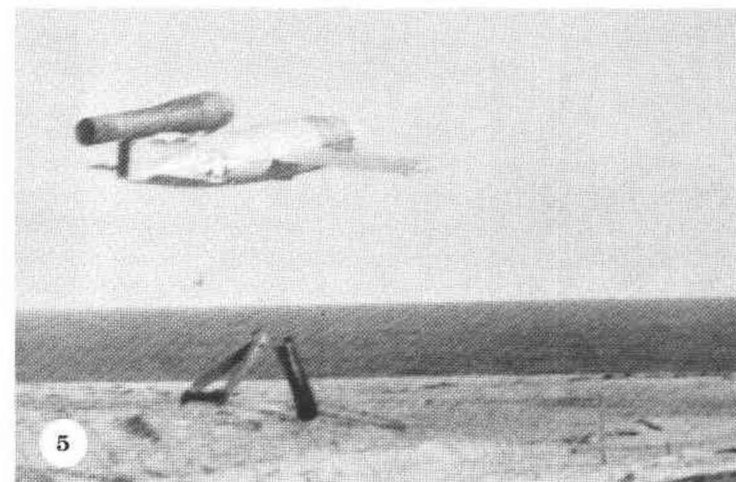

8


9

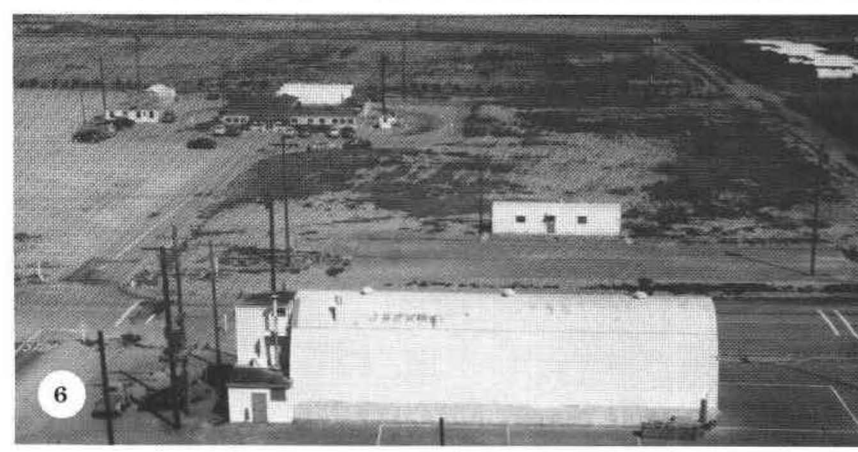


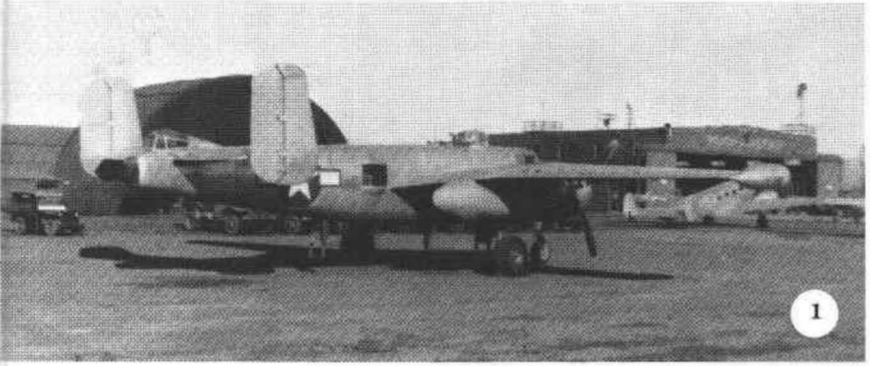


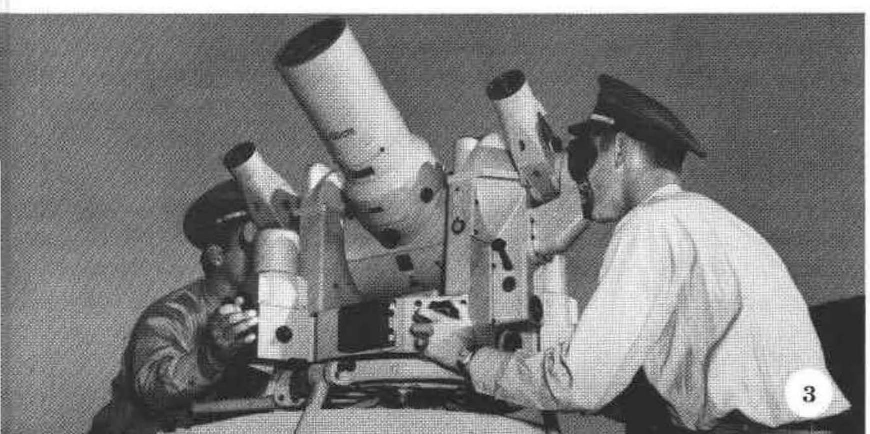


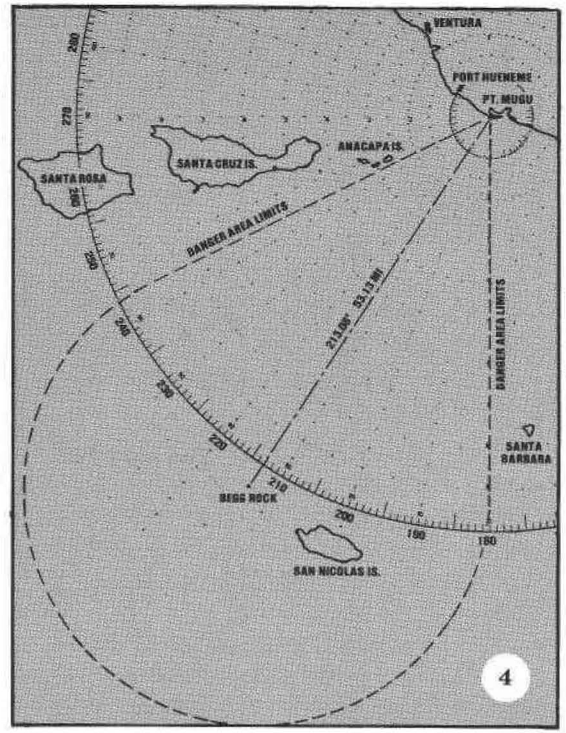


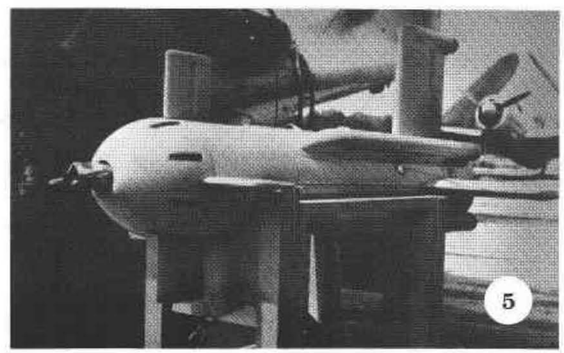
1. Launch pad Baker under construction on the beach at Point Mugu (1947). 2. LOON missile on the McKierman Terry XM-1 catapult launcher (1948). 3. LOON missile firing on the XM-1 powder launcher (circa 1948). 4. Point Mugu airstrip: pavement has replaced Marston mat (1947). 5. LOON missile shortly after launch. 6. LOON hangar and office building at Point Mugu.

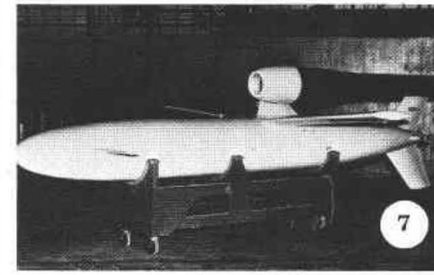


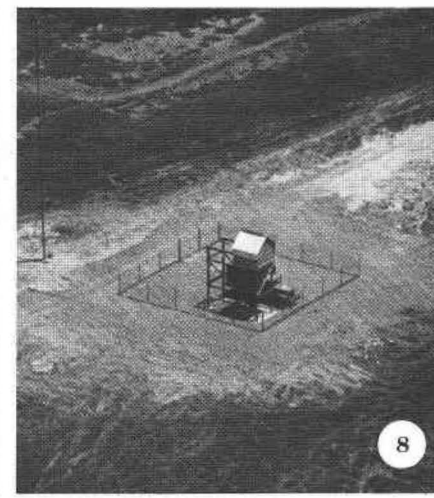




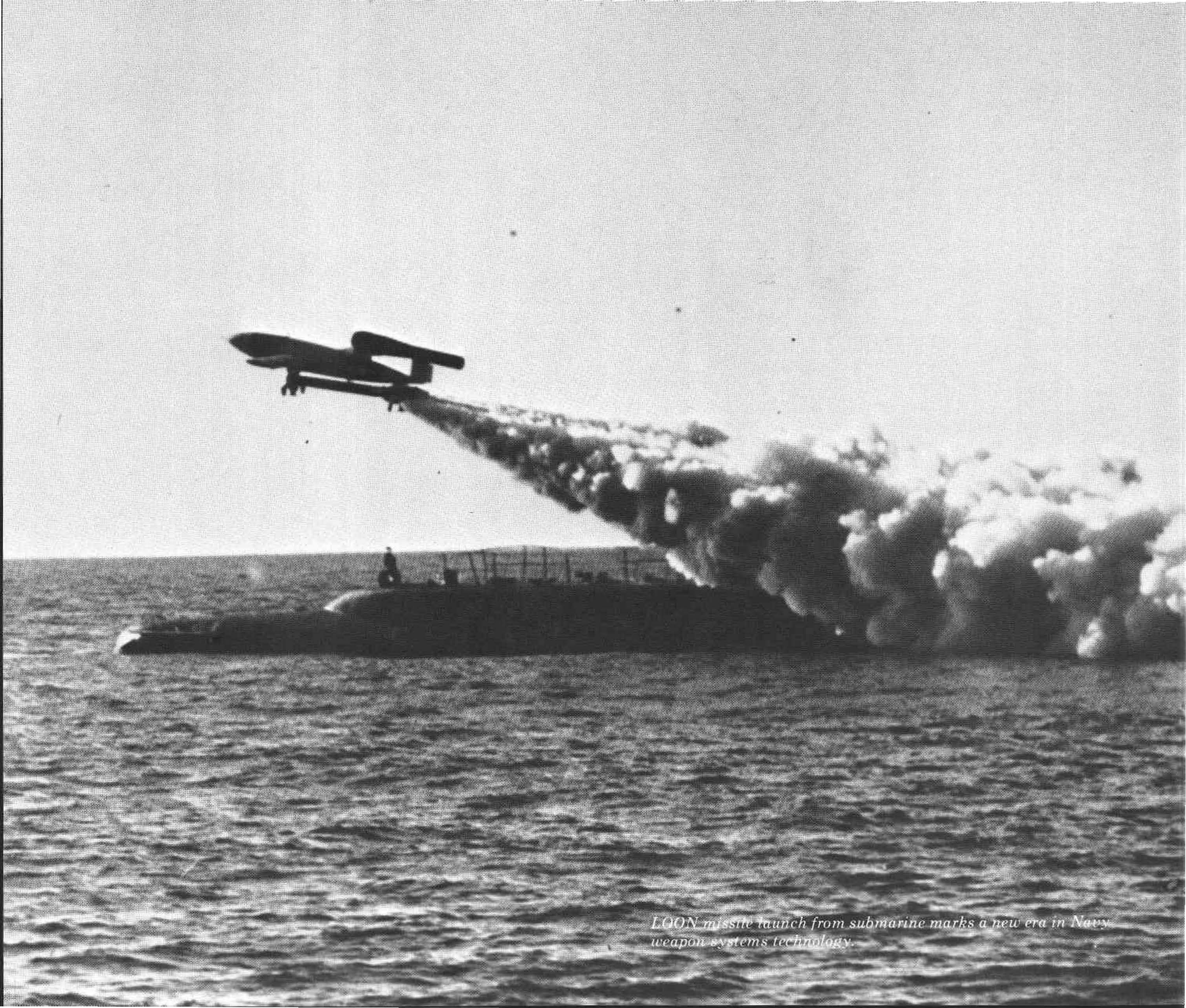








1. B-25 (PBJ-1) weapons launch plane on the Point Mugu airstrip. 2. Point Mugu's early-day administration buildings in "Six Area" (1957). 3. Askania cine-theodolite optical tracking apparatus (1946). 4. Chart of target launch area on original Sea Test Range. 5. "Little Joe," a radio-controlled short-range (10,000 feet) KAM anti-aircraft missile. 6. Radar-guided BAT, first fully automatic guided missile to be used successfully in combat (1945). 7. GORGON II Control Test Vehicle (CTV-2) used primarily to evaluate the C-20-.85C ramjet engine. 8. Aerial of Point Mugu cine-theodolite station (1947).



LOON missile launch from submarine marks a new era in Navy weapon systems technology.

"Growth is the only evidence of life."
—John Henry, Cardinal Newman

CHAPTER 2

EXPANSION

By the end of 1946, with the somewhat hectic and unsettled pioneering days behind them, the men and women of NAMTC were able to settle down to the job of building a modern test and evaluation facility.

Early in the new year, it became abundantly clear to all concerned that the future of NAMTC hinged as much on events going on in Washington, D.C., as it did on successes on the launching pad. All eyes were turned toward Congress where the appropriations bill was being debated. To build the facilities needed for present and future programs would take a sizeable financial investment, estimated at over 30 million dollars. No longer was it possible to "make do" with surplus material or procure equipment by "scrounging."

To further its cause in Congress, NAMTC held an open house in April 1947. In attendance were official visitors from Washington, including several admirals, and a large contingent of the press. One of the main attractions was a LOON launch from the beach. Unfortunately, the first missile off the launcher crashed unceremoniously near the water's edge, eliciting a never-to-be-forgotten remark from a naive visitor:

> *"I think it's mighty inconsiderate not to arrange a longer flight with all these people out here."*

Witnesses report that the Test Officer nearly bit the stem off of his pipe.

Fortunately, there were several successful LOON firings the same day and the *Los Angeles Times* reported: "The event was a huge success." Also, fortunately for the future of Point Mugu, the 80th Congress appropriated $34 million for NAMTC. Of this, $14 million was allocated for initial construction in 1948 and 1949. On August 3, 1948, Parsons-Aerojet Company was awarded a contract for $1.2 million for surveys, engineering investigations, and preparation of construction drawings and specifications.

As quickly as possible, property which was being leased was purchased, along with additional acreage. One concession was made to the local agricultural community when a rancher was allowed to continue farming on the Center. About three years later he decided to no longer farm the land for reasons of his own.

In addition to land acquisition on the mainland, work was initiated to build roads and facilities on several offshore islands, principally San Nicolas and Santa Cruz. In 1947, San Nicolas was used for the first time for communications, weather reports, and instrumentation.

Inasmuch as some parts of the Center were barely above sea level, one of the first major undertakings was to fill low lying areas. This was done by dredging from Mugu Lagoon and transporting the sand through large diameter, lightweight pipes to the low spots. Two huge dredges—the "Los Angeles" and the "Beaver"—were used to expedite the work.

Early construction included the Administration Building, a new runway, enlisted men's barracks, and a mess hall. The last two facilities permitted 600 men to move from Quonset huts to modern permanent quarters.

LOON

The major programs at NAMTC during the late 1940's continued to be the LOON, LARK, GORGON IV, and several target drones. LOON's were launched regularly from both the catapult launcher and by rocket booster from the ramp. Also, Project Derby, the training of Fleet personnel in launching the LOON, continued. During the period of 1947 to 1949, great progress was made in improving LOON flight performance, and the total number of successful flights steadily increased as seen in the following chart.

Period	# Launched	% Success
January 1946-June 1946	21	0.0
July 1946-January 1947	21	9.5
February 1947-May 1947	21	9.5
June 1947-December 1947	21	23.8
January 1948-June 1948	33	42.1
July 1948-March 1949	37	62.1

Some of the major accomplishments in the LOON program were listed in the Interim Report covering 1 January 1948 to 1 March 1949. These included the first launch of the LOON from a surfaced submarine, the USS CUSK, on February 12, 1947, and the first zero launch from the USS NORTON SOUND on January 26, 1949. Both launches were successful and rank as milestones.

LeRoy E. Day also remembers a development that solved a major problem in the LOON's boost phase:

> *"The boost phase of the LOON missile was often disappointing because alignment of the multiple boost rockets through the center of gravity (c.g.) was seldom very accurate. Willi Fiedler invented the jetevator, two gimballed shrouds mounted at the exit plane of the rocket nozzle. When rotated a slight angle, they gave a small variation in the direction of the thrust, providing pitch and yaw control. I was asked to do the stability and control analysis of the device on a single large JATO rocket to be slung under the LOON. We hooked the jetevator into the autopilot system that also controlled the rudder and elevator.*
>
> *"In order to prove the effectiveness of the device, Willi purposely misaligned the thrust vector above the c.g. of the missile. Without the jetevator, the missile would crash just off the beach area.*
>
> *"I well remember the tension as we watched the launch. Despite the misalignment, the LOON flew a straight trajectory . . . a first order success. At last we had a simple way of providing thrust vector control during boost."*

Other significant events were control of the LTV-2 LOON from shore and shipboard command stations placed along the flight path to a range of 135 nautical miles, increased performance expectancy so that it was feasible to train Fleet operating personnel, continued high reliability of the XM-1 catapult launcher, solving of problems associated with the four-rocket sled configuration, and feasibility of zero-length launching capabilities.

One major guidance problem that was prosecuted and solved was predicting the impact point of the LOON. Several methods of flight termination were attempted including spoiler flaps, full-down elevator, cutting the engine fuel supply, and throwing the rudder hard-right or hard-left. The final solution used a combination of cutting the fuel supply while at the same time blowing off the wings. The LOON then became in effect a bomb. With this method, success was achieved in hitting a mile-square target in the majority of tests conducted.

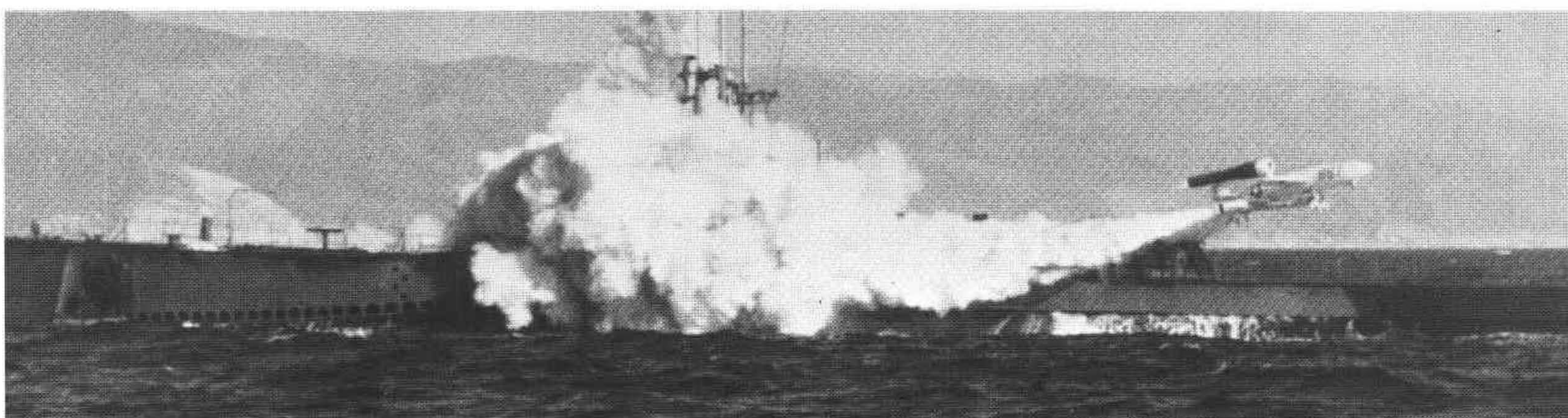
Problems that remained to be solved revolved around obtaining a more consistent missile speed, reducing excess control surface oscillation, and remedying the marginal stabilization for rocket launchings in which there were unusual attitudes or little recovery altitude.

Looking forward at the time, NAMTC considered it was feasible to start tackling the problem of tracking and controlling two or three LOON's from the same control station.

LARK

The ongoing LARK program during 1947, 1948, and 1949 accomplished a number of quite significant firsts in radar guidance of missiles. In one test, guidance was provided by two anti-aircraft radars. One maintained line-of-sight direct to the target while the other directed the missile. By using angular differences of radar line-of-sight, corrective commands could be sent to control the missile. Another test successfully demonstrated the use of the NAMTC mid-course guidance computer. The LARK missile was directed along a radar line-of-sight path for 20,000 yards with a maximum deviation error of approximately 50 yards.

On September 21, 1949, for the first time, a LARK rode a moving radar beam, remaining within .75 degree of the radar beam for approximately 50 seconds. Three months later, a LARK successfully guided toward an aircraft using for the first time an optical missile and target tracking system, and employing an automatic electronic command



First launch of LOON missile from a submarine, USS CUSK (1947).

signal computer which derived intelligence from an optical tracking device. Such achievements were very encouraging.

TARGETS

For testing and evaluating targets, NAMTC was assigned several different pilotless aircraft projects. In addition to the KDD-1, described in Chapter 1, these were the KDR, XKD2R-1, KDG-1, KDG-2, XKDG-4, XKDG-5, KDG-6, and the KD2C-1.

The KDR, like the KDD-1, was a ground-to-air or possibly air-to-air target. It was a streamlined, high-wing monoplane with an all metal fuselage and wooden wings. Powered by a KB-35 engine, it was capable of speeds of approximately 155 mph. NAMTC successfully launched the KDR target both from the ground and from an Aircraft Rescue Vessel (AVR).

The XKD2R-1, a high-wing target with a monocoque fuselage and continuous wing, was powered by a four-cylinder engine that produced a speed of 210 knots. Tests were made for control, stability, and ease of handling.

The KD2C-1 target, SKEET, was unique in that it was the first United States pilotless aircraft powered by an internally mounted pulsejet engine. Considerable testing was performed to evaluate the effectiveness of cooling the fuselage and power plant.

In addition to various missile targets under development, NAMTC was also working on the radio control of full-size aircraft. Pursuant to this effort, Cliff Vige' recalls two early-day episodes:

> *"In one case, a concerned Camarillo resident, not knowing that we were flying radio-controlled and pilotless aircraft, called in to report seeing one of our F6F target aircraft without a pilot. Straw dummies were then put in some of our target aircraft to avoid such concerns. There were numerous cases of these aircraft appearing to have minds of their own and bringing their wheels up or veering off in some unwanted direction completely out of control just as they were about to touch down for a landing. For some reason such events seemed to happen mostly on Friday afternoon just about quitting time.*
>
> *"One of the most exciting events involving target aircraft occurred on San Nicolas Island on a project known as DOG. This project was to test and evaluate a proximity fuze jammer which was installed in a propeller-driven F6F drone aircraft. As fate would have it, the first attempted live firing to determine the effectiveness of the jammer was also the Center's first attempt at 'out-of-sight' control. The target would be tracked by radar and command-guided from observation of the radar track rather than visually.*
>
> *"Shortly after the target aircraft reached test altitude, and as the test was about to commence, Stan Radom asked one of the project technicians where the drone was. He replied it was up there doing a loop. A loop was exactly what it was doing, followed by an uncontrolled spin. It appeared to be heading right for us, and not knowing which way to run, most of us stood fast as the target aircraft, with full power on, dove into the ground a quarter of a mile away. We recovered the project equipment, which was half its original length but, strangely, still had the original height and width. It appeared as though it had been miniaturized. That was not the end of Project DOG, but was certainly a memorable plateau."*

NAVAL AIR STATION

By direction of the Secretary of the Navy, the Naval Air Station, Point Mugu, was commissioned on August 1, 1949. The mission of NAS was stated as follows:

> *"Provide material and service support, including military personnel administration, for the Naval Air Missile Test Center."*

NAS was placed under the military command of the Commander, NAMTC, and under the management control of BuAer, exercised through the Commander, NAMTC.

MARINES

In the last quarter of 1948, a small group of Marine Corps aviators arrived at NAMTC for indoctrination and training in the LOON guidance and launching systems. While thus engaged, the Marines conceived the idea of ground-controlled aircraft flying in any type of weather and under any conditions in support of ground troops. Work began on their project in November 1949.

The hand-built system was promising, and a proposal was submitted to Marine Corps Headquarters that a highly mobile system be developed at Point Mugu along the experimental path already pioneered. The proposal was favorably received, and work began in the summer of 1950 on a guidance system which later became the Radar Course Directing Central AN/MPQ-14A. One model was battle tested in Korea. Another system was retained at Point Mugu for further refinement and evaluation and was used extensively until 1953.

GERMAN SCIENTISTS

The scientific community at NAMTC benefited from the contributions of scientists and engineers from Germany for several years, starting in 1947. These men had considerable experience in rocketry and guidance and included Willi Fiedler, T. F. Sturm, Dr. A. A. Wagner, Dr. Hans Hollmann, Otto Schwede, and Dr. Robert Lusser.

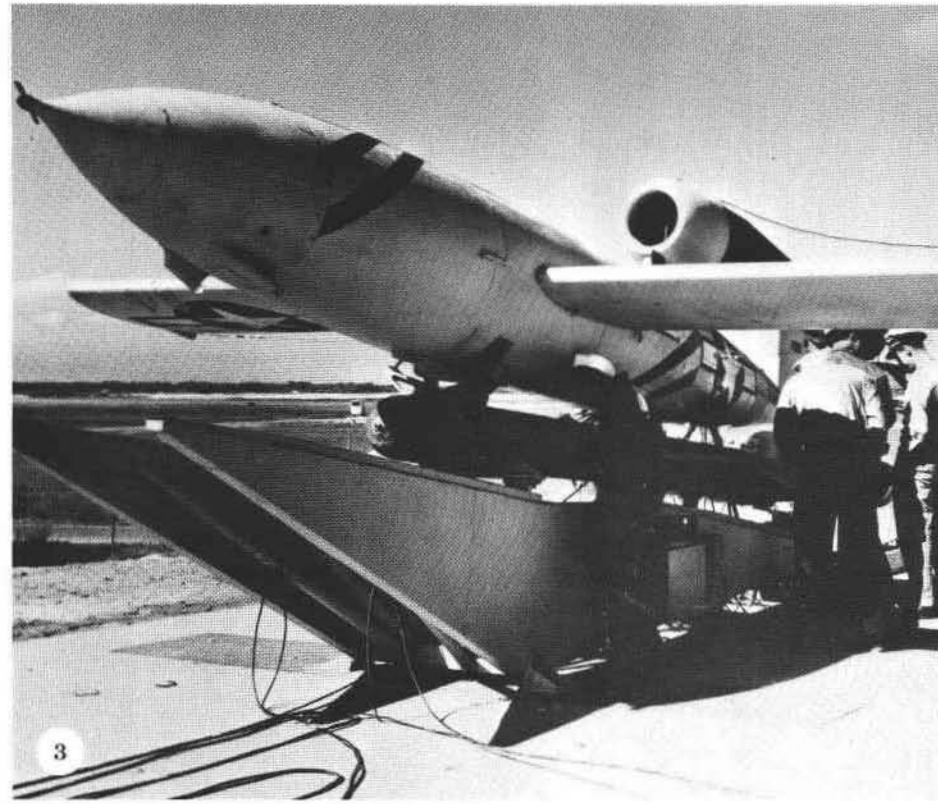
CHIEF SCIENTIST

In June 1949, Dr. Royal Weller became the first civilian Chief Scientist at NAMTC, a position he held for eight years. As Chief Scientist, Dr. Weller advised the Commander and coordinated efforts to solve scientific problems. Regarding the research at Point Mugu, he once wrote the following:

> *"We are exploring the outer boundaries of science and technology as well as the conventional aspects. We do not hesitate to direct our attention to what we believe will be the principles and practices of tomorrow, and we try to organize them in order to better direct the programs of today."*

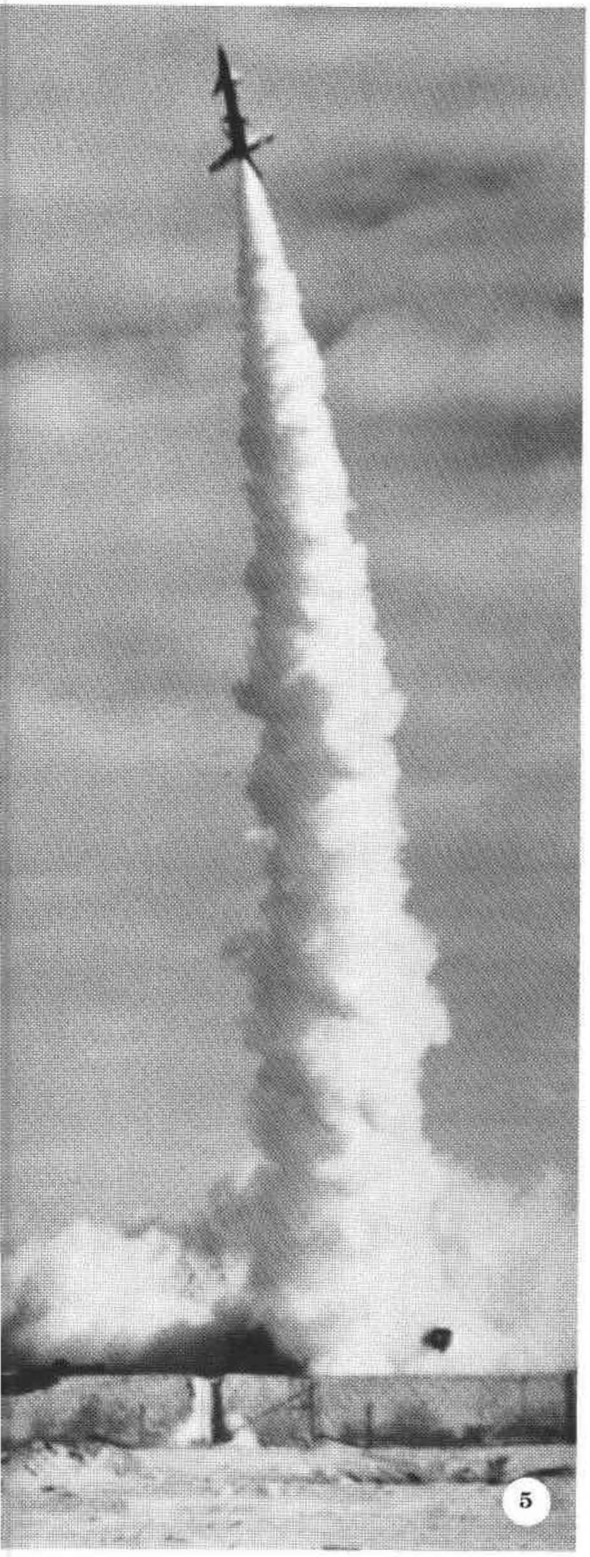
Dr. Royal Weller, first civilian Chief Scientist at NAMTC (1949).

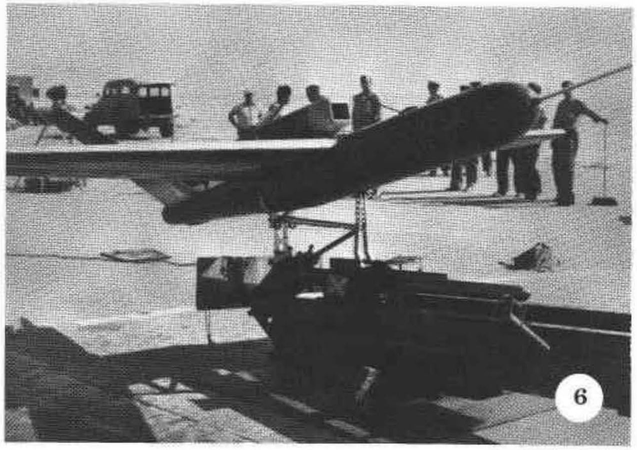

1

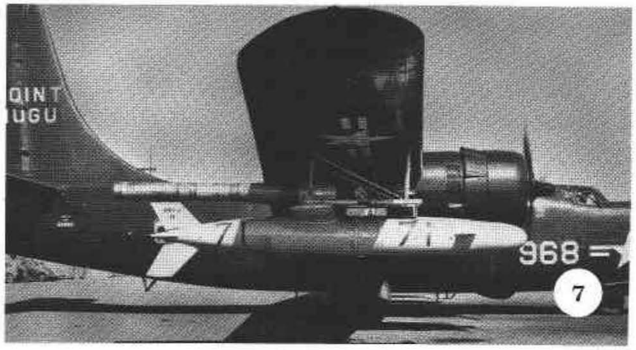

3


2

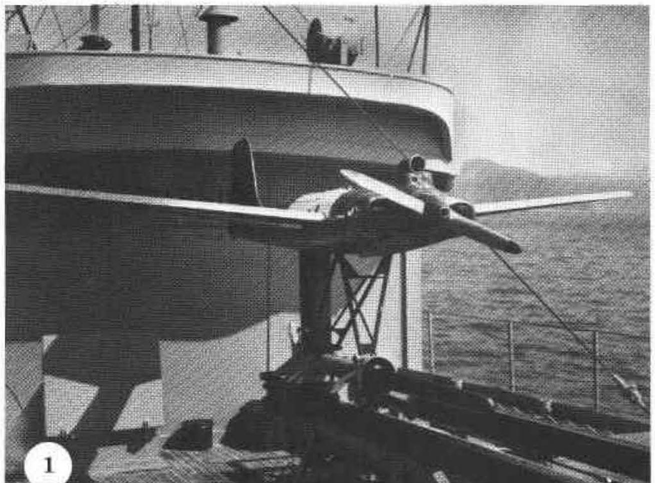

4

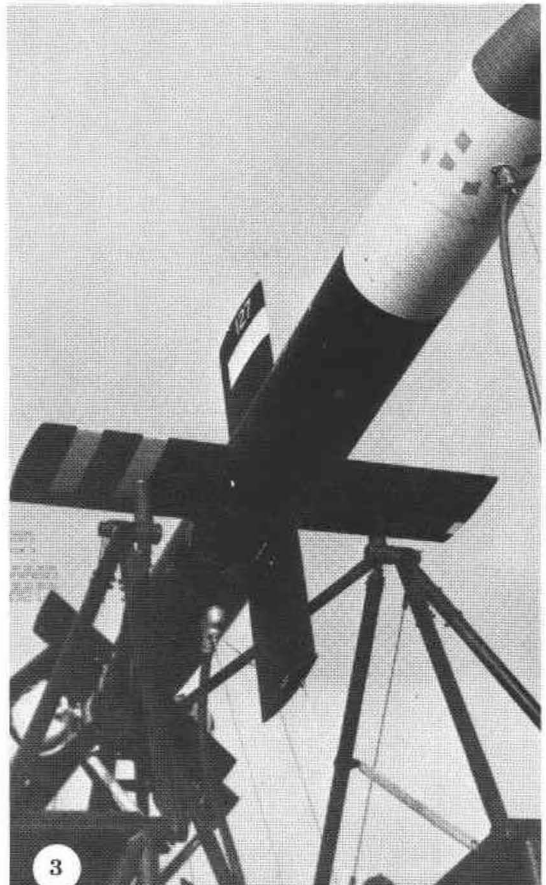


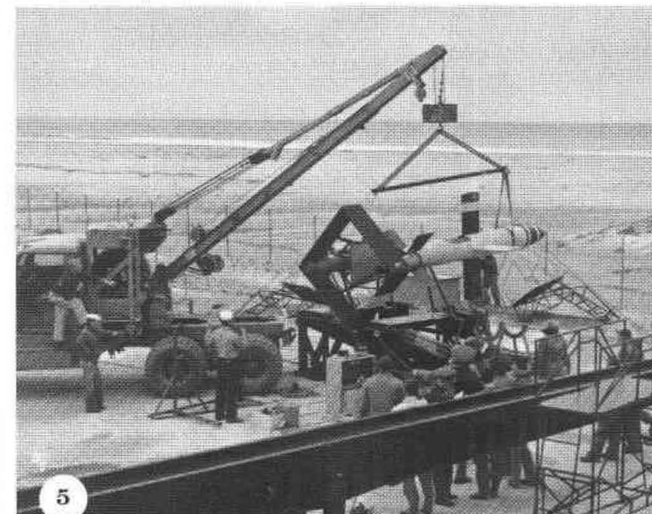


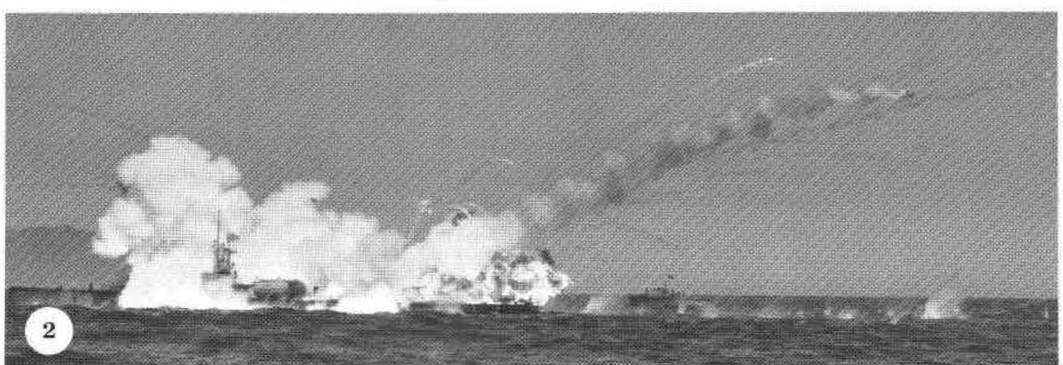


1. Aerial of dredge working on Mugu Lagoon (circa 1947). 2. Launching pad Baker on Point Mugu beach (late 1940's). 3. LOON missile on zero-length launcher. 4. LOON missile on submarine ramp launcher. 5. RIGEL missile launch (1948). 6. KDH target drone ready for launch (1949). 7. GORGON II Control Test Vehicle (CTV-2) mounted on wing of PB4Y-2 aircraft. 8. First zero launch of JATO-rocket-boosted LOON missile from a surface ship, the USS NORTON SOUND (1949).

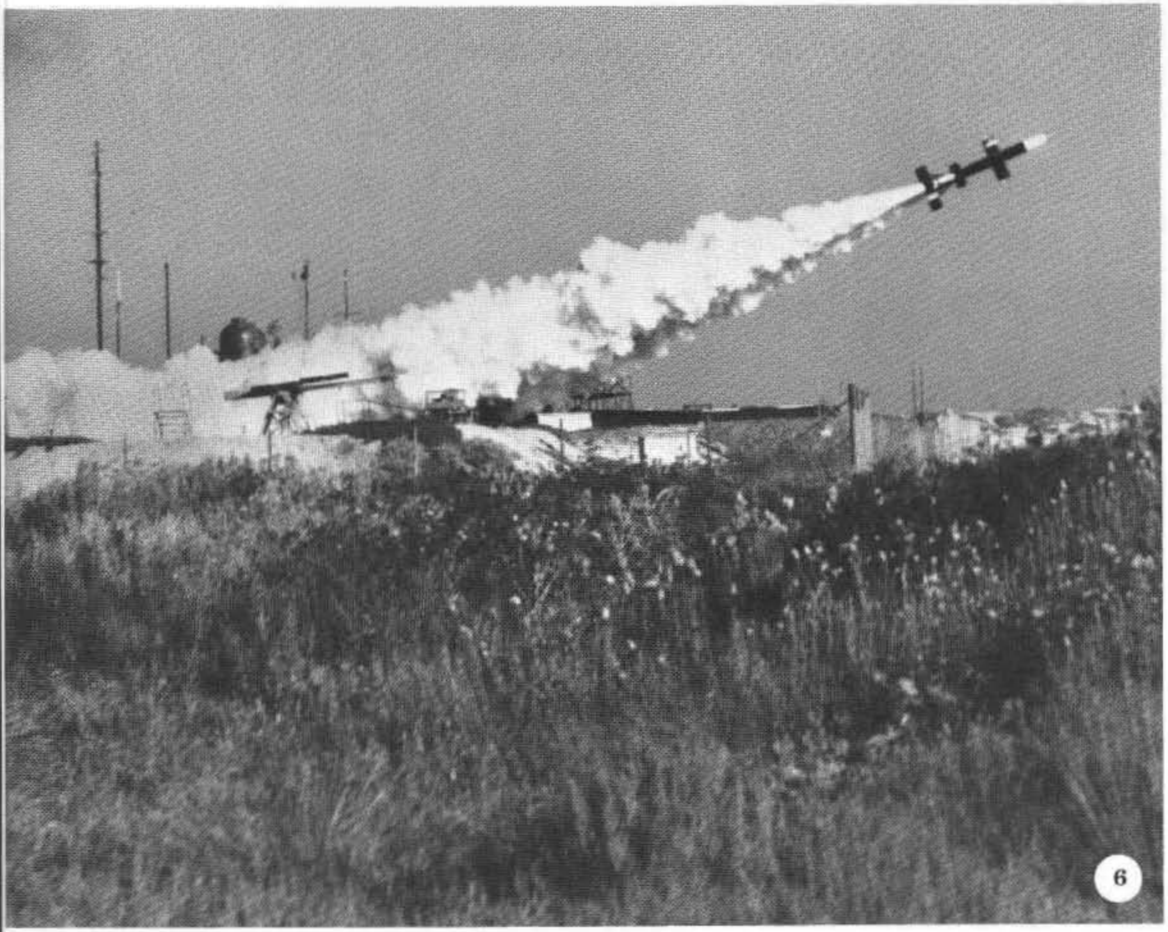








1. KDG-2 target ready for launch from KDCB control boat (1949). 2. Trial and error approach to weapons testing sometimes ended in spectacular defeat. 3. LARK radar-guided missile getting ready for launch. 4. LARK missile in flight shortly after launch. 5. Placing the LARK missile in position for launch. 6. Lateral view of a LARK missile shortly after launch (1950). 7. LOON missile after launch from Point Mugu beach pad (1950). 8. F8F aircraft in flight over Point Mugu. 9. Point Mugu airstrip (1948).



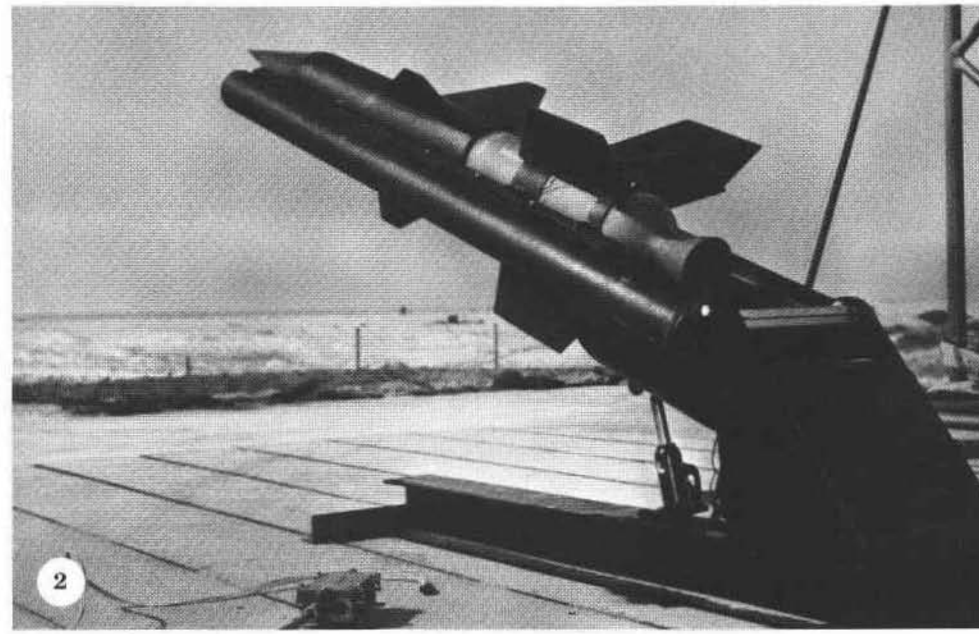
6

7

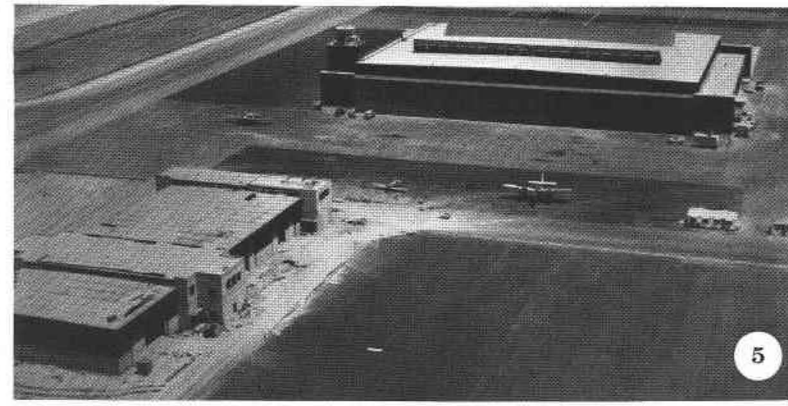
8

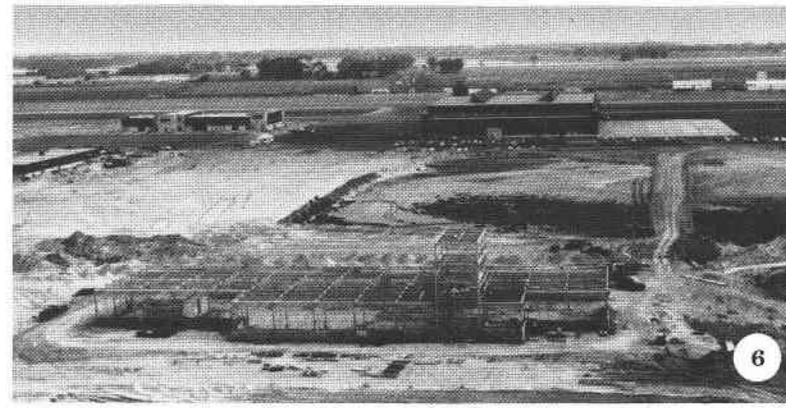
9


1

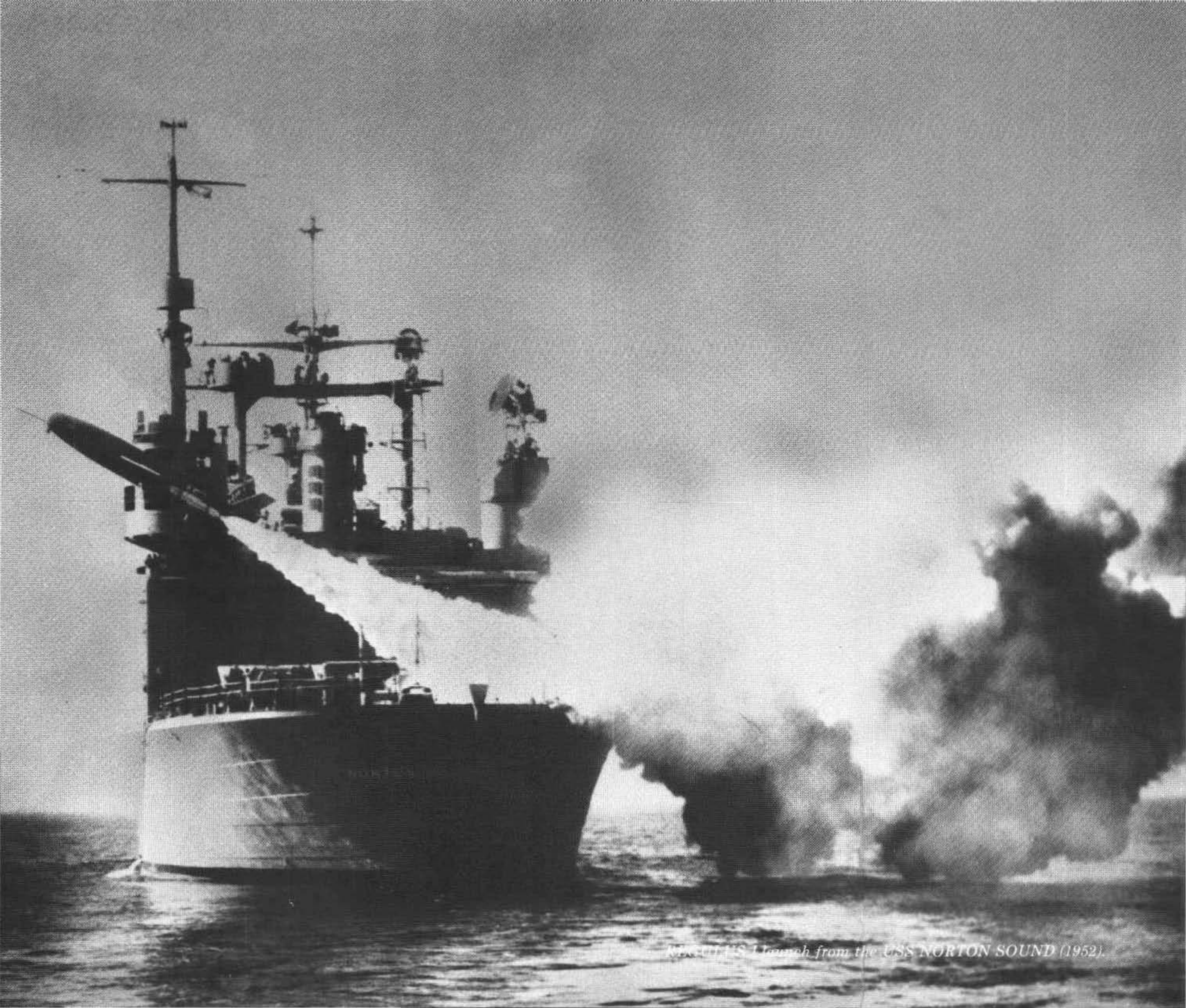

2


3





1. Point Mugu's commanding officer, CAPT R. S. Hatcher, with Fleet Admiral Nimitz during visit (1947). 2. DRAKE missile on short launcher (1949). 3. View of NAMTC from Laguna Peak. 4. Building 1, the new Administration Building (1950). 5. Building 34 (hangar) in background, and Building 35 (Missile Test Building) under construction in foreground. 6. Building 50, the Range Instrumentation Building, under construction in early 1950's. 7. Instrumentation vans on Laguna Peak (late 1940's).



REGULUS I launch from the USS NORTON SOUND (1952).

"There is nothing permanent except change."
—Heraclitus

CHAPTER 3

TRANSITION

For NAMTC the late 1940's and early 1950's were a period of transition. Several programs initiated during World War II and subsequently transferred from other facilities to Point Mugu were gradually coming to an end. Other programs, started soon after the end of hostilities, were winding down or falling victim to rapid advances in technology. At the same time, new missiles and targets were appearing on the scene to occupy the attention and imagination of NAMTC engineers and technicians.

Launching, propulsion, guidance, and instrumentation technology were also in transition. For example, progress was being made in the use of the short-rail and zero-launch techniques, internally mounted power plants—pulsejet and ramjet—were being investigated, and guidance systems using radar were opening up a relatively new field—electronic countermeasures and counter-countermeasures.

For several more years, missiles such as LOON, LARK, and GORGON would continue at Point Mugu, but soon new names—REGULUS, RIGEL, ORIOLE, and SPARROW—would join the lexicon.

LOON

Before proceeding with a description of new missiles and technology, a few final words should be said about the LOON. By 1949, it was becoming evident that the missile had reached a point where its principal employment was as a test vehicle. The almost daily problems and solutions that had attended the LOON program had produced invaluable advances that set the stage for surface-launched weapons of far greater range, accuracy, and lethality.

During its years at Point Mugu, LOON had shown the feasibility of launching guided missiles from naval vessels, rocket launching from a surfaced submarine, and guiding a missile over an extended flight path by the use of relay stations. Also, progress had been made in improving reliability and controllability to the limits imposed by the material and equipment available. Although LOON would still make some further contributions, in 1949 NAMTC recommended to the Navy Department that more emphasis be placed on Fleet exploitation of the remaining missiles.

LARK

In the area of guidance and control technology, two different systems were being investigated using the surface-to-air, liquid-propelled LARK missile airframe. The LARK missile system developed by the Fairchild Engine and Airplane Corporation utilized the SKYLARK guidance system, consisting of a passive-type radar target seeker for terminal guidance and a radio-link with automatic computer for mid-course guidance, while the missile system manufactured by Consolidated-Vultee Aircraft Corporation (CVAC) used a beam rider mid-course guidance system with an active radar target seeker.

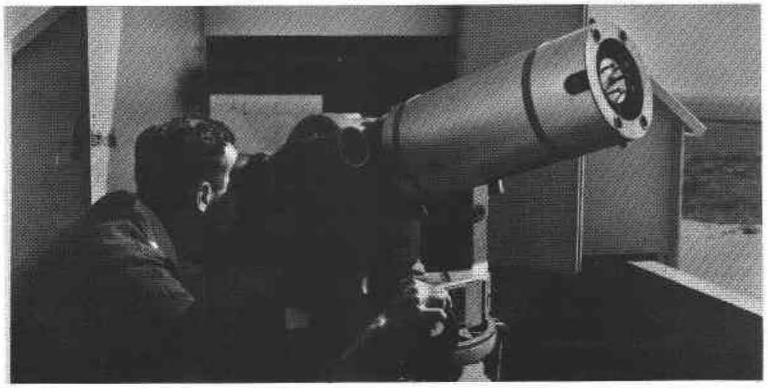
Through 1949, both contractors had performed the initial phase of testing at NAMTC and the Naval Ordnance Test Station, Inyokern, California, but no marked success had been achieved. One LARK, built by CVAC, did achieve a record flight time of four minutes and 56 seconds, but it was not until January 13, 1950, that a major breakthrough occurred. On that date, a LARK, XSAM-N-4, Number 90, utilizing an active target seeker, successfully homed in on an F6F drone.

During the following year, on December 18, 1951, LARK performed perhaps its most successful flight when, for the first time in the history of NAMTC, a guided missile made a contact hit on an aerial target. (Previous "kills" had been a result of the missile passing within lethal range.) In this operation, the missile launched at a 20-degree elevation angle was controlled along the flight path and impacted the F6F near the left wing root. The left wing panel was torn off and the target burst into flames.

COUNTERMEASURES

In keeping with the development of radar guidance, a new phase of testing was initiated at Point Mugu on December 5, 1950, when a countermeasures project and program were established for the purpose of testing and evaluating missile susceptibility to countermeasures. This work was to be performed concurrently with the test and evaluation of missiles and missile components. The program, considered at the time to be one of the most important undertakings introduced thus far at NAMTC, placed the Center in the forefront of electronic countermeasures (ECM) technology. The BuAer's letter, Aer E1-901.1, Serial 03458, of March 1951, set forth the official purpose:

> *"The development of a versatile guided missile target seeker simulation test range whereby guided missile target seeker components can be expeditiously and economically tested for susceptibility to countermeasures under pseudo-operational, i.e., physically scaled down, conditions."*



Point Mugu theodolite station (1950).

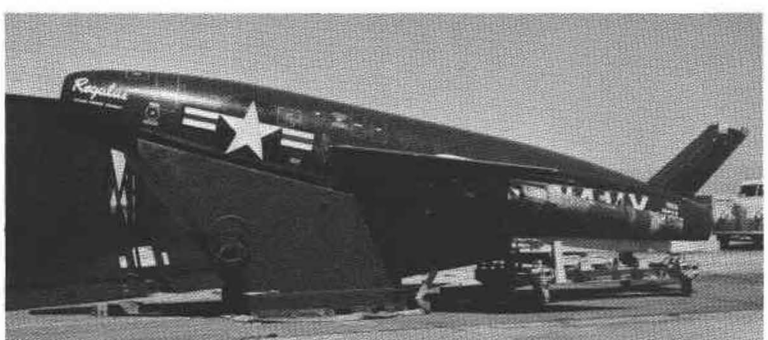
REGULUS I

Although the REGULUS (later REGULUS I) came to NAMTC in 1947 in the form of a model drop test program, it was not until two years later that an actual flight test program began. The purpose of the project was to demonstrate the general workability, including freedom from recurrent material failure, of the XSSM-N-8, REGULUS, a 500-mile-range, surface-to-surface, subsonic, guided (cruise) missile and its components.

Before the test program began at Point Mugu, a program was initiated at Edwards Air Force Base (AFB), California, to demonstrate the low-speed flight control and recovery characteristics of a REGULUS Flight Test Vehicle (FTV). The tactical plan for the FTV was to climb to 35,000 feet, after a JATO launch from a short-rail launcher, and cruise at Mach 0.9, guided first by pre-set dead reckoning controls and later by missile-mounted electronic distance measuring equipment working in conjunction with surface beacons. The FTV program consisted of low-speed taxi tests, high-speed taxi tests, and flight tests.

The initial test in the flight program was unsuccessful, so it was decided to make 20 simulated flight tests. This program had not progressed far before it was discovered that there were problems in the hydraulic servo system. Corrective measures were taken, and the second FTV completed the endurance runs without incident. The first successful flight test was then made on March 29, 1951, and by September of that year, a total of 11 flight tests had been completed. Successful recovery of the test vehicle was achieved on 10 of these flights.

While flight testing was underway at Edwards AFB, zero-length launcher tests were conducted at NAMTC. Also, a training program was undertaken to prepare personnel directly associated with REGULUS radio control operations, and some special tests were performed at both facilities



REGULUS surface-to-surface guided (cruise) missile (early 1950's).

to determine the environmental shock and vibration problems resulting from JATO operation and engine-induced vibration.

One important side benefit of the REGULUS FTV program was the very good reliability achieved by the telemetry system. Approximately 95 percent coverage of the essential flight data was recovered and in only one operation did a failure occur. According to Technical Report No. 89:

> *"The value of the telemeter instrumentation for these tests cannot be overemphasized."*

TARGETS

The early 1950's witnessed an intense period of target flight test and evaluation activity, including laboratory testing of guidance and propulsion components for target drones. During 1951 and 1952, no less than ten separate Navy target programs and one Army target project were pursued at NAMTC. These programs are shown in the following chart:

Target	Purpose or Status
XKD6G-1 and 2	Testing of Kiekhaefer XV-105-2 engine
KDM-1	Controlled flight
KD6G-1	Completed Test Program
KD4G-1	Completed Test Program
KD2G-2	96 free flight tests
XKD5G-1	Laboratory and captive flight tests
KD2R-3	49 flight tests
Model 33M	18 free flight tests
Army Model XM-5	Flight and laboratory testing
Component tests	Gyroscope and gyro servo

Public interest in the target programs at Point Mugu was shown in a headline story in the Oxnard *Press Courier* in 1949. The article, reporting on the successful flight of the KD2G-2 target, quoted Defense Department statements:

> *"Speeds attained by the KD2G-2 are considered to be the fastest of any pilotless aircraft in the same weight class and will provide Navy gunners with a realistic target capable of making any type of approach to simulate attacking aircraft."*

LABORATORIES

Along with the major missile and target programs, the men and women of Point Mugu were kept busy with a number of special flight and laboratory projects. Examples were "Radiant Emission of Air Targets for Evaluation of Infrared Seekers," "Test and Evaluation of Guided Missile Miss-Distance Indicator," "Test and Evaluation of Magnetic Recorders for Telemetry," and "Test and Evaluation of Corner Reflectors."

To assist in obtaining aerodynamic data on missiles and targets, NAMTC operated one of the most advanced supersonic wind tunnels in the area. It was powered by the power plant from a World War II aircraft carrier.

FACILITIES

In keeping with the increasing workload assigned to the Center—a total of thirty-nine projects in 1952—numerous new facilities and rehabilitation projects were completed, placed under construction, or under contract. The first increment ($14,000,000) of construction was completed in 1952, and negotiations and actual construction were started on the second increment ($6,000,000). Some of the major facilities completed were the Instrumentation Building, Fuel Tank Farm, and the sewage system; nearly completed was the Air Blast Facility; and underway were the San Nicolas Island runway, the Missile Assembly Building, and additional space for the Industrial Relations Office (Personnel).

Total square footage of building space at the main base in 1952 came to 966,887 square feet, with an additional 53 temporary buildings on San Nicolas Island and 5,605 square feet of space on Santa Cruz Island.

COMPUTERS

In the early 1950's, NAMTC had one of the first large digital computers ever built, RAYDAC,* which was used as the nucleus of a real-time telemetry data reduction system. Called PROJECT HURRICANE (and later PROJECT BREEZE) it was an abortive attempt which nevertheless taught personnel at NAMTC a great deal about real-time data handling and digital processing. RAYDAC consisted of a large number of vacuum tubes and banks of mercury-filled acoustic delay lines. It was considered very advanced for that time and was "showcased" for visitors through a large glass window. Lloyd Ritland remembers:

> *"The computer had a built-in check on itself and malfunctions in its operation caused a halt. It then became the task of the operating personnel to discover the cause of the malfunction and correct it. With its operation depending upon thousands of vacuum tubes, the computer's reliability was low and the mean time between failure was usually on the order of 10 to 15 minutes. The maintenance personnel*

* Raytheon Digital Automatic Computer.

developed amazing abilities and clever tricks to restore the computer back to operation."

Also in this same period, NAMTC laboratories began to make use of analog and hybrid computers.

COMMUNICATIONS

In the very early days at Point Mugu, communications equipment consisted of a surplus shipboard-type magneto switchboard telephone system and several tube-type transmitter and receiver sets. Army field wire was used to interconnect the system. In 1947, NAMTC installed the first automatic telephone system which was used for both administrative and operational communications.

With the establishment of the Range Instrumentation Division in 1949, operational and administrative communications were made separate functions, and specialists were assigned the task of developing a communication system specifically for operational use. In 1950, an Army surplus radio carrier was installed for voice and data communications between San Nicolas Island and Point Mugu via Santa Cruz Island. Because of propagation fading and lack of reliability, the unit was replaced in 1954 by a Lenkurt radio carrier which incorporated space diversity. It worked better than its predecessor, but still experienced propagation and fading problems.

FREQUENCY INTERFERENCE MONITORING

In 1951, the first frequency interference and control section was established at Point Mugu. It consisted of three people, a corner of the receiver building for a monitoring facility, an old panel truck for chase down, and the shared use of an area-clearance aircraft. Prior to this, beginning in 1947, frequency management had consisted of one man with a telephone who had the responsibility of scheduling the use of radio frequencies. There was no monitoring, and with very poor records, no way to police their use.

TIMING

The timing section, established in the late 1940's, was quartered in a Quonset hut in the beach area. It was very limited in timing equipment as well as timekeeping. A crystal with a temperature-controlled oven was used as the primary standard. Accuracy was in the area of plus or minus two milliseconds (two one-thousandths of a second).

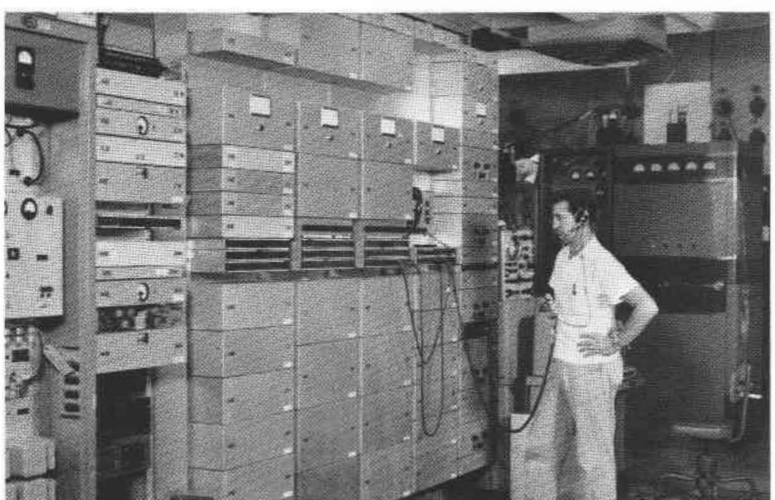
OPERATIONAL CONTROL

Operational control back in the 1940's and early 1950's was relatively primitive. Information from surveillance radars (surplus World War II devices) was interpreted by operators at the plan position indicator (PPI). Target coordinates were then relayed by telephone to the control center and plotted with grease pencil on a large plastic screen. The control centers were modeled after World War II shipboard Combat Information Centers and the plot board operators consequently had to be adept at writing backwards to display the target identification data and tracks as well as operation information.

Data from tracking radars, modified SCR-584 fire control devices, were displayed in track and control rooms adjacent to each radar. Analog data in spherical coordinates were converted to cartesian coordinates and plotted automatically on electro-mechanical plot boards. If everything worked, two target tracks would be displayed on each board, but only from adjacent radars. Instrumentation engineers had not yet developed sufficient technology to transmit radar data across the base, let alone from San Nicolas Island to Point Mugu. At that time there were three track and control rooms, two at Point Mugu and one on San Nicolas Island.

TRACKING RADARS/POSITION LOCATION

The initial requirements for determining the position of test vehicles, missiles, and aircraft on the range were met by adapting the fire control and weapon system radars to instrumentation systems. NAMTC used such systems as the M-33, the SCR-584, and an instrumentation version of the SCR-584 redesignated the AN/MPS-26. Mobile AN/MPS-26 radars provided a capability to relocate to a new site on very short notice.



Lenkurt multichannel phone system on San Nicolas Island (1954).

SURVEILLANCE RADAR

An early surveillance radar at NAMTC was the AN/SPS-8A. Installed on the Range Operations Building in the early 1950's, it rotated continuously in azimuth or back and forth in selectable azimuth sectors. The radar could provide the normal PPI range/azimuth display and an elevation display. Primarily an air surveillance instrument, the SPS-8A was accurate to eleven degrees.*

For sea surveillance coverage, AN/APS-20 S-Band radars were installed in the early 1950's at Laguna Peak, San Nicolas Island, and Santa Cruz Island. These radars were extremely simplified one-megawatt, magnetron-based instruments that provided continuous coverage. They could detect small boats from fifteen to thirty nautical miles, but were blocked at shorter ranges by sea states greater than 3.**

To further increase surface surveillance, AN/APS-20 radars were flown aboard S-2 and EC-121 aircraft. At 2,000 feet altitude, these radars could provide coverage at one square meter cross section on larger surface boats from twenty to forty nautical miles distance. The radars could achieve this because of their one-megawatt power, S-Band frequency, two-microsecond pulse width, and relatively narrow azimuth bandwidth.

RANGE COMMANDERS COUNCIL

By 1950, the United States had established three major test ranges: the White Sands Proving Ground, New Mexico;

*The AN/SPS-8A was removed in 1975.

**The AN/APS-20's are being replaced with AN/FPS-14 radars that are solid state and have a very narrow pulse width and antenna beamwidth for resolution of small boats.

the NAMTC, California; and the Long Range Proving Ground, Florida. The Commanders of these ranges, recognizing that they had mutual interests, decided to meet and discuss ways of assisting each other in solving common problems. At the first meeting at White Sands, New Mexico, in August 1951, the Range Commanders Council (RCC) was formed. It was quickly realized that many range problems involved instrumentation and its use, and that these could only be resolved at the working level by appropriate engineers and technical specialists. As a result, the Commanders agreed to have representatives meet on a regular basis thus establishing the Inter-Range Instrumentation Group (IRIG). The working groups composing IRIG included Data Reduction and Computing, Electronic Trajectory Measurement, Frequency Management, Meteorology, Optical Systems, Telecommunications, and Underwater Systems.

The purposes behind the Range Commanders Council are summarized in the following quote:

> *"The objective of the Range Commanders Council is to preserve and enhance the efficiency, effectiveness, and economical operation of member ranges, individually and collectively, thereby increasing the national capability for research, development, and operational test and evaluation.*
>
> *"The scope of the activity is to resolve common problems; discuss range matters in an organized forum; exchange information and control duplication; conduct joint investigations pertaining to research, design, development, procurement and testing; coordinate major or special procurement actions; and develop operational test procedures and standards for present and future range use."*

SECNAV J. L. Sullivan and CAPT R. S. Hatcher (1947).

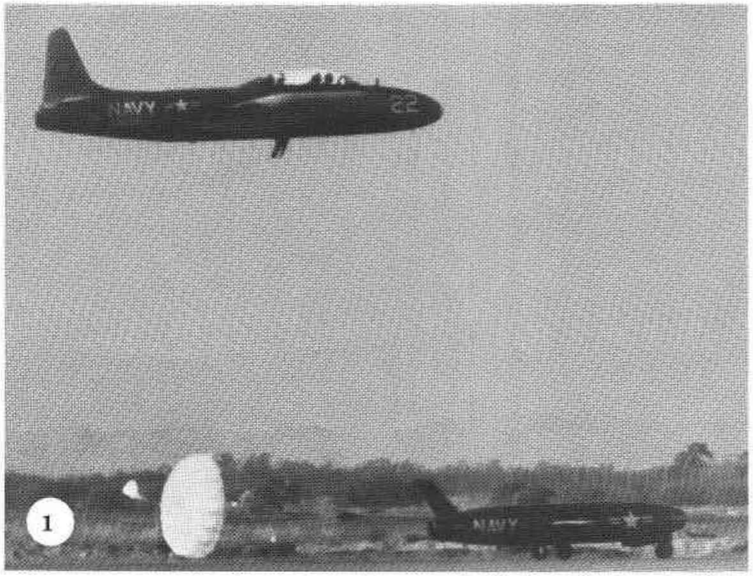
In all RCC matters, the generic term "range" was intended to include test centers as well as the conventional use of the word.*

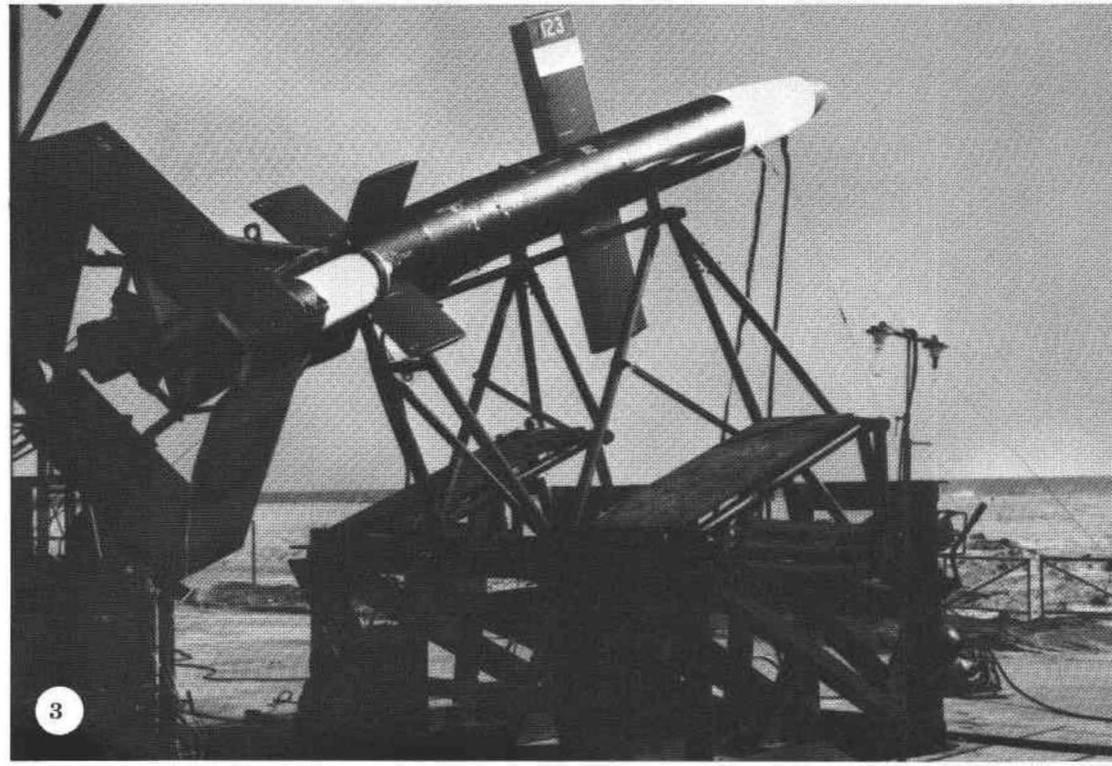
VISITORS

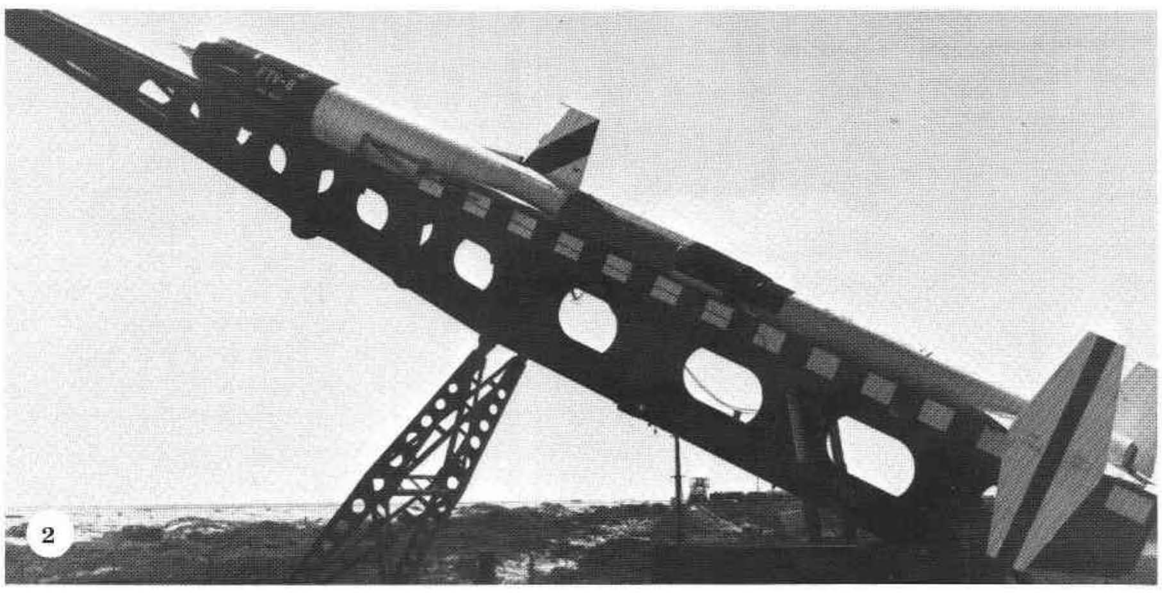
In addition to new work and new facilities, Washington also showed its support for NAMTC through the visits of numerous officials including two Under Secretaries of the Navy, an Assistant Secretary of the Navy, several admirals, and even a number of high-ranking Canadian and British military and civilian officials.

---

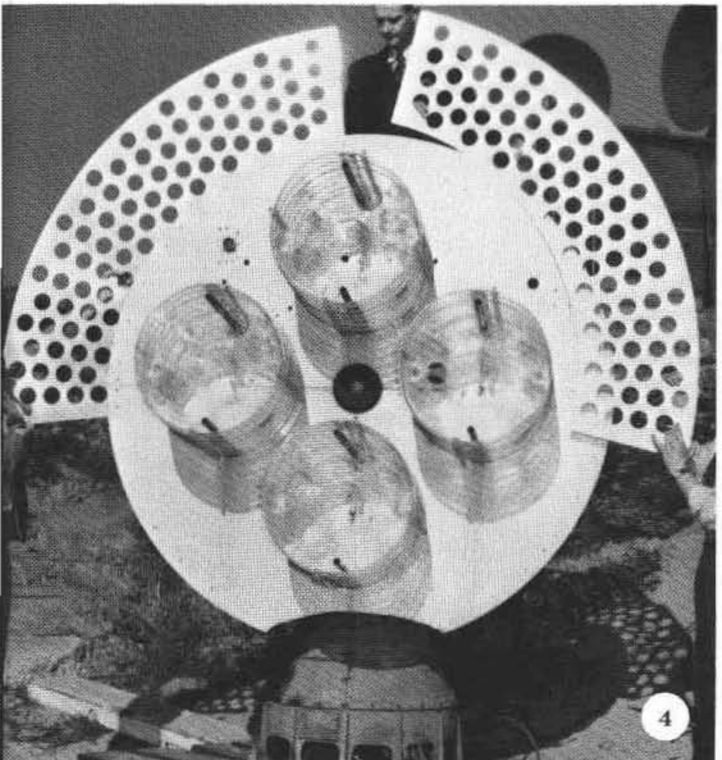
* Since its establishment, several changes have taken place in the original Range Commanders Council. Membership has increased to thirteen and includes the major test centers within the Department of Defense (DOD) concerned with aircraft-related testing as well as missile ranges. Also representatives from 85 DOD and non-DOD government agencies participate in the activities of special groups.



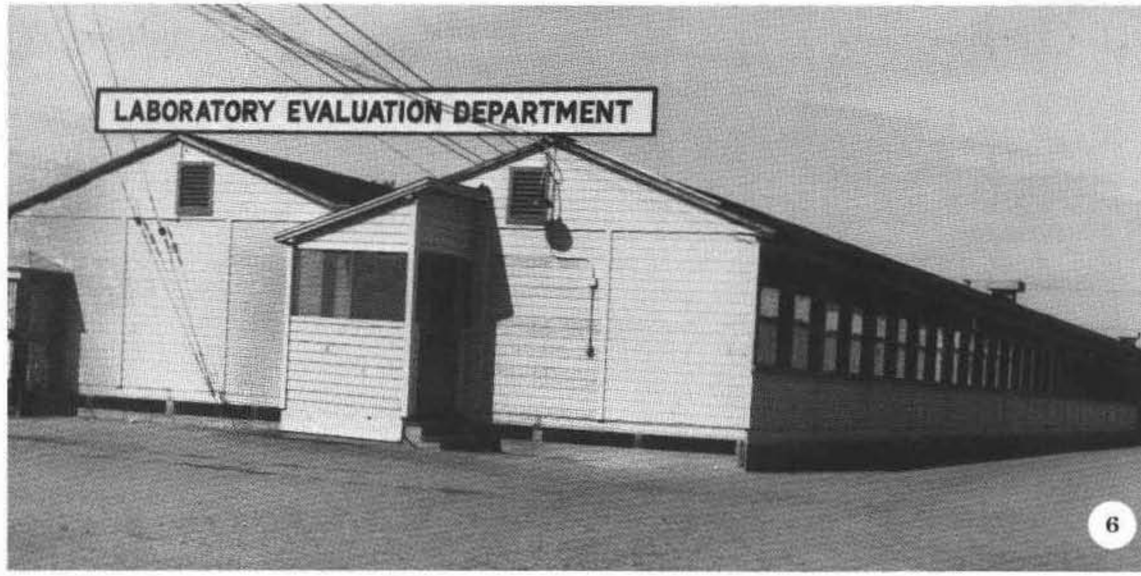




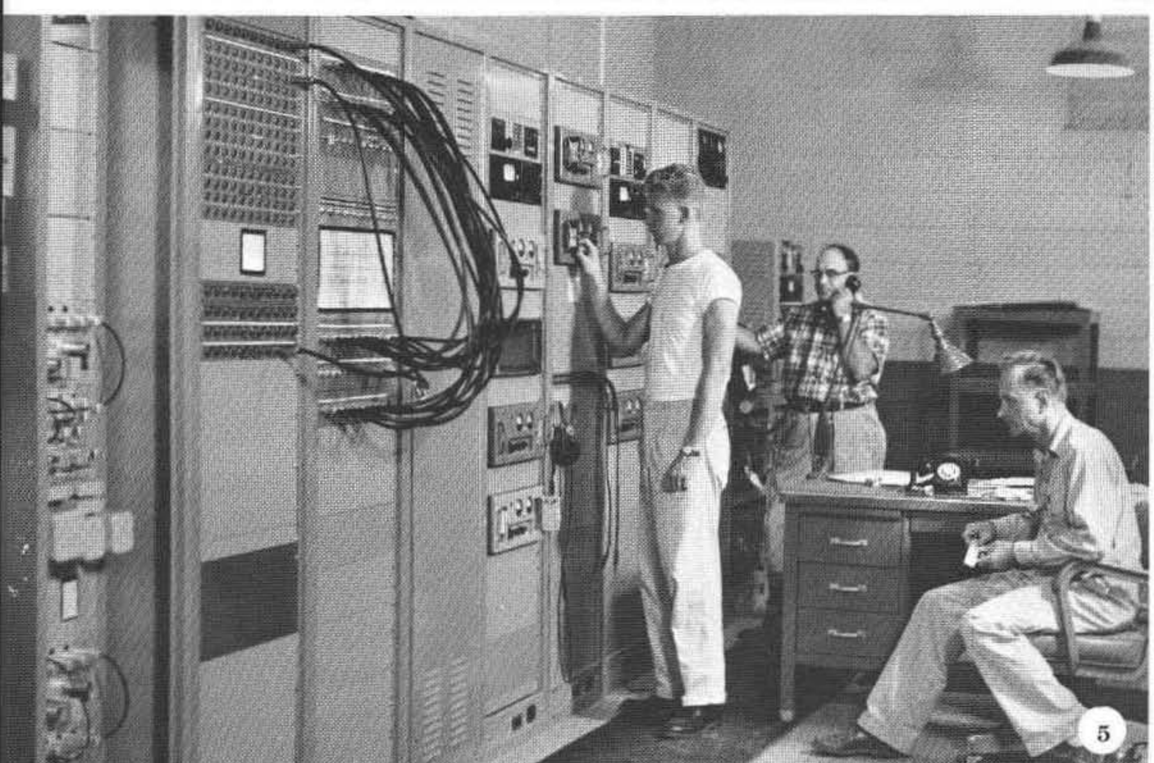
1. T-33 aircraft guiding a REGULUS I missile to a perfect landing. 2. RIGEL missile waiting to be fired. 3. LARK radar-guided missile (circa 1950). 4. Teletracker helical antenna with extended ground plane (1951). 5. Patch Panel Receiver on San Nicolas Island. 6. Laboratory Evaluation Department Building 6-2 in "Six Area" at Point Mugu. 7. SPARROW I missile ready for a restrained firing.



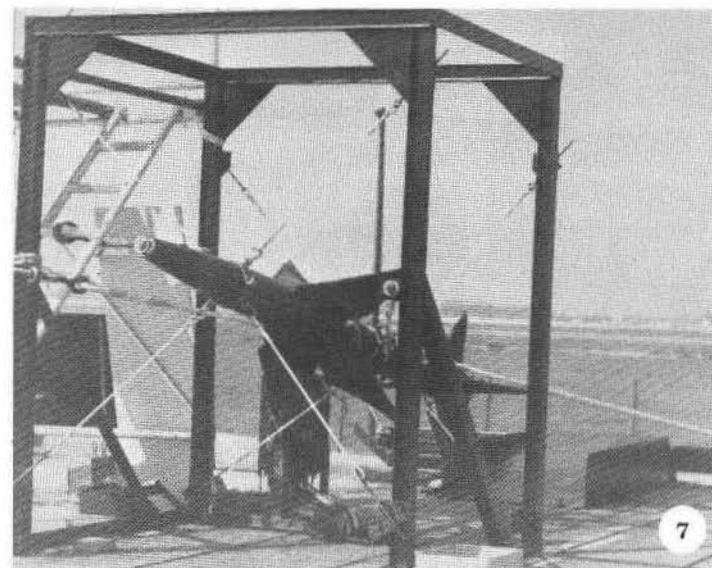
4



6

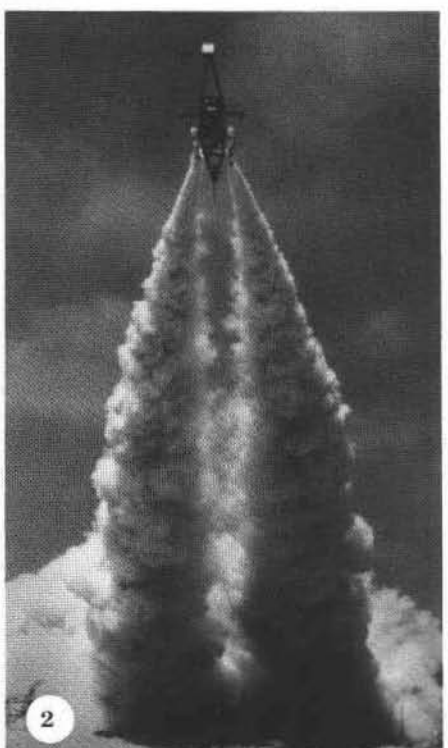


5



7

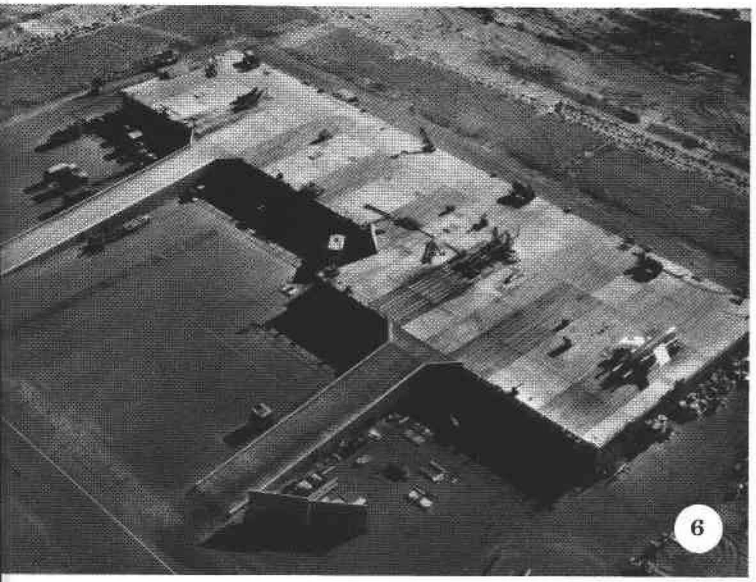

1


2


3


4


5

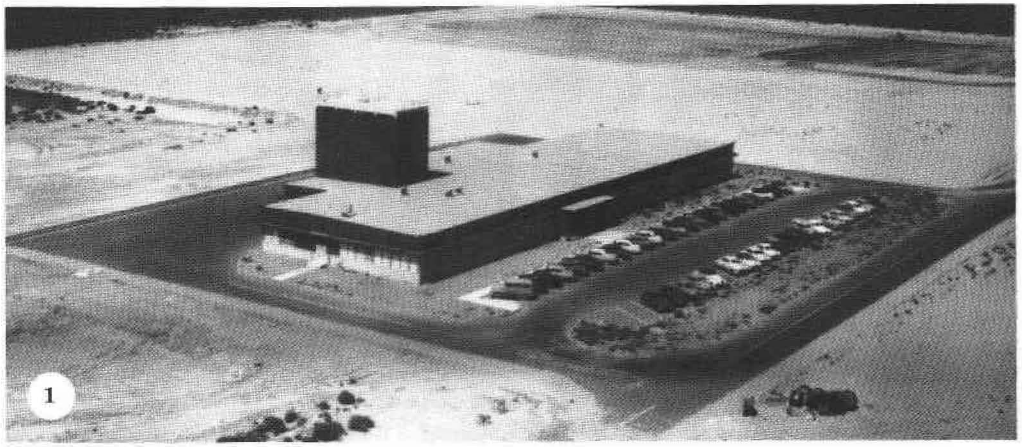


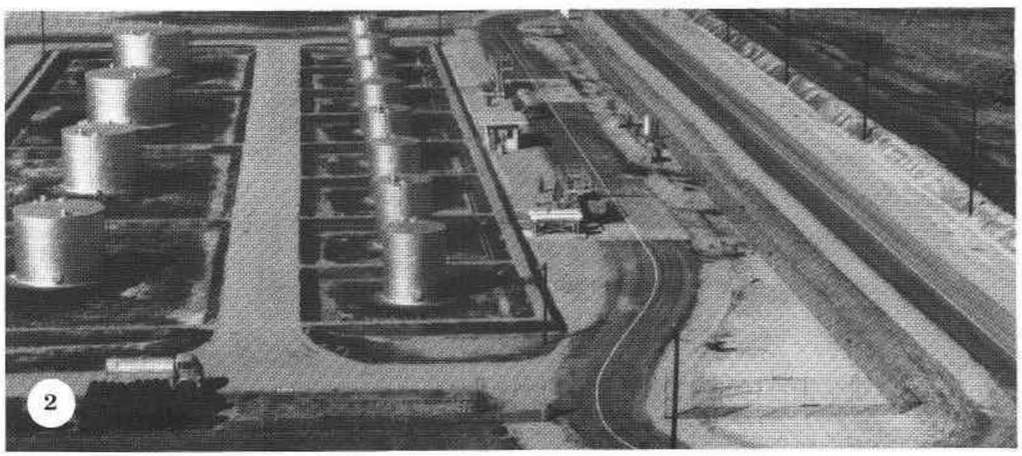
6

7

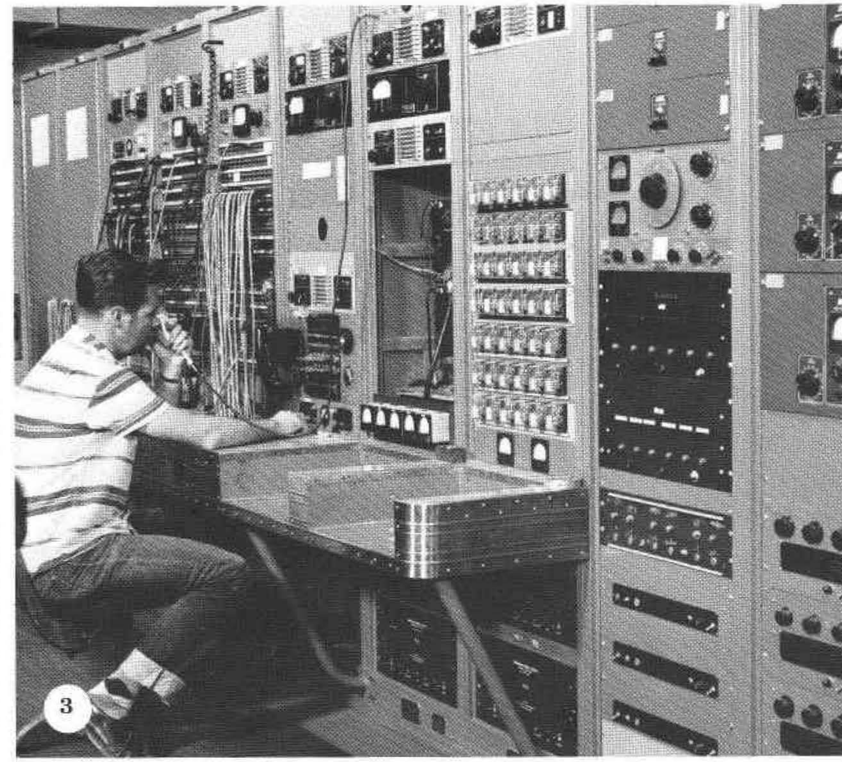
8

1. Wind tunnel for testing air-injected engines such as ramjets (1950). 2. Launch of a dummy REGULUS I SAM-N-2 (1950). 3. REGULUS I SAM-N-2 launch from Point Mugu beach pad. 4. Raytheon Digital Automatic Computer (RAYDAC) at NAMTC (1953). 5. Headquarters building for NAMTC (1950). 6. Launch pads (Building 55) with REGULUS I on pad at right (1950's). 7. Underground control room on San Nicolas Island (1957). 8. Rocket Test Facility Shop, Building 6-23, in "Six Area" (1957).





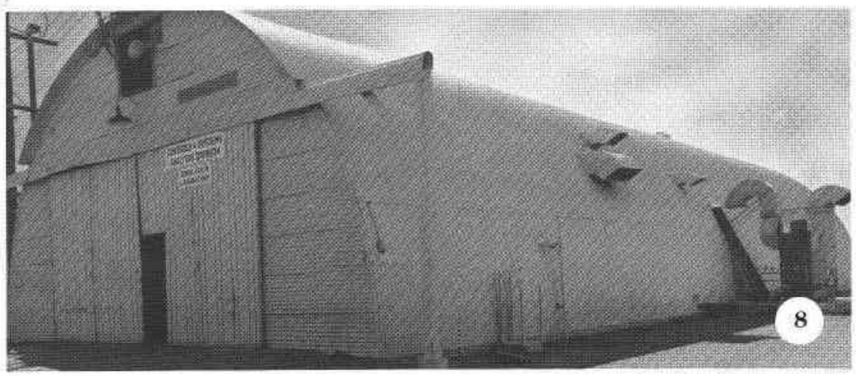
1. Recently completed Range Instrumentation Building (Bldg. 50) at Point Mugu (1951). 2. Point Mugu tank farm (1952). 3. Control Panel Transmitter on Santa Cruz Island (1957). 4. Target drone on AT-1 catapult at Point Mugu beach (1950). 5. CAPT Dudley discussing scale model of NAMTC with SECNAV (AIR) J. F. Floberg and VADM J. Cassady (1950). 6. KD6G-2 target drone suspended under 32′ recovery parachute (1954). 7. Range Commanders Council (RCC), established in 1951. 8. Early-day simulation laboratory. 9. WV-Z (EC-121K) Constellations lined up on Point Mugu airstrip (1959). 10. San Nicolas Island telemetry station (1957).



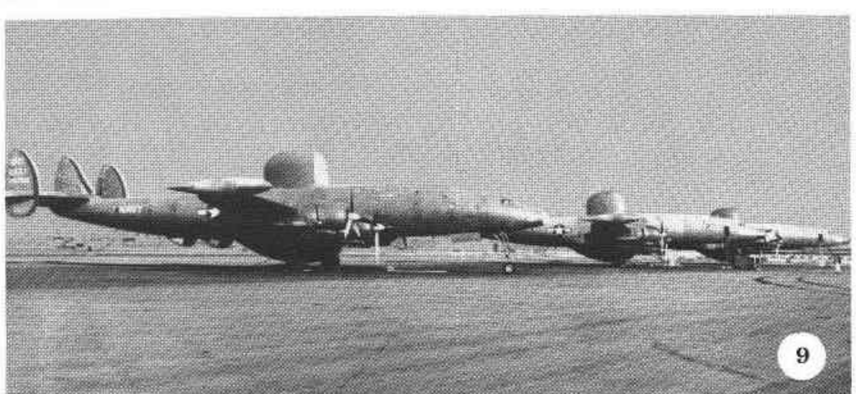
5

7

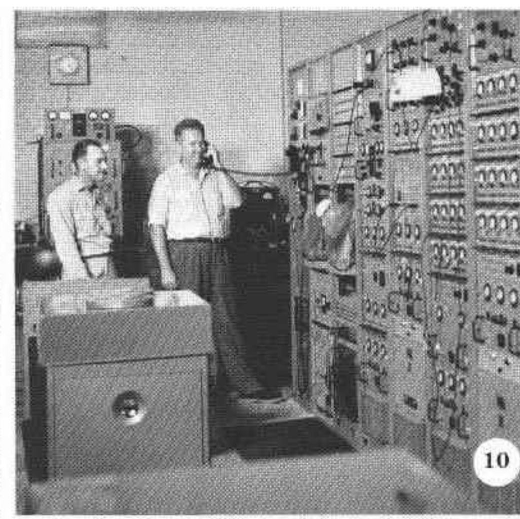
6



8



9



10

F6F aircraft with XAAM-N-2 SPARROW missile No. 9 on wing pylon (1950)

"It takes a long time to bring excellence to maturity."
—Publilius Syrus

CHAPTER 4

COMING OF AGE

As NAMTC approached its first decade, the Center had reached the position of being a major Navy test facility and a valuable national asset. The growing pains of the early years, followed by a period of expansion and consolidation, had produced a framework in which trial and error testing was rapidly being replaced with scientific procedures that incorporated both flight and laboratory testing. Test and evaluation was developing into a distinct engineering discipline upon which the future of NAMTC would be built. At the same time, the range was gradually becoming one of the most highly instrumented sea test areas anywhere in the world, and long range plans envisioned even further increases in size and scope.

During the first half of the 1950's, major missile programs centered on the surface-to-surface REGULUS; the surface-to-air RIGEL; the air-to-surface anti-radiation CORVUS; the short-range air-to-air missile family SPARROW I, II, III; and the long-range air-to-air METEOR and ORIOLE. Also, as each weapon was tested, countermeasures research attempted to provide a simulated but realistic electronic threat environment. With greater weapon sophistication, new laboratory techniques were developed to help "prove" components before they were launched in a missile or test vehicle.

SPARROW

The SPARROW I, II, and III programs which began in 1950 actually represented three approaches to developing an air-to-air combat weapon that could replace cannons and guns on fighter aircraft. The original concept was to use the same engine, warhead, and control package for the missiles. Different seeker heads would be installed to make the missile a beam rider (SPARROW I), fully active radar (SPARROW II), or semi-active radar (SPARROW III). SPARROW I was built by Sperry Gyroscope Company, SPARROW II by Douglas Aircraft Company, and SPARROW III by Raytheon Manufacturing Company. SPARROW I and III received the majority of the test time from 1950 to 1955.

The SPARROW I was a short-range missile (two to six miles) designed to ride a radar beam directed at the target by the launch aircraft. Rear Admiral C. C. Andrews (USN, Ret.), the Project Officer, remembers a test conducted on the launcher prior to the first air launch:

> *"We conducted the test using an inert piece of pipe the shape of the yet-to-be-launched missile. The launcher design seemed ingenious—small ramps to force the missile down and away from the aircraft as it was fired. It was quite a milestone and so dignitaries from Washington were on the beach to observe as were most of the Mugu personnel. Range instrumentation had it well covered and communications were on loudspeakers so everyone could hear.*
>
> *"The launch pattern was for me to fly low over the station, pull up at the beach and fire. There was just one problem. Instead of the missile being forced down, it forced the aircraft wing up with no small shock. Captain Al Packard used to like to recount the*

countdown as it came from the aircraft—'5, 4, 3, 2, 1, God Almighty!' The launcher was redesigned prior to the next launch."

The first launch of an actual missile was made remotely from an F6F-5K drone aircraft, a modified World War II Hellcat fighter. The decision to make the launch from an unmanned aircraft resulted from a tragic incident in 1942 at the Naval Ordnance Test Station when Lieutenant Armitage was killed during a missile test that resulted in the rocket exhaust destroying the launch aircraft's tail surface. Max White recalled the first launch:

"Before we dared to make any air launchings, SPARROW or otherwise, we first conducted ground tests to determine what effect a motor explosion under the aircraft wing would have on the aircraft survivability. We then transported a fully-equipped F6F-5K to the beach, held it aloft with a crane, and fired a SPARROW missile from a wing-mounted launcher. Since the aircraft survived these tests, we were emboldened to attempt a firing from an aircraft, though still an unmanned one.

"At this time the SPARROW Project Office and general test operations were entrusted to three people: Lieutenant Jack Miller, Lieutenant (junior grade) Don Heile, and myself. About six weeks before the firing, I had an alternate control transmitter shipped to San Nicolas Island as a back-up for the primary airborne firing control to be flown aboard an F-7F fighter. The missile was shipped early the day of the test and the drone was flown there later under onboard pilot control. There the missile was fitted to the aircraft.

"With the F6F-5K drone airborne, I headed for the underground to man the alternate firing transmitter. Arriving there I found that no one knew where the transmitter was! We went on a frantic hunt to find it. We finally did and got it operating just as Jack Miller in the F-7F was turning into the firing leg of the pattern with the missile-armed F6F-5K drone.

"Lieutenant Miller made the countdown and pressed the arm and then the firing button, but nothing happened. He came around the second time and repeated the operation. Still the missile did not fire. It was then that Jack called to me to use the alternate transmitter for the third try. This time I pressed the arm and then the firing button. First there was silence and then after about five seconds I heard him say, 'It's off, it fired!'

"It turned out to be a successful test and it didn't destroy the launch drone in flight. But there was something else we did not know. When we brought the drone in at San Nicolas Island, it cracked up and we later learned the launcher had been defective. Had the drone been forced to land with the live missile it would have taken off from the launcher in the direction of the enlisted men's barracks. Thus it was most fortunate we did get it off on the third try.

"After that there were no more firings from drones. The next air launch was made by Lieutenant Commander C. C. Andrews, later Rear Admiral C. C. Andrews (USN, Ret.)."

April 2, 1951—a big day—SPARROW I achieved the first successful test in which it rode a radar beam. In this case the missile was launched from the SPARROW 35-degree, short length ground launcher employing a booster equipped with a JATO rocket. The launch, boost, separation, and motor burn phases were normal. Radar plots and theodolite trajectory established that the missile stayed within the beam for a minimum of 18 seconds of the 40-second flight. In July 1952, the first prototype SPARROW I was air launched, and, before the year-end, the missile achieved a direct hit on an Air Force QB-17 target drone on December 3. Rear Admiral C. C. Andrews (USN, Ret.) tells the story of this first intercept:

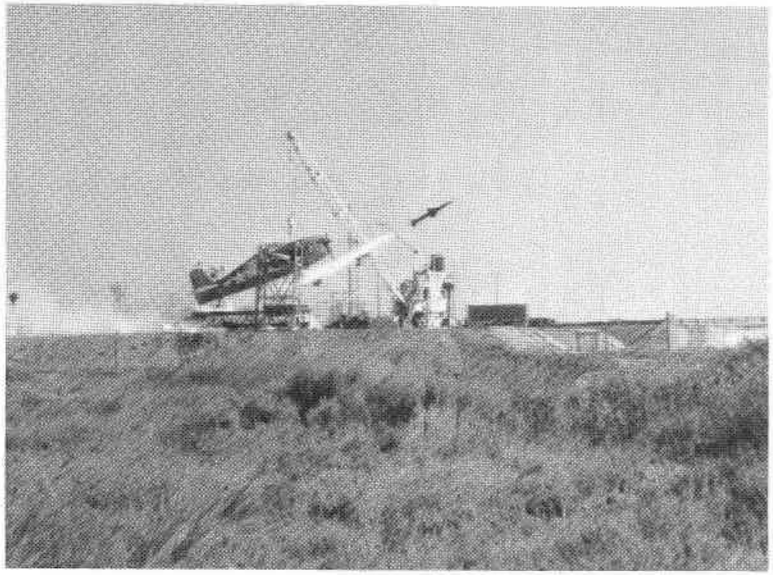
> *"The SPARROW I rode a fixed beam and the technique was to point the beam at a target (B-17) approaching in a head-on aspect. The missile went through the engine into the leading edge of the wing and out the trailing edge of the wing. It left a tail fin on the aircraft spar. It was a far cry from a tactical weapon, but a great boost to the air-to-air missile program. To our knowledge, it was the first in the world to hit an aircraft. Mugu was on the leading edge of the missile age."*

Other major accomplishments in the SPARROW I program at NAMTC are summarized below:

Date	Accomplishments
September 22, 1953	First production model flight
October 8, 1953	First ripple firing
June 7, 1954	Live MARK VI warhead launch
June 18, 1954	First warhead kill
July 29, 1954	First launch from carrier-operated aircraft
April 6, 1955	Completed first successful Fleet evaluation
July 1955	First "pitch up" climbing attack — target hit
November 29, 1955	First successful all-weather night attack

One interesting sidelight of the SPARROW I program was related by Gail Gerblick:

> *"The SPARROW I was somewhat state-of-the-art in manufacturing techniques and at the time there was a possibility we would want a large quantity. So we went out on a parallel contract for a design which we called 'Tinkertoy' SPARROW I. It was a modular approach which would be very current today. The concept of little replaceable units means you can easily replace a defective unit. The same concept is used in the F-14 today and in many other weapon systems."*



F6F aircraft captive launch of SPARROW missile, Pad Baker.

SPARROW II, a fully active radar-guided missile, was air launched for the first time on July 25, 1952. Although telemetry was lost after 16 seconds, the supersonic portion of the flight was achieved and all test objectives were met. In August 1954, the SPARROW II missile achieved what is believed to be the first single target kill when launched against multiple targets. The complexity and cost of the SPARROW II missile with its vacuum tube technology contributed to its demise. Solid state integrated circuits, yet to be developed, would revive the concept two decades later.

Testing of the semi-active radar-guided SPARROW III began at Point Mugu in April 1952 with a ground launch of a LARK missile in which several prototype guidance components were installed. An air launch of the component test vehicle followed in November. Significant tests conducted at NAMTC between 1952 and 1955 were as follows:

Date	Accomplishments
February 12, 1953	First complete SPARROW III launched from an F3D aircraft
July 30, 1953	First free flight test
October 16, 1953	Successful guidance flight; launched head-on against F6F target
September 16, 1954	Contractor day-fighter system demonstration flight
August 12, 1955	First live warhead flight; target destroyed

By 1955, SPARROW III had finished the developmental test phase in which 24 missiles were launched—14 developmental and 10 demonstration. It was concluded that the missile demonstrated "a potentially high lethality and around-the-clock attacks (from any point of the compass) were possible at medium and high altitudes." Accuracy, reliability, serviceability, and type of attack were also investigated. In February 1955, BuAer directed NAMTC to proceed with a Navy Technical Evaluation (NTE).

ORIOLE

In an effort to develop a long-range (25 miles) active homing air-to-air missile system the ORIOLE project was established in 1947. In 1948, the project was stopped as a missile project but allowed to continue as a guidance development program. However, it was soon discovered that this was not practical, and a small-scale design study of the missile and guidance was carried on. In 1950, the ORIOLE was reactivated as a research test vehicle. The program came to NAMTC the same year and in October 1951 was redesignated as an experimental air-to-air missile.

F3D (F-10) aircraft launching a SPARROW missile (1950).

By the time the ORIOLE began its test program, the specifications had been redefined to a missile capable of use against targets at ranges of five nautical miles, such targets to be capable of speeds up to Mach 0.9. The flight test program involved fifty-six ORIOLE plus three dummy missile launches. In addition, NAMTC performed roll balance tests (to determine the magnitude of the rolling moments that were encountered during launching), restrained firings and ignition shock tests, missile break-up theoretical studies, aerodynamic evaluations of the airframe, and environmental evaluations.

REGULUS I

By March of 1953, the ongoing REGULUS FTV program mentioned in Chapter 3 had accumulated 40 flights at NAMTC and Edwards AFB. These flights demonstrated the possibility of early Fleet use of the missile with control and warhead detonation exercised by escorting fighter aircraft.

To provide for early Fleet deployment, the CNO established the REGULUS Assault Missile (RAM) program. The program would give selected cruisers and carriers a medium-range attack weapon for use against heavily defended targets. Accuracy was to be that of a piloted aircraft dropping bombs. At the time, it was anticipated that REGULUS would be equipped with high-explosive warhead and television guidance for use against small important targets, or special warheads capable of either air, surface, or subsurface bursts for use against area targets.

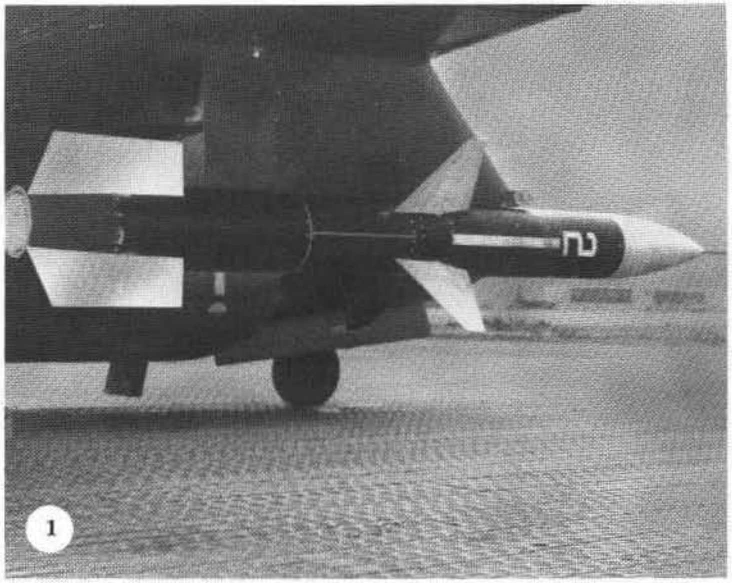
The REGULUS FTV would fly various tactical profiles after launch from the dry lake bed at Edwards AFB. Besides its use in training personnel in preparing, launching, and controlling such a vehicle, the program would be used to evaluate assault missile techniques and equipment.

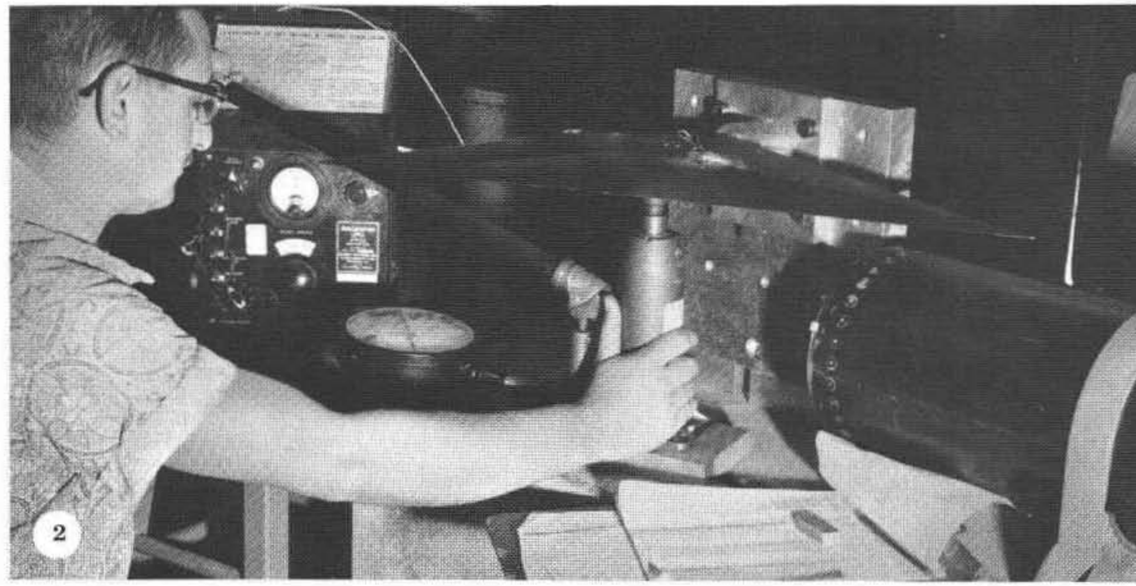
Later in 1953, NAMTC undertook another phase of the REGULUS program when it was assigned the launching of dummy missiles from the submarine USS TUNNY. These launches, which took place on June 18 and 30, were the first in which the short-rail launcher was installed on a submarine. An important part of these operations was the first flight demonstration of the REGULUS Integral JATO Ejection System developed at NAMTC. The tests of the dummies proved successful and the launching configuration satisfactory. Use of the Integral JATO Ejection System and flight tests of the REGULUS from a submarine were recommended for the future.

While developing another REGULUS launcher, a portable unit to be placed aboard carriers, Gail Gerblick remembers one of a series of tests made to determine what would happen if inadvertently one of the boosters did not fire as planned:

> *"We intentionally disabled one of the two boosters and ignited the other. We found out exactly what we were interested in. It would be a catastrophe because the missile picked up the launcher and then peeled it back like a piece of ribbon candy. We tried to tie it down for the next launch and the only things that held were the ties."*

In a second approach to launching REGULUS from a carrier, a special cradle was designed for use with the newly introduced aircraft steam catapult, a British innovation just coming into use by the U.S. Navy. The USS HANCOCK, one of the first carriers to be retrofitted, was chosen for the test. The feasibility of launching REGULUS using the steam catapult was demonstrated by two successful missile launches following two successful tests using dummies.

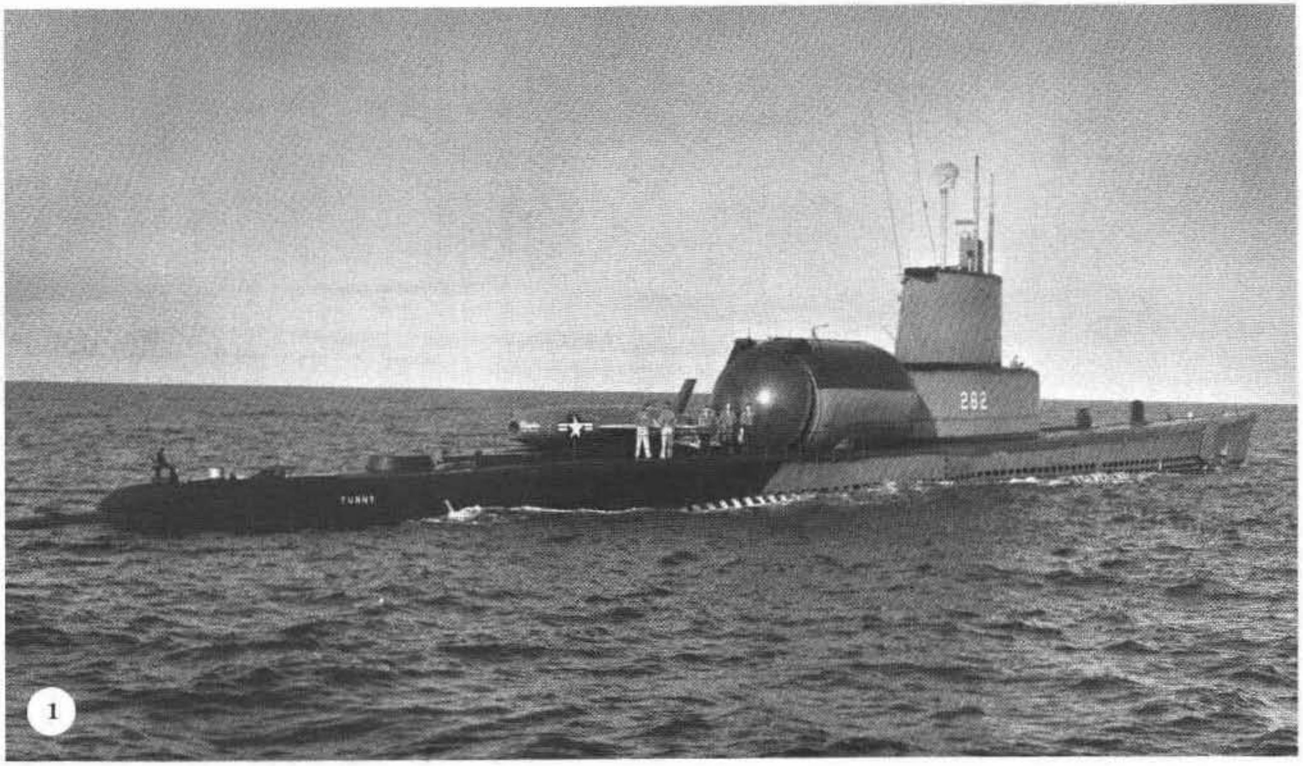

1

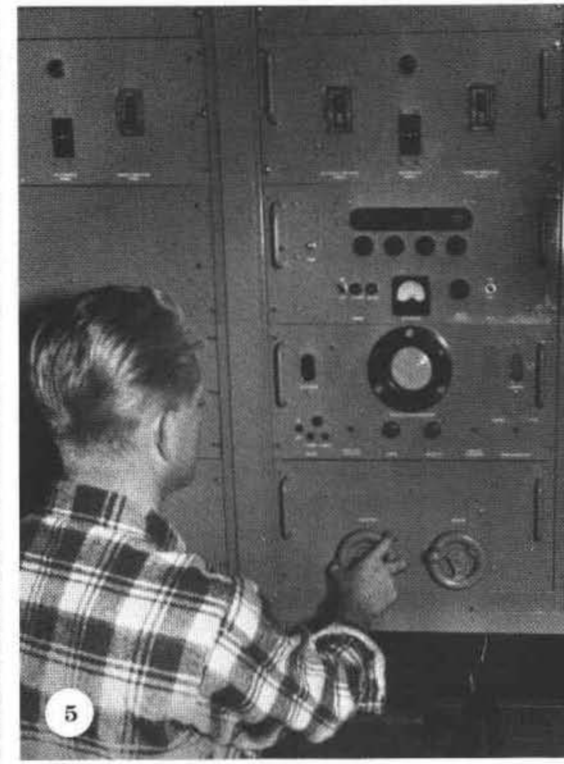

2


3

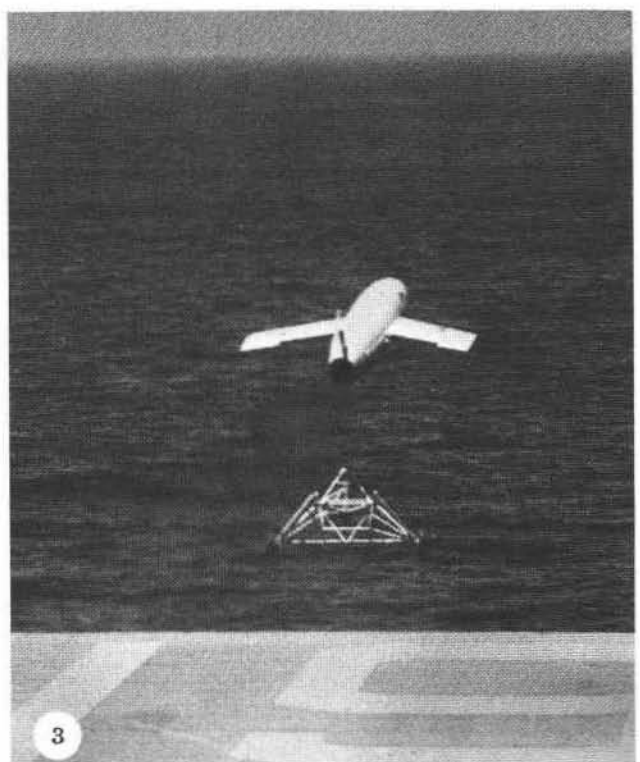

NAVY
4

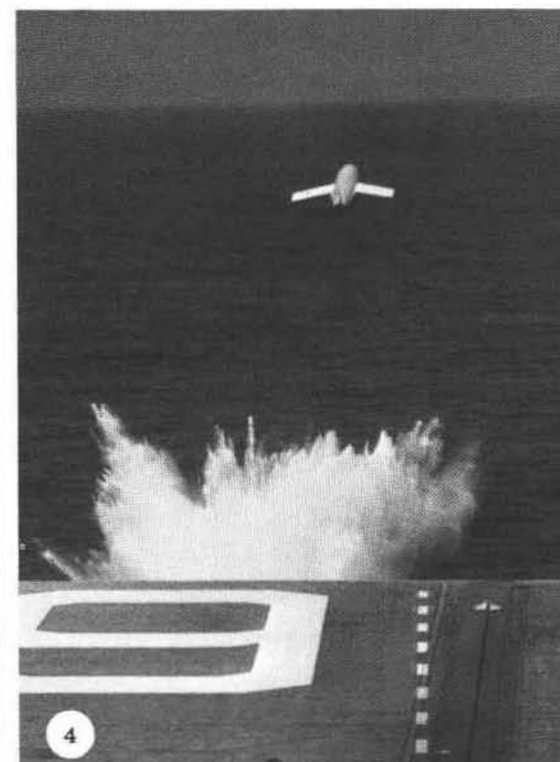
1. ORIOLE missile on F3D aircraft wing pylon. 2. A stress test stand in laboratory (1955). 3. F6F drone aircraft at Point Mugu (1958). 4. F7U aircraft with four SPARROW I missiles (1955). 5. F3D aircraft with SPARROW II missile mounted on wing. 6. SPARROW I missile on the wing of a F3D aircraft. 7. CTV-N-10 LARK missile No. 99 on launcher.

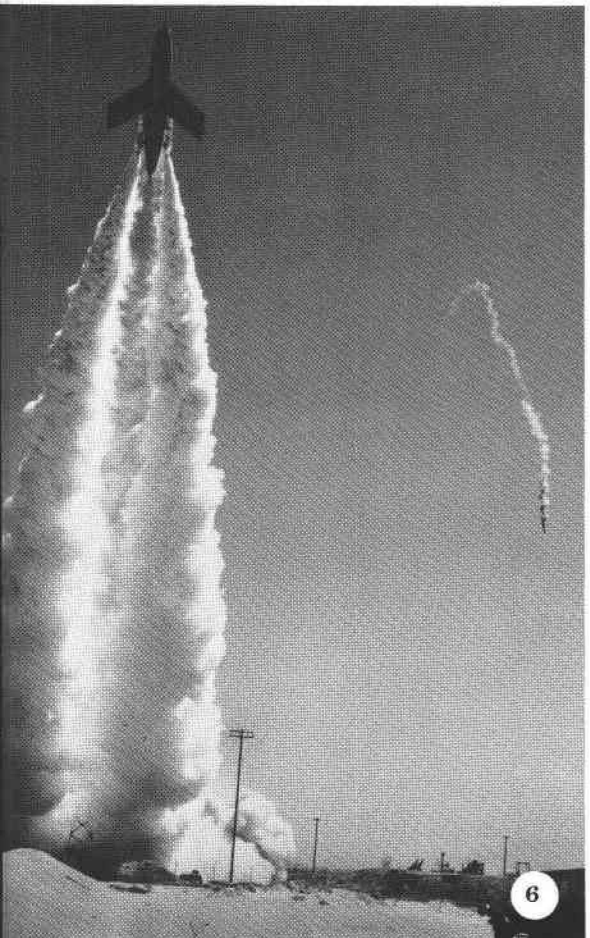

282
1

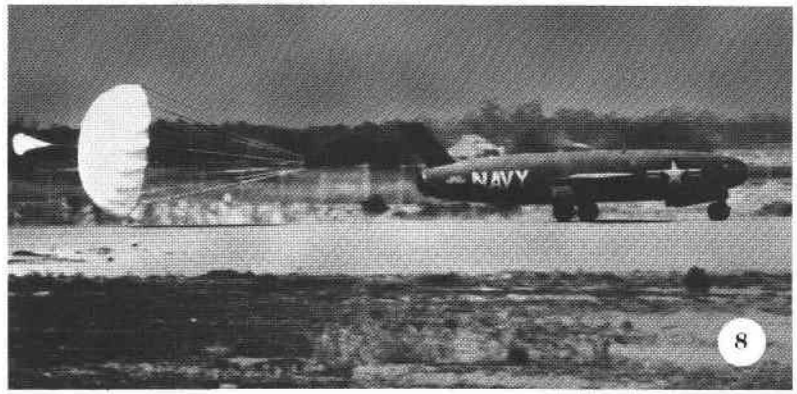

5

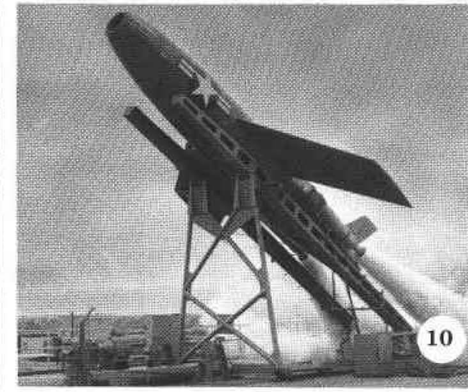

2

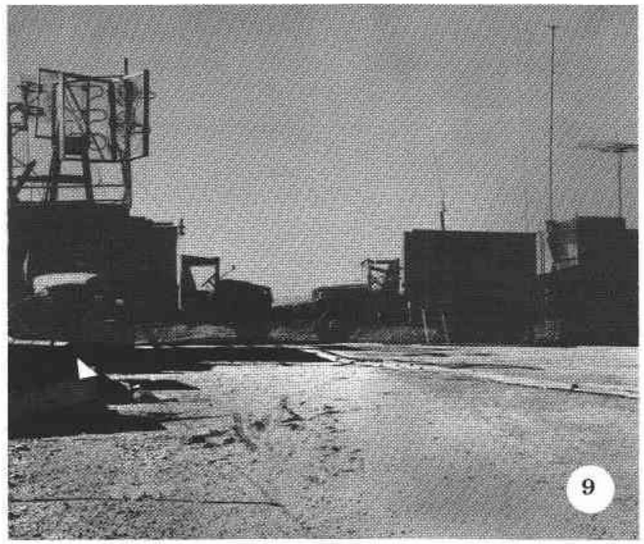

3

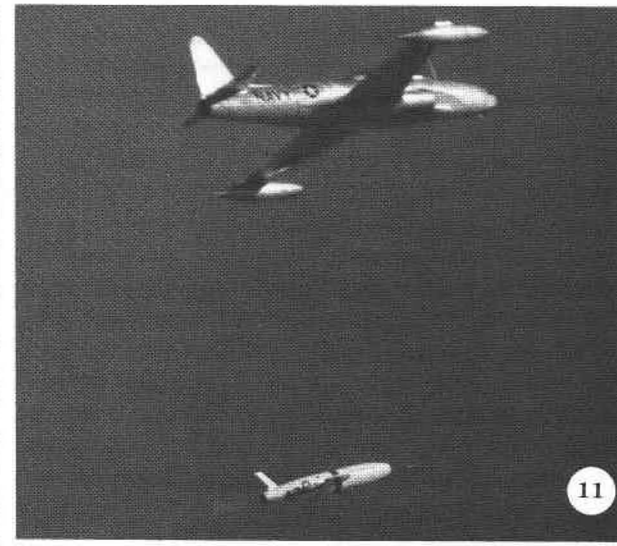

4











1. A Nate cargo container used as a missile hangar for REGULUS I aboard the submarine USS TUNNY. 2. REGULUS I during launch from flight deck of the aircraft carrier USS HANCOCK. 3. Launching platform drops away as REGULUS I is launched from USS HANCOCK. 4. REGULUS I in flight shortly after launch from USS HANCOCK. 5. Tele-tracker console in van controlling helical antenna (1951). 6. REGULUS missile in flight shortly after beach launch (1952). 7. REGULUS I missile on a SR-MK4 launcher (1957). 8. REGULUS missile landing at Point Mugu with brake parachute. 9. Mobile radar installation on Santa Cruz Island (1950). 10. REGULUS missile launch from Building 55 in the new launching area (1949). 11. T-33 chase aircraft with FTV-8 REGULUS I missile (1953).

Recoverable REGULUS I missile on launching pad at NAMTC (1957).

"The brightest flashes in the world of thought are incomplete until they have been proved to have their counterparts in the world of fact."

—John Tyndall

CHAPTER 5

MAINTAINING MOMENTUM

Throughout the mid-1950's, both the number of projects pursued at NAMTC and the complexity of the weapon systems continually challenged the Center to maintain its technological momentum. Recruiting of engineers and scientists, developing new facilities, expanding the range, and investigating advanced testing techniques were some of the major concerns.

In particular, the Command recognized that a steady influx of new talent was necessary to meet not only its present but future needs. One program initiated in the early 1950's that proved successful was the Junior Professional or JP program, which rotated newly hired engineers into different technical areas to enable them to better define their particular interest or specialty.

Simulation and analytical studies were emphasized during this period so that in each flight the maximum quantity of data could be obtained. Whether the missile would fly, how far, or how well were now only part of program requirements. A great deal more information was needed. Therefore, as part of each evaluation, NAMTC performed standard tests for lethality, reliability, serviceability, operating environment, and handling and checkout. Also, individual components were subjected to both laboratory and captive flight tests to help not only in the development of the missile but to ensure its continuing reliability.

Missile programs of importance during the 1955 to 1958 period included REGULUS I, REGULUS II, CORVUS, SPARROW I, II, and III, and BULLPUP. In addition to developmental testing of these missiles on the range, support was provided for surface launches of TERRIER, TARTAR, and TALOS. In electronic warfare, research stressed developing devices to help simulate a hostile electronic environment in order to determine the vulnerability of a particular weapon system.

REGULUS I

In November 1955, REGULUS I completed Phase A of the REGULUS I/Submarine TROUNCE 1A flight test program, and in December Phase B commenced, which consisted of 105 instrumented flights and two tactical missile flights. The primary purpose was to determine whether the weapon system could meet the operational requirement of a circular probable error of 1,000 yards at a guidance range of 100 nautical miles, and to determine the origins of errors in the weapon system. Additional objectives were to evaluate qualitatively the serviceability of the weapon system and to determine the reliability of its components.

The program involved both flight and laboratory tests. In the lab, the navigational computer was subjected to simulations designed to determine its contribution to the total error in the system. As a result of these tests, basic component faults were found that prevented accurate and stable calibration. Modifications were recommended to correct these and other problems.

The flight test program involved launches from Point Mugu followed by the missile climbing to 35,000 feet. After several simulated target runs over San Nicolas Island under

TROUNCE control, the missile was landed on the island.

As a result of the program, it was determined the weapon system would not meet operational requirements even under ideal conditions in which numerous factors that would further degrade tactical performance were eliminated. Sources of error were partially isolated, but no single major contributing error was discovered.

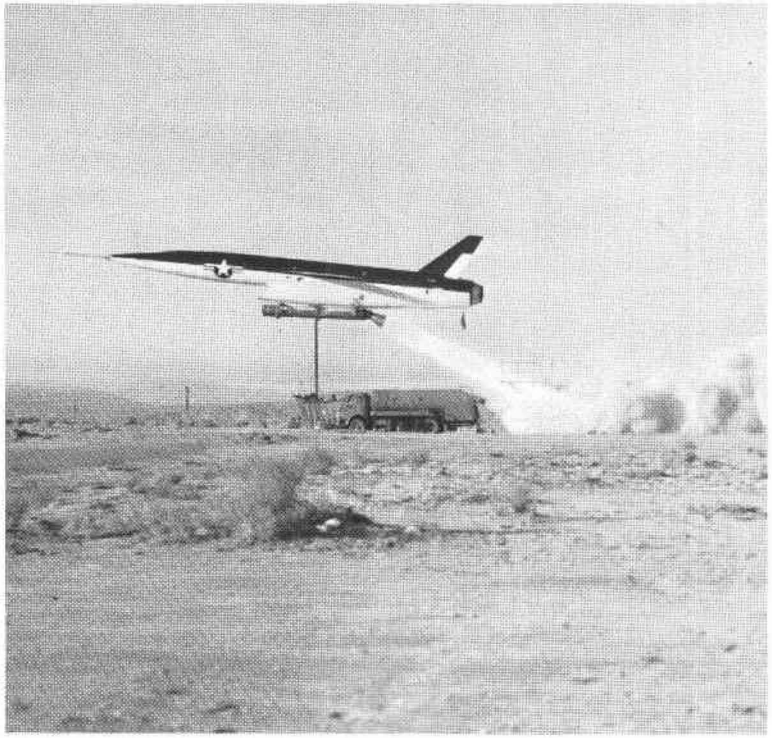
In June 1956, REGULUS I made its first inland flight over the California coast, successfully impacting at Salton Sea. This operation was a triumph for both the missile system and range safety controls which were sufficiently perfected to permit flight over an inhabited area.*

REGULUS II

The REGULUS II flight test program began on March 19, 1956, with taxi tests at Edwards AFB. The REGULUS II, a surface-to-surface missile, was the Navy's first supersonic missile with nuclear capability. Fifty-seven feet long and weighing 21,000 pounds, REGULUS II was boosted at launch by a rocket motor that was jettisoned, and then powered by a 10,000-pound-thrust turbojet engine to a speed of Mach 2. During testing and later when converted to a target, REGULUS II was recovered by the addition of a landing gear. Landings were made on the 10,000-foot runway at San Nicolas Island or on the dry lake bed at Edwards AFB.

The first flight test of REGULUS II was in May 1956 from Edwards AFB. The missile flew at just 352 knots and an altitude of 10,000 feet. Four months later, the missile made its first supersonic flight, reaching Mach 1.5 at 35,000 feet. In preparation for launching from a submarine, the missile made its first successful rocket-boosted launch in October 1957, and in June of the following year it was successfully fired from the NAMTC pad.

Fred Ballinger clearly remembers that mixed in with the



Launch of REGULUS II at Edwards AFB (1956).

* Both REGULUS I and REGULUS II were recoverable. One REGULUS I made a total of 20 successful flights, a tribute to the idea of recoverable test vehicles.

successful REGULUS II launches were a few less than successful ones. In particular, he recalled:

> *"One launch from Building #55, the missile got off the pad, the booster rocket motor ejected, and then it went straight up. The missile started to porpoise, and no matter where you were you could swear it was right overhead. It was obviously losing speed, the afterburner was on full, and there was no doubt it was coming down. It was a terrible feeling to look up and see that missile full of fuel and losing altitude. As it turned out, it landed in the marsh and did no damage, but it was pretty exciting."*

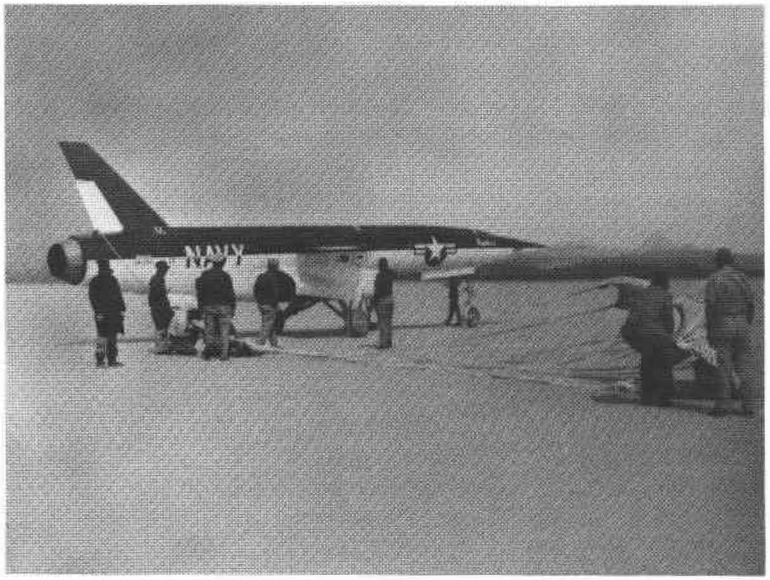
Perhaps the biggest milestone in the REGULUS II program took place on September 19, 1958. On that date, the missile was launched from the submarine USS GRAYBACK with the objective of flying inland to Edwards AFB under out-of-sight control. Other objectives were to determine if the launcher was reliable, whether the configuration of the submarine would be practical for launching missiles under operational conditions, and how much affect ship motion would have on the launch.

Virgil Ketner remembers a sidelight of the program. By placing a number of letters aboard the REGULUS II, the first official delivery of U.S. mail by missile was made. According to Mr. Ketner:

> *"Everything went according to plans until near the end of the missile flight when it was discovered that the wheels would not extend. The missile landed on its belly and consequently was destroyed. However, since the landing was not a critical part of the test, the operation was considered successful. Strangely enough, the mail was recovered undamaged."*

In preparation for launching the REGULUS II over land, Don Sullivan, who at that time was with the Range, recalls that the program had a lot of big plans, but in Washington no one could decide the exact route the missile would take:

> *"We wondered how we were going to instrument it all the way if we didn't know the flight path. So we came up with the concept of a mobile range. We put the equipment in vans and just built concrete pads. We set it up, and the program kept pretty much the track we had expected. Later when the program was ended, there was a big payoff in that the mobile equipment could be 95 percent recovered and used elsewhere."*



Collapsing a brake parachute after REGULUS II recovery (1956).

SPARROW FAMILY

Air-to-air missile test activity continued during the mid-1950's primarily with the SPARROW family of missiles and the heat-seeking SIDEWINDER.

On June 28, 1955, NAMTC achieved a significant first when a SPARROW I was launched against a high-speed KDU-1, the target version of the REGULUS I. The attack was successful and the target destroyed. The following year, the first aircraft squadron (VA-83) to be equipped with SPARROW I missiles saw deployment aboard the USS INTREPID (CVA-11).

F3H-2N aircraft with SPARROW I missiles on wing pylons (1956).

In late 1956, the first SPARROW III missile was launched from an F3H, and in early 1957 NAMTC was assigned the technical evaluation of the SPARROW III/F3H-2 weapon system. This combining of a missile and aircraft into a total system was relatively new concept that would eventually lead to the F-4 aircraft being designed specifically for the SPARROW III.

The evaluation program, like many others to follow in the long history of SPARROW III, was designed to determine the worth of the weapon system, delineate the areas within which the weapon system could be fruitfully employed, and describe the areas which needed improvement. Ninety-two missiles were scheduled for launch, and twelve others were set aside for captive flights and ground reliability tests. Approximately 120 captive flights would help determine the pre-launch flight reliability and the countermeasure characteristics of the F3H-2 aircraft system.

BULLPUP

The Navy Technical Evaluation of the AGM-12A BULLPUP weapon system was performed by NAMTC between November 19, 1956, and January 30, 1958.

The BULLPUP was a supersonic air-to-surface missile used by conventional carrier-based aircraft in close air support and for the attack of small surface targets. Propelled by a solid rocket motor and guided visually through a correlation radio link, the missile flew a line-of-sight to the target.

The overall objective of the technical evaluation was to establish the readiness of the BULLPUP for Fleet use. Specific objectives were to assess the airborne hit accuracy, airborne reliability, the flight limitations of the operational envelope, and the limitations of the control pilot as a "human servo and computer" since he was to control the missile from launch to impact.

Flight testing commenced on November 19, 1956, and a total of 85 missiles were launched. In the latter part of the program, the FJ-4B aircraft was used to launch 42 missiles. Twenty-seven of these missiles were launched in an accelerated flight test program on November 5 and 6, 1957, to evaluate the accuracy, reliability, and serviceability characteristics of the weapon under conditions simulating service usage. In the accelerated evaluation program, the airborne reliability was 85.7 percent.

SERVICEABILITY

One of the first major serviceability programs conducted by NAMTC was "Operation Snowball." In March 1957, aboard the USS FRANKLIN D. ROOSEVELT in the waters off Newfoundland, tests were made to determine the cold weather performance of our Navy's missiles. During the operation, the first BULLPUP was launched at sea against a floating target. It was a near miss. Gail Gerblick recalled Operation Snowball:

> *"It was an interesting operation which was keyed to people as much as hardware. We found that the hardware really didn't know it was cold, but with a 40-knot wind over the deck, the people felt the cold. We had a lot of people data to report."*

Night landing exercise during "Operation Snowball" (1957).

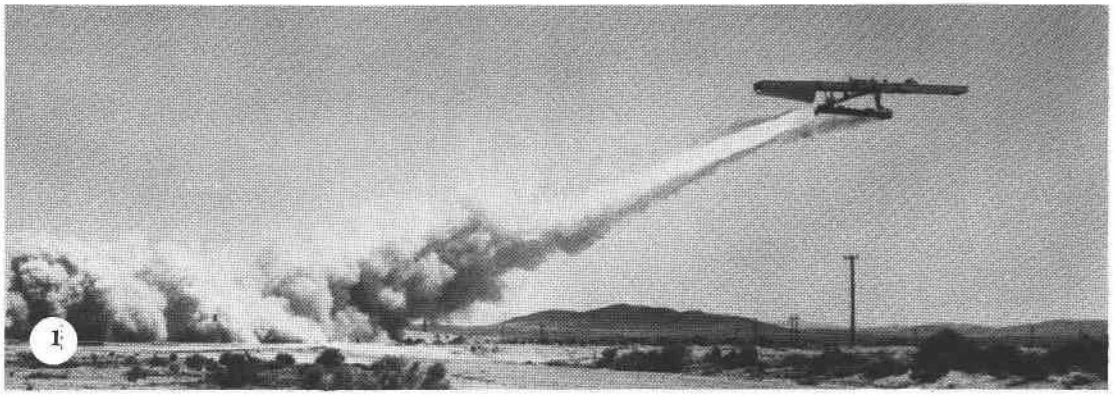
ELECTRONIC WARFARE

During the mid-1950's, electronic warfare (EW) was primarily concerned with vulnerability, and a number of devices were developed to test air-to-air weapons. These devices were enclosed in pods to be flown aboard fighter aircraft. Frank Miley remembers one unfortunate incident that happened in the early days:

> *"One of the early pods was an old fuel tank. We painted it black and white so there would be no mistake. However, a sailor put gas in on top of the jammer. It didn't do the equipment any good."*

Despite minor setbacks such as the above, Mr. Miley also recalled that he saw EW efforts grow from such devices as the APR-9 receiver and the ALQ-2 and APQ-6 basic noise jammers to some extremely sophisticated countermeasure systems. He related:

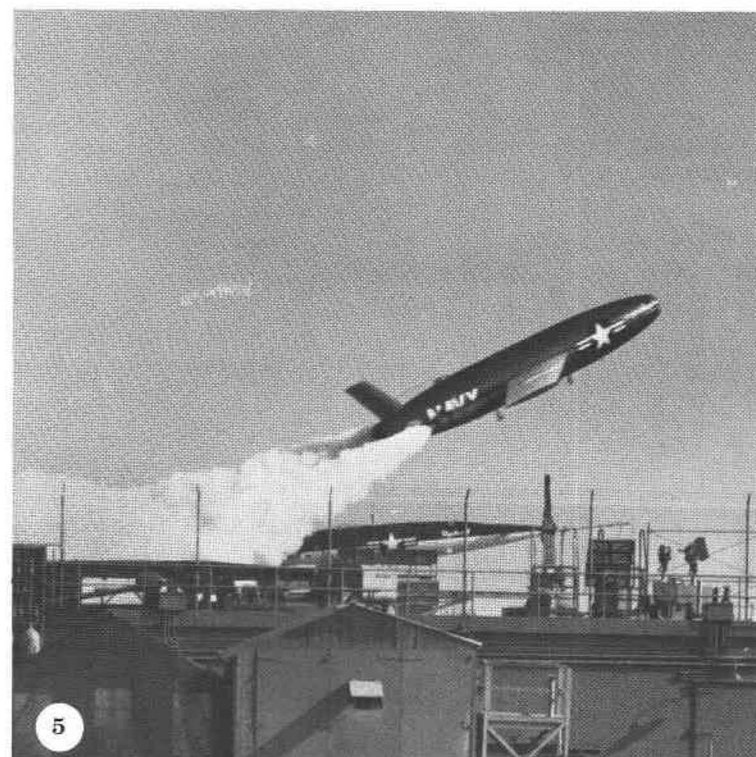
> *"As the weapon systems got more sophisticated, we continued to play the countermeasures/counter-countermeasures game. As soon as we could jam a system, we would turn around and try to find a way to unjam it."*


1

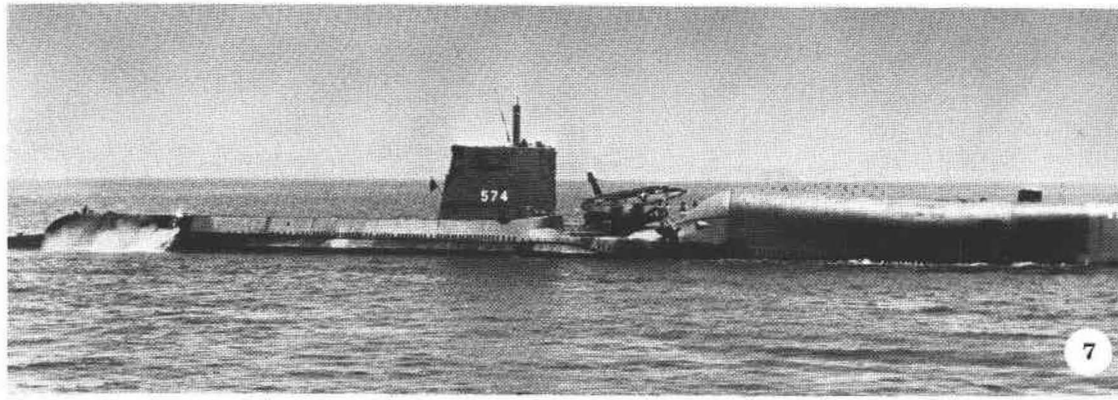

2

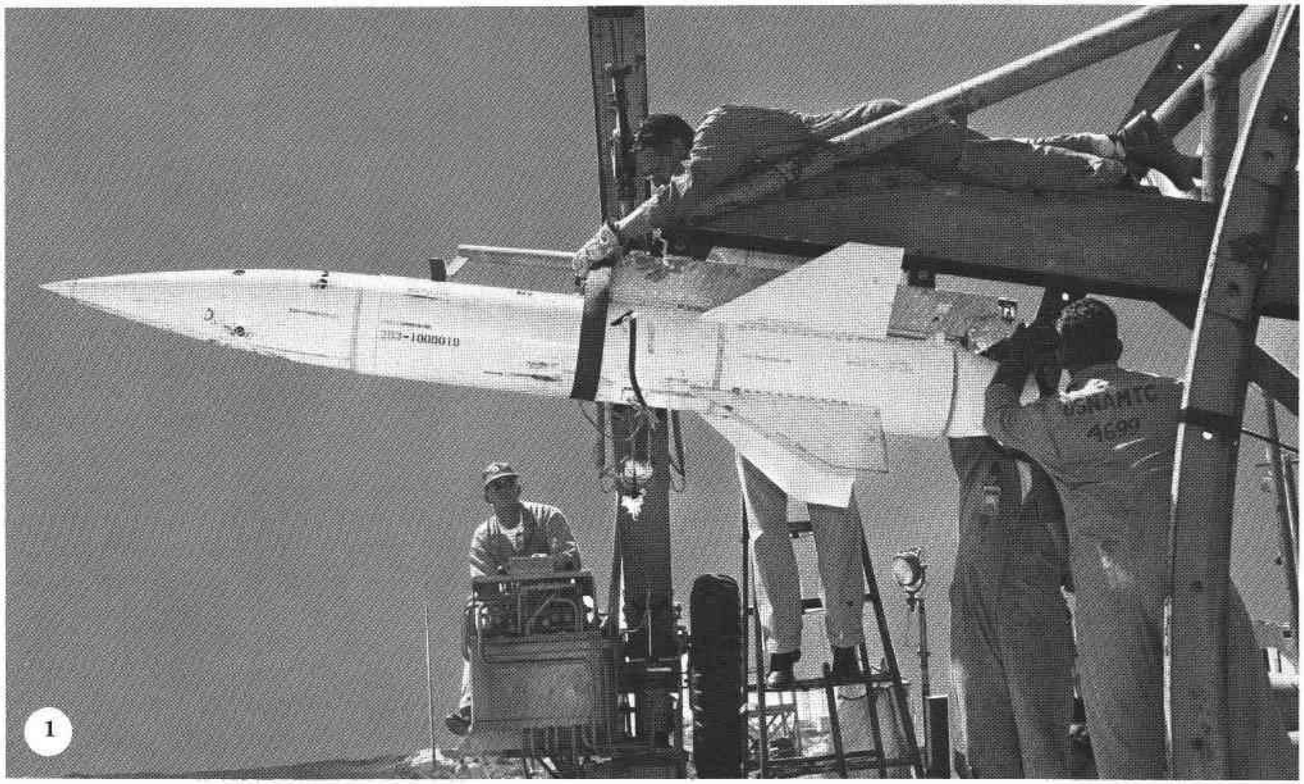

NAVY
3

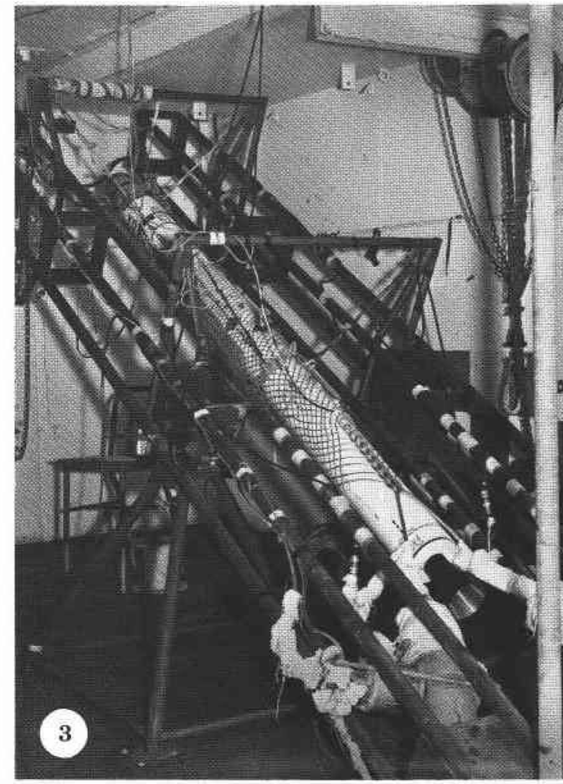

4


5

1. *REGULUS II dummy launch at Edwards AFB (1957).* 2. *Recovery of a REGULUS I on San Nicolas Island (1957).* 3. *REGULUS II on launcher, Edwards AFB (1957).* 4. *Postmaster Otto Olson and RADM J. P. Monroe stamp the first U.S. mail to be delivered by a missile, the REGULUS I (1959).* 5. *REGULUS I after launch from Point Mugu pad with REGULUS II in the background.* 6. *REGULUS II delivered to Point Mugu via a C-124 aircraft (1958).* 7. *USS GRAYBACK with REGULUS II on launcher (1958).* 8. *Removal of protective cage from instruments prior to flight.* 9. *F3H-2N aircraft with two SPARROW III missiles (1956).*

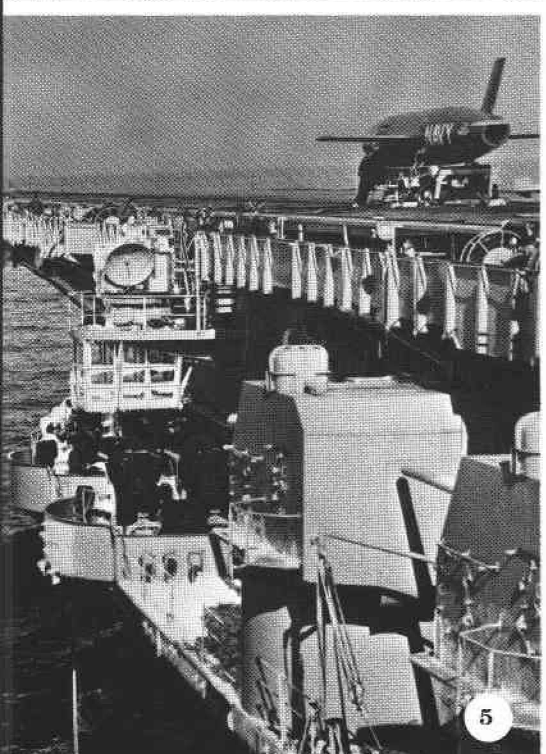






1. Makeready of BULLPUP A missile (1959). 2. FJ-4B aircraft with three BULLPUP missiles (1958). 3. Restrained firing setup for SPARROW III pre-packaged liquid engine test (1960). 4. Model antenna range with REGULUS I copper-coated test model (1954). 5. REGULUS I on its launcher aboard the USS FRANKLIN D. ROOSEVELT during Operation Snowball (1957). 6. Camera pod and infrared emitter mounted on wingtip of F6F-5K target drone (1957). 7. P4Y-2 aircraft used for electronic countermeasures.

4



5

6

7

Tranquillion Peak, Naval Missile Facility, Point Arguello (Vandenberg AFB, 1961).

"A National Missile Range is defined as a Department of Defense missile, drone, rocket, or space vehicle flight test facility, which, because of its size and general purpose facilities, is considered a national asset, equally available to all U.S. Government users on a common basis."

—Secretary of Defense
memorandum of 9 March 1961

CHAPTER 6

A NEW NATIONAL RANGE — THE PACIFIC MISSILE RANGE

By 1956, the Naval Air Missile Test Center employed 4,800 people and had a physical plant worth 50 million dollars. It was at this time that a Defense Department committee was established to investigate the feasibility of conducting the expanding national programs for missiles and satellites at existing ranges, including Point Mugu. The committee, designated the Special Committee on the Adequacy of Range Facilities (SCARF), recommended that the Point Mugu facilities serve as a nucleus for a "National Facility," and declared the intent to reprogram $11,567,000 of Fiscal Year 1958 funds for this purpose.

In the SCARF report it was also recommended that South Camp Cooke, including Point Arguello, be included in the new national range. From Point Arguello, satellites could be launched into polar orbit without the danger of the first stage rocket impacting in an inhabited area. (The remainder of Camp Cooke became Cooke Air Force Base and later Vandenberg AFB.)

On November 22, 1957, the Director of Guided Missiles issued a memo to the Secretaries of the Army, Navy, and Air Force on the "Peacetime Firings at Cooke Air Force Base." This memo ordered that the SCARF recommendations be followed in connection with the Cooke Air Force Base launchings and the operations at Point Mugu. Two weeks later, on December 7, another memo from the Director of Guided Missiles assigned to the Navy management control, range operation and safety, and responsibility for operations, with necessary instrumentation in support thereof to meet NAMTC range expansion and Air Force ballistic missile training requirements.

A memo from the CNO to the Chief of BuAer, dated December 27, 1957, stated that the expansion of NAMTC should be on a high-priority basis in order to meet test, evaluation, and training requirements of the three services. Phase I of the expansion was to include establishment of the instrumentation, launch, and operations control at Point Arguello, with hangar and personnel support at Cooke AFB.

On February 14, 1958, the Army transferred 19,861 acres of South Camp Cooke to the Navy on an interim basis, and within three weeks the Naval Missile Facility, Point Arguello (NMFPA) was established. Three months later the facility received official recognition by a Secretary of the Navy note dated April 15, and on May 27 the Army had completed the Camp Cooke transfer.

ESTABLISHMENT

June 16, 1958, was perhaps the second most auspicious date in the history of Point Mugu, following in importance only the original commissioning of NAMTC. On that date, the Secretary of the Navy established the Pacific Missile Range (PMR) with headquarters at Point Mugu.

From the earliest days, the range at Point Mugu had been a fundamental and integral part of missile testing. Over the years, new equipment, instrumentation, and facilities had been acquired to increase range capabilities. But it was the birth of PMR that produced a quantum leap forward, an advancement which might be best appreciated by quoting the original SCARF report:

> *"The 'Pacific Missile Range' includes all common guided missile range capability for missile launching from the West Coast of the United States, including the instrumented adjacent sea areas, impact areas, and launching installation with their associated technical support, but excluding operational and operational training installations including ships which are located in the geographical area. Operations from the excluded organizations or from other ranges which result in aircraft flights, sea traffic, frequency usage, or actual missile flights, which by their proximity could result in 'Pacific Missile Range' conflict, shall be under the coordination of the 'Pacific Missile Range' for this portion of their operations. In addition, missile launchings in peacetime of these organizations shall utilize the common range facilities of the 'Pacific Missile Range' for instrumentation support in the area."*

Thus PMR became the western member of the triad of national ranges, the others being the Atlantic Missile Range and the White Sands Missile Range.

Inasmuch as PMR would be required to support intercontinental ballistic missile (ICBM) launches into the mid-Pacific, in June 1958 a PMR ICBM Survey Team was dispatched to find suitable areas for instrumentation that would locate missile impact (missile impact location or MIL). The team visited several Pacific islands and eventually selected Wake, Eniwetok, and Midway Islands for use in constructing a far-flung Sound Fixing and Ranging (SOFAR) network of hydrophones.

Two events in August 1958 indicated the importance that the Navy attached to the new PMR. One of these was Secretary of the Navy Instruction 5450.6 which assigned high priority to support of PMR by all bureaus and offices of the Navy Department. The second event, on August 5, was a visit by Admiral Arleigh Burke, CNO.

As the year 1958 wore on and PMR entered into 1959, the pace of work in preparing the range for its new role accelerated, as shown by the following brief chronology of events:

Date	Event
September 25, 1958	Establishment of the PMR organization
October 9, 1958	Bilateral agreement between PMR and the First Ballistic Missile Division
November 20, 1958	BuAer instruction on use of test facilities for conducting tests by private parties
December 4, 1958	Range ships designated — USS BRINKLEY, BASS, DUNCAN, and BRADFORD
December 16, 1958	First ballistic missile, a THOR ICBM, was fired into PMR by Air Force
December 16, 1958	Memo from SECNAV to Chief of BuAer on organization of PMR authorizing COMPMR to report directly to CNO on matters of high priority
January 16, 1959	South Point, Hawaii, and Kaene Point, Oahu, to be transferred to PMR effective 1 February
February 5, 1959	Memo from RADM A. S. Hayward, Jr., to Asst. Secretary of State for Far Eastern Affairs on foreign-owned sites for potential PMR use

REAL ESTATE

Another indication of PMR's rapid growth was that it had accumulated by the beginning of FY 1959 seventeen pieces of real estate on which instrumentation was installed or soon would be installed. In addition to the main facilities at Point Mugu and Point Arguello, these included coastal sites at Point Dume, Point Sur, Pigeon Point, Point Pillar, Point Montara, and Point Arena; island sites on Santa Cruz and Anacapa Islands as well as San Nicolas Island; inland sites at Dugway, Utah, and Tonopah, Nevada; and mid-Pacific sites in Hawaii and on Midway and Wake Islands.

CONSTRUCTION

New construction and improvements to facilities reached a high point in the 1958 to 1960 period. Les Maland recalls:

> *"It was at this time that the original FPS-16 radars were installed. They were located at Point Mugu, San Nicolas Island, Vandenberg, and up the coast. These metric tracking radars were our first instrumentation in the space age. About the same time we extended the runway at Point Mugu and made runway improvements at San Nicolas Island. We also managed the improvements at Point Arguello."*

In addition to facility construction on the mainland, PMR was responsible for the building of general instrumentation and nonproject facilities at Kwajalein. This was another very large and important undertaking.*

BROAD OCEAN AREA SHIPS AND AIRCRAFT

In addition to new real estate and land-based facilities, PMR embarked on a program of procuring and modifying ships and aircraft for use in the Broad Ocean Area (BOA) of the Pacific. Eventually a total of eleven ships and five aircraft were developed under the direction of PMR engineers for use in instrumentation and recovery. The ships and aircraft provided many of the same services as a land range, including such instrumentation systems as telemetry, radar, navigation, communications, data processing, timing, and meteorology.

Some of the programs supported included POLARIS; the Army's SAFEGUARD; the Air Force's ATLAS, THOR, MINUTEMAN, TITAN, and ATHENA; NASA's MERCURY, GEMINI, and APOLLO; and the Department of Energy's SKOL.

COMMUNICATIONS

In the mid-1950's, a major upgrading of communications equipment took place on the range and new facilities were constructed. These included the Range Operations Control Center, and transmitter and receiver buildings at Point Mugu, Laguna Peak, and San Nicolas Island. With the completion of these facilities, a 200-line PBX was installed at the Range Operations Control Center and on San Nicolas Island. These exchanges, dedicated to operational support, became known as "Red Ball." A teletype network was also installed between sites to facilitate scheduling. In 1955, a two-wire patching and conferencing system was designed and installed to allow subscribers to participate in network conferences. The system also gave access to radio circuits on San Nicolas and Santa Cruz Islands.

The first video display system (cameras and monitors)

* Later Kwajalein Missile Range became the Army's second National Range.

was installed in 1957. It provided prelaunch information and missile status from the launch pad to the blockhouses and control center and was also used for pad safety. Later the television system was expanded to include facilities for transmitting daily briefings and operational status reports to the Commander, PMR and various locations.

In mid-1958, the FRW-2 Command Control Transmitters became operational and were used to control various targets such as the FIREBEE and B-17 and PB4Y2 drones. The FRW-2's were also used as command destruct transmitters (CDT). In 1960, high-powered CDT vans were installed at San Nicolas Island to support Point Mugu and Vandenberg AFB launches.

Also in 1960, the problem of reliable transmission paths from offshore islands to Point Mugu was finally resolved with the installation of the Collins microwave system. For the first time, reliable voice and data communications were established. The system also provided a microwave link to Vandenberg AFB which allowed PMR to provide extensive tracking support for space and ICBM programs.

FREQUENCY MANAGEMENT

In 1957, frequency management took a major step with the establishment by the Military Communications Electronic Board (MCEB) of the Area Frequency Coordination (AFC) system. In the following year, the Department of Defense established the AFC function at Point Mugu with primary concern being the frequencies used at Point Mugu, China Lake, and Edwards AFB. Since operations conducted during that time were low level, few mutual interference problems were encountered.

During 1960, the PMR Frequency Monitoring Network was established with fixed stations at Point Mugu, San Nicolas Island, and Point Arguello. Mobile facilities located at the three sites and two EC-121 aircraft were also a part of the network. In 1961, a Joint Service Directive expanded the AFC function into actual control of ECM operations.

OPERATIONAL CONTROL

By the mid- to late 1950's, computers and digital technology, first evidenced by the aforementioned FPS-16 metric tracking radar, allowed more sophisticated use of data in real time. Tracking and control data could now be transmitted considerable distances over wire and microwave, operated on mathematically, and then plotted with reasonable reliability. Display technology, however, had not advanced as rapidly, and data for operational control use was still presented on mechanical plot boards.

The advent of the Navy Tactical Data System (NTDS) in the Fleet during the early 1960's improved the display capability to some degree. This new tool allowed handling and displaying surveillance radar data that was vital to range and operational control. Data were digitized, operated on by computer, and presented automatically on cathode ray tubes along with symbols and identification information. A modified NTDS was installed at Point Mugu, but for large-scale situation display, manual "grease pencil" displays were still being used.

METRIC TRACKING RADAR

Beginning in 1958, the first radar (the AN/FPS-16) specifically designed for instrumentation was installed at PMR. Four systems were located at Point Mugu and four on San Nicolas Island. From that time forward the FPS-16 was continuously updated through rigorous modification and improvement programs.

In 1959, a Correlated Orientation Tracking and Ranging (COTAR) field was installed near the FPS-16's at Point Mugu to provide angle measurement data to the radars for acquisition of cooperative targets.*

During 1961, PMR acquired four AN/MPS-25 radars and a basic FPS-16 system reconfigured to a mobile version and upgraded to include a solid state digital data system and hydrostatic bearing pedestal with hydraulic drive. The MPS-25's provided a capability to deploy the primary instrumentation standard worldwide on a short-term basis. The system was deployed as far as South Africa, Johnston Atoll, and aboard the USNS WHEELING.

USNS WHEELING was outfitted in 1960 with an FPS-16 radar which included a ship-motion compensation system.

SURVEILLANCE RADAR

In the early 1960's, an AN/SPS-10 C-Band radar was installed on the Range Operations Building to provide close-in sea surface coverage of the area off the end of the drone launch pads and runway.

An L-Band ARSR-1 Federal Aviation Administration Air Route Surveillance Radar began operating on San Nicolas Island in 1963. It was equipped with an Identify Friend or Foe (IFF) transponder-based surveillance system and Moving Target Indicator (MTI). The ARSR-1 provided air surveillance out to 300 nautical miles from San Nicolas Island on the Sea Test Range.

* COTAR was operational until 1968.

TELEMETRY

The use of telemetry in gathering data during missile launches at Point Mugu began in 1946 and gradually expanded over the years until at the time of the establishment of PMR there were sites at Point Mugu, Laguna Peak, San Nicolas Island, Santa Rosa Island, Point Arguello, Kokee Park and Barking Sands (Kauai), Tern Island, South Point, Ennylabegan (Kwajalein Atoll), and Canton Island. Also, there were seven ships and five EC-121 aircraft equipped with telemetry equipment. The aircraft flew missions out of nearly every continent of the world. In one instance, an EC-121 aircraft was used in the Strato Lab High operation out of Pensacola, Florida. For fourteen hours the aircraft, via telemetry, monitored the vital statistics of two balloonists as they rose to an altitude of more than 102,000 feet in an open gondola.

CROSS RANGE VELOCITY CORRELATOR

Beginning in 1962, PMR pioneered in the development of the Cross Range Velocity Correlator, an instrument which would give an early indication of a malfunction turn during the launch phase. The device resulted from a mathematical investigation that described the dynamics of a missile during a turn malfunction in terms of time after the malfunction had occurred.

From the mathematical calculation it was apparent that measurable cross range velocity could be detected sooner than measurable deviations in radar-determined position. This earlier determination, on the order of one second, was very critical in keeping the corridor of hazard as narrow as possible. Inasmuch as POLARIS and follow-on missiles transmitted telemetry from the on-board guidance system in real time, it was determined that a device could be constructed consisting of a telemetry receiver and electronics to isolate the required data and convert it to cross range velocity. Another desirable feature would be a switch that activated when cross range velocity attained or surpassed a designated value.

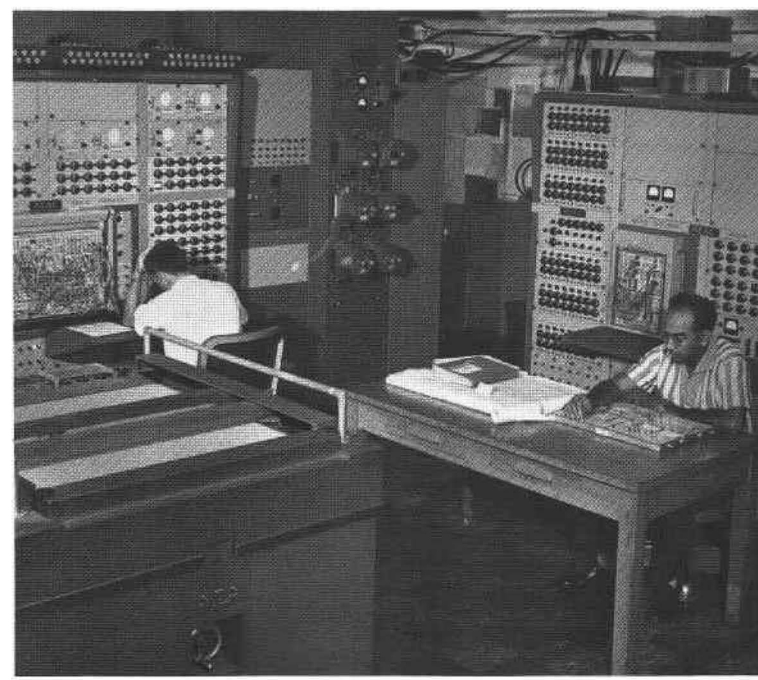
The design for the Cross Range Velocity Correlator was submitted to the Department of the Navy, subsequently built by a contractor, and then incorporated into the Range Safety system with great success.

REAL-TIME COMPUTATION

With the expanding workload of PMR, it was soon evident that the development of a real-time missile impact prediction computation system was imperative. Accordingly, a contract for drawing up the specifications was let, and late in 1959 the specifications were ready for procurement.

To help PMR select the winning proposal from the seventeen proposals submitted, a panel was formed consisting of five computer experts from the Bureau of Standards, a man from the Department of the Navy, and PMR representatives. The winning proposal featured a computer with fantastic capabilities for that time. It was in advance of the "state-of-the-art," so it was deemed wise to assign a second contractor to also proceed to the next phase. At the conclusion of the first phase, the original contractor was judged to be proceeding satisfactorily; therefore, the second contractor's contract was terminated. Plans for implementing the system were made, but concerns began to surface that the system might be too visionary. The result was that a committee of three nationally prominent computer experts was formed. After a review they recommended that the original plan not be implemented and that a more conventional system be procured.

By this time many fine computers were coming on the market and real-time systems were proving that the need for great computer speed had been over emphasized in the original specifications. A conventional system was obtained for both Johnston Island and Point Mugu, and a few years later a more powerful computer was procured for the Underwater Range at Barking Sands, Kauai.



Reeves analog computer used in tracking missile trajectories.

The experience gained in this first abortive attempt to procure a real-time computation system taught PMR engineers a valuable lesson—to write their own specifications rather than contracting the work. However, it was also realized that at the time of contracting the specifications, PMR did not have sufficient personnel for that undertaking. About five years later when PMR wrote the specifications for the real-time computer for the Underwater Range, the Commander, PMR, was repeatedly told by bidders that the specifications were the finest they had ever seen.

PHOTO-OPTICAL INSTRUMENTATION

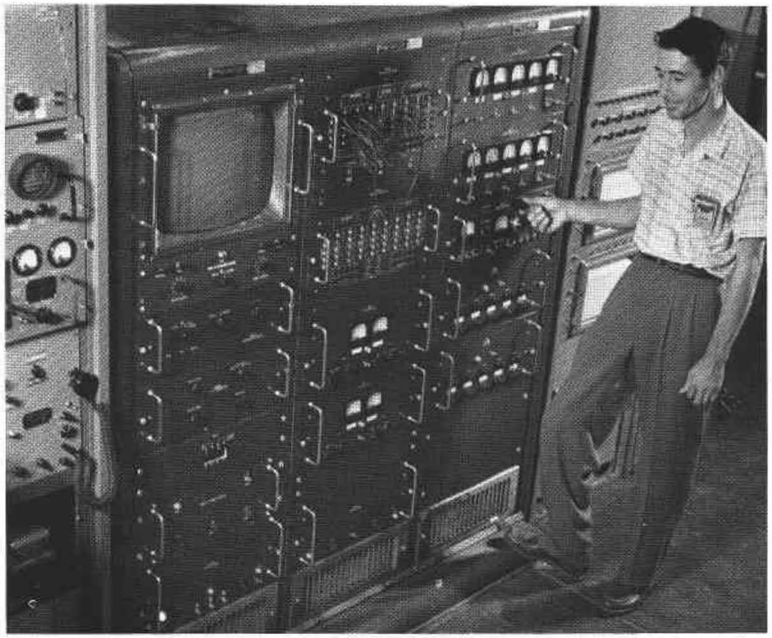
The Askania cine-theodolites, mentioned in Chapter 1, continued during the early days of PMR to be the backbone of photo instrumentation. Built in Germany prior to World War II, these instruments were pulsed variable frame rate-type devices with each frame recording the missile plus azimuth and elevation readings. In conjunction with the Askania, the Ray Dot tracking system was used. The operator viewed the missile on a grid and used a control stick to keep a dot centered on it. This in turn operated the Askania to keep it pointed at the missile.

Optical data was also obtained with the Mobile Optical Tracking Unit (MOTU) developed by PMR engineers. This two-man-operated tracking unit used servos attached to drive belts to operate the instrument in azimuth and elevation. Seventy-millimeter cameras were used on the mount with various short or long focal length lenses.

For recording surface-launched missiles during first motion, remote control Bowen-type cameras were installed on both sides of the launcher. Started just prior to ignition, they provided a continuous record of lift off.

TIMING

In the late 1950's, maintaining precise time was still very complicated and used a crystal as the primary standard. At this time, PMR started to tie into the National Bureau of Standards (NBS) by receiving a radio signal from World Wide Time Hawaii and the proper propagation delay from the East Coast. This brought time accuracy down to less than plus or minus one millisecond. With the introduction of the PMR-GUQ-4A time generator, the task of generating serial time code was made easier.



Ascop Timing Station used in telemetry (1957).

Timing accuracy was further improved in 1961 with the introduction of the Manson Model RD-180-1 oscillator, the latest instrument for maintaining a stable frequency. The stability of the oscillator in conjunction with timing signals broadcast by World Wide Time, NBS, brought accuracy down to less than a millisecond (in the area of plus or minus 50 microseconds).

IBM 709 Data Processing System, part of Impact Prediction System.

The first use of the atomic standard at PMR took place in 1964 and greatly improved accuracy. Also the U.S. Naval Observatory brought a portable flying clock to synchronize the primary standard at the Timing Center.

POSTOPERATIONAL DATA PROCESSING

During the decade of the 1950's, postoperational data processing gradually made the vital transition from predominantly manual handling of data through a period of semi-automation to virtually full automation. The evolution, necessitated by a continuously increasing workload and the need for improved accuracy, was facilitated by the development of data processing equipment which had faster execution speeds and expanded capability.

Starting with the IBM Card Programmed Calculator and later the one-of-a-kind RAYDAC described earlier, the data processing operation at Point Mugu subsequently procured such computers as the IBM Card 650 which replaced the IBM Card Programmed Calculator, the IBM 709 which replaced RAYDAC in 1960, three IBM 1401's purchased in 1961 and 1962, and two IBM 7090's which were upgraded to the IBM 7094 in 1963.*

GEOPHYSICS

From the earliest days of missile testing at NAMTC, it was very evident that meteorological data was important to test operations. Thus it was that in March 1946, seven

* Upgrading and procurement of new computers and peripheral equipment continued through the years, eventually resulting in the Computer Centralization and Modernization Program (CCMP) described in a later chapter.

months before the commissioning of NAMTC, a weather observation and forecasting program was established at Point Mugu.

Later, with the increased use of radar for tracking high-altitude and longer range missiles and aircraft, it became important to make meteorological measurements of the upper air. The need stemmed from the fact that all electromagnetic energy is bent or refracted while passing through the atmosphere, particularly at low elevation angles, and it is necessary to make corrections for this refraction. Upper air rawinsonde balloon measurements were therefore begun on a several-times-a-day basis from Point Mugu and San Nicolas Island to obtain data for refraction correction.

With the establishment of PMR in 1959, range meteorological facilities were established throughout the Pacific and aboard range instrumentation ships. By March 1960, personnel and equipment procurement was complete, and a twenty-four-hours-a-day, seven-days-a-week operation had begun. In October 1959, the Meteorology Division became a charter member of the Meteorological Rocket Network when high-altitude weather rockets were fired from the beach. The first few firings provided information only on wind speed and direction, but soon temperature data were also available. These firings provided information routinely to altitudes in excess of 200,000 feet.

In late 1960, computers were first utilized at Point Mugu for automatic computation of upper air meteorological information. The initial transmission of weather charts from computer to computer was successfully accomplished in January of 1961 when the Northern Hemisphere surface analysis was sent from the Fleet Numerical Weather Facility, Monterey, to Point Mugu, in thirty-four seconds.

In September 1960, Point Mugu was selected as the Meteorological Satellite Readout Station. About one year later, in November 1961, readout and analysis of cloud pictures transmitted by TIROS III commenced.

In 1963, geodetic and oceanographic responsibilities were assumed by the Meteorology Division and its name changed to the Geophysics Division.

RANGE SCHEDULING

At the time PMR was established, Range Scheduling relied heavily on typewritten weekly forecasts and daily schedules. Also all historical reports were typewritten. The first step toward automation was the Operational Automated Scheduling Information System (OASIS) which used the Electronic Accounting Machines (EAM's). Handwritten forecasts, daily schedules, and resume worksheets were being submitted to the EAM section and processed using key punch, sorter, interpreter, and printer to provide a working copy for reproduction. During this period, the scheduling function included resources at Point Mugu, Point Arguello, Hawaii, and Kwajalein. Considerable effort and manpower were required to produce a final product each Friday afternoon.

In the 1960's, the printed schedule was augmented by the use of closed circuit television with monitors throughout the base so that everyone could observe changes in the schedule. The TV system was also used for weekly scheduling conferences attended by all range users.*

* In 1967, the TV system was expanded to daily briefings for the Commander, PMR and his staff on significant operations scheduled for that day and the results of operations the previous day. Also a daily weather brief was presented.

The production of the printed schedule was further automated in 1963 using IBM computers. The scheduling office continued using punched cards but implemented the Program Identification Data System (PIDS) and Program Identification Code (PIC) system numbers. This replaced OASIS. The new system, containing improved logic and historical reports, became more meaningful and more in demand with the passage of time.

RANGE SYSTEMS DEVELOPMENT

Initial range systems development took the form of modifying or adapting existing military equipment, but as time went by, the emphasis shifted to conceiving and building systems specifically designed for range use. During the rapid expansion of the early 1960's, this was particularly true as PMR became responsible for not only range system development at Point Mugu and the offshore islands, but also at places such as Point Arguello, Kwajalein, and numerous sites along the California coast, inland as far as Utah and Nevada, and on mid-Pacific islands. An example of this was PMR's important role in the development and deployment of an entire range system complex at Johnston Atoll, including ballistic missile launch facilities, for a critical series of nuclear weapon tests.*

DESIGN AND ENGINEERING

With the acceleration in missile testing at Point Mugu during the late 1950's and early 1960's, there evolved a growing need for an organization that would maintain, install, or even design specialized test equipment including radars and telemetry systems. Originally named the Engineering Department, the organization was later known as Technical Support.** Eventually it included a standards laboratory, instrumentation, calibration laboratory, engineering group, maintenance group, and fabrication and installation shops.

SAN NICOLAS AND SANTA CRUZ ISLANDS

Although development of facilities on San Nicolas Island began quite soon after the establishment of the Naval Air Missile Test Center, early day range communications and data systems were extremely primitive, with outside cable plants of the old armored tape jute cable running from building to building and only radio handset systems for communications with the mainland. The housing was World War II-vintage barracks.

Later, as the range expanded its capabilities, new equipment and facilities were added or improvements made so that gradually over a period of years field telephones, two-wire control systems, patch panels, APS-20 radars, radio Lenkurt systems, and diesel generators were replaced with modern transmitters and receivers, complex microwave systems, transfer switching systems, telemetry facilities, frequency interference control, FPS-16 and FPQ-10 radars, surveillance radars, target launching facilities, an operational control center, master timing facility, and an FRW-target control system.

The use of Santa Cruz Island began in 1949 when the Navy

* In later years, support was provided in the development of range and target systems at the Air Combat Maneuvering Range, the Atlantic Fleet Weapons Facility, the Naval Air Test Center, and White Sands Missile Range.

** The organization is now the Design and Engineering Department.

leased a ten-acre tract and established communications, optical tracking, and surveillance radar facilities. These were gradually updated, and in the mid-1960's telephone exchange communications to the mainland were installed. Between the late 1960's and 1980, the microwave system of the F-114 radar was upgraded. The FPS-114 surface surveillance radar was installed to replace the APS-20.

PROGRAMS

Even as the organization, expansion, and construction of PMR took place, missile programs continued to be supported on the range. In addition to test and evaluation programs assigned to Point Mugu, other range users and programs included the following:

Navy

REGULUS	Training
TERRIER	First Fleet Pacific, BuOrd (NORTON SOUND) and Marine Corps training at NMFPA
SPARROW III	Fleet training
SIDEWINDER	Fleet training
HAWK	Marine Corps training at NMFPA
Carrier Qualifications	
Countermeasures	
RARE	Naval Ordnance Test Station project
TERRASCA	Naval Ordnance Test Station project

Air Force

MILS and other installations for ATLAS ICBM

Instrumentation of THOR missile impacts

Support, including air launch, bomb drops, and refueling

Marquardt Hyperjet

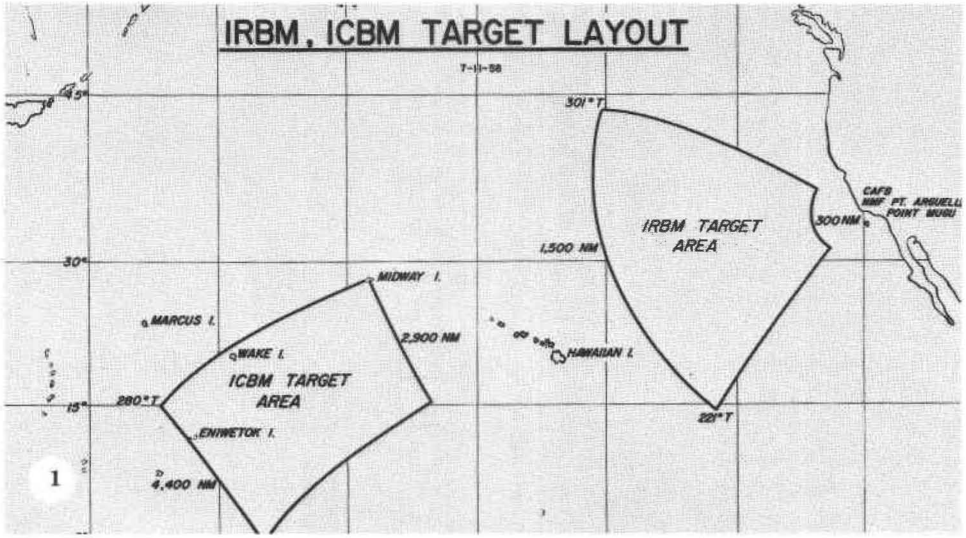
F-108/GAR-9

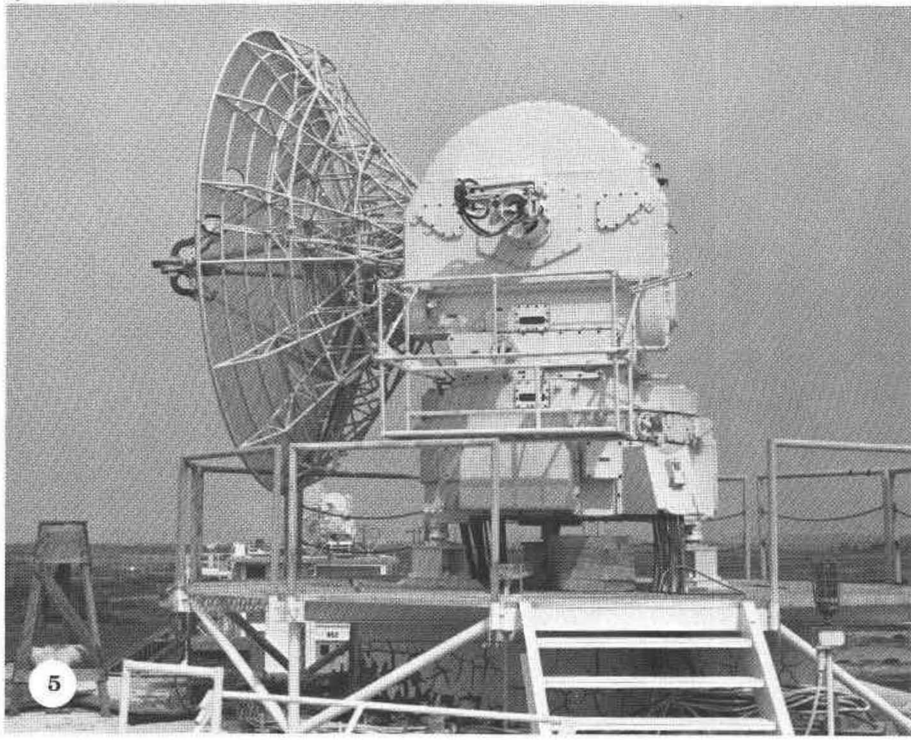
ECM flights

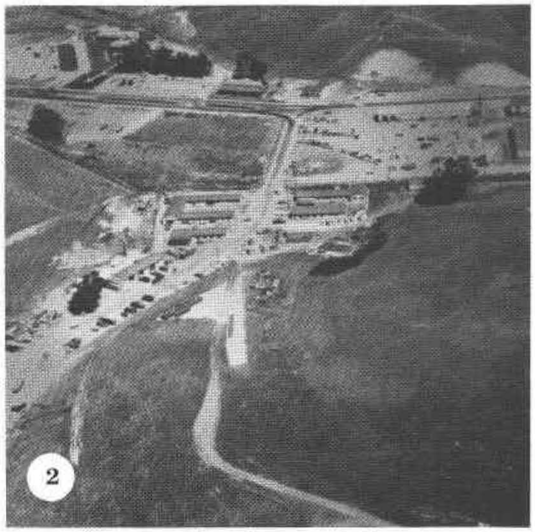
Army

Facilities planning for SERGEANT and NIKE-ZEUS launches

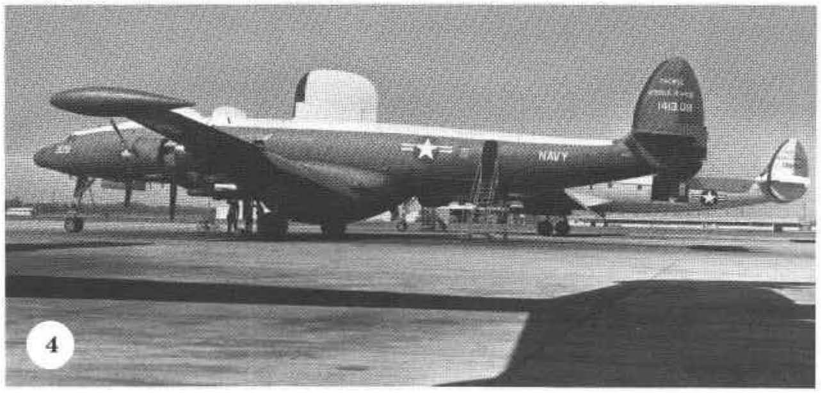
HAWK missile launch at Naval Missile Facility, Point Arguello.

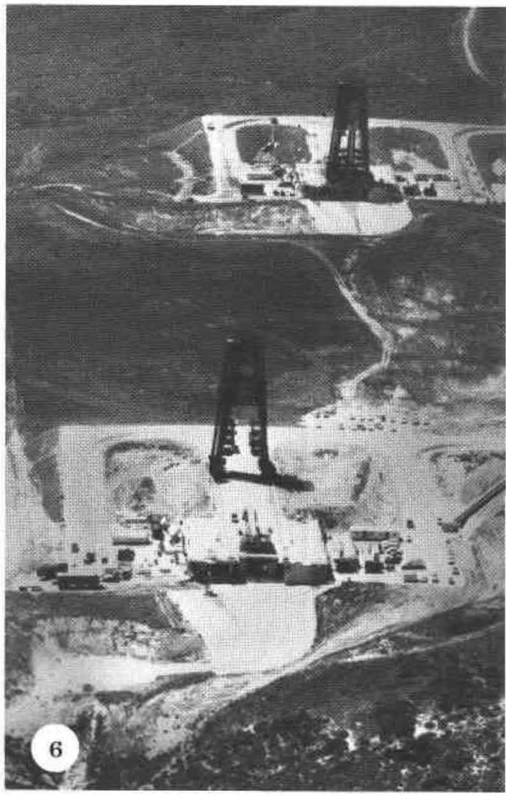

IRBM, ICBM TARGET LAYOUT
7-11-58
301° T
IRBM TARGET AREA
1,500 NM
300 NM
CAFB
NMF PT. ARGUELL
POINT MUGU
MIDWAY I.
MARCUS I.
WAKE I.
2,900 NM
HAWAIIAN I.
ICBM TARGET AREA
280° T
221° T
ENIWETOK I.
4,400 NM
45°
30°
15°
1


5

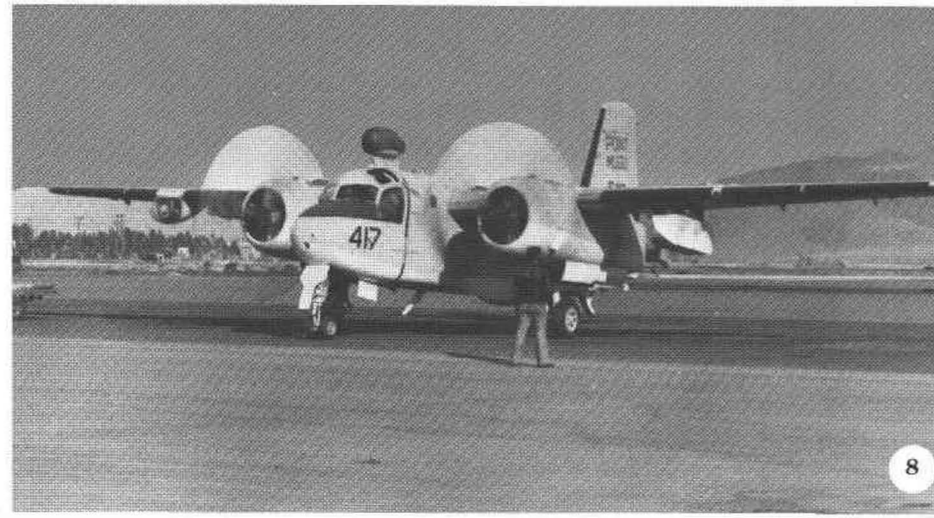

2


3


NAVY
4


6

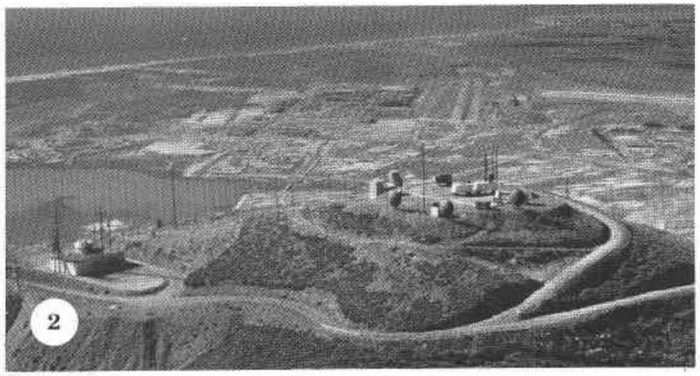
7

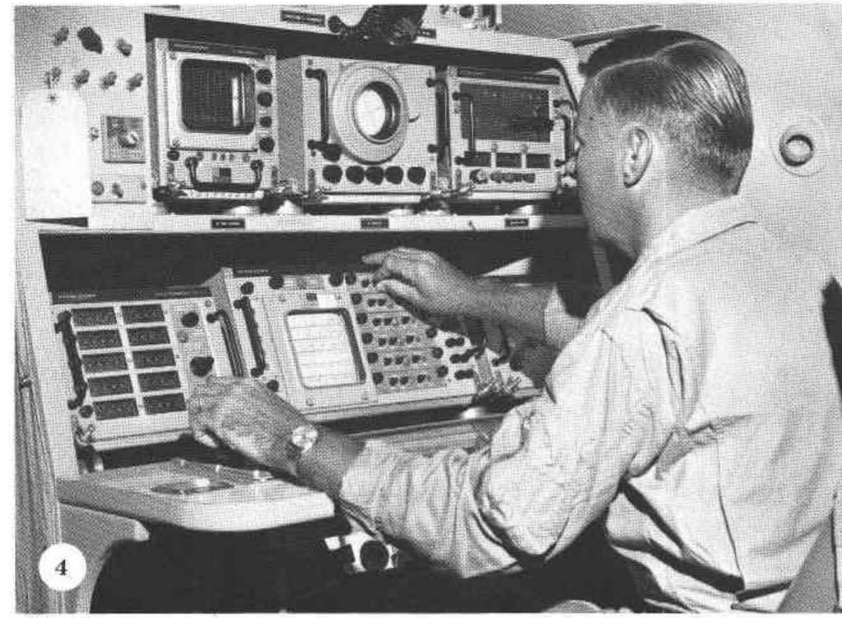


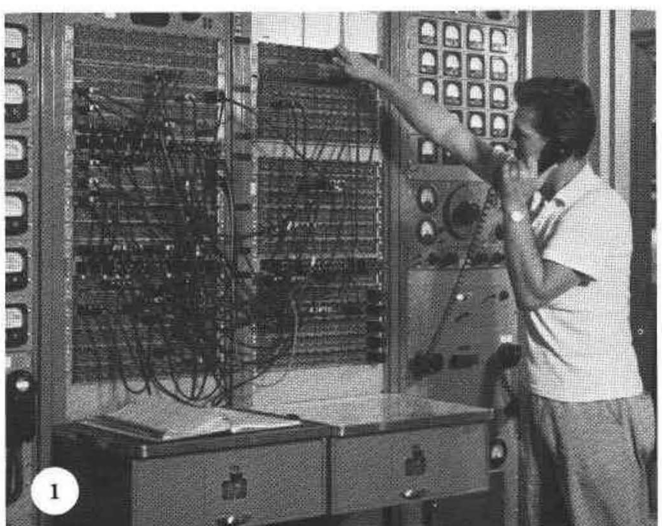
8

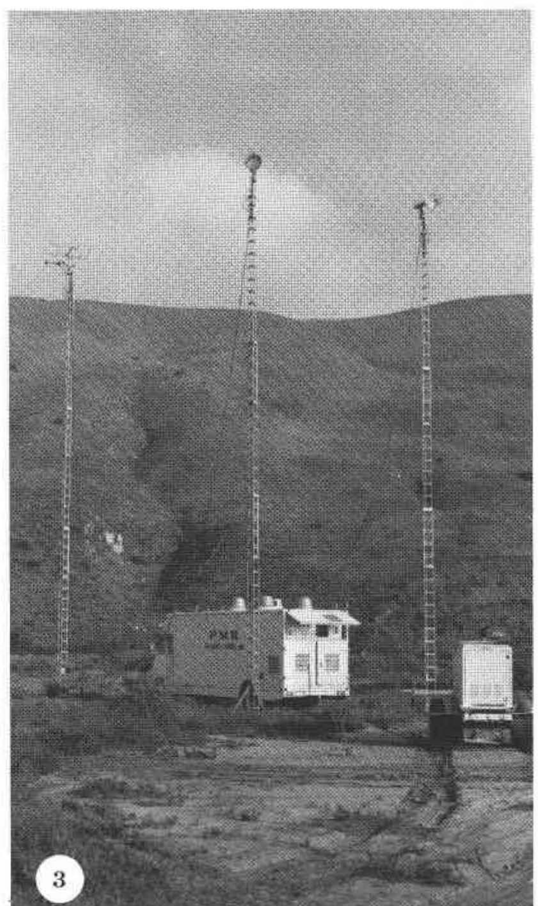
1. Intermediate-range ballistic missile and intercontinental ballistic missile target areas on chart of PMR (1958). 2. Headquarters area of NMF Point Arguello (1959). 3. RADM J. P. Monroe speaking at NMF Point Arguello commissioning (1958). 4. Pacific Missile Range EC-121K range aircraft preflight checkout. 5. AN/FPS-16 radar at Point Mugu lagoon. 6. ATLAS missile launch sites at NMF Point Arguello (1960). 7. Cook Air Force Base (later Vandenberg AFB) looking northwest (1958). 8. S2F range clearance aircraft on the Point Mugu airstrip (1961). 9. Building 53, the Range Operations Building at Point Mugu (late 1950's).

9

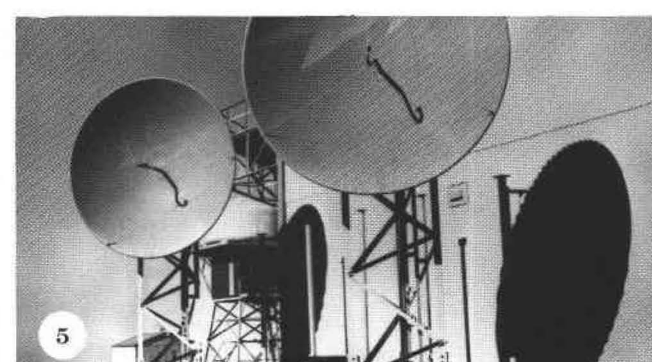






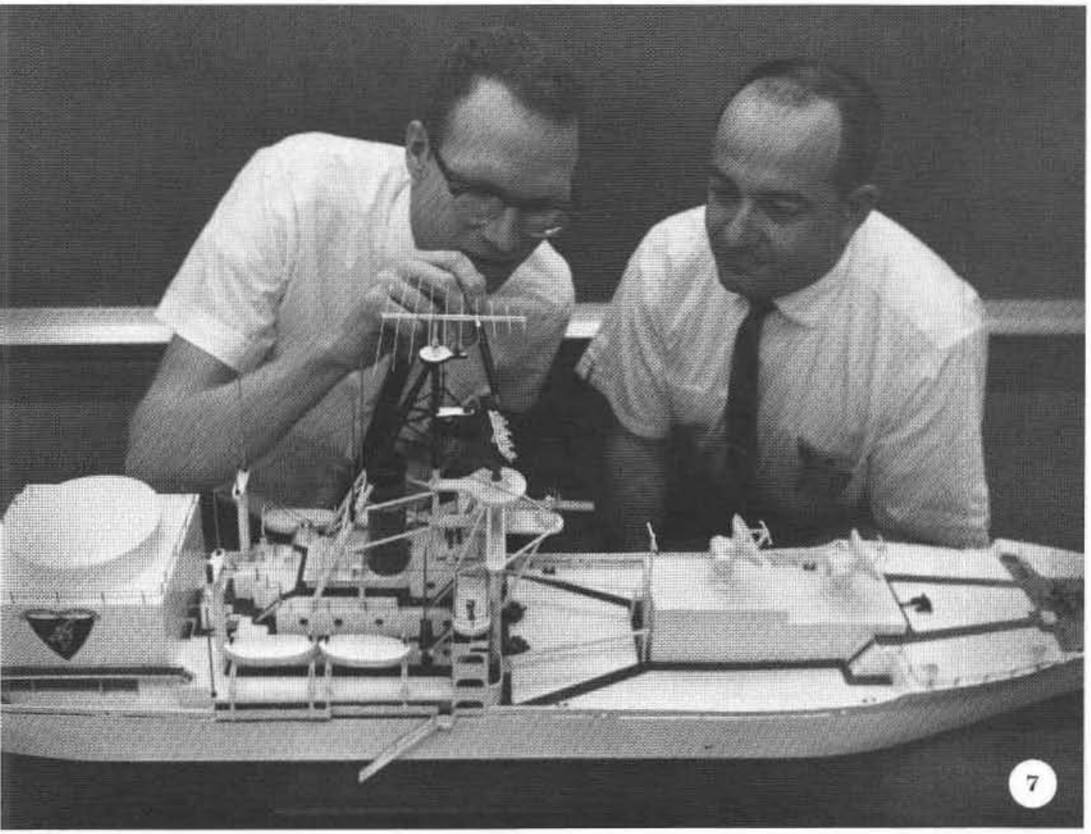


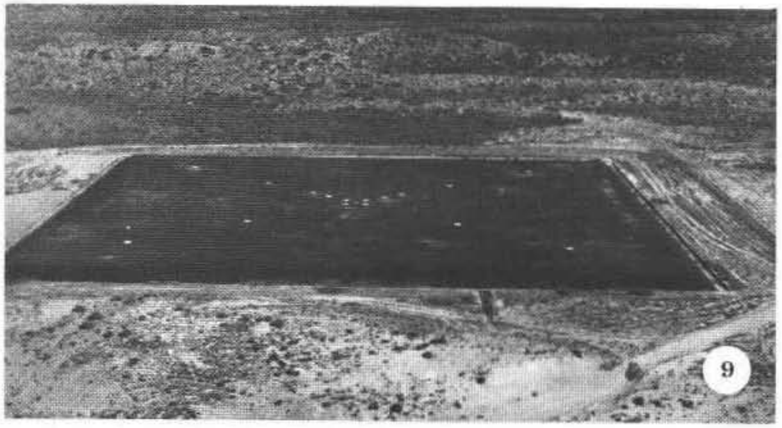
1. Operations communication control room at Point Mugu (1957). 2. View of Laguna Peak with the Naval Missile Center (NMC), Point Mugu in background (1960). 3. Pacific Missile Range frequency control van and related antenna systems in the field (1963). 4. USR-1 radio equipment installed in an EC-121 aircraft (1968). 5. Microwave link antennas on a remote radar building, NMF Point Arguello (1960). 6. Instrumentation radar console in the Range Operations Building at Point Mugu (1957). 7. Scale model of the PMR Range Instrumentation Ship USNS WHEELING (1966). 8. Air-to-air missile test plotting underway at Point Mugu (1960). 9. Correlated Orientation Tracking and Radar (COTAR) field at NMF Point Arguello (1961).

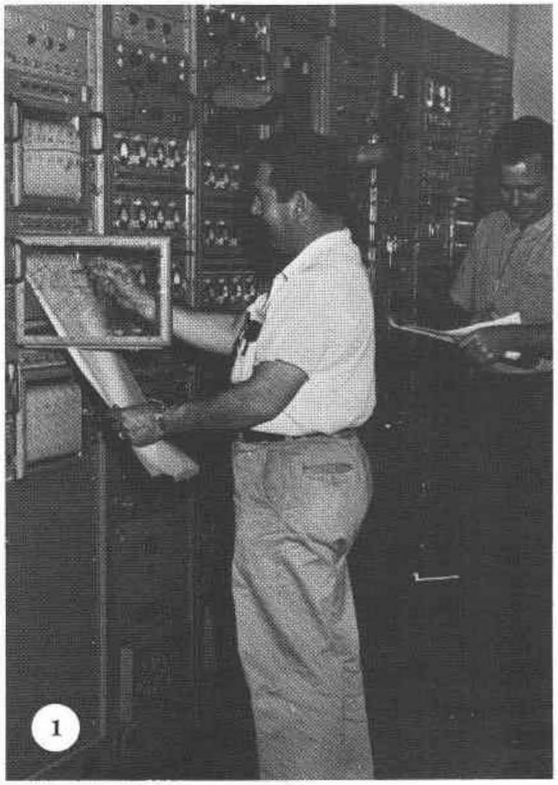


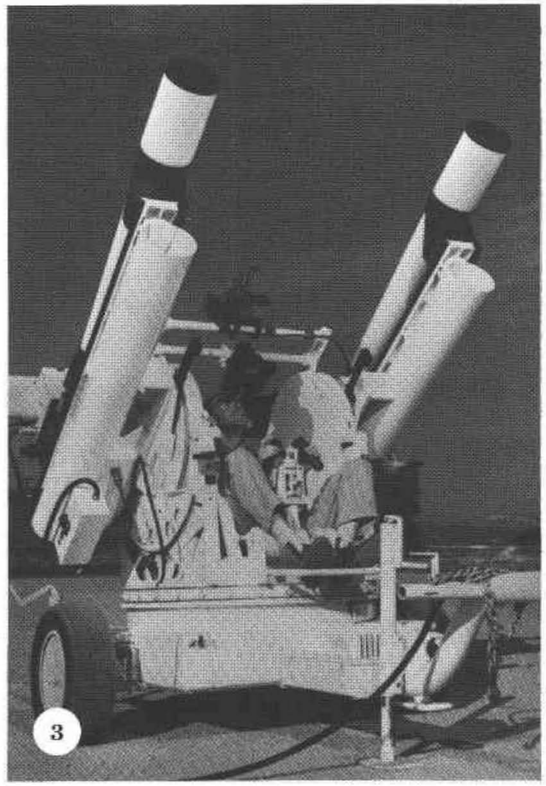

6

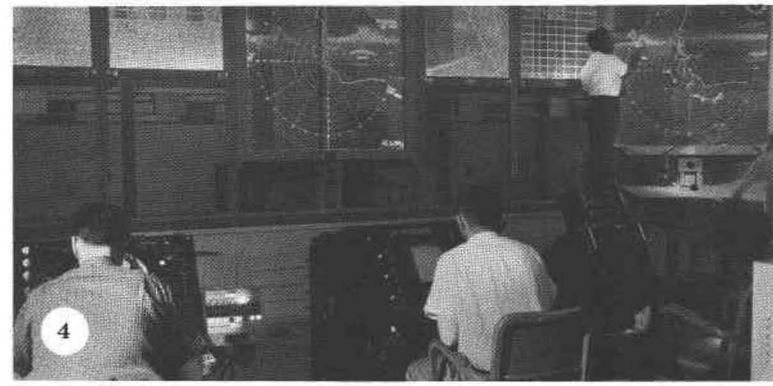

8


7


9



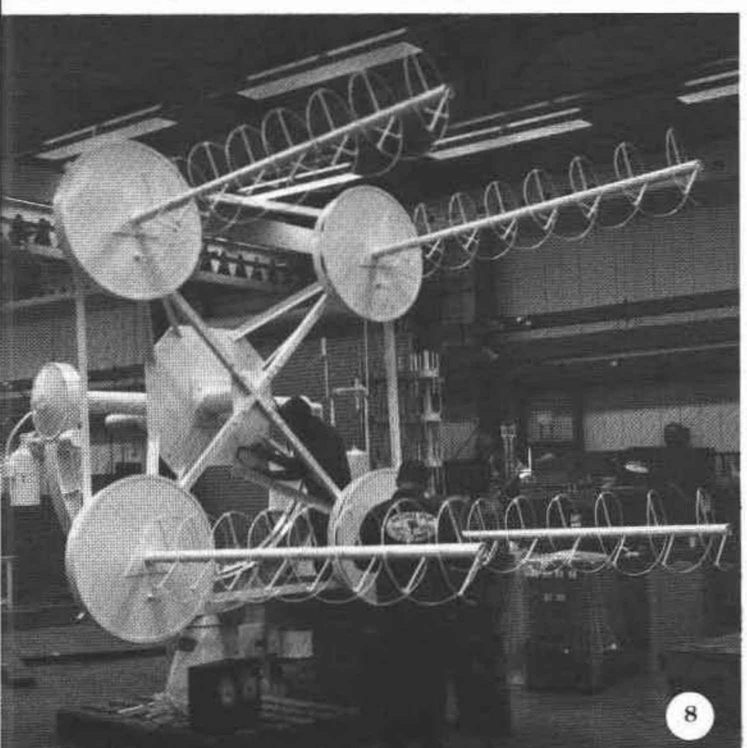


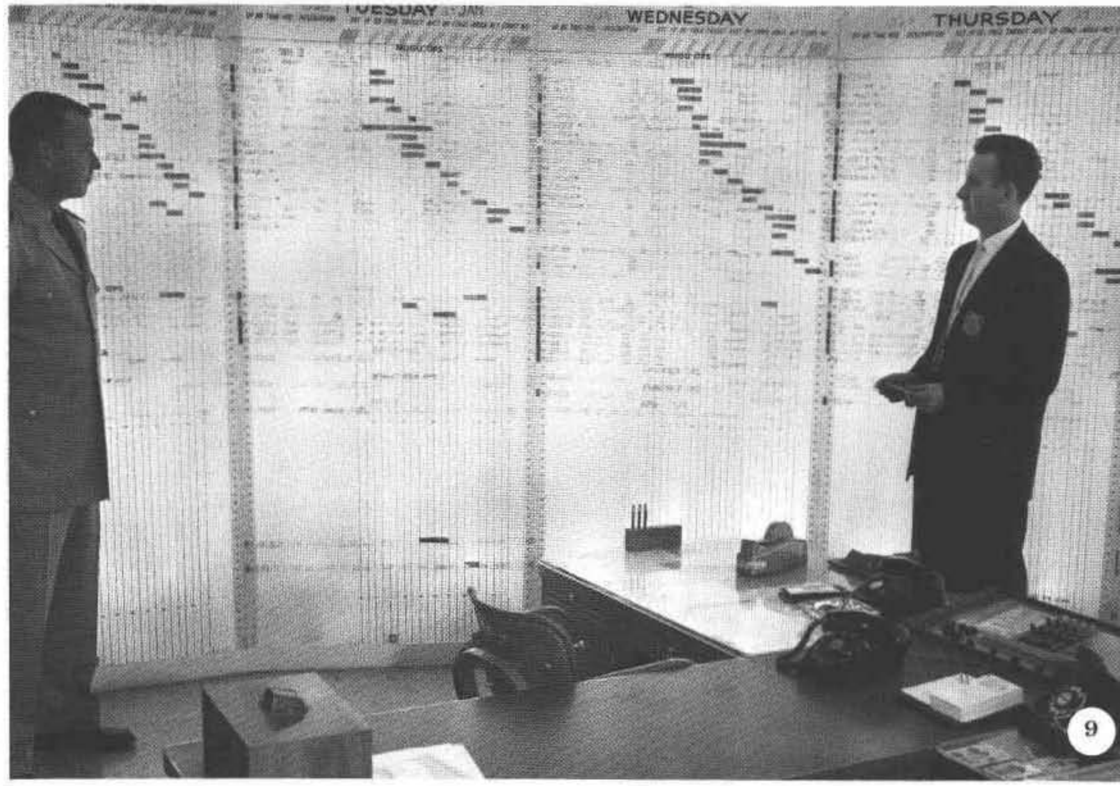


1. Telemetry receivers/recorders at Point Mugu (1960). 2. Range safety officers at their control console, NMF Point Arguello (1961). 3. Mobile camera unit NMF Point Arguello (1961). 4. Area clearance room, Point Arguello (1961). 5. Meteorology Center at PMR. 6. Point Mugu Weather Center's teletype room (1961). 7. Airstrip on San Nicolas Island (1966). 8. Telemetry antenna in the Technical Support Department antenna shop, Point Mugu (1966). 9. Point Mugu range scheduling board (1962). 10. Launching a polyethylene balloon at NMC Point Mugu (1963). 11. ASP-20 radar relay antenna on San Nicolas Island (1958).


6

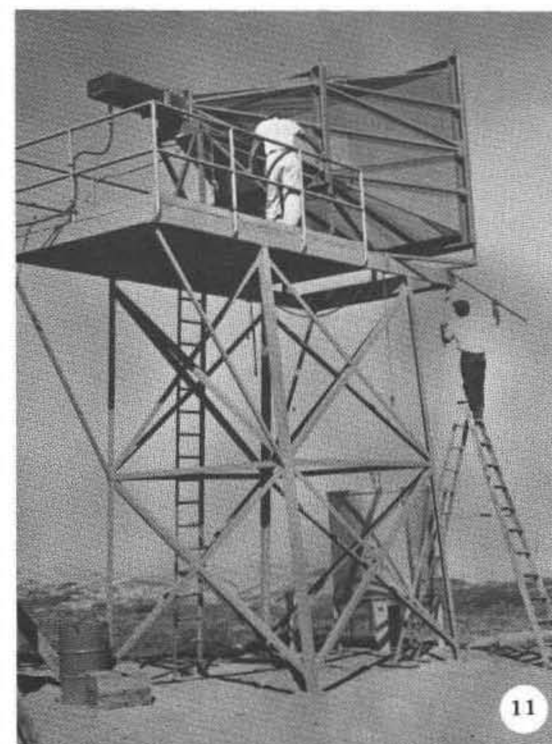

7


8



9


10


11

On the flight line, Naval Missile Center (NMC), Point Mugu (1962).

"Progress, therefore, is not an accident . . . It is a part of nature."
—George Spencer

CHAPTER 7

THE NAVAL MISSILE CENTER

Even as the range was undergoing rapid expansion as a result of the establishment of PMR, the original mission of test and evaluation continued unabated. This work, performed primarily by NAMTC organizations remaining after PMR's commissioning, was assigned on January 7, 1959, to a new organization—the Naval Missile Center (NMC). NMC was placed under the military command of the Commander, PMR, and under the management control of the BuAer. The stated mission of the new NMC was to:

> *". . . certify Fleet ready missiles to the operating forces of the Navy as rapidly as professionally possible, by virtue of its mission which is (1) to conduct test and evaluation of guided missiles, their components, and weapon systems, and (2) to provide services and support to the Pacific Missile Range Facility."*

Later the mission was augmented to include efforts in the field of astronautics and life science.

During the years 1958 to 1960, Navy weapon projects assigned to NMC gradually shifted emphasis toward air-launched weapons. This resulted at least in part from the REGULUS I becoming operational and the cancellation of the REGULUS II program. Both missiles continued at Point Mugu as targets. The REGULUS II, designated the KD2U-1, filled a particularly urgent need for a Mach 2 high-altitude target that could challenge new high-speed weapons such as the SPARROW III. The KD2U-1, because it was recoverable and also used existing REGULUS II airframes, produced considerable financial savings to the government.

SPARROW III

In January 1959, the supersonic SPARROW III was introduced to the Fleet. At about the same time, the F4H-1 Phantom II aircraft came aboard the Center for armament system developmental testing with the SPARROW III. The importance of the latter event is well stated in the *Command History for FY-1960:*

> *"The importance of the F4H as a military aircraft lies not alone in its speed and long range, but primarily in the fact that, combined with the SPARROW III, it will provide the Navy with a new and superior weapon system that will greatly increase the defensive force of the U.S. Fleet against aerial attack."*

On September 17, 1959, the first successful target intercept was made by a SPARROW III launched from a F4H-1 aircraft. More "firsts" followed in quick succession. For instance, just three months later, on December 4, the first four-missile ripple firing was staged, this time using the F3H-2 aircraft. Next came the first supersonic flight. There were many other important events in the SPARROW III program during this period. The following are representative of those that were perhaps most significant: the test launch of the first fully instrumented missile using a solid propellant motor; the first firing of the missile at Cold Lake, Canada, to evaluate its all-weather capability; and the first launch of a SPARROW III using a liquid propellant rocket engine.

BULLPUP

The BULLPUP supersonic air-to-surface missile was also tested at NMC and introduced to the Fleet in 1959. At that time, two aircraft, the A4D-2 Skyhawk and the F4J Fury, were configured to launch the missile. It was very gratifying to NMC that the BULLPUP, after introduction to the Fleet, was found to be 85 percent reliable.

To increase BULLPUP's range and reliability, a prepackaged liquid propellant rocket engine was introduced. After testing at NMC, it was scheduled to become standard equipment on all third-year production missiles. In addition to testing the first BULLPUP with a liquid engine, the Center conducted several series of flight tests on the BULLPUP missile. Also, the development of the BULLPUP "B" missile was ahead of schedule in FY 1960 with the result that it would be introduced early to the Fleet.

CORVUS

Between June 1957 and April 1961, NMC conducted a contractor development test program for the CORVUS weapon system. CORVUS represented a Navy effort to produce a Fleet weapon system based essentially on the state-of-the-art anti-radiation seekers developed by the Naval Ordnance Laboratory at Corona, California.

During the program, 28 CORVUS missiles were air-launched from A3D and A4D aircraft over PMR. Eight of these missiles were program-controlled and the remaining 20 were equipped with radar-seeking guidance systems. Limited studies and tests were also conducted on missile guidance, countermeasures, hazards to ordnance from electromagnetic radiation, measurement of missile operating environment, and serviceability.

The principal conclusion drawn from the test program was that the goal of a successful and timely development program could not be reached. This was because the requirements for time and funds were underestimated and the reliability of the developmental hardware was such that consistent operation of the system was difficult to achieve. NMC further concluded that the complexity of the missile was the principal contributing factor to the poor reliability,

CORVUS missile ready for loading on an A4D aircraft (1959).

and the missile's propulsion system, a liquid fuel rocket engine, was the greatest single problem area.

On the positive side, NMC engineers and test personnel felt that the experience and information gained through the CORVUS program would contribute substantially to the development of a similar weapon system in the future. Furthermore, NMC concluded that a long-range, air-to-surface, anti-radiation guided missile system of the CORVUS configuration was feasible because in three operations the missile homed successfully on target radars at ranges up to 100 nautical miles, a program-controlled missile flew 161 nautical miles, and no evidence was found to indicate that a missile of this configuration would not be capable of at least a 160-mile range.

CROW

The late 1950's and early 1960's proved to be a very interesting and exciting period of time for young engineers joining NMC. Many of these engineers participated in the Junior Professional or JP program mentioned in Chapter 5, and a number of them worked on an NMC-initiated program called CROW for Creative Research on Weapons. As Jim Perkins now recalls:

> *"E. Quimby Smith, the CROW manager, put a number of JP's to work on the project. He gave each one an area of development and attempted to have them push the state-of-the-art. We did a lot of exploration and reading, although few were full-time on the project. Each week we'd get together on an informal basis and philosophize about a particular technical subject.*
>
> *"CROW lasted several years and we produced a vehicle that would fly at Mach 2 and 60,000 feet for a long time. However, no one needed such a vehicle at that time because guidance technology was not far enough advanced."*

LABORATORIES

Although NAMTC and NMC had consistently conducted ground and laboratory tests of missiles and components since the time of the LOON (see Chapter 1), in 1959 the Navy decided that to better utilize missile development effort, new emphasis should be placed on laboratory methods of test and evaluation.

To further this aim, construction began that year on a component test building which would be the nucleus of an entire complex, providing facilities for laboratory research and evaluation. A new rocket test facility was also established to study the compatibility of rocket power plants with the missiles that would use them. Through these tests it was anticipated that integration problems could be discovered and resolved before flight.

NMC's new environmental facility, built about this time, performed simulated environment and climatic tests on missiles, components, checkout equipment, and maintenance equipment. In the large sea level chamber, it was also possible to evaluate and train personnel under simulated climatic conditions ranging from tropic to polar, and including rain or snow.

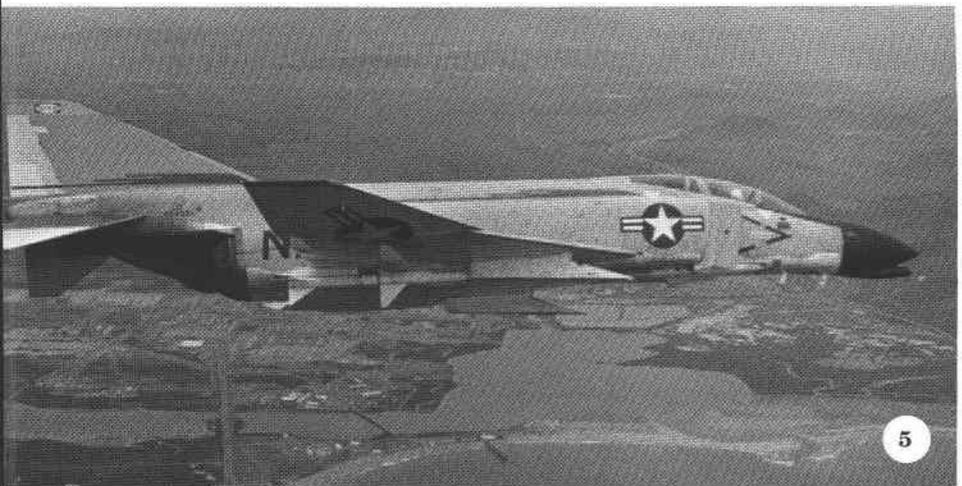
An inertial guidance laboratory was formally dedicated in 1959. The laboratory provided equipment for evaluating gyroscopic components up to complete inertial guidance platforms. There was also a sea motion simulator device, a precision centrifuge, and a two-axis flight table.


NAVAL MISSILE CENTER
612
1

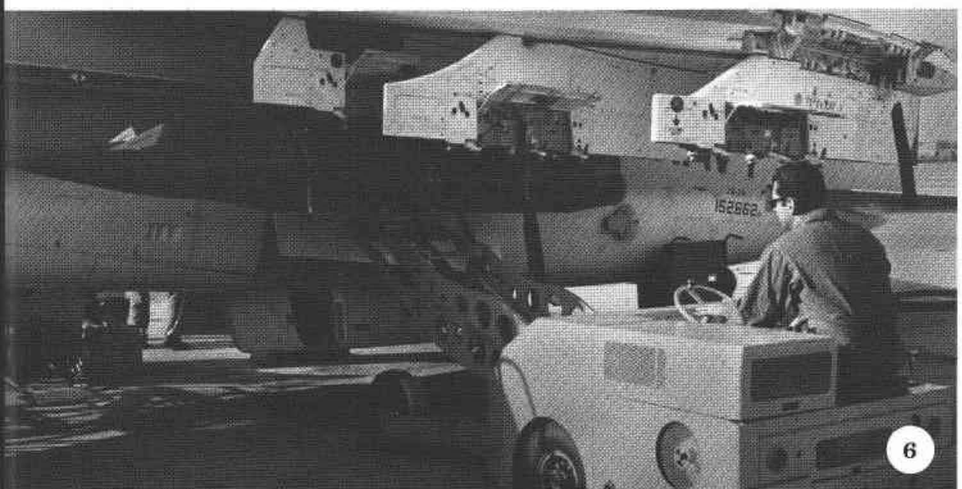

NAVY
539
NAVY
2


484
NAVY
3484
3


4

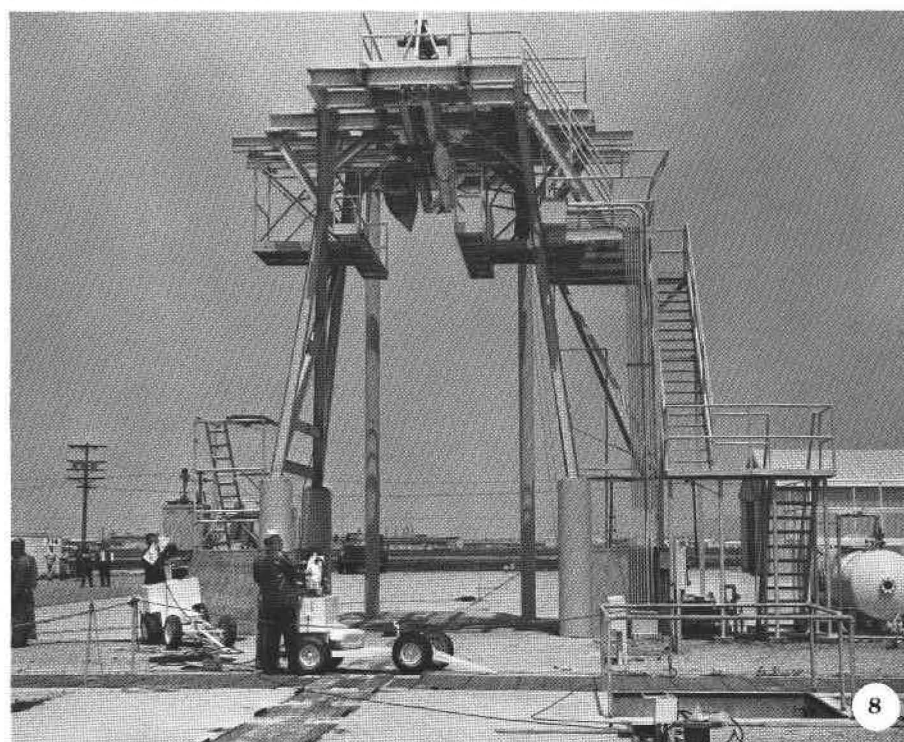


5



6

7

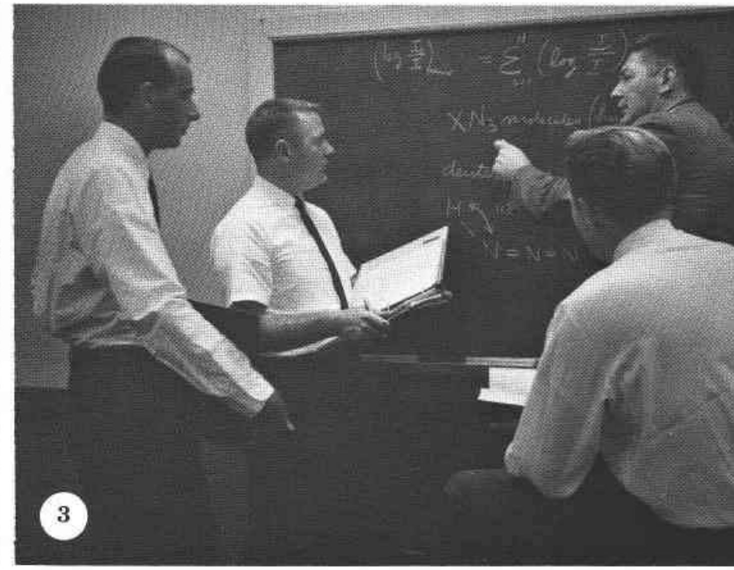


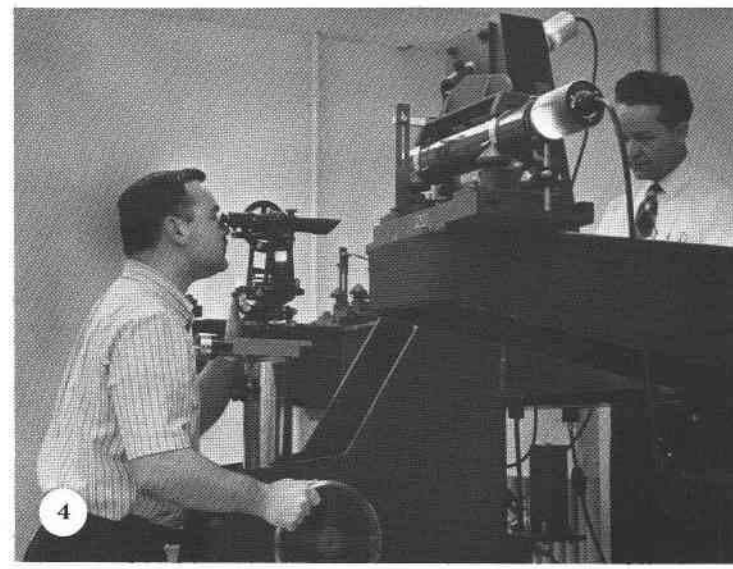
8

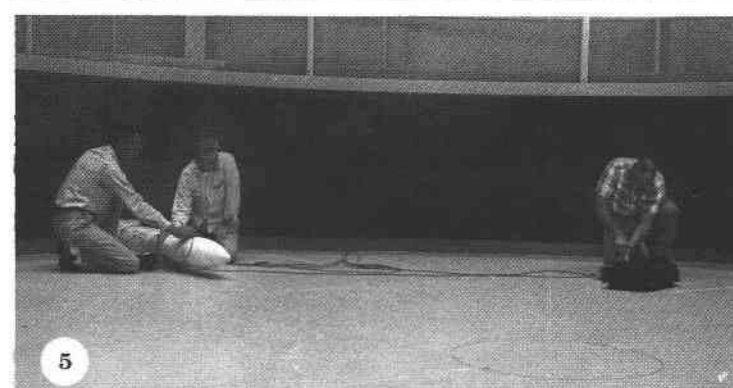
1. Headquarters Building of NMC Point Mugu (1968). 2. KD2U (REGULUS II) missile target with TV-1 (T-33) control aircraft (1962). 3. SPAROAIR high-altitude probe on F-3B aircraft. 4. F-4B aircraft line check in progress (1965). 5. F4H (F-4B) aircraft in flight with SPARROW III missile. 6. Loading BULLPUP "B" on outboard pylon during A-7A BIS trial (1966). 7. Pair of BULLPUP "A" missiles on wing of A-1 aircraft for launch pylon test (1957). 8. Preparing a launch stand for BULLPUP "A" launch (1965).

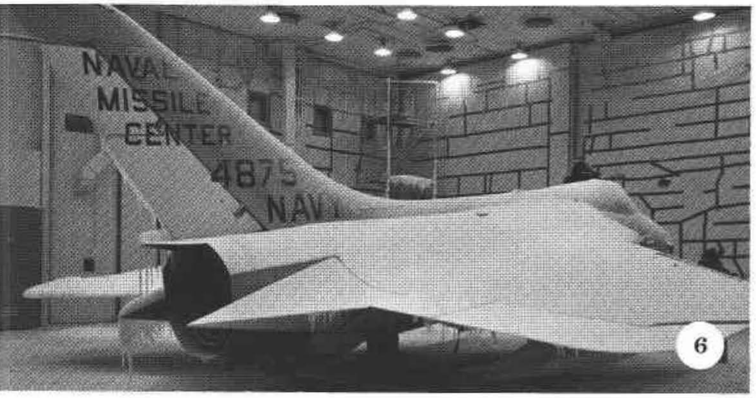
1

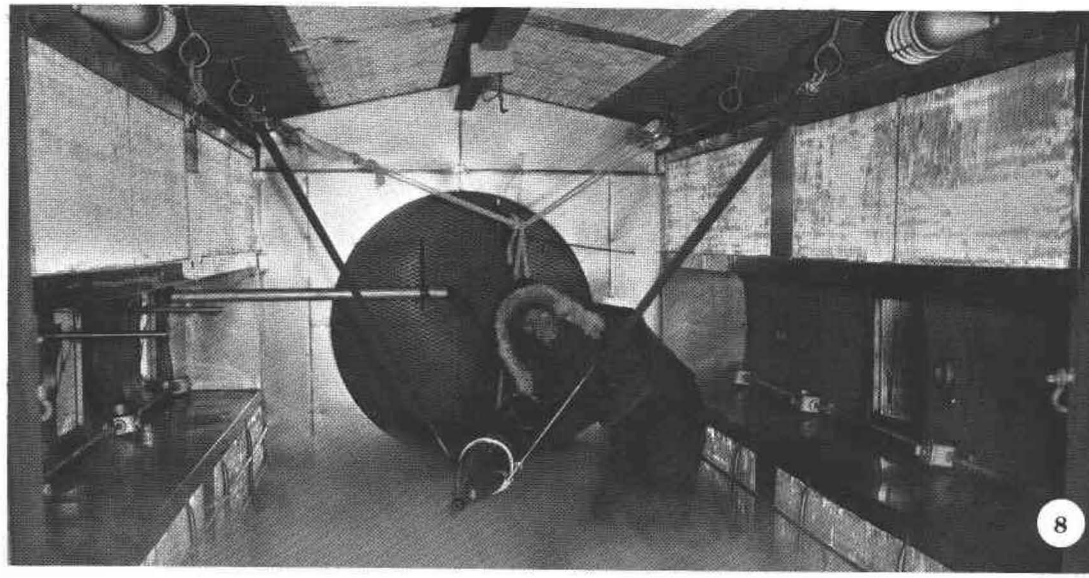
2

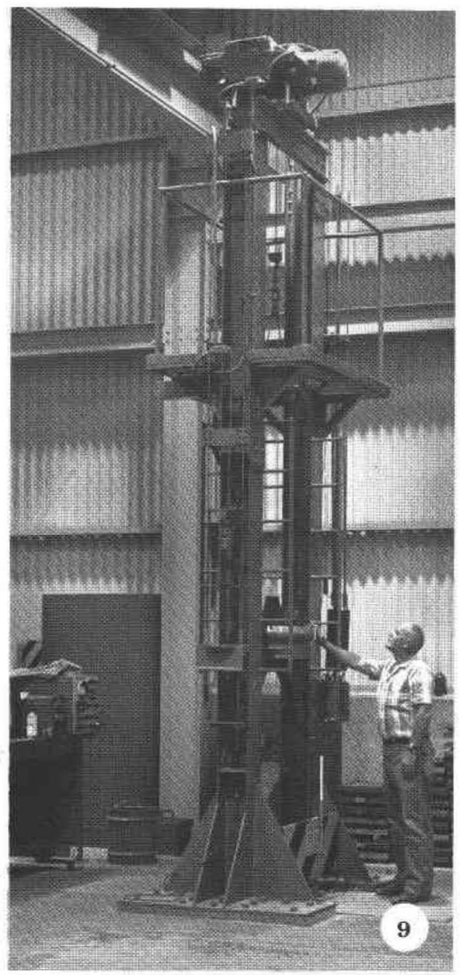

3

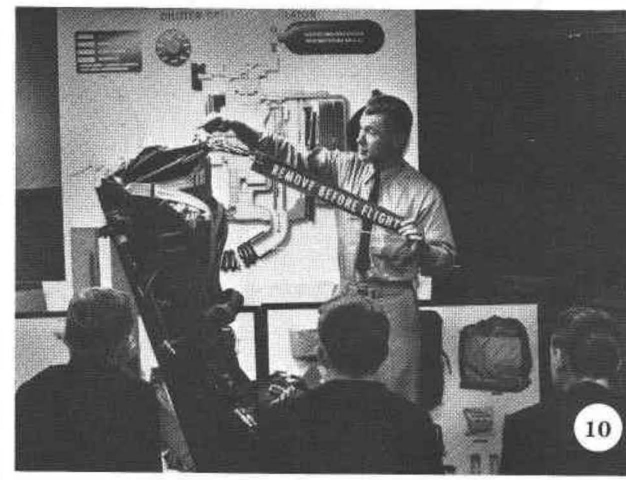

4

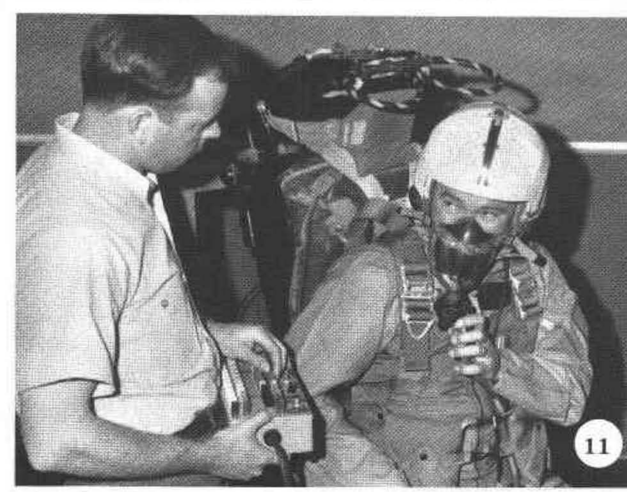

5











1. CROW missile on rail of F4H (F-4B) aircraft in flight. 2. Navy pilots on the Point Mugu flight line (1962). 3. Classroom situation as part of Junior Professional (JP) program. 4. Junior Professionals in the Standards Lab. 5. Disc centrifuge in Environmental Test Lab (1962). 6. F4D aircraft in freezing temperatures of the Sea Level Environmental Chamber, Building 513. 7. Testing an aerospace flight suit in a cold weather simulation (1960). 8. Technician working inside the temperature chamber in the Environmental Laboratory (1961). 9. Sixteen-foot drop tester in the Environmental Test Lab, Point Mugu (1962). 10. Explaining safety pins on Martin Baker Ejection Seat to class at Physiology Training Branch (1964). 11. Check out procedure at Air Crew Equipment Branch (1968).

Preparing for launch of a HUGO III high-altitude probe at Point Mugu (1961).

"The past is but the beginning of a beginning, and all that is and has been is but the twilight of the dawn. A day will come when beings who are now latent in our thoughts shall stand upon the earth, as one stands on a foot stool, and shall laugh and reach out their hands amid the stars."

—Herbert George Wells (1901)

CHAPTER 8

ENTERING THE SPACE AGE

With the experience gained in propulsion, guidance, and instrumentation of missiles and other vehicles during the preceding decade, it was natural for PMR and NMC to enter enthusiastically into the age of space technology. The programs introduced during this period were in reality an outgrowth of a long-standing Navy interest in space. The following quote from a presentation by the Senior Scientist of the West Coast Laboratories makes this historical background quite clear. He wrote:

> *"The Navy's present interest and effort in space is not a sudden outburst triggered by international competition, but is the logical result of a continued program of scientific exploration which for many years has probed the borders of space. Well-known milestones of the program are Project SKYHOOK and studies from V-2's in 1946, AEROBEE high-altitude rocket probes in 1947 and 1948, Project VIKING in 1948 to 1953, and VANGUARD from 1955 to 1959.*
>
> *"The Navy will participate fully in space technology . . . the Navy astronautics program will receive high priority in the overall Navy research and development program."*

Recognizing the tremendous challenge facing PMR in both missile and space technology, the Command, on October 14, 1958, established the PMR Advisory Board consisting of distinguished scholars, scientists, and executives. The task of the committee is stated in the letter of invitation from Rear Admiral R. E. Dixon, Chief of the Bureau of Aeronautics:

> *"The recent establishment of the Pacific Missile Range Facility, with headquarters at Point Mugu, California, will result in a marked increase in missile test and evaluation programs on the West Coast . . . I am currently establishing a Navy Public Advisory Committee to assist me and the Commander and Technical Director of the Pacific Missile Range Facility in planning and directing the programs. . . If you will serve, will you please let me know at your earliest convenience? The problems we face are urgent and they demand the best minds we can bring to bear."*

TRANSIT

As might be expected, a prime Navy interest in space utilization was for navigation. Consequently, one of the earliest programs at PMR was TRANSIT. The program, first under Advanced Research Project Agency (ARPA) and later Navy sponsorship, was to investigate the use of satellites and space vehicles as radio frequency navigational aids. PMR participated in the planning for TRANSIT launches for several years, and then on July 1, 1960, the responsibility for the program was assigned to PMR, and a program office was established at Point Mugu.

SPACE SUPPORT

Space-related activities at PMR in the 1958 to 1960 period included not only Navy programs but support to a relatively large number of Army, Air Force, National Astronautics and Space Administration (NASA), Advanced Research Projects Agency (ARPA), and Atomic Energy Commission (AEC) projects. A major part of this support was instrumentation, and PMR, in addition to its mainland facilities, established a number of downrange sites on the islands of Oahu, Kauai, Wake, Johnston, Canton, and Kwajalein.

Also, for those portions of a missile's flight beyond land-based instrumentation, the range had at its disposal four range ships equipped with instrumentation and two WV-2 aircraft for telemetry data collection. Two of these ships could monitor the re-entry of space capsules and recover them at sea.

Support for the Air Force was provided primarily in the launch of the DISCOVERER series of satellites from Vandenberg AFB, the monitoring of orbiting satellites, and the recovery of space capsules. The DISCOVERER, a stabilized satellite, was placed in polar orbit by a THOR/AGENA rocket. Of the first 18 launched, 10 stabilized in orbit and three capsules were recovered.

Project MERCURY, the nation's first manned orbiting space capsule, involved PMR heavily in planning support to NASA. For this project, far more instrumentation and communications would be required than in any previous program, and PMR's island sites and range ships were key links in a worldwide network.

Also, at this same time, PMR conducted drop tests on the Nuclear Emulsion Recovery Vehicle (NERV) being developed by ARPA for NASA. The range proposals for launching NERV were accepted and six launches were assigned.

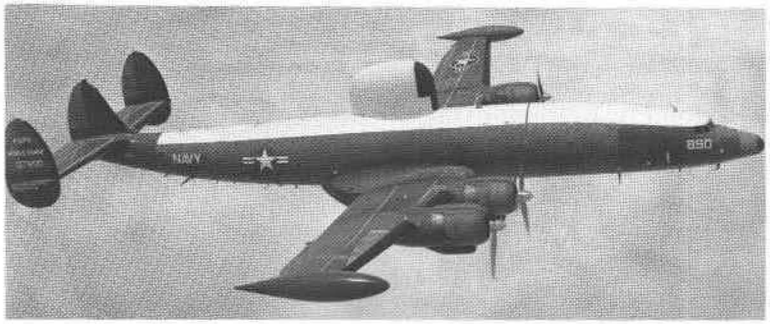
Projects assigned to PMR by ARPA included SARV (Mk IV) Air Force nose cone drop tests, instrumentation support for the Air Force manned boost-glide space craft DYNA SOAR project, and work on TEEPEE, a Navy program for detecting ICBM launches and nuclear explosions by "back scatter"; that is, bouncing radar signals off ionized trails produced in the ionsphere.

AEC programs involving PMR centered on the construction of a launch facility at NMFPA to be used in Project TUMBLEWEED. On February 4, 1960, the first TUMBLEWEED launch was made from NMFPA.

ASTRONAUTICS AT NMC

While PMR was actively engaged in expanding its support for a wide variety of space programs, NMC also began to emphasize space technology. It organized the Astronautics Department whose mission was to plan, coordinate, and prosecute Navy astronautics programs at PMR/NMC. Also, one of the divisions of the department was responsible for conducting orientation courses for senior Navy officers and training courses for Fleet personnel.

Major Navy programs of interest to the Astronautics



WV-2 (EC-121) Constellation, a range instrumentation aircraft.

Department were the previously mentioned TRANSIT satellite system, which by 1960 had demonstrated an accuracy of 0.1 mile, thus making the attainment of 0.03 mile accuracy probable; geodetic satellites; solar radiation satellites; communication satellites; reconnaissance/surveillance systems; anti-satellite weapons; high-altitude probes; and various techniques for launching probes from air, ship, or water.

HIGH-ALTITUDE PROBES

In conjunction with the satellite programs, NMC in the early 1960's participated in the development of a number of high-altitude probes. Since this work involved a considerable amount of time and interest, and included development as well as testing, it occupies a significant place in the history of this period.*

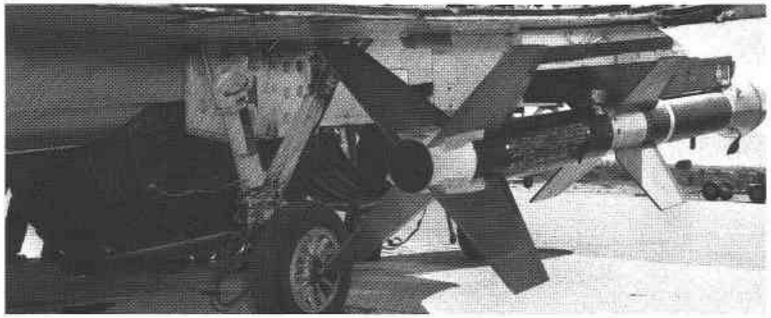
The SIDEWINDER-ARCAS system was developed by NMC to provide a low-cost, surface-launched, atmospheric sounding rocket capable of lifting a 10- to 15-pound payload to approximately 350,000 feet. Flight tests were made at White Sands Missile Range in 1963, and then starting in October 1964 the vehicle was used extensively in support of the Air Force Cambridge Research Laboratory.

SPAROAIR II, a two-stage, air-launched sounding rocket, was designed and then developed by NMC. Using two SPARROW motors in tandem, the rocket was launched from an F3H aircraft using the "over-the-shoulder" bombing technique. SPAROAIR II, which could lift a 40-pound payload to 100 miles, was used for Project TEEPEE (mentioned earlier), the Joint Army-Navy high-altitude infrared measurement experiment (JANE), the REDGLARE communications experiment, and the high-altitude ultraviolet measurement program (NITEOWL).

There were two follow-on programs to SPAROAIR II. SPAROAIR III involved an effort to significantly improve performance and reduce cost with a modest development program, and SPAROAIR/JAVELIN was a program to develop a first-stage booster to allow surface launches.

The TERRIER/NOTS-551 vehicle, developed in conjunction with the Naval Ordnance Test Station, China Lake, was a surface-ship-launched probe. It utilized an advanced TERRIER booster and a specially designed second stage in order to lift a 50-pound payload to 450 miles. Another vehicle employing the same first stage was the TERRIER/HYDAC.

Perhaps the most unique high-altitude probe was the HYDRA-IRIS (described at length in Chapter 16) which used a sea-launching technique. The design goal was to launch a 100-pound payload to 175 nautical miles. In theory, sea launching the probe would mean that a launch could be made from practically any ocean in the world.



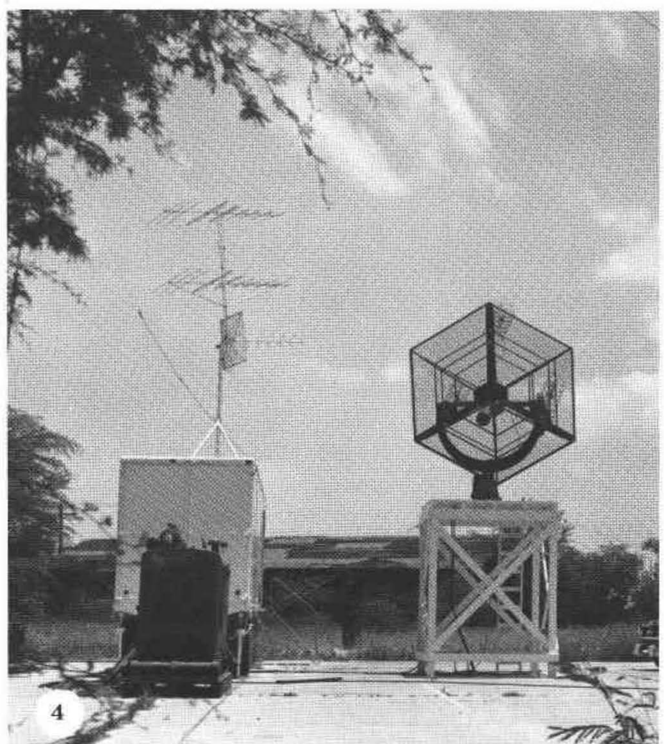
SPAROAIR II air-launched sounding rocket.

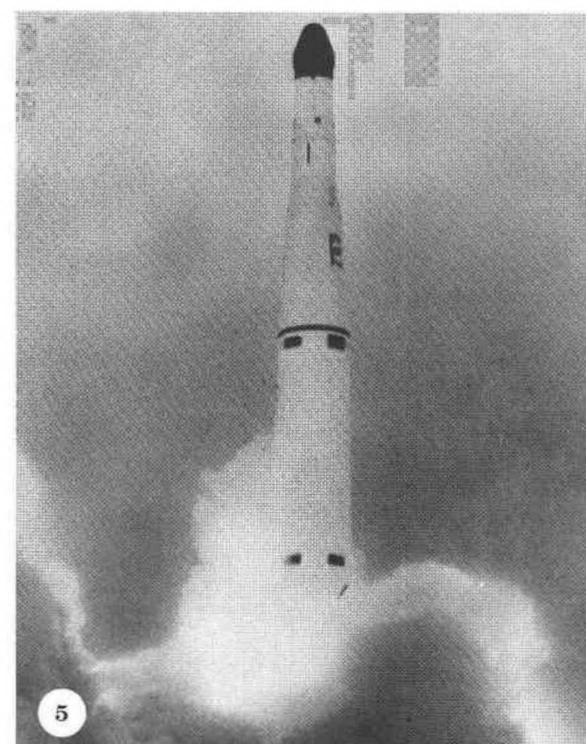
* Some of the NMC high-altitude probes supported the International Geophysical Year (IGY).

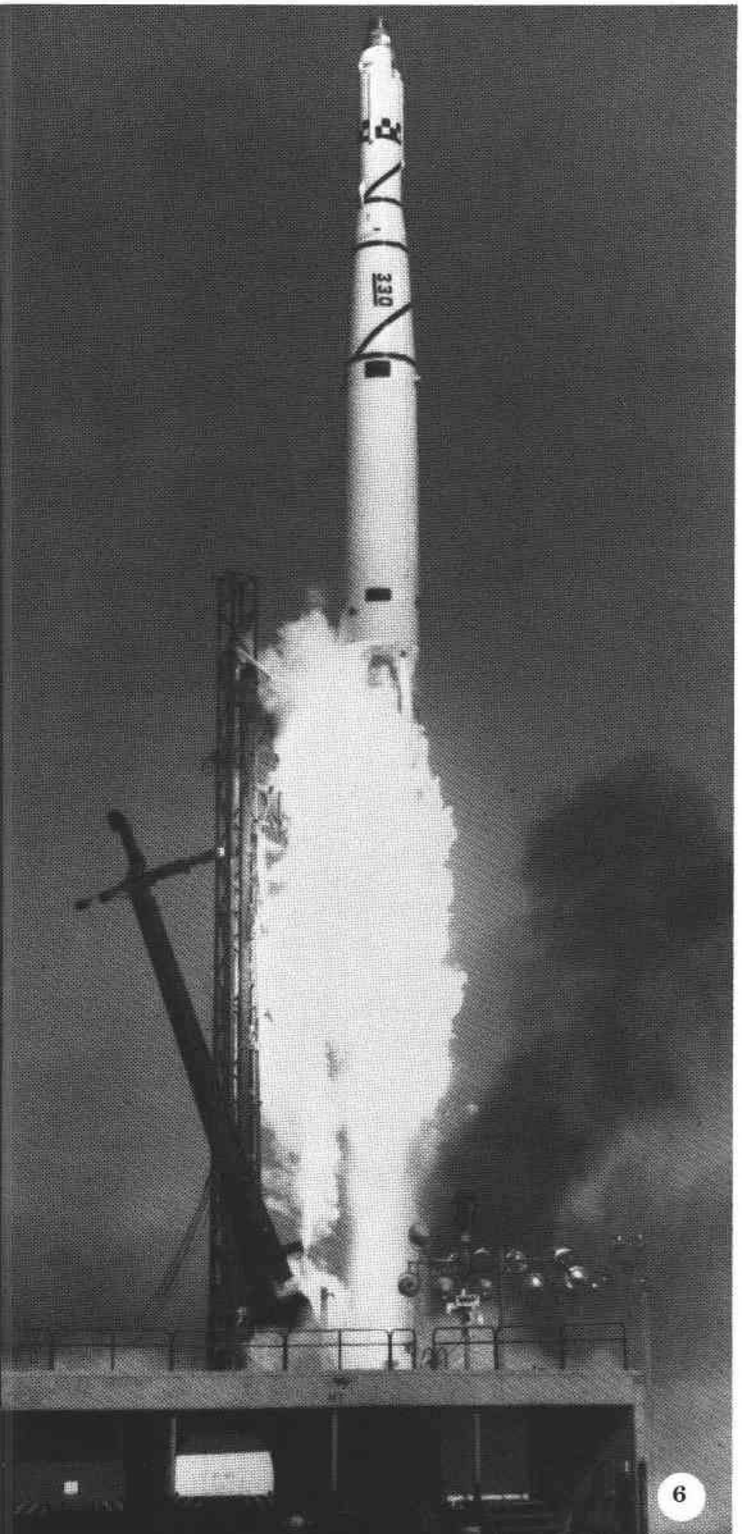

1


2

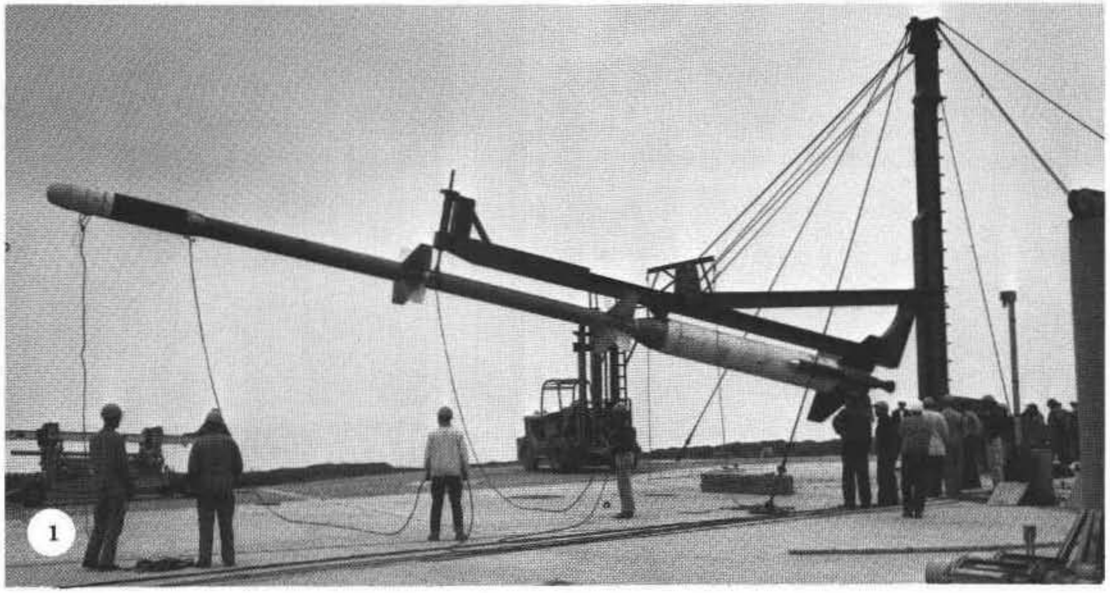

3

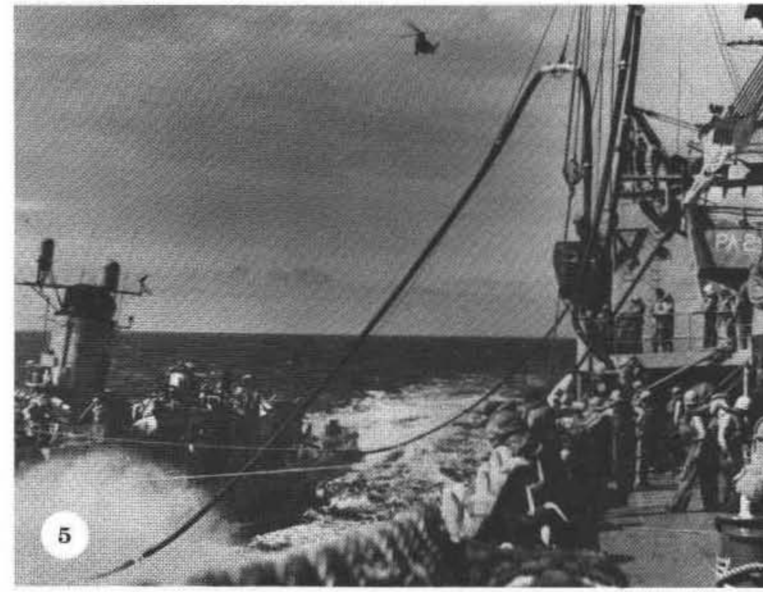

4


5

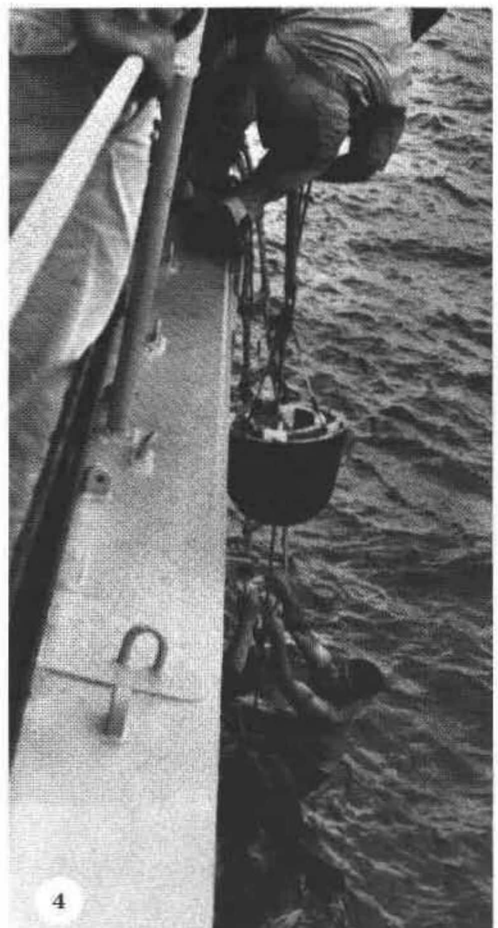


1. Building 36, Headquarters, Pacific Missile Range, circa 1962. 2. Aerial of the Marine Corps Air Station Kaneohe Bay, Oahu, Hawaii (1961). 3. Kwajalein Island in the Marshall Islands Group (1962). 4. Tracking facility at Barking Sands, Hawaii, used in support of ICBM and space missions. 5. TRANSIT navigational satellite launch by THOR/ ABLESTAR rocket at Cape Canaveral (1960). 6. THOR/ AGENA rocket launch of a DISCOVERER satellite from NMF Point Arguello (1961). 7. PMR range ship USNS WATERTOWN (1961). 8. Telemetry antenna tower and building at Kokee Park, Kauai, Hawaii (1960).


1

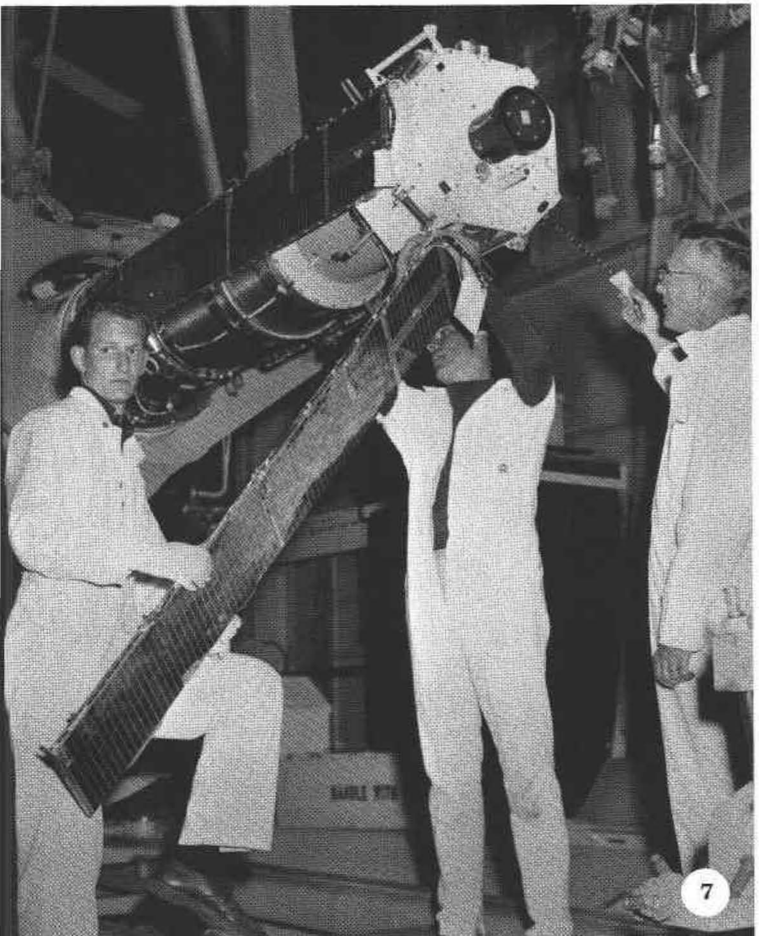

5


2

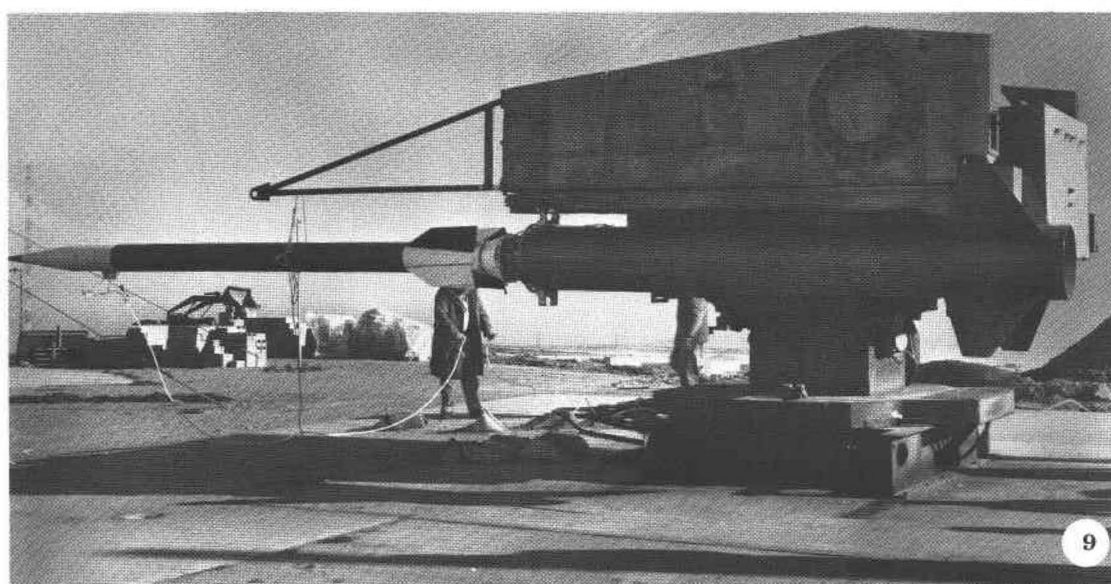

4

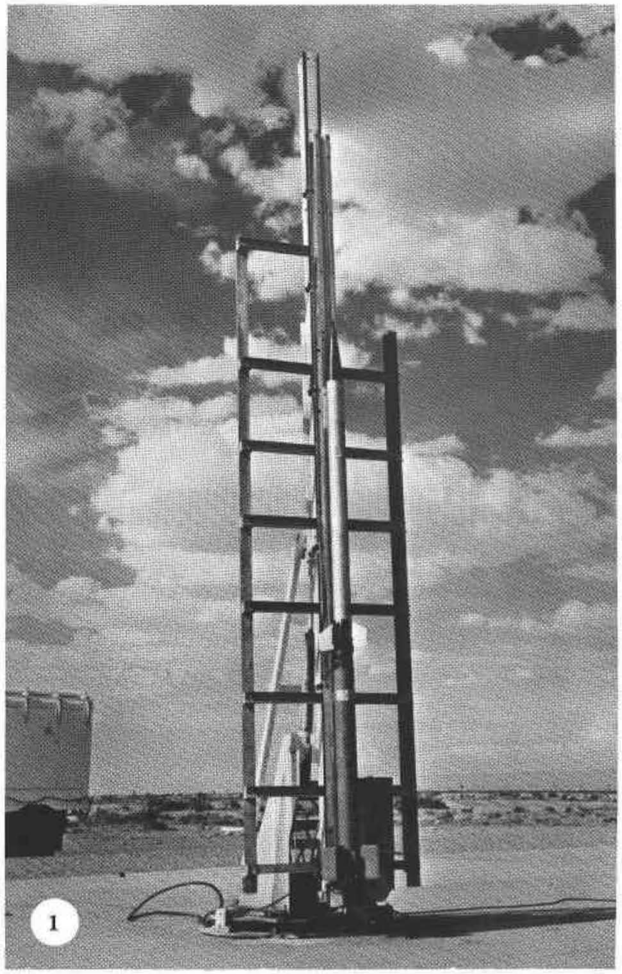

3

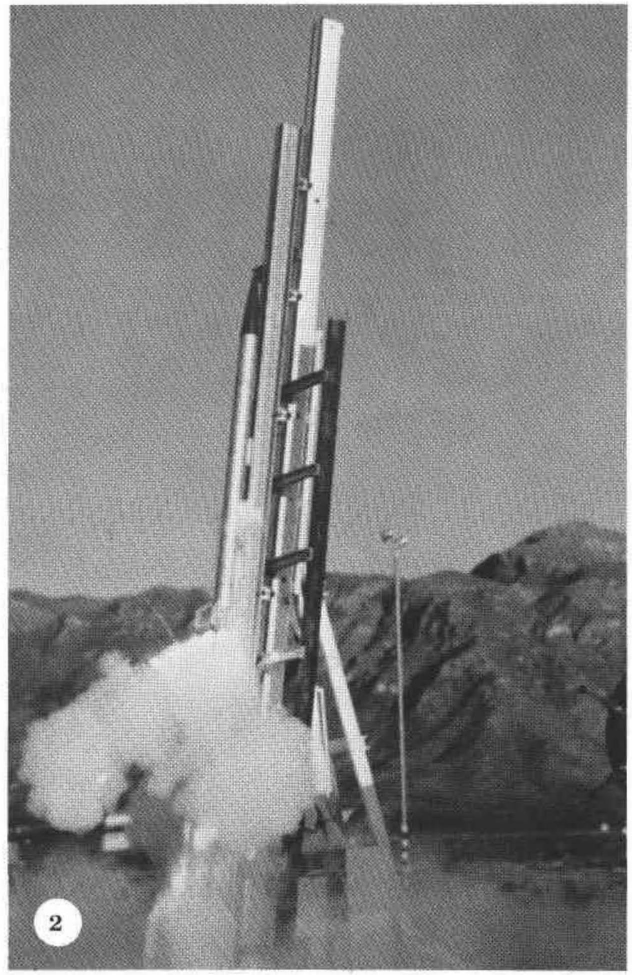

6

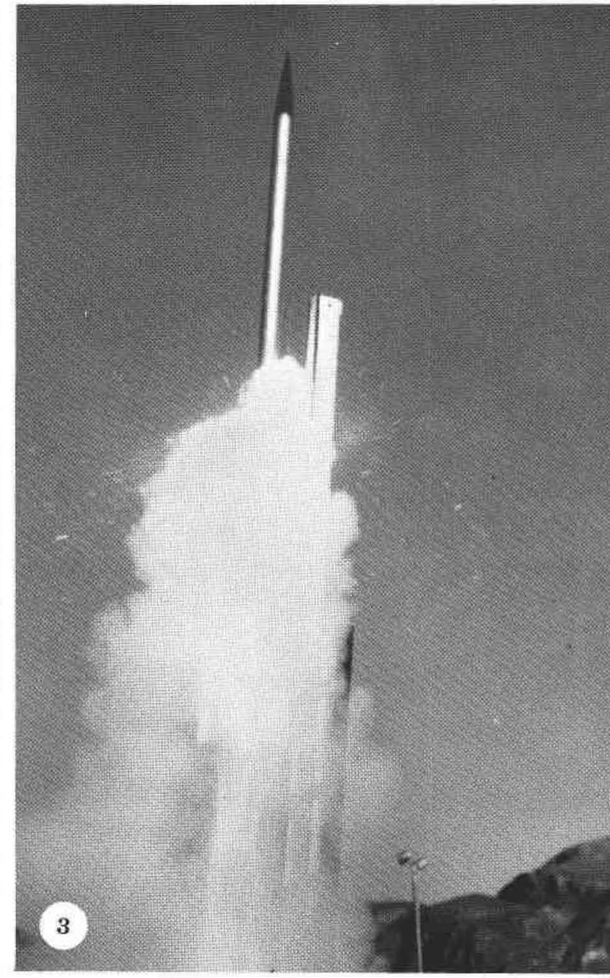


1. NERV (Nuclear Emulsion Recovery Vehicle) undergoing preparation for launch at NMF Point Arguello (1960). 2. PMR helicopter and frogman practicing nose cone recovery (1961). 3. Recovered NERV nose cone aboard the USS PAUL REVERE (1960). 4. NERV nose cone recovery underway alongside the USS ROWAN (1960). 5. USS GURKE refueling alongside the USS PAUL REVERE during NERV recovery operation (1960). 6. Helicopter landing, USS PAUL REVERE (1960). 7. Navy navigational satellite mated to a SCOUT booster (1963). 8. Mating the booster to the second stage of HUGO IV (1964). 9. TERRIER/HYDAC high-altitude probe on the launcher (1966).

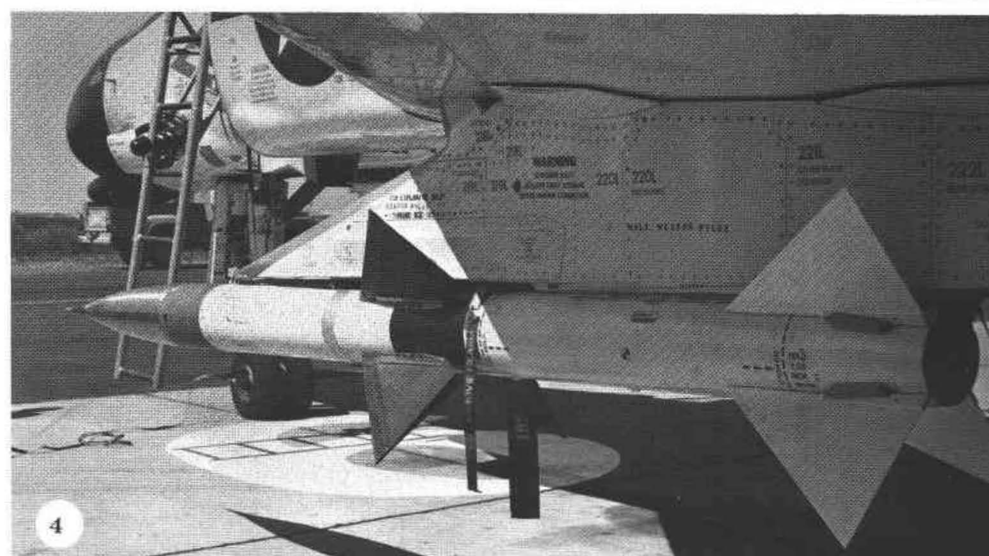




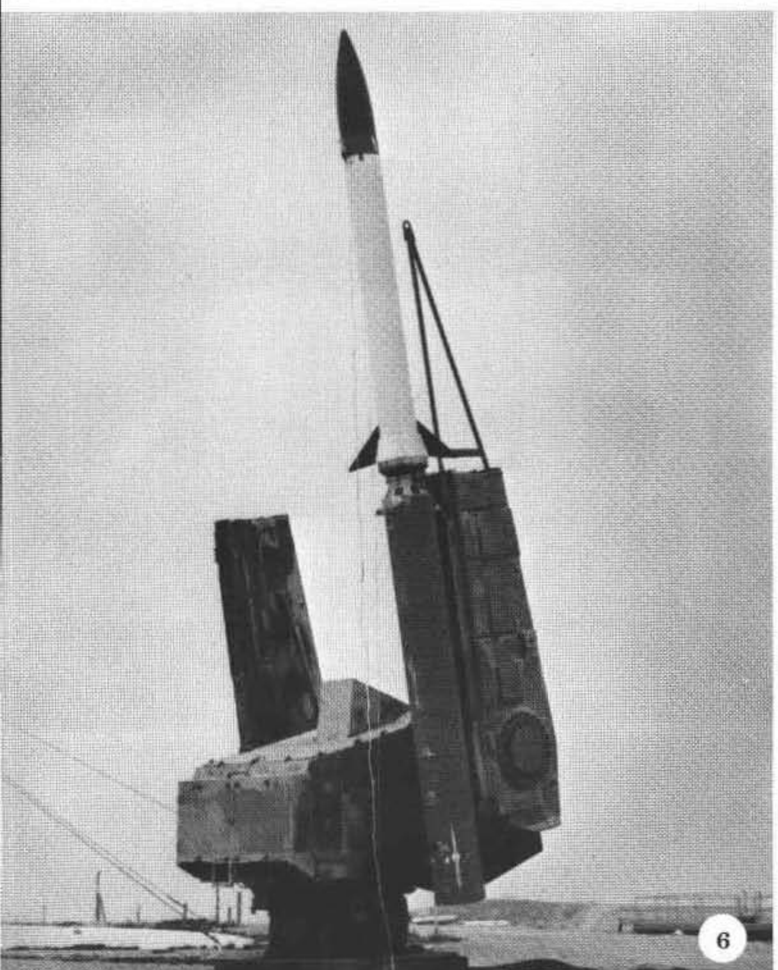


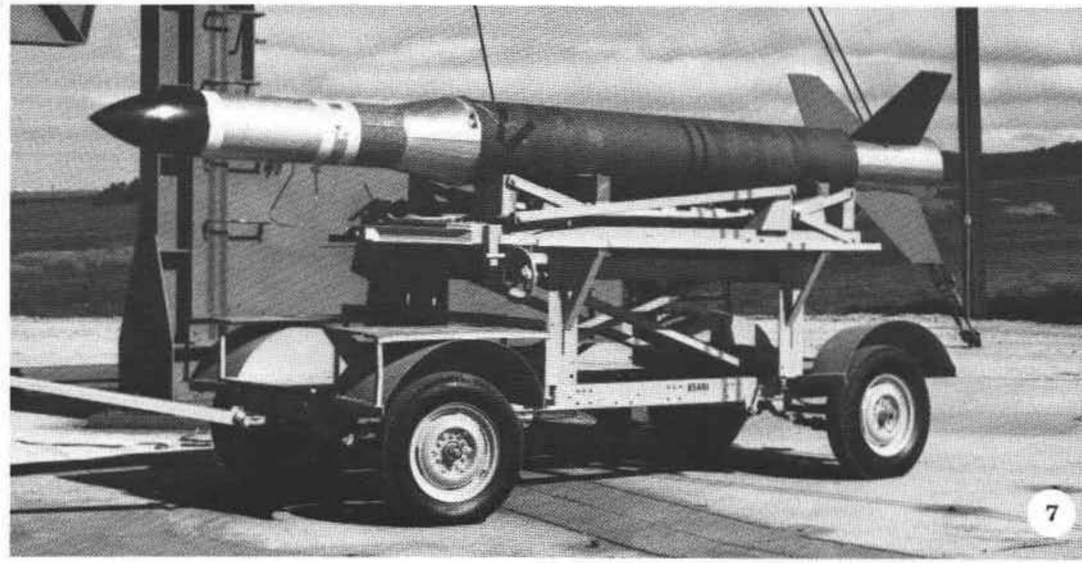


1. Boosted ARCAS sounding rocket elevated on launcher at White Sands, New Mexico (1964). 2. Boosted ARCAS just after ignition (1963). 3. SIDEWINDER-boosted ARCAS nearly clear and away (1964). 4. SPAROAIR on the rail of a F-4B aircraft (1964). 5. Range ship HAITI VICTORY. 6. TERRIER/NOTS-551 high-altitude probe on launcher at San Nicolas Island (1966). 7. Project HAD third-stage with payload (1963). 8. TERRIER/HYDAC high-altitude probe.

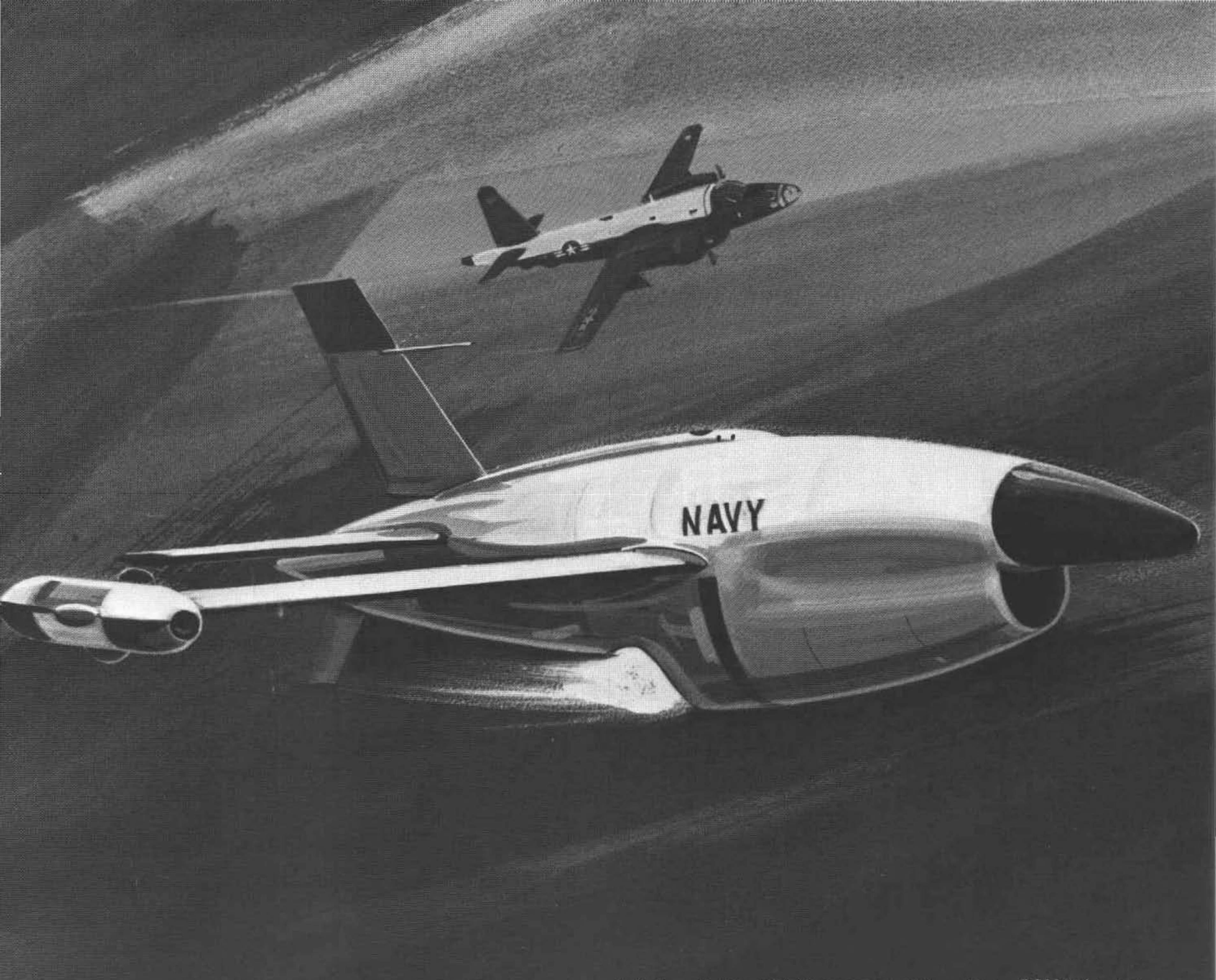



5


6


7


8



Artist's rendering: P2V Neptune aircraft launching a BQM-34A target.

"We should provide in peace what we need in war."
—Pubilius Syrus

CHAPTER 9

SIMULATING THE THREAT

The need for gunnery targets and drones, as previously related, placed a considerable impetus on pre-World War II era pilotless aircraft and missile development. Over the years, this need not only continued but accelerated, and, as a result, a steady stream of target projects was pursued at Point Mugu. Naturally, as missiles became faster and more accurate, target developers were challenged to increase the speed and maneuverability of the targets that simulated the threats. Consequently, propeller-driven drones were replaced with jet- and rocket-powered targets. Also, as former operational aircraft became available, they were modified or converted for use as full-size targets.

Another major effort in target development was the test and evaluation of augmentation devices installed in drones to increase radar reflectivity or record miss-distance. Augmentation devices such as Luneberg lenses, traveling wave tubes, or radar corner reflectors enhanced the radar cross section to make a small target appear larger to a weapon system's radar guidance. This not only increased the realism of the presentation, but often allowed smaller, less expensive targets to be used in certain operations.

When PMR and NMC were established, target activities were divided between them. PMR was responsible for the day-to-day target operations on the range while NMC was assigned the testing of experimental targets and systems. It is not practical to recount all the many threat simulation programs that took place at Point Mugu; however, a few representative ones from this period will be presented. Subsequent programs will appear in later chapters.

KDA-4 (AQM-34C)

Starting in December 1958, NMC provided PMR users with the KDA-4 (AQM-34C), a jet-powered missile target capable of high subsonic speeds and altitudes in excess of 45,000 feet. Air-launched, it could fly up to 60 minutes depending on speed and altitude. For economy, the KDA-4 was recoverable by parachute and after decontamination could be used again. NMC provided both production monitoring and product improvement tests on the KDA-4. In proof of its reliability, the target, during one period in the early 1960's, achieved a success rate of 83.7 percent in a total of 169 missions.

XKD2B-1 and Q2C

Experimental target programs at NMC included the XKD2B-1 (AQM-37) and Q2C (BQM-34A). The XKD2B-1, developed for the Air Force and Navy, was an air-launched, liquid-engine-propelled, expendable target with associated equipment. Starting in 1960, NMC was responsible for monitoring contractor development efforts, exercising technical control, providing constructive criticism, and evaluating the product. After successful inert drops, the flight test program began in early 1961. The first powered flight was unsuccessful, but the second test was generally satisfactory. During the program, NMC gave full support to the contractor by providing computer facilities, environmental facilities, and technical assistance.

On the Q2C target, NMC performed practically all of the tests required to reveal and define defects. In addition, the radar augmentation kits were evaluated by means of radar tracking and missile firing exercises performed in conjunction with Fleet units operating on the range. Also included was the first evaluation of the traveling wave tube radar

Recovery of a BQM-34A FIREBEE target.

cross section augmentation device for Fleet use. Passive radar augmentation devices such as Luneberg lenses and corner reflectors were evaluated as a replacement for the more expensive traveling wave tubes. By 1963, the Q2C had the highest usage rate at Point Mugu due to its reliability and the fact that its aerodynamic performance was within the range of such a large percentage of the threats being simulated by NMC.

SURFACE TARGETS

Along with aircraft and missile targets, NMC modified and augmented a wide variety of surface craft, ranging from small, high-speed boats on up to full-size decommissioned warships.* Also, considerable work was performed on control systems and target auxiliary systems.

JINDIVIK

One notable program at PMR during the early 1960's involved the Australian JINDIVIK target. This subsonic, jet-powered, pilotless aircraft was launched from a three-wheeled dolly which ran on an ordinary runway. After separation, the dolly was automatically braked to a stop. Both takeoff and landing were controlled visually by two controllers out on the runway. During flight, control was handed over to an operator at the radar site. At the termination of a flight, the target was recovered by landing it

*The emergence of the missile-firing fast patrol boat as a significant threat to the Fleet resulted in a high level of emphasis being placed on simulating this threat with high-speed (40-knot) Seaborne Powered Targets (SEPTARs) which were used for surface-to-surface and air-to-surface weapon testing and Fleet training exercises.

using a skid that extended from the underside of the fuselage.

PMR supported JINDIVIK with instrumentation radar, photo-theodolites, telemetry, radio command control, land-line communications, meteorology, electrical power, frequency control, aircraft fuel, a "display van" for observers, and a holdback device on the runway. Ten successful demonstration flights were conducted in July and August 1962 with Australian crews handling the targets while PMR personnel provided support.

ELECTRONIC COUNTERMEASURES

Another type of threat simulation provided by PMR and NMC was the production of an electronic countermeasures environment for weapon tests and Fleet exercises. As mentioned, EW development at NAMTC began in 1951, and by 1961 this effort had reached a state where a great deal of realism could be created. Although many details of this effort contain sensitive information, the broad picture of electronic countermeasure simulation in the early 1960's can be presented.

The countermeasures group had three basic objectives: determining and reducing the vulnerability of our own missiles, developing and evaluating countermeasures equipment and techniques for defense against enemy missiles, and testing and evaluating offensive and defensive countermeasure equipment and techniques in various simulated tactical environments.

Countermeasure test facilities were developed at NMC to allow missile system manufacturers to test vulnerability throughout the development of the weapon. Thus, changes could be made as the work progressed so that the end product would be either "jam-proof" or could be used in a way that would make it less susceptible to enemy countermeasures. Also, to keep their testing capability current, NMC developed and evaluated countermeasure equipment, methods, and techniques.

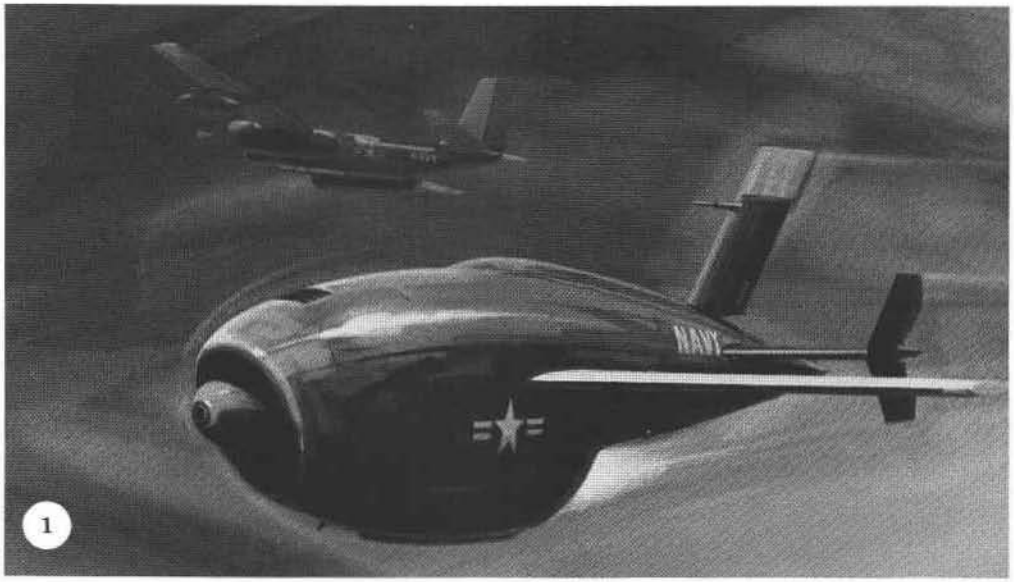
Since the initial consideration in electronic countermeasures is detection, NMC investigated potential enemy jamming and deception sources so that realistic threat simulation devices could be developed. During this process of analyzing potential threats and determining the best way to simulate them, it was soon learned that each threat presented a unique set of problems. Therefore, the approach adopted was that there was no final solution, but only a solution for the next problem.

For Fleet exercises, NMC supplied R4Y-1 and A3D-1 aircraft which could be readily configured to simulate either the attacker or defender. Operating with the aggressor force, the planes could provide search and intercept jamming or deception for an attacking strike force. On defense, they could fly as an early warning barrier to protect the Fleet from the aggressor.

To supplement flight testing, NMC developed several specialized laboratories and ground test facilities for component or for full system evaluation. Also, according to Frank Miley:

> *"Laguna Peak gave us a unique capability to fly over the ocean as well as over land. We did some interesting tests on ranging and interference."*

Because of its unique facilities, NMC was frequently requested to support other shore establishments or research and development centers. Also, in those days the Center provided training for other activities and the Fleet in electronic countermeasures.

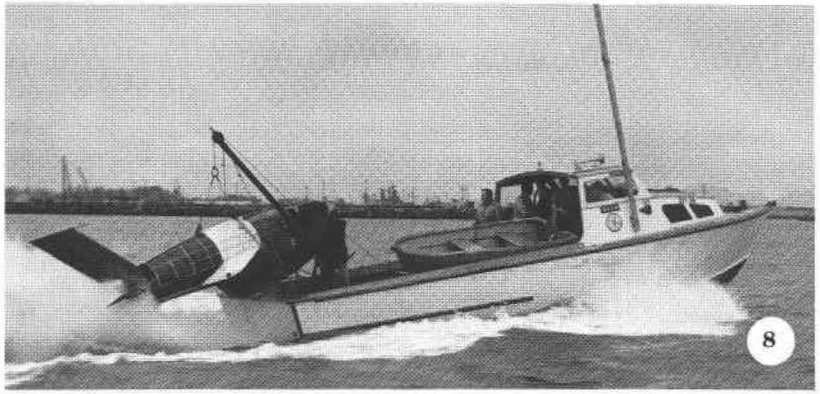

NAVY
1

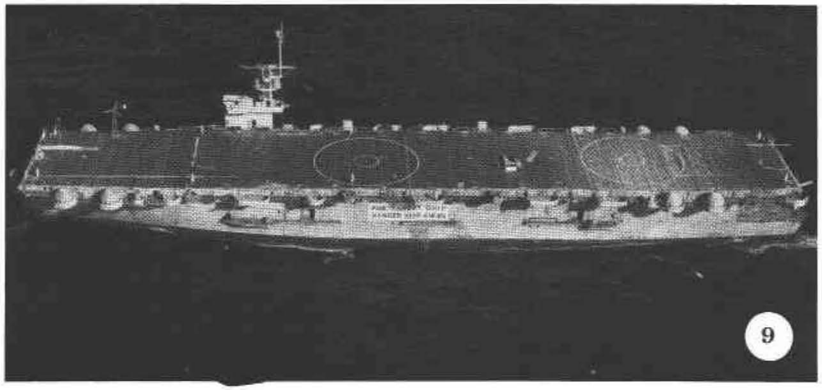

2


3

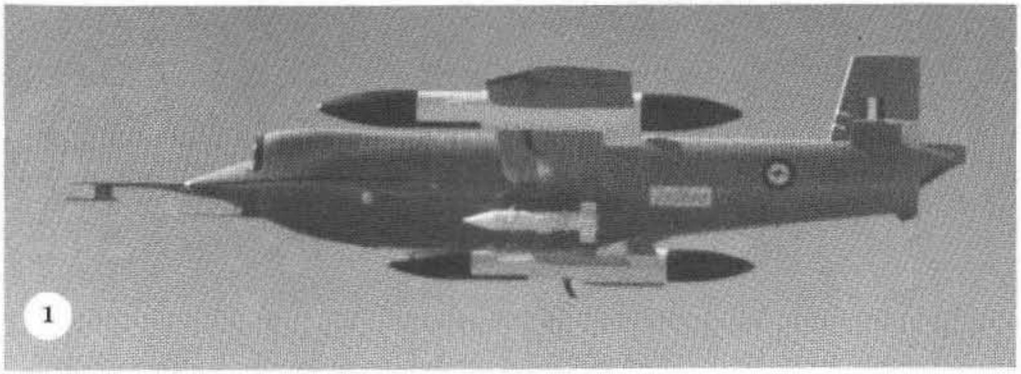

NAVY
4


5

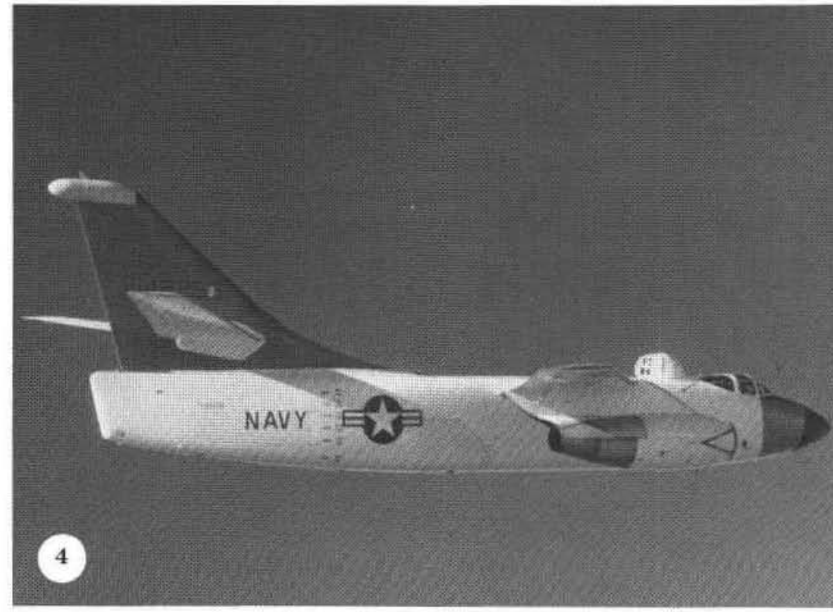




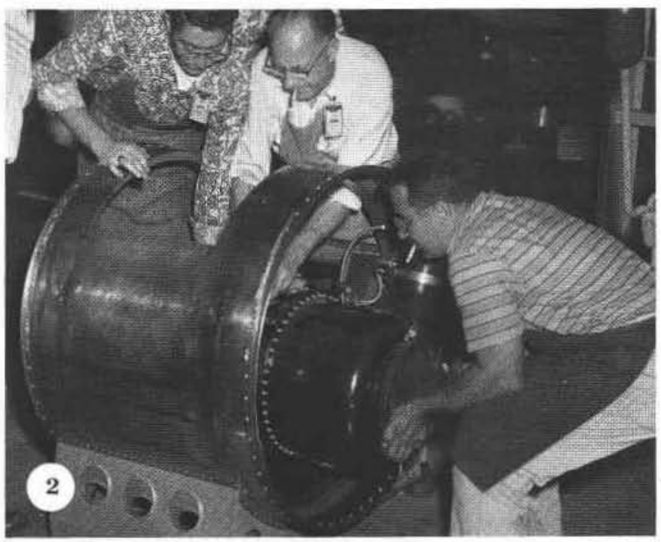
1. JD (B-26) aircraft launching an XKDA-2 (Q2C) drone target (1958). 2. Loading an XKD2B-1 (AGM-37) missile target on an F4H aircraft (1962). 3. BQM-34A targets at Hangar 553, Naval Missile Center, Point Mugu (1966). 4. Starting the engine on KDB-1 aerial target (1959). 5. Mounting a JINDIVIK target on ground support equipment. 6. CT-41 target launch (1963). 7. Mounting a BQM-34A on the wing of a P-2 aircraft (1968). 8. KDA-1 target is recovered during practice recovery run (1954). 9. Aerial of the ex-USS MAKASSAR STRAIT ship target off the Southern California coast (1961). 10. One-hundred-four-foot-long ex-AVR target boat (1965).



1



4



2

3

5

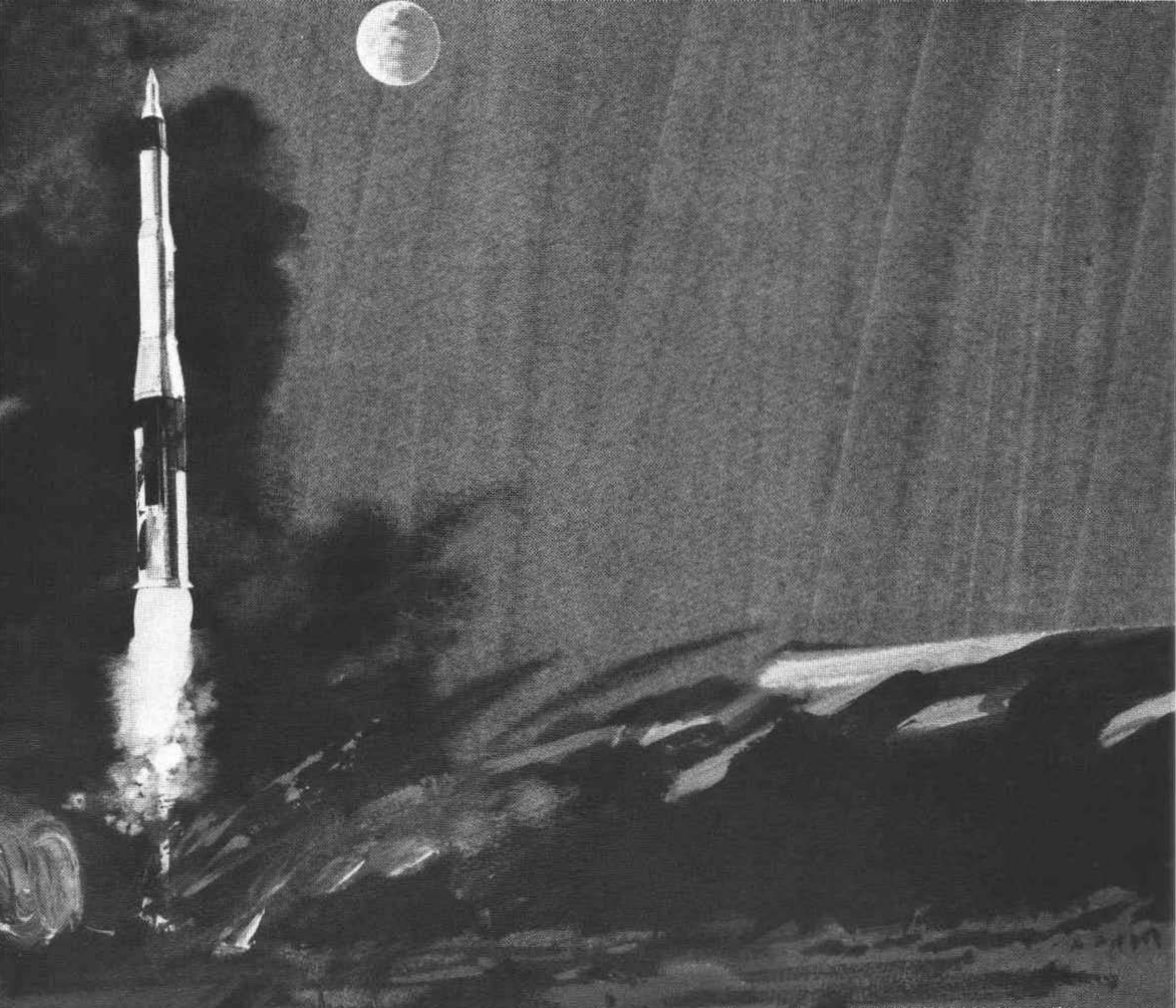
6

7

8

1. Australian JINDIVIK target in flight near Point Mugu. 2. Technical Service Department personnel introducing a turbine generator into a fairing for installation on R4Y(C-131) aircraft (1959). 3. Helicopter recovery of a Q2C target. 4. A3D-1 aircraft used as deception simulator for an attacking strike force. 5. Placing dust gear on tail hook of an A4D-1 aircraft as part of countermeasures project, DIRTY (1969). 6. Technician working on AN/ALQ-31 electronic warfare countermeasures equipment (1966). 7. SPARROW III missile guidance system installed in nose of A3D-1 aircraft (1959). 8. Technicians check over A3D aircraft in pre-flight checkout of electronic equipment (1963). 9. Countermeasures research aircraft, R4Y (C-131) (1959).

9



Launching a MINUTEMAN I missile.

"To be prepared for war is one of the most effectual means of preserving the peace."
—George Washington

CHAPTER 10

RISE AND DECLINE

During the first fifteen years of testing, Point Mugu became almost synonymous with *Navy* missile development test and evaluation. However, with the establishment of the National Range, this parochialism rapidly changed as a multitude of new projects from the Army, Air Force, NASA, Atomic Energy Commission, and the Advanced Research Projects Agency sought to use new or existing PMR facilities at Point Mugu, San Nicolas Island, and a number of downrange island sites. Also, range instrumentation ships were almost constantly at sea as the area between Southern California and Kwajalein Atoll became a gigantic shooting gallery. Foreseeing the need for even greater tracking distances, surveys and negotiations were already underway for instrumentation sites in the South Pacific.

The atmosphere of enthusiasm at Point Mugu is well remembered by James Means:

> *"What I found when I arrived was even more than I suspected. PMR was responsible for the entire Pacific Missile Range, including Point Arguello, the Pacific Missile Range Facility (Hawaii) and Kwajalein. Major portions of work were being accomplished for Vandenberg AFB and other government/contractor activities, PMR was a beehive of activity, and the Technical Support Directorate was up to any technical challenge. Range instrumentation aircraft were routinely operating all over the Pacific in support of ICBM and other programs. Major ground-based instrumentation systems were under development throughout the entire Pacific area. Solid state developments were exploding and everyone was hard at work on major range upgrades. Digital computer technology also consumed a great deal of time and most smart people were busy trying to harness that newly found machine.*
>
> *"Likewise the Naval Missile Center was hard at work conducting test and evaluation on aircraft and missile systems and developing missiles such as CROW. The concepts of digital simulation were being developed and test chambers were springing up everywhere."*

NIKE-ZEUS

Many of the employees who were at Point Mugu in the early 1960's remember that some of the most spectacular tests ever performed from these shores involved the Army's NIKE-ZEUS missile. The mission of the NIKE-ZEUS weapon system was to provide a fast, high-altitude defense against all possible high-altitude targets including ICBM's. The research and development portion of the program was designed to demonstrate the capability of the three-stage, solid propellant missile to intercept and destroy ballistic missile re-entry bodies.

In September 1961, the first launching of the NIKE-ZEUS missile from Point Mugu was conducted. The 488,000-pound-thrust first-stage rocket was the most powerful ever fired from Point Mugu. Fred Ballinger remembers:

> *"The NIKE-ZEUS was unique in that the ground hazard area was quite large and we had to evacuate a*

number of buildings during a launch. The acceleration rate of the missile was terrific and it would actually erode in the air."

A total of nineteen successful firings was completed by November 1962. The project was moved from Point Mugu to the PMR facility at Kwajalein for advanced testing that would pit the missile against an ATLAS re-entry body fired from Vandenberg AFB. The first successful intercept of an ICBM was accomplished in 1962.

NIKE-ZEUS launch from Point Mugu (1961).

Support for the launches at PMR included providing a unique range safety system that would ensure the NIKE-ZEUS did not violate certain pre-established boundaries. Even though the ZEUS system itself contained a built-in control of missile position, the fact that the entire ZEUS system was being tested precluded PMR reliance upon the ZEUS radar as a sole source of position data. Therefore, PMR had to provide a system of real-time cross checking of the ZEUS radar data using COTAR/FPS-16 data. The large, high-acceleration vehicle posed difficult flight safety problems resulting in many firsts for Range Safety.

In addition to the PMR facilities at Point Mugu, the NIKE-ZEUS program was supported by photography and data collection from Laguna Peak, San Nicolas Island, and range tracking ships. The Office of the Deputy, Army, reported on the PMR support as follows:

> *"PMR support to the NIKE-ZEUS project in the form of instrumentation, data processing, communications, scheduling, maintenance, transportation, utilities, and range safety procedures contributed significantly to successful completion of the R&D effort of the project."*

PROJECT PRESS

Another Army project actively supported by PMR was Project PRESS—Pacific Range Electromagnetic Signature Studies—a part of Project DEFENDER. Although far less spectacular than NIKE-ZEUS, this was a very important effort to determine how to defend against extra-atmospheric offensive weapons.

At that time in the early 1960's, the threat of satellite-launched weapons was of great concern, especially since little was known about the re-entry phenomenon. Project PRESS was set up to perform experiments and feasibility demonstrations, and consisted of studying re-entry bodies using the TRADEX radar on Roi Namur Island, Kwajalein Atoll. Ground and airborne infrared/optical instrumentation were also employed.

PMR provided Project PRESS with base and logistic support, communications, and, as the project progressed, high-altitude meteorological data on the re-entry area.

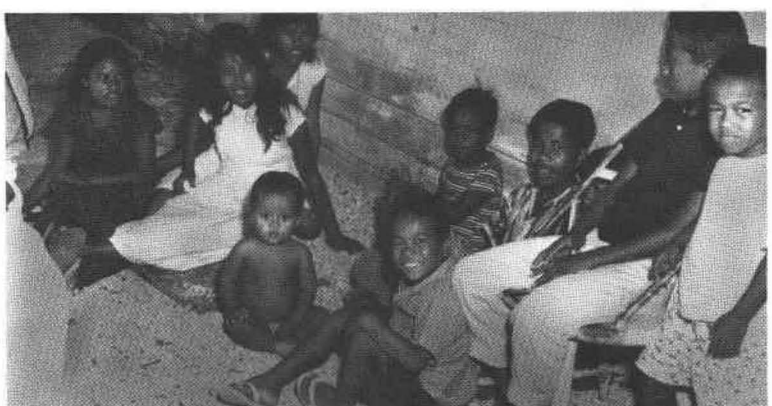
POLARIS

In 1962, PMR provided support for the POLARIS PX-1 program which consisted of a series of four launches from the USS OBSERVATION ISLAND with impact near Kwajalein Atoll. Initially the Department of the Navy selected Midway Island as the site for range safety instrumentation and commissioned PMR to develop the facility. However, since there was already an instrumentation site on Johnston Island, PMR suggested using the facility for range

Aerial view of Roi Namur Island, Kwajalein Atoll, South Pacific.

safety. The primary objection to this idea was that launching from the vicinity of Johnston Atoll would require the overflight of islands occupied by the Marshallese natives. Through mathematical analysis PMR showed that a corridor could be selected that would satisfy Navy safety criteria. As a result the launches were conducted from a site 100 miles south of Johnston Atoll, and the instrumentation facility there was used for range safety. A considerable savings was realized by eliminating the need for the instrumentation facility on Midway Island. The Range Safety Program at Johnston Atoll involved the first downrange software provided by PMR. The real-time computer program was written and supported on site by a team of PMR mathematicians and programmers.

In addition to range safety, PMR provided the POLARIS PX-1 program with frequency monitoring/control, launch ship precise locating, metric data during launch, photography



Some children of Kwajalein Atoll (1961).

at the terminal area, and the services of the range instrumentation ship—USS SUNNYVALE.

DOMINIC

During 1962, the Department of Defense and the Atomic Energy Commission conducted a series of nuclear tests in the Pacific. Called DOMINIC, this project received considerable support from PMR at several downrange sites and at Point Mugu. Originally, the support requested was for limited range safety. However, the work eventually snowballed into a major effort involving many echelons at Point Mugu and PMR facilities spread over a wide geographic area.

Burnie Dunlap recounts some of PMR's involvement with the Atomic Test Program:

> *"I was the director of a project which required PMR to provide the facilities and expertise necessary to protect the Hawaiian and other islands, plus providing observation points at sea during the launch of missiles carrying nuclear devices.*
>
> *"Only 74 days were allowed to design, fabricate, assemble, check-out, transport, emplace, and recheck-out the needed facilities plus training the operational personnel. Due to the hard work and devotion to the task of those involved, the project was successfully completed in 72 days. As a matter of interest, the PMR project even got the attention of Time magazine."*

The following list of shore stations involved will illustrate the administrative as well as geographic scope of the project. Support was provided to some degree by Point Mugu, Point Arguello, Kaneohe, South Point, Barking Sands, Kokee Park, Ka Lae (Hawaiian Islands), San Nicolas, Tern, Christmas, Midway, Canton, and Johnston Islands, and Kwajalein Atoll.

One essential element in the support provided was rockets which obtained samples of radioactive substances during actual events. For each event, up to 30 such rockets were launched from Johnston Island, while others, as part of Project SKIP, were fired from what was formerly Bonham Air Force Base on the Hawaiian Island of Kauai.*

It is difficult in a few pages to give an overview of the many and diverse projects conducted at PMR during the 1960 to 1963 period of time. However, so that the support provided to the many different agencies and offices might at least be glimpsed, a partial list of major projects for one calendar year—1962—follows:

Navy	Air Force	Army
POLARIS PX-1	DYNA SOAR	PRESS
VISTA 300	GAR-9	NIKE-ZEUS
PSV-1 ARMAMENT	ATLAS	
HUGO III	TITAN I & II	
SOLAR INSTRUMENT PROBE	THOR	
TRANSIT	THOR/AGENA	
HIHOE	MINUTEMAN	
JANE	BLUE STRAW	

* Bonham Air Force Base later became the Pacific Missile Range Facility, Hawaiian Area, Barking Sands, Kauai (see page 133).

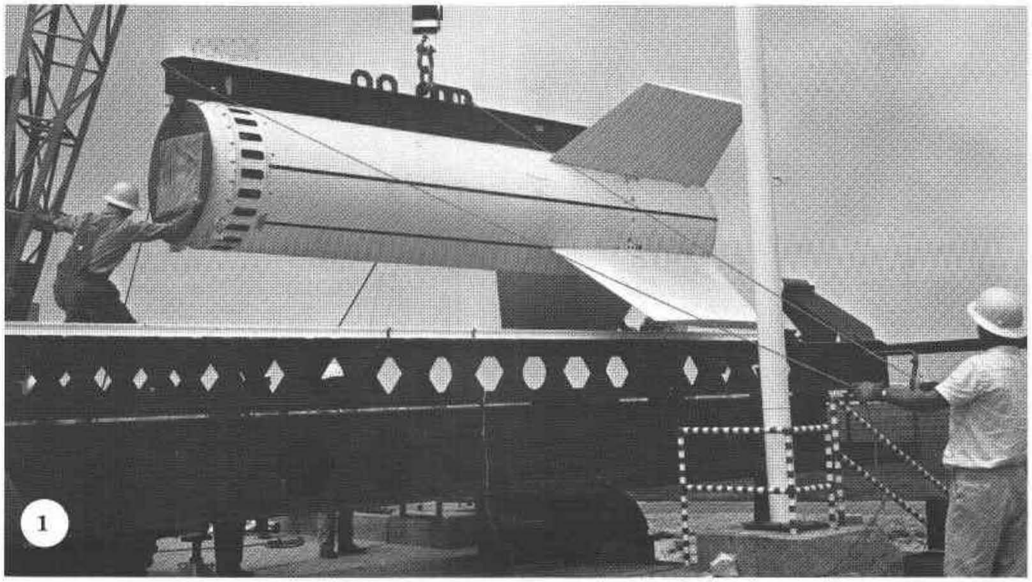
AEC	NASA	
SAIL	GEMINI	TELESTAR
CLEANSWEEP II	MERCURY	CENTAUR
SKIP	TIROS	

DISMANTLEMENT

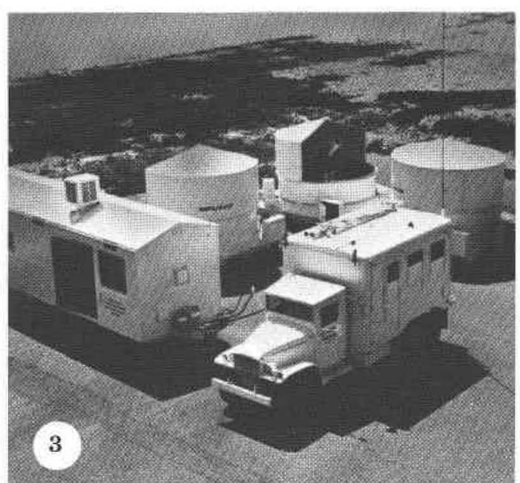
As the year 1962 drew to a close, the future of PMR appeared very bright. Rapid expansion of facilities and acquisition of new property, a wide variety and number of programs, and plans for the future all helped to produce a feeling of optimism. But this euphoria was to be short-lived.

On November 16, 1963, following a series of conferences and discussions, the Secretary of Defense issued a fateful memorandum entitled "Management and Organization of DOD Ranges and Flight Test Facilities." It contained instructions for the orderly dismantlement of PMR. Kwajalein was to be transferred to the Army. The Air Force took over the 20,000-acre establishment at Point Arguello and acquired every PMR establishment in the Pacific except Barking Sands, plus operational control of range ships and aircraft as well.

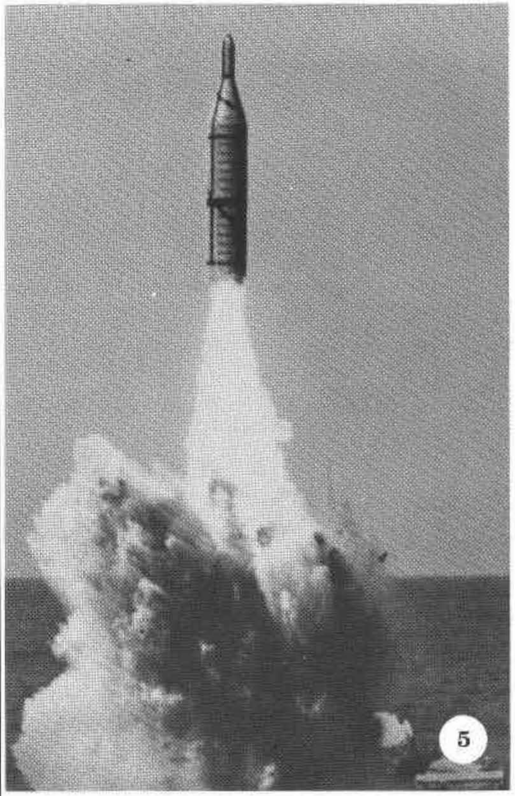
The Navy was left with the facilities at Point Mugu, San Nicolas Island, Barking Sands, and some minor mainland and Channel Islands sites. PMR also retained a sea-launch mission. As a result of the preceding, range capital value dropped from $590 million to $321 million, and authorized billets plunged from 9,090 in FY-1964 to 4,882 in FY-1966, a 47 percent reduction.

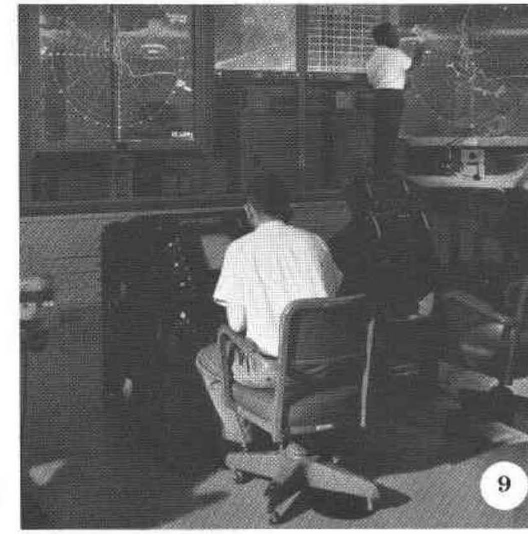

1

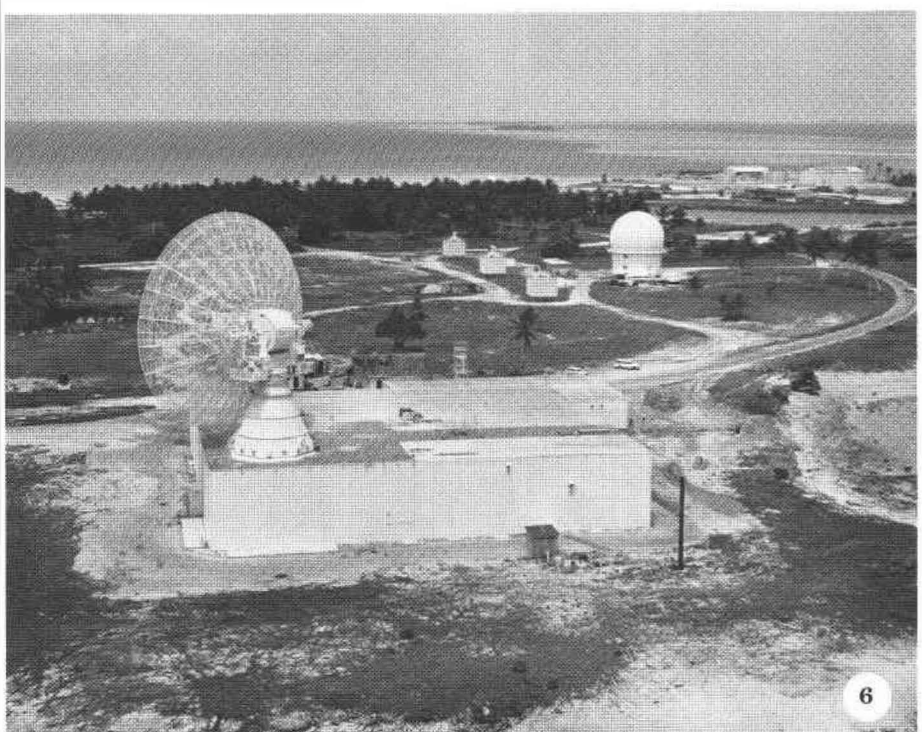

2


3

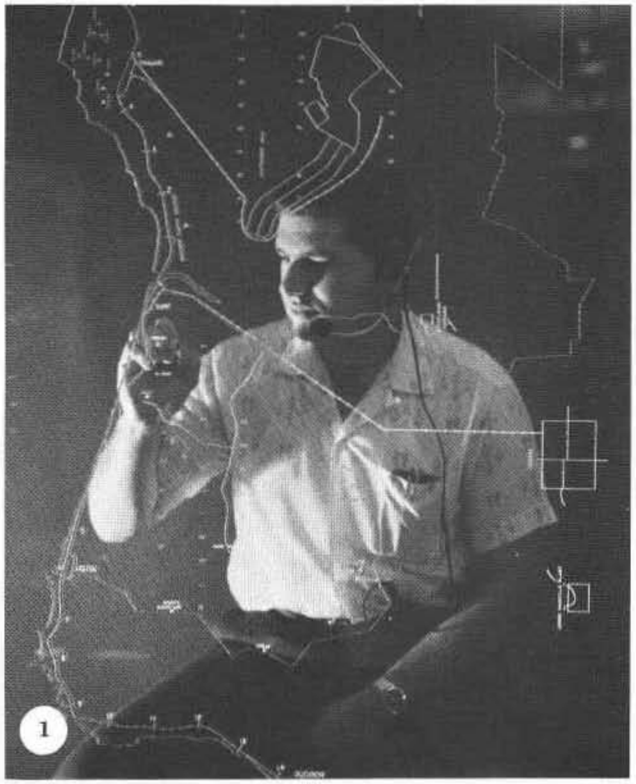

4







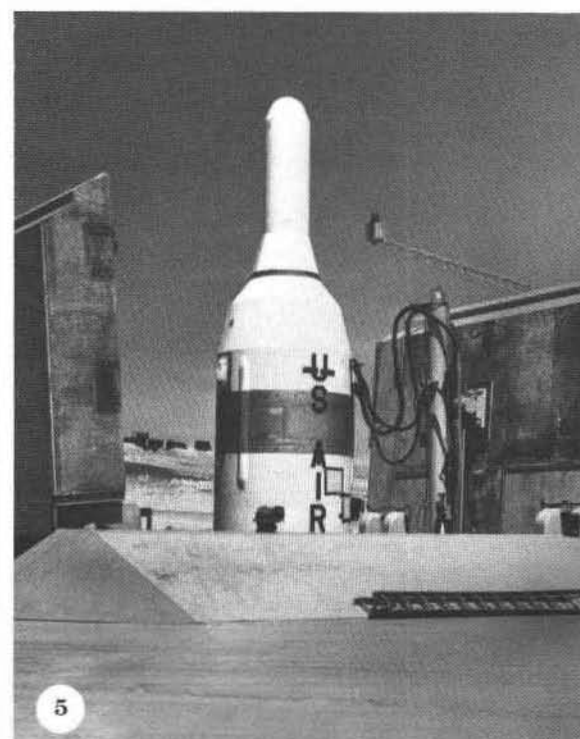
1. Mounting a NIKE-ZEUS booster on a launcher during missile assembly (1961). 2. NIKE-ZEUS launch pads under construction at Point Mugu (1960). 3. Instrumentation field units at Point Mugu (1963). 4. POLARIS missile launch from USS OBSERVATION ISLAND. 5. POLARIS missile launch under the PX-1 program. 6. TRADEX antenna on Roi Namur Island, Kwajalein Atoll (Project PRESS). 7. Aerial view of Johnston Island in the Johnston Atoll, South Pacific (1963). 8. PMR tracking installation at French Frigate Shoals, Tern Island (1961). 9. Area clearance room at Naval Missile Facility, Point Arguello (1961).

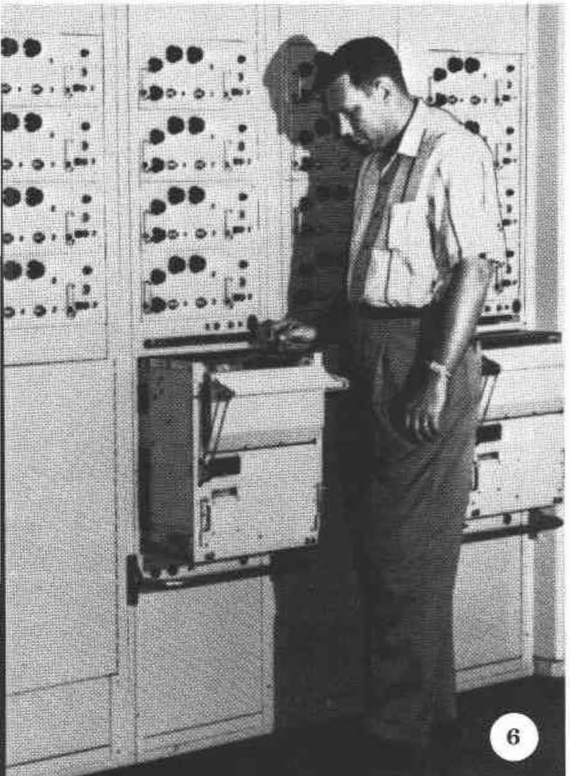

1

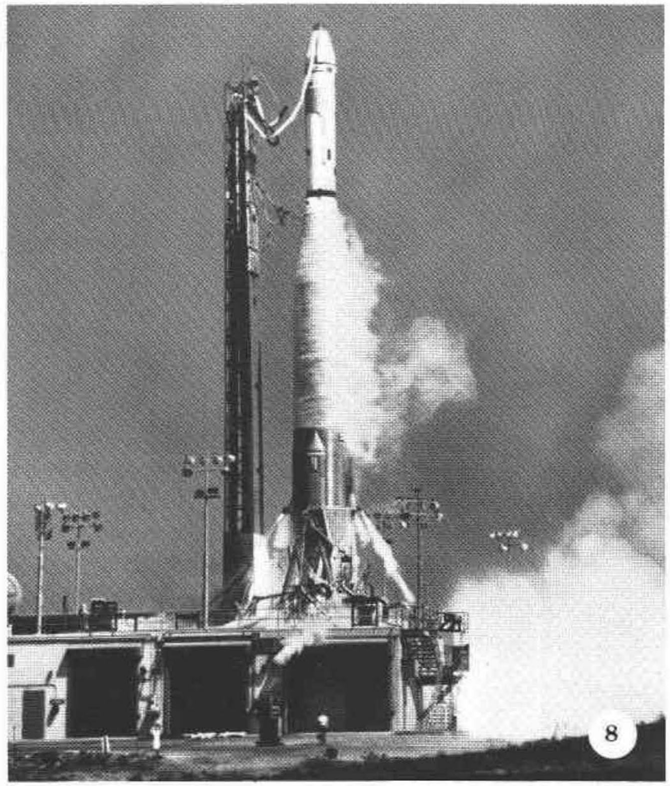

2


4

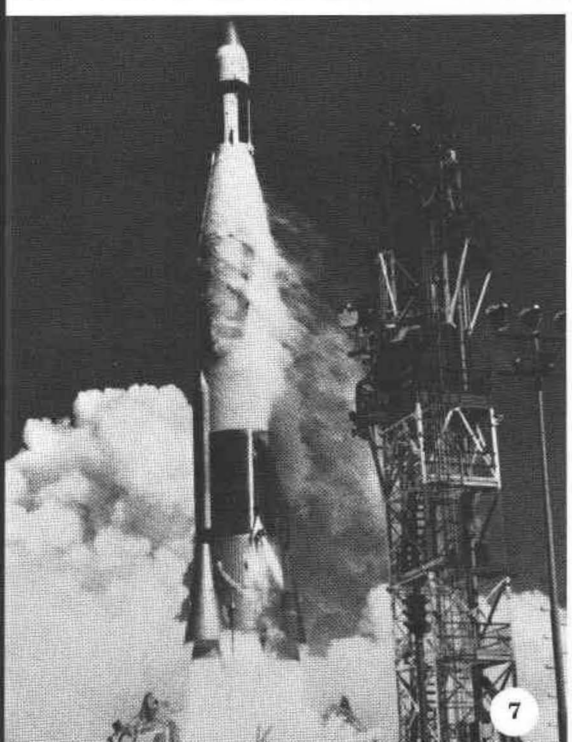

3


U
S
A
I
R
5





1. Range clearance ground plotting board, NMF Point Arguello (1961). 2. MERCURY team during the John Glenn orbital flight, NMF Point Arguello (1962). 3. USNS RANGE TRACKER leaving Port Hueneme Harbor. 4. MERCURY tracking station at Kokee Park, Kauai, Hawaii (1962). 5. TITAN missile rising from silo at Vandenberg AFB (1963). 6. Missile Impact Location System (MILS) at Kaneohe, Hawaii (1961). 7. Lift-off of an Air Force ATLAS missile. 8. Launch of an ATLAS/AGENA missile at NMF Point Arguello (1961). 9. MERCURY tracking station on Canton Island (1962).



WALLEYE weapon being prepared for a test flight.

"But Times do change and move continually."
—Edmund Spenser

CHAPTER 11

RETRENCHING AND MOVING ON

PMR's management, although somewhat disheartened by the loss of so many functions and facilities during 1963, nevertheless began 1964 by looking to a future which would see major concentration on testing air-to-air, surface-to-air, air-to-surface, surface-to-surface, and sea-based missiles and scientific probes.

At NMC, 1964 would produce a number of important innovations. It marked the completion and occupancy of a large new Systems Laboratory and an augmentation effort in the field of Airborne Tactical Data Systems in conjunction with improved facilities. It also saw the start of such important and long term programs as PHOENIX, WALLEYE, SHRIKE, and SIDEWINDER 1C, and the continuation of testing on the SPARROW III, BULLPUP, CONDOR, and several experimental targets. Another important first of a different nature was the establishment of the Manned Orbiting Laboratory Field Office at the Air Force Space Systems Division Headquarters in Los Angeles. There was also a definite increase in support services to the Fleet, including targets, all phases of electronic warfare, and surface-launch and air-launch operations.

TAWS-PEP

A rather unique program of this period was the Total Airborne Weapon Systems Performance Evaluation Program which went by the acronym TAWS-PEP. As Jack Martin related:

> *"It was unique in that it attempted to address problems not strictly related to a missile or aircraft or fire control system. Rather it took on the whole gamut of problems involving all three coming together. The project crossed organizational lines and involved flight tests, the laboratories, as well as instrumentation."*

TAWS-PEP testing involved SPARROW III and SIDEWINDER missiles mounted on the F-4B aircraft. All flights were captive, flown against manned aircraft of high and low performance, and were conducted in clear and ECM environments. The main objective was to find solutions to problems encountered by the Fleet squadrons. A typical investigation at the time involved the low-altitude clutter environment problem. Subsidiary efforts were expended on improving the maintainability, reliability, and system performance aspects of the missiles.

BULLPUP

By 1964, the BULLPUP Program involved primarily "proof" firings and tests of improvements to the missile. In 1964 alone, NMC conducted 136 missile launches at NOTS China Lake (later NWC), while Air Test and Evaluation Squadron FOUR (VX-4) fired six missiles on the Sea Test Range at Point Mugu. Technical assistance was also provided to the North Atlantic Treaty Organization (NATO) BULLPUP program. This included training NATO personnel

SHRIKE anti-radiation missile tested

at Point Mugu as well as missile evaluation. There were actually three phases to the NATO BULLPUP program. Phase I consisted of firing five missiles assembled in Europe from components manufactured in the United States. In Phase II, NMC fired 10 missiles that were a mixture of U.S. and European fabricated parts. Phase III, started in 1965, sampled the first units fabricated by the NATO countries.

The BULLPUP effort at NMC continued for several more years in the form of production monitoring tests and improvement evaluation. Also, NMC played an increasing role in in-service engineering, with technical personnel traveling worldwide to provide service and training. Representatives were assigned to accompany carriers in transit to Southeast Asia to work with ship and squadron personnel on BULLPUP problems.

SHRIKE

The suppression of enemy radars was a continuing problem for attacking aircraft, dating back to World War II. With the advent of enemy radar-controlled surface-to-air missiles in Southeast Asia, the problem became very critical. Consequently, the Navy urgently pressed the development

A-6 Intruder aircraft during captive flight of CONDOR Missile System (obscured) (1972).

of the SHRIKE anti-radiation missile, and NMC and PMR became heavily involved in its test and evaluation.

SHRIKE underwent laboratory simulations, captive carry, and flight tests at Point Mugu. Then the Center took it a step further by conducting suitability trials aboard a carrier. These tests, designed to ensure reliability under operating conditions, consisted of transferring missiles at sea, strike down to stowage, strike up, and loading.

ELECTRONIC COUNTERMEASURES

In another area of radar suppression, NMC's work in electronic countermeasures mushroomed as ways were sought to protect Navy attack aircraft. In particular, critical work was pushed on warning systems that could be flown by Fleet aircraft already on duty in Southeast Asia.

Frank Miley remembers that the "Big Look" aircraft was used while this work of retrofitting was underway. This was an EC-121 Constellation aircraft equipped with detection equipment that flew around looking for early warning or fire control radars. If these were spotted, the pilots operating in that area could be warned to "duck." The "Big Look" aircraft was later supplemented with the introduction of the APR-25, our first warning receiver carried aboard tactical aircraft.

ATDS

To help protect the Fleet from potential hostile air attack, NMC performed long term evaluation of the E-2A/ATDS (Airborne Tactical Data System) carried aboard the E-2A Hawkeye aircraft. The E-2A/ATDS, an all-weather aircraft carrier or shore-based system, had the primary mission of maintaining a duty station at a predetermined altitude and distance from a task force, alerting it to the approach of hostiles, and controlling and vectoring interceptors into attack position. The system was designed to simultaneously handle up to 250 targets and 30 interceptors. It could also provide a data link—a high-speed exchange of intelligence among ATDS, interceptors, and other tactical data systems.

On February 19, 1964, the first data link missile shot in naval history was made at PMR, demonstrating the feasibility of the data link controlling the F-4B autopilot and transitioning to the aircraft fire control.

WALLEYE

The new television-guided WALLEYE weapon system developed during the mid-1960's came aboard NMC in 1966 for its critical Navy Technical Evaluation. Designed for use against high-priority targets, WALLEYE would allow attacking aircraft to lock the weapon on a target and then, immediately upon weapon release, perform evasive maneuvers. In the evaluation, the weapon was both captive-carried and launched.

Thirteen WALLEYE's were fired at San Nicolas Island and the Naval Ordnance Test Station, China Lake. Targets were barges, parked aircraft, missile erectors and launchers, an anti-aircraft gun, and a flare. Radar tracking, cinetheodolite, and impact data were acquired. Weapon performance was evaluated by analyzing weapon space position data and by telemetry. Although discrepancies were found, the weapon system was approved for introduction into the Fleet.

TARGETS

Also, in conjunction with weapon system developmental testing, several experimental targets and target systems were part of the NMC workload. In 1964, the Navy accepted 126 surplus BOMARC "A" missiles from the Air Force and began preparations to use them as targets on PMR. It was decided to locate the launch site at the Air Force Western Test Range (Vandenberg AFB) in order to provide the optimum flight path and because the site was more readily accessible than an island launch complex. By 1966, construction and missile preparation had progressed to where it was possible to attempt a launch of a BOMARC target. The first launch was unsuccessful due to a malfunction; however, subsequent launches were successful.

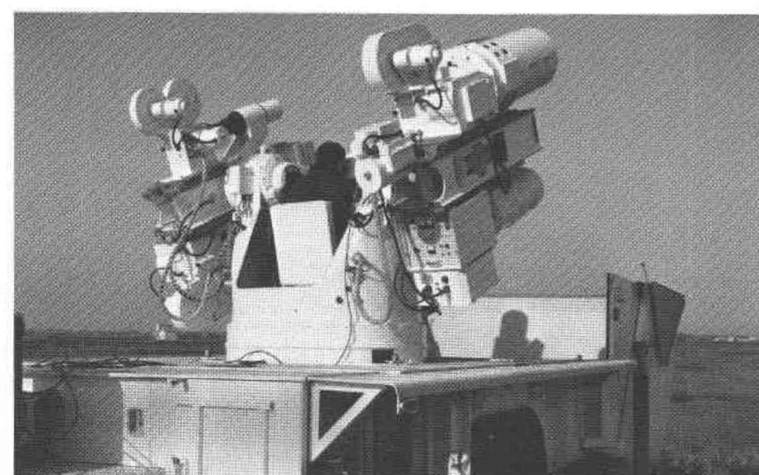
Other important target projects that began about this time were the XBQM-34E supersonic target, on which NMC provided consulting services, and the MQM-74 subsonic target, which was launched for the first time from Point Mugu in 1966. NMC also pioneered in target augmentation for electronic countermeasures, both chaff and jamming, and in miss-distance indicators and control systems.

PHOTO-OPTICAL INSTRUMENTATION

In 1963, funding was acquired to purchase state-of-the-art camera mount systems for use at PMR. These would replace the extensively modified World War II machine gun mounts being used as tracking mounts. The funding go-ahead led to an extensive evaluation of available tracking mounts and the eventual selection of the Cine-Sextant system. The superiority of the Cine-Sextant was confirmed by a team of technical experts from the Optical Systems Working Group of the Inter-Range Instrumentation Group (IRIG). PMR contracted for twelve units and the system, which was also purchased by other ranges, was subsequently acceptance tested at PMR.

The Cine-Sextant tracking mount proved to be a versatile precision tracking system which provided high performance and rather large payloads. An emphasis on human factors engineering also made it possible to obtain high dynamic accelerations and velocities.

In use, the Cine-Sextant provided an effective system for obtaining photographic surveillance data on missile launches, flights, and target intercepts. Subsequent additions to the system of azimuth and elevation encoders provided a system for pointing information on the film in the form of a binary data matrix on the prime data camera. In addition, slant range information was introduced on the film by the use of on-board "X" band radar. Slant range data was later provided by on-board lasers. IRIG timing data could also be included in the data obtained.



Cine-Sextant apparatus used at NMC Point Mugu (1966).

Some of the early uses of the Cine-Sextant tracking mount system included mounting special experimental sensors (or radiators) along with cameras on the payload platform, thus obtaining a comparison of the two types of data relative to the dynamic target.

RADAR CALIBRATION/JRIAIG

In the mid-1960's, PMR's Range Instrumentation Performance Evaluation (RIPE) Branch initiated a highly successful worldwide radar calibration program using the NASA Geodetic Earth Orbiting Satellite (GEOS). Originally, GEOS was designed for testing methods to improve earth measurements; however, by the addition of two C-band transponders, the satellite could be used to calibrate metric tracking radars.

Mobile radar calibration van with AN/FPS-16 radar (1968).

The transponders allowed seventy-five FPS-16 or FPQ-6 class radars to track a dynamic target whose orbit was well defined. This data could then be used to calibrate the radars through a mathematical procedure. Ranging errors were particularly amenable to detection and solution using the GEOS. This type of calibration, that is, abstracting the numbers for the coefficients in an error model through mathematical procedures, could be described as a "global solution."

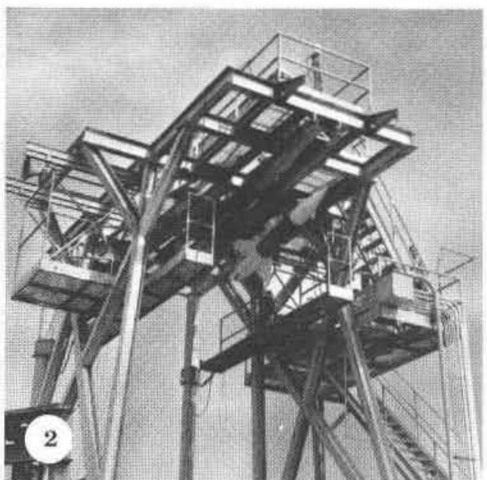
Another radar calibration program, conducted in 1968, resulted from a MINUTEMAN I testing program called PACER KITE. The purpose of PACER KITE was to determine the sources of targeting error. FPS-16, TPQ-18, and FPQ-6 radars would be used to aid in this determination; however, since the radars themselves had errors it was first necessary to minimize the errors through a calibration program. This was accomplished in the following way.

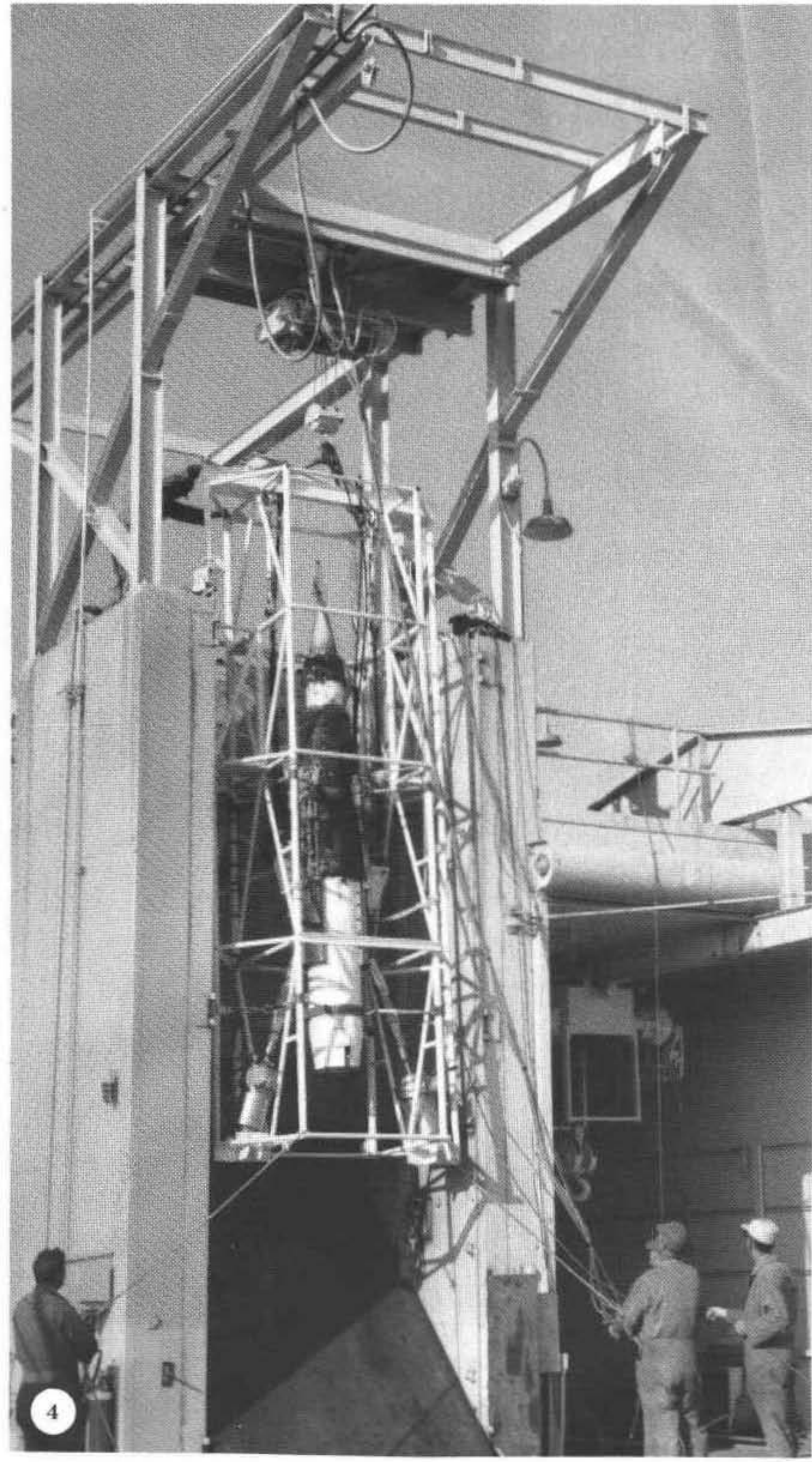
The program involved measuring separately each possible source of tracking error and developing error models and procedures. The radar error models that finally evolved represented thirty-two separate errors requiring seventy-nine coefficients for each radar. The measurement of separate errors in a radar could be called a "local solution."

In either "global" or "local" solutions, the numerical values for error coefficients which are determined are placed in equations which are then used to correct measurements coming from each radar.

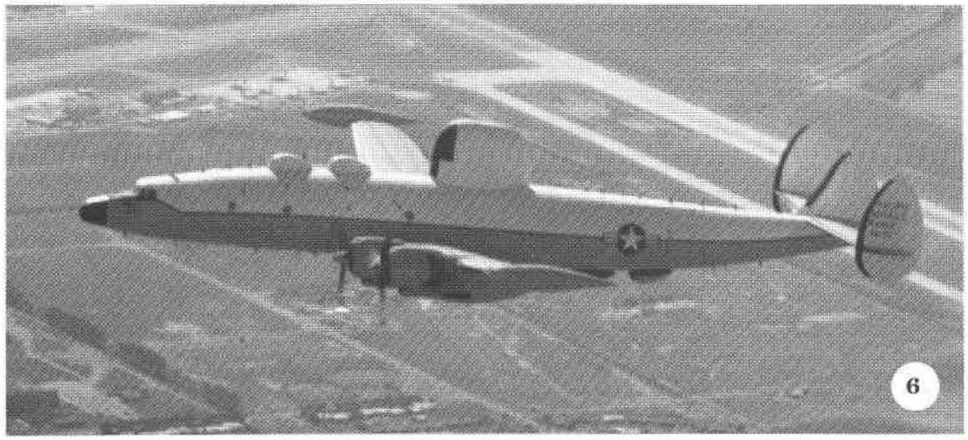
The lessons learned during the PACER KITE program inspired the formation in November 1968 of the Joint Range Instrumentation Accuracy Improvement Group (JRIAIG) to further support the calibration program for MINUTEMAN. JRIAIG later became a part of the Range Commanders Council as one of the working groups.


XF
3494
14
NAVY
143494



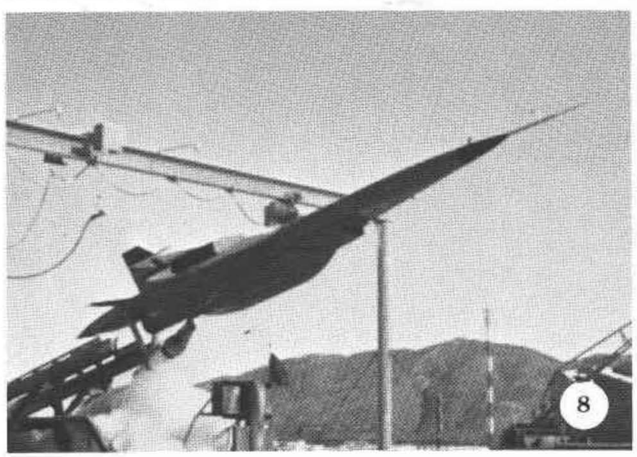


5



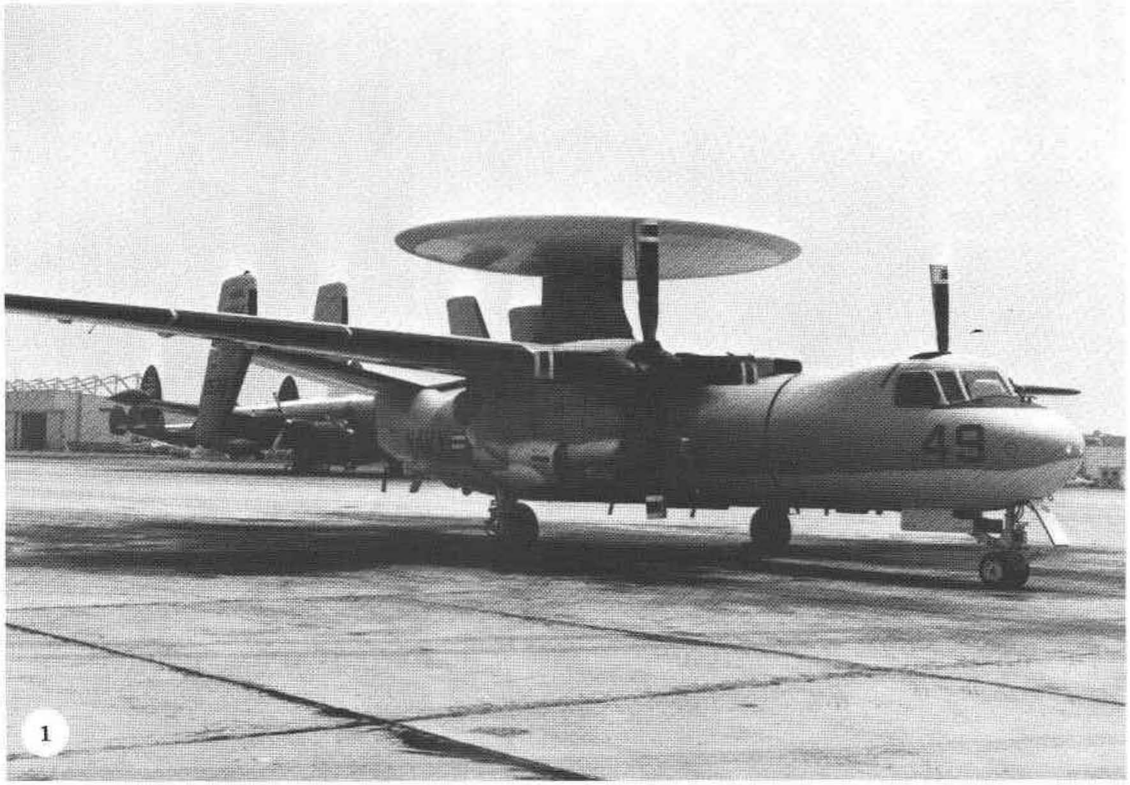
6

7

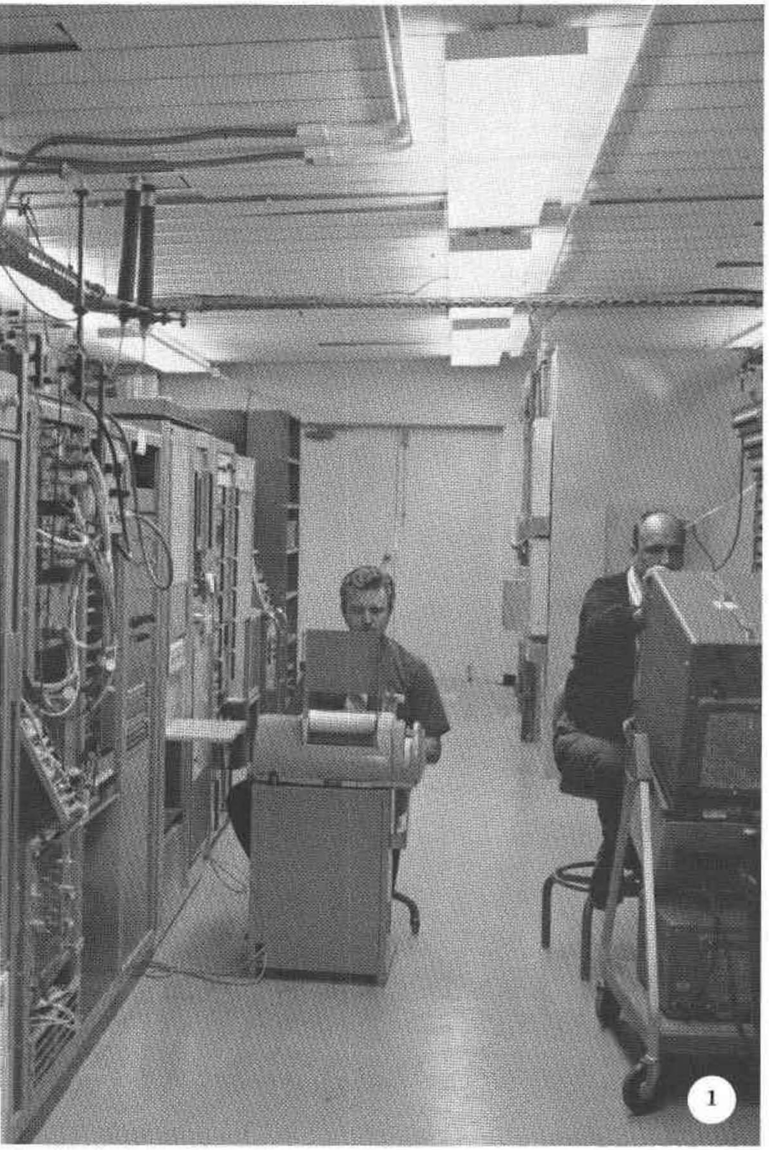


8

1. BULLPUP "A" missiles on an FJ-4B aircraft. 2. AGM-12B BULLPUP missile prepared for launch from an Aero 5A-2 launcher (1966). 3. Loading a WALLEYE II onto an A-7 aircraft (1971). 4. Preparing for restrained test firing of AGM-12C BULLPUP missile (1967). 5. BOMARC target launch from Vandenberg AFB by NMC Point Mugu personnel. 6. EC-121 aircraft in flight (1971). 7. Lowering an MQM-74A missile target onto soft pad (1973). 8. Launch of XBQM-34E from Point Mugu.



1. E-2A Hawkeye aircraft equipped with rotodome antenna and Airborne Tactical Data System (1966).
2. CH-46 helicopter at-sea transfer of missiles.
3. SHRIKE EX-53 missile Captured Launch Facility stand (1967).



1. Point Mugu electronic warfare (EW) counter-countermeasures laboratory. 2. Pre-flight testing of an EW countermeasures pod carried by an RA-3B aircraft (1968). 3. F-4B Phantom aircraft with SIDEWINDER missiles.

SH-3 helicopter releasing MK-30 underwater target (Barking Sands, 1973).

"An ocean is forever asking questions and writing them aloud along the shore."
—Edwin Arlington Robinson

CHAPTER 12

LAND, SEA, AND AIR

From 1940 to 1958, a strip of coastal land at Barking Sands, Kauai, Hawaii, had been used as an airfield, first by the Army and then by the Air Force. By 1954, when the Navy began leasing 36.67 acres, the area had become Bonham Air Force Base. Four years later, all 1,885 acres of the land were transferred to the Navy and placed under the Commanding Officer, NAS Barber Point.

In 1964, the Navy decided to establish a densely instrumented, three-dimensional underwater tracking range in Hawaiian waters. As a result, the parcel was transferred in 1965 to the Commander, PMR, and renamed the Pacific Missile Range Facility (PMRF).

BARKING SANDS UNDERWATER RANGE

The purpose of this unique range would be to provide the Pacific Fleet Operating Forces with anti-submarine tactical launching and training capabilities, including exercises that involved submarines, surface vessels, aircraft, torpedoes, and targets. The underwater tracking network would cover an area 5 by 10 miles to water depths ranging between 2,400 and 6,000 feet. Shore-based facilities at Barking Sands and a remote radar site for surveillance and tracking of air and surface objects, located at Makaha Ridge, would support the underwater range.

Initial efforts in the Calendar Year 1965 centered on preparing detailed performance specifications for the underwater system, monitoring the contract, and also preparing specifications for land-based instrumentation at Barking Sands and Makaha Ridge.

The actual installation of the underwater range began in 1966. The work included marine construction for cable trenching, delivery of data/display equipment, installation of the cable termination hut, and installation of operations control center equipment. Also, construction on Makaha Ridge, overlooking the range, included the two buildings housing two FQS-10 and two FQS-12 radars, a power plant building, a communications building, and access roads.

Cable laying and installation of the 37 bottom-mounted hydrophones and junction box was started in February 1967 and was completed the following June. Measurement of the exact hydrophone positions was conducted in July. Land-based equipment installation also kept pace so that acceptance testing of the Barking Sands Tactical Underwater Range (BARSTUR) was completed by August 1967. On the basis of these tests, the Commander, PMR, conditionally accepted the range in August 1967, and before the month was out a portion of Anti-Submarine Warfare Group FIVE's Operational Readiness Evaluation was conducted on the new underwater range.*

During 1968, the first full year of operation, approximately 800 hours were devoted to Fleet Operations such as Operational Readiness Evaluations and Inspections, Prospective Commanding Officer exercises, and sonar anti-submarine warfare (ASW) torpedo attack exercises. Also,

* All vehicles tracked on BARSTUR are equipped with an acoustic beacon (pinger) that emits a frequency coded signal at one of eight discrete pre-operation assigned frequencies in the range of 13-50 hertz. BARSTUR has the capability to track eight underwater objects simultaneously.

USNS WHEELING serves as miniature range

United Kingdom forces conducted ASW exercises at PMRF.

To support the new three-dimensional range, numerous acquisitions and construction projects were undertaken to upgrade or expand base and general purpose facilities. Some of these were the acquisition of two 85-foot Weapon Recovery Boats, construction of a rocket motor storage facility and a launch pad for MQM-36A targets, and the installation of an SPS-10 surveillance radar and a medium gain automatic telemetry antenna. In the following fiscal year, a telemetry building, a radar maintenance shop, Communications and Operation Center additions, a Missile Assembly Building, and a Post Operational Data Analysis Facility were built.

In addition to new construction, the Barking Sands Operations Display System (BODS) was fabricated and installed. This real-time, large-screen display system would enable operational personnel to maintain cognizance of all phases of an operation taking place on the underwater range or in the neighboring water or air space.

JOHNSTON ISLAND

Besides Barking Sands and other Hawaiian island sites, PMR continued to maintain a detachment on a five-acre site on Johnston Island. This site included a well-equipped tracking station, funded by the Defense Atomic Support Agency (DASA) and operated and maintained by PMR personnel and contractors in readiness for resumption of Project DOMINIC (which never did resume). The spacious computer center was equipped with modern buffering and computing hardware. The real-time data handling capability was one hundred percent redundant for high reliability. The center became a laboratory for developing, testing, and operating real-time range software.

From 1962 until 1970, PMR range software personnel shuttled between Point Mugu and Johnston Island supporting operations. During this time, a nucleus of tracking software was developed. From this evolved a library of programs that established the foundation for computer-driven tracking stations not only at Johnston Island, but also at Barking Sands, Point Mugu, and aboard the range ship, the USNS WHEELING.

The Johnston Island facilities provided important support to projects like POLARIS, Joint Task Force EIGHT, and other military launches and/or re-entry vehicles.

USNS WHEELING

As part of the 1963 range reorganization (Chapter 10), six of the seven range instrumentation ships under operational control of PMR were transferred to the Air Force, leaving only the USNS WHEELING (AGM-8). Originally a cargo ship named the SETON HALL VICTORY, the USNS WHEELING was modified in the early 1960's for range tracking. Further instrumentation improvements were made in 1962.

The basic purpose of the ship was to provide range safety, and in order to perform this function it had to have every capability that a land-based range would have. In essence it was a miniature range that incorporated the following: a navigational system for precise ship positioning; a target acquisition system; two tracking radars; a telemetry system that received, recorded, displayed, and reproduced data; a computer system; a timing system; radio communication; command control for sending signals to missiles or vehicles in orbit; and a meteorology system.

The USNS WHEELING was used extensively for about fifteen years on both local and down-range operations. In the mid- and late-1960's, it supported such programs as the GEMINI and APOLLO space flights, and the HYDRA IRIS mid-ocean launches.

TRANET

An important off-range service provided by PMR during the 1960's was TRANET support. TRANET was a network of satellite doppler ground stations used for geodetic space programs. PMR support included selecting, implementing, operating, and maintaining the tracking sites, and this, in turn, involved developing plans for the operation of existing sites, conducting the site surveys, and developing and integrating the proposed sites into the tracking network. Also, the TRANET support office participated in negotiations and drafting of tenancy agreements with local and foreign governments.

The TRANET sites and mobile vans were for the most part manned and operated by personnel from the Physical Science Laboratory of the New Mexico State University. However, PMR personnel often traveled to these sites, which were located in such distant places as Guam, Ascension Island, Australia, Manua Island, Brazil, Alaska, the Philippines, Japan, Greenland, England, and South Africa.

FIRSTS

The mid-1960's recorded several important firsts at PMR and NMC. In 1965, the first surface-to-air launch was made by a foreign ship on the range and the first air-to-air firing was made by an Air Force squadron deployed to Point Mugu. Their first SEA SPARROW was launched to test the concept of using the air-to-air SPARROW III as a surface-to-air missile. Next came the first airborne test of the PHOENIX missile. In May 1966, the first PHOENIX separation test missile was launched and, just a month later, the first PHOENIX missile was fired and successfully intercepted the target.

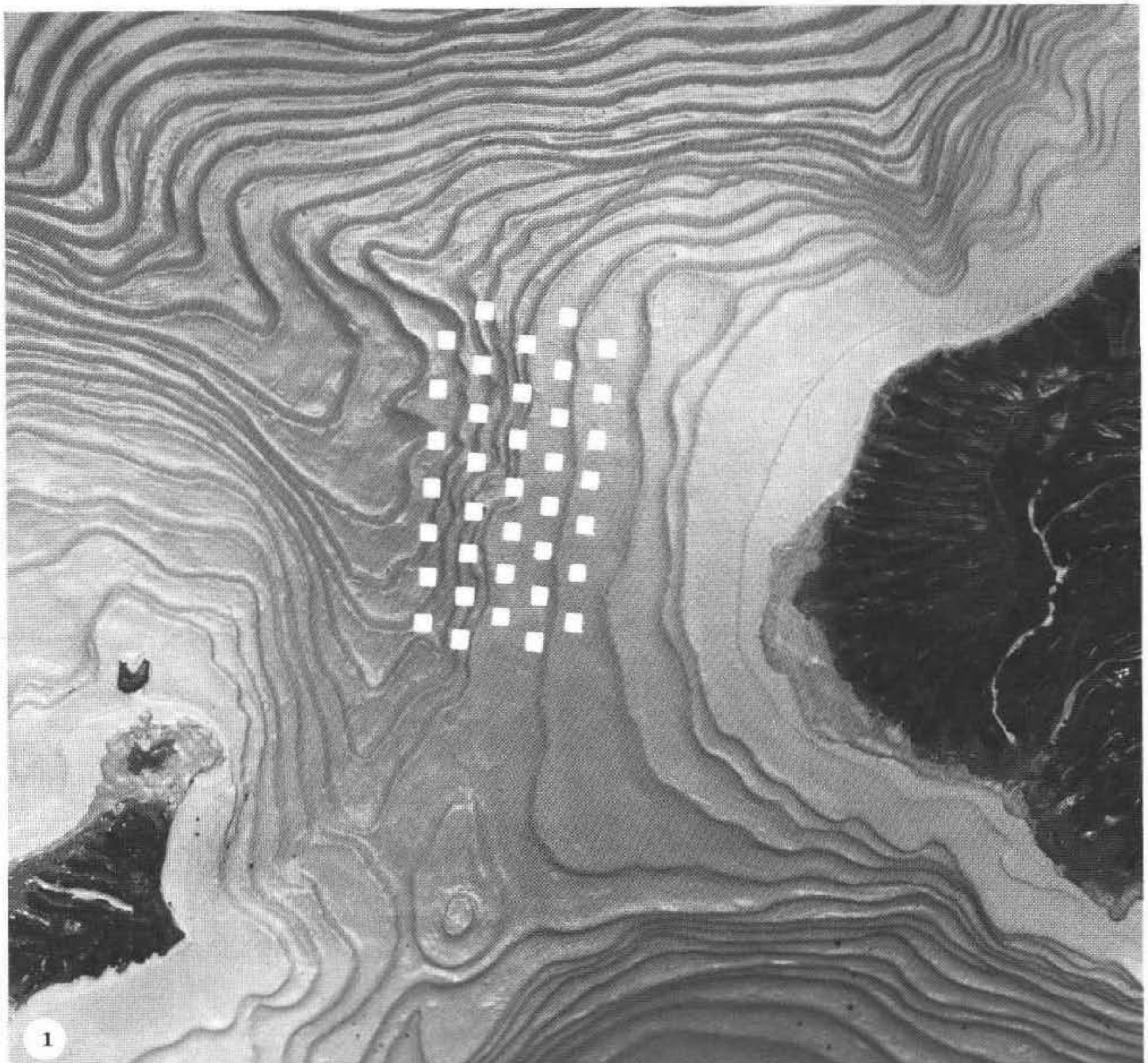
FLEET WEAPONS ENGINEERING

For a number of years, NMC had been moving towards greater engineering involvement with missile systems after they were deployed with the Fleet. In 1965, the Fleet Weapons Engineering Office was formed as part of the Laboratory Department and initially assigned engineering cognizance for air-launched rockets and the AGM-12B BULLPUP missile. Subsequently the organization acquired responsibility for the AGM-12C BULLPUP B and aircraft bombs.

In 1969, the Field Service Branch and the Weapons Liaison Division were brought into the Fleet Weapons Engineering Department. The mission was to manage, direct, and control the engineering cognizance efforts of NMC and related field activities.

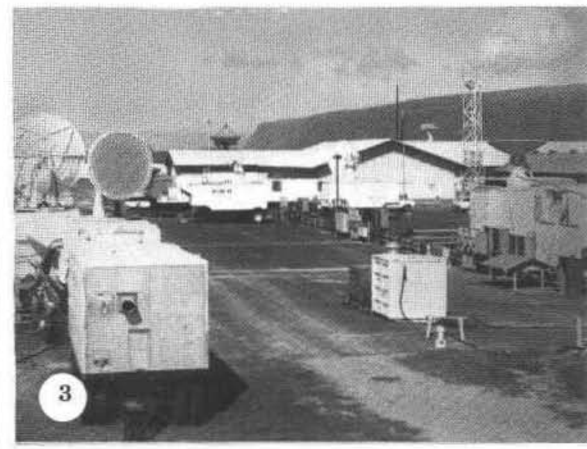
In 1970, the Naval Air Systems Command assigned integrated logistics support (ILS) of air-launched missiles, aircraft guns, bombs, rockets, and targets to NMC. This assignment created a complete engineering activity for updating, support, and problem solving. It also instituted a new in-house capability, as opposed to previously contracting for these services, for support of the operational forces.

In 1971, in-service aircraft gun support was initiated and WALLEYE engineering cognizance was assigned. The following years saw a continual increase in this area as NMC became the in-service engineering activity for a growing list of missiles and conventional ordnance.



1

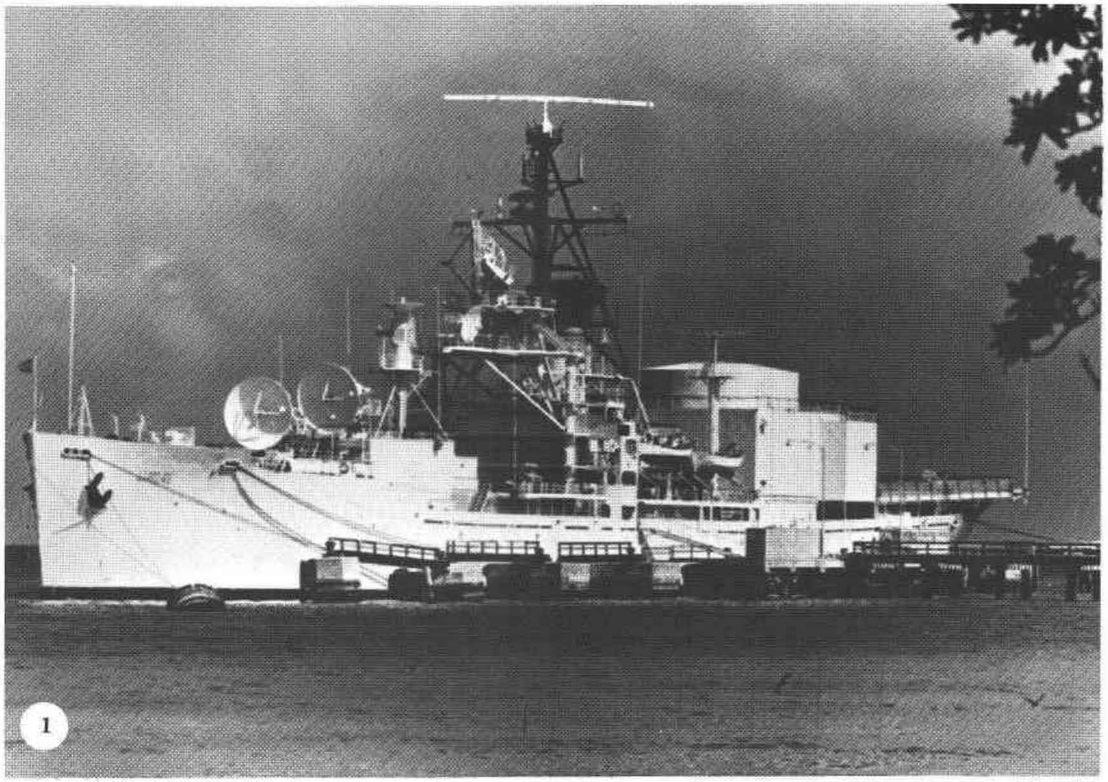
2

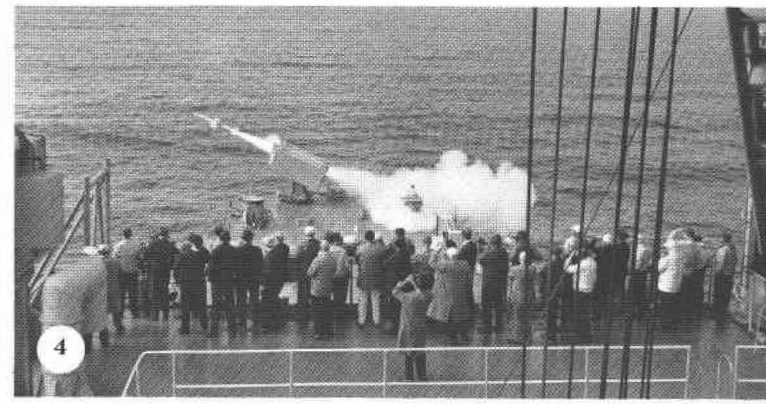


3

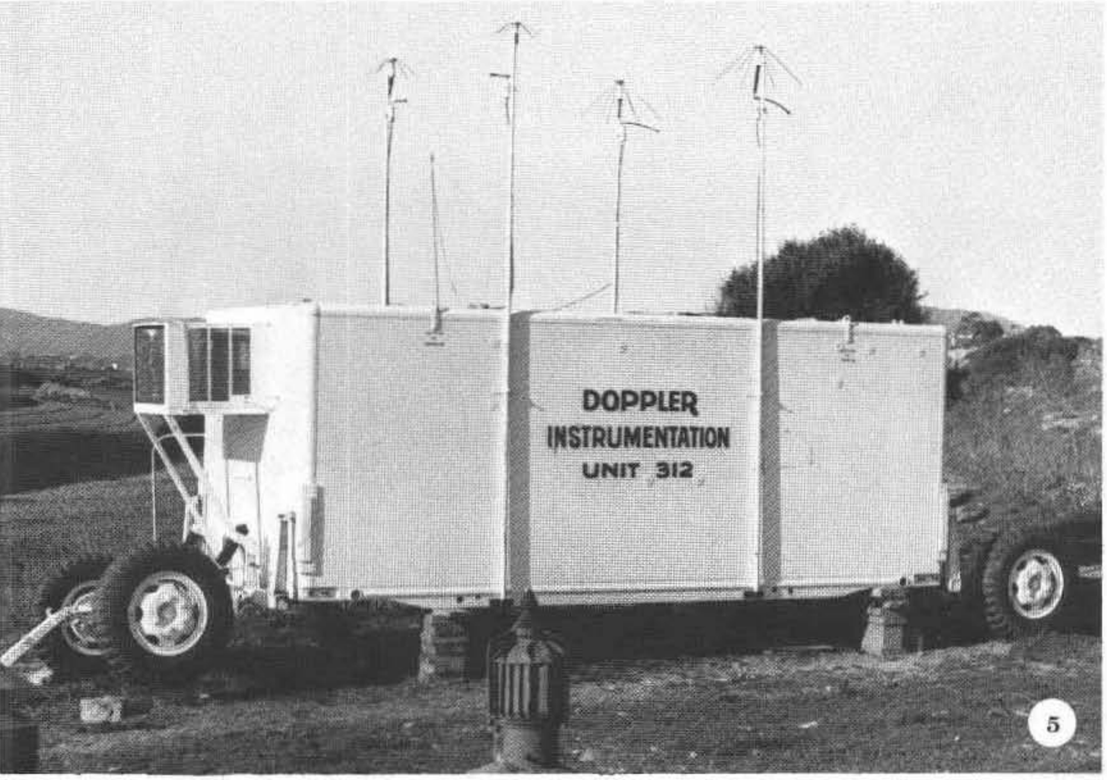
4

1. Pattern of hydrophone distribution in Barking Sands Tactical Underwater Range, between Niihau (lf.) and Kauai (rt.) islands (1966). 2. Track and Control Room "ALPHA" at PMRF Operations Building, Barking Sands, Hawaii (1970). 3. Barking Sands tracking instrumentation site (1961). 4. SCUBA diver working on hydrophone cables, Barking Sands Tactical Underwater Range (1971). 5. Aerial view of airstrip and operations complex, PMRF, Barking Sands (1970). 6. Power plant, communication, and radar buildings at Makaha Ridge, PMRF (1967). 7. PMRF target launch pad with BQM-34A target (1970).

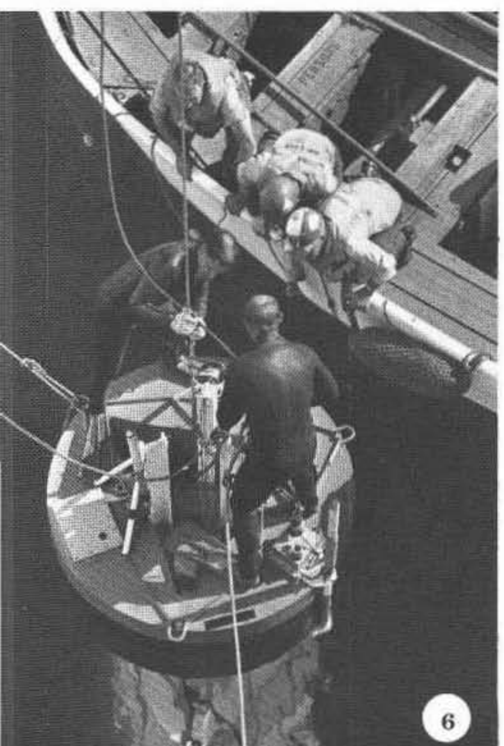




1. USNS WHEELING range instrumentation ship with helicopter landing platform (1966). 2. Aerial view of Johnston Island, a PMR downrange instrumentation site with airstrip (1961). 3. Eighty-five-foot Weapons Recovery Boat (WRB) underway on PMRF range (1967). 4. The first SEA SPARROW was launched as a surface-to-air missile (1968). 5. TRANET instrumentation site in Lisbon, Portugal (1967). 6. Recovery of the floating rail launcher for the HYDRAS-IRIS high-altitude probe (1965). 7. Fleet Weapons Engineering personnel examining launcher on an F-4 aircraft. 8. WALLEYE guidance and control assembly test underway at Guided Missile Unit No. 41 facility (1970). 9. Fleet Weapons Engineering field service representative explaining features of an MQM-74 target (1970).

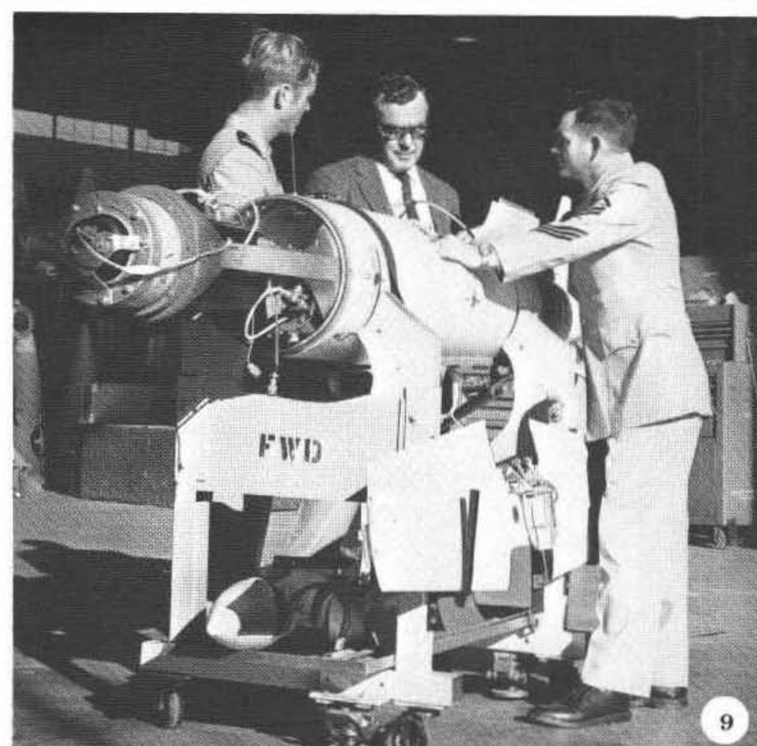


5


6


7


8



9

Launch of PHOENIX missile from modified TA-3B aircraft (1966).

"Enough if something from our hands have power to . . . serve the future hour."

—William Wordsworth

CHAPTER 13

PHOENIX

Up to this point, the history of Point Mugu has been presented in a more or less chronological order with weapons introduced as they came aboard and then reintroduced in later chapters as they progressed through test and evaluation to deployment. This chapter, however, will employ a different approach and attempt to describe the test and evaluation history of just one weapon system—the F-14/PHOENIX. Through this approach it will be possible to examine in detail how a long-term project was conducted, and how the organizations at Point Mugu assumed greater and greater responsibility with regard to the weapon system's reliability.

Before beginning, a brief description of the PHOENIX missile is in order. The AIM-54A PHOENIX is a long-range, highly sophisticated weapon designed for Fleet defense. Originally, it was intended as the primary armament on the F-111B fighter. Later, when the Navy cancelled the F-111B, it became a major part of the armament on the F-14 aircraft. The F-14 is also designed to launch SPARROW III and SIDEWINDER missiles and has a 20mm rapid firing gun.

PHOENIX COMES ABOARD

In 1964, NMC began its participation in the PHOENIX program by detailing the support it could provide for the development program. Historic events occurred soon after.

The first airborne test of the missile, an inert launch, was performed on January 26, 1965, using an A-3A aircraft as the launch platform. In other tests that year the A-3, equipped with a Luneberg lens, served as a target for testing the AWG-9 missile control system. Also, studies were made of the PHOENIX missile signature and clutter characteristics to help develop a target generator for laboratory simulation.

FIRST LIVE FIRING

The year 1966 saw the first launch of a "live" PHOENIX missile. It was fired from an A-3 aircraft and scored a direct hit on a BQM-34A target. Later that year, the total PHOENIX weapon system was flown for the first time aboard an F-111B aircraft.

LABORATORY INTEGRATION SYSTEM

In the laboratory, NMC made plans to construct the PHOENIX Laboratory Integrations System (LIS), a hybrid system consisting of actual missile hardware augmented by digital/analog computers. LIS would be able to simulate free space missile flight and/or the actual F-111B attack environment with an airborne missile control system in a mock-up cockpit. Targets and clutter would be generated, thus permitting the F-111B/PHOENIX weapon system to operate against all types of threats flying in different deployments, an exercise not previously possible short of actual combat conditions. The following year the contract was let for the LIS hardware.

F-111B LAUNCH

On March 17, 1967, the PHOENIX was launched for the first time from the F-111B. Following this there were subsonic launches from the weapons bay and from the pylon stations. All told, there were 137 operations of all types conducted that year as part of the Contractor Development Test (CDT) program.

CONTRACTOR DEVELOPMENT TEST

The CDT continued into 1968 with major milestones achieved in the first supersonic flight launch, the first launch of a single missile against multiple targets, and the first firing of two missiles against two targets. This last operation, the ripple firing, was only partially successful.

Eight missile launches were conducted in 1969 as part of the CDT.One of these operations, on March 9, was a second attempt at a two-missile ripple firing against two widely separated targets. On this occasion, both missiles guided satisfactorily to intercept.

F-14/SITS

During 1969, the F-14 aircraft contract was awarded and preparations were begun to install an F-14 Systems Integration Test Station (SITS) at Point Mugu. SITS was designed to help expedite the integration and development of the F-14 aircraft through validating interfaces, developing software programs, testing prototype innovations, and simulating difficult malfunctions. It would also serve as a training aid for aircrews.

The following year, the Center supported the installation of the SITS frame. Between February and December of 1970, the F-14A avionics navigation, weapon control system (AWG-9 and AWG-15), controls and displays, identification, and electronic warfare subsystems were integrated into SITS. On September 15, the SITS AWG-9 radar radiated for the first time into the range against a live target. On March 9, 1971, the first YAIM-54A PHOENIX missile was successfully launched. Lastly, on June 11, the first XAIM-54A warhead missile was fired from an F-111B, scoring a direct hit on a QF-9J target.

F-14/PHOENIX TESTS

During 1971, 210 captive flights were conducted for the CDT of the F-14A aircraft weapon system. In the PHOENIX CDT, four launches were made from the F-111B. Work also continued in the laboratory to determine enemy ECM that could be used against the PHOENIX missile as well as work on the development of electronic counter-countermeasures (ECCM). The laboratory was equipped with a special AWG-9 radar and AIM-54A missile configured to permit ECM tests and the incorporation of new ECCM techniques.

Test and evaluation during 1972 included samples from the Production Improvement Program (PIP) and the continuation of launches from the F-14A. Also, NMC conducted four launches for the Production Verification Launch (PVL) program and Government Lot Acceptance Testing (GLAT).

"SIX ON SIX"

The year 1973 proved to be one of the most momentous in the F-14/PHOENIX program at Point Mugu. At the request of a congressional committee, the Navy decided to conduct an operation in which six PHOENIX missiles would be launched from a single F-14A to simultaneously attack six independent targets. The operation, referred to as "Six on Six," would thereby demonstrate that the F-14A weapon control system could select a target for each missile and then, after launch, guide all six of the missiles simultaneously to separate intercepts.

The operation, which took place on November 21, 1973, was preceded by several weeks of preparation involving over 500 people. Not only was it necessary to check out and prepare the missiles, the flight crews had to be trained and checked out, aircraft maintained, and targets prepared and augmented. The task of presenting the six targets for the operation was almost as difficult as the launch itself. The results of "Six on Six" were very satisfactory. All six missiles were successfully launched and four scored direct hits on their designated targets.

RECONFIGURATION TESTS

A somewhat less spectacular but highly significant event in 1973 was conducted by NMC to determine the time and manpower required to reconfigure the F-14A for various missions. The length of time it would take to remove and replace launchers and weapon rails could be a critical factor in the overall effectiveness of the airplane. NMC recommendations resulting from the study were accepted by the Naval Air Systems Command, and it was stated that:

> *"The changes recommended by NMC will convert the F-14 aircraft from one of the most difficult planes in the U.S. inventory to reconfigure into the easiest to reconfigure."*

TECHEVAL

During the very busy year of 1973, Contractor Demonstration Testing continued, but gradually this effort was replaced by two Navy programs—the PHOENIX Weapons Technical Evaluation (TECHEVAL) and the F-14/PHOENIX Operational Evaluation (OPEVAL). The laboratory portion of the TECHEVAL was initiated in July and the flight test portion began in October. However, the total effort was interrupted during the second week in October by the "Six on Six" operation.

SOFTWARE SUPPORT AGENCY

On February 15, 1973, NMC was designated as the F-14 Software Support Activity. This meant that the Center's activity would change from passive monitoring of the contractor's effort to active participation in the management of all software, including that used in trainers and in ground support equipment.

NTE/SHIP SUITABILITY

During 1974, the formal portion of the Navy TECHEVAL was completed on the PHOENIX missile with five launches. Subsequent testing featured a successful launch against a target maneuvering at six g's and a "kill" scored on a low-flying QF-4 aircraft target.

Also in 1974, NMC activities moved from Point Mugu to the Fleet for the F-14A Ship Suitability Tests. Conducted between April 18 and 26, these evaluations aboard the USS ENTERPRISE were designed to ensure that all supporting elements on the ship were able to perform their tasks so that the aircraft and weapon system could accomplish their mission. The tests included assessing the effect on the missiles of long-haul trucking, underway replenishment, strikedown, and stowage; the electromagnetic interference the aircraft might experience from ship radars; the space and functional adequacy of the ship for F-14A armament suspension equipment; the adequacy of the ready service

F-14A OPEVAL one of PMTC'S primary efforts in mid-1970's

planning and ground support equipment required for F-14A conventional armament; performance of reconfiguration and preflight checks; loading and servicing of the 20 mm M61A1 gun; the functional compatibility of the AWG-9 weapon control system and the AWN-23 radar shop; the compatibility of the AWG-15 and the Versatile Avionics Shop Test; and the functioning of the ground support equipment in its intended environment.

OPEVAL

One of the primary efforts at the Pacific Missile Test Center (see Establishment, page 201) during 1975 was supporting the prosecution of the F-14A OPEVAL. This included 12 PHOENIX missile launches as part of ANNEX E (air maritime superiority in a clear environment) and 14 launches in ANNEX F (air maritime superiority in an ECM environment). A number of missions involved multiple missile firings against multiple targets and required detailed planning, analysis, and coordination. The F-14 SITS also supported the OPEVAL by preflight simulation and analysis of Air Test and Evaluation Squadron FOUR's mission profiles.

OPEVAL support continued into 1976 with seven of the PHOENIX missiles air-launched against a variety of targets employing barrage noise, swept noise, standoff jammers, chaff, and other countermeasures. Five hits were achieved. There was one miss and one "no test." PMTC also supported the contractors in follow-on development test and evaluation of the F-14A, its software, and the PHOENIX.

FOREIGN MILITARY SALES

During August 1977, PMTC supported foreign military

Ground launch of XAIM-54A PHOENIX missile.

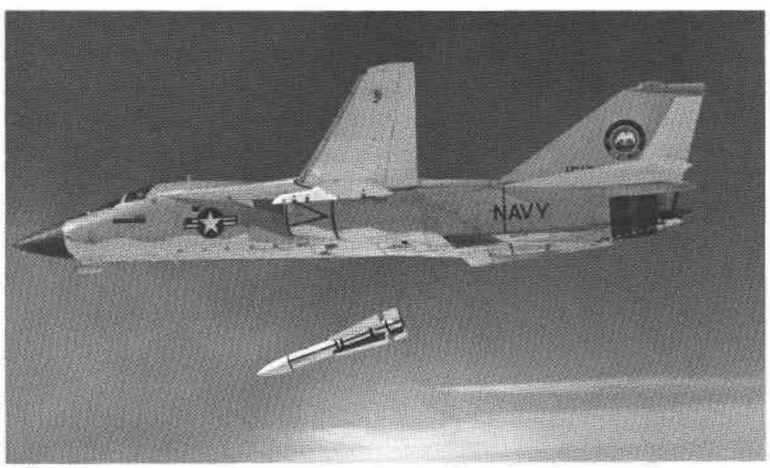
F-111B aircraft in flight.

sales by hosting Imperial Iranian Air Force personnel and providing training for weapon buildup and testing, F-14A weapons loading and checkout, and aircrew procedures. The effort culminated with the launch of two missiles by Iranian aircrews. Both missiles scored direct hits on BQM-34E targets.

Also in 1977, four launches were made in support of the PVL and the GLAT programs.

CONTINUING SUPPORT

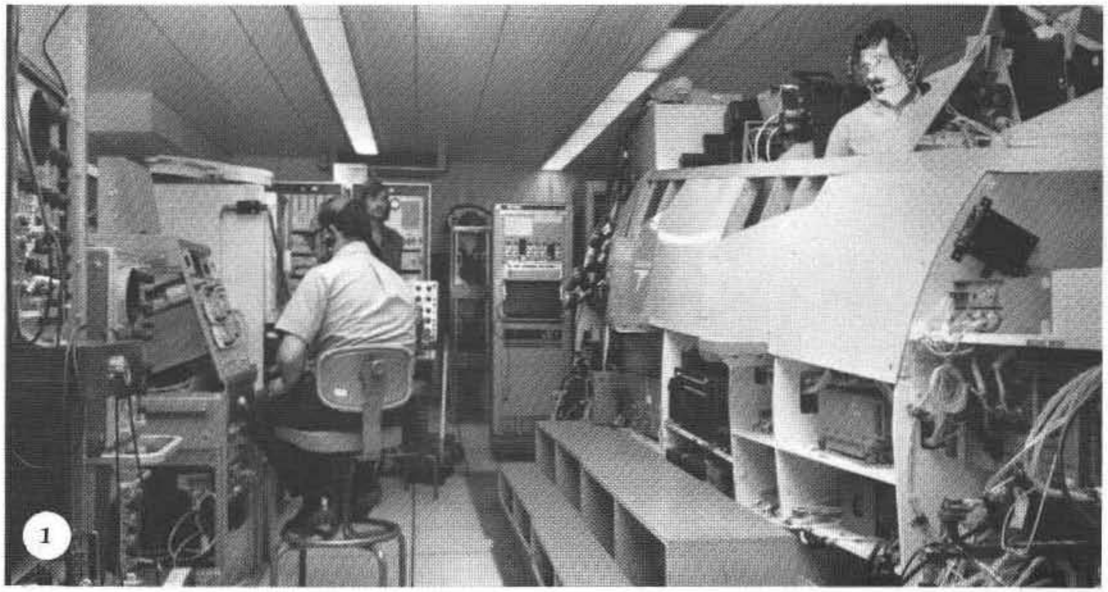
A very successful high-altitude missile firing against a BOMARC target was conducted on March 24, 1978. On May 18, the PHOENIX successfully demonstrated the Reject Image Device in a lookdown launch. On June 7, the Television Sight Unit installed on the F-14A was successful in making a positive identification prior to a launch. During 1978, the SITS frame/cockpit was modified for update to the digital AWG-9 configuration; then, a second SITS frame was obtained for installation. In the PHOENIX simulation laboratory, significant progress was made toward updating and expanding the closed-loop test system in preparation for the test and evaluation of the advanced model AIM-54C PHOENIX missile.

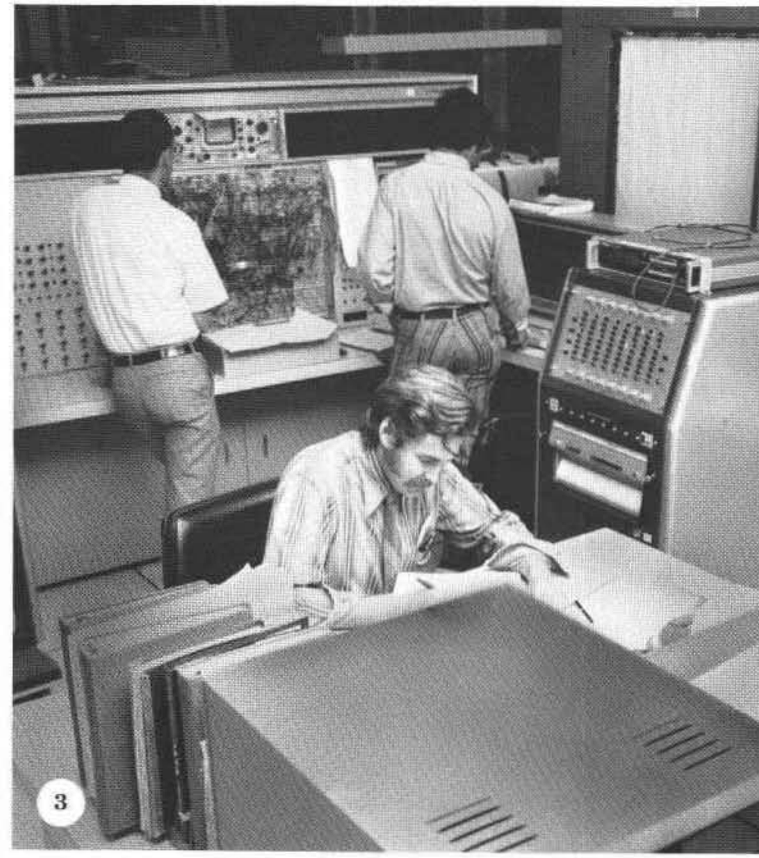


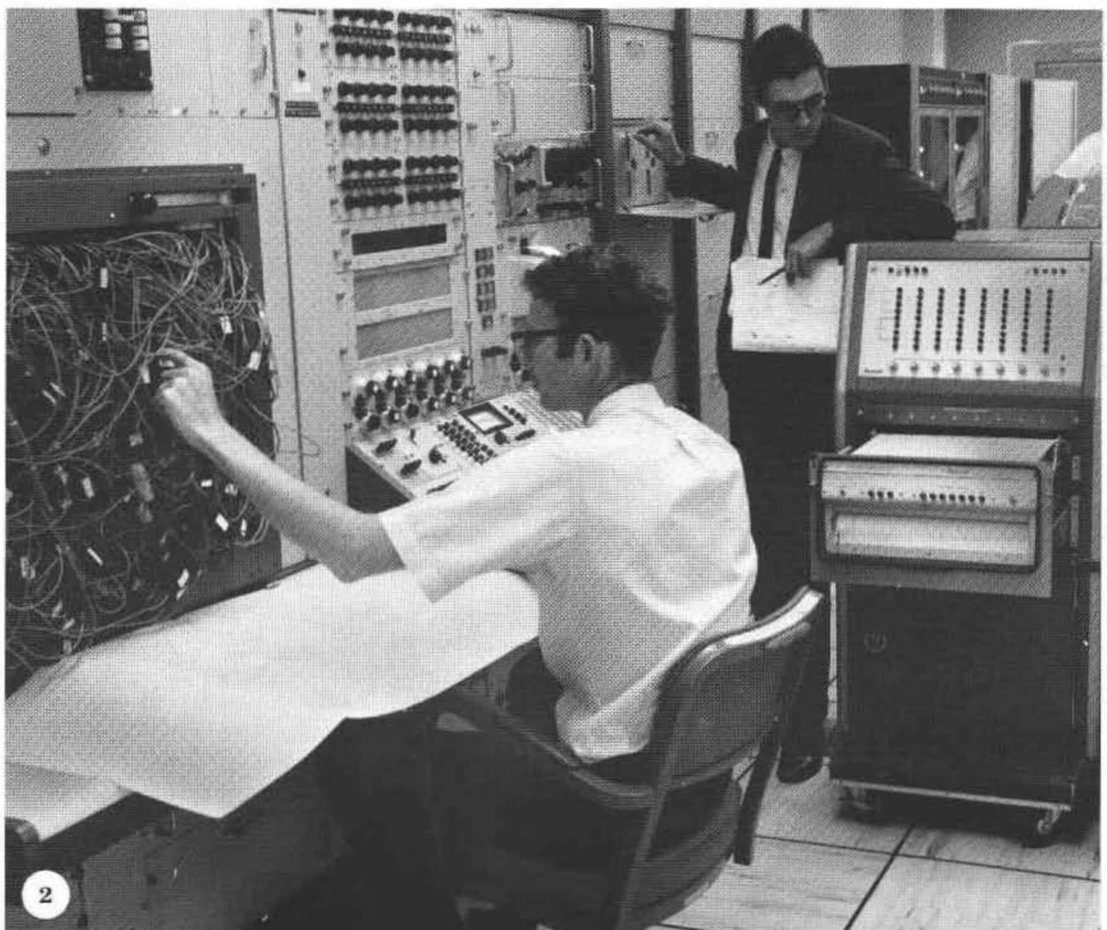
PHOENIX developmental launch from F-111B aircraft (1966).

On June 30, 1979, the first AIM-54C Engineering Development Model (EDM) PHOENIX missile was delivered to Point Mugu. After several minor problems were corrected, the missile was captive-flight tested for an accumulative 48 hours and then sent back to the contractor. It was returned in November and a second EDM missile arrived in December. In August 1979, PMTC delivered the latest revision of the F-14 software package, TAPE 111C/P7C, to the Fleet. Also, during 1979, modifications were made to the SITS laboratory to eliminate unnecessary equipment.

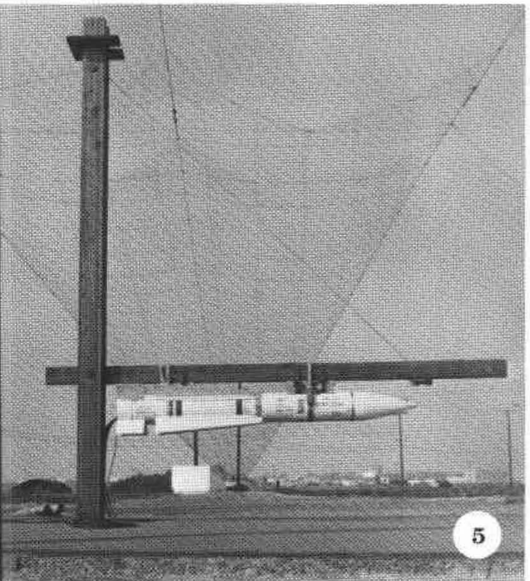
During 1980, the PHOENIX XAIM-54C missile passed the Navy Acquisition Review Council III milestone after completing three launches satisfactorily, but a fourth launch resulted in a failure. Production of the PHOENIX AIM-54A was completed, and the final samples for the GLAT passed satisfactorily. The first Navy-developed F-14 software, TAPE 111D, was released to the Fleet in October. The tape both corrected deficiencies in the previous tape and incorporated design improvements. Also, PMTC wrote the very first Software Technical Directive for the release of TAPE 111D, a new concept in tape release procedures tying software to the normal hardware process. The second F-14 SITS was fabricated during the year, and extensive development and evaluation work continued on the XAIM-54C EDM with a total of 297 cumulative captive flight hours flown using a total of six EDM missiles.

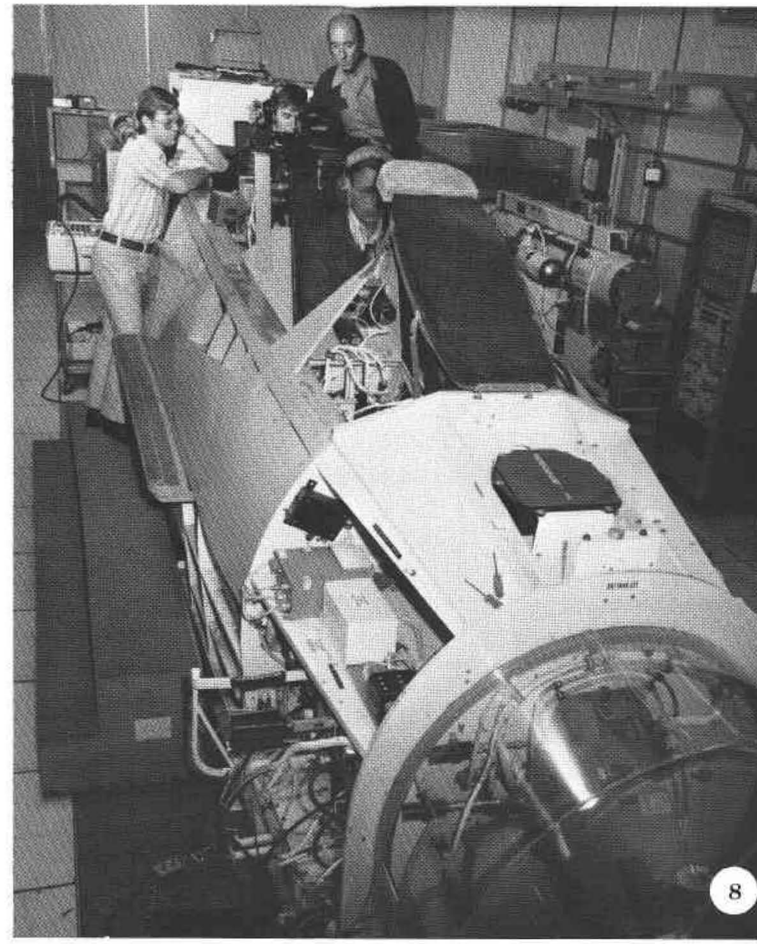

1


3


2


4



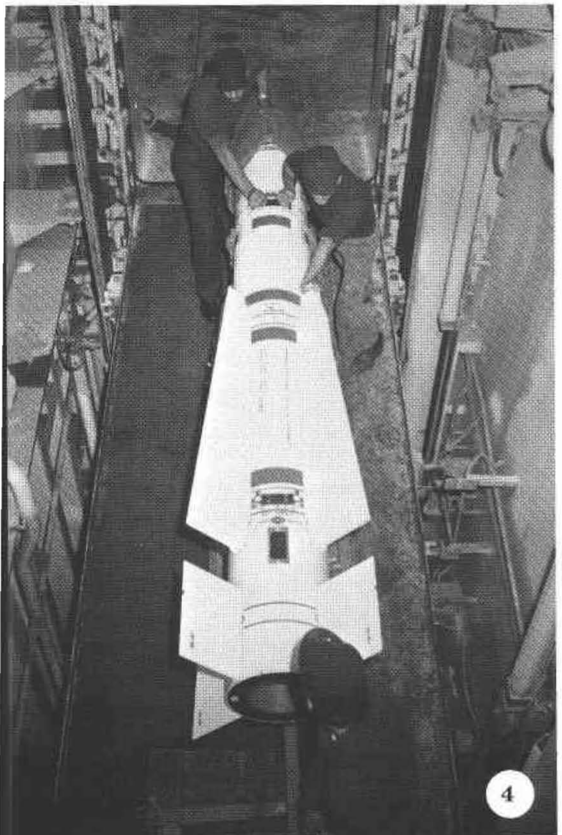


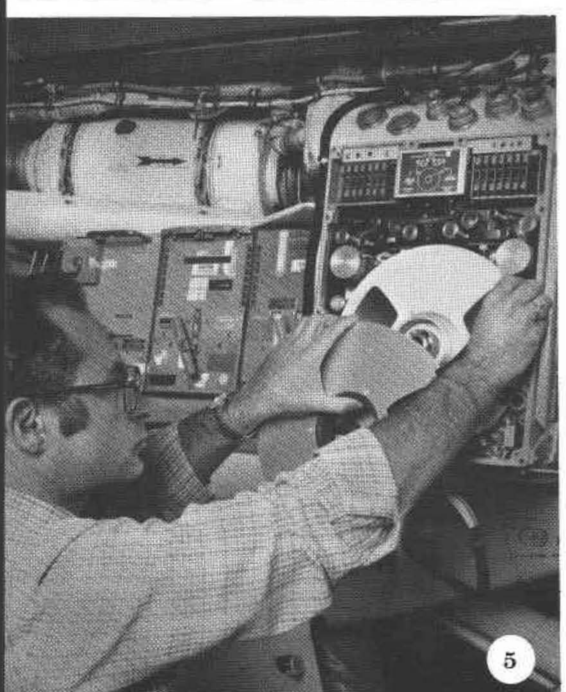
1. The PHOENIX/F-14 Systems Integration Test Station (SITS), used in validation of tactical software configuration updates. 2. Personnel at work in the Simulation Lab, Building 761 (1968). 3. Data recording station for LIS and SITS facilities (1972). 4. PHOENIX/F-111B missile loading demonstration (1967). 5. EW countermeasures electromagnetic radiation environment simulator at Point Mugu. 6. Loading a PHOENIX missile with developmental nose cone on an F-14 aircraft (1972). 7. F-111B aircraft launching a PHOENIX missile. 8. SITS, used for integration of control and display avionics with weapon control system.

1

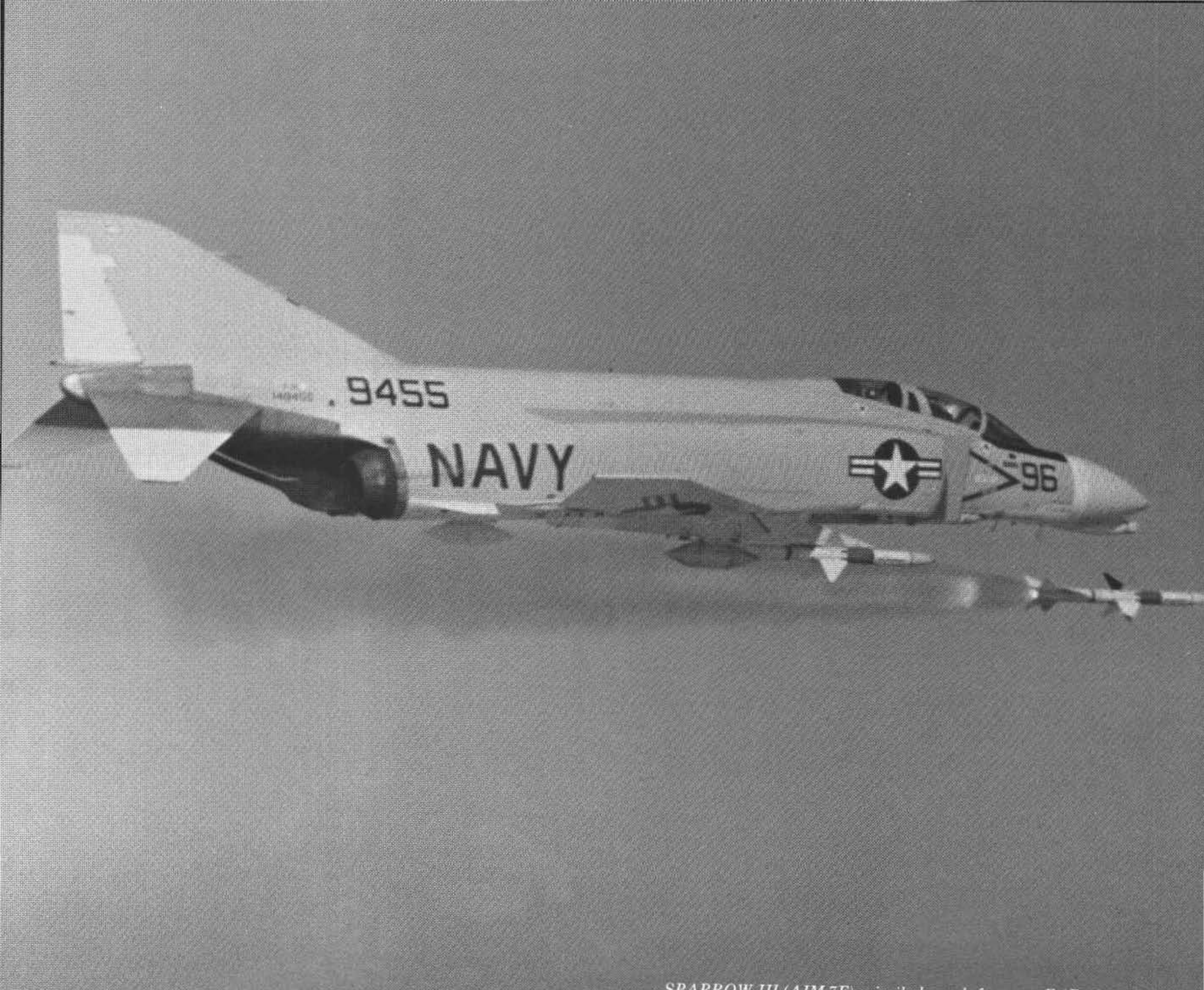
2

3





1. F-14 with PHOENIX missile in the Sea Level Climatic Chamber (1974). 2. Military personnel loading a 20mm ammunition canister on an F-14 aircraft. 3. Loading PHOENIX missile on F-14 during Ship Suitability Trials. 4. PHOENIX missile on flight deck elevator of aircraft carrier. 5. F-14/PHOENIX Tactical Data Recording Station. 6. F-14/PHOENIX missile on flight deck of USS ENTERPRISE. 7. Launch of PHOENIX missile from an F-14 aircraft during OPEVAL.



SPARROW III (AIM-7F) missile launch from an F-4B aircraft (1968).

"I learned in the regiment and the class the conclusion, at least, of what I think the best service that we can do for our country and for ourselves . . . to hammer out as compact and solid a piece of work as one can, to try to make it first rate."

—Justice Oliver Wendell Holmes, Jr.

CHAPTER 14

PROGRAM AND FLEET SUPPORT

The end of the 1960's and the early 1970's did not see spectacular changes or major innovations at Point Mugu. These were years characterized by continuing service and support, especially to Fleet activities in Southeast Asia. Lessons learned in the Vietnam conflict had to be quickly applied to existing weapon systems and electronic warfare equipment through modifications, improvements, and retrofitting.

At the same time, new weapon systems had to be initiated to meet anticipated threats. During this time period, the HARPOON Anti-Ship Missile System came aboard, joining other major projects such as PHOENIX, SHRIKE, SIDEWINDER, SPARROW III, CONDOR, and STANDARD ARM. Also, EW systems test and evaluation gained considerable emphasis, both in radar suppression devices and warning equipment. Increasing emphasis was placed on production testing and in-service engineering for those weapons already deployed. Support was provided the Fleet for launching TERRIER, TARTAR, and TALOS on the range and for the developmental testing of the Basic Point Defense System.

SPARROW III

In 1969, NMC provided contractor support both in the air and laboratory for the developmental testing of an improved SPARROW III (AIM-7F). In addition, assistance was provided NWC China Lake and NWC Corona in the development of an optimum warhead for the missile. This latter support included conceptual design of the armament by determining and assessing potential effectiveness.

In 1970, twenty-two AIM-7F missiles were launched for contractor development and NTE purposes. Although the tests showed performance improvements over earlier models, there were some major areas which required additional research and development before release for production.

In 1972, the AIM-7F NTE was successfully completed and the OPEVAL begun. Along with AIM-7F missile testing, feasibility and laboratory tests were made on various methods of telemetering missile data. The final choice was pulse amplitude modulation/frequency modulation (PAM/FM).

HARPOON

NMC's involvement with the HARPOON development program commenced in June 1970 with seeker tests in which captive flights were performed to assess the capabilities of candidate seeker systems against seaborne targets. These tests complemented similar investigations by other program participants. Continuation of the program in the following year included the design and fabrication of several instrumentation systems. Captive propulsion tests were completed in 1972, and the captive flight program, including countermeasures environments, was begun. The first guided flight of the HARPOON missile was successfully made on December 20, 1972. The missile scored a direct hit on the target.

SHRIKE

NTE of the AGM-45A-6 SHRIKE missile was completed in 1969. Eight missiles were laboratory tested and four were launched into a multiple target environment, impacting the primary target area. Production testing of earlier models continued with a special laboratory facility being used extensively in this work. In 1970, NMC supported the NTE of a new model of SHRIKE, the AGM-45A-7. The years 1971-1972 were devoted primarily to production monitoring tests.

WALLEYE

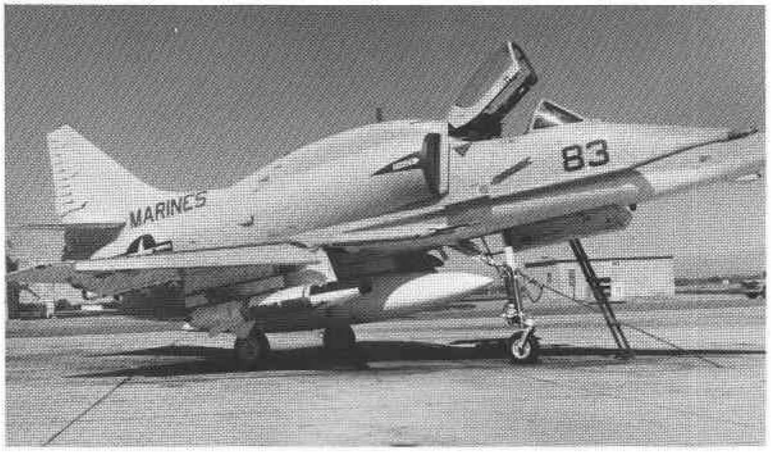
The WALLEYE program at Point Mugu during these years included both production monitoring tests and support for the NTE of improved weapons. In addition to launching a large number of weapons, production monitoring also used a specially equipped A-3 aircraft, or flying laboratory, to help diagnose missile problems during captive flight. During 1971, the testing of WALLEYE I guidance improvements continued and the NTE of WALLEYE II commenced. The latter program was concluded in 1972. At the same time, planning was initiated for the Extended Range WALLEYE weapon system.

Other programs pursued and/or supported included STANDARD ARM, SIDEWINDER, BULLDOG, SUPER BULLDOG, and CONDOR.

ELECTRONIC WARFARE

In addition to weapon system development and improvement programs, the Vietnam War stimulated a high level of activity in electronic warfare. Enemy radar-guided surface-to-air missiles and sophisticated air-launched weapons were placing urgent demands on ECM equipment development and the test and evaluation of new EW devices. Information on some of these items is still classified, but a general picture of NMC's work can be gained by listing the types of projects that came aboard in the 1969 to 1972 time period. These included equipment to increase the frequency range of transmitters carried aboard the EKA-3 aircraft; radar, ultraviolet, and infrared warning receivers; advanced radar, display, and data processing equipment; newly designed antennas; improved chaff dispensers and rockets; laser countermeasures; and equipment improvements for the "Big Look" ECM-equipped aircraft.

NMC also performed foreign technology and tactical environment studies. These encompassed such things as defining the threat to specific weapon systems, threat models for various ECM equipment, target definition, radar cross-section measurement, infrared and ultraviolet



BULLDOG missile on the rail of an A-4M aircraft (1971).

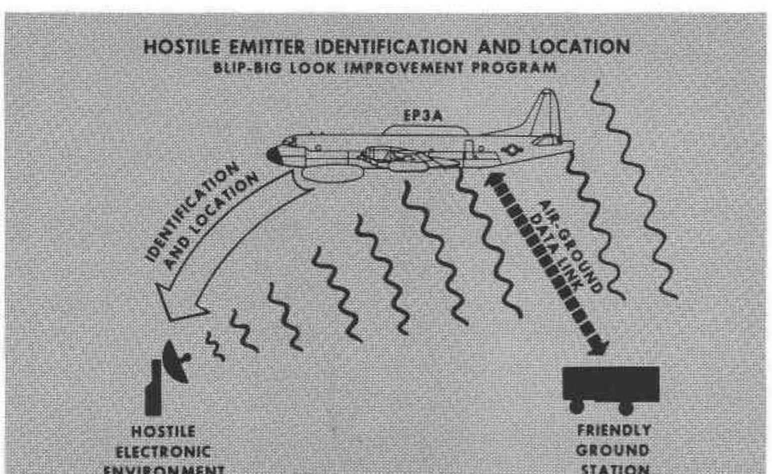
measurements, physical vulnerability investigations, antenna pattern measurement, and also the analysis of electronic subsystems.

EELS

In January 1967, the Department of the Navy formally established the Electronic Emitter Location System (EELS) and gave it a Quick Reaction Capability priority. Both PMR and NMC contributed personnel and facilities to this very critical project which was to provide a system that could detect and position-fix emitters from a stand-off range and then vector attack aircraft against them.

The program employed four cooperating aircraft, one master and three slaves. Each was equipped with Unit Location Equipment, emitter receivers, and integration and buffer equipment. The master station also had a computer and data recorder. Vic Orris remembers that EELS was unique in that:

> *"A Marine major came up with the idea and we started with the basic concept and went through the contractor phase, brought equipment aboard, and had EELS hardware within two years."*



RANGE DEVELOPMENT

While providing the many range services necessary to test and evaluate Navy weapons and support range users, the Fleet, NASA, and the Air Force, PMR continued to look to the future uses of the range through the initiation of range development programs at Point Mugu, San Nicolas Island, Barking Sands, Johnston Atoll, and also aboard the USNS WHEELING. For example, instrumentation accuracy and range were increased, through the installation of new equipment and upgrading of existing efforts, to improve track and control and the real-time display of data.

In 1969, two large general purpose track and control rooms were completed and placed in operation. Video target simulators were acquired for Point Mugu, San Nicolas Island, Barking Sands, Johnston Atoll, and the USNS WHEELING. In 1972, four Integrated Circuit Digital Range Machines were received, with three more scheduled for the following year. These machines would provide increased radar range, system reliability, and simplified maintenance.

At Barking Sands, the Post Operational Data Analysis Facility was completed in 1973. This system was designed to facilitate the processing and analysis of data acquired during an operation, and the replaying of the data later, on a large screen display.

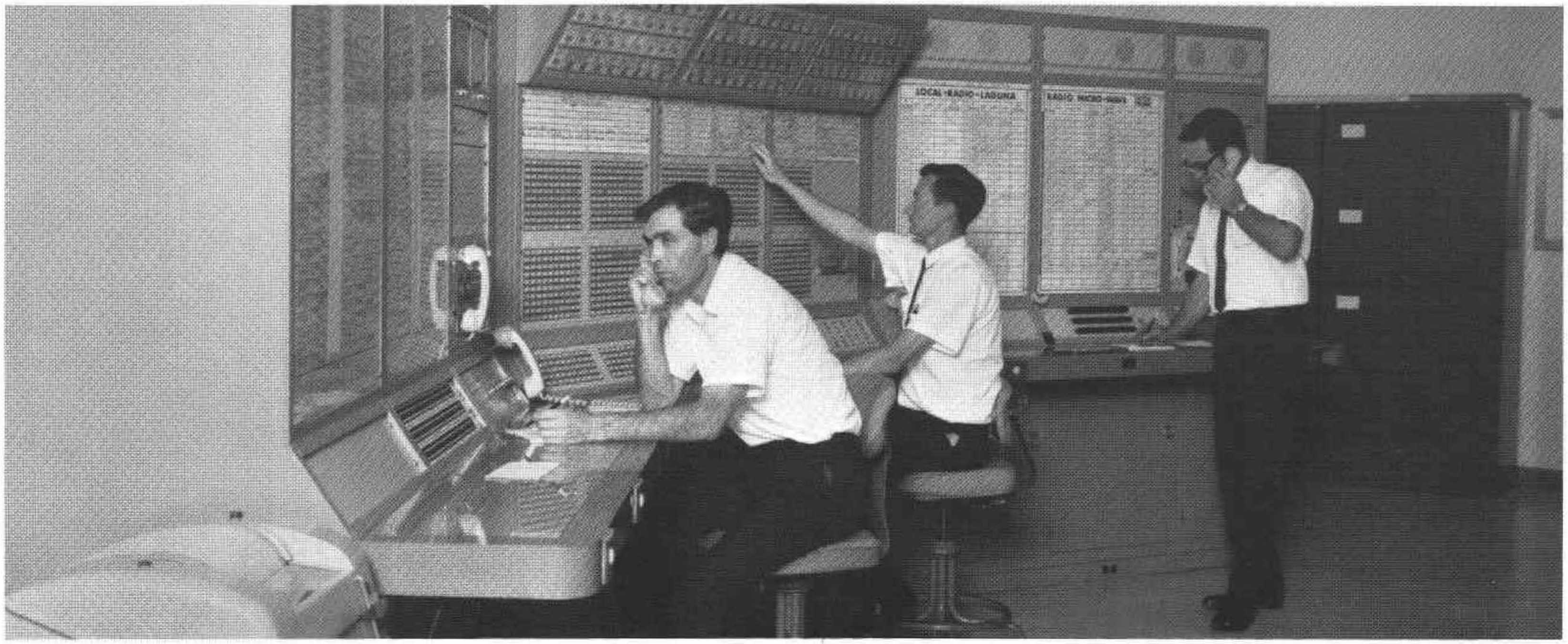
Range Communications achieves milestone

COMMUNICATIONS

Through the mid-1960's and early 1970's, RF transmitting and receiving equipment in the HF, VHF, and UHF frequency spectrum, including antennas, was installed at Point Mugu, Laguna Peak, San Nicolas Island, and Santa Cruz Island. With the acquisition of this new equipment, a gradual phase-out of surplus World War II and Korean War equipment was accomplished.

In 1967, Range Communications achieved a major milestone with the construction of the Range Communications Building which housed the Telecommunications Switching System (TSS) and microwave system. This central control facility allowed the distribution of communication circuits to the various range operations facilities and monitored circuits for quality control.

The TSS, designed specifically for range operations test and evaluation efforts, is an array of electronic hardware that uses cross-bar switching capability operated from a

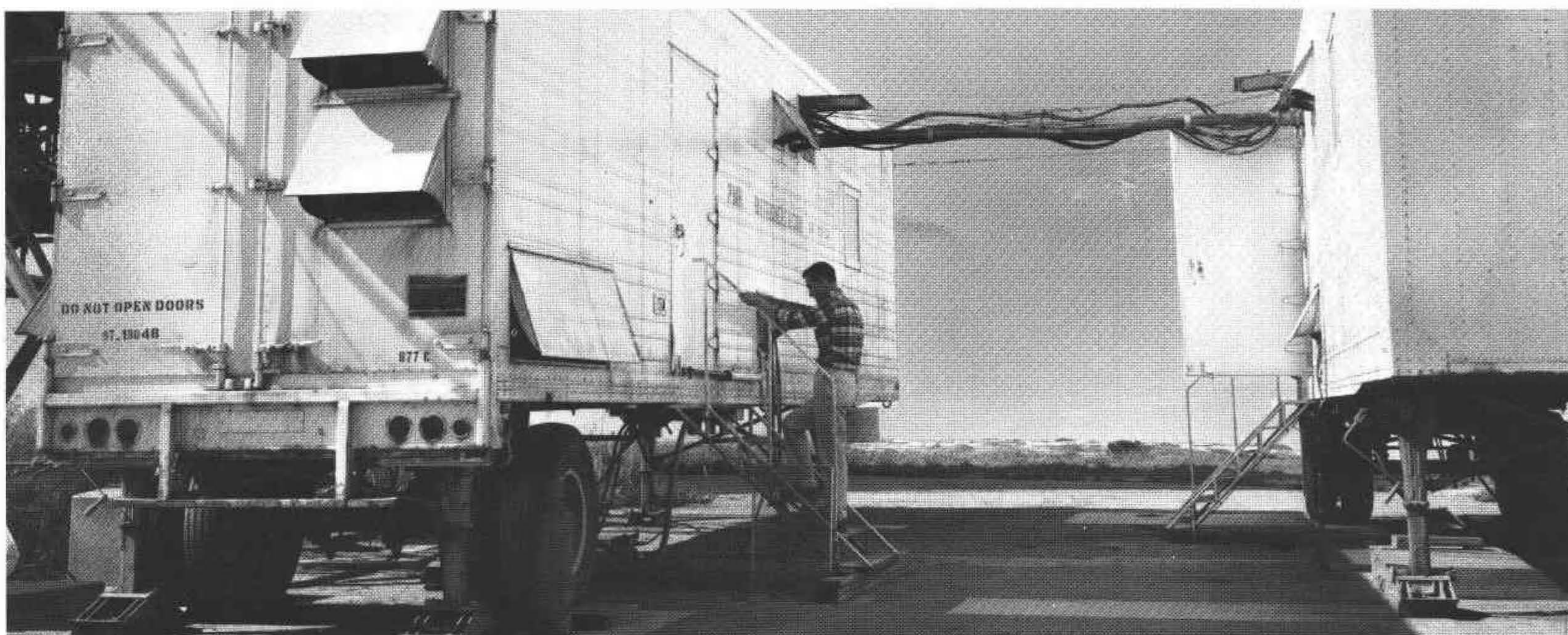


Range Communications Control Center switching console, Building 531 (1968).

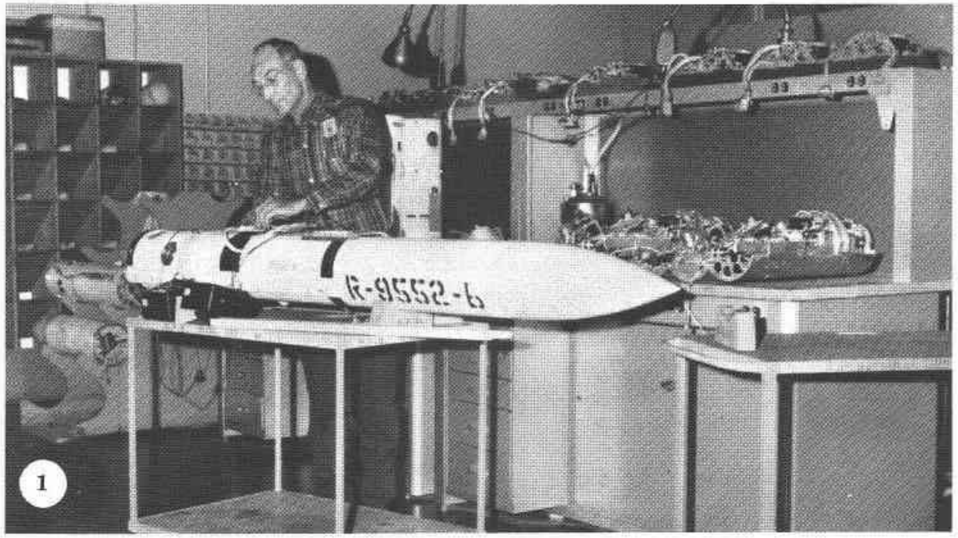
master control console. It is a control system with full flexibility, capable of configuring subscriber stations for almost any conceivable operational need without noticeable degradation of service. Also in 1967, a major upgrading of the outside cable plant at Point Mugu and San Nicolas Island was undertaken. This upgrading provided for the special transmission characteristics of data and video information, as well as separation of operational and administrative transmission paths.

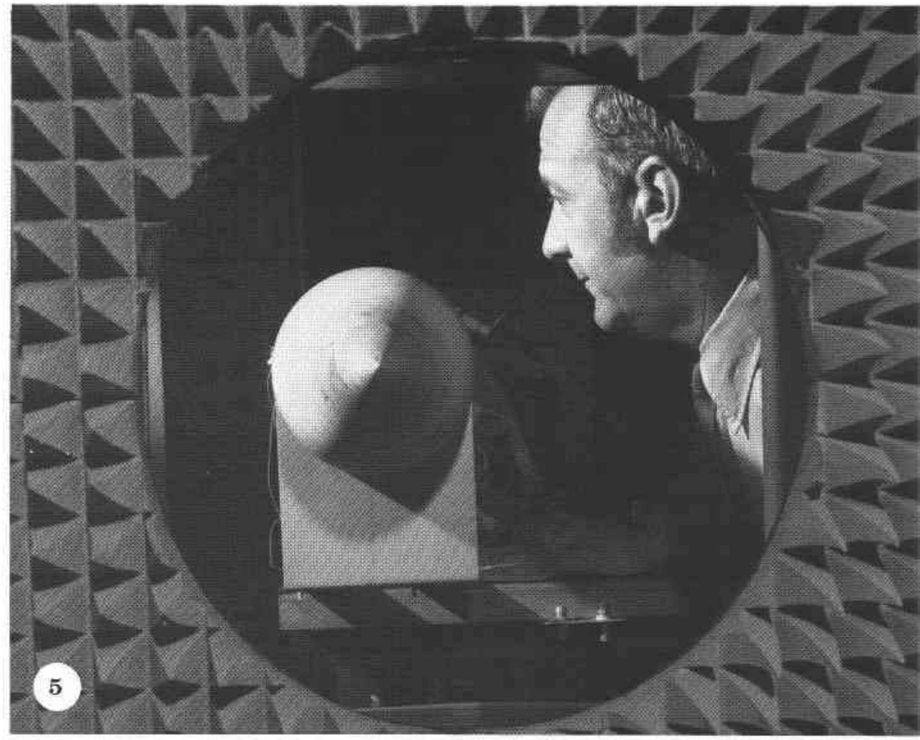
In 1970 and 1974, additional microwave systems were installed. The surveillance transmission system was used to transmit surveillance radar information to Point Mugu for operational control. Also, a telemetry transmission system for real-time readouts was installed for wide-band data transmission from San Nicolas Island to Point Mugu.

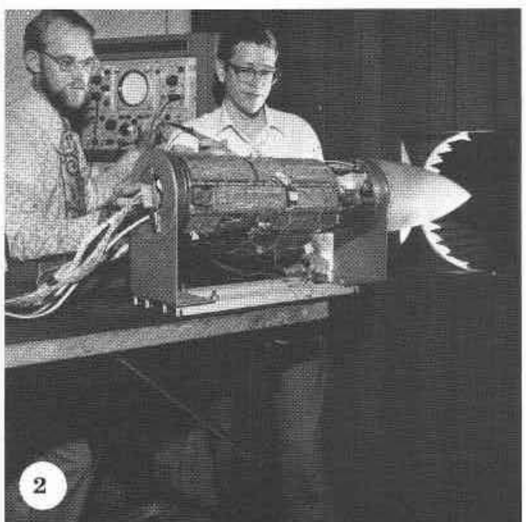
In 1973, the Site 6 Command Destruct Transmitter (CDT) site was installed at Laguna Peak. With this installation the CDT vans at San Nicolas Island were phased out.

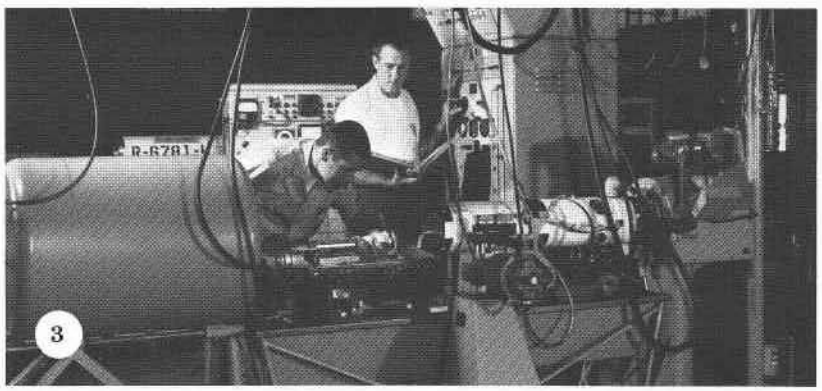


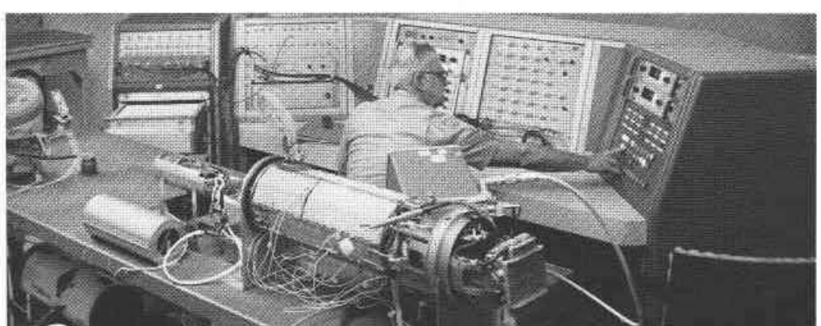
Range Communications Command Destruct Transmitter (CDT) van, San Nicolas Island (1968).

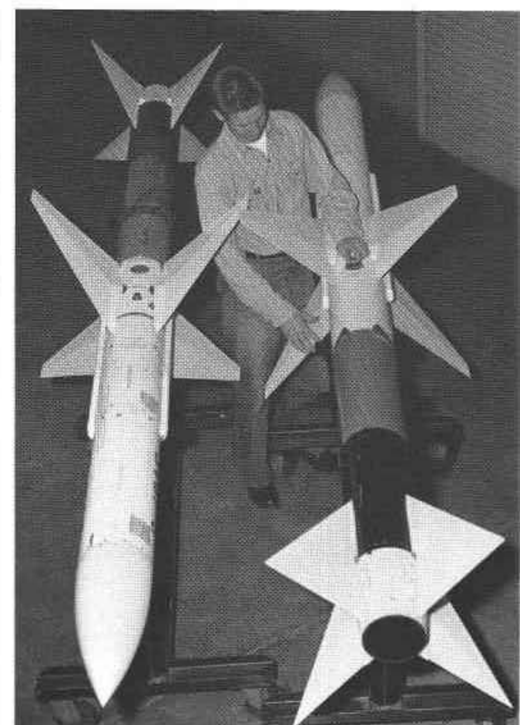

R-9552-6
1

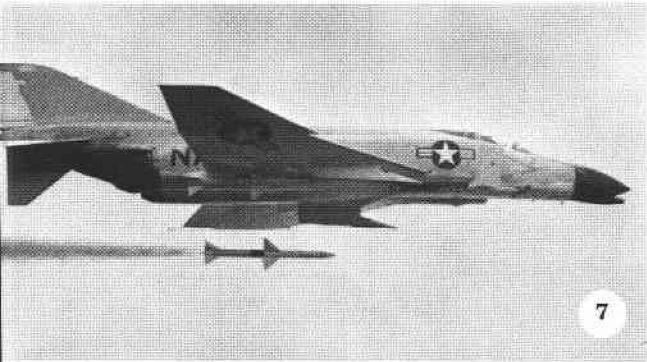

5

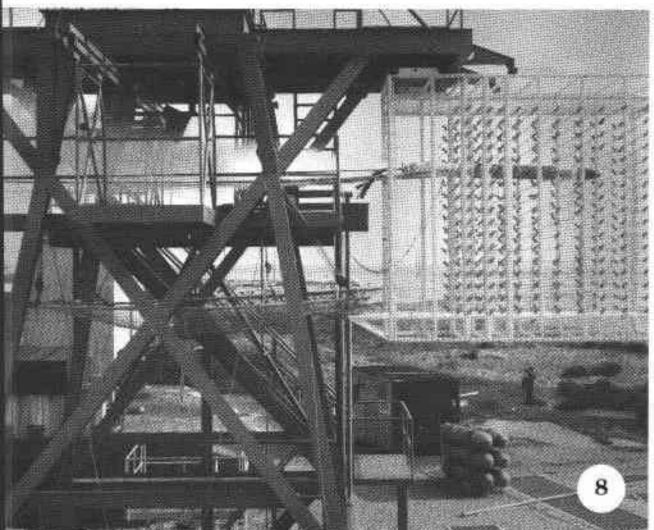

2

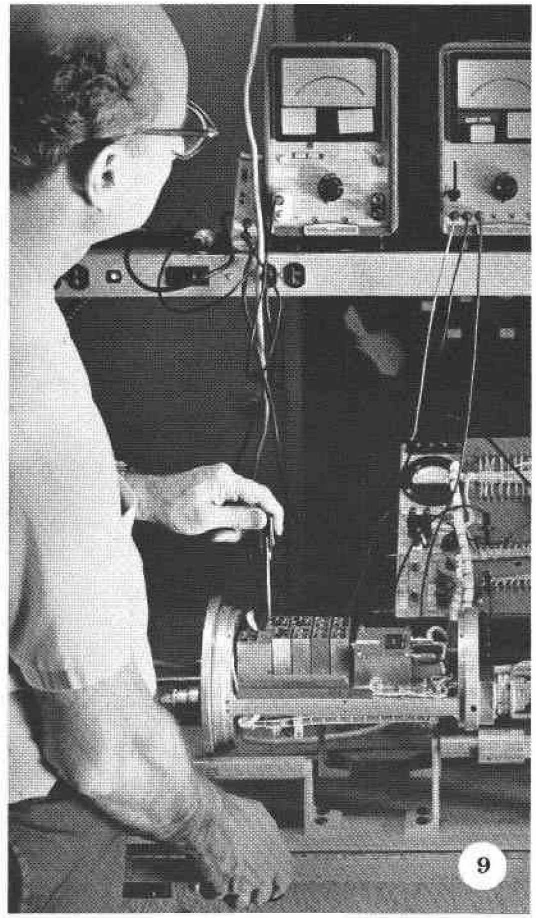

3

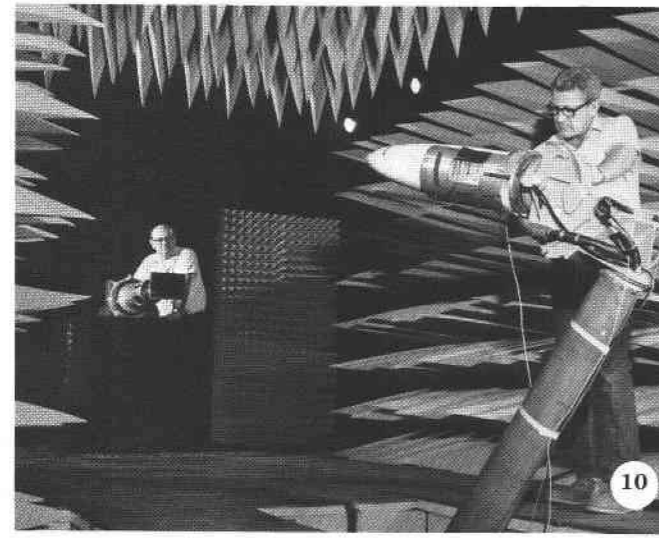

4

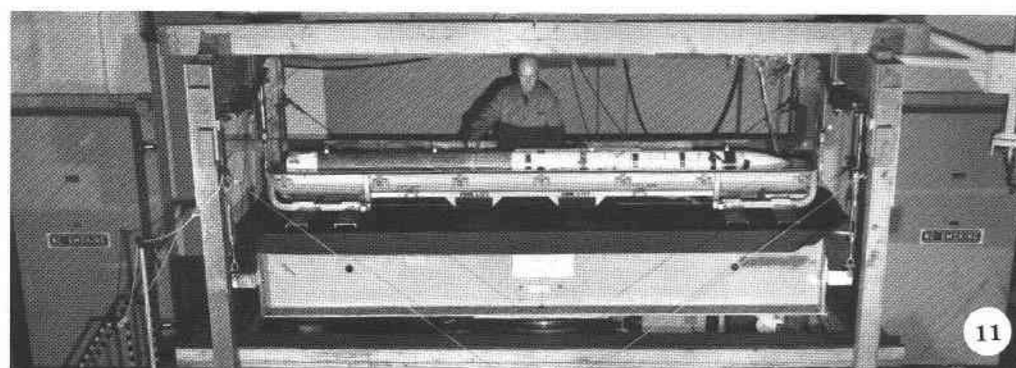

6





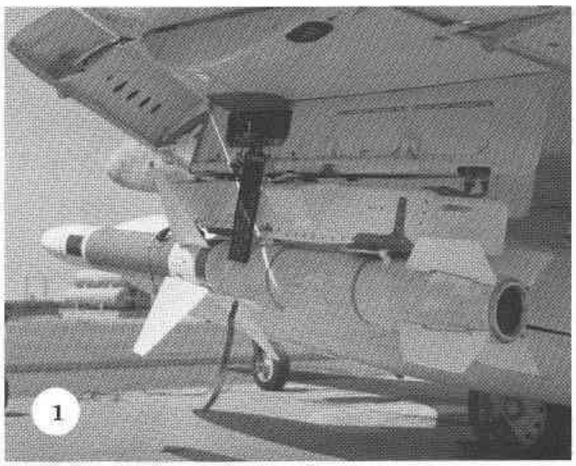


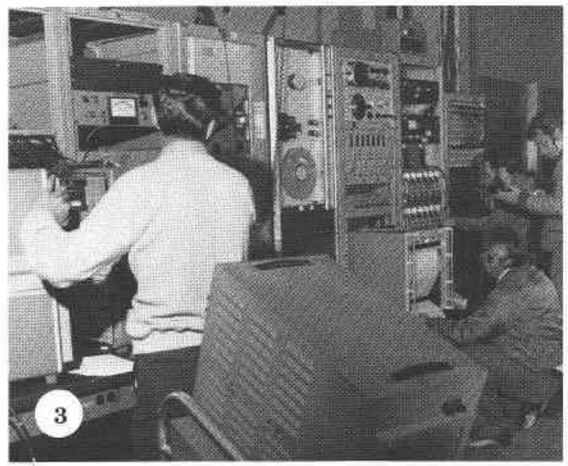


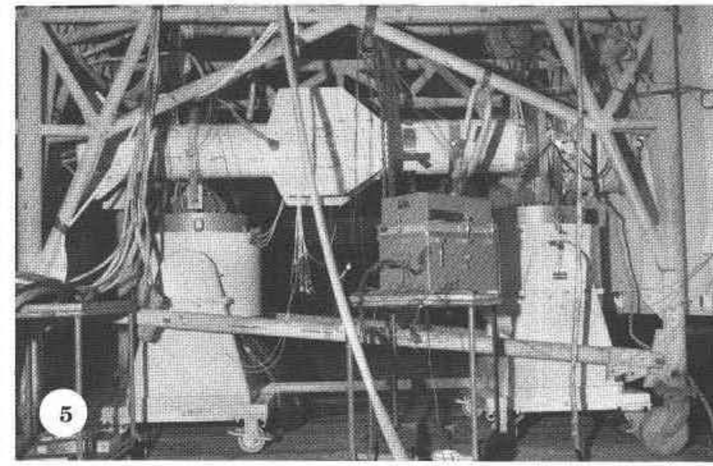


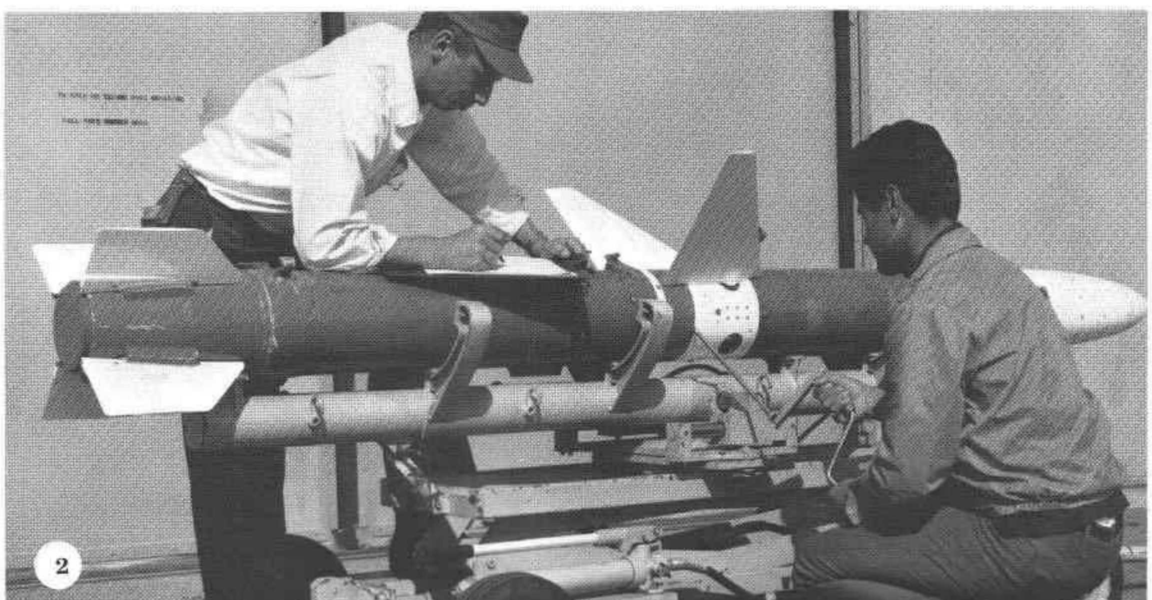
1. Mechanical assembly/disassembly work station at SPARROW III and SIDEWINDER test facility (1967). 2. Technicians testing a SPARROW III missile seeker receiver. 3. Missile Preparation Branch personnel testing SPARROW III seeker on DPM7 sloping panel (1966). 4. SPARROW III test bed missile undergoing missile-target trajectory simulation. 5. View from inside an anechoic chamber where SPARROW III missile is undergoing testing. 6. Preparing test models of SPARROW III missiles (1963). 7. SPARROW III missile launch from an F-4B aircraft (1964). 8. SHRIKE missile captive launch at Pad ABLE, NMC Point Mugu (1968). 9. Instrumentation and Flight Support Division check out of SHRIKE telemetry package. 10. Special acoustic lining inside an anechoic chamber. 11. SHRIKE missile and transport container in shaker apparatus (1966).

4

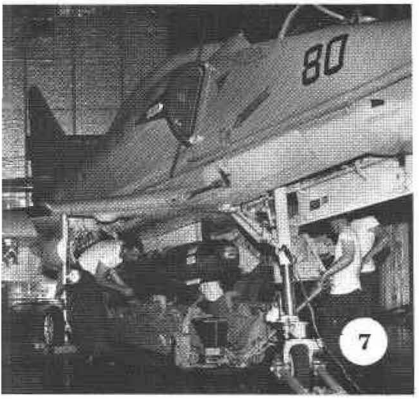

1

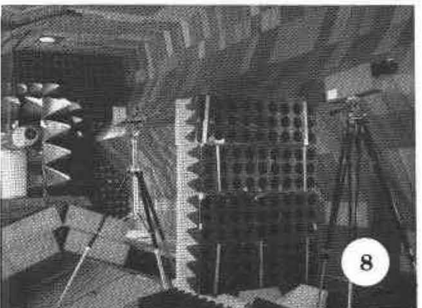

3

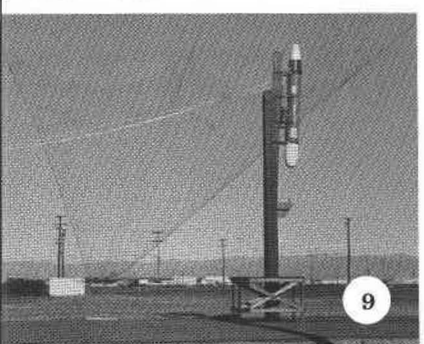

5

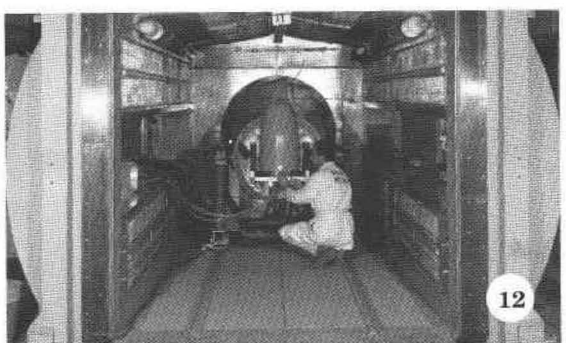

2

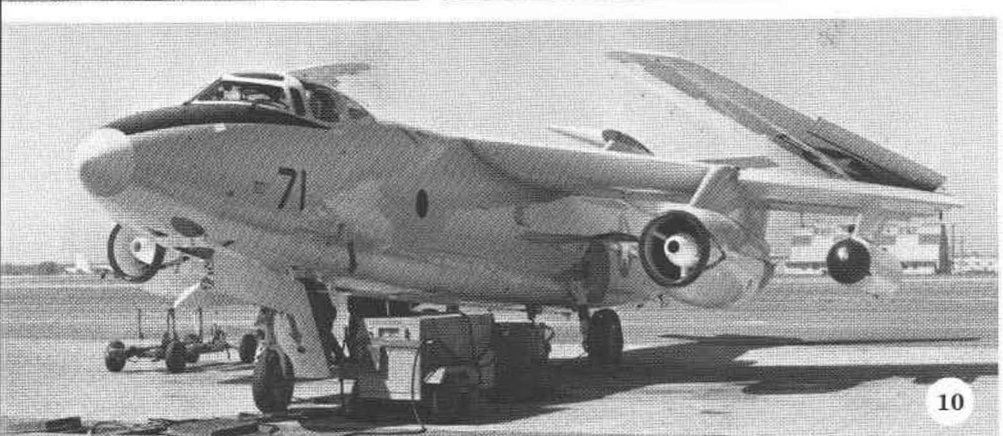

6

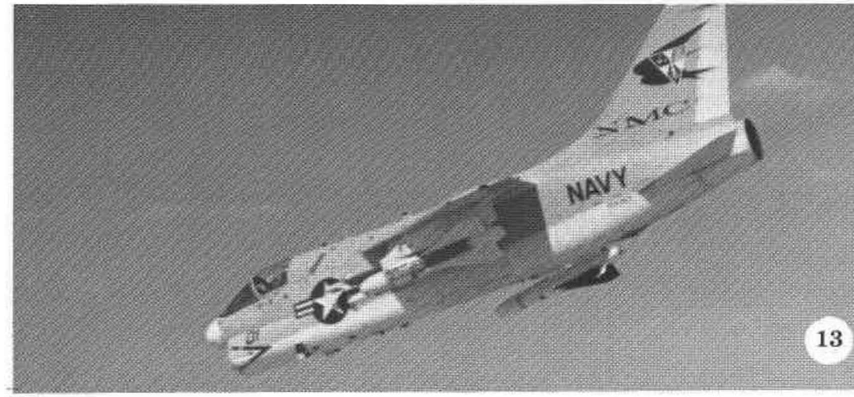




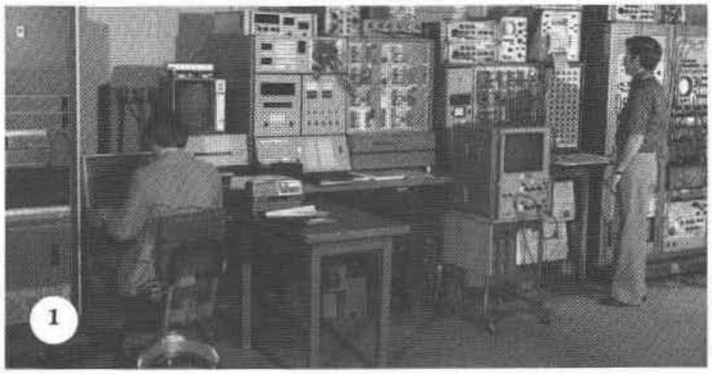








1. SHRIKE missile loaded on A-4 aircraft with Aero 5A-2 rail launcher. 2. Weapons Handling Branch (Building 355) personnel with SHRIKE missile (1968). 3. Instrumentation Systems personnel in action during HARPOON turbojet random vibration test (1974). 4. HARPOON GTV-3 launched from a P-3 aircraft against ex-USS INGERSOLL ship target (1973). 5. HARPOON vibration test using dual 310S shaker system. 6. HARPOON en route to impact on ex-USS WICKES ship target (1974). 7. Loading WALLEYE on JA-4F aircraft in Sea Level Climatic Chamber (1967). 8. WALLEYE undergoing testing inside anechoic chamber (1975). 9. Countermeasures electromagnetic radiation environment simulator (CERES). 10. A-3 aircraft on flight line at Point Mugu (1972). 11. WALLEYE prepared for ejection test at NMC (1966). 12. Testing WALLEYE seeker head in Temperature/Altitude/Humidity Chamber in Building 513, NMC. 13. A-7 Corsair aircraft launching an air-to-surface WALLEYE missile.


1

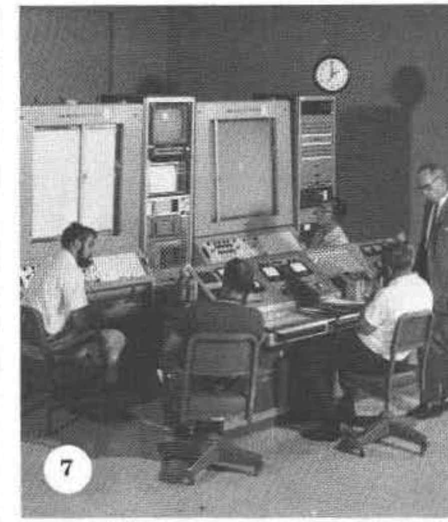

667
2


NAVY
3

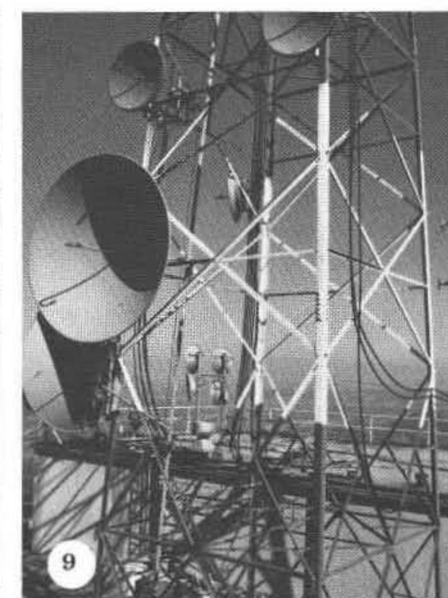

70
4

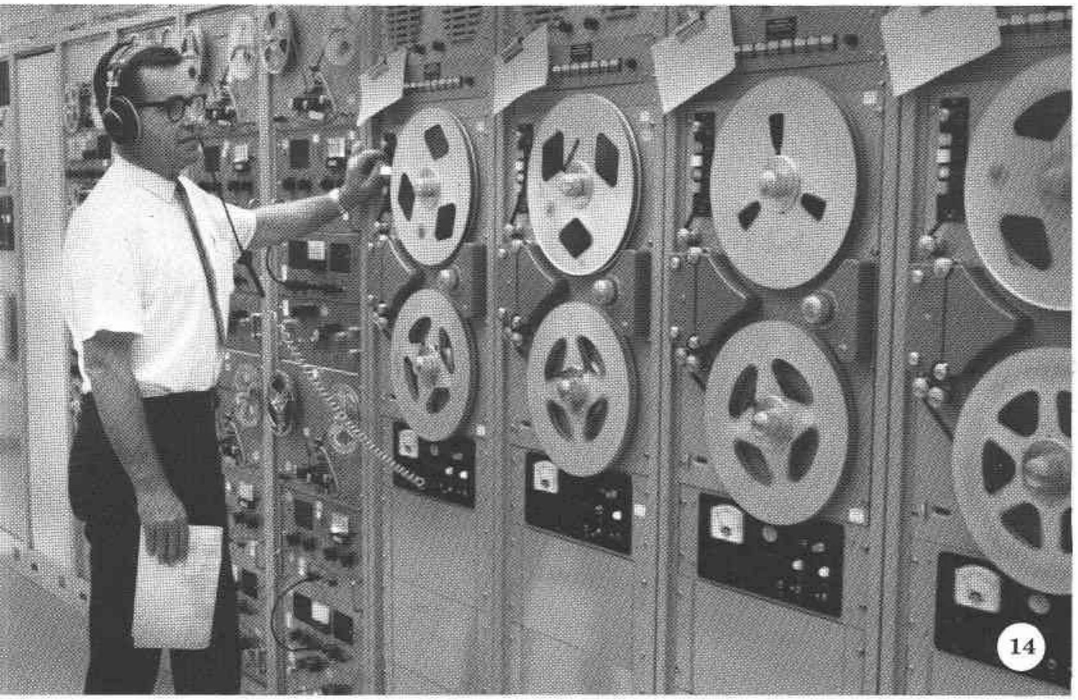

5


6

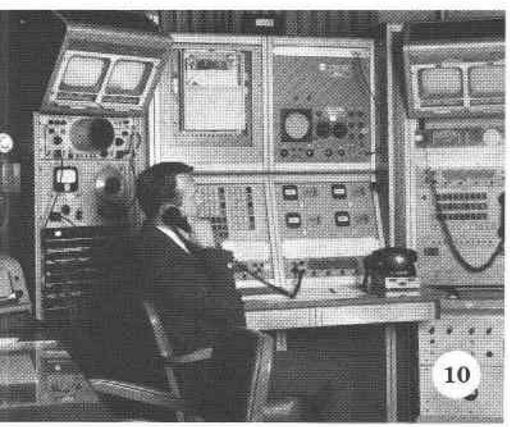

7

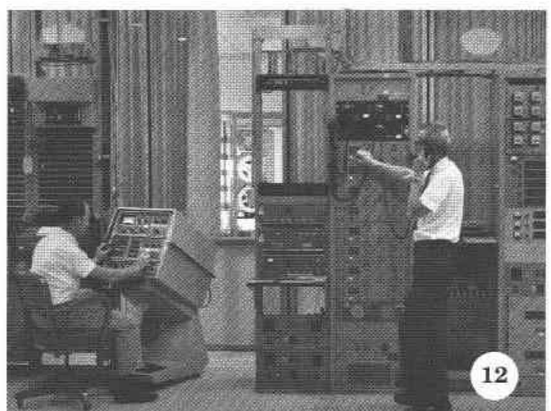

8

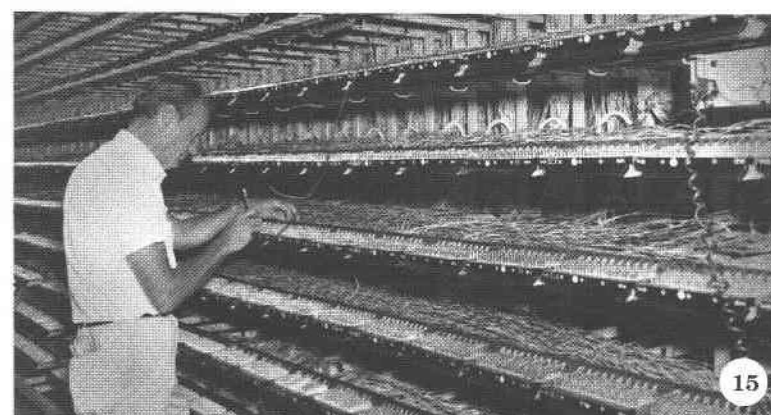

9

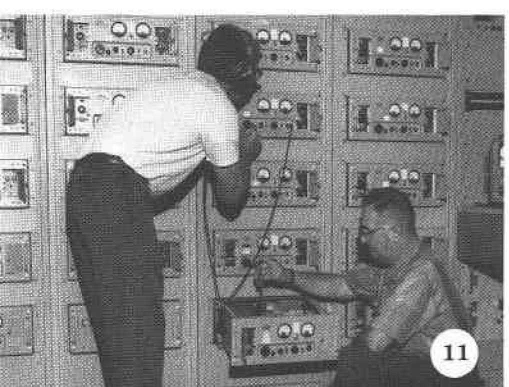

14

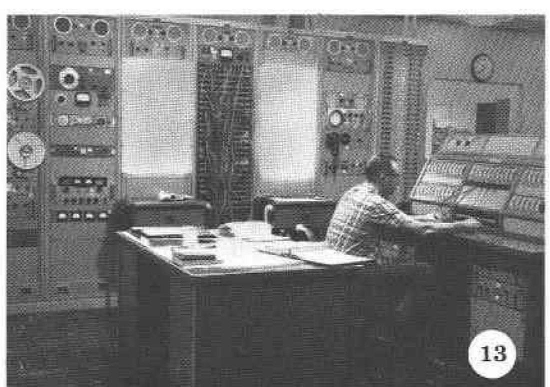
1. Early electronic warfare (EW) countermeasures lab. 2. Electronics personnel conducting preflight check of EW countermeasures equipment (1963). 3. Loading an EW countermeasures pod on an RA-3B aircraft (1966). 4. EW antenna isolation test (1972). 5. Early airborne radar test bench. 6. Flight test support personnel plotting data in tracking and control room, Building 53. 7. Tracking and control operation conductors in Building 53, Point Mugu (1966). 8. USNS WHEELING, a PMR instrumentation ship, underway in Santa Barbara Channel. 9. UHF antennas on Laguna Peak, Point Mugu. 10. Master Video Control Room, Building 53, for the Airborne Instrumentation Data Transmission System (1967). 11. UHF receivers in Range Communications receiver building, Point Mugu (1968). 12. Range Communications operational and long-line teletype carrier terminal with test board facilities, Building 531 (1968). 13. Range Communications Patch Board, Building 57 (1968). 14. Checking audio quality at the Master Recording Center, Point Mugu (1968). 15. Main communications distribution frame of the Range Communications Division (1968).


10


12


15


11


13

Environmental Simulation Laboratory hyper-altitude chamber, NMC (1964).

"Man's flight through life is sustained by the power of his knowledge."
—U.S. Air Force Academy

CHAPTER 15

THE INDOOR AND OUTDOOR RANGES

While the events taking place in air launch and weapon system testing were more conspicuous and sometimes spectacular, significant advances were also being made inside NMC laboratories. Through new techniques and facilities, the laboratories were developing realistic simulations for use on both the "indoor" and "outdoor" ranges. These evaluations not only allowed components and missiles but entire weapon systems to be subjected to nondestructive tests. The savings in time and money were obvious, and each year new capabilities were added to existing ones. Thus as weapons became more complex, the means of testing them kept pace. As part of testing more sophisticated weapons, the laboratories made increasing use of computer simulation to not only help analyze data, but to actually make the weapon system "think" it was in the real world.

ENVIRONMENTAL SIMULATION

A very significant area of laboratory testing developed during the 1960's was environmental simulation, which was designed to determine how a weapon system, missile, or component would react or perform under certain climatic and operating conditions. The most common variables were temperature, altitude, acceleration, and vibration, although tests could also be made to determine the effects of salt fog, humidity, and shock.

Increased use was made of tests that combined several variables, for example vibration and altitude. In every case the tests were part of a well-developed scenario which might start with component tests and culminate in testing the entire weapon system or even the aircraft that would launch the missile.

The environmental chambers that were installed could send the temperature to a frigid 100 degrees below zero or up to a searing 1,000 degrees. Altitudes ranging from sea level to 300 miles could be simulated and accelerations of up to 1,000 g's produced.

To answer specific questions, NMC even developed some unique environmental tests. For example, in 1968, flight tests showed that the BULLPUP missile had a voltage dropout. To find the cause, NMC engineers mounted the missile on a shaft turned by two air motors and then placed the entire apparatus on a centrifuge. With this test they were able to gather data while simulating the roll of the missile while it was also in simulated flight.

As mentioned in Chapter 7, NMC constructed a large sea level environmental chamber to permit men and equipment to be tested under a variety of climatic conditions. Not only could missiles and weapon systems be exposed to rain, snow, sleet, heat, and cold, but the entire fighter aircraft could be subjected to these elements while ordnance personnel loaded the weapons using the actual ground support equipment. For example, during the 1967 Bureau of Inspection and Survey (BIS) trials for the F-4J Phantom II, the SPARROW III missile was loaded aboard the aircraft during a simulated torrential downpour, similar to those it would experience in Southeast Asia. How well the men and gear functioned together under adverse conditions could affect the redesign of equipment or procedures.

The chamber was also used for non-weapon purposes when two prototype modules of the Air-Transportable, Self-Contained, Mobile Tactical Treatment Facility were exposed to high- and low-temperature environments. In these tests, the models underwent a simulated snow load test and expansion and contraction tests.

ANECHOIC CHAMBERS

In 1968, radar reflectivity studies at NMC were greatly enhanced by the completion of two large anechoic chambers. Anechoic means "echo-free," and an anechoic chamber is essentially a room lined with microwave absorbing material such that it simulates conditions in free space. Scale models or actual weapons, placed in the chamber, were illuminated with microwave energy. The return signals, free of extraneous reflections, were recorded and measured. The results were radar "signatures," or in other words, what the radar would "see." The signatures were used to identify enemy aircraft or missiles, to help make our own aircraft and weapons less vulnerable to hostile radars, and to assist in the designing of more realistic targets.

FUNCTIONAL TESTING

To greatly increase the quantity of data available for evaluating the performance of a weapon system in both a clean and ECM environment, NMC pioneered in developing functional laboratory tests. In specially designed and constructed "closed-loop" laboratory facilities, actual missile guidance systems were tested under carefully controlled conditions using a computer-controlled target, EW jamming signals, and computer programs.

The laboratory tests were often used as a basis for conducting flight tests, while the flight tests and launches provided data for developing new simulations in the functional laboratory. These "closed-loop" tests were particularly valuable in analyzing the effect of enemy ECM and in developing counter-countermeasures.

ELECTRO-OPTICAL

To test devices using the visible and infrared portions of the electro-magnetic spectrum, NMC developed specialized laboratories, ground facilities, and airborne equipment. The work included infrared measurement and system development, system evaluation, and performance analysis.

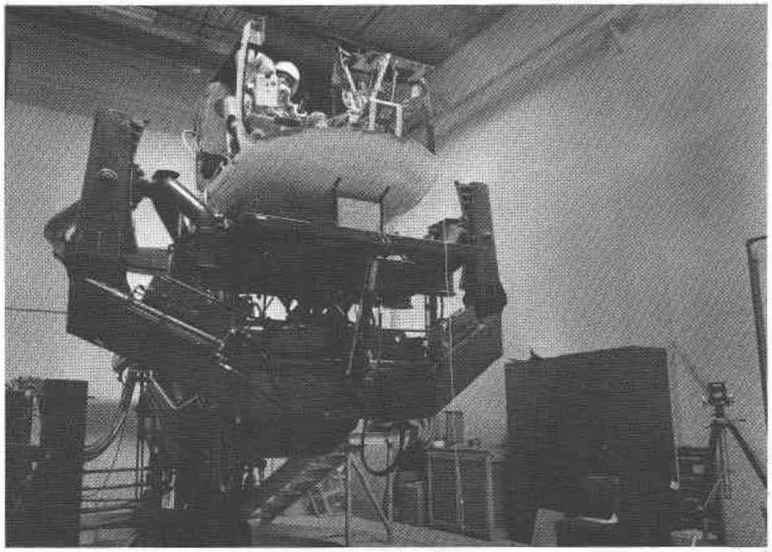
One very important part of the NMC effort was to make measurements of the infrared radiation from aircraft on the ground and in the air, and rocket-powered missiles being launched from the ground or air. NMC also did very early work on laser systems to be used as target designators or range finders. The reverse of this was the development evaluation of detection systems to warn an aircrew that they were the target of enemy lasers.

To supplement laboratory tests and flight tests, NMC and PMR developed a unique laser facility on San Nicolas Island. This 13,000-foot range provided a natural salt fog environment that was particularly useful in evaluation of Navy electro-optical equipment. Also, tests were made from the 1,400-foot level of Laguna Peak on aircraft traversing the range.

HUMAN FACTORS

During the 1960's and early 1970's, NMC performed a considerable amount of human factors work tied to the need to determine the relationship between man and weapon system. The Center conducted such evaluations as the "Human Factors Analysis and Simulation of Display Parameters for Electro-Optical Guided Systems." This was a reconnaissance transparency projection system that simulated WALLEYE and the terminal CONDOR camera scenes.

In 1970, a three-dimensional terrain model and gantry were constructed to simulate low-flying aircraft and air-to-surface missile flight. Using a modular approach, the model could be rearranged into different terrain configurations to ensure that an observer would not "learn" the lay of the land. The gantry system contained all six-degrees-of-freedom of aircraft flight, and it was designed to permit installation of actual missile system optical components. Speeds up to 1,000 knots and altitudes up to 40,000 feet could be flown by a pilot in a remote cockpit. The model was also used to investigate low-altitude stereoscopic systems and factors affecting ground target detection by airborne electro-optical systems.



Human Factors Engineering lab with 3-axis platform simulator.

PDAS

Another rather unique optical laboratory device, adapted and further developed by NMC in the 1969-1970 time period, was the Photo Data Analysis System (PDAS), used to determine the range and aspect of a missile or aircraft from an observer. The system used a television camera and scale model plus actual film footage. The television image of the model was compared with the film image and the model positioned until the two images matched. The relationship of the model to the observer could then be measured, revealing the actual relationship of the aircraft or missile to the observer. In the following years, PDAS was adapted and used extensively to gather stores separation (launch) data.

SITS

With the cancellation of the F-111B aircraft in 1969, an LIS Task Force was formed to design, develop, and install an extremely sophisticated facility for the integrated test and evaluation of the F-14/PHOENIX weapon system. Eventually designated SITS, the laboratory would operate alongside the PHOENIX AIM-54A LIS, sharing the same operating equipment. (See Chapter 13 for details of SITS.)

SOFTWARE

During the late 1960's and early 1970's, a rapid expansion of the NMC role in weapon system software (computer programs) development and management began. In 1972, the Center was designated the system software activity for the F-14A weapon system and the HARPOON weapon system. Also, the Center was requested to make a study of S-3A aircraft software and recommendations for subsequent software management.

PHOTO-OPTICAL INSTRUMENTATION

A milestone event in photo-optical instrumentation at PMR/NMC occurred during 1965 with the design and development of the AFH-14 supersonic aircraft camera pod. The pod, attached on the center line of the photo chase airplane, had a forward-looking camera station and multiple side-looking stations. It could carry a 70mm sequential camera, 35mm and 16mm high-speed instrumentation cameras, and a television camera. An IRIG timing receiver and television transmitter were also included. Power was supplied by an aft-mounted, airscrew-driven alternator. The pilot's view finder was an in-cockpit optical/mechanical device or a miniature television monitor. The AFH-14 camera pod found extensive use in photographic surveillance of aircraft, missile launches, flights, and intercepts. It was also used on other ranges.

Another major step in optical instrumentation was the use of high-speed 16mm cameras with 180-degree-coverage lenses on SEPTAR's and target ship hulks. The cameras were installed on the targets so that they would record the missile impact or miss, no matter from what quandrant the missile approached. However, the lens provided a "fish-eye" or non-linear field which was very difficult to use for data reduction until the advent of the Photo Data Analysis System (PDAS). Inasmuch as PDAS used the same super wide-angle lens, the distortion was cancelled and the data made usable. The end result of combining the two optical systems was accurate data on the roll, pitch, yaw, velocity, and angle of impact or closest approach of the missile.

A major improvement to the on-board camera system was the development by PMR/NMC of a flotation pod system. Prior to this, DBM-4 cameras were mounted on pedestals aboard ship, but not provided with either environmental protection or a recovery system.

The flotation pod system consisted of a camera enclosure, a stanchion for mounting and aligning the camera, and a styrofoam flotation jacket. There were two different models:

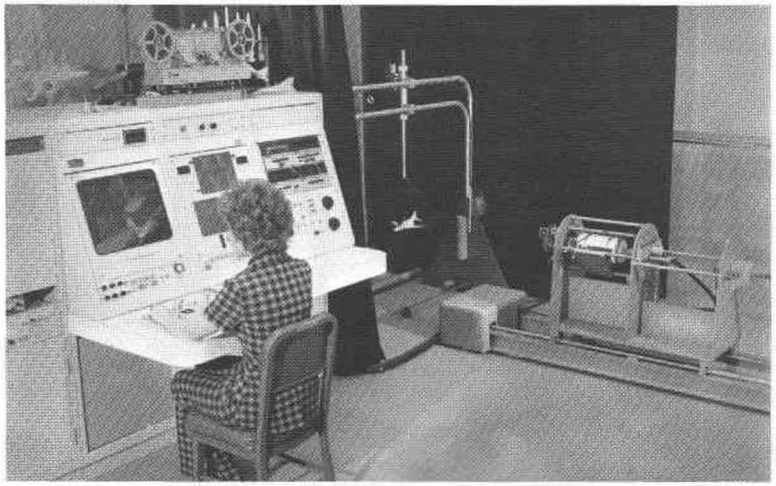


Photo Data Analysis System (PDAS) optical device (1970).

M-2 and M-4. The M-4 was larger than the M-2 and added a strobe light and radio beacon to aid in locating the pod after it was separated from the target. In addition to the airtight enclosure, the system had internal batteries; a heat, salt water, and mechanical release mechanism; a quick access hatch; and an ejectable spray shield window.

The camera pod was used on several ranges and provided protection against explosions, shrapnel, fire, and salt water. It survived immersion in the sea with little or no damage to the camera or film.

TELEMETRY

During 1964, PMR acquired the TAA-2 eighty-five-foot parabolic dish antenna. It was first modified to receive the satellite television signals of the Olympics in Japan and then reconfigured to track experimental satellites including those involving the monkey in space program.

In August 1967, a big change took place in telemetry at PMR when the auto-tracking thirty-foot parabolic dish antennas were placed in use. They replaced the trainable quad-helical antennas.

Because of international agreements concerning the use of the radio frequency spectrum, this era saw a mandated change of telemetry systems from the very-high-frequency (VHF) regime to the ultra-high-frequency (UHF) regime. This was a tremendous technical and economic undertaking for all weapon systems and ranges. However, on the positive side, the new higher frequencies permitted a much greater magnitude of data transmission due to the increased bandwidth. PMR had the distinction of being the first national or service range to be fully converted to the new telemetry system.

METRIC TRACKING RADAR/POSITION LOCATION

During the 1966 to 1969 time period, PMR acquired six new AN/FPQ-10 instrumentation radars to replace the MPS-26 systems. They were installed at Point Mugu, San Nicolas Island, and on Makaha Ridge at PMRF. Unique features of the FPQ-10 were the extensive use of solid state circuitry and a torque drive pedestal.

TIMING

In 1968, the HP 5060A cesium beam frequency standard was introduced on the range as the primary timing standard. Accuracy was improved to ±5 microseconds or less. A later

Telemetry Building under construction at Point Mugu (1967).

model, HP 5061A, was acquired in 1971, and in conjunction with the Loran C receiver further improved accuracy to ± 5 nanoseconds (five one-billionths of a second).

FREQUENCY MONITORING

In 1967, the Military Communications-Electronics Board (MCEB) expanded the Area Frequency Coordination (AFC) system and the Commander, PMR, was assigned the responsibility of Western Area Frequency Coordinator (WAFC). The function of the WAFC was to coordinate the use of frequencies of all military activities and contractors in the area of California south of latitude 37° 30′ north.

Later, in 1970, the Frequency Management Division was assigned the responsibility as a Federal Government Field Level Frequency Coordinator for the 1435-1535 megahertz telemetry spectrum in Southern California.

RANGE SCHEDULING

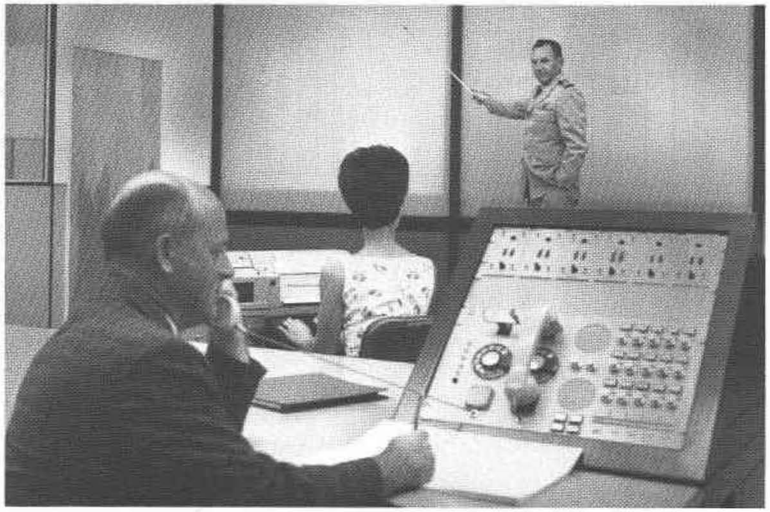
Another upgrade in the scheduling function occurred in 1968 with the implementation of the Range Operations Control System (ROCS). Utilizing a computer entirely dedicated to the scheduling function, a data base was constructed containing over 1,500 resource plans and providing a printout of the schedule with all associated resources. Punched cards were used for the forecast and data base, and a cathode ray tube display was used for daily changes to the schedule as well as for historical resumes.

PHALANX SUPPORT

In December of 1970, PMR's Range Development Department was assigned the task of developing facilities on San Nicolas Island for support of the Navy's brand-new PHALANX "Gatling Gun" Close-In Weapon Support System (CIWS). The system was designed to provide primarily shipboard point defense against incoming missile threats at low altitude and close range. An advanced radar would provide arming and fire control.

It was deemed by the Naval Ordnance Systems Command that it would be more efficient and economical to test PHALANX on land instead of at sea, especially if a machine could be found to simulate ship's motion. After a thorough search, no suitable ship's motion simulator could be located that would accommodate all the weights and forces exerted by the PHALANX CIWS during firing.

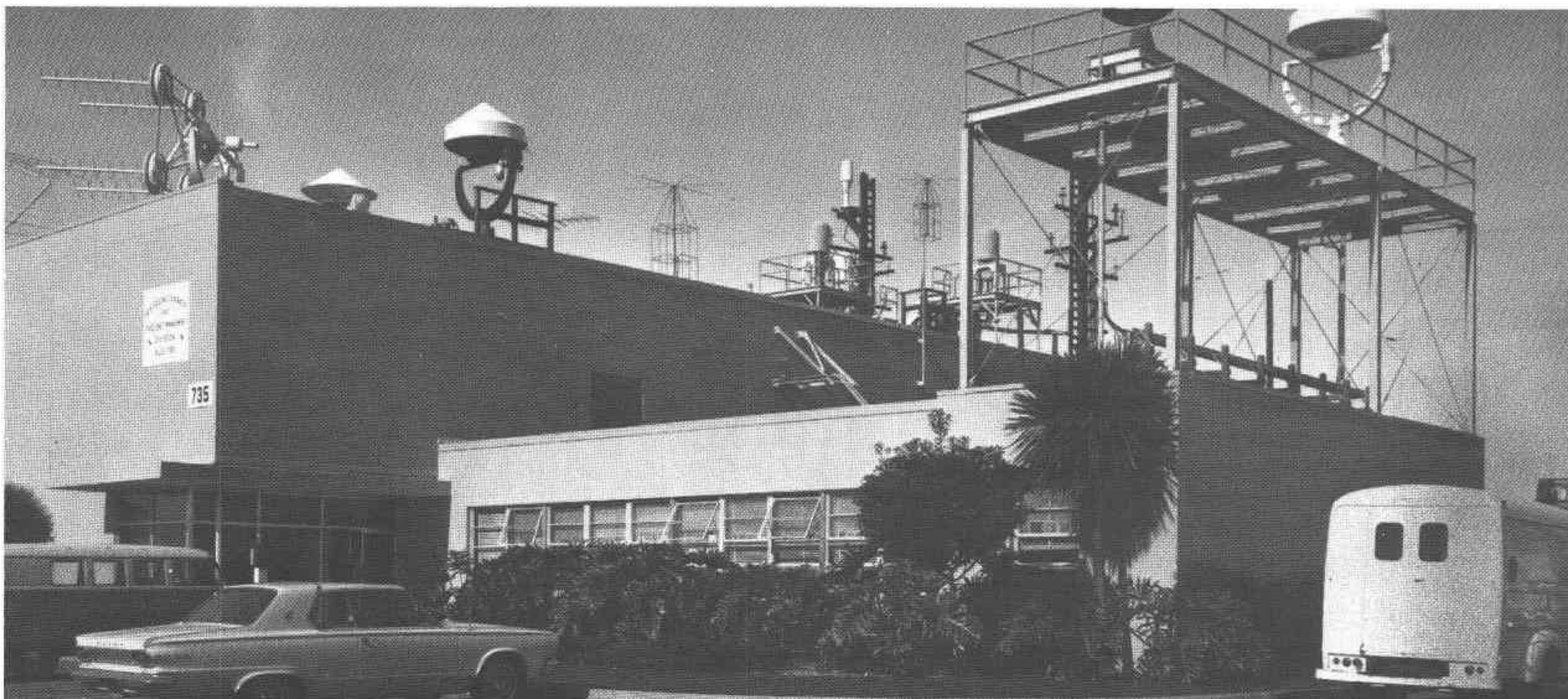
Therefore it was agreed that PMR would design and build the simulator. Having made this decision, it was then



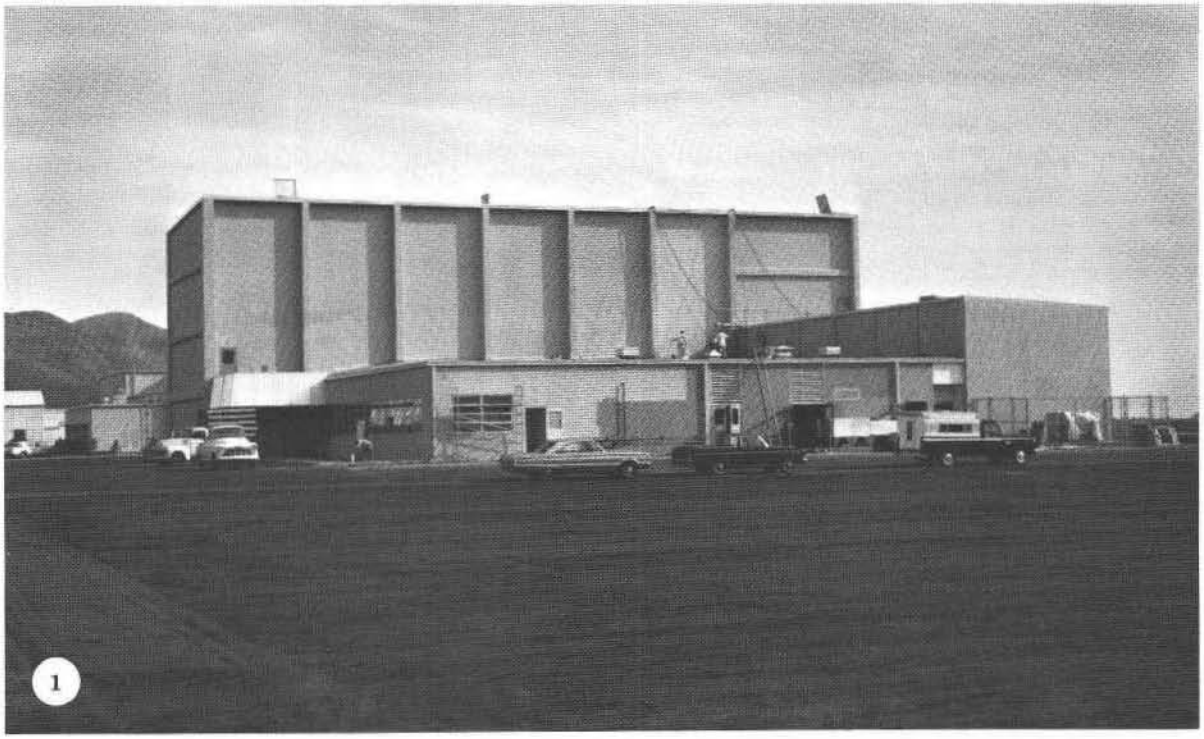
PMR range scheduling operational control center.

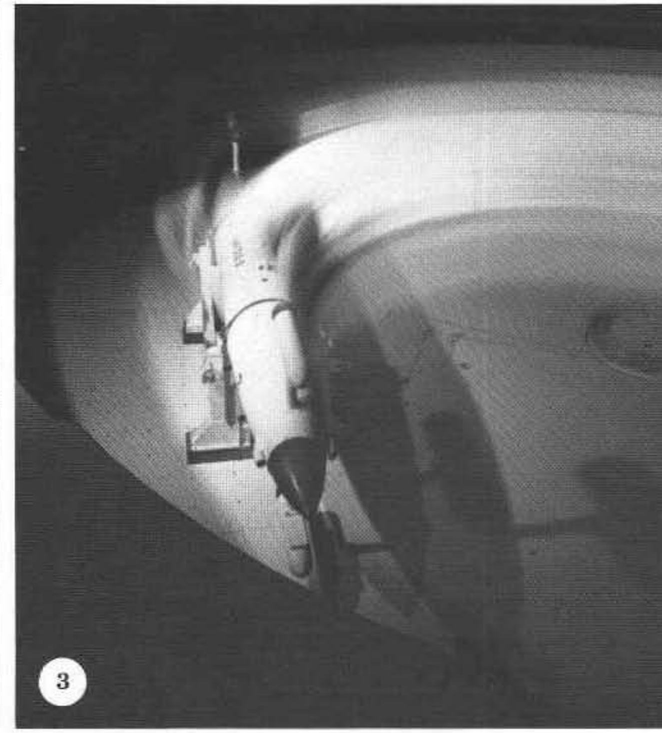
possible to finalize specifications for the blockhouse which would house all control equipment. The simulator was designed to provide an excursion of 30° in ship's roll with a variable period of 6-16 seconds, and an excursion of 8° in the pitch mode with a variable period of 6-9 seconds. These motions would simulate conditions of a Sea State 5 for vessels such as an LST.

The blockhouse was completed in the fall of 1971, and the simulator was completed, installed, and tested that winter. The PHALANX system was mounted on the simulator, control equipment was installed, and testing was begun in early 1972. Progress was so brisk that the contractor was able to conduct a successful live-firing against a PMTC-developed towed aerial target at San Nicolas Island in June 1972.



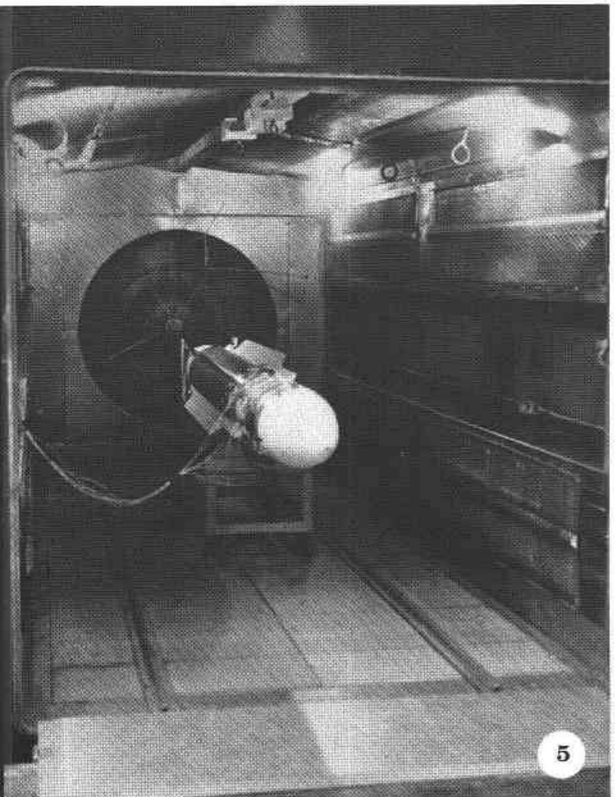
Frequency Interference Control Center, Point Mugu (1966).

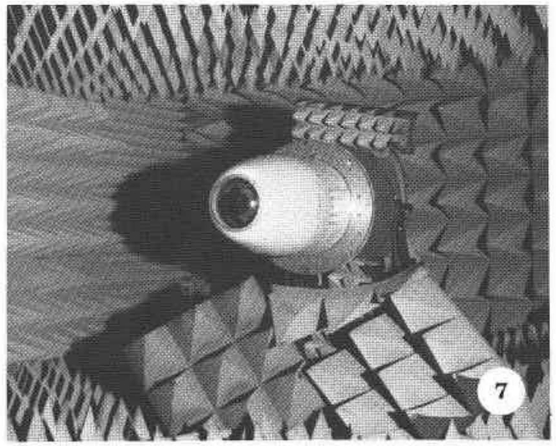

1

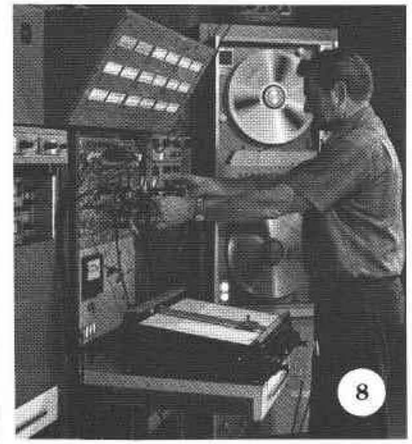

3

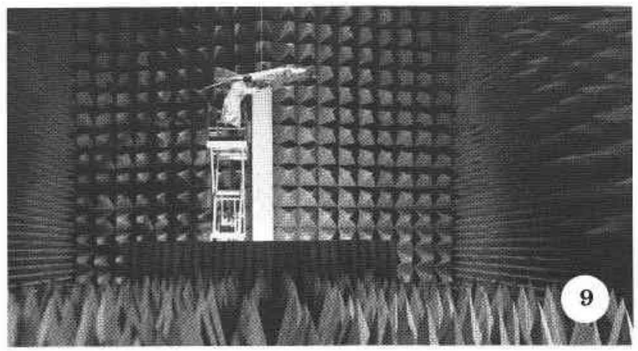

2

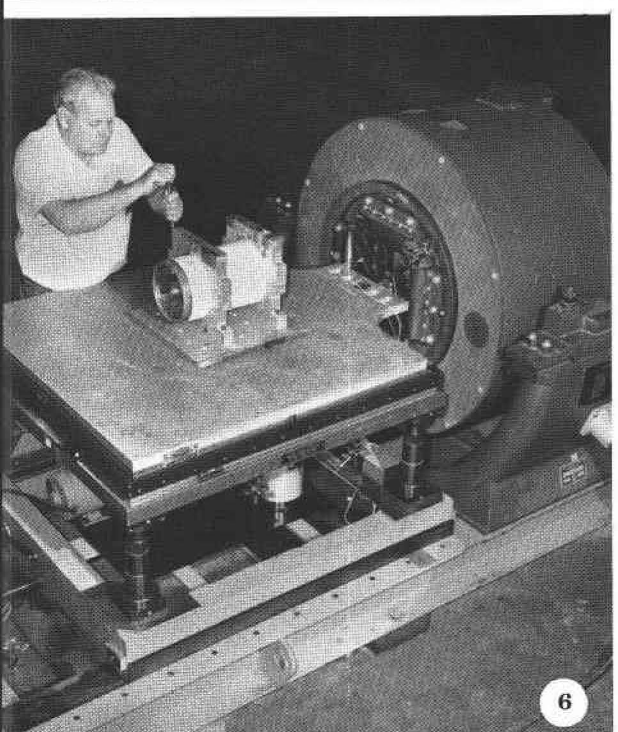

4



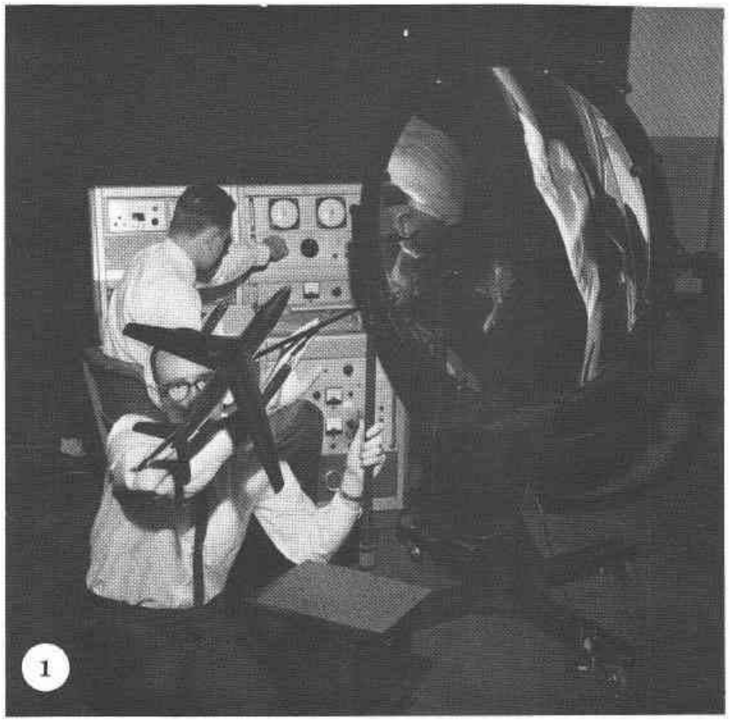




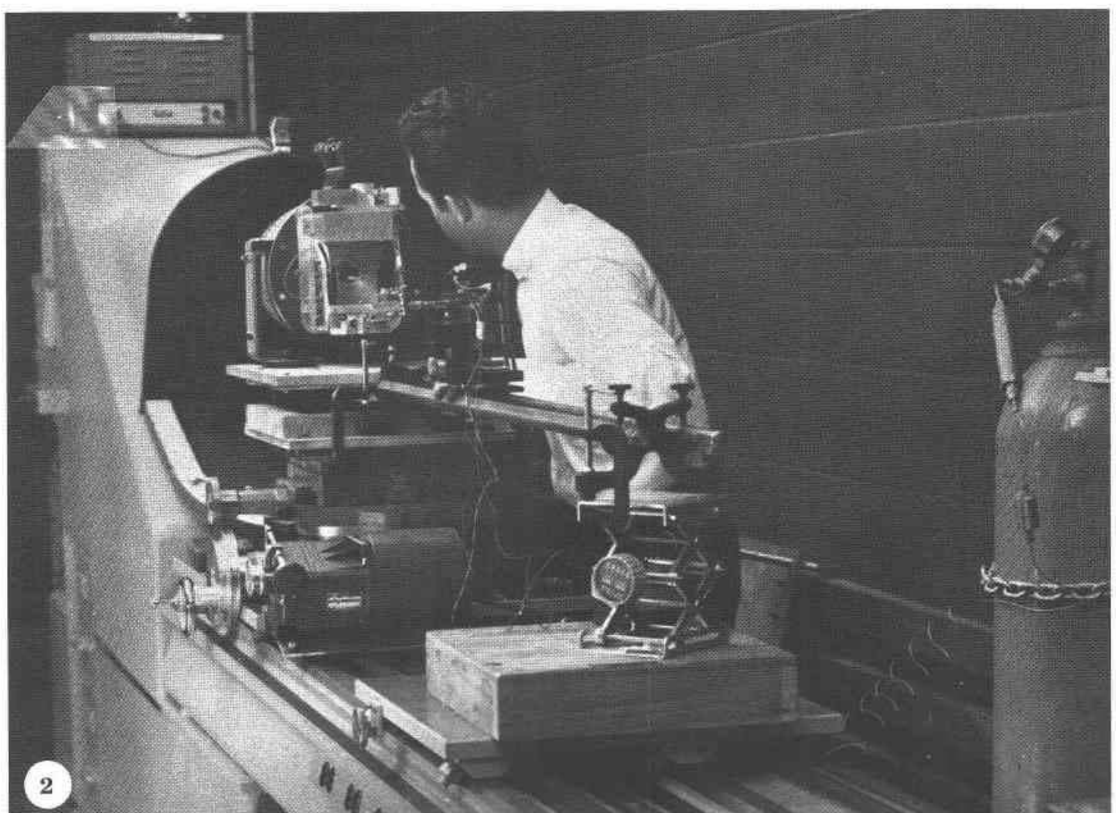




1. Radar Measurement Facility (Building 509) under construction at NMC (1966). 2. F-8 aircraft in Sea Level Climatic Chamber simulating arctic conditions (1968). 3. DLQ-3 countermeasures pod on Acceleration Tester. 4. STANDARD ARM missile and ejector launcher undergoing vibration testing (1967). 5. Environmental Lab test chamber with STANDARD ARM missile during condensation test (1967). 6. Technician installing component on vibration table in Environmental Lab (1967). 7. WALLEYE seeker in anechoic chamber (1975). 8. Anechoic chamber median plotter that provides data reduction readout (1970). 9. F-4 aircraft model in anechoic chamber for radar cross-section measurement (1970). 10. Closed-Loop Simulator located in the Tactical Environment Simulation Laboratory.

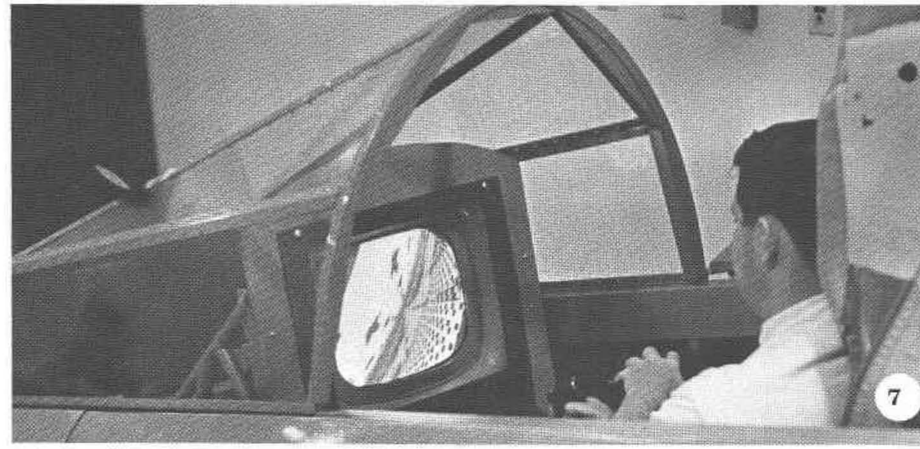

1

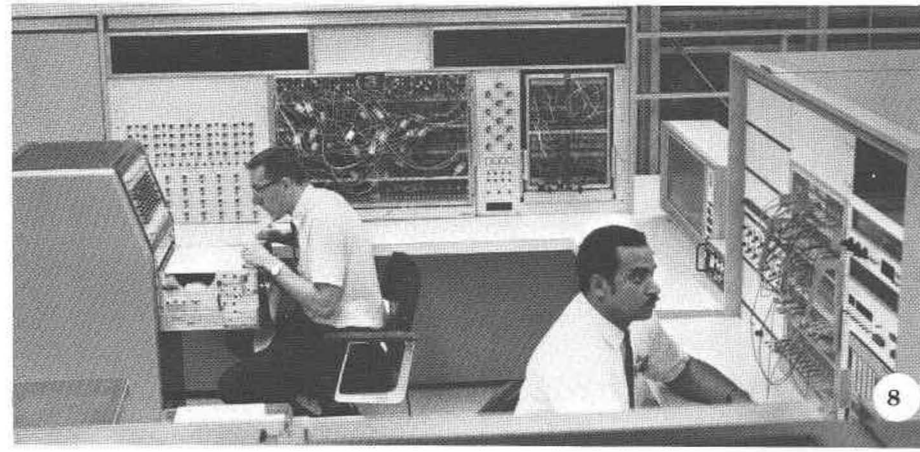

3

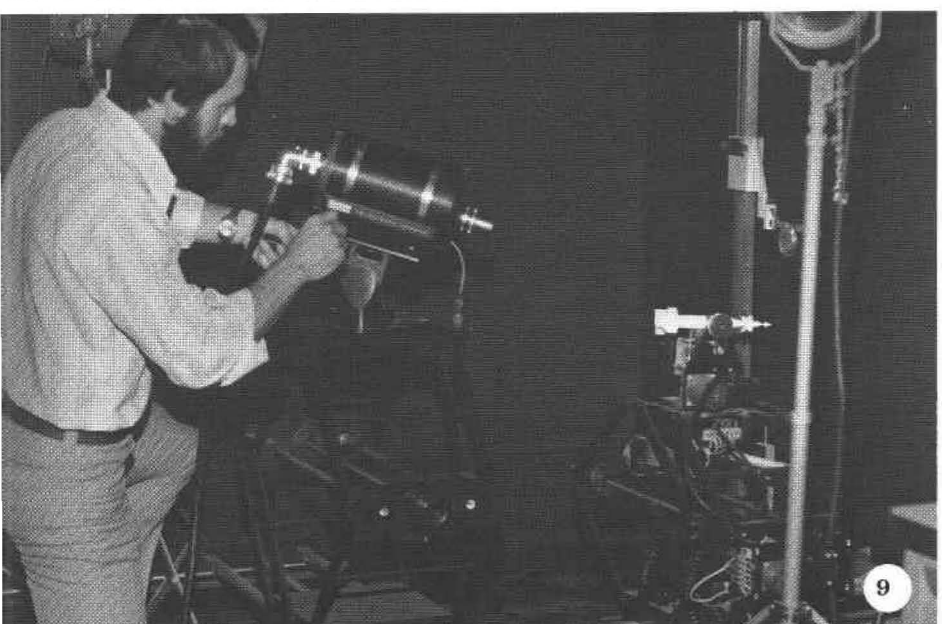

2


4


5

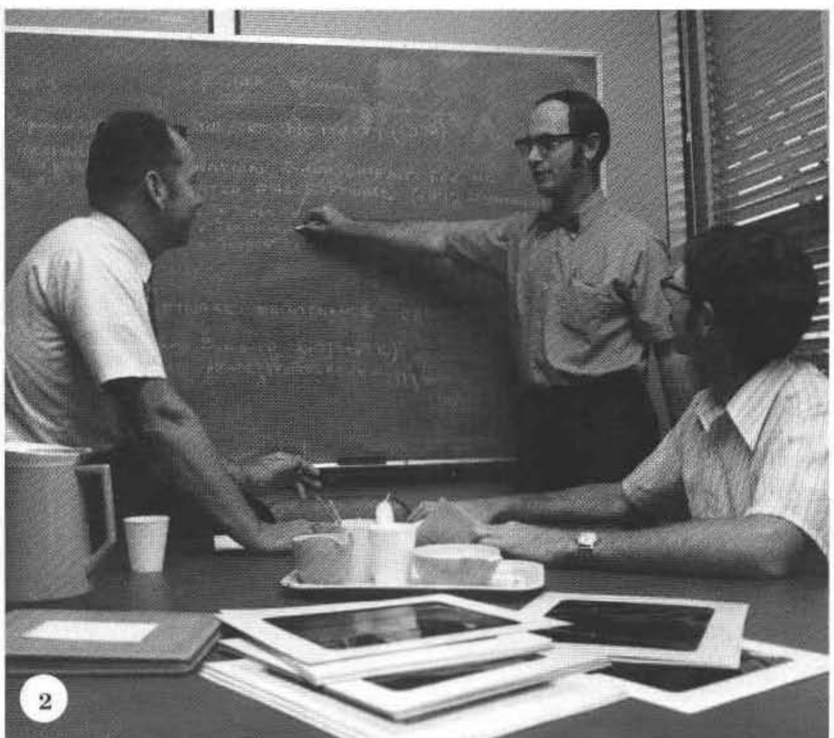




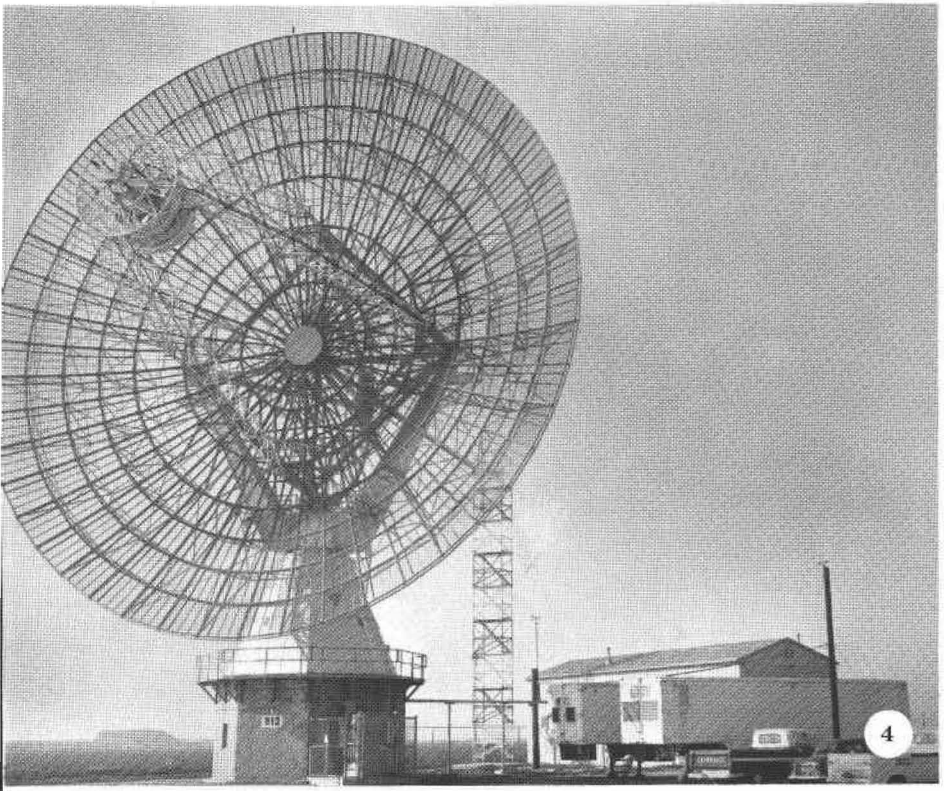


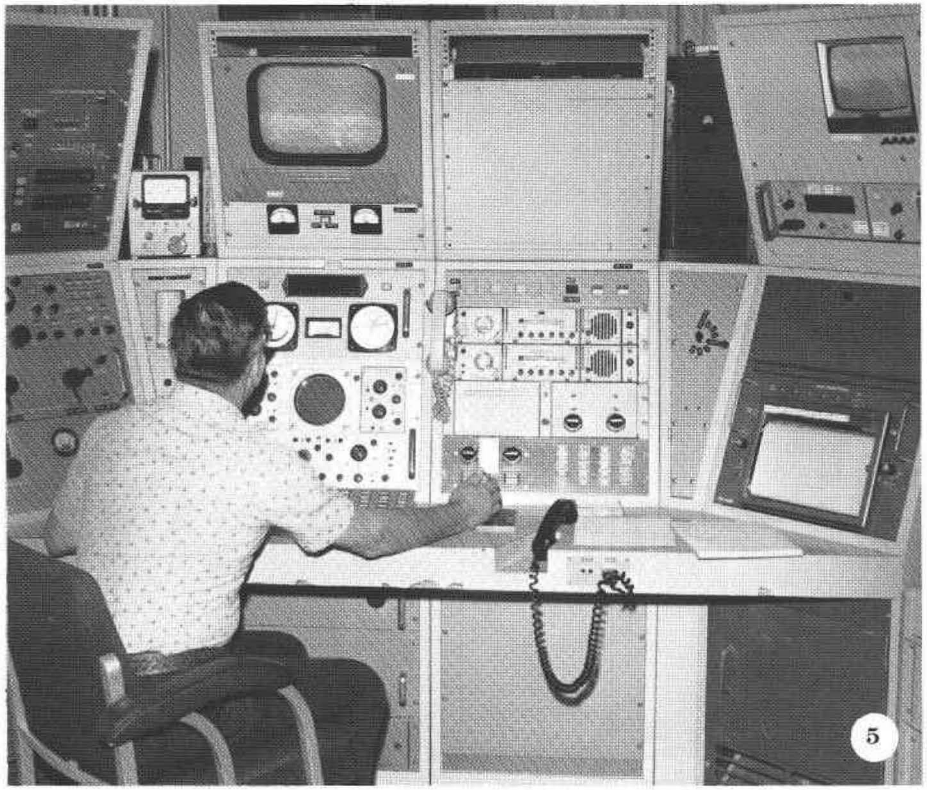
1. Setting up aircraft model for Optical Simulation (1965). 2. Davidson 16-inch collimator used for alignment and calibration of infrared systems (1968). 3. System Development Branch personnel taking measurements of laser radiation backscatter (1968). 4. Terrain simulation gantry system used to simulate low-flying aircraft and missile flights (1971). 5. Studying eye movement patterns during visual search (1964). 6. Subject's viewing station at the Target Presentation and Response Apparatus (1971). 7. Remote cockpit where speeds to 1,000 knots and altitudes to 40,000 feet were simulated. 8. Human Factors Engineering Laboratory instrumentation. 9. Photo Data Analysis personnel using television and scale models to refine miss-distance accuracy.

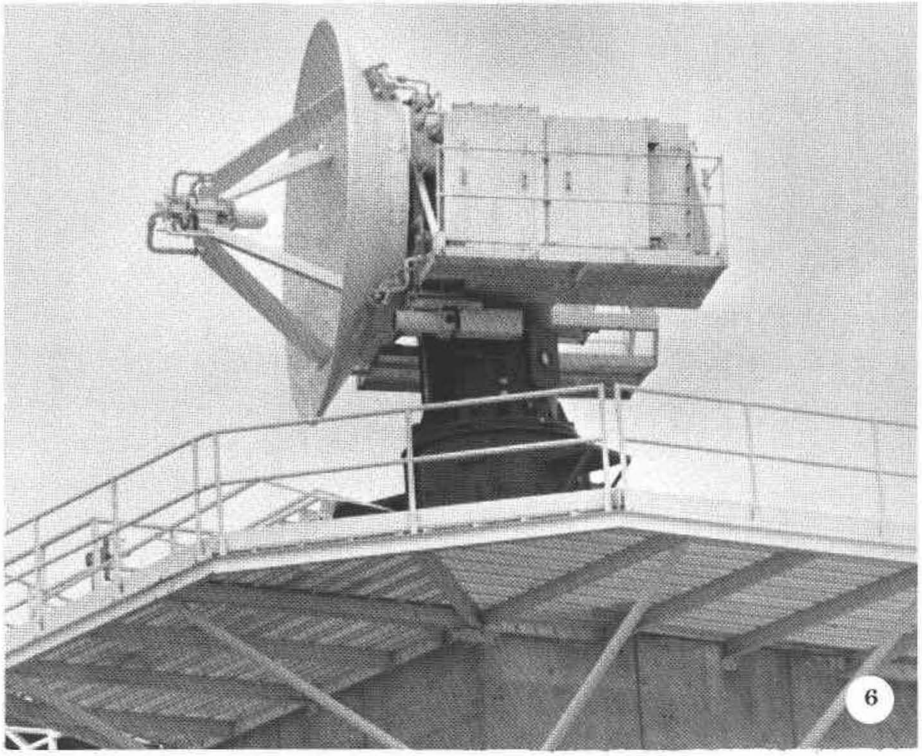

1


2


3







1. First SITS lab where entire F-14A/PHOENIX flight operation was "flown" in the laboratory. 2. Engineers from the Laboratory Department devising F-14A software management plans (1972). 3. AFH-15A camera pod installed on A-4C aircraft. 4. TAA-2 eighty-five-foot parabolic dish antenna on top of Laguna Peak used to track experimental satellites (1967). 5. Control console, for the AN/FPQ-10 radar, in Point Mugu Range Operations Building (1976). 6. One of six AN/FPQ-10 radars acquired by PMR (1966 to 1969).

Ballasting the HYDRA-SEABEE vehicle, a sea-launched rocket (1961).

"Science is vastly more stimulating to the imagination than are the classics."

—J.B.D. Haldane

CHAPTER 16

RESEARCH

As national space and missile efforts expanded, tasks and requirements at Point Mugu became more extensive and complex. In 1959, NMC redesignated its Test and Evaluation Directorate as the Missile and Astronautics Directorate and established within this framework two new organizations, the Astronautics Department and the Life Science Department. Both departments were staffed by highly qualified military and civilian professionals offering a broad spectrum of talents in engineering, electronics, physics, and aerospace medicine. These high-level groups, utilizing both the existing NMC/PMR facilities and the talents and facilities of other organizations, performed investigative and experimental research on a wide variety of Navy and national-interest projects.

HYDRA

One of the first efforts undertaken by the Space Research Division of the new Astronautics Department was a study of the comparative merits of methods for launching satellite and high-altitude probe vehicles at sea. This study led to the concept of launching rocket vehicles from bodies of water and was designated Project HYDRA.

HYDRA used a floating launch technique. A unit composed of a rocket vehicle and its necessary launching equipment was floated in a vertical position like a spar buoy with its nose slightly above the waterline. When fired, the rocket exhausted its gases directly into the water with the ocean acting as the launch pad.

Early HYDRA research concentrated on such basic areas as underwater rocket motor ignition and then moved on to launching simple wooden test vehicles. The first wooden rocket vehicle (HYDRA I) was 5 feet long, weighed 150 pounds, and was propelled by a 2.75-inch rocket motor. As experimentation continued, longer and heavier wooden test vehicles were sent aloft.

One unique test vehicle consisted of a 105-foot-long telephone pole weighing 11,000 pounds that was sea-launched using the MD-1 GENIE AAM rocket motor for propulsion. Such crude beginnings helped prove the viability of the concept and provided the impetus for additional research and development efforts.

From the start of the HYDRA program, considerable effort was directed toward maintaining and improving the hydrodynamic stability of a floating rocket in rather heavy sea states. In addition to the instrumented launch tests, model tests were conducted in the wave motion tank at the Naval Civil Engineering Laboratory, Port Hueneme, to study the ability of various rocket designs to maintain the vertical launch attitude. As later experience would prove, good hydrodynamic stability could be designed into the system so that rockets would leave the water close to the vertical attitude.

During the 1960's, several HYDRA launching equipment designs were investigated using various rocket propulsion systems and payloads. One of the first devices was little more than a metal tube with a frangible cover. Buoyancy was obtained by leaving some airspace at the top of the tube above the rocket's payload. This tube method of sea-launch was used for more than 15 firings of HYDRA 1A, an 8-foot-long wooden rocket vehicle weighing 350 pounds.

While launching from a tube seemed well adapted to small rockets, the Bureau of Naval Weapons viewed the HYDRA project as a promising concept applicable to future Navy astronautics missions such as vertical probes to collect data at high altitudes. Such missions would require larger rockets and suitable launching equipment. Likewise, there were proposals under study that suggested using the HYDRA concept for sea launching large strategic ballistic missiles.

With an eye toward the future of heavier vehicles, a small step forward was made in September 1960 when HYDRA II was fired for the first time. Larger and heavier than its predecessors, it was a steel vehicle about 44 feet long, 42 inches in diameter, and weighing about 10 tons in firing condition. From a spot in the ocean just off the Point Mugu beach, an aircraft-type booster rocket furnishing 36,000 pounds of thrust for two seconds successfully launched HYDRA II into free flight, reaching an apogee of approximately 120 feet.

One of the most significant research efforts under Project HYDRA involved the design, construction, and analysis of a large, 37,000-pound, unguided probe vehicle designated HYDRA IV. It utilized a reject AEROJET SENIOR motor obtained from NASA, had a steel conical nose cone, steel fins, and a flared skirt. With its extensive instrumentation, including a variety of sensors, telemetry transmitter, radar beacon, and command receiver, it was intended to act as a basic test bed for water launch investigations.

HYDRA IV was transported aboard the USS POINT DEFIANCE (LSD-31) to its scheduled launch point, 120 degrees west, 0 degrees north, in June 1961. While the feasibility of handling such a large rocket vehicle using simple shipboard equipment was adequately demonstrated, the planned test firing was not completed due to failure of the forward flotation gear which caused the vehicle to assume an inverted attitude. Salvage being impractical, the aft flotation tank was deliberately ruptured, permitting HYDRA IV to sink in 2,300 fathoms of water.

Although HYDRA IV went to the briny deep, the lessons learned were applied in perfecting techniques for a variety of successful sea launches. Rockets developed for land launching were found to be adaptable to sea launching using strongback assistance. This technique utilized a metal framework which was floated by buoyant chambers at its nose and which supported the rocket before and, in some cases, during firing.

The ARCAS meteorological sounding rocket and the POGO-HI target rocket were both adapted to the marine environment and successfully launched from the Pacific Ocean. These adaptations were appropriately named by adding the "HYDRA" prefix to the name of the rocket, such as HYDRA-ARCAS and HYDRA/POGO-HI.

The bare-rocket sea-launch method was also successfully investigated. This technique, adaptable to rockets of practically any size, used a rocket which was unsupported along its length and which floated vertically in the water. Flotation was provided either by the natural buoyancy of the rocket or with flotation compartments, usually in four quadrants, which were attached to the nose so that they were automatically jettisoned upon rocket firing. HYDRA-SEABEE, which used a modified AEROBEE 100 sounding rocket, was launched as a bare-rocket twice in 1961. The vehicle was recovered and refurbished to demonstrate the feasibility of reusing liquid rockets.

Several technical studies were completed, including a concept proposing the use of a submarine capable of navigating under the ice pack to launch the X-17 sounding rocket in polar regions (HYDRA-SHARK). One study resulted in development of the first full-term, multi-stage launch vehicle, HYDRA-IRIS. The design goal of the HYDRA-IRIS system was to loft a 100-pound payload to an altitude of 175 nautical miles when launched from a floating rail launcher.

The HYDRA-IRIS vehicle had a modified Atlantic Research Corporation (ARC) IRIS sustainer motor, a booster assembly containing three SPARROW rocket motors and a common ignition system, both designed by NMC, and a standard IRIS nose cone assembly that was watertight. The launcher was basically a truss structure, triangular in cross section, with three launch rails inside that protruded through a cylindrical flotation cell. Electronics included a remote command control canister and a launcher motion sensor with a coincident firing circuit to assure vertical alignment of the launcher at firing.

Successful development of the HYDRA-IRIS system led to a joint Atomic Energy Commission and Navy series of flights conducted at several points in the Pacific and Atlantic. The HYDRA-IRIS launch vehicles carried X-ray astronomy payloads designed and built by the Laurence-Livermore Radiation Laboratory. By June 1968, eight launches had been made with complete success. But as satellite delivery systems became more sophisticated, the need for high-altitude probes diminished. The last HYDRA launches supported by NMC/PMR were in the early 1970's, using an improved vehicle (HYDRA-SANDHAWK) and a floating rail launcher.

The Navy's HYDRA launch concept, born at Point Mugu, is still not a dead issue. As recently as 1980, the idea of sea-launched ICBM's was reconsidered in government circles as a possible alternative to MX horizontal shelter basing. The former HYDRA Project Manager, Captain John E. Draim (USN Ret.), told Congress:

> *"These same missiles could easily be transported and deployed by a number of platforms such as surface ships or by merely rolling or sliding the missile into the water from a barge or pier. These methods could be done with a high degree of deception and concealment. They were all demonstrated by the U.S. Navy at Point Mugu during the early 1960's."*

MARINE BIOLOGY

Also during the 1960's, a rather unique marine biology research program with dolphins was conducted at Point Mugu. Although this program was under the direction of the Naval Ordnance Test Station (NOTS), China Lake, California, the project was supported with complete cooperation from NMC's Life Science Department as well as other Point Mugu organizations.

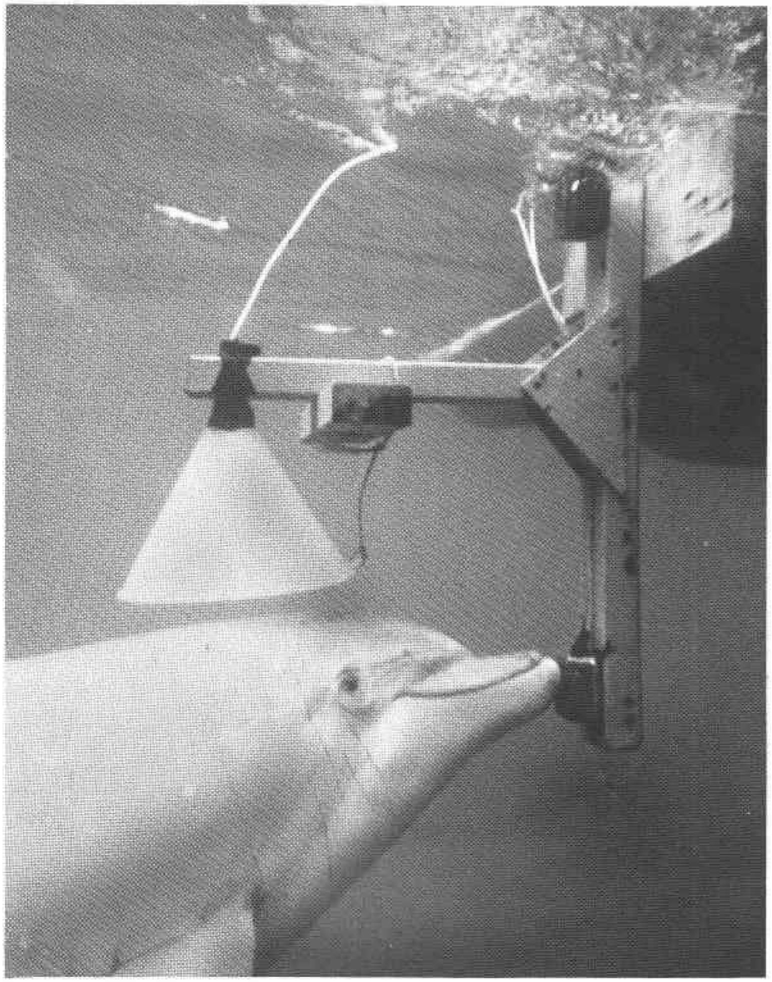
On a narrow strip of beach between the ocean and Mugu Lagoon, an aquatic test facility was constructed and equipped to meet all the test conditions the program scientists needed for their experiments. In addition to filtered seawater pools and tanks for the dolphins' living quarters, a comprehensive array of high-frequency sonar equipment, hydrophones, speakers, and recorders were installed. Staffing the facility was an impressive research team that included marine zoologists, trainers, veterinarians, and sonar experts.

There were many reasons why the Navy was studying dolphins and other marine mammals, such as Orcas (killer whales), seals, and sea lions. Dolphins were known to be friendly, intelligent animals that might assist in underwater operations if given proper training. These creatures could do many things extremely well, including an ability to dive to great depths with no visible ill effects, but it was the dolphin's remarkable sonar and directional hearing capabilities that were of prime interest. In studying the dolphin's physiology, the scientists would be looking for ideas that might be applicable to Navy sonar equipment.

At times, as many as a dozen dolphins were kept at the facility, each active in some part of the research program. They enjoyed comfortable living conditions, were fed 15 to 20 pounds of fresh fish daily, and got their vitamins and the very best of medical care. In fact, all the dolphins received weekly physical examinations.

This close medical watch saved the life of one female which had developed a case of seriously infected ovaries, a condition that would have been fatal to a wild dolphin. But Dr. Sam Ridgway, program research veterinarian, using an anesthetic procedure he perfected, was able to perform a hysterectomy on the sick dolphin—the first successful major surgery in history on a marine mammal.

One of the early program objectives was to learn if dolphins could be controlled in the open sea where, if they chose, they could just swim off and never return. After months of work with a 270-pound bottlenose dolphin named Tuffy, the scientists turned him loose in the sea and held their breath. But when they sounded the "return to the trainer" signal, he



"Tuffy" the bottlenose dolphin pressing a buzzer button.

came back to the boat in a flash. This marked a critical milestone in the program, for it meant that man would be able to control and work with the dolphin in his natural environment, the sea, and not just in a tank.

When the need arose to quickly train a dolphin to work with aquanauts who would live under the sea for 30 days in the Sea Lab II experiment, the immediate choice for the job was Tuffy. He had been learning new tasks in as little as ten minutes, and he adjusted easily to new situations. Tuffy's performance was superb. While the aquanauts were living 200 feet below the surface of the sea, Tuffy carried tools down to them and brought mail back to the surface.

Tuffy was also on stand-by duty to go to the rescue of any aquanaut who might find himself lost in the black water surrounding his sea floor habitat. By sounding a buzzer, a lost aquanaut could expect Tuffy to dive down and find

"Tuffy" leaps on command from his trainer.

him. Then by taking a line from Tuffy and following it back to the Sea Lab, his rescue would be assured. Although such a rescue never became necessary, Tuffy never failed in drills which simulated this kind of emergency.

Over an eight-year period of investigation, numerous sonar-related experiments generated a vast library of tape-recorded dolphin sounds and noises. Similar work was done with the Orcas. From those experiments, the scientific team came up with new approaches on the use of sonar that resulted in the sea becoming a little less opaque to man.

LIFE SCIENCE

While the dolphin research program was unique, the Life Science Department investigated a variety of medical, biological, and psychological factors relating to NMC's aeronautic and astronautic activities.

One project of major consequence in 1961 was based upon a need to establish design specifications for the flight cabins of manned space vehicles. Consideration had to be given not only to the environment of the occupants, but also to the structural limitations of the craft. While the astronauts had to be provided with an atmosphere which would maintain their normal physiological state, with safety devices to protect against unexpected changes in their environment, these requirements could not place impossible demands upon the structure of the cabin.

It was decided that the best combination of features would be an intracabin atmosphere of 100 percent oxygen under a pressure of 3.5 psi, a pressure altitude of 34,000 feet, with the occupants wearing pressure suits. Since space vehicles would be exposed to a near perfect vacuum, a reduction of internal pressure from 14.7 to 3.5 psi would considerably lessen the force on the inside of the flight compartment and thereby reduce cabin structure size and weight appreciably.

In a previous study, a subject protected by a full pressure suit had been exposed to pressure altitudes above 30,000 feet, breathing 100 percent oxygen for 72 hours, with negligible physiological and psychological deterioration. But the results did not preclude the possibility that cumulative effects might occur during a more prolonged exposure.

The Bureau of Medicine (BuMed)-sponsored project was a logical extension of the earlier study and called for an exposure of two human subjects to 100 percent oxygen at a simulated 34,000-foot altitude for five days. Also, the comfort of the full pressure suit in contrast to a standard Navy summer flight suit would be evaluated by attiring the subjects in these respective garments.

The experiment, conducted in the Life Science Department laboratories, used a specially modified low-pressure chamber in which two volunteer Navy enlisted men were subjected to the test environment for a period of 120 hours. One man wore the Navy Mark IV Full Pressure Suit and was fed a special low-bulk diet. The other was clothed in a regular flight suit and ate normal Navy food. Both men were kept in an isolated environment as much as possible and were subjected to various physiological and psychological tests.

Results showed both men tolerated all aspects of the five-day exposure very well. Some physical difficulties included inflamation of the sclera* in both subjects and symptoms of "immersion foot" in the subject wearing the full pressure suit, but these were considered minor and preventable in future experiments. Essentially, the experiment produced additional evidence that it should be possible for man to exist indefinitely at 34,000 feet on 100 percent oxygen.

During 1963, there was a major shift at NMC in research orientation. Although there continued to be interest and a capability in the area of bio-astronautics, research efforts were directed toward supporting the primary missions and activities associated with the test and evaluation of current naval weapon systems. This resulted in various studies of aircrew equipment, bio-acoustics, and also related human factors engineering.

Under the sponsorship of the Bureau of Weapons (BuWeps), a Navy-wide program in the general area of bio-acoustics expanded rapidly in the early 1960's and continued for several years. Equipment for noise measurement, hearing tests, and hearing conservation programs were widely distributed among naval air stations and

Measuring noise attenuation, Human Factors Engineering (1970).

* The sclera is the tough, white, fibrous outer envelope of tissue covering all of the eyeball except the cornea.

Life sciences technologist testing bio-pack for full-pressure suit.

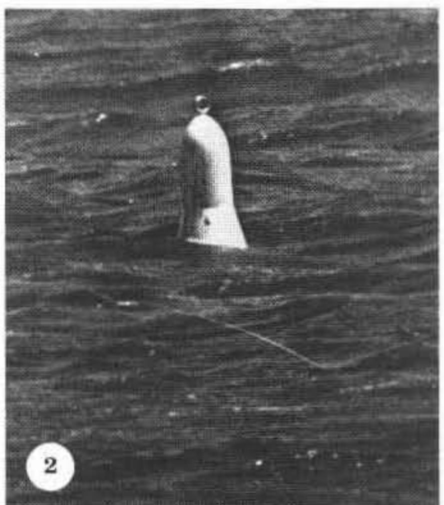
throughout the Fleet. Courses of instruction in the operation of this equipment and these programs were established and held twice a year at the School of Aviation Medicine, NAS Pensacola, Florida, and twice a year at NMC Point Mugu, in alternating quarters. In addition, studies were performed on high-energy acoustic levels of aircraft, missiles, and impulse noise associated with naval weapons and their various effects on humans.

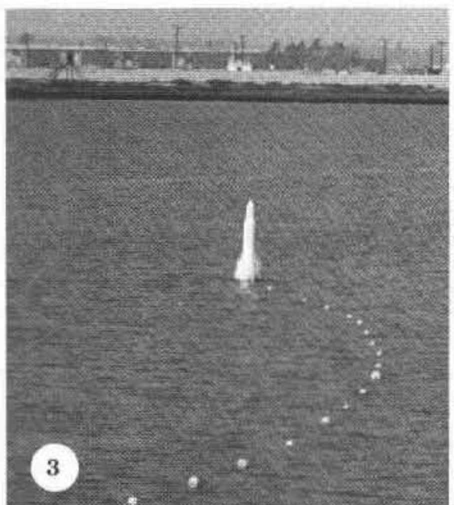
Human factors engineering became a part of every weapon system program, providing an influence on the design and development of each. Where previously there had been a lack of adequate specifications in this general area, NMC gradually expanded its technical human factors support in the planning, evaluation of contractor development, and operational test and evaluation phases.

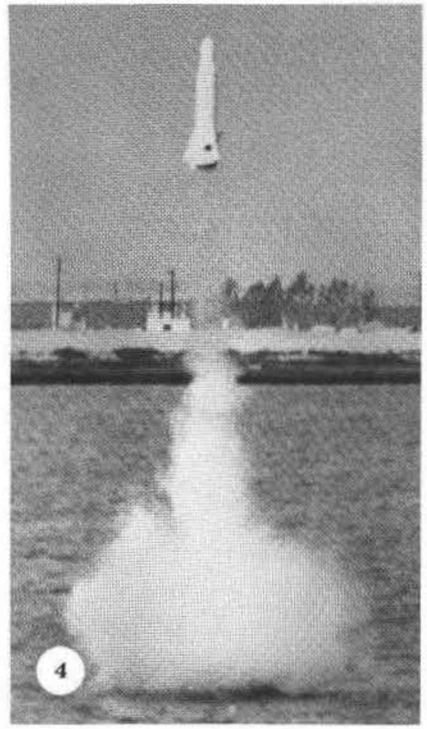
Typical tasks included the development of flight test measures of operator performance, participation in formulating and conducting ground simulation studies, and performing task-equipment analyses. A staff of engineering psychologists examined functions assigned to the human operator, instrumentation of manual functions, and procedures of equipment operation. As a result of these examinations, they recommended redesigning of control, display, or communication elements and changes in operating doctrine. In addition, they assessed operator proficiency as it related to system effectiveness and reliability in order to identify special requirements for personnel selection, training, and training devices.

While the importance of human engineering in perfecting the man-machine weapon systems that defend our nation was recognized early in Point Mugu's third decade, the need for these efforts has never diminished.

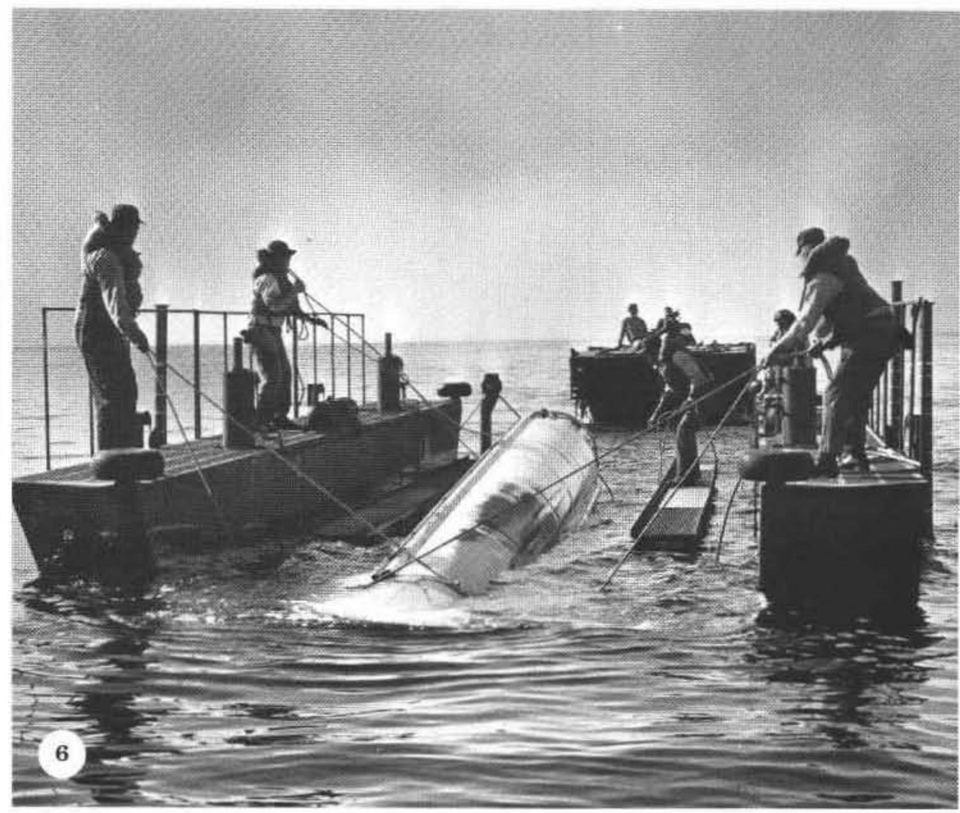

1

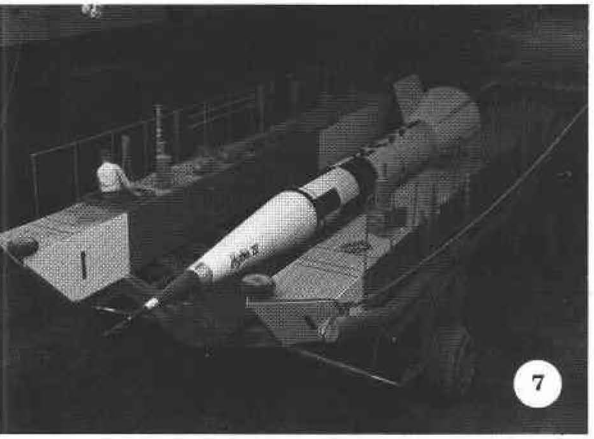

2

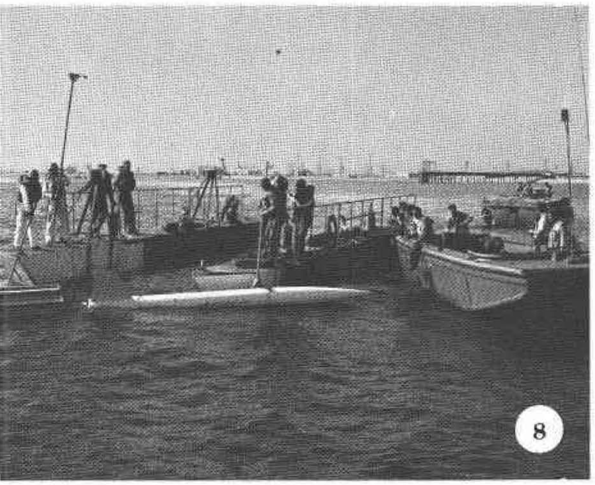

3

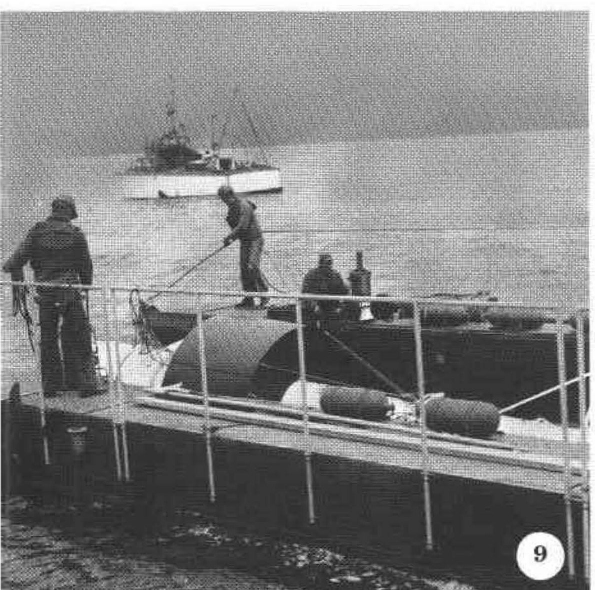

4

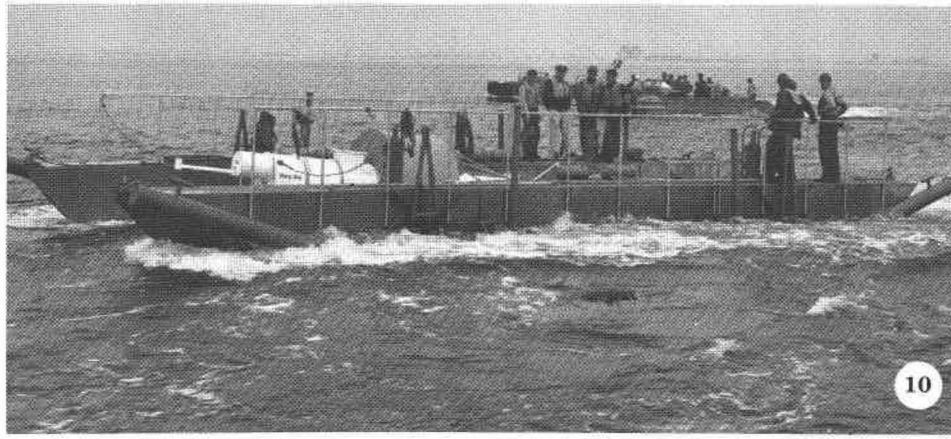

5

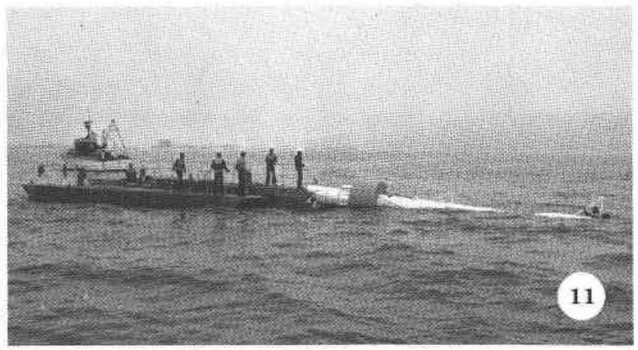

6

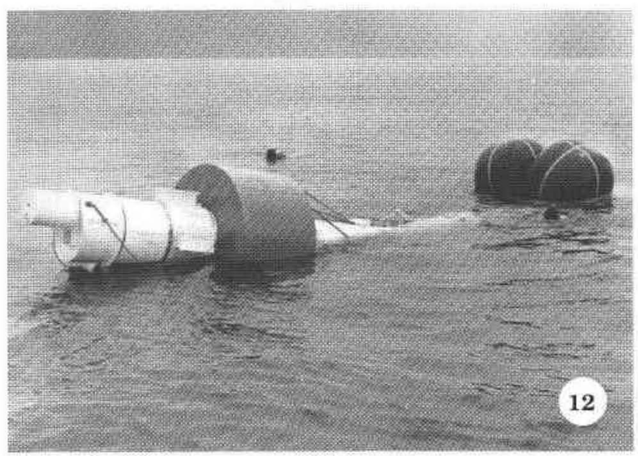








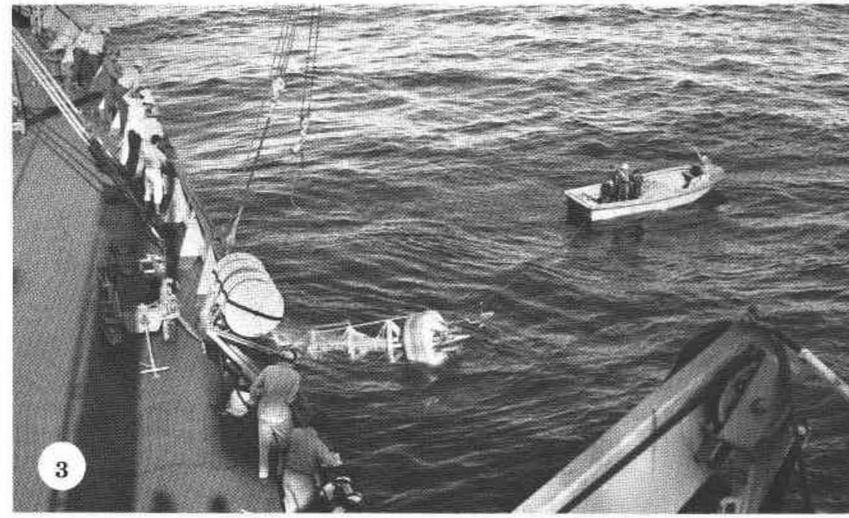


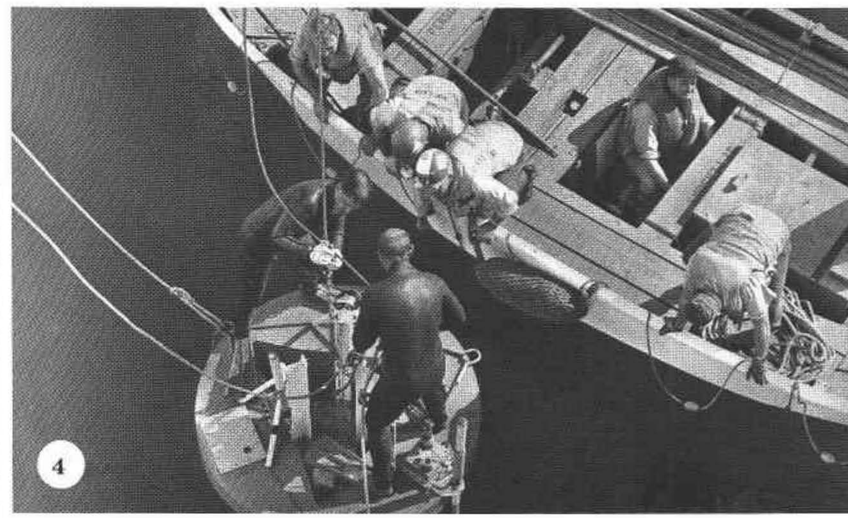


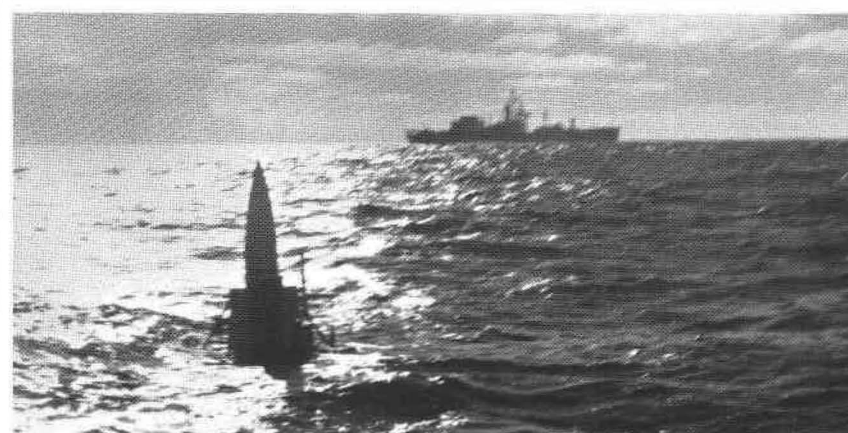
1. NMC divers use a lift raft to place HYDRA I in the Mugu Lagoon for test firing (1960). 2. HYDRA vehicle floating vertically in the sea prior to launch (1960). 3. HYDRA sea-launch with vehicle beginning to lift from lagoon (1960). 4. HYDRA sea-launch with vehicle airborne (1960). 5. HYDRA II handling operation at the head of Point Mugu pier (1960). 6. HYDRA II at-sea handling operation (1961). 7. HYDRA IV in the well deck of USS POINT DEFIANCE (1961). 8. HYDRA-SEABEE removal from R3Y beaching cradle off Point Mugu (1961). 9. HYDRA V operation underway (1965). 10. HYDRA V in transit to launch area (1965). 11. Removing HYDRA V from the R3Y beaching cradle (1965). 12. Flotation supports a HYDRA V during launch preparations (1965).


1

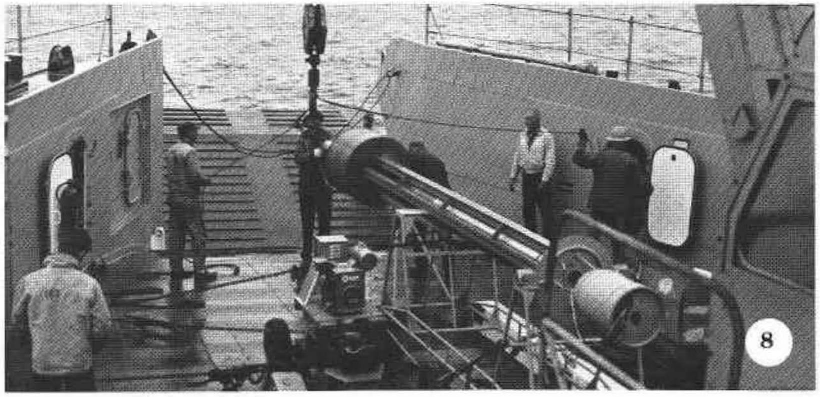

2


3

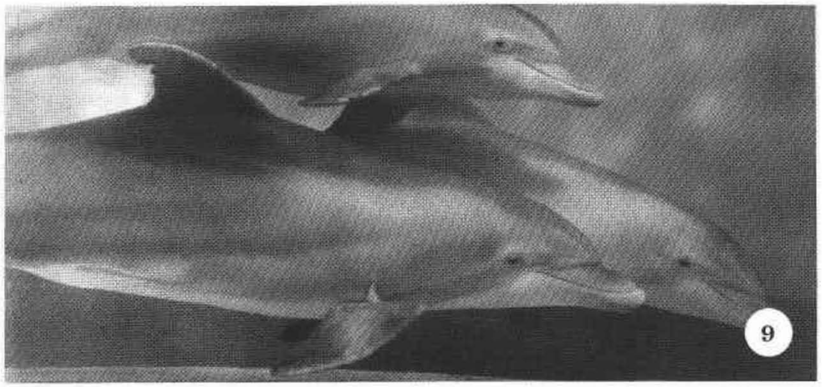

4


5

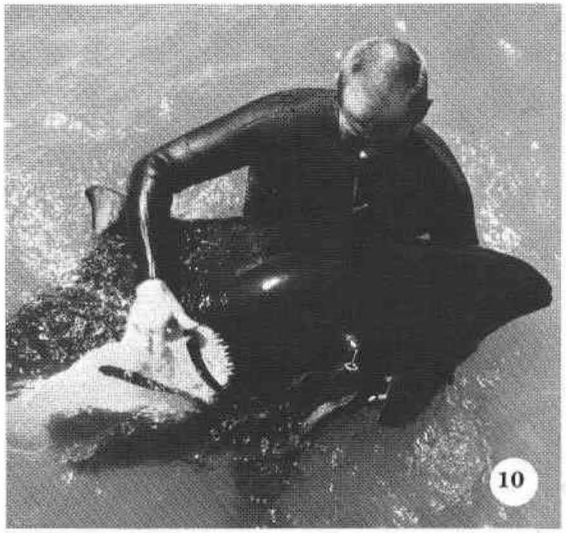
6



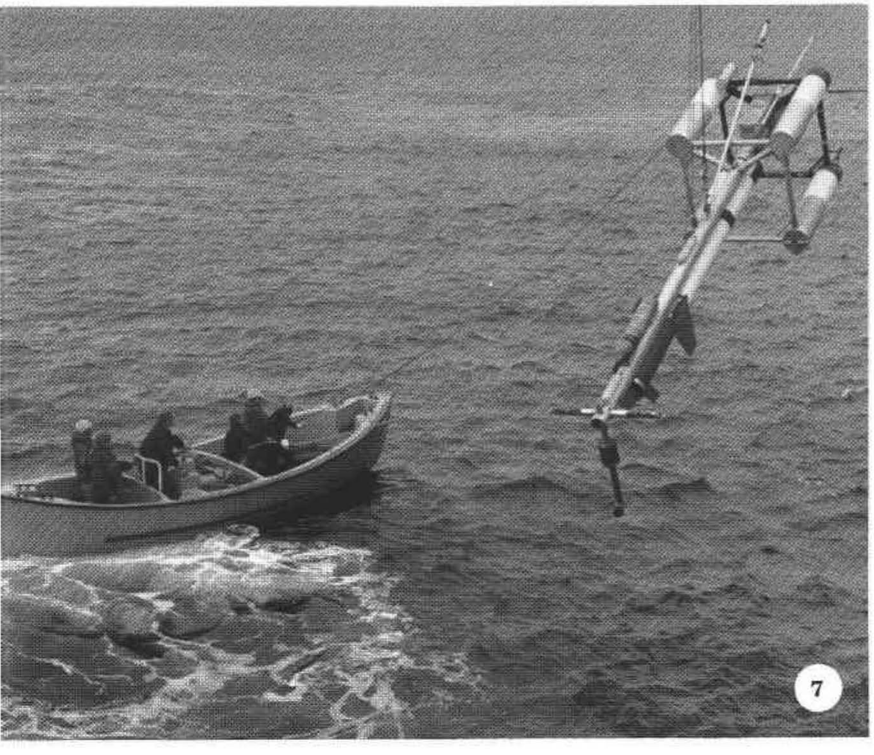
8



9

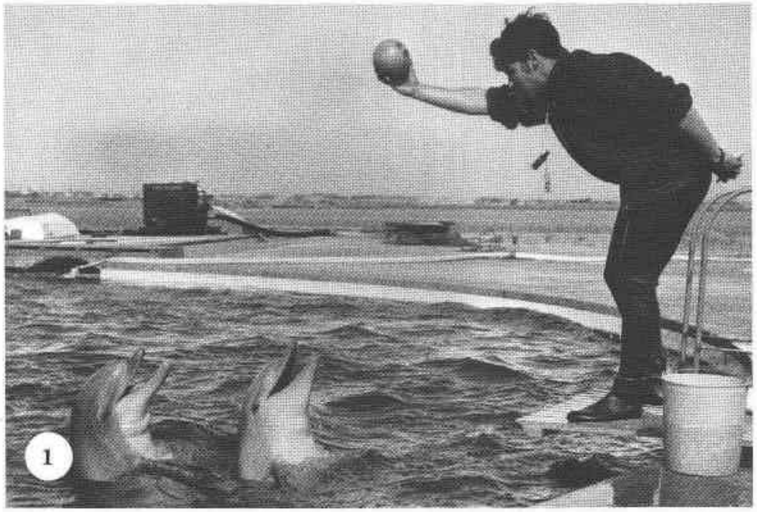


10



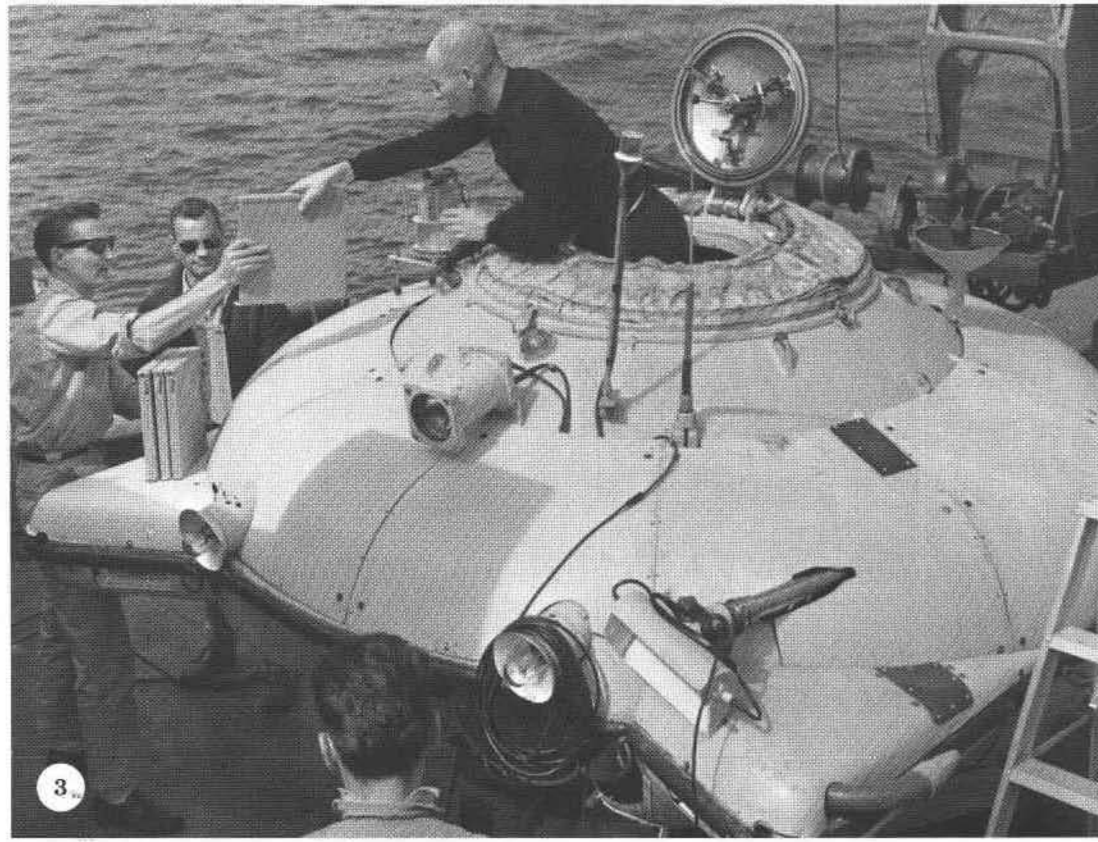
7

1. USNS WHEELING, used as control ship in HYDRA-IRIS operations (1964). 2. Motor whaleboat from the USNS WHEELING during a HYDRA-IRIS operation (1965). 3. Lowering a HYDRA-IRIS vehicle into the sea prior to launching (1963). 4. Retrieving the HYDRA-IRIS launcher after vehicle launch (1965). 5. Control ship USNS WHEELING on horizon, with HYDRA-IRIS in foreground waiting countdown (1966). 6. HYDRA-IRIS launch vehicle in floating rail launcher. 7. Lowering HYDRA-SANDHAWK launch vehicle deployed from USS NORTON SOUND (1971). 8. YFU-5 launch support craft with HYDRA/POGO-HI rocket target (1964). 9. Dolphins in the Marine Biology Facility research tank, Point Mugu (1962). 10. Dolphin with instrumentation and diver/scientist (1965).



1

2



3

4

5

7

6

1. *Trainer working with dolphins, "Salty" and "Dash" (1964). 2. Aerial of dolphin pool and pens alongside Mugu Lagoon (1964). 3. Sea Lab used in conjunction with dolphin experimental research (1960). 4. Acoustical engineer recording dolphin sounds picked up by research tank hydrophones (1965). 5. Subject is readied in the Bio-environmental Division low-pressure chamber (1961). 6. Airman reaches for ejection curtain release during research by Life Sciences Department (1967). 7. Observer, test coordinator, and controller in Human Factors Engineering project aboard R5D (C-118) (1963).*

Preparing a supersonic BQM-34E missile target for launch.

"Then shall the right aiming thunderbolt go abroad; and from the clouds, as from a well-drawn bow, shall they fly to the mark."

—Wisdom v:21

CHAPTER 17

LAND, SEA, AND AIR THREAT SIMULATION

By the late 1960's, targets, or threat simulation, at Point Mugu had reached a point where a large number of diverse aircraft, missile, and surface targets were either in use on the range or undergoing test and evaluation. Aerial targets ranged from simple tow targets and banners to high-altitude supersonic missile targets, and from small expendable subsonic targets to full-size aircraft. Surface targets ranged from high-speed patrol boat simulations to full-size decommissioned warships. In addition, very sophisticated devices, particularly for simulating an electronic warfare environment, were being developed. The following projects are representative of the target programs that were being vigorously pursued.

XBQM-34E

For several years the Navy had under development a supersonic missile target, the XBQM-34E, which would operate at between 50 feet and 60,000 feet and remain on station for a relatively long period of time. By March 1969, the Contractor Demonstration Tests were completed, and shortly thereafter the NTE began. A total of 23 flights were made in this program which came to an end on July 1, 1970.

During 1971, 12 flights were made: 8 for proving the compatibility of the automatic flight control and 4 for Fleet operations. In the same year three production BQM-34E's were evaluated using 45 channels of instrumentation. By 1972, the production target was blasting off regularly from the launch pad, with a total of 34 flights recorded. These flights were to evaluate performance of the autopilot and for air-to-air target presentations.

MQM-74A

Another missile target—the subsonic MQM-74A CHUKAR—underwent Contractor Demonstration Testing the same year as the XBQM-34E. Designed to simulate a medium-performance aircraft, the MQM-74A could fly at speeds up to 500 knots and altitudes to 40,000 feet. Following the Contractor Demonstration Tests, a controller training program was conducted at Twenty-nine Palms, California, using production units prepared and operated by Fleet personnel in a Fleet environment. The training program produced valuable evaluation information. Since performance was generally satisfactory, mass production was initiated while NMC personnel began an improvement program to explore the extremes of the performance envelope and to test radar and infrared augmentation, scoring device installation, and ECM equipment.

In 1971, NMC conducted production monitoring tests and improvement flights, and supported Fleet operations. Production improvement tests concentrated on evaluating visual augmentation, scoring devices, chaff dispensers, and infrared systems. The first air launch of the MQM-74A was made using an H-3 helicopter.

CQM-10A

During 1969, the BOMARC, CQM-10A, completed its first year of operational service. A total of 16 targets, launched by a 40-person Point Mugu detachment permanently stationed at Vandenberg AFB, was presented on the Sea Test Range for RDT&E and Fleet weapon system firings. Thirteen of the flights were successful. In the following year, several product improvements were made, including programming the ramjet engines for maximum power during the boost phase to improve climb, changes to check-out procedure tolerances and improved test techniques to increase reliability, and improved relay/receiver system modules to facilitate quick changes. Also, a number of ground support system improvements were made.

In 1972, the BOMARC target was modified to provide a stairstep-type of flight profile, permitting the user to test both high- and intermediate-altitude surface-to-surface missiles with each target presentation.

AIRCRAFT TARGETS

In full-size aircraft target development, both the QT-33A and QF-4B targets came aboard during the 1969 to 1972 period. The QT-33A flight evaluation of the preproduction model was completed in 1969, and after three No-Live Operator (NOLO) flights, it was declared operational at NMC subject to certain restrictions. Late in the same year, evaluation of a QT-33A high "g" configuration target was initiated. In the first high "g" NOLO test conducted in 1970, five maneuvers were commanded, with the target pulling 4 "g's" in each instance. NMC also conducted a successful operation with forward-looking television cameras installed in the target.

The prototype of the QF-4B target, a converted F-4B Phantom II fighter, arrived at Point Mugu in March of 1972 and underwent 17 flights as part of the Development Flight Programs operations. The choice of the F4-B for conversion offered several advantages, one of which was its secondary use as a target control aircraft. The target was designed so that it could be reconfigured from aerial target to target control aircraft with a minimum expenditure of time by using easily installed, interchangeable equipment consoles.

ITCS

In the Integrated Target Control System (ITCS) program, the first PSW-1 portable control station was delivered for contractor service testing during 1971. This lightweight station was designed for use aboard ships where less than a 50-mile range was required for target control. Thirty-eight test flights were flown with the unit using QT-33A aircraft and MQM-74A drones. The next year the Contractor Service Test and Navy Performance Evaluation of the PSW-1 were completed. Also, the Contractor Development Tests were begun on the TSW-10 station, used for controlling four targets at a range of 250 nautical miles; the MSW-10, used as a short-range station in command/control or FOX vans; and the ASW-36, used in chase and control aircraft.

LOW-ALTITUDE AQM-37A

In 1970, NMC personnel designed and successfully flew a system that gave the AQM-37A target a cruise altitude of 100 feet over a landmass, at a speed of 600 knots, with a lateral course control capable of bringing the target within plus or minus 50 yards of a prescribed point. This system was designed in support of weapon systems intended to defend against low-altitude threats, such as cruise missiles. Sixteen low-altitude AQM-37A targets were successfully flown in support of Navy weapons system users.

SURFACE TARGETS

Seaborne target work from 1968 to the early 1970's included contracting for construction of SEPTAR Mk 33 and Mk 35 boat targets and the evaluation of a seaborne target information control for use with the Mk 34. Forty-nine SEPTAR Mk 35's were delivered in 1972. Initially, two targets each were deployed to Pearl Harbor and Puerto Rico. In the same year, BQM-34A missile targets were launched from SEPTAR Mk 34's under remote control to simulate cruise missile launches from patrol boats.

SHIP TARGETS

The need for full-size ship targets at NMC increased during 1971 due to the initiation of the HARPOON missile weapon system test program. On January 7 of the following year, the ex-USS INGERSOLL was assigned as a candidate target. The ship underwent conversion and preparation that included the installation of simulated threat emitters, automatic monitoring equipment for seaworthiness and navigation, and remotely monitored systems for the electrical power generator, navigation lights, fog warning system, and radar beacons.

Recognizing that HARPOON and other antiship weapon programs would have a continuing need for ship-size targets, a request was made for additional FLETCHER-class destroyers. Five additional candidates were thereafter assigned. To differentiate these ships from less expensive target ships used in operations likely to result in ship loss (warhead shots), they were designated long-term targets. Long-term targets were configured so they could be moored for extended periods of time at open ocean buoys. During 1973, the two target ships ex-USS INGERSOLL and ex-USS BELL sustained 13 direct hits by inert missiles.

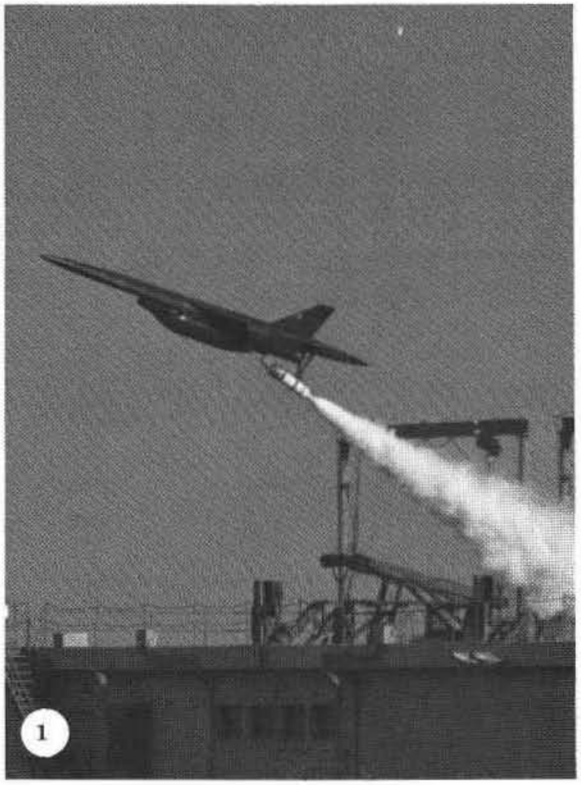
LAND TARGETS

NMC developed mobile land targets during the 1960's and early 1970's. The QM-56 and QM-41 involved the conversion of the M-56 gun carriage and M-41 tank to radio-controlled targets for use at Navy bombing ranges. In 1973, conversions of two vehicles were completed and successfully tested. These were subsequently replaced by the QLT-1.

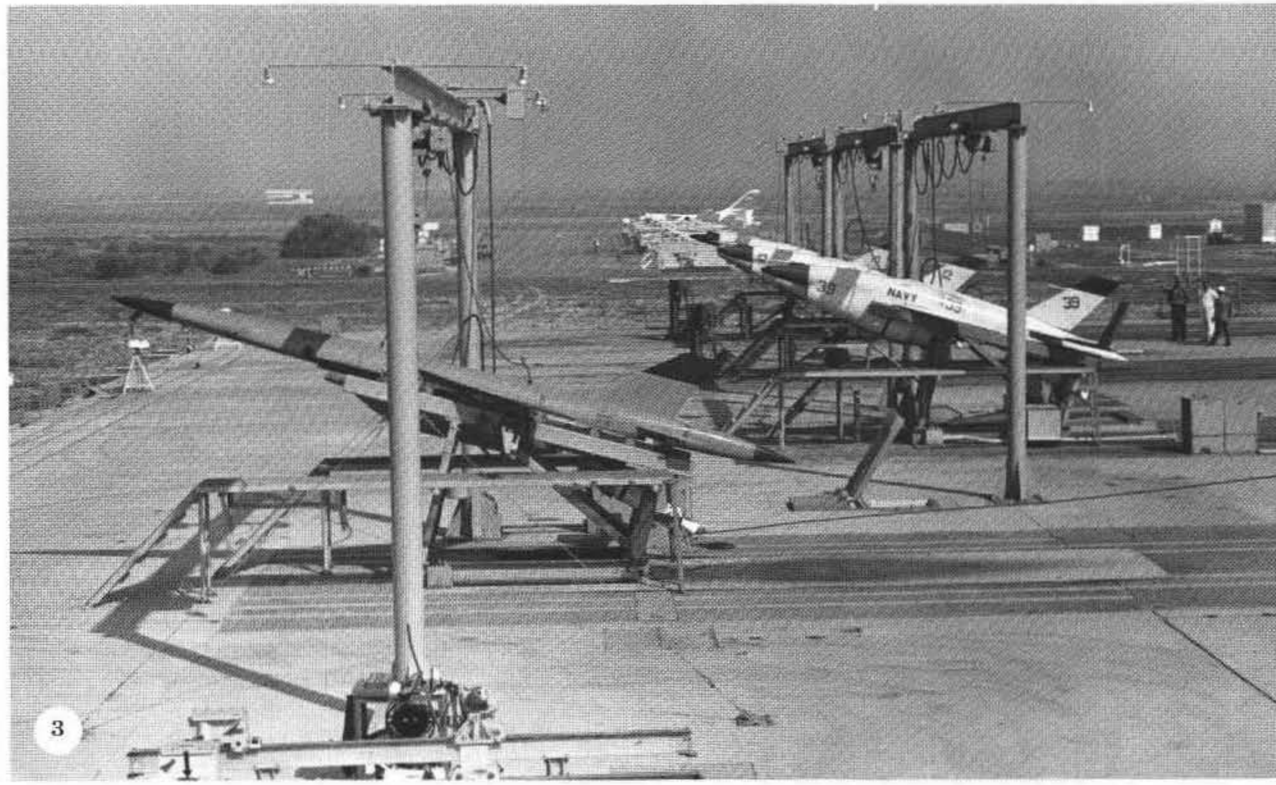
THREAT RESEARCH

A threat effectiveness program was initiated in 1973 to increase the realism of all types of threat simulations provided by NMC to range users. The program specifically helped develop a systematic method of comparing threat simulation capabilities with actual enemy threat characteristics. Significant progress was made in radio frequency signature and kinetic performance comparisons.

In a similar vein, a program was started to provide for quick assessment of target requirements for NMC and Navy aerial target presentations. The program depended on a well-established liaison and coordination effort with Navy weapon system RDT&E programs. An attempt was made to set up a system which would incorporate a standardized format and computerized data retrieval. It was anticipated that this system would provide longer range inputs to NAVAIRSYSCOM for procurement, deficiency analysis, and development of more effective threat simulations.

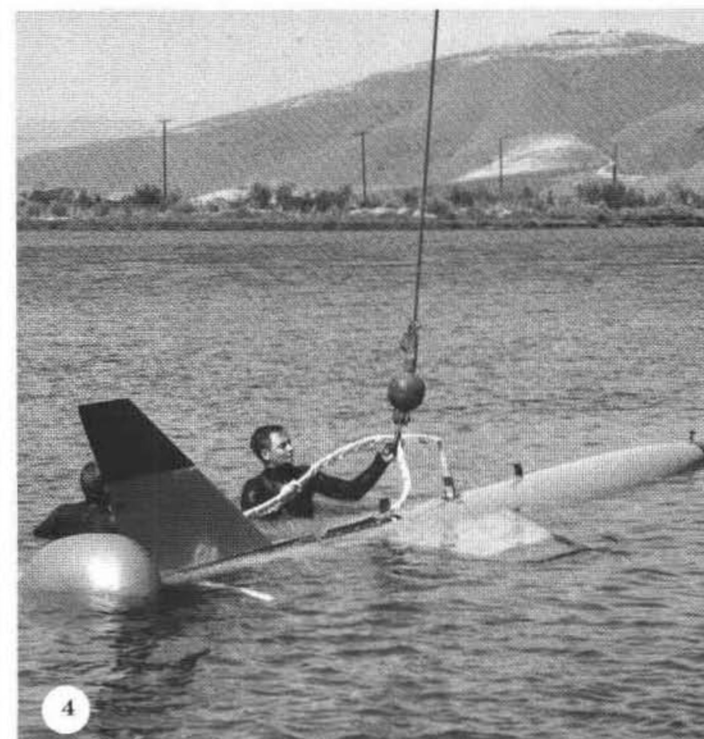


1



3

2



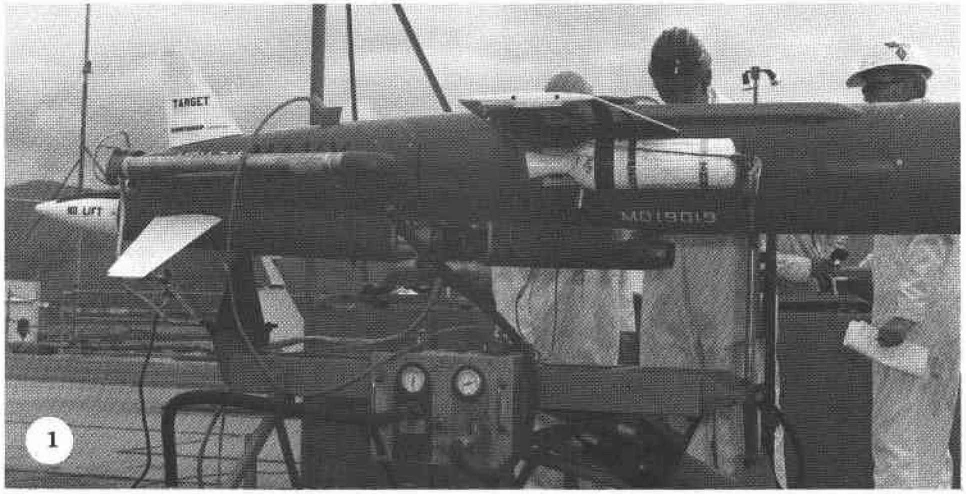
4

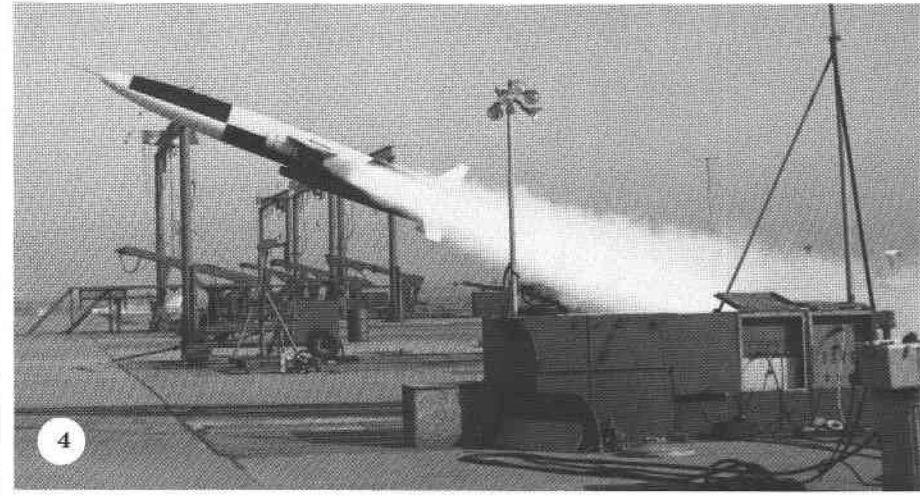
5

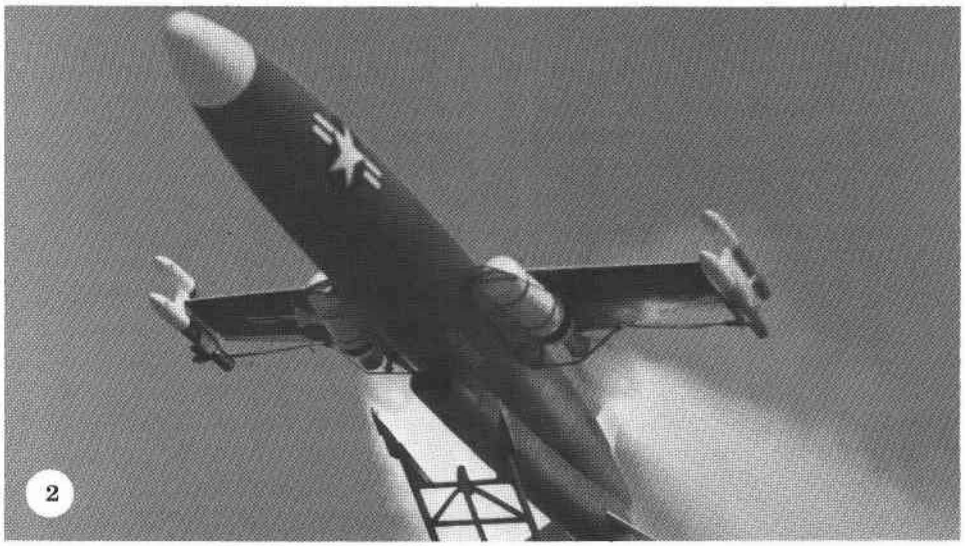
6

7

1. Ground launch of BQM-34E missile target from Point Mugu launch pad (Building 55) (1975). 2. P-2 aircraft with BQM-34A and experimental BQM-34E targets during T&E phase (1969). 3. Three BQM-34A targets ready to launch, with BQM-34E in foreground (1970). 4. Diver connecting crane to XBQM-34E target in Mugu Lagoon (1968). 5. Loading an XBQM-34E target on wing of DC-130A aircraft using the 47A Missile Loader (1970). 6. Aft view of subsonic missile target MQM-74A CHUKAR on ZL-5 Launcher (1968). 7. DC-130A aircraft in flight with BQM-34E target (1970).

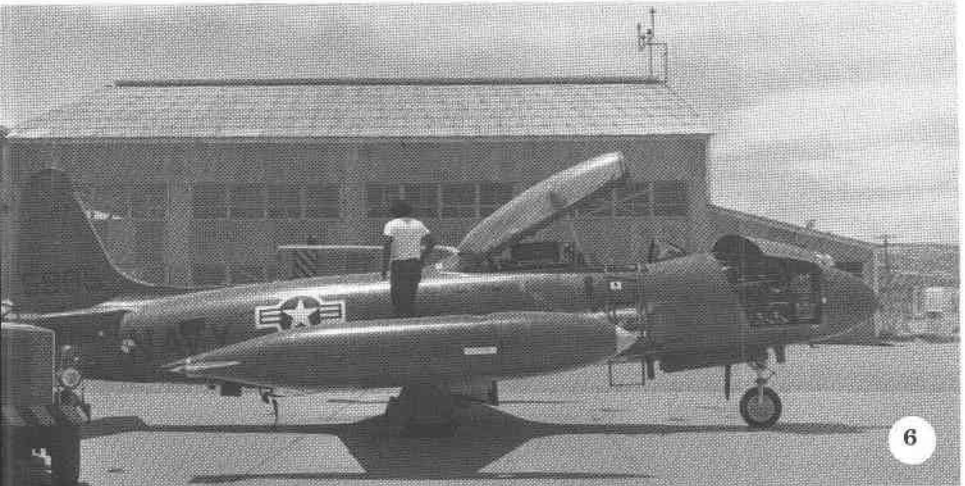

TARGET
NO LIFT
1

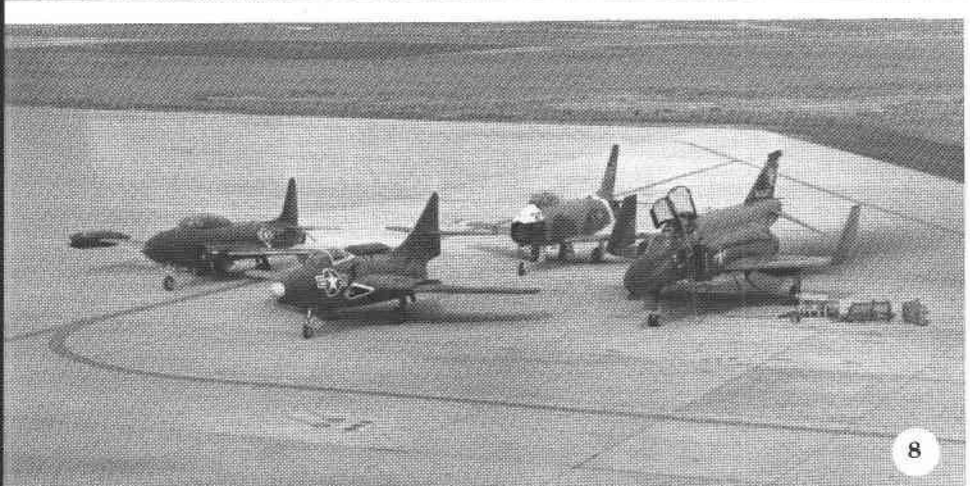

4

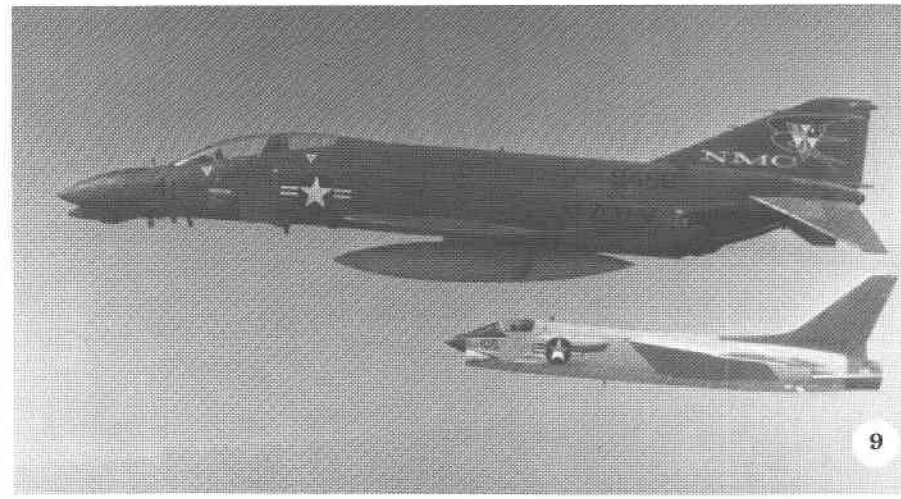

2

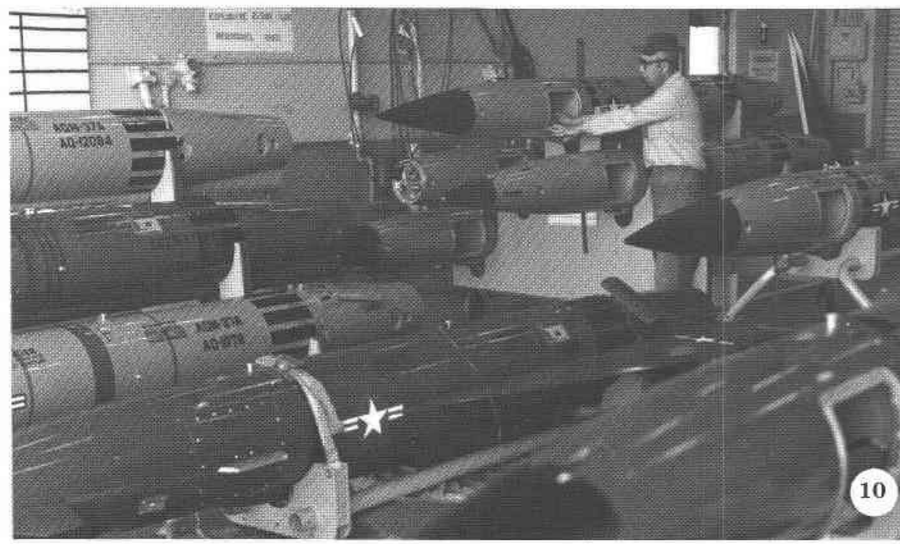

64
3


5

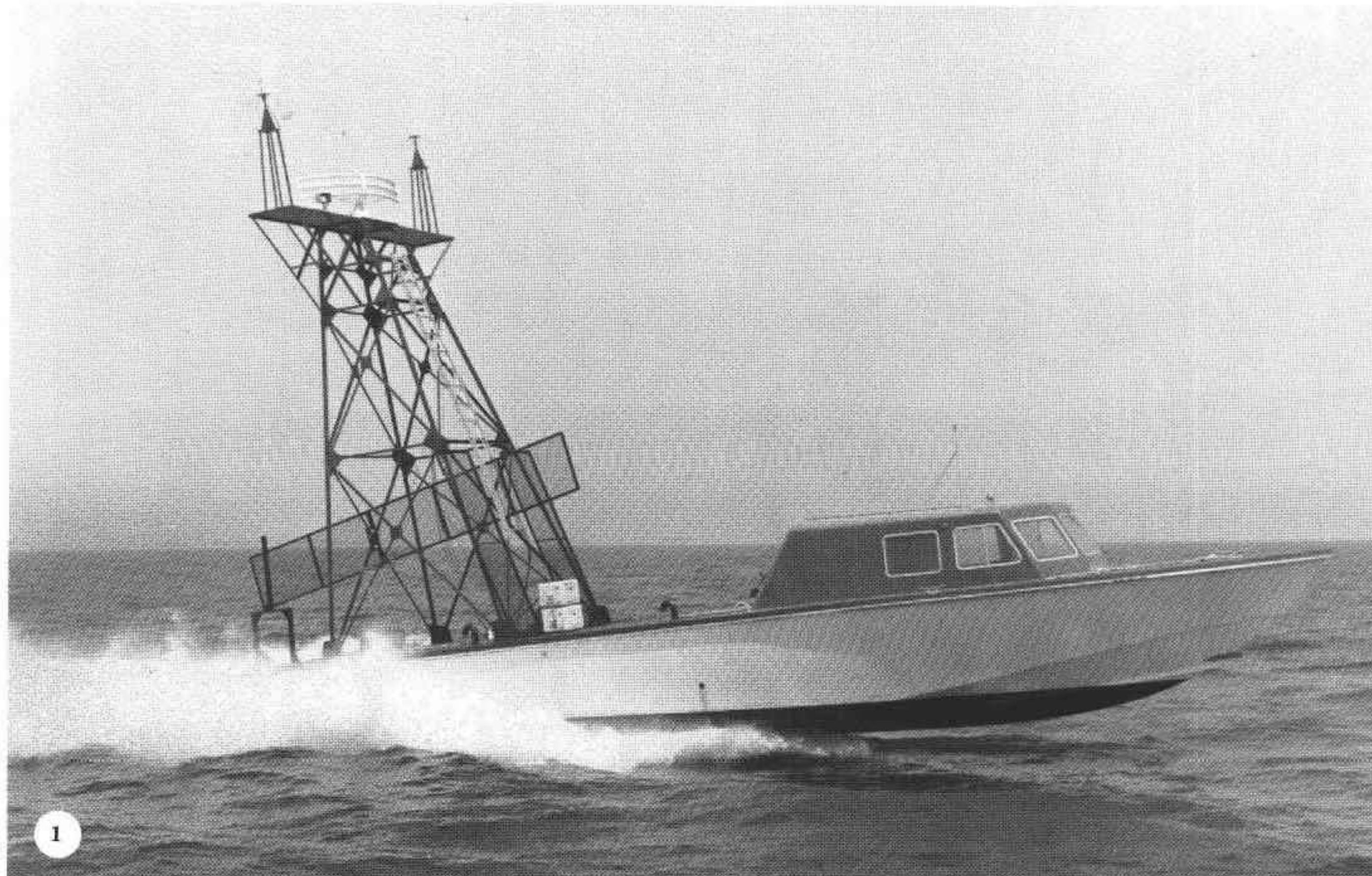








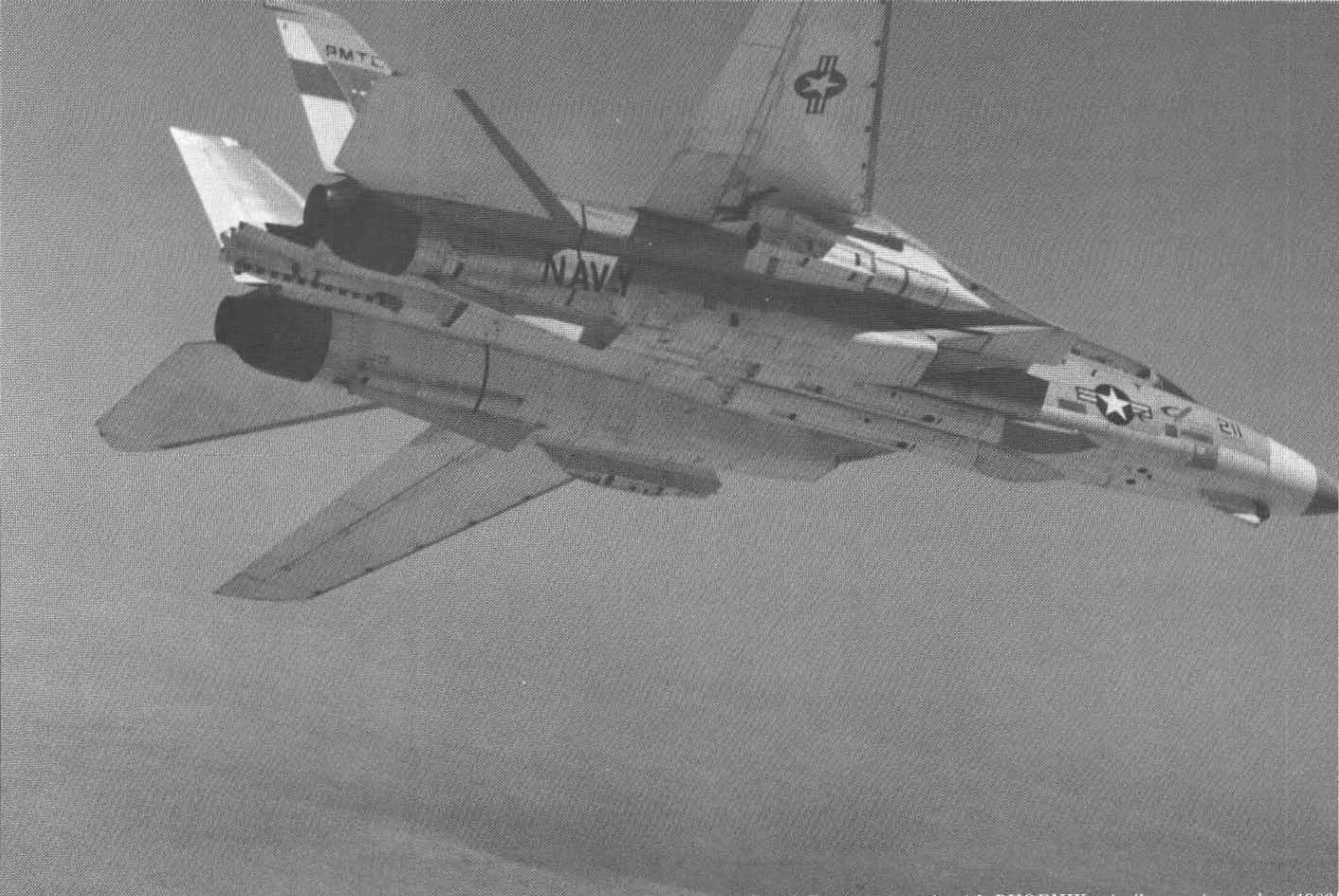
1. Pyrotechnic Optical Plume Simulator (POPS) on MQM-74C target (1976). 2. Ground launch of MQM-74C subsonic missile target (1975). 3. MQM-74C target mounted on A-7 Corsair II aircraft (1974). 4. MQM-74C target during ground launch (1973). 5. CQM-10B BOMARC supersonic target being launched from Vandenberg AFB (1970's). 6. QT-33A aircraft target (1976). 7. QT-33 aircraft target in flight. 8. NMC aircraft targets: QT-33A, QF-9J, QF-86H, QF-4B (1974). 9. QF-4 aircraft target with DF-8 Crusader control aircraft in background (1974). 10. AQM-37A targets in ready storage (1966).


1


602
2


3

1. SEPTAR Mk 34 boat target at speed under radio control (1973). 2. BQM-34A aerial target launched from SEPTAR Mk 34 boat target (1969). 3. AQM-37A target on F-8 Crusader aircraft (1974). 4. P-3 aircraft flying over ship target, ex-USS INGERSOLL. 5. Converted Army mobile gun carriage, the QM-56 mobile land target (1966). 6. Threat Simulation Department technicians servicing BQM-34A targets.



F-14A Tomcat aircraft with PHOENIX missile on wing pylon (1980)

"Perform developmental test and evaluation, developmental support, and follow-on engineering, logistic and training support for naval weapons, weapon systems, and related devices, and provide major range, technical, and base support for Fleet users and other Department of Defense Government agencies."

—Mission Statement of the
Pacific Missile Test Center

CHAPTER 18

THE PACIFIC MISSILE TEST CENTER

As indicated in earlier chapters, the organizations established over the years at Point Mugu largely reflected the particular needs of the Navy at a particular time in history. NAMTC, commissioned in 1946, resulted from an awareness that missiles and pilotless aircraft testing should be consolidated into one organization. Then, in 1958, PMR was created in response to President Eisenhower's policy of National Ranges with specific missions, available to all services. Maximum flexibility and capabilities seemed to be the driving philosophy. Also, the range mission was linked with the massive space effort taking place in the late 1950's and early 1960's. The commissioning of NMC in 1959 was due to the recognition of a need for an organization dedicated to Navy missile test and evaluation, the continuation of one of the major functions of its predecessor, NAMTC.

With the reduction in scope of PMR in 1963 and the subsequent decline in space-related activities, test and evaluation increased in relative importance at Point Mugu. Through the later part of the 1960's, communication and mutual support were required between the range and the test and evaluation activities, and efforts were made to improve the relationship.

By 1970 it was obvious that test and evaluation would increase in importance in the forseeable future, a point made quite evident by the Blue Ribbon Defense Panel Report which recommended:

> *". . . test and evaluation receive a greater share of the cumulative resources allocated to RDT&E, receive greater management attention from the highest levels of the Defense Department, and be tied more closely to the weapons acquisition process."*

ESTABLISHMENT

Recognizing the increasing interdependence of the range and test and evaluation activities for the same resources, studies were undertaken during the mid-1970's on the consolidation of PMR, NMC, and NAS Point Mugu into one organization. The result of these studies was the establishment on April 26, 1975, of the Pacific Missile Test Center with the following long-range goals:

Maximum weapon system effectiveness

Optimum test range facilities

Optimum threat simulation services

Human resources development program implementation

Accomplishment of EEO and Affirmative Action goals

Progress toward becoming the Navy's Center of

Excellence in weapon system test and evaluation

Initiation of mission-related action to support weapon system development, production, and application.

Even before the end of 1975, there was evidence that the consolidation was achieving a significant and meaningful shift in the attitude of the employees toward a singleness of purpose. Although overcoming parochialism would take time, there was optimism that soon everyone would be striving toward the stated goals and that in the long run the formation of PMTC would be beneficial to weapon system test and evaluation.

The need to continually improve test and evaluation became very evident at this time when it was seen that a shift in national priorities was taking place. There would be fewer new weapon systems and greater reliance on improving those weapons in existence. Also, sophistication and the resulting increase in cost would necessitate ensuring reliability through the use of nondestructive testing methods.

PROJECT MANAGEMENT

In 1975, the Command established the Project Management Group (PMG) to direct and control the diverse projects that were coming aboard PMTC and to provide a single point of contact for external assignments. Members of this organization were assigned individual projects for which they provided financial management, interface with other laboratories and test centers, initial planning, acceptance, approval and continuing management, and final performance assessment. The group also provided long-range planning and coordination to make sure that PMTC was ready for the work that might be assigned five, ten, or even twenty-five years in the future.

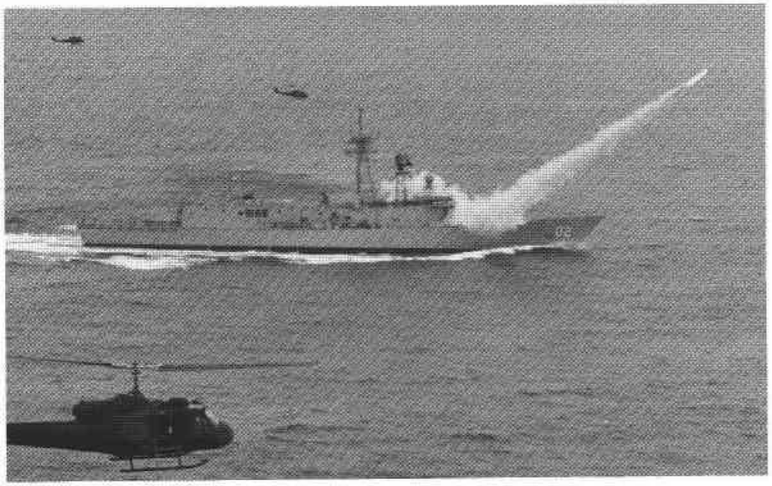
Projects that came to PMTC were assigned to various offices depending on the type of weapon system: airborne, surface weapons/special projects, or threat simulation/electronic warfare. For high-visibility projects the Command established a special category called "Designated Projects." These weapons included HARPOON, F-14/PHOENIX, TOMAHAWK, and TRIDENT. The Mobile Sea Range was added at a later date. At that time, HARPOON and F-14/PHOENIX were in full swing while TOMAHAWK

Project Management Group plans for diverse PMTC projects.

and TRIDENT were primarily in the preparation and planning stages.

HARPOON

During 1974, PMR/NMC supported twenty HARPOON missile launches while NMC designed and fabricated telemetry and command destruct systems for the contractor. In 1975, HARPOON reached the NTE phase, which consisted of eighteen firings, seeker captive flights, and an airborne missile environmental qualification program. Highlights of the launch phase were two warhead firings with good success, the first launches of missiles from DLG- and DDG-type ships, the first launches of missiles from canister launchers and from a TARTAR launcher, and the first missile launches from a submarine and an A-7 aircraft.



HMAS CANBERRA launches HARPOON against ship target (1981).

Operational evaluation was also initiated in 1975, with PMTC providing primary support to OPTEVFOR. More than 40 flight operations of the A-3 aircraft equipped with a HARPOON seeker were conducted in accordance with the OPEVAL test plan.

PMTC supported VX-4 in the captive missile reliability program, provided test support for three launches, and designed the ground support equipment which was eventually selected by the contractor. This final effort was quite unique in that the ground support equipment was originally intended as interim items for use in the PMTC HARPOON activities. When NWS Concord began their HARPOON activities, these items were delivered to them by PMTC. While the prototype units were in use, they were assessed by the contractor who concluded they were superior and recommended their adoption.

TOMAHAWK

As mentioned, TOMAHAWK was a relatively new PMTC program in 1975. During the year, it involved modifying an A-3 aircraft and conducting captive guidance tests. It also involved designing suitable extensions of the test range, providing facilities for contractors, and generally planning for the Center's role.

SPARROW III

In 1973, the newest model of the SPARROW III (AIM-7F) missile underwent Air Force/Navy OPEVAL with NMC providing engineering and laboratory support to VX-4. Fuze reliability improvement was also initiated. The effort continued into the following year. In 1974, NMC supported the OPEVAL Phase II.

The NTE of the improved fuze was conducted in 1975 with 12 missile firings, various captive flights, and laboratory tests. In addition, PMTC was assigned the responsibility for testing and evaluating the next generation of SPARROW III guidance, the monopulse, being developed by two separate contractor facilities.

SIDEWINDER

A significant design change to introduce lead bias and improve lethality was made in the SIDEWINDER AIM-9H missile in 1974. The missile was then subjected to NTE and an OPEVAL was recommended. The follow-on missile, AIM-9L, underwent technical evaluation the same year, and in 1975 the NTE was conducted.

MK 94/PEGASUS

In 1975, a rather unique program at PMTC was the support provided the Mk 94/PEGASUS (PHM-1) program. PEGASUS was a high-speed hydrofoil patrol boat equipped with the Mk 94 Fire Control System and the 76mm/62 caliber mount MIT 75 system. This armament was intended for use against both surface and airborne targets. Firing runs were made against moored target hulks and aerial targets of the BQM type. In addition to providing targets, the Center supplied data reduction and processing, documentary photography, telemetry, communications, and other range services.

RANGE METEOROLOGICAL SOUNDING SYSTEM

In 1973, PMR initiated an effort to develop and procure a Range Meteorological Sounding System (RMSS) to replace the obsolete AN/GMD rawinsonde system. Under the auspices of the Range Commanders Council and assisted by the RCC Meteorological Group Advisory Committee, PMTC supervised the development contract.

The RMSS is an advanced, state-of-the-art, upper atmospheric sounding system used to determine vertical profiles of temperature, humidity, pressure, wind velocity, refraction index, and density for the purpose of weather forecasting and operational support. It consists of a ground-based tracking antenna with associated electronics and a balloon-borne radiosonde with sensors.

The initial RMSS installation was made at the Army's Kwajalein Missile Range.*

AIR COMBAT MANEUVERING RANGE

In the early 1970's, PMR was assigned the additional role of coordinating agency for test instrumentation, data collection, and data reduction at the new Air Combat Maneuvering Range located near Yuma, Arizona. This 700-square-mile instrumented area was designed and developed to teach pilots how to recognize when they were within a firing envelope, how to use their missiles, and how to fire them effectively. The range uses a multi-aircraft tracking display and exercise data recording system which is able to track four aircraft equipped with Airborne Instrumentation Systems, compute and display significant flight data in real time, and record data for debriefing playback.

During the acceptance testing of the Air Combat Maneuvering Range, PMR cine-sextant tracking mounts were utilized extensively in providing precision data on the

* Production units are now in use at Point Mugu.

performance of high-speed maneuvering aircraft in relation to the sensors that were being evaluated. Data reduction on the film footage provided azimuth, elevation, slant range, timing, and tracking error. The relative attitude of the aircraft was also determined using the Photo Data Analysis System (PDAS).

PHYSIOLOGICAL RESEARCH

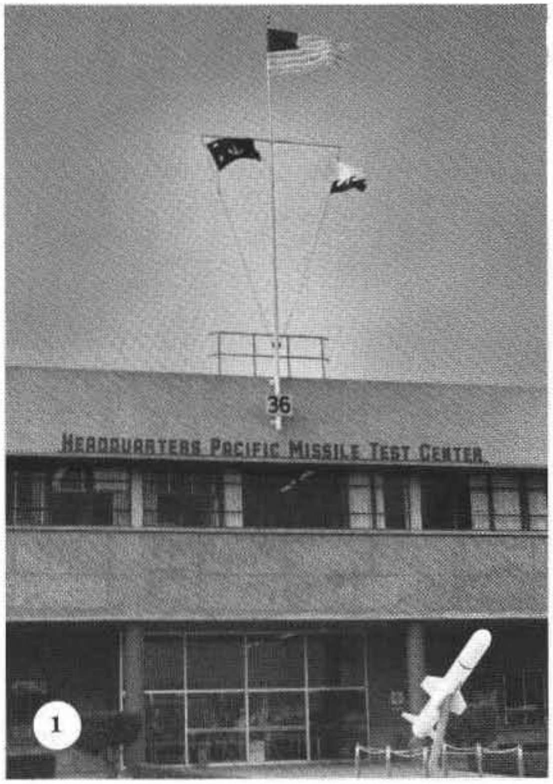
For a number of years, PMTC supported the Fleet in the development and use of techniques for obtaining in-flight physiological data, especially in the multi-stress environment of tactical jet flying. As early as 1958-1959, research was conducted at Point Mugu to design and build an instrument that would monitor and record in-flight aircrew electrocardiogram, respiration, and pulse rate. However, technical problems delayed this work, and it was not until the late 1960's that the Navy developed an in-flight recorder Bio-Pack for use in monitoring such functions.

Although initially pleased with the Bio-Pack, plans were soon made to develop a smaller and lighter package with longer recording time. The result was the In-Flight Physiologic Data Acquisition System (IFPDAS) which was used at PMTC to monitor aircrews flying the A-4, F-4, and F-14 aircraft. In 1976, an improved unit, the IFPDAS II, was flown on approximately thirty flights, including missile launches, strafing, and bomb drops. In 1977, the PMTC Microelectronics Laboratory began work on the third generation IFPDAS and associated hardware and software. Following extensive environmental qualifications and calibration, the IFPDAS III became completely functional. PMTC then began using the system to monitor jet aircrewmen to obtain baseline data in the laboratory and airborne physiological and performance data. The knowledge thus obtained would be used to help develop specifications for life support systems that would allow the operator to employ his airborne weapons effectively and without human limitations.

OTHER PROGRAMS

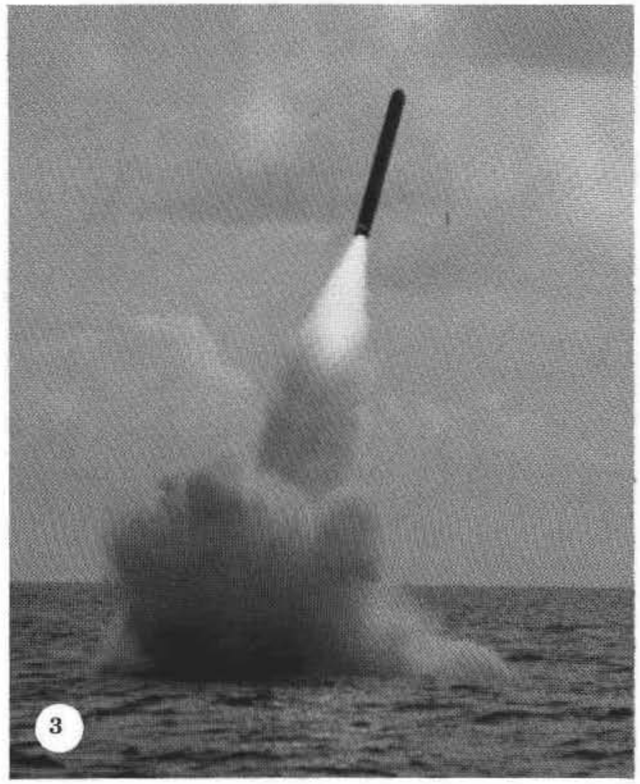
Other programs pursued at PMTC during its first year included assistance to the United Kingdom (UK) in the development and evaluation of the air-to-air XJ-521 missile weapon system, the NTE of the SHRIKE AGM-45-9, -10, and -7A missiles, special electromagnetic interference studies on the WALLEYE and CONDOR electro-optical missiles, captured launches of the Air Force MAVERICK missile, technical support of the OPEVAL of CONDOR, technical evaluation of the STANDARD ARM Avionics System, and engineering support for testing and evaluating the Air-Launched Low-Volume Ramjet (ALVRJ).

STV-1 Air-Launched Low-Volume Ramjet on A-7A aircraft (1974).

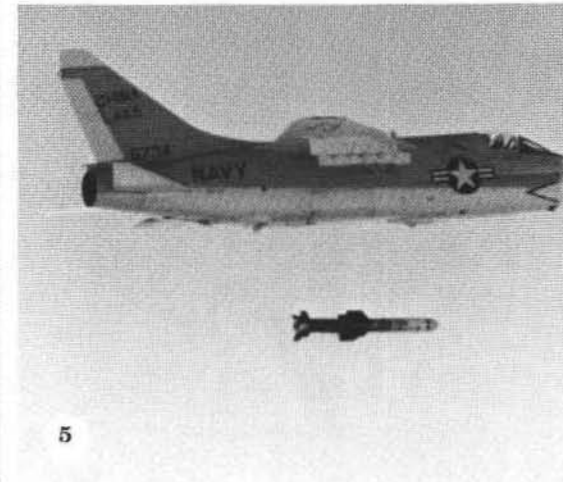


1


2

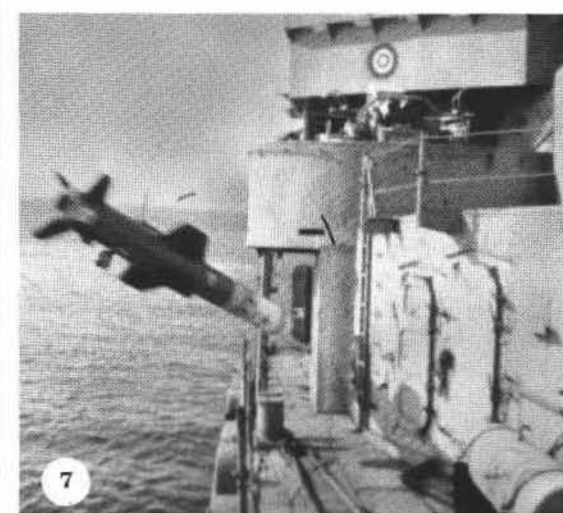

3

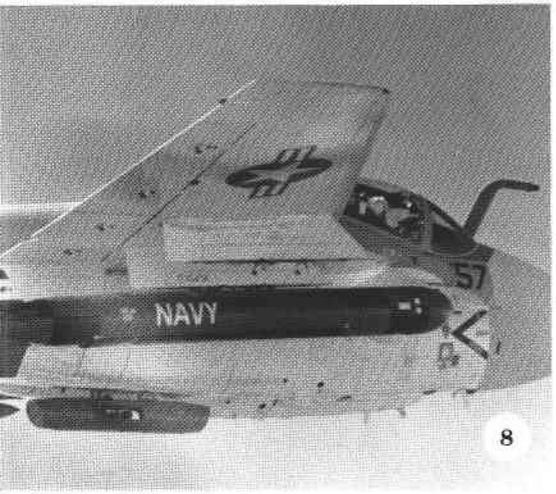

4



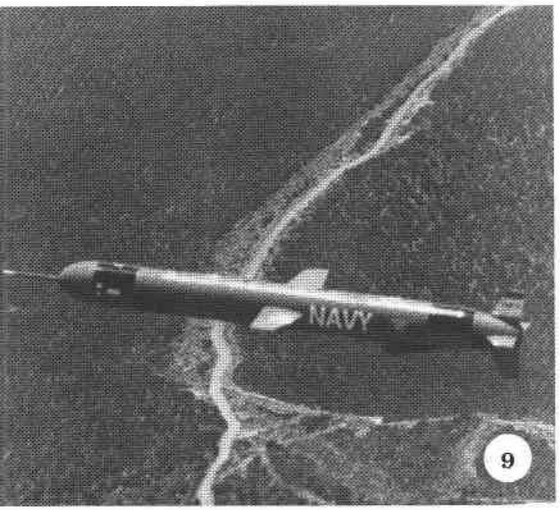
5


6


7

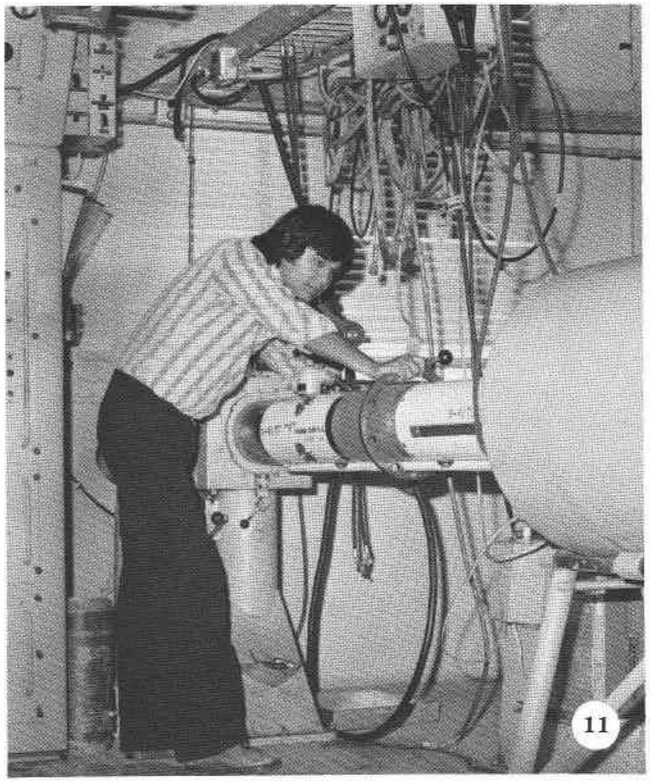


8

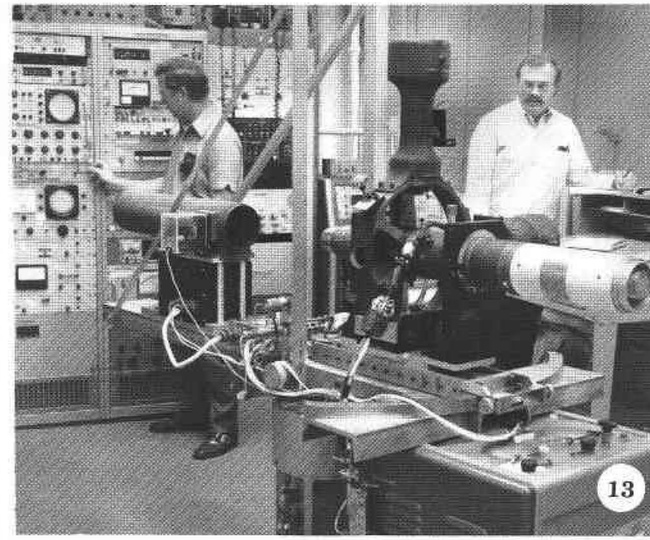


9

10


11


12


13

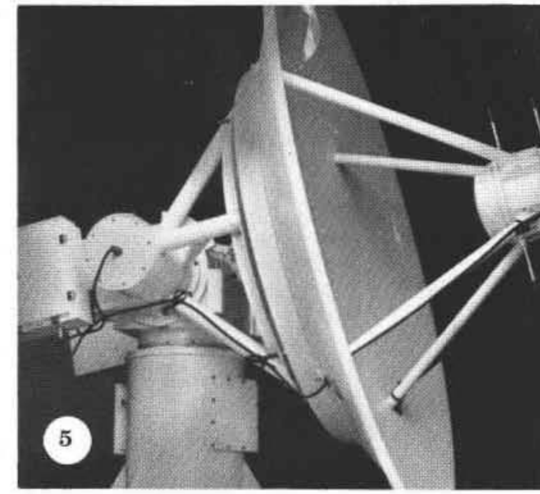
1. HARPOON permanently on display in front of PMTC Headquarters. 2. Air Test and Evaluation Squadron FOUR (VX-4) aircraft in flight over Point Mugu complex. 3. TOMAHAWK missile launch from the submarine USS GUITARRO. 4. TOMAHAWK missile vertical launch test from PMTC's launch pad BRAVO. 5. HARPOON missile launch from A-7 aircraft. 6. Control room at HARPOON Instrumentation and Test Site (1972). 7. HARPOON missile just before impact on the ship target, ex-USS HARDEN. 8. Close-up of A-6 aircraft in flight with TOMAHAWK missile on wing pylon (1976). 9. TOMAHAWK missile in flight over White Sands, New Mexico (1976). 10. F-4 Phantom II aircraft firing a SPARROW III missile. 11. System checkout of SPARROW III guidance and control. 12. AIM-9L SIDEWINDER missiles with F-4 Phantom aircraft in background. 13. SIDEWINDER missile rate table at the Missile Preparation Branch, Point Mugu (1973).

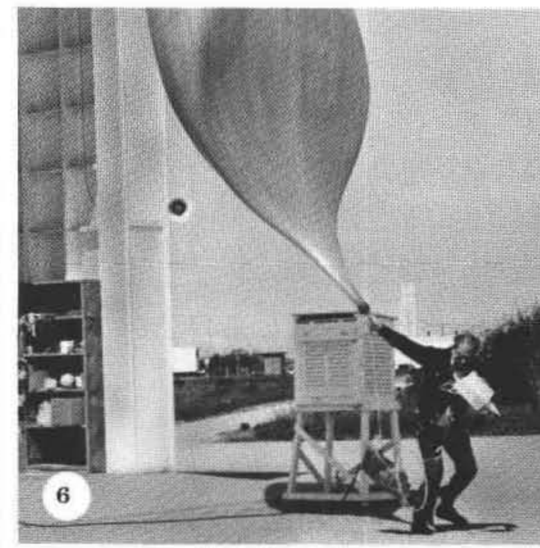

1


2

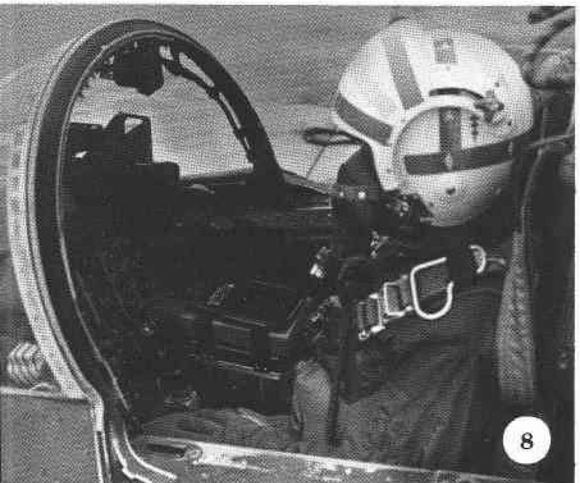
3


4


5


6


7



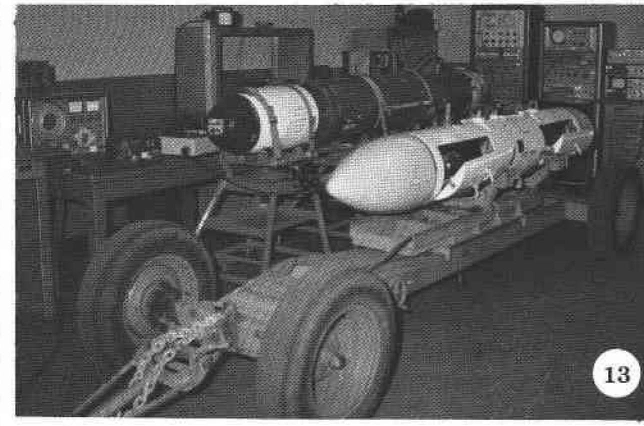
8

9

10

11

12



13

1. Loading a SIDEWINDER missile onto an F-4 aircraft wing pylon. 2. Preparing to load a SIDEWINDER missile onto an F-14 aircraft. 3. Weapons configuration takeoff of F-14A Tomcat aircraft loaded with bombs, missiles, and fuel tanks (1973). 4. USS PEGASUS hydrofoil with HARPOON launchers on stern and 76mm/62 caliber mount MIT 75 system on foredeck (1975). 5. Meteorological Sounding System (MSS) antenna for receiving data telemetered from a weather balloon. 6. Releasing a balloon with radiosonde attached to collect atmospheric data. 7. Cinesextant tracking mount at REDEYE Site, San Nicolas Island (1972). 8. The Bio-Pack recording human biological factors during weapon system test. 9. In-flight recorder Bio-Pack for aircrew physiological monitoring. 10. Bio-Pack with sample of strip-chart output. 11. The Microelectronic Facility at Point Mugu testing microcircuitry. 12. Preparing to illuminate the guidance sections of SHRIKE missiles by a radar horn. 13. WALLEYE and CONDOR missiles in Electro-Optical Weapons Laboratory.

Preparing for a flight simulation at Missile Simulation Lab.

"In peace, as a wise man, he should make suitable preparation for war."

—Horace

CHAPTER 19

LIFE CYCLE SUPPORT

The evolution of test and evaluation at Point Mugu is most frequently seen in the projects conducted or new facilities developed. However, there is another aspect of growth that is perhaps more subtle, but equally important. This aspect is usually referred to as "Life Cycle Support," which means extending weapon system test and evaluation back to the conceptual phase and forward to Fleet deployment. Life Cycle Support has been alluded to in several preceding chapters, but before proceeding with this history, a closer look at this vital aspect and its relationship to weapon system procurement is appropriate.

Life Cycle Support begins with establishing the need and basic requirements of a new or improved weapon while taking into consideration the Navy's changing mission and defense situation. The Center provides assistance in analyzing enemy threats, preparation of the Test and Evaluation Master Plan, and developing the laboratory and range facilities that will be needed perhaps many months or even years in the future. A good example of the last activity is the TRIDENT program, which came aboard for planning in 1975, several years before the first scheduled missile launch in the Pacific.

In planning for test and evaluation of a missile, one of the things PMTC considers is the way it will be used. Will it be used against a massed threat or individual combatant? Will it be used at long range or close in? Will it be used in isolated incidents or total war? In addition, the electromagnetic environment likely to be encountered must be considered.

Another factor in developing the test and evaluation plan is the type of threat. Modern weapons must be tested against simulated threats that display the dynamic performance, electro-optical, electromagnetic, and tactical characteristics of the enemy. Furthermore, they must be operated in a very complex threat environment that may include surveillance ships, aircraft, open-ocean combatants, missiles, and advanced electronics. Simulating these complex threats is as much a part of test and evaluation as launching the missile and may be almost as difficult.

During the development phase of a weapon's life, PMTC is frequently involved in component testing; for example, flying a missile seeker or guidance section in a specially configured aircraft or performing functional closed-loop tests in the laboratory. Environmental tests such as vibration, shock, and altitude are also frequently performed. Then, as the weapon progresses in development, PMTC conducts or supports the Contractor Test and Evaluation (CTE), the NTE, and the OPEVAL. Along the way, the Center may provide integration testing; that is, operating the total weapon system along with software and avionics.

PATE

Once a missile has been approved for production, PMTC supports the procurement process by performing Production Acceptance Test and Evaluation (PATE) on missiles randomly selected from each production lot. The PATE activity helps assure continued reliability and is rather unique to PMTC. As Jim Perkins relates:

> *"PATE is one of the three T&E areas defined in DOD directive 503.3. The others are developmental and operational. Before we had PATE, customers interested in acceptance testing often got two proposals, one from Flight Test and the other from the lab. To remedy that situation, an ad hoc committee was formed to investigate acceptance testing, develop a process, and set up an organization. When PMTC was established, the PATE Division was formed. We developed reliability test techniques for acceptance testing, and, as these became accepted, they were found to be equally useful in reliability evaluation during weapon development. About half our work is now performed during the development phase."*

PATE testing on both developmental and production missiles encompasses functional, climatic, and dynamic tests, and combined environmental reliability tests, frequently called Flight Test Simulation (FTS). FTS is based on the premise that if the environmental stresses of service are reproduced in the laboratory, then the service reliability and failure modes will also be reproduced. In reproducing the environment, PATE subjects the missile to vibration, temperature fluctuation, and operating stresses in a "stochastic" process with correct distribution, correlation, and sequence.

The special facility developed for FTS consists of a reverberant acoustic chamber in which several missiles are mounted on shakers. A thin, flexible thermal duct surrounds each missile and conditioned air is passed through it to simulate various altitudes while the missiles are subjected to acoustic and mechanical vibration. The facility is almost entirely controlled by digital programs and magnetic tape.

READY MISSILE TEST FACILITY

To allow PATE on completely assembled missiles with warheads and motors attached, PMTC built the Ready Missile Test Facility during the 1974 to 1978 period. Here, through simulation, the weapon is subjected to a wide range of environmental conditions while simultaneously undergoing a complete checkout of internal and external components. The facility permits testing at temperatures ranging between -40 and 160 degrees Fahrenheit, combined with vibration and shock loads.

The Ready Missile Test Facility complex consists of seven ordnance test cells, with four control buildings, a missile assembly building, and a storage building. The test cells and control rooms are massive earthen mound-type structures, each containing over three hundred tons of concrete, steel, and earth. They are capable of withstanding an accidental explosion comparable to hundreds of pounds of TNT while providing safety to test personnel.

IN-SERVICE ENGINEERING

The final stage in the test and evaluation cycle is Fleet weapons or in-service engineering. With the missile deployed in the Fleet, it might be assumed that PMTC's work is complete. However, problems frequently arise in an operational environment that were not suspected during development. Also, improvements, engineering changes, and modifications are sometimes necessary to keep the weapon current with the threat.

Unlike the days of iron bombs, the life of a modern missile or weapon system is never static, and PMTC has been given cognizance to assure a large number of weapons remain current and reliable. By 1981, PMTC was the cognizant field activity on nine weapon systems, nine target systems, and a number of types of aircraft guns, ammunition, and bombs. The following is a list of these weapons and targets, excluding conventional ordnance:

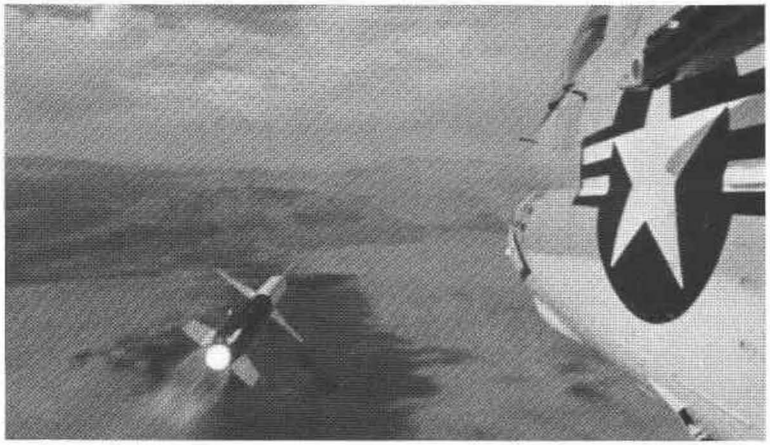
Weapon System	Target System
SPARROW III	BQM-34A/S
SIDEWINDER	BQM-34E/T
PHOENIX	BQM-74C
SHRIKE	AQM-37A
STANDARD ARM	BATS
HARPOON	Mobile Land Target
TOW	Aerial Tow Target
WALLEYE	Target Auxiliary Systems
Laser Guided Bomb	Seaborne Targets

In addition to its day-to-day cognizance, PMTC's Fleet Weapons Engineering has managed a number of significant general projects. The following are representative of these.

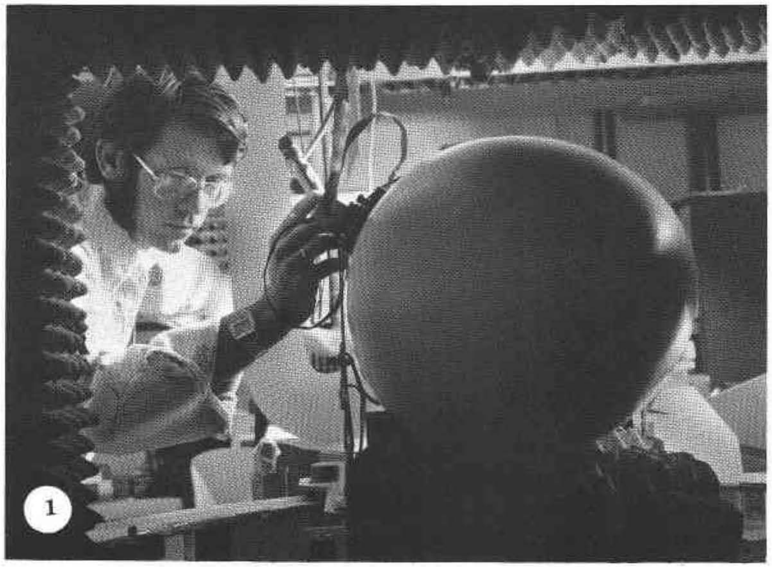
In 1976, planning and coordinating support was provided for establishment of the PHOENIX missile repair and rework facility at the Navy Air Rework Facility, Alameda,, California, and at the HARPOON Missile System Test Facility at NWS Concord, California. Also, a 1.5 million-dollar procurement of modification kits for SPARROW was directed. An on-line automatic data processing system was designed and implemented for maintaining configuration and data management control over various air-launched weapon systems.

The following year, PMTC participated in the improvement and standardization of the Navy's maintenance engineering effort and instituted the "MISSILEX" Assist Team. The purpose of the latter was to identify the reasons for instances of poor performance of missile weapon systems during Fleet firings. The goal of the team was to provide a comprehensive analysis of the weapon system performance during the exercise.

In 1979, PMTC was designated the Prospective Cognizant Field Activity for the High Performance Anti-Radiation Missile (HARM). Also, the first Fleet Review Board was instituted to assist in the analysis of weapon system failures, and for the first time in field testing of ground support equipment, the SIDEWINDER DSM-152 I-level test set was field tested before introduction into the operational phase of its development.



HARM missile launch from A-7 Corsair II aircraft (China Lake).

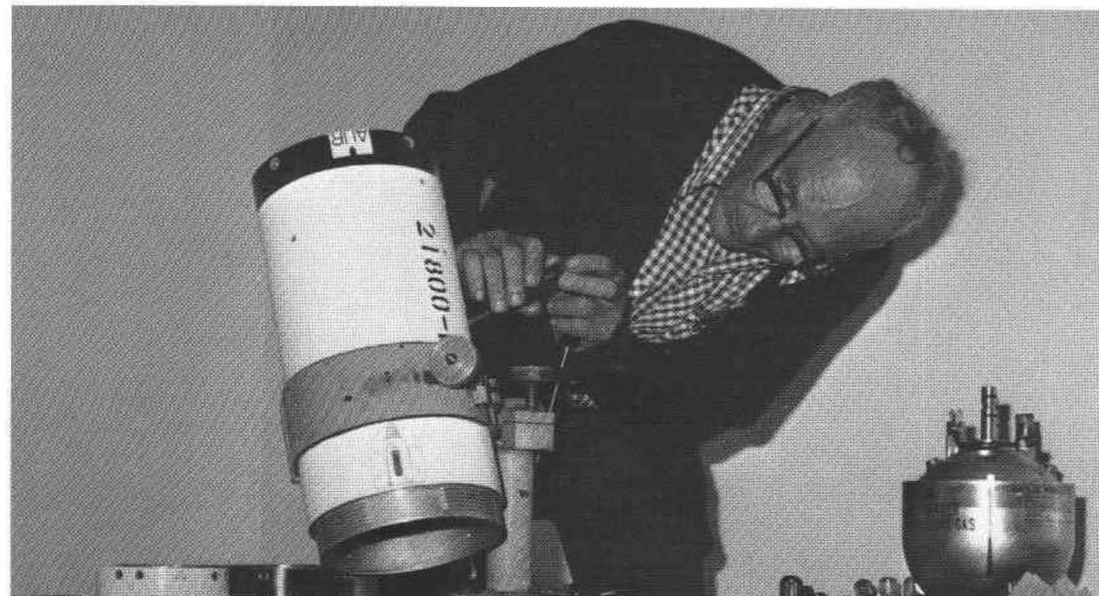


1

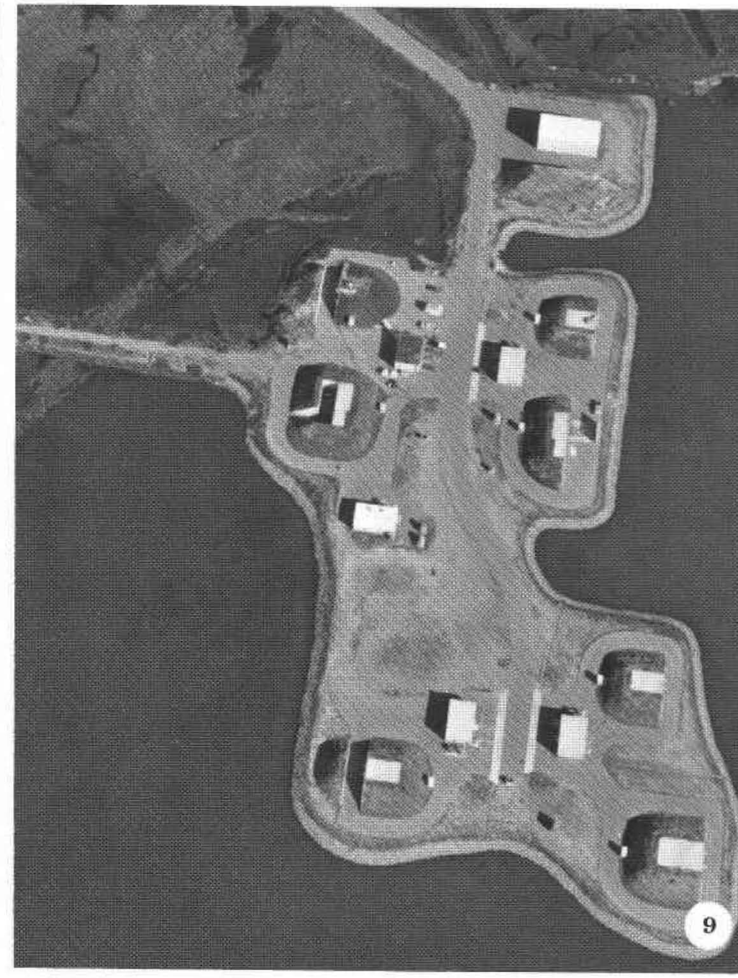
2

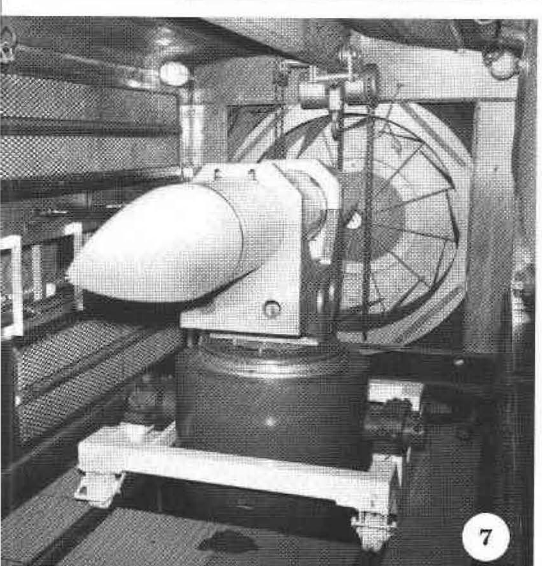
3

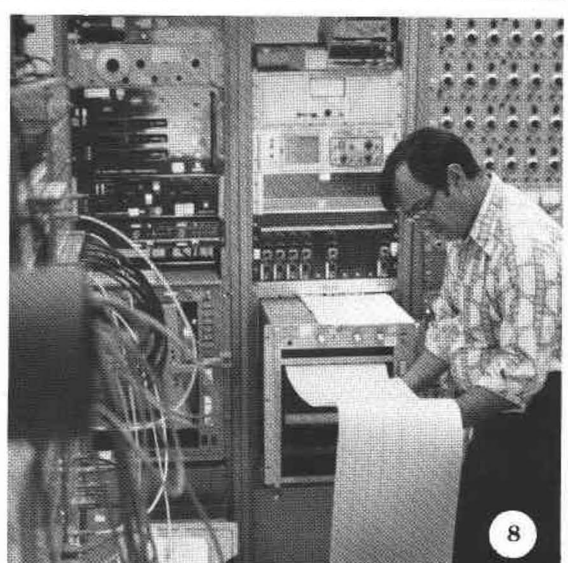
4



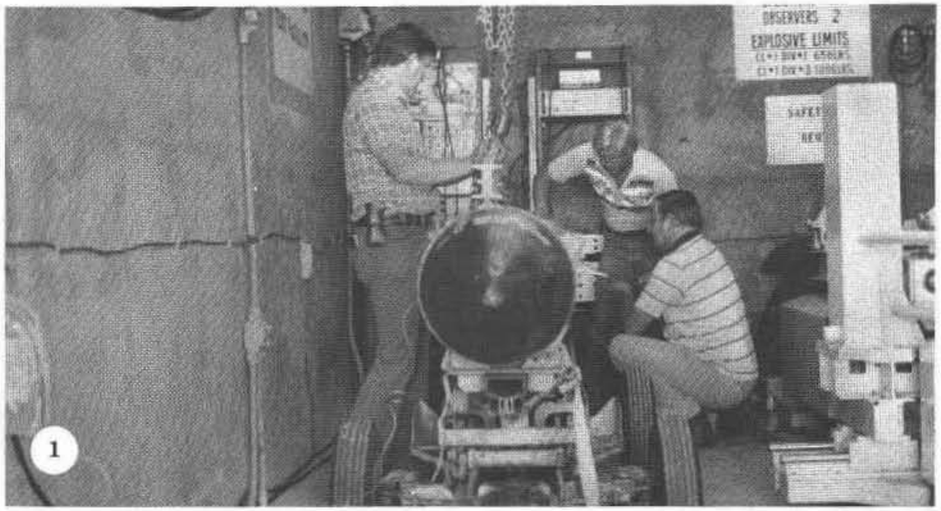
5

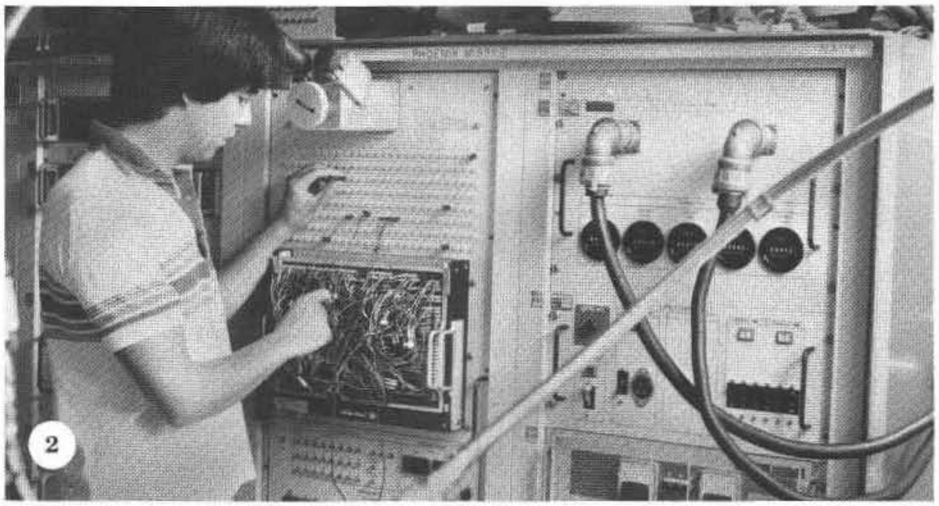




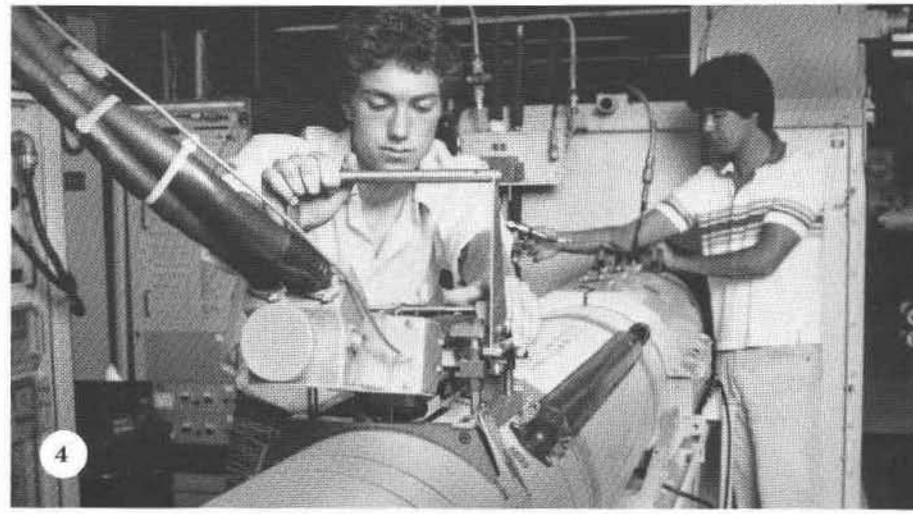


1. STANDARD missile seeker head protruding into anechoic chamber. 2. Preparing a BQM-34A target for launch at sea. 3. Calibrating an airborne jammer in the Countermeasures Electromagnetic Environment Lab. 4. Climatic hangar evaluation of F-14 Tomcat (1974). 5. Assembling a SPARROW missile at the Ready Missile Test Facility. 6. SIDEWINDER missiles in reverberant acoustic chamber during shaker test. 7. PHOENIX missile mounted on a vibrator inside the temperature-altitude-humidity chamber. 8. PATE Control Room with automated digital equipment for test control and data analysis. 9. Ready Missile Test Facility on an island in Mugu Lagoon.


1
OBSERVERS 2
EXPLOSIVE LIMITS

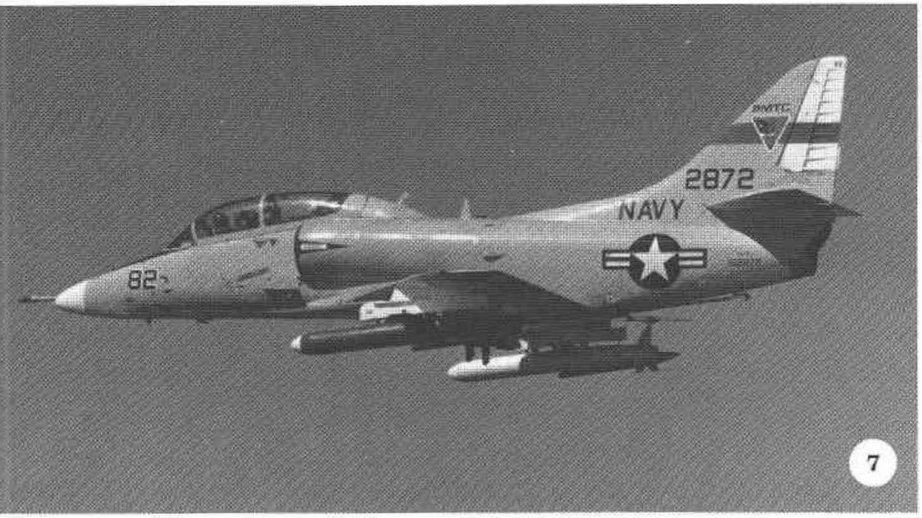

2

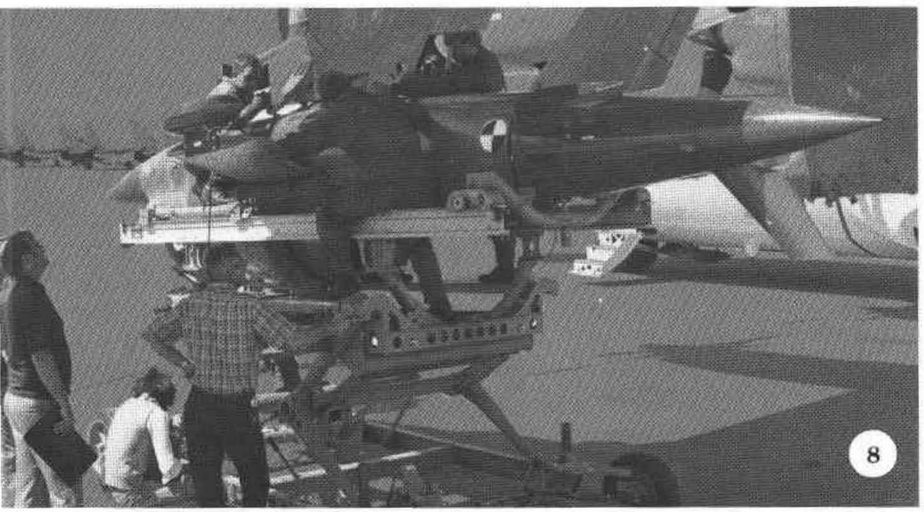

3

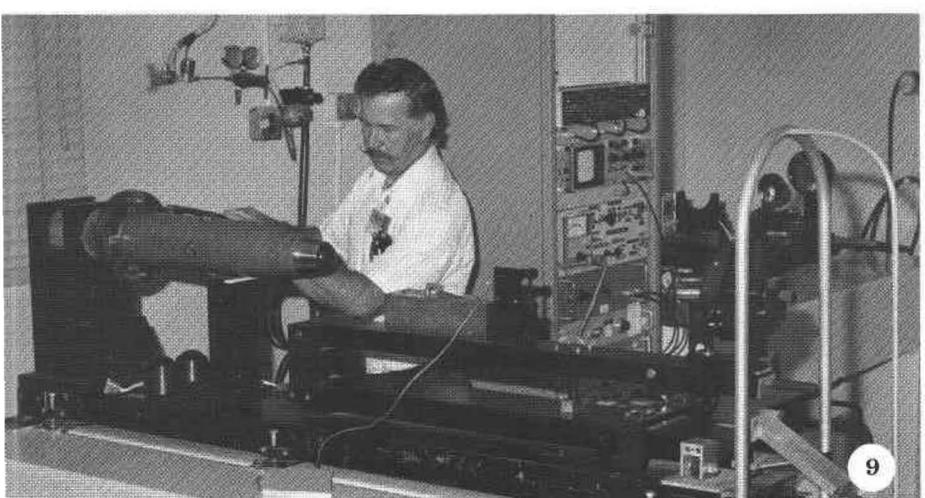

4

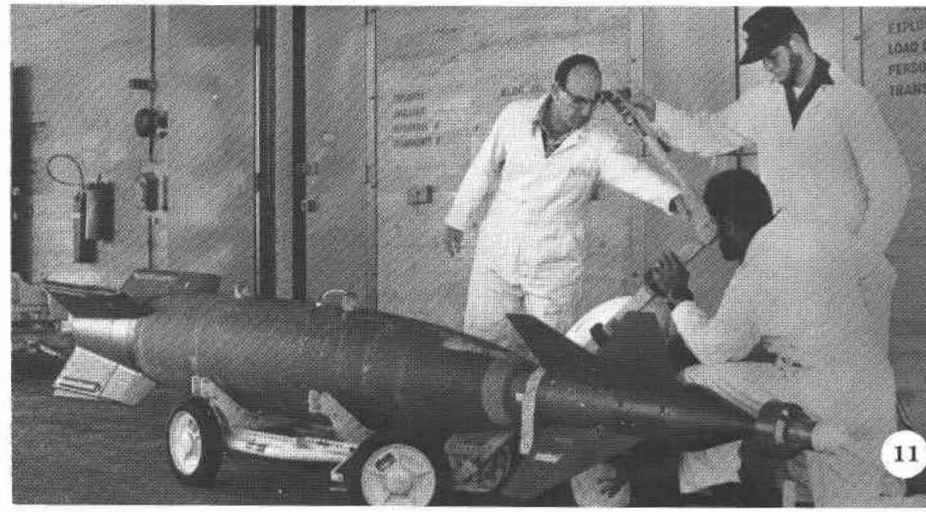

5


6









1. Positioning a missile for checkout in a functional test cell. 2. Checking out equipment for the PHOENIX missile at the Ready Missile Test Laboratory. 3. View from inside an anechoic chamber, Electronic Warfare Support Equipment and Systems Integration Engineering Lab, Point Mugu. 4. PATE Ready Missile Test Facility, Building 525, Point Mugu. 5. In-service engineering personnel providing on-site assistance to Fleet unit. 6. F-14A Tomcat aircraft with full armament display (1973). 7. TA-4J Skyhawk aircraft in flight with BQM-74C targets. 8. Make-ready of BQM-34S for low-altitude (below 200 feet) target operation (1977). 9. Production acceptance test and evaluation of a SIDEWINDER missile. 10. QF-4B Phantom aircraft target in flight. 11. In-service Engineering providing laser-guided bomb assembly assistance to Fleet.

STANDARD ACTIVE missile launch from USS HEEL (1973).

"Every generation adds . . . its own discoveries in a progression to which there seems no limit."

—Thomas Love Peacock

CHAPTER 20

CONTINUING TEST AND EVALUATION

As PMTC approached the decade of the eighties, the roster of missiles being tested at Point Mugu contained both new names and some that had been part of the Center for many years. In the latter category there were such missiles as SPARROW III, SIDEWINDER, SHRIKE, and STANDARD ARM. The fact that improved models of these weapons continued to be introduced to the Fleet bore witness to the soundness of their basic design concept and the continuing need for missiles.

SPARROW III/SKYFLASH

The testing performed on the SPARROW III in the late 1970's primarily involved evaluating modifications to the AIM-7F model, continued production missile reliability testing through the GLAT program, AIM-7E model rework testing, and planning and preparation for testing the newest model, the AIM-7M.

In 1978, PMTC, in conjunction with NWC and NAVAIR, initiated an in-depth Product Improvement Program (PIP) for the AIM-7F missile. The objective was to correct or improve design and operational deficiencies. The program spanned a three-year period and made use of not only PMTC's facilities and assets, but also those of Air Test and Evaluation Squadron FOUR and the U.S. Air Force Operational Test and Evalution Center. The captive flight portion of the program used specially instrumented missiles called "Goldenbirds," while the laboratory tests consisted of closed-loop simulations against a wide variety of targets. Six improved missiles were launched, and as a result of the PIP a decision was made to incorporate the changes into the production line missiles and retrofit existing AIM-7F missiles.

Another AIM-7F modification evaluated at Point Mugu involved an effort to find the solution to a wing flutter phenomenon occuring in the high Q (dynamic pressure) flight environment. The Center conducted extensive tests of both stainless and bronze-tipped wings.

In addition to performing missile test and evaluation, in 1978 and 1979 the engineers at PMTC developed a package that would simulate the interface signals between the AIM-7E/F missile and the F-4 or F-14 aircraft. This unit would reduce the need to carry actual missiles during tactical exercises and would aid in the detection of malfunctions. In 1979, two hundred simulators were delivered to the Fleet and an additional 800 more were ordered.

In 1978, the United Kingdom completed test and evaluation of the SKYFLASH, a SPARROW III missile modified with a monopulse guidance unit. This 22-launch program was supported by PMTC with a wide range of services: aircraft support, targets, range data reduction, laboratory simulations, missile build-up, and checkout.

As mentioned earlier, preparation for the SPARROW III AIM-7M monopulse missile test and evaluation began in 1978. The initial tests, performed to select the contractor, used monopulse guidance units installed in the AIM-7F missile. The evaluation included closed-loop simulations, captive carry, and free flight in a very difficult clutter environment. Beginning in 1978 and continuing into 1979, planning took place for the Contractor TECHEVAL and the Joint TECHEVAL. The first prototype missile was delivered in December 1979 for ground integration testing on the F-4 and F-14 aircraft.

The Contractor TECHEVAL of the AIM-7M and its sea-launched version, the RIM-7M, was conducted between January and August 1980. Numerous captive flights were made to evaluate the weapon in clear, clutter, and ECM environments. Four ship launches and seven air launches were completed. The Joint TECHEVAL was initiated in September 1980, and by the end of the year five ship launches and four air launches had been made. The Joint TECHEVAL on these two missiles was scheduled for completion the following year.

SIDEWINDER

SIDEWINDER programs at PMTC during the 1978 to 1980 period involved primarily a Logistic Engineering Improvement Program (LEIP) for the AIM-9G/H and the AIM-9M Joint TECHEVAL.

The AIM-9G/H LEIP, conducted in 1978, was a positive and constructive attempt to assist rework facilities in their efforts and to ensure that modifications and additions to the missile met appropriate Airborne Weapon Changes (AWC). The program included laboratory analysis, environmental simulations, and captive flights.

When the AIM-9M Joint TECHEVAL conducted by the Navy and the Air Force began on April 4, 1979, a series of background captive flights were already underway at NWC China Lake, California. Part of the Developmental Test phase, these tests were to determine the percentage improvement, if any, of the AIM-9M missile over the AIM-9L in respect to rejecting unwanted background signals, the ability of the missile to track low-level targets with a high line-of-sight rate, and the suitability of the audio cues. In 1980, a similar series of tests were conducted during an extensive captive flight program.

Of the eight missiles launched during the Joint TECHEVAL, six were successful. Six of the launches were made against flares with a desert background, and two were made without flares. The missile was released for full OPEVAL on August 16, 1980.

In the area of PATE, a Flight Test Simulation Facility for SIDEWINDER AIM-9L was completed and placed in operation in 1979. A mission profile was developed based on information from the Air Force Tactical Air Command and OPTEVFOR on missions and carrying aircraft. The results from several thousand hours of testing compared favorably with the results of flight testing.

SHRIKE

During 1978 and 1979, PMTC continued to provide GLAT on the SHRIKE AGM-45-9 and -10 missiles. GLAT involved extensive environmental simulation, captive flights, and laboratory tests. In 1980, the program was completed and planning was begun to convert SHRIKE equipment for use by the High Performance Anti-Radiation Missile (HARM).

Other SHRIKE missile involvement during this period was confined to monitoring and conducting an independent TECHEVAL of the launching of five SHRIKE BIAS missiles by Air Force crews at NWC China Lake, and participating in a PIP, both conducted in 1978.

STANDARD ARM

In order to evaluate a proposed armament design change for STANDARD ARM, two specifically configured AGM-78D-2 missiles were successfully launched in 1978 against the target ship hulk, ex-USS HISSEM. Also, in the same year, PMTC assisted the Air Force in the firing of two missiles from an F-4G fighter as part of the Follow-On Test and Evaluation (WILD WEASEL) program. Product improvement work in 1978 included upgrading a data package for the LAU-77B/A launcher, modification kits for the USAF LAU-80A/A launcher, and updating the missile container. In 1979, a fuze/armament system analysis was made based on flight tests of modified STANDARD ARM missiles against target ships.

AEGIS/STANDARD ARM

Between 1978 and 1980, PMTC provided substantial support to the AEGIS/STANDARD missile program in the areas of instrumentation development, ECM, and targets. The AEGIS/SM-2 was designed for surface ship defense against a variety of threats. The Center developed for the engineering program a micro-circuit telemetry system that was installed in the dorsal fin of the SM-2 missile and a wraparound antenna for the SM-1 missile. Laboratory simulations using the SM-1 guidance section were made to determine the effect of aluminum oxide from the booster motor on radome error slopes. The technique used a digital data acquisition system.

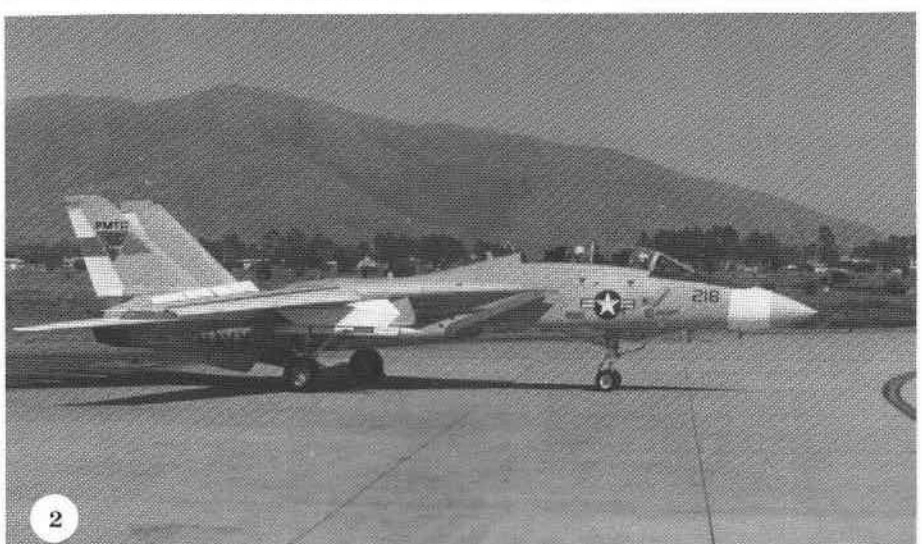
During the at-sea operations aboard USS NORTON SOUND in 1978, PMTC supported developmental tests and operational assessments. The highlight of the testing was the successful AEGIS/SM-2 versus HAST (High Altitude Supersonic Target) test program. Two HAST's were engaged in separate tests. PMTC also provided other targets and electronic warfare analysis, plus ECM modification pods. In addition to the USS NORTON SOUND support, CS/SM-2 OPEVAL's off of Puerto Rico were supported with targets and ECM.

FREQUENCY MANAGEMENT

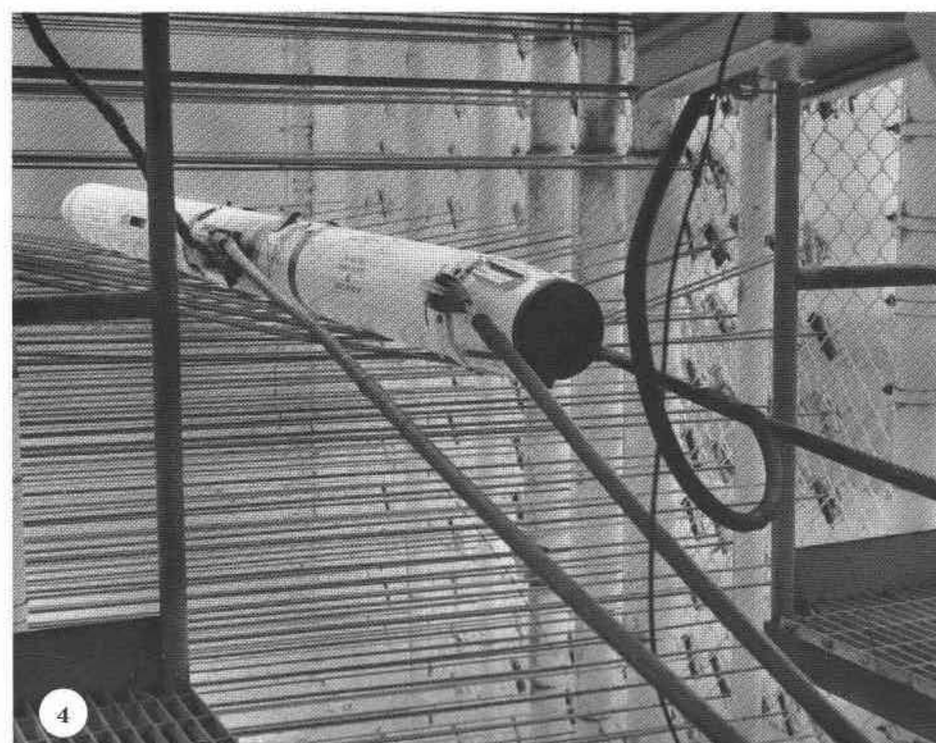
In 1977, the Frequency Management Division of PMTC was assigned another responsibility by the Chief of Naval Operations as the Navy Frequency Coordinator for the Western United States. It was also assigned management responsibility for the Naval Shore activities in the Eleventh, Twelfth, and Thirteenth Naval Districts.

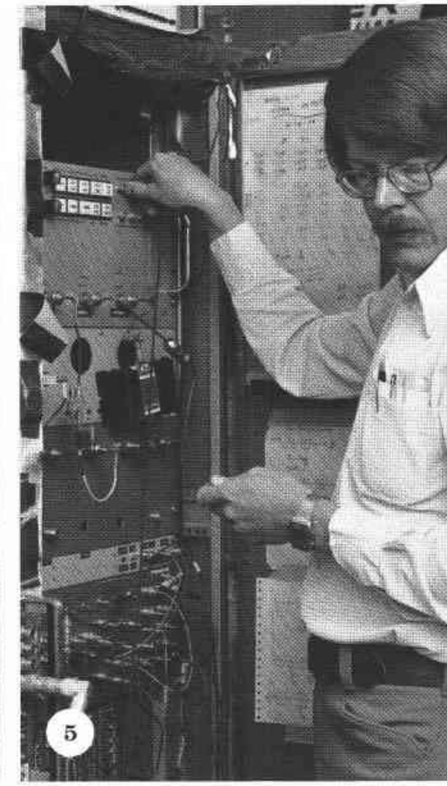
Antennas on Frequency Management Bldg., Point Mugu (1968).

1

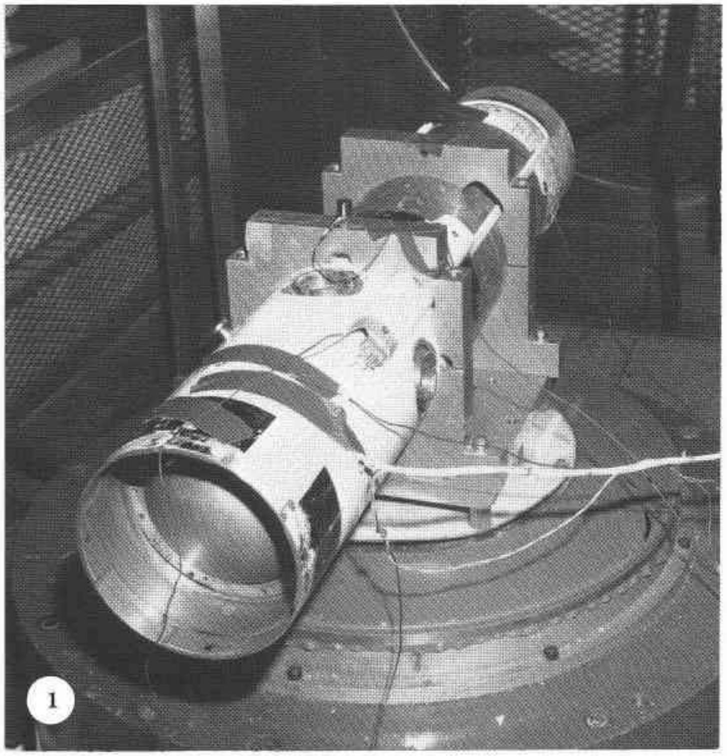

2

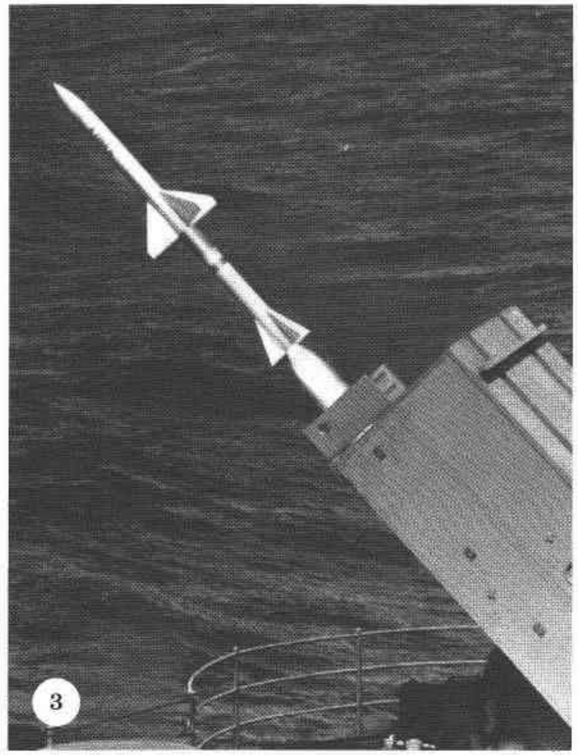

3

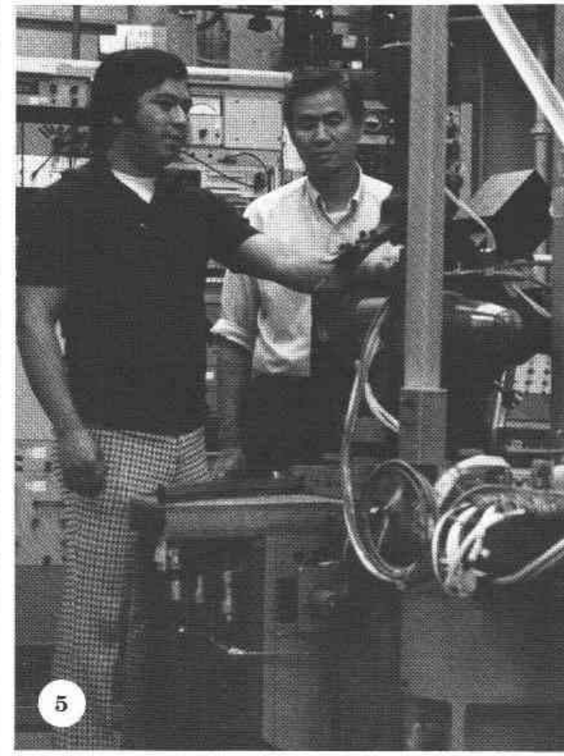

4

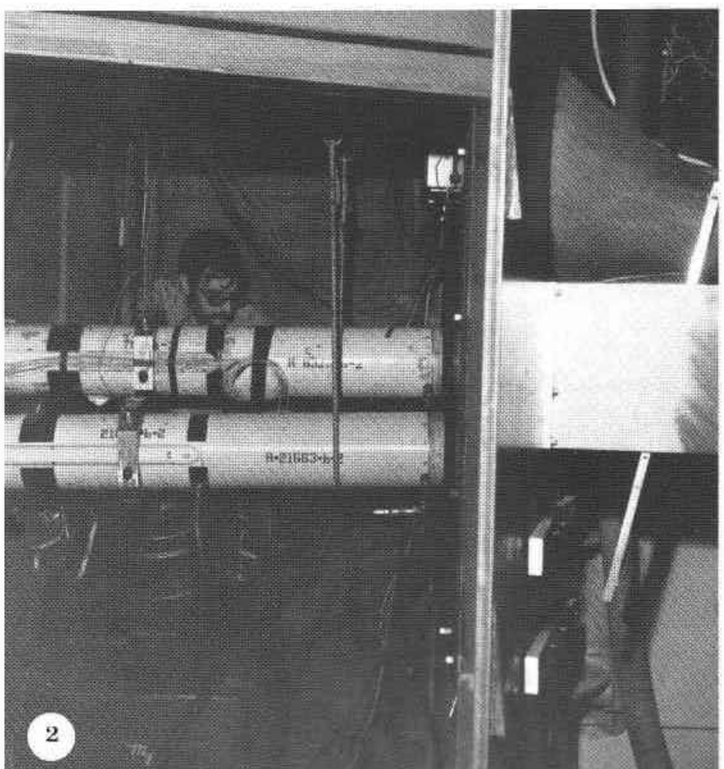

5

1. Setting up an F-4 aircraft for British SKYFLASH missile captive flight (1976). 2. F-14A Tomcat aircraft loaded with a SPARROW III AIM-7M monopulse missile. 3. NATO SEA SPARROW captured launch preparations getting underway (1974). 4. NATO SEA SPARROW after captured launch firing. 5. Target generator rack in SPARROW Missile Lab, Point Mugu. 6. Interface Console in SPARROW Missile Lab. 7. View from inside an anechoic chamber, SPARROW Missile Lab. 8. Reconfiguring the target horns for closed-loop testing in the SPARROW Missile Lab.

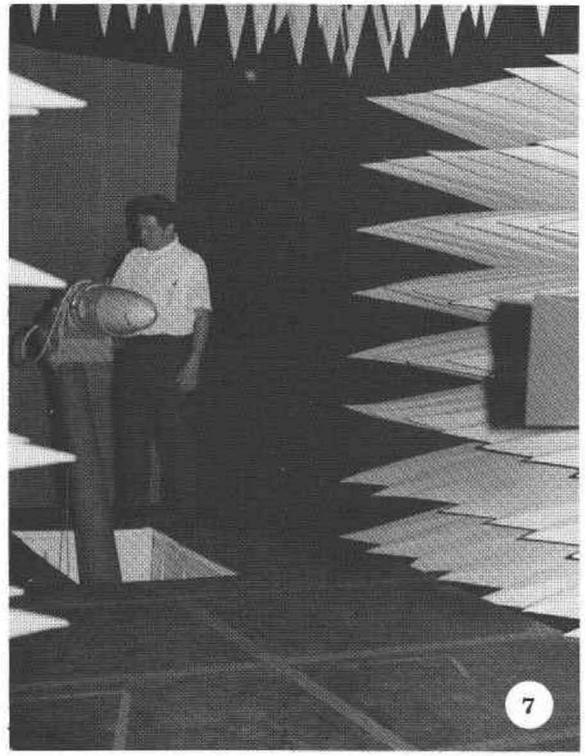

1


3

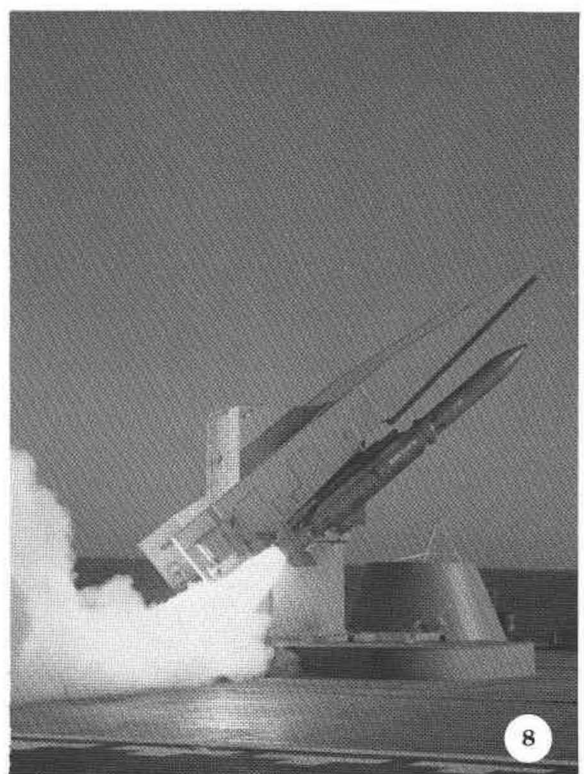

5


2

4



1. SPARROW missile section mounted in Environmental Chamber, Building 513 (1974). 2. Acoustic testing of SPARROW missiles in PATE Acoustic Chamber. 3. Firing of SEA SPARROW from USS NORTON SOUND's Mk 25 System Launcher (1968). 4. F-14 Tomcat firing SIDEWINDER missile (1973). 5. SIDEWINDER Missile Test Laboratory at Point Mugu. 6. SIDEWINDER missiles ready for loading on F-4 aircraft (1968). 7. SHRIKE missile homes on electronic radiation source during production test. 8. AEGIS Weapons System structural test firing from USS NORTON SOUND (1973). 9. First vertical launch from a U.S. Navy ship, the AEGIS/SM-2 missile launched from USS NORTON SOUND (1981). 10. Frequency Management Division personnel examining radio spectra chart.



HARPOON missile being launched from USS LEAHY (CG-16)

"We can only pay our debt to the past by putting the future in debt to ourselves."

—John Buchan

CHAPTER 21

PRESENT AND FUTURE

One of the purposes of any history and particularly a technical history is to show the influence of the past on the present and the way it prepares us for the future. Chapter 20 took a look at the almost continuous updating of missiles such as SPARROW III and SIDEWINDER that came aboard in the 1950's and 1960's. This chapter will take the next step and review newer weapon programs being conducted at PMTC. Some of these missiles will eventually replace existing weapons; for example, HARM will someday take the place of SHRIKE. Others will supplement the weapons in our arsenal or fill a need that did not previously exist. A few such as the High Energy Laser and, perhaps later, the direct particle beam weapons will exploit new and rapidly developing technology.

HARPOON

The Navy's antiship missile HARPOON project, which came aboard in 1971, had by the late 1970's already undergone extensive testing as part of the Contractor TECHEVAL and the Navy TECHEVAL. PMTC provided considerable support of the OPEVAL, which the missile reached in 1977. Thirteen HARPOON launches were made in the air/surface OPEVAL and the subsurface OPEVAL. Five of the missiles were launched from P-3C aircraft, five from the frigate USS GRAY (FF-1054), and three from the submarine USS PERMIT (SSN-594). Eleven of the missiles were equipped with telemetry sections and two with warheads. As a result of these firings, two ship target hulks were sunk (the ex-USS CUNNINGHAM and the FALGOUT), as were two QST-35 boat targets. The tests were to evaluate launch conditions, missile mode performance, and missile counter-countermeasures. OPEVAL launches were concluded on March 8, 1977.

Following Chief of Naval Operations review of the OPEVAL results and the status of other program elements, initial operational capability for the surface-launched HARPOON Weapon System was declared in October 1977.

Along with OPEVAL support, PMTC supported NAVAIRSYSCOM in two launches and 120 captive seeker flights conducted as part of the Block 1 guidance modification phase in the follow-on test and evaluation program. These modifications were changes made to the seeker and midcourse guidance in order to improve performance in countermeasure environments.

A significant milestone in HARPOON reliability testing was reached during 1977, with the installation of the HARPOON Missile Subsystem Test Set (MSTS) in the Product Reliability Test (PRT) facility, also completed in the same year. In 1978, PRT began testing missiles by subjecting them to simulated air carry and then periodic checks on the MSTS at the rate of one missile per month. In 1979, the MSTS was moved to the Ready Missile Test Facility so that the missile could be tested with warhead attached. Also that same year, PMTC software support for the MSTS made the transition from training/monitoring to active participation in updating and technical support.

Six launches and fifteen captive flights were made during 1978 as part of the OPEVAL of the Fiscal Year 1978 HARPOON Electronic Countermeasure Improvement Program. Also, in the same year, the Imaging Seeker Surface-to-Surface Missile Demonstration (ISSSMD) was successfully completed. The program demonstrated the operational ability of a missile composed of a HARPOON airframe, a CONDOR guidance section, and a WALLEYE data link. Three missiles were launched from the USS PEGASUS (PHM-1) as part of the demonstration.

Next, the HARPOON Imaging Infrared (IIR) seeker development program began in 1979 with seeker captive flights made at PMTC; Roosevelt Roads, Puerto Rico; and Vandenberg AFB. Flights were made over land and open ocean using targets of opportunity and small range ships provided by PMTC. The data collected was used to aid design refinements of seeker-detection, recognition, and acquisition techniques. The program was concluded in 1980.

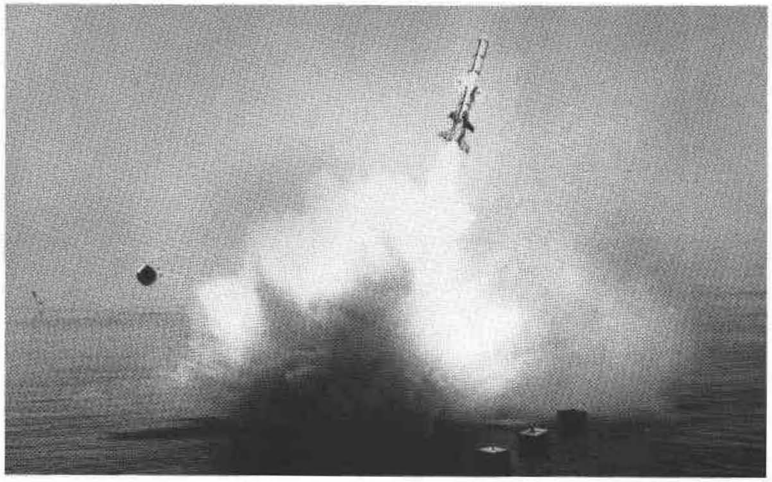
Another area of PMTC support for HARPOON was in Foreign Military Sales. In 1978, extensive planning was done for the Royal Navy (UK) Submarine HARPOON Program scheduled for development trials the following year. Also, PMTC participated in HARPOON in-country site surveys and weapon station technical reviews.

During 1979, PMTC supported the United Kingdom in the successful completion of the HARPOON development round trials phase. Eight missile firings were made from the Royal Navy submarine H.M.S. CHURCHILL between July and December. PMTC personnel traveled to Great Britain to provide engineering support to the air carry trials and to participate in planning the installation of Great Britain's HARPOON weapon station. Personnel also visited the Netherlands for HARPOON weapon station installation and checkout, and Australia and Japan for site surveys and preliminary planning.

Other HARPOON activities during the late 1970's included support for Fleet firings, testing of a proposed clutter detection modification, continued reliability testing, support to the HARPOON Improvement Program, and integration of the missile with the A-6 aircraft.

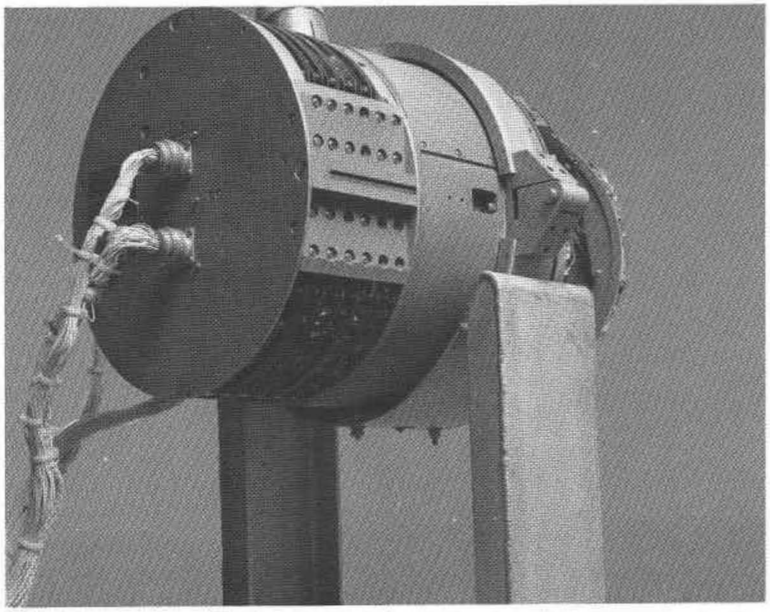
TOMAHAWK

On January 6, 1977, the Defense System Acquisition Review Council II (DSARC II) decision/approval was given



Underwater launch of HARPOON missile by submarine.

to proceed with TOMAHAWK Cruise Missile Full Scale Engineering Development (FSD). During the year, PMTC, as the lead test activity, provided flight test support for nine operations consisting of TOMAHAWK Land Attack Missile (TLAM) flights from San Clemente Island to Dugway Proving Ground, and TOMAHAWK Anti-Ship Missile (TASM) launches from a hydraulic torpedo tube launcher and an A-6 aircraft. Also, analytical model simulations were developed to the point where they could be used to predict preflight missile performance and perform postflight checks as required. PMTC was assigned the task of performing



Missile Guidance Set for HARPOON missile.

software configuration management planning for both versions of the TOMAHAWK. A Software Life Cycle Management Plan was prepared.

Full Scale Engineering Development continued during 1978 with ten TLAM firings, three TASM launches, and one TLAM captive flight. PMTC had a major role in planning, performing, and analyzing these tests and providing flight instrumentation, environmental qualification tests, electromagnetic vulnerability and compatibility tests, targets, simulations, and data management.

In the period 1978 through 1980, PMTC participated in a large number of TOMAHAWK firsts and milestones:

1978

First submarine launch of the TLAM

Designated data reduction center for TOMAHAWK survivability tests

Integration and checkout of the Santa Cruz Island Acoustic Range Facility (SCARF)

First flight of TOMAHAWK airfield attack missile

First launch from the ground-based Ship Motion Simulator

Configuration of the A-6 aircraft for carrying and launching TOMAHAWK

Development of a real-time telemetry system to provide selectable visual displays of instrumentation data in the aircraft, presented in engineering units.

PMTC engineers help design TRIDENT missile test system

1979

First vertical launch

First launch from SCARF

First land recovery of the TASM

First successful free-flight demonstration of the Passive Identification/Direction Finding Equipment in the TASM.

1980

First launch from four-cell Armored Box Launcher at Point Mugu

First Armored Box Launcher firing from USS MERRILL (DD-976)

First Ground Launch Cruise Missile mission at Utah Test Range

Last Contractor Test and Evaluation mission for the submarine-launched TASM.

Throughout this period, PMTC continued to conduct captive flights of the missile and A-3 seeker captive flights. In 1979, PMTC was assigned as the Software Support Activity for the TOMAHAWK Anti-Ship Missile.

TRIDENT

In 1977, PMTC began the initial phase of a technical capability development program in support of TRIDENT missile launches to be conducted in the Pacific. A major part of the Center's support was the construction of the PMTC Missile Tracking Facility, a computer, data processing, and telemetry center. The facility would provide real-time data processing for range safety, land-based telemetry, and destruct systems.

PMTC engineers were also involved in the design of the Pacific TRIDENT Missile Test Instrumentation System consisting of systems installed at Point Mugu, San Nicolas Island, and a large number of remote sites: aboard the Launch Support Ship, the Terminal Area Support Ship, and in the launch and impact areas. In 1980, integrated testing of the system began on schedule. Also that same year, final acceptance tests of the flight test support system were completed.

In support of TRIDENT missile launches off Cape Canaveral, Florida, PMTC provided the CAST GLANCE,

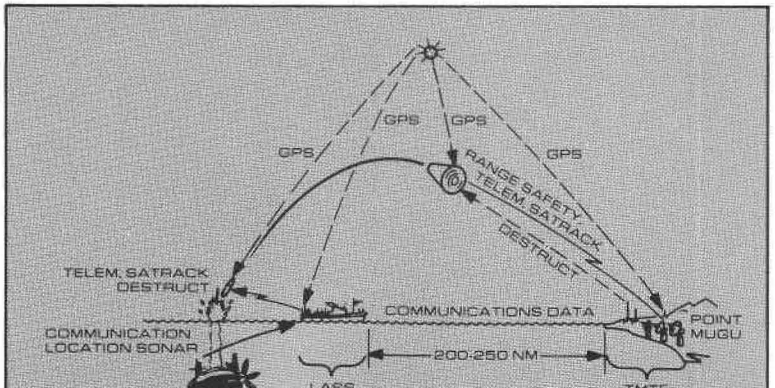
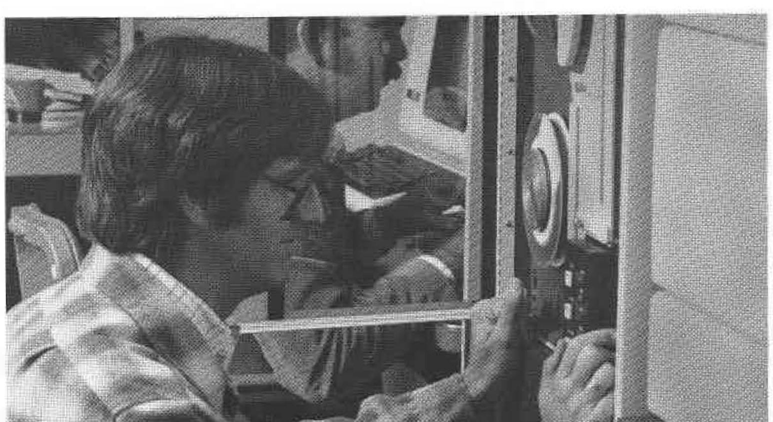


Diagram of TRIDENT Pacific Operational System.

an airborne stabilized optical system that permits high-quality photographic instrumentation from long range. In some TRIDENT launches, CAST GLANCE was above the cloud cover and was thus able to obtain photographic data unobtainable by ground-based optics.

AMRAAM

The Advanced Medium Range Air-to-Air Missile (AMRAAM) program at Point Mugu began in 1977 with PMTC assisting in developing the Test and Evaluation Master Plan (TEMP). The following year, the Center participated in the source selection process which would lead to two contractors developing the prototypes for Contractor Development Testing (CDT). Also, the negotiations for building an AMRAAM simulation laboratory were completed. By 1980, PMTC was preparing for the start of the CDT and work was continuing on the laboratory.



PDP-11/60 computer system in the AMRAAM Support Lab.

HARM

For the HARM project, PMTC supported contractor development tests in 1980 and prepared for the Navy TECHEVAL in the following year. HARM is a passive anti-radiation air-to-surface missile system to be used against radars in enemy ground defense complexes and radars aboard enemy ships. PMTC services provided in the Contractor Development Testing phase were test planning, range documentation and preparation, radar target acquisition, test conducting, and range support. A total of 10 captive flights and two launches were conducted.

ELECTRONIC WARFARE

Throughout the 1970's, along with testing some of the Navy's newest missiles, PMTC also continued to make significant contributions in the field of electronic warfare. Briefly, these included engineering support for the integration, installation, and interfacing of EW equipment in tactical aircraft; the design and development of specialized devices; performance evaluations; software support; threat simulation device development and evaluation; product improvement; in-service engineering for EW ground support equipment; command and control-related radar and communications systems evaluation; and support for Foreign Military Sales.

Representative of the work performed to simulate enemy countermeasures was the development by PMTC of the AN/DLQ-3B set used to evaluate the electronic counter-countermeasure capabilities of our weapon systems. The AN/DLQ-3B was originally designed for installation in the unmanned BQM-34S/T target, but later adapted to full-size aerial targets. Based on this experience, engineers at PMTC realized that the countermeasures set could be flown on manned aircraft for operations where missiles would not be fired and for EW operator training.

The result of this was the development of the pod-mounted AN/ALQ-167 which is physically and electrically compatible with most Navy aircraft. It was also found that the AN/DLQ-3B could be used in the laboratory for weapon system development and test and evaluation. Both the Air Force and Army have joined the Navy in using the countermeasures set, and the Center now provides support to all three services in the development of procurement packages, integration test and development, reliability and maintainability evaluation, and pod certification/safety demonstration procedures.

EA-6B SOFTWARE

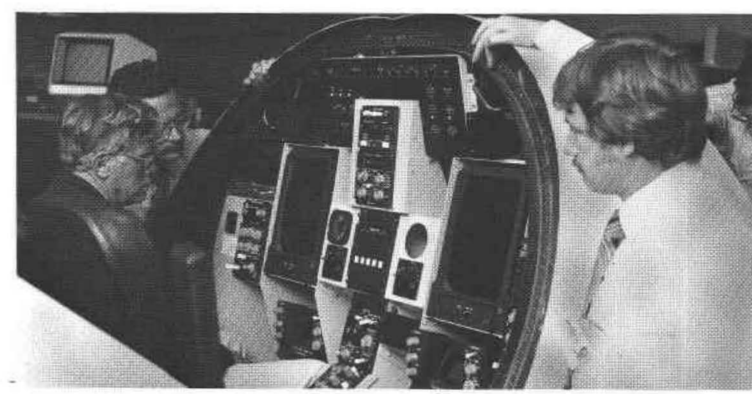
With the growth of EW has come the need for software computer programs to operate various devices and ground test equipment. PMTC has been actively involved in several software programs, one of the most extensive being the work performed on the EA-6B Prowler aircraft. As the designated software support activity for the EA-6B Operational Flight Program, the Center prepared and implemented the Software Life Cycle Management Plan and developed and fabricated a complete Weapon System Support Laboratory. The laboratory, completed in June 1980, contains a cockpit mockup with system hardware interfaced with a tactical environment generator. It permits design and verification of EA-6B software and will later provide for weapon system integration testing.

A major EA-6B software effort in the late 1970's was the Improved Capability Program (ICAP) in which the Center provided effort for mission planning, ECM technical evaluation, ECM exciter design, and the tactical flight program. In 1980, PMTC was assigned the software design/in-service support for ICAP.

The EA-6B weapon system laboratory was also used for development of the EA-6B Memory Loader Verifier (MLV). As the lead activity for the MLV since 1977, the Center, in 1980, developed two major software programs to enable aircraft technicians to fault-isolate EA-6B computer systems on the flight deck.

TACTICAL SOFTWARE

In the area of tactical aircraft and weapon system software support, PMTC has rapidly increased its participation. For example, as the F-14 Software Support Activity, the Center has assumed responsibility throughout the weapon systems's life for not only the software used in the aircraft but also that used in the trainer and automatic Ground



Cockpit mockup in EA-6B Weapon System Support Lab.

Support Equipment (GSE). This support starts with early computer feasibility studies and contractor evaluations and then extends through configuration management during use in the Fleet.

In August 1979, PMTC achieved a major milestone in F-14 software development when Tape 111C/P7C was released to the Fleet. The tape had approximately 400 functional software revisions and enhancements designed into it, and the design affected nearly 40,000 orders. To produce the tape, 189 test procedures were developed and approximately 1,000 laboratory tests were conducted in the F-14 SITS.

ELECTRO-OPTICAL

During the 1970's, PMTC pursued a variety of electro-optical programs. One of these, mentioned earlier as part of TRIDENT support, was the stabilized photographic system named CAST GLANCE. Designed and developed by the Center, CAST GLANCE also supported TOMAHAWK, HARPOON, High Energy Laser, and Fleet intelligence. A major test event in the program was the first CAST GLANCE II test flight in a P-3 aircraft on April 12, 1979. The flight was an outstanding success. Since that time, the system has been installed in the C-130 aircraft and aboard an LST for surface vessel use.

Prototype of CAST GLANCE Camera System (1979).

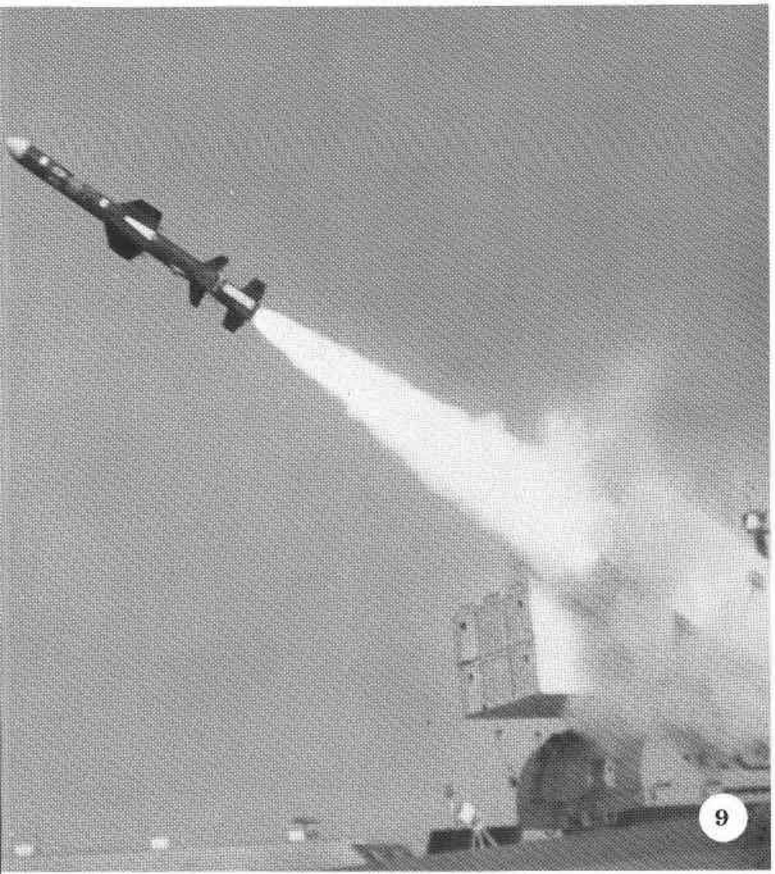
In the development of high energy lasers, the Center participated in the Damage and Vulnerability Field Test Program (D&V IV) conducted at the TRW Capistrano Test Site near San Clemente, California, during 1978. Participation involved turbojet engine damage experiments, using the J-69 engine, and photo instrumentation. In 1979 and 1980, emphasis was on designing a series of experiments for a major test program in 1981. Test samples were prepared and specialized test equipment was developed.

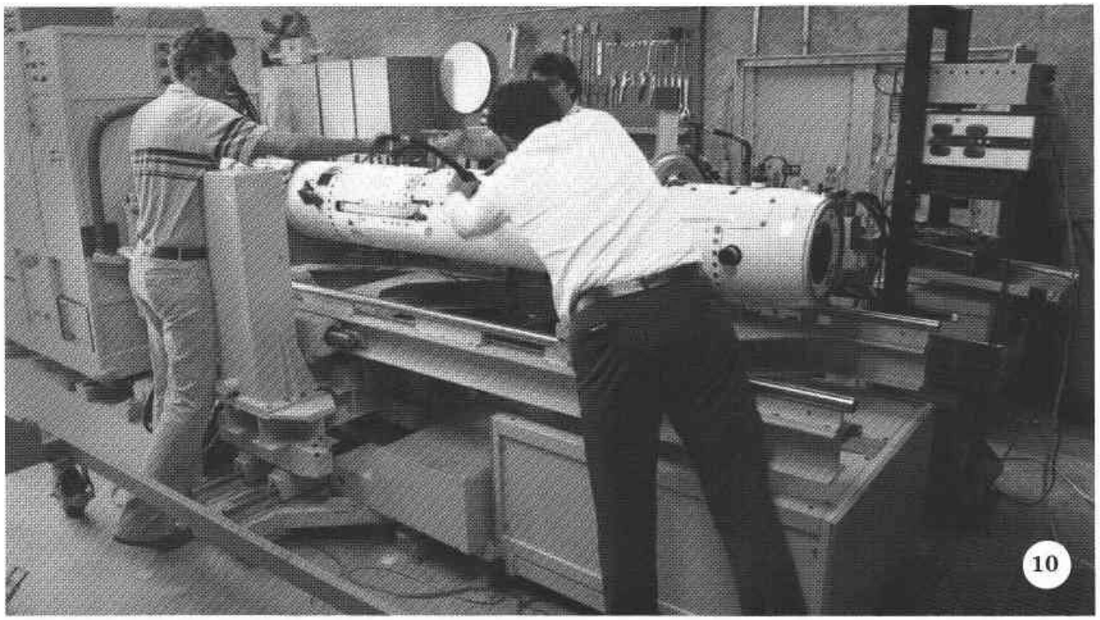
In 1980, PMTC also conducted operations for the Joint Air Force/Navy Airborne Laser Laboratory project. These included a series of practice scenarios to establish range procedures and to checkout the Airborne Laser Laboratory in a marine environment.

Another important area of laser technology was determining the laser threat to Navy aircraft. The data derived from studies at PMTC will be helpful in developing a laser warning system.

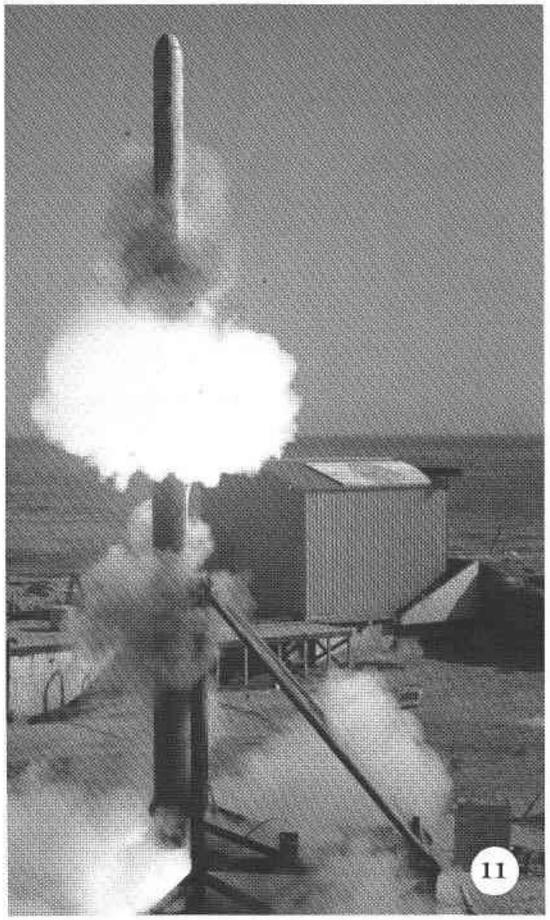
Other areas of electro-optics activity include infrared and ultraviolet warning receivers, countermeasures support, F-14 Television Sight Unit support, the Multi-optical Reconnaissance Pod, optical signature measurement, the Airborne Turret Infrared Measurement System (ATIMS) miss distance indicator development, and the Tactical Aircraft Passive Warning Receiver.


1
2
3
4
5
HARPOON
6
7
JA
NAVY
8



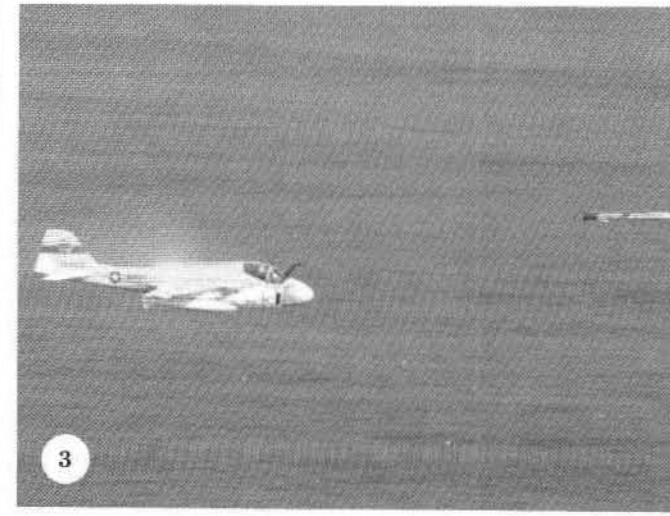


1. HARPOON missile impact on QST-35 SEPTAR. 2. HARPOON missile impacting on QST-35 SEPTAR. 3. HARPOON missile direct hit on QST-35 SEPTAR. 4. HARPOON Guided Missile Seeker Unit on test stand. 5. HARPOON Missile Lab equipment used in seeker performance testing. 6. HARPOON turbojet random vibration test equipment (1974). 7. HARPOON missile shortly after launch from P-3 aircraft. 8. Loading ASROC missile into launcher as part of Project HARPOON (1972). 9. HARPOON launch from ASROC launcher at Pad BAKER (1972). 10. HARPOON missile on PATE test cell at Point Mugu. 11. First vertical launch of TOMAHAWK missile from an experimental vertical launcher. 12. Launch of TOMAHAWK missile from armored box-launcher aboard USS MERRILL.




1

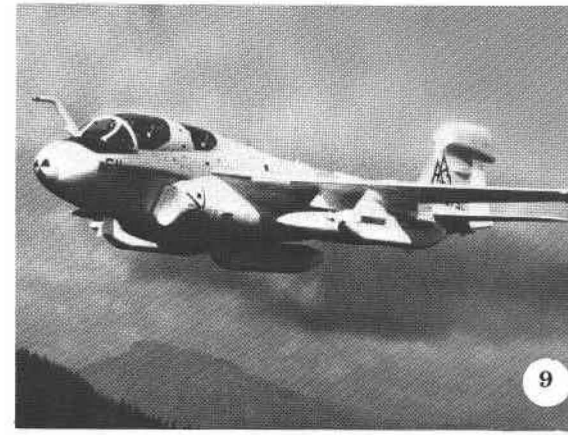

2

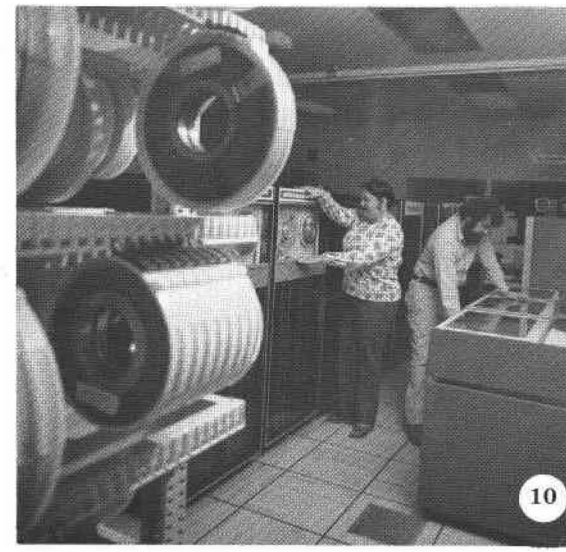

3


4

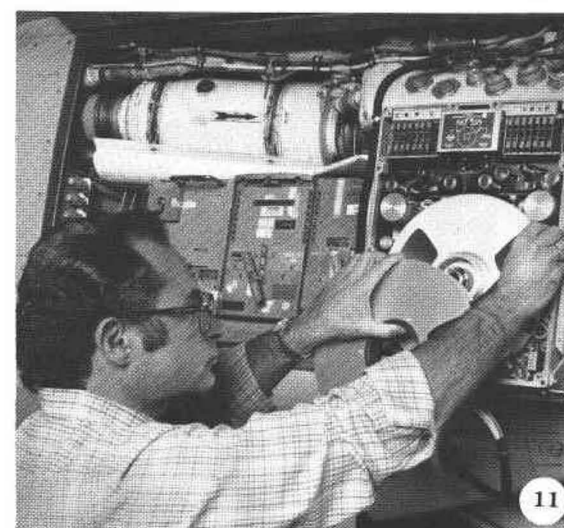

10
5


6





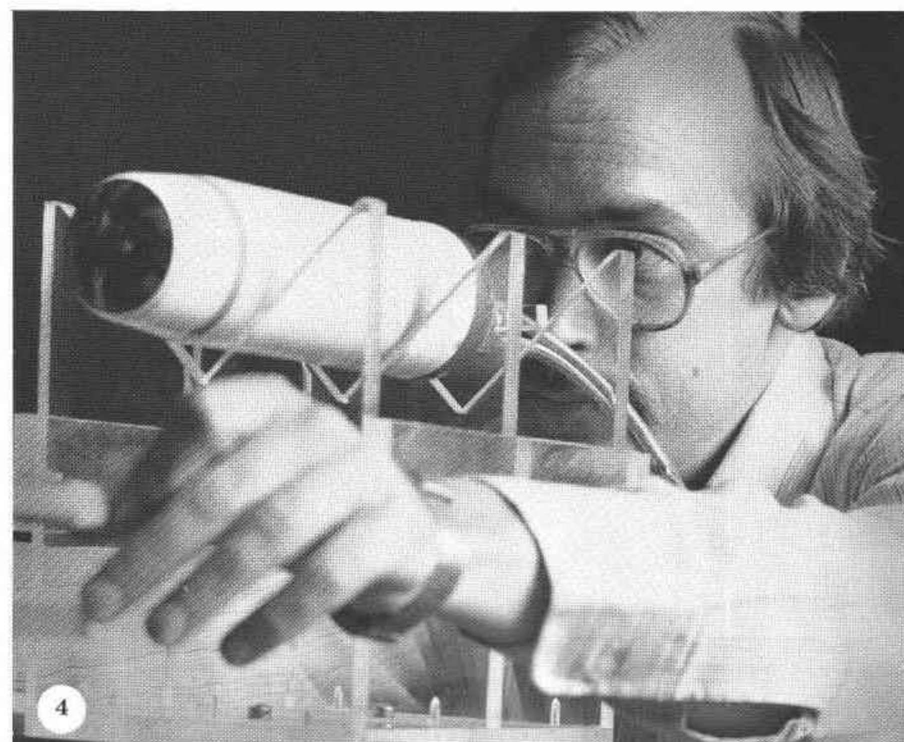
1. Tube launch of TOMAHAWK missile at Pad BAKER, Point Mugu. 2. Submarine launch of a TOMAHAWK antiship missile. 3. TOMAHAWK missile and A-6 chase aircraft in flight. 4. An ocean recovery of TOMAHAWK missile. 5. H-46 helicopter retrieving TOMAHAWK missile off Point Mugu. 6. Setting up for a simulation in the TOMAHAWK Laboratory. 7. DLQ-3 MACE electronic countermeasures pod on wing of A-6 aircraft. 8. Electronic warfare equipment readied for installation in nose of an A-3 Skywarrior. 9. EA-6B aircraft for Navy tactical support jamming. 10. Operating the XDS-560 computer in the Software Support Laboratory. 11. F-14/PHOENIX Quick Look Data Station instrumentation on F-14A aircraft.

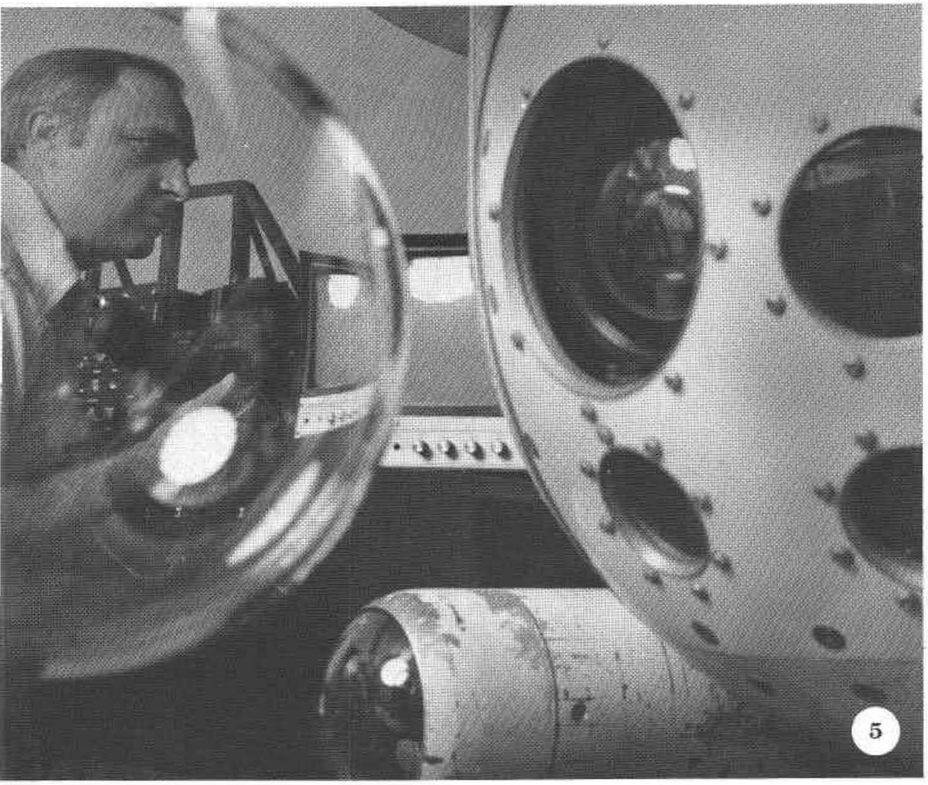



1

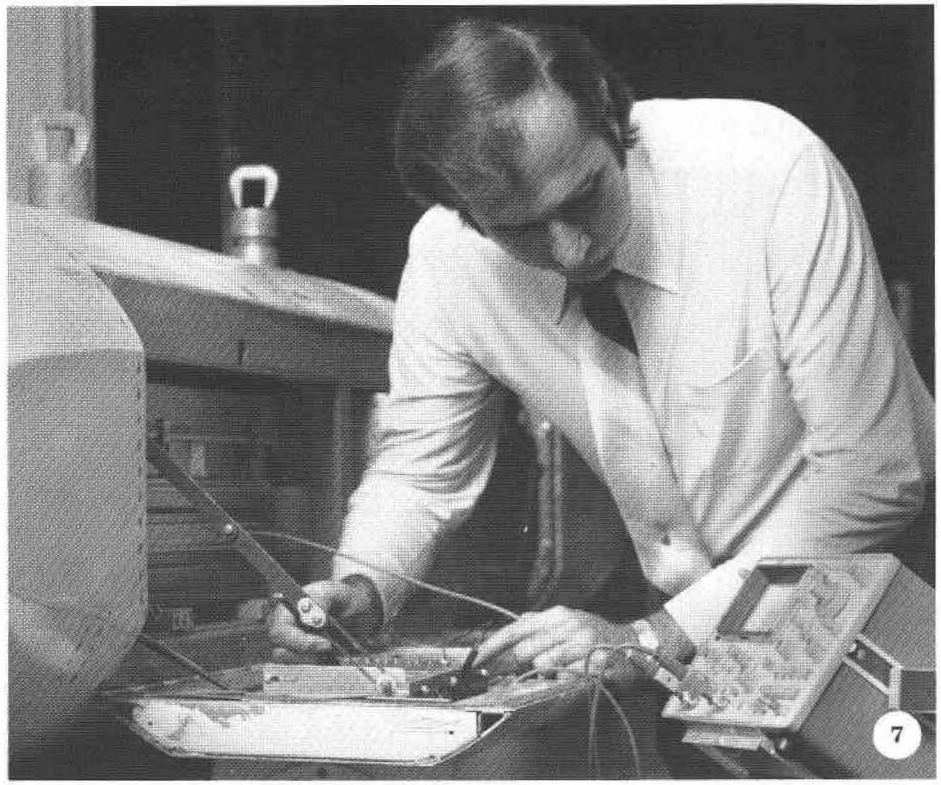

2


3

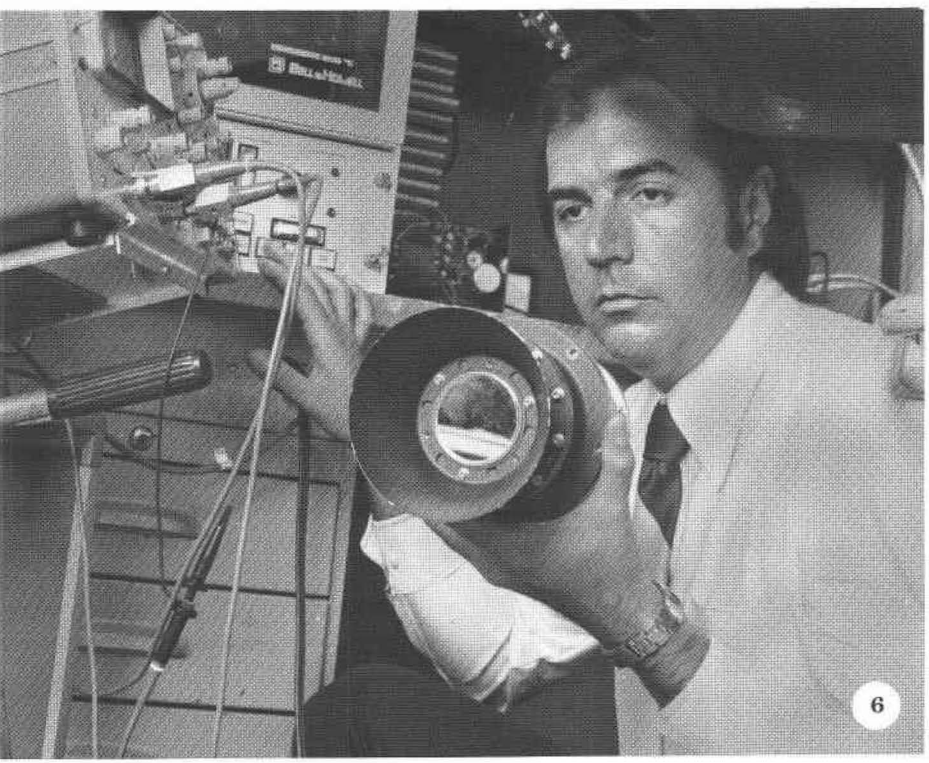

4



5



7



6

1. Hybrid computer simulation system which generates the environment for F-14 SITS simulator. 2. Weapon Control Officer's Station in the F-14 SITS mockup. 3. Underside of F-4J Phantom II aircraft equipped with Airborne Turret Infrared Measurement System II. 4. Aligning an electro-optical missile tracking system on PMTC-designed rate table. 5. Operating the PMTC-fabricated Airborne Turret Infrared Measurement System II. 6. AN/AAR-46 Missile Warning Receiver for use on helicopters. 7. High Speed Special Instrumentation Pod built by PMTC for evaluation of seekers and jammers in an air-to-air environment.

Range Operations Building, Pt. Mugu

"... and would you realize what Progress is, call it Tomorrow."

—Victor Hugo

CHAPTER 22

BUILDING FOR THE FUTURE

To some readers, the XM-1 powder launcher and the F-14 Systems Integration Test Station may seem technologically worlds apart. Yet in a very real sense they are similar in that they serve a similar purpose—testing a weapon to evaluate its performance. Thirty-five years have elapsed since the first LOON missile thundered across the beach at Point Mugu, and it is quite possible that by the time another 35 years have rolled by, some future historian will consider everything accomplished until now as only a prologue to later achievements.

Although the future can be only dimly glimpsed, there are still good indications of the path that test and evaluation will follow, at least for the next few years. Consequently, PMTC has initiated or completed several facility improvement programs designed to meet expected test and evaluation and Fleet needs throughout the 1980's and 1990's. No one can predict the weapons that new technology may spawn in the years ahead; yet, for those we can foresee, PMTC is making preparations.

CCMP

In 1977, PMTC established the Computer Centralization and Modernization Program (CCMP) to centrally locate and update all range data processing capabilities. This program would provide four systems—a Central Computer System, an integrated and automated real-time Telemetry Data Handling System, a Range Instrumentation Interface System, and an advanced software system.

By 1978, the Phase I CCMP Cyber 175 computer mainframe and related equipment had been accepted and time-sharing support started. Also, the Phase II Cyber 175 mainframe, peripheral, and remote equipment, plus the telemetry handling system and real-time graphics system, had been delivered and were undergoing on-site development and integration.

On August 29, 1979, the CCMP hardware and software began the 30-day Standard of Performance testing. The system met a reliability factor of better than 90 percent for all subsystems. Between March and June 1980, the entire CCMP system was relocated to a new permanent facility.

BSURE

Ever since World War I, when submarines became a potent offensive weapon, antisubmarine warfare has been a very critical part of the Navy's defense role. To help develop antisubmarine warfare weapons and tactics, PMTC in 1967 completed the underwater range at Barking Sands, Kauai, Hawaii. However, as useful as this range proved to be, by the early 1970's it was evident that a much larger tactical underwater range was needed to permit Fleet exercises using weapons and tactics in a "free play" environment.

To instrument a range of the size and depth contemplated was a formidable challenge and one that would require a new approach. Whereas the original underwater range used bottom-mounted hydrophones connected to the near shore by individual cables, it was evident from the beginning that this approach was impractical for a range 20 times larger.

Therefore, PMTC engineers in the Barking Sands Underwater Range Expansion (BSURE) program elected to use a new concept—spacing multiple hydrophones along just two cables as an "in-line" system. To provide the desired coverage of 1,000 square miles, each cable would be about 65 miles long with 16 hydrophones on each string.

In order to use this vastly expanded instrumentation, a new type of tracking known as binary phase coding would be employed. In this system, target identification, ping sequence, and depth information would be encoded in the signal by reversing the phase of the signal frequency. On-shore equipment would convert this phase reversal to binary "1's" and "0's" for digital processing, resulting in accurate vehicle location.

The BSURE project, as might be imagined, required far more than simply laying two cables, difficult as this was in itself. It meant designing and fabricating devices never built before: building an electronic housing that could withstand extreme pressures; developing pingers for targets, torpedoes, and vehicles; and producing the on-shore equipment to process the signals. Each of these tasks involved hundreds of smaller jobs, many of which were performed simultaneously in order to meet the schedule dictated by the availability of the CS LONG LINES, one of the few ships capable of laying the cable strings.

Phase I of the project (design/development) began in December 1973. A major design consideration was the watertight enclosure or pressure vessel that would protect the sensitive electronics at depths as great at 16,000 feet. Complicating the picture was the fact that the pressure vessel had to be compatible with the cable laying engine on the CS LONG LINES. The latter problem was solved by placing the pressure vessel and the hydrophone in a fiberglass cocoon. The cocoon would pass through the cable laying engine and then open to deploy the hydrophone. Extensive tests of the pressure vessel, cocoon, and hydrophone were made in the laboratory, aboard the CS LONG LINES, and in the open ocean.

Phase II involved the actual fabrication of the underwater hardware, the pingers, and the on-shore data processing equipment. The in-water hardware, since it would be almost as inaccessible as in outer space, actually was manufactured using many space technology techniques.

Cable and hydrophone installation began on September 21, 1976. "A"-cable laying experienced no problems, but during the laying of "B"-cable problems developed and three hydrophones were removed, slightly reducing the size of the range. During subsequent operation, several other hydrophones went dead due to a cable connection problem, further reducing the instrumented area. Nevertheless, the active area remaining proved more than adequate for the desired Fleet exercises which would include ships, submarines, and aircraft.

On August 1, 1979, a major improvement to BSURE was undertaken when a contract was awarded for an underwater communication system. This system consisted of two dual-band bottom-mounted projectors located such that voice communications would be possible between range operations conductors and all submerged exercise participants, over the entire underwater range. The system was designed to be fully compatible with Fleet underwater communication systems that were already in existence.

BUILDING 333

Dedicated in May of 1972, Building 333, the Threat Simulation Facility, was built to provide a central facility for the Targets Directorate. At the time of completion, the target organization consisted of three divisions, and two of the divisions—Missile Targets and Aircraft Targets—moved into the 76,000-square-foot building, while Surface Targets remained at Port Hueneme.

Building 333, which consists of high-bay hangars for targets such as the QF-4 and a low-bay hangar for missile targets, has adjacent shops and laboratories that are used for developing target auxiliary systems. The second deck of the building houses the engineering and administrative offices of the Targets Directorate.

Building 333 still serves as headquarters for the Targets Directorate even though the Directorate, now consisting of five divisions, has outgrown the building. Three Butler-type buildings have been built near Building 333 to house some of the overflow. Target activities are also carried on in four other buildings at various locations at PMTC.

BUILDING 7020

On April 16, 1981, a groundbreaking ceremony took place on the Point Mugu beach for building number 7020, the Missile/Weapon System Support Center. On January 11, 1983, Undersecretary of Defense for Research and Engineering Richard D. DeLauer, Ph.D., dedicated the completed project. The building was conceived to accommodate part of the burgeoning electronic warfare activity at PMTC.

Laboratories in the building have advanced the state of the art of methods for designing and testing software for digital computers embedded in aircraft, missiles, and trainers. Presently, the building is utilized to develop, test, evaluate, and document software for the EA-6B aircraft, F-14 training devices, Tactical EA-6B Mission Support System, Tactical Electronic Reconnaissance Processing and Evaluation System, and AMRAAM. Also, the added capabilities provided by Building 7020 have helped PMTC to become NAVAIR's "right arm" for EW systems DT&E.

METEOR

The effectiveness of a shipboard defensive weapon system depends to a large extent on its ability to accurately and quickly detect an enemy threat. Accomplishing this end with electro-optical target acquisition systems, however, can be complicated by environmental factors. An illustration of the unexpected effect of the environment comes from World War II when a U.S.-developed bomb sight was tested in the relatively clear atmosphere of North America, only to prove less effective in the cloudy skies of Europe.

To obtain basic marine environmental data and help evaluate electro-optical devices under near at-sea conditions, PMTC established the Marine Environment Testing of Electro-Optical Radiation (METEOR) Range on the northwest tip of San Nicolas Island. This location provided an environment relatively unaffected by the land mass/sea interface and surf action. It offered a wide range of climatic conditions, and the northwest winds sweeping the island produced conditions similar to those surrounding a ship at sea.

PMTC installed four transmissometers at the METEOR Range to study infrared transmission characteristics over water paths of 4 kilometers and 2.6 kilometers, while at the same time gathering macro- and micro-meteorological data over or near the same paths for later correlation analysis and model development.

Representative work performed at METEOR included two Optical Signature Programs (OSP) conducted in 1977 and 1978, in which government contractors and agencies measured infrared signatures of liquid and solid rockets, aircraft, and surface ships. A number of prototype electro-optical shipboard devices were also evaluated.

During the OSP III program, 180 flyovers were made, 30 rockets launched, and four bomb drops conducted. There was also a BQM-34A target presentation and a tracking operation on the USS CHICAGO. Other experiments performed concurrently and subsequently to the Optical Signature Programs would help to characterize the range as representing a true marine environment.

EXTENDED AREA TEST SYSTEM

The Extended Area Test System (EATS) was developed in 1975 to accommodate the test and evaluation of longer range missiles and reduce the problem of offshore oil well drilling encroachment on the existing range. It extended PMTC's instrumentation into the open ocean area 250 nautical miles seaward of San Nicolas Island.

EATS can provide over-the-horizon tracking, telemetry data collection, target control, and UHF communication relay for a large number of exercise participants. It also allows relatively unrestricted "free play" for weapon system evaluation and Fleet training. At the time of this writing, development and implementation of EATS was still in progress.

In 1977, the emphasis was primarily on design and the building and testing of engineering models of tracking system components. Studies were completed which indicated that EATS would operate at its selected frequency without adversely affecting other in-band or near-band users. Also, wind tunnel tests were conducted on the P-3A aircraft to determine if installation of the telemetry data collection system would affect the aircraft's flying qualities.

Design and engineering model building continued into 1978, and the factory demonstration of the tracking system was accomplished between October and December. Preparation for shipment of the hardware to Point Mugu commenced in the last week of 1978. Tracking demonstrations were made using the A-6 aircraft, which was tracked solidly at a distance of 130 nautical miles from the Master Operations Control Station (MOCS) located at that time in San Diego.

In 1979, the EATS tracking ground stations (eight ground reference stations, one ground interrogation station, and the Master Operations Control Station) were moved to their respective locations on the PMTC Sea Test Range. Initial tests and checkout of the complete tracking system continued through the year. The initial installation of the tracking subsystem in the EATS P-3 aircraft (redesignated EP-3A) was accomplished and the first EATS Airborne Instrumentation Station arrived at PMTC for test and evaluation in August.

Intersite ranging tests were also conducted in 1979 between the EATS MOCS at Point Mugu and ground stations on San Nicolas, Santa Cruz, Santa Rosa, and San Clemente Islands, and Hondo Ridge, Vandenberg AFB, to determine the stability of the tracking system and to establish the various signal paths between the sites.

During 1980, as part of the on-site checkout and tests, tracking exercises were conducted using the instrumentation packages installed on civilian light aircraft. All environmental and flight qualifications of the airborne instrumentation packages and the Airborne Instrumentation Station tracking equipment were successfully completed. Formal on-site demonstrations were begun in August, and by the end of the year the formal testing was 90 percent complete, with only the full dynamic tests remaining. Government acceptance testing was also underway.

MOBILE SEA RANGE

Each year since 1977, PMTC has supported Fleet Readiness Exercises that utilized the Mobile Sea Range (MSR). This support encompassed modifying targets and providing the personnel to launch and control them during an operation. Also, the Center participated in developing new targets and a target control system.

The MSR is an outgrowth of a Chief of Naval Operations directive to investigate establishing an Anti-Ship Missile Defense Test Range. It gives Fleet Commanders the capability to conduct free-moving air defense missile firing exercises in a realistic open-ocean environment. Also, the range provides the ability to control and analyze the exercises.

The MSR development program was divided into four phases. Phase I involved developing and demonstrating a system whereby the BQM-34 target drone could lock onto the TACAN air navigation channel of a ship and fly a simulated cruise missile profile against it. Phase II would add Air Combat Patrols to the exercise and, for efficiency and safety, a Cooperative Data Collection System and a lower cost target drone, the BQM-74C. Phase III would expand the MSR by including antisubmarine warfare, while Phase IV would provide for a full "free play," three-dimensional, war-at-sea scenario between opposing forces.

OPERATION CONTROL

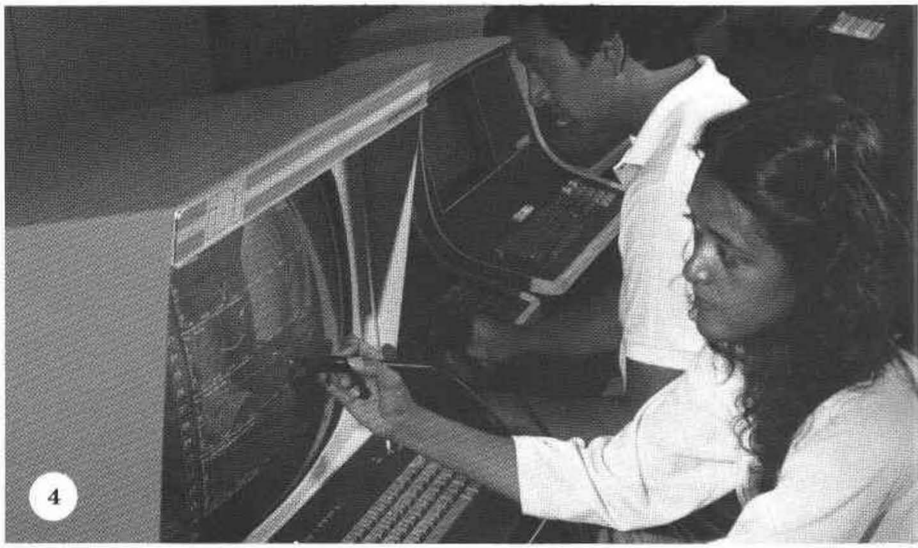
In the late 1970's, operational control and display capability took a giant step with the construction of the Range Display and Control Center (RDCC). It was designed to provide real-time data presentations for a multiple number of tests and test parameters. Employing current computer technology, the RDCC allowed the interoperation of related data from many sources: planned operation scenarios and parameters, telemetry, tracking radar, surveillance radar, and the interactive display of the information on both cathode ray tubes and large projection screen displays.

METRIC TRACKING RADAR

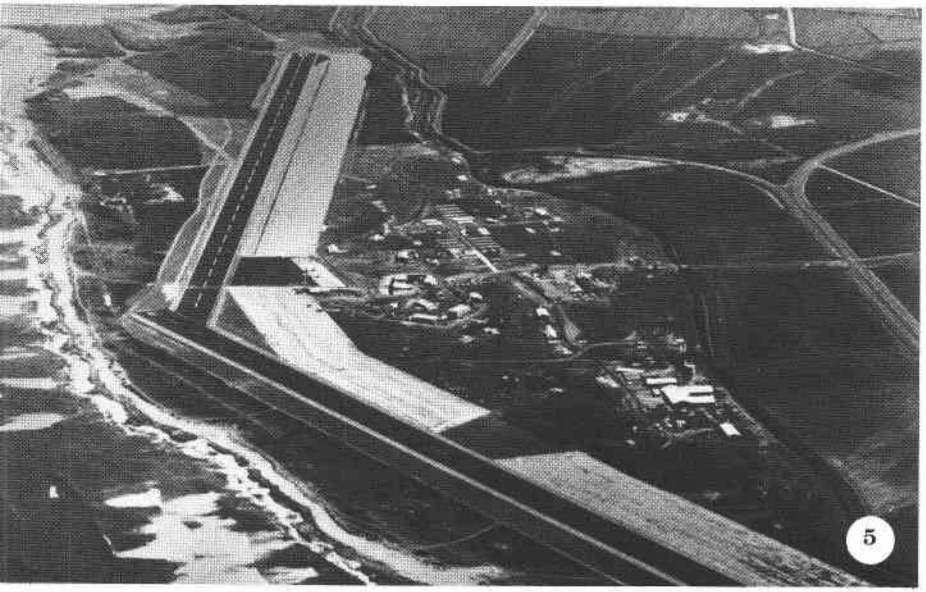
Future metric tracking radar plans at PMTC include implementing two AN/FPQ-17 radars at Point Mugu and San Nicolas Island. These radars, on which PMTC is presently conducting test and evaluation, are phased array instruments which provide multiple object tracking with a single radar. The FPQ-17 will track up to sixteen targets simultaneously with performance comparable to that of the current FPS-16 radar.

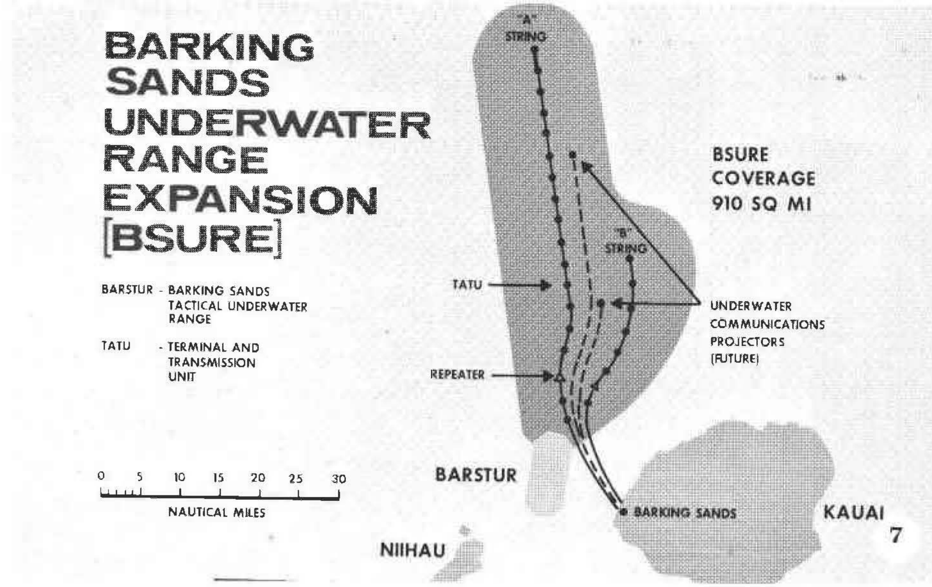
SCHEDULING

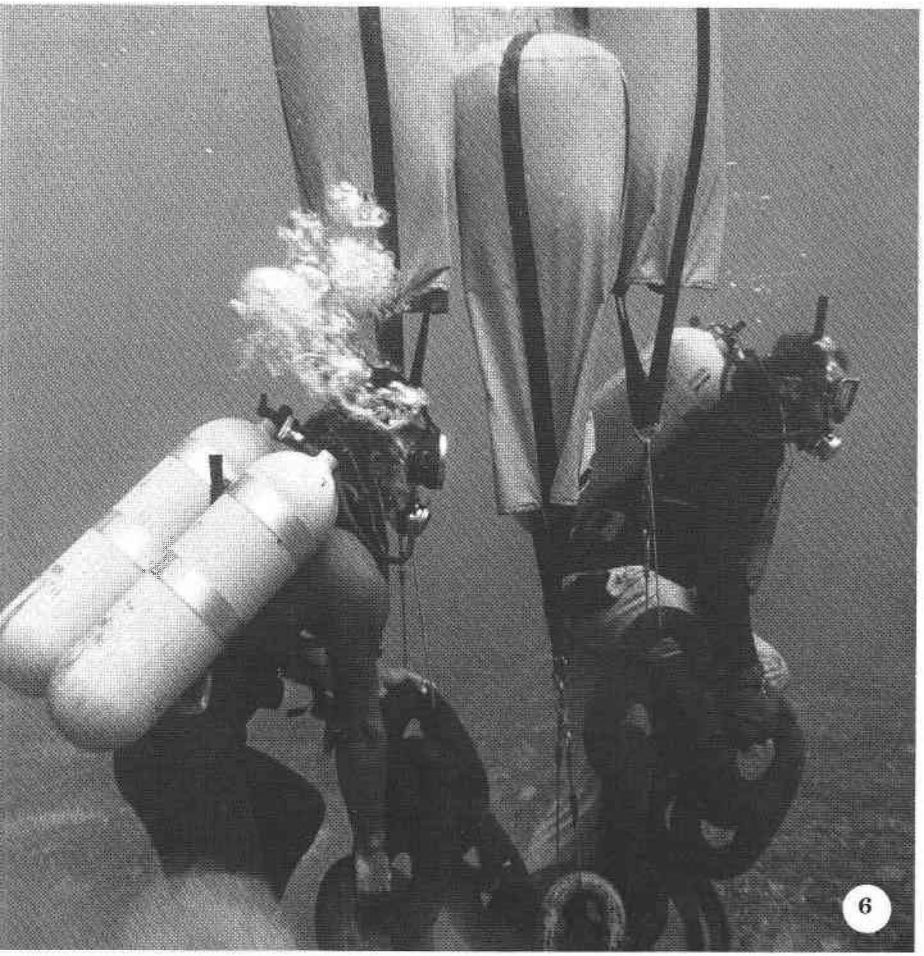
In the early 1980's, range scheduling acquired the new Range Operations Automatic Scheduling and Information System (ROASIS) which uses a Cyber 175 computer. A new data base was created and punched cards were no longer used. Cathode ray tube terminals were employed for all inputs and resume purposes.

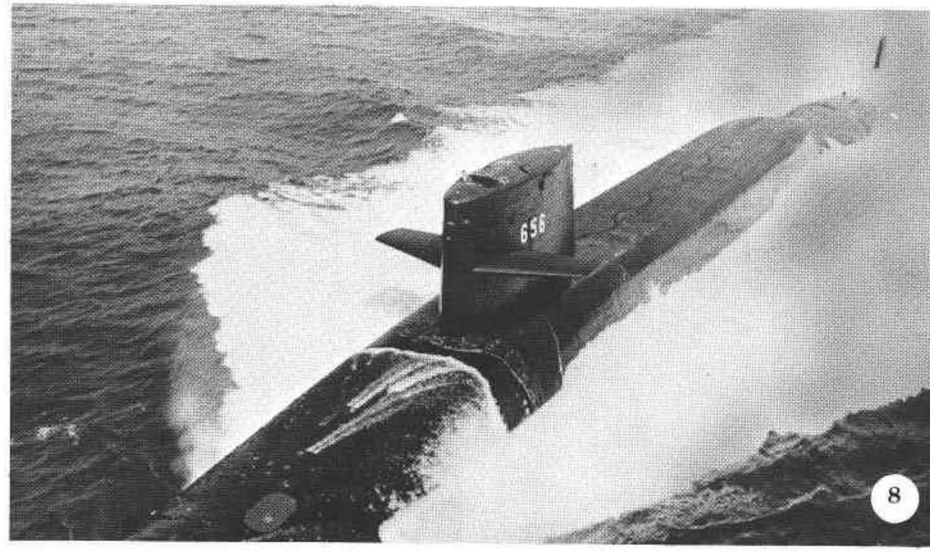


1. Cyber 175 computer, part of the Computer Centralization and Modernization Program (CCMP). 2. Telemetry Data Handling System equipment in Cyber Center. 3. Computers in new Range Data Processing Center (CCMP), Building 53 (1982). 4. Test data analyst controlling test data display. 5. Pacific Missile Range Facility (PMRF), Barking Sands, Kauai, Hawaii. 6. Underwater cable salvage project at PMRF (1970). 7. PMRF hydrophone array, largest underwater tracking system in the world. 8. Submarine SSBN-656 GEORGE WASHINGTON CARVER. 9. UH-3A helicopter loaded with MK-30 underwater mobile target.

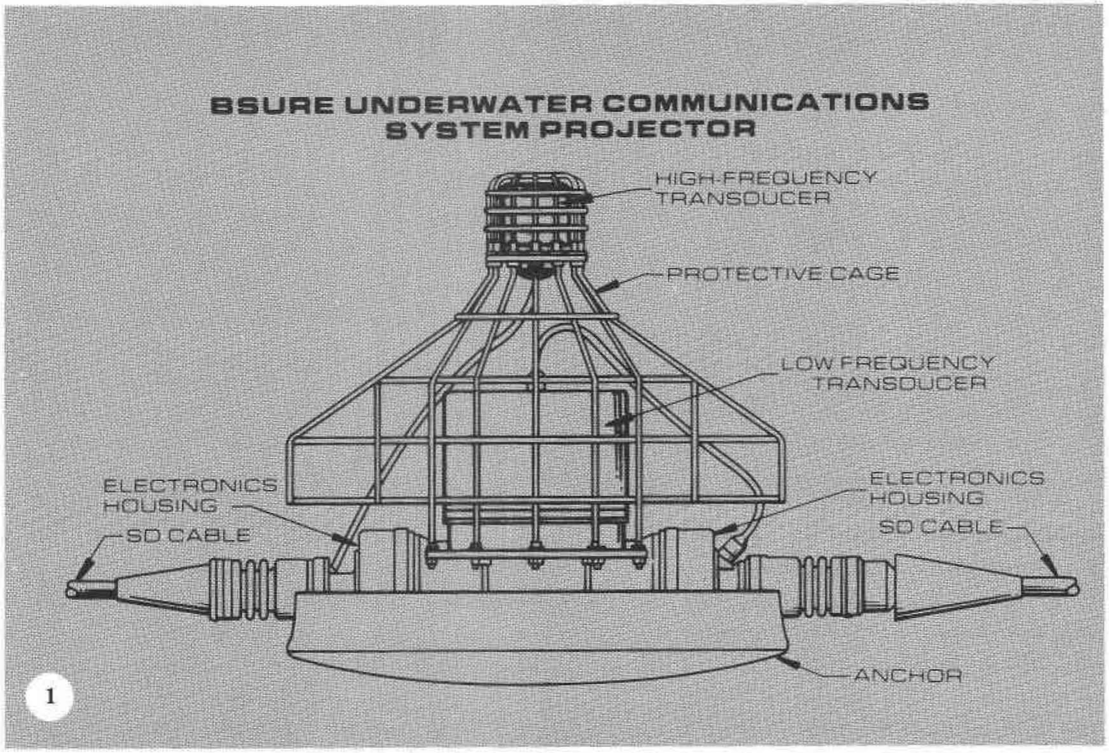

5


BARKING SANDS UNDERWATER RANGE EXPANSION [BSURE]
BARSTUR - BARKING SANDS TACTICAL UNDERWATER RANGE
TATU - TERMINAL AND TRANSMISSION UNIT
0 5 10 15 20 25 30
NAUTICAL MILES
"A" STRING
"B" STRING
BSURE COVERAGE 910 SQ MI
TATU
REPEATER
UNDERWATER COMMUNICATIONS PROJECTORS (FUTURE)
BARSTUR
BARKING SANDS
KAUAI
NIIHAU
7

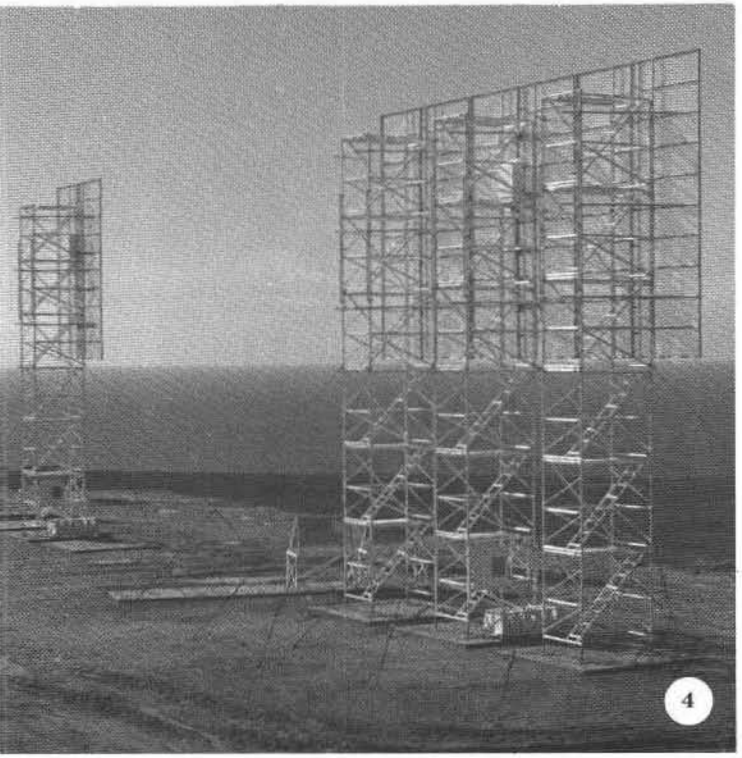

6


656
8


NAVY
NAS POINT MUGU
7141
9



1. Underwater communications projectors for communications to submarines on PMRF underwater range. 2. Technical Cooperation Program personnel visiting METEOR Range site, San Nicolas Island. 3. Aerial view of San Nicolas Island looking southeast from approximately 35,000 feet. 4. Extended Area Test System (EATS) remote antennas at San Nicolas Island. 5. EATS Master Operations Control computers, Building 53, Point Mugu (1982). 6. EATS P-3 aircraft with phased array antenna. 7. Preparing for first flight test of EATS aircraft instrumentation package.

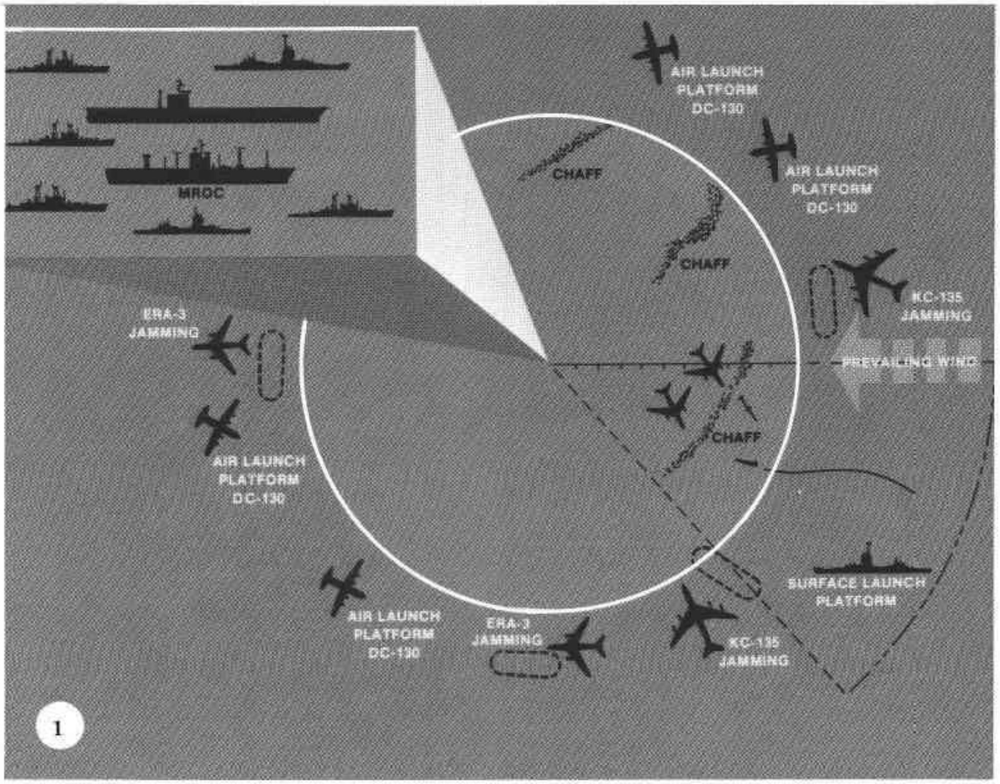


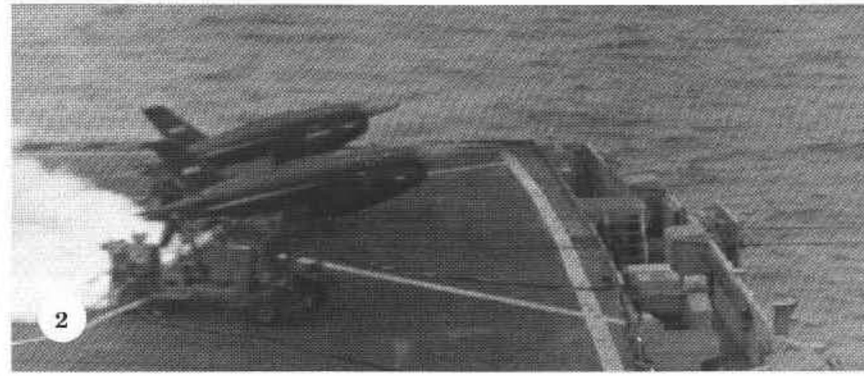
4

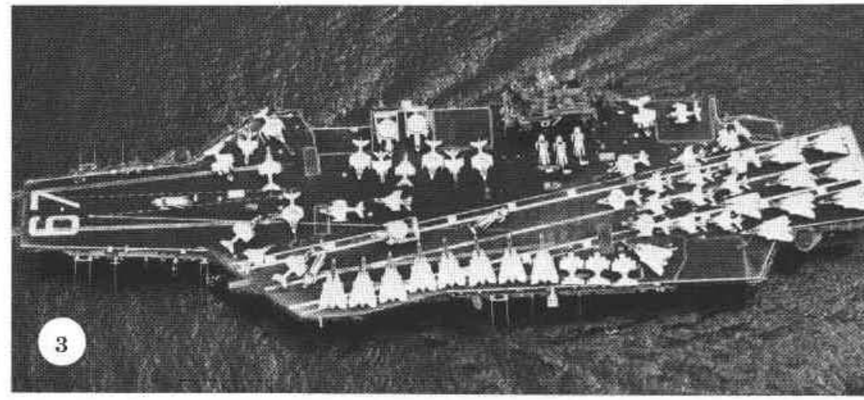
5

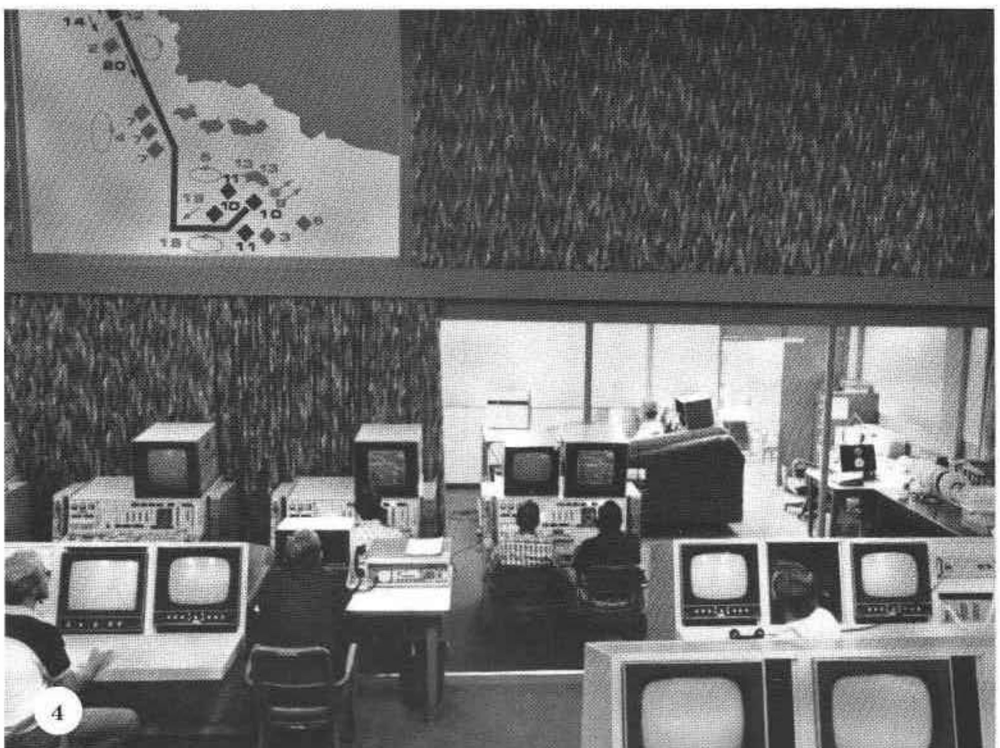
6

7

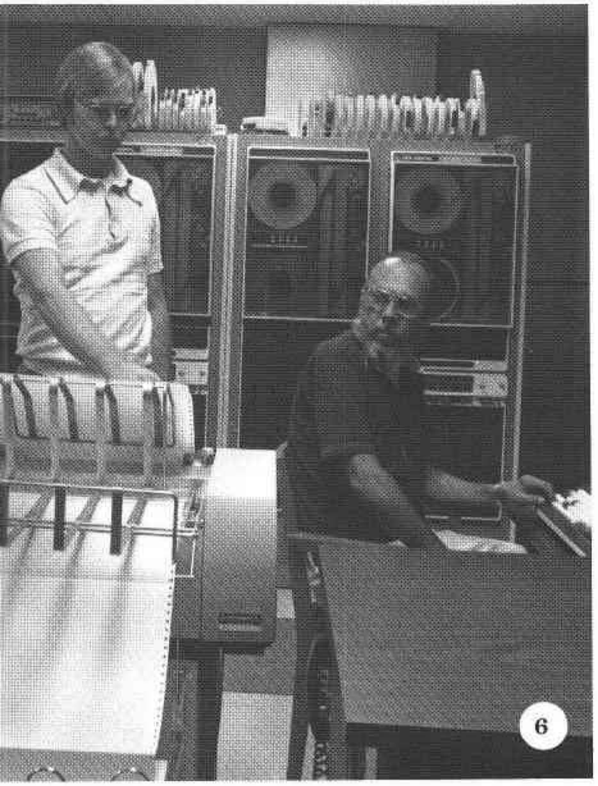

AIR LAUNCH
PLATFORM
DC-130
AIR LAUNCH
PLATFORM
DC-130
MROC
CHAFF
CHAFF
KC-135
JAMMING
ERA-3
JAMMING
PREVAILING WIND
CHAFF
AIR LAUNCH
PLATFORM
DC-130
SURFACE LAUNCH
PLATFORM
AIR LAUNCH
PLATFORM
DC-130
ERA-3
JAMMING
KC-135
JAMMING
1


2

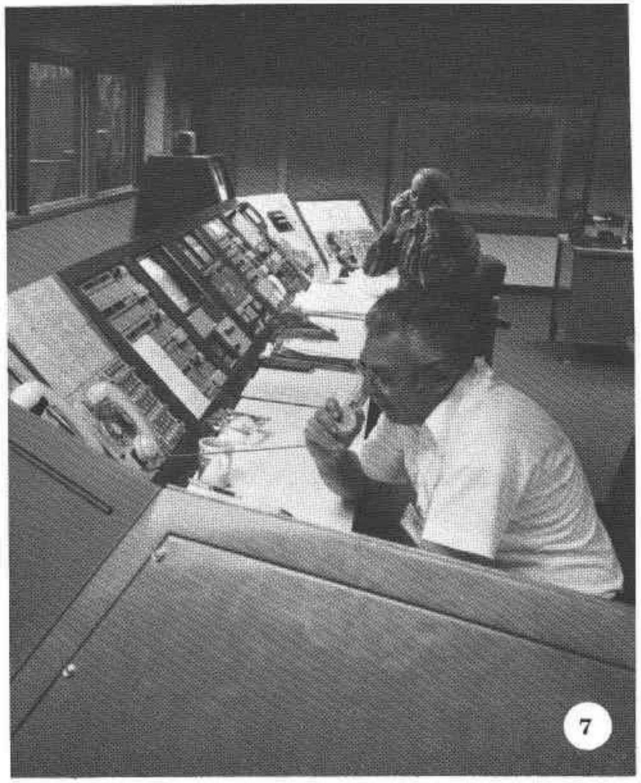

67
3


4

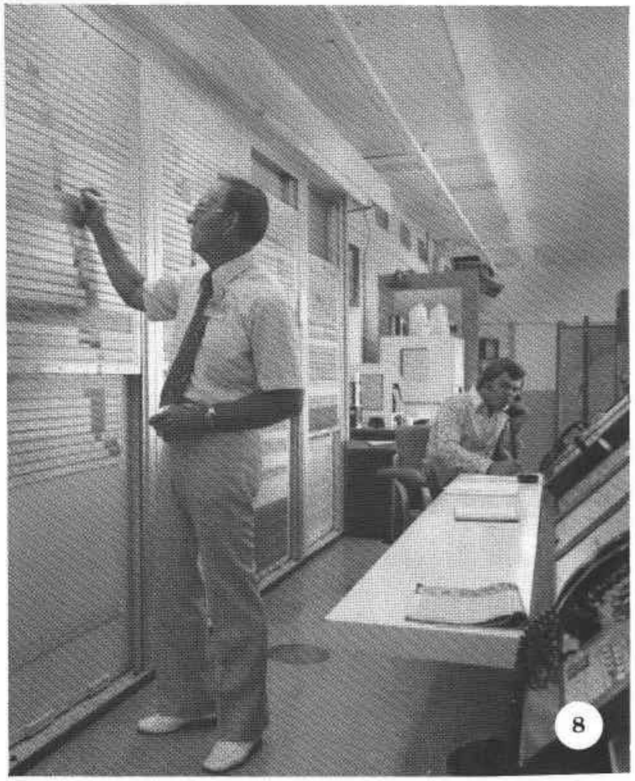

5



6



7



8

1. Mobile Sea Range can be set up anywhere in the world. 2. BQM-34A launch from fantail of USS CLEVELAND. 3. Aircraft carrier USS JOHN F. KENNEDY (CV-67). 4. Integrated Target Control System (ITCS) and Range Operations Display System (RODS) in Building 53, Point Mugu. 5. ITCS in use at the Range Display and Control Center (RDCC) in Building 53, Point Mugu. 6. Computers in RDCC, Building 53, Point Mugu (1982). 7. Range Control Officer consoles in tracking and control room. 8. Master Range Scheduling Board (MRSB), Range Operations Building, Point Mugu. 9. AN/FPS-16 radars near Point Mugu Lagoon.

9

"You're not the only pebble on the beach."
—Harry Braisted

APPENDIX I

TENANT ORGANIZATIONS

The sands of Point Mugu have felt the footprints of many people with diverse skills who filled the rosters of resident units. While some came to work on missile-oriented projects, others came to perform unrelated missions of importance to the naval establishment. As a result, the base has enjoyed many excellent tenant relationships.

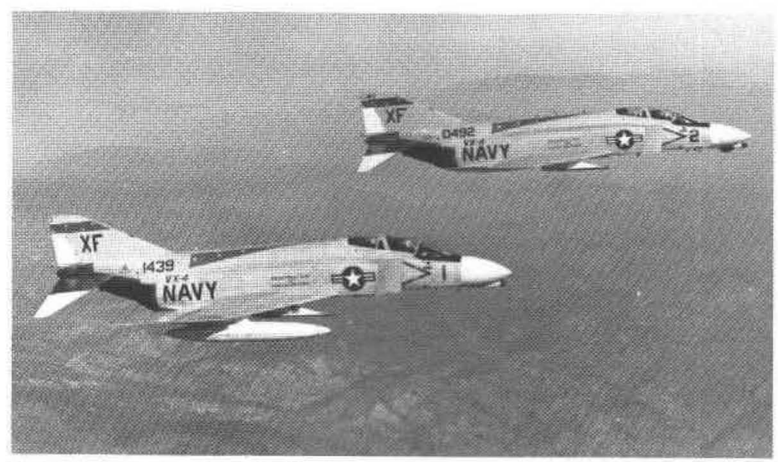
AIR TEST AND EVALUATION SQUADRON FOUR (VX-4)

Air Test and Evaluation Squadron FOUR (VX-4) is one of Point Mugu's oldest, continuous tenant organizations. Originally commissioned as Air Development Squadron FOUR in September 1952, VX-4's primary mission involved the operational evaluation of air-launched guided missiles.

The squadron, presently under operational control of the Operational Test and Evaluation Force, takes newly acquired aircraft weapon systems and tests them in a Fleet operational environment similar to where they will be used. Squadron personnel, known as "The Evaluators," go aboard aircraft carriers and check out the suitability of an aircraft and its weapons. Then they develop tactics, techniques, and procedures for making the best use of these assets, and this detailed operational procedure information is assembled for inclusion in Navy Tactical Manuals.

Nearly all of the Navy's air-launched guided missiles underwent evaluation by VX-4. SPARROW I, SPARROW III, and BULLPUP missile weapon systems occupied a sizeable amount of project time in the 1950's. Evaluations were performed during the 1960's on CORVUS, PETREL, and BULLPUP B, but pressures in Vietnam dictated that considerable emphasis be placed on SPARROW III (AIM-7) and the improved SIDEWINDER (AIM-9). Various generations of modified SPARROW and SIDEWINDER systems were evaluated later, and the PHOENIX missile was a major program during the 1970's.

In 1961, aircraft evaluations by VX-4 included the F-4 Phantom II and the F-8 Crusader. Following comprehensive operational tests of both aircraft's weapons and support



F-4 aircraft, Air Test and Evaluation Squadron FOUR (VX-4).

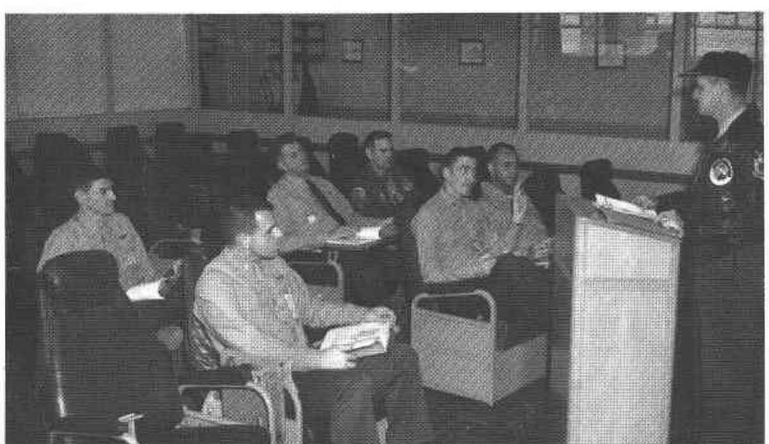
systems equipment, and development of all-weather fighter intercept tactics against various targets, tactical manuals were written by VX-4 project officers. The high-performance, sophisticated F-14 Tomcat received similar scrutiny during the 1970's.

Squadron assignments have entailed a variety of tasks. For example, in May of 1967, a detachment was sent to the USS FORRESTAL (CV-59) to evaluate the Navy's Automatic Carrier Landing System (ACLS), and VX-4's pilots became the first members of an operational squadron in naval aviation history to make "hands-off" carrier landings.

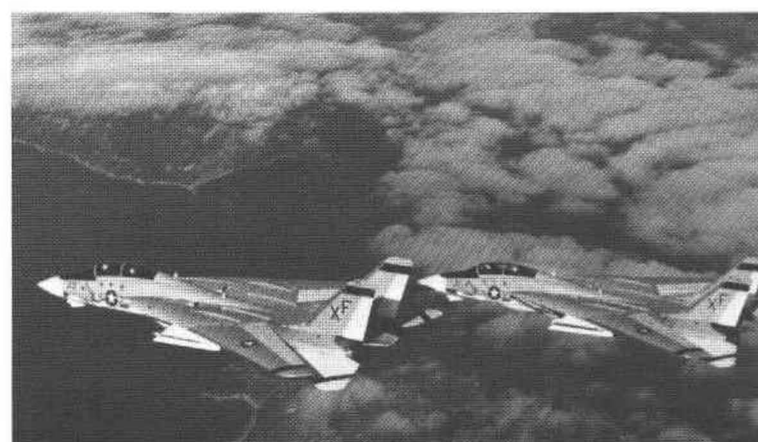
The conflict in Vietnam underscored the importance of VX-4's work, especially in the area of developing new missile launching tactics for use by pilots in the war zone. The tactical manual for the F-4 was rewritten in 1966 by squadron officers to reflect the newly developed concepts. It was updated again about a year later. They also revised the F-8 manual. By 1969, almost half of VX-4's pilots were fresh from combat. Their experience soon became a priceless asset performing the squadron's mission.

Today, many VX-4 pilots are graduates of the Naval Test Pilot School, and enlisted personnel have been selected because they possess a high degree of skill in their respective specialties. This expertise is shared with members of Fleet squadrons when they deploy to Point Mugu for training on the Sea Test Range.

Once a year VX-4 takes a break from their busy work schedule to coordinate the Point Mugu Air Show (formerly the Space Fair). In addition to playing host to the Navy's visiting flight demonstration team, "The Blue Angels," VX-4 pilots fly their own assigned aircraft to demonstrate their skill in executing maneuvers used in tactical warfare.



VX-4 and Fleet pilots receiving brief.



F-14 aircraft in flight (VX-4).

NAVY ASTRONAUTICS GROUP

The Navy Astronautics Group, with headquarters at Point Mugu, was commissioned in April 1962 to operate and maintain Navy space and satellite systems. Since then, they have operated the Navy Navigation Satellite System (NNSS) that permits Fleet units to fix their precise positions at sea, day or night, in any kind of weather.

The NNSS had been under study and development since 1958 after scientists working for the Navy, at the Applied Physics Laboratory/Johns Hopkins University, noted that signals received from the Russian Sputnik experienced a Doppler frequency shift that depended on the relative velocity between the satellite and the receiver. They plotted the Doppler shift of the beeps from Sputnik I and later satellites, and learned that from a single plot they could reconstruct the complete orbit of each satellite. It followed that if a satellite orbit could be plotted from a known or fixed point on Earth, then the reverse procedure could be used to locate a fixed point on Earth from a known satellite orbit.

In 1963, the destroyer USS HAZELWOOD (DD-531) was the first Navy vessel to test a then-secret navigation system that received data from an orbiting satellite. In 1964, the USS LONG BEACH (CGN-9) used the system during its cruise around the world. Shortly thereafter, the system was made operational with the completion of successful testing of the navigation equipment in POLARIS ballistic missile submarines and aircraft carriers.

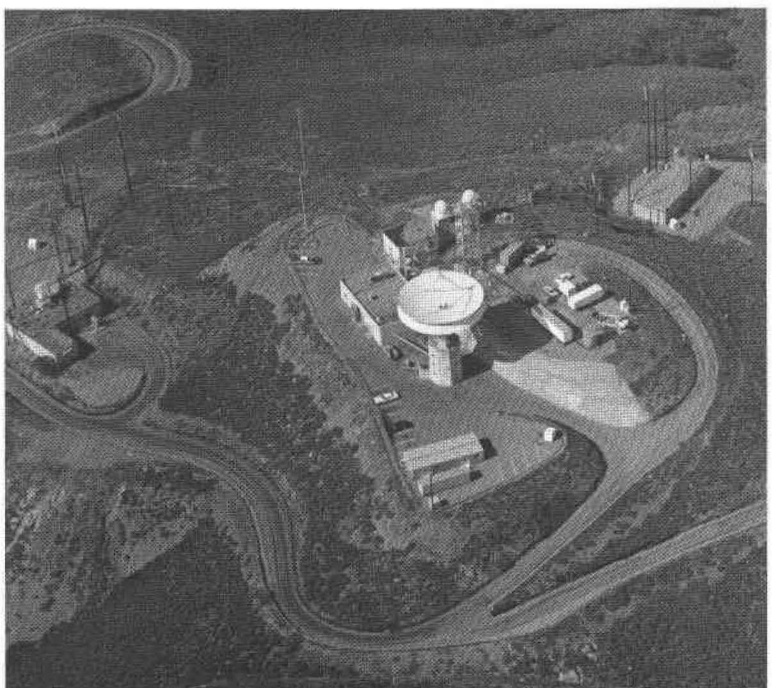
In 1967, the Government authorized manufacture of commercial versions of the shipboard navigation sets and sale to non-military interests in this country and other nations. There are many applications for the system in oil exploration, mapmaking, world-wide commercial shipping, and as a universal time standard. Accuracy of the system was emphasized during rendezvous and recovery operations in connection with our astronauts returning from APOLLO expeditions to the Moon.

Presently, the navigation satellites are launched into 600-mile circular polar orbits from Vandenberg Air Force Base. They orbit the Earth every 107 minutes, transmitting a message every two minutes describing where they are in

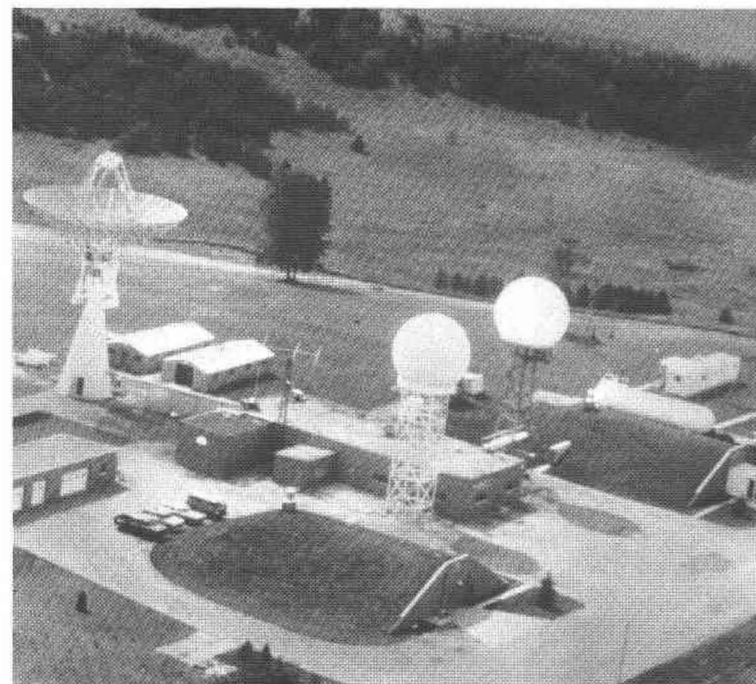
NAG Building during final phase of construction (1966).

space. The position messages are transmitted to the satellite from ground-based injection stations, and it takes only 15 seconds to fill a satellite memory with data that is valid for the next 16 hours. To ensure that these messages are valid, the memories are refilled or updated every 12 hours. The process involves satellite tracking, network data communications, computerized program preparations, and satellite injection operations; all are carried out around-the-clock according to strict satellite timetables maintained in terms of microseconds.

The Navy Astronautics Group has tracking and injection stations in Maine, Minnesota, on Laguna Peak at Point Mugu, and in Hawaii. Within the Point Mugu headquarters, there is a communications center, computer center, test and evaluation station, and an operational control center to manage the entire system.



NNSS tracking and insertion antenna, Laguna Peak.



Naval Astronautics Group Detach. B, Rosemont, Minnesota.

VXE-6 lands first airplane at South Pole in history

ANTARCTIC DEVELOPMENT SQUADRON SIX (VXE-6)

A theory advanced by Rear Admiral Richard E. Byrd that "aircraft alone could triumph over Antarctica" has been proven by a Point Mugu tenant, Antarctic Development Squadron SIX (VXE-6). VXE-6 provides air support for scientific explorations and research in Antarctica which are sponsored by the National Science Foundation as part of the Navy's Operation Deep Freeze.

Established as Air Development Squadron SIX (VX-6) at Naval Air Station, Patuxent River, Maryland, in January 1955, it was to serve as Naval Air Group for Task Force 43 with a basic mission of providing airlift operations for the scientific programs in Antarctica. Later that year, the first deployment was undertaken by the new squadron.

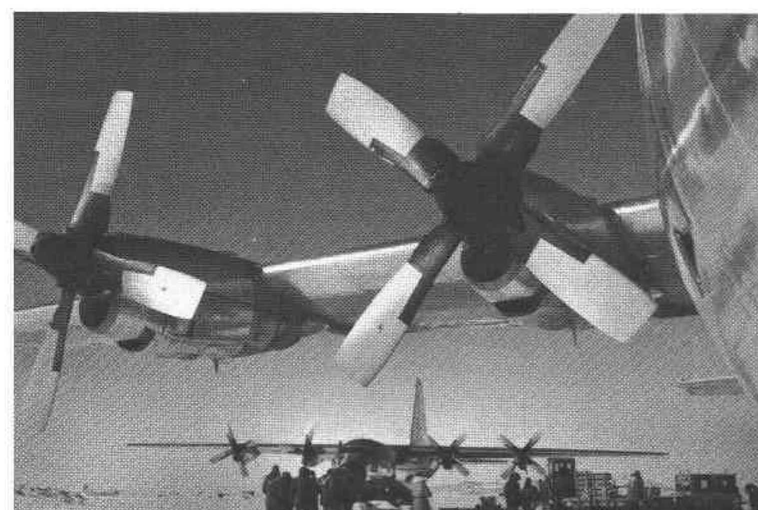
On December 19, 1955, Rear Admiral George J. Dufek ordered the squadron's P-2V, C-54, C-47, and SA-16 planes to depart from New Zealand for the 2,100-nautical-mile flight to McMurdo Sound, Antarctica. The planes encountered 20-knot headwinds which ate up fuel and forced the SA-16's to turn back. Later, the C-47's ran low on fuel, and they too were ordered to turn back. But the P-2V's and the C-54's continued on, landing safely at McMurdo and marking the first time in history that any aircraft had assaulted the continent from an outside land mass.

In 1956, the squadron returned from its first deployment to the icy continent and, that same year, was relocated to the Naval Air Station, Quonset Point, Rhode Island. Before moving to Point Mugu in October 1973, the squadron made 17 deployments from Quonset Point.

A noteworthy event occurred during the squadron's second deployment when, on October 31, 1956, a C-47 named "Que Sera Sera" became the first plane to land at the South Pole. Aboard was a party of seven men, including RADM Dufek, who became the first Americans at the South Pole and the only men to set foot there since the Amundsen/Scott expeditions in 1911-12.

During the International Geophysical Year (IGY), which ran from July 1957 through December 1958, scientists from twelve countries conducted ambitious programs of Antarctic research. A network of some 60 stations on the continent and sub-Arctic islands studied oceanography, glaciology, meteorology, seismology, geomagnetism, the ionosphere, cosmic rays, auroras, and airglow.

In support of the IGY program, squadron planes flew 3,229 hours, photo-mapped 633,374 square miles of terrain,



C-130 Hercules aircraft on VXE-6 resupply mission, South Pole.

carried 2,496 passengers, 756 tons of cargo, and 24 tons of mail. At the termination of the program, bases were to be closed and scientific personnel returned home, and with the passing of the IGY the squadron was to be decommissioned. However, because the gathering of scientific data exceeded expectations, Congress authorized an indefinite continuance of the program.

The squadron utilized a variety of aircraft for those early explorations including the De Havilland Otter; Lockheed Neptune; Douglas C-47, C-54, and C-117; the Lockheed C-121 Super Constellation, and Sikorsky LH-34 and CH-19 helicopters. Presently, only two types of aircraft are flown, the LC-130 ski-equipped Hercules and UH-1N Huey helicopters. Both aircraft are a familiar sight around Point Mugu each year between March and September when VXE-6 returns from McMurdo for upkeep and training.

Despite the harsh physical obstacles presented by 5.5 million square miles of frozen continent, VXE-6 personnel built a record of achievements. With their help, a vast unknown area of the world was charted, new island stations established, and a wealth of scientific information gathered. Daring rescue flights were made with visibility so poor only the outlines of the men below could be seen. They flew some of the longest logistic and exploratory flights ever made in Antarctic history. And when their huge LC-130's crashed hundreds of miles from McMurdo Sound, they mounted unprecedented salvage operations, repaired aircraft in the field, and flew them back to base.

VXE-6 has a motto consisting of three appropriate words: "Courage — Sacrifice — Devotion."

UH-1 Huey helicopter used to support VXE-6 Antarctic research.

C-121 Constellation unloading at Williams Field, Antarctica.

Four major Naval Air Reserve units based at PMTC

NAVAL AIR RESERVE

When the nation entered the era of an all-volunteer military, its reserve assets became increasingly important. The "weekend warrior" concept changed to one of a professional backup force that is as fully trained as the regular active duty military forces.

This change has been evident ever since elements of the Naval Air Reserve came to Point Mugu during the 1970's and eventually occupied a new $3.5 million hangar, administration, and training building that was completed in 1975. Included were four major reserve commands: the Naval Air Reserve Unit (NARU), Patrol Squadron SIXTY-FIVE (VP-65), Attack Squadron THREE-ZERO-FIVE (VA-305), and Helicopter Attack Squadron (Light) FIVE (HAL-5). In addition, many smaller reinforcement units are based here representing almost all aspects of naval aviation.

NARU

Commissioned on February 1, 1971, NARU is under the command of the Chief of Naval Reserve located at New Orleans. Its primary mission is providing training and support services to all reserve activities aboard NAS Point Mugu, which includes the administration and training of about 1,800 air reservists.

These reservists serve in command, management, and support capacities, drilling and training one weekend each month and spending two weeks each year on active duty training. Since 1975, most of the subordinate commands and units reporting to NARU's commanding officer have conducted their drills in the new hangar complex which is located on the north side of Point Mugu's airfield. Reserve personnel also use Station facilities for weekend drill.

VP-65

VP-65 was commissioned at the Naval Air Station, Los Alamitos, California, on November 1, 1970, and moved to Point Mugu in January 1971. One of 12 Naval Air Reserve Patrol Squadrons in the nation, its purpose is to provide a combat-ready patrol squadron for mobilization during a national emergency.

As a complete capability response unit, VP-65 has the same billet and organizational structure as active duty squadrons. In time of need it would augment regular forces

Naval Air Reserve Unit hangar facilities at PMTC.

to search for, detect, track, and destroy enemy submarines.

VP-65 was assigned and operated the P-2 Neptune aircraft until November 1974, when it transitioned into the P-3A Orion. The squadron's active duty tours have included deployments to Hawaii and Guam, to augment forces of the Pacific Fleet, and to Spain, in support of Sixth Fleet training and operational commitments in the Mediterranean.

In March 1973, VP-65 was awarded the Noel Davis Trophy for squadron excellence.

VA-305

VA-305 is also a complete capability response unit like VP-65, structured and equipped the same as an active duty light attack jet squadron of the regular forces. It is tasked to maintain combat readiness at all times, so it can replace or supplement squadrons of the Pacific or Atlantic Fleets.

When commissioned at the Naval Air Station, Los Alamitos, California, on July 1, 1970, the squadron began training and operations with the A-4C Skyhawk aircraft. In January 1971, VA-305 moved to Point Mugu and continued flying the Skyhawk for about a year and a half until transitioning into the A-7A Corsair II, the plane it presently flies and maintains.

Squadron pilots are highly experienced with an average of over 2,400 hours of military flight time including 250 carrier landings, and many are Vietnam combat veterans.

A-7A Corsair II aircraft from VA-305.

HAL-5

HAL-5 is the newest squadron attached to the reserve complex at Point Mugu. It was commissioned in June 1977 and is a member of Helicopter Wing Reserve located at Naval Air Station, North Island, San Diego, California.

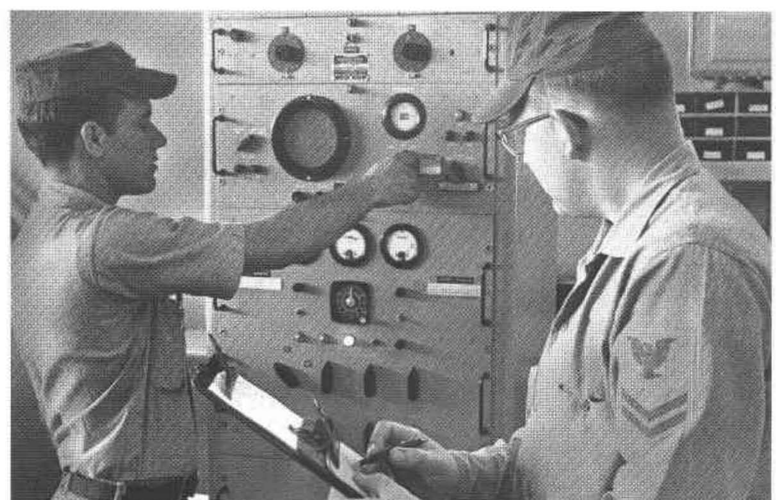
. Known as the "Blue Hawks," the squadron operates seven HH-1K helicopter gunships equipped with the M-21 weapons subsystem. Its function is to provide a quick-reaction close air support capability, one which is vital to special warfare group operations.

GUIDED MISSILE UNITS AND GROUPS

In August 1953, Guided Missile Unit No. 41 (GMU-41) was established at Point Mugu with the mission of assisting Air Development Squadron FOUR (now Air Test and Evaluation Squadron FOUR) in Fleet evaluation of assigned missiles. Later, GMU-41's mission was expanded to include supporting Fleet operational squadrons through missile inventory, supply, checkout, troubleshooting, buildup, telemetry, telemetry readout, reporting, and analysis. Also, the unit assisted in product improvement programs for such missiles as BULLPUP. Over the years, GMU-41 has handled and prepared nearly every type of air-launched missile deployed with the Fleet.

Guided Missile Group No. 1 (GMG-1) was commissioned in September 1956 at the Naval Air Station, North Island, San Diego, California. This was the first group established specifically to work with the REGULUS I missile. Subsequently, the group was moved to Barbers Point, Hawaii; however, a Continental Detachment was simultaneously established at the Naval Air Missile Test Center. The primary tasks of the GMG-1 (Continental Detachment) was to provide chase and recovery aircraft services to the Fleet, support Fleet training, provide base support for operational REGULUS I missiles, and assist in KDU-1 target operations at NAMTC. (The KDU-1 was the target version of the REGULUS I missile.) During the late 1950's the group participated in the REGULUS I/TROUNCE programs, supported KDU-1 target evaluation, and assisted in presenting the KDU-1 target for TERRIER and SPARROW III missile operations.

Guided Missile Unit No. 55 (GMU-55) was commissioned in March 1957 to assist in the development of the REGULUS II missile. Later the mission was expanded to include assisting the Naval Missile Center in maintenance, handling, and recovery of all surface-to-surface missiles and the KD2U-1



GMU-41 tests SPARROW III missile guidance system (1967).

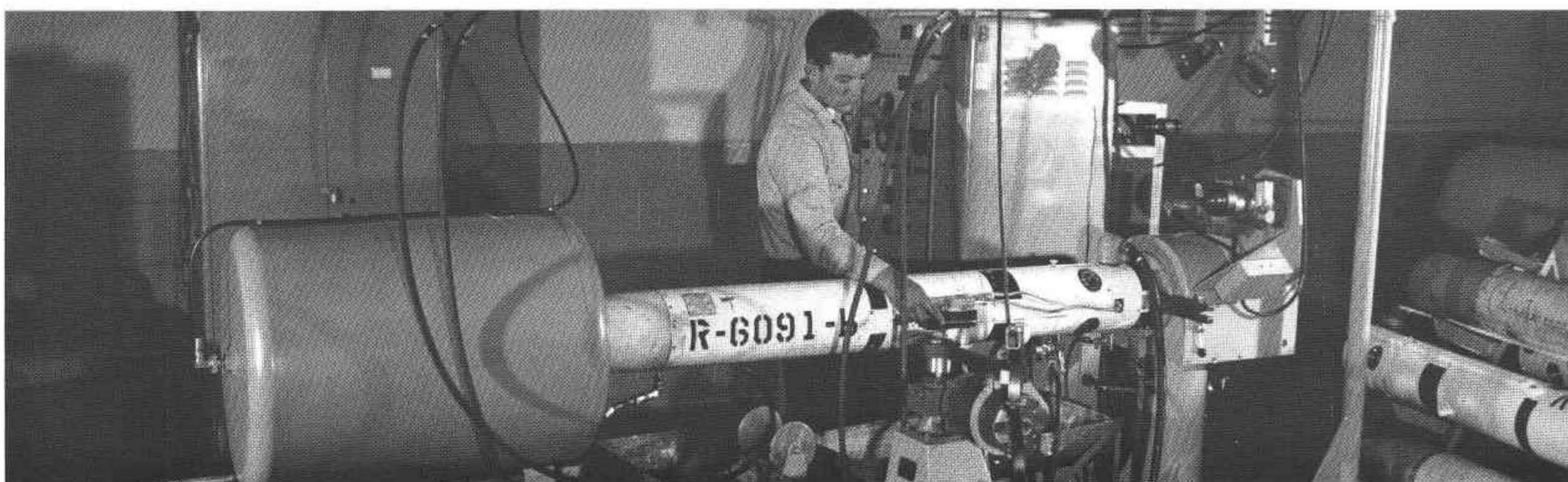
target. (The KD2U-1 was the target version of the REGULUS II missile.) Two highlights of GMU-55's history were the first Navy launching of the REGULUS II at Point Mugu on June 5, 1958, and the first REGULUS II launching from the submarine USS GRAYBACK on September 16, 1958.

In January 1960, Guided Missile Unit No.4 (GMU-4) was disestablished and the tasks and personnel transferred to GMU-7 at Point Mugu. Thus GMU-7 became the Air Launched Guided Missile Unit with responsibility for handling such missiles as SPARROW III, CORVUS, BAT, PETREL, and CROW. During 1966, GMU-7 and GMU-55 were disestablished and their functions absorbed by the Naval Missile Center. This left GMU-41 as the only remaining such unit at Point Mugu until 1982 when it, too, was disestablished.

3235TH DRONE SQUADRON, U.S. AIR FORCE

On July 1, 1952, the 3235th Drone Squadron, U.S. Air Force, was commissioned at NAMTC. Under the command of the 3205th Drone Group, Eglin AFB, Florida, the squadron provided support to the Air Force and Navy guided missile units at Point Mugu and the Naval Ordnance Test Station, China Lake, California. The squadron maintained and operated several B-17 aircraft, including both control planes and No Live Operator (NOLO) drones. A unique feature of their work was that observers could study the reaction of the aircraft to various influences during actual missions. The drone squadron was decommissioned in the mid-1950's.

All of the tenant organizations mentioned in this appendix have made vital contributions to the mission of PMTC.



GMU-41 technician checking out a SPARROW III missile, Building 553, Point Mugu (1966).

"There can be no progress except in the individual and by the individual himself."
—Charles Baudelaire

APPENDIX II

HUMAN RESOURCES

In the world of test and evaluation, the Pacific Missile Test Center has become a thriving community workshop equipped with tools and machines for the job. However, a tool is but the extension of a man's hand, and a machine is but a complex tool. Our richest resource, our greatest asset, is our people.

To fully realize the potential of our human resources, several on-going activities function to protect and improve PMTC's work environment by safeguarding equal opportunity, helping the disadvantaged, utilizing the handicapped, developing careers, and assisting those with problems they cannot handle by themselves.

EEO Office and related programs

Emphasizing the importance of assuring equal employment opportunity for all, PMTC's Equal Employment Opportunity (EEO) Office is a Command Staff function. It provides advice, policy, guidance, and assistance on EEO matters throughout the PMTC complex, including EEO counseling, complaint adjudication, hearings, and investigations. In handling discrimination complaints, EEO counselors have demonstrated a high level of professional effectiveness which has resulted in an approximate 80 percent resolution rate at the informal stage.

Each year, the EEO Office develops Affirmative Action Plans and follows through with the implementation of these plans. Workshops and training sessions are scheduled for managers, supervisors, and other key personnel to increase their EEO functional awareness and assist them in planning and executing effective management actions that will further the goals of the EEO program.

The EEO staff gets involved with community activities where they pertain to, or impact on, Command programs. Presentations to local junior and senior high schools regarding Federal careers are regularly made, and PMTC supports the Navy Employment Information Center located in Oxnard, which provides Federal job information to the local community. Liaison is maintained with the Ventura County Equal Employment Opportunity Commission, Ventura County Civil Service Commission, and the Ventura County College Advisory Committee on the Status of Women.

Various Command programs, such as the Federal Woman's Program (FWP), have been developed and are managed by the EEO Office. One objective of the FWP is to enhance the employment and advancement of federally employed women. The FWP manager meets with the FWP committee on a monthly basis and sponsors such events as workshops on the preparation of job applications and on the structure, development, and use of individual development plans. The FWP participates in studies of problems affecting professional employees and sponsors luncheon meetings with the Commander, PMTC, to discuss concerns of women employees. Typical of the many positive results this program has obtained was issuance in 1980 of official instructions setting forth Command policy on sexual harassment and identifying the FWP Manager as the control point for sexual harassment concerns. FWP activities also include participation in Women's Week, Equality Day, and Secretaries' Week celebrations which are held on base annually.

The Hispanic Employment Program (HEP), like the FWP, was developed by the EEO Office and is administered by the HEP manager who works in conjunction with a selected HEP Committee. A basic objective of HEP is striving for equal employment opportunity for the Hispanics in all aspects of Federal employment. For example, when PMTC's college recruitment schedule is prepared each year, a special effort is made to ensure that predominantly minority schools are included, such as Hispanic and Black colleges. HEP also sponsors workshops for supervisory personnel to further the goals of the Hispanic employee, and sponsors activities for Cinco de Mayo and National Hispanic Heritage Week. In addition, other programs have been implemented which are designed to hire and develop low-skilled and disadvantaged people. Furthermore, in all personnel policies and actions, EEO impact is considered by having an EEO staff representative on all such committees and panels.

Federal Woman's Program career development participant.

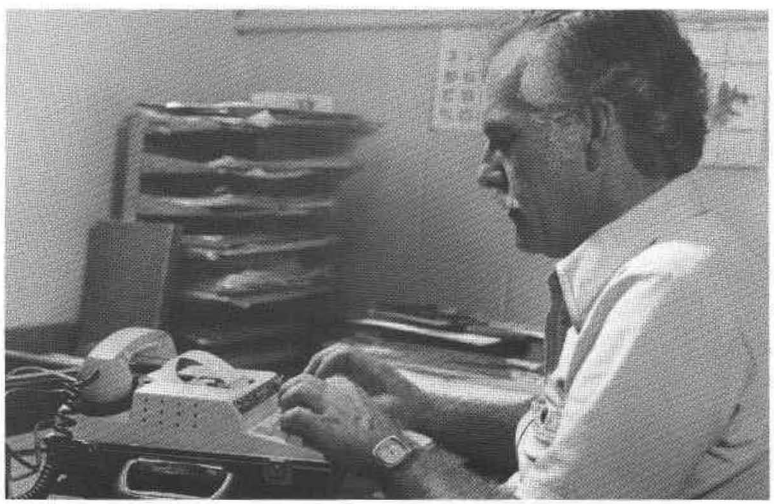
PMTC Equal Employment Opportunity (EEO) training session.

Aids to the handicapped added, barriers removed

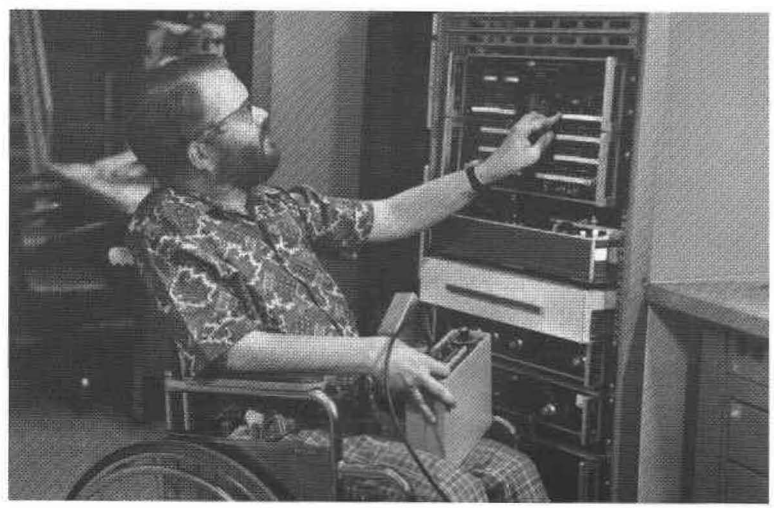
HANDICAPPED PROGRAM

PMTC's Handicapped Program (HP) is another EEO function, with a manager to meet the needs of the handicapped population, which amounts to over ten percent of the civilian work force. Through the Foundation for the Junior Blind Summer Work Experience Program, high-school-age young people who are blind, partially sighted, or deaf have worked on the base in a wide variety of jobs since 1972. The first Advisory Committee for the Handicapped, formed in 1975, resulted in a series of surveys that looked into architectural barriers and investigated assistive devices. As a result, several barriers were eliminated, wheelchair lifts were installed, ramps were built, telephone booths and drinking fountain facilities were made accessible, elevators were installed, and restrooms were redesigned for wheelchair employees. Assistive devices were purchased to permit telecommunications for the deaf. Also, a lift was installed in a Navy van so that wheelchair employees who do not drive their cars to work can get around the base. In the commissary a handi-cart was provided, and Braille menus were made available in the clubs.

Stimulated by the Handicapped Program, Supervisory Awareness Training sessions are now conducted to make managers sensitive to the handicapped and their potential contributions. Classes are held to teach emergency communications with the deaf and the sign language alphabet. Other facets of the program involve publicizing employment opportunities for the handicapped, supporting special



Handicapped employee uses communication device for the deaf.



Barrier removal at PMTC aids wheelchair-handicapped employees.

training projects, participating in national and international conferences, and investigating National Science Foundation devices for the handicapped.

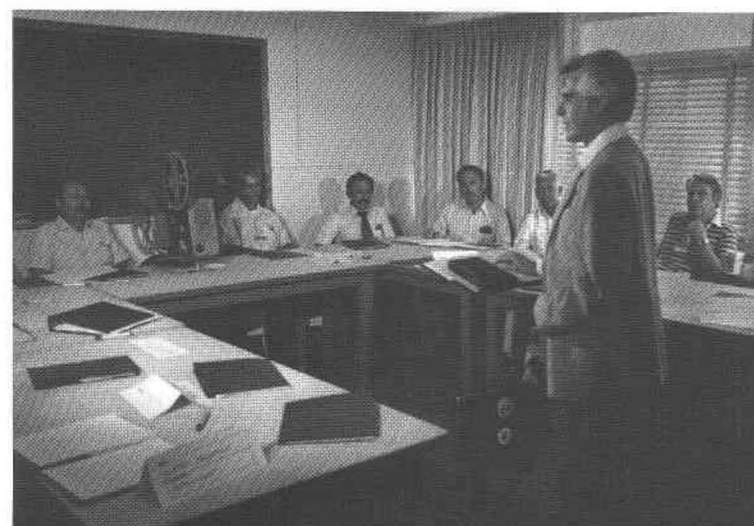
HUMAN GOALS

The Navy recognizes that some people may have problems they cannot handle by themselves. For this reason, the Human Goals Office plans and implements the Human Goals Program for PMTC. It has a three-fold responsibility: operating a military and civilian drug and alcohol education program, operating an interracial and ethnic relations course for military personnel, and operating a military and civilian counseling center for personnel and their dependents. As part of the on-going alcohol/drug control and prevention program, hundreds of military and civilian supervisors have received alcohol and drug abuse training by which they learn to recognize the signs of abuse and how to refer such cases for treatment. Each year, employees with alcohol/drug problems have been successfully rehabilitated and continue to be a part of the productive workforce. Encouraged by the results of their efforts in control and prevention of alcohol and drug abuse, the Human Goals Office staff implemented a Smoking Control Program in 1979 and has continued to conduct "stop smoking" clinics ever since. And in the area of race relations, which has never been a major problem at PMTC, when serious complaints have been received, they have been resolved by the Human Goals staff to the satisfaction of all concerned.

TRAINING

Many professional and personal training opportunities are available for PMTC employees. The Civilian Personnel Office has within its organization a Career Development Division which develops and maintains a comprehensive system of education and career development programs, provides career counseling services, and advises management on employee and workforce development. Both onboard and off-Station training courses are provided in support of engineering, scientific, management, supervisory, administrative, clerical, trades, and skills development.

PMTC's strength is in its people. By furnishing assistance to its people, PMTC is providing for a better match between employee needs and organizational goals. And this facilitates employee satisfaction, productivity, and accomplishment of Navy goals.



Handicapped Program training session for supervisors at PMTC.

APPENDIX III

PERSONAL REFLECTIONS

Probably the most memorable circumstance of my years at Point Mugu was the constant and rapid transition that was taking place. From a local test range with fixed geographical instrumentation points, the advent of the space age transformed this small Navy test facility into a major segment of a worldwide tracking and data gathering facility in just a few hectic years.

My group, Facilities Development Division, expanded from about 5 to 45 people. We provided not only fixed tracking and test facilities in permanent buildings, but also range ships, range aircraft, and, in addition, over-the-road and air-transportable mobile radars, communications, telemetry, and optical trackers. It was the unbelievable dedication and competence of highly motivated professionals that made this development possible.

—Donald R. Bennett

During my tenure at Point Mugu, 1954-1971, the branches I supervised were involved in the design and fabrication of launchers, support equipment, and launch complexes for the military and space programs, some 128 projects. One of our most notable accomplishments was the design and fabrication of the NERV launcher which supported the NERV operation that was the first successful recovery in the Pacific Range for the Naval Research Laboratory. We designed and built the first all purpose launcher from a twin 5" - 38 gun mount salvaged from a ship, which is the most efficient launch system built. The NERV launcher was fabricated from the trusses of a Butler building. A picture of this launcher is hanging in the Space Museum in Washington, D.C. All my tasks were approached with efficiency and austerity in mind.

—Charles C. Carr

The era I recall with most nostalgia spans from 1950 to the mid-1960's. It was an era of problem solving . . . (with) all disciplines being integrated into missile design . . . It was an era of mutual support wherein the boundaries between contractors, laboratories, and academia were undefined and unimportant. In this spirit, programs such as the "Model Missile Program" yielded not only "real world" aerodynamic data of missile behavior in true free flight, but contributed significantly to the development of miniature high-quality telemetry systems, power supplies, miniature transmitting antennas, and a host of other advances that became significant in the diagnostic testing of subsequent missiles and space probes.

—F.A. Cavanagh

"Days of Challenge, Years of Change"—I can't think of a more descriptive characterization of my career at Point Mugu, beginning fresh out of college as a Junior Professional with NAMTC, participating in those extraordinarily exciting days of building PMR, a test range that spanned quite literally half the globe; and now involved in the management of PMTC, our Navy's premier weapon system T&E activity. Point Mugu has indeed been my career—some eight thousand working days of interesting and often exhilarating challenge, some thirty years of profound change!

—Hugh J. Crawford

I can look back at my eighteen years of work at Point Mugu with satisfaction and pleasure. Satisfaction from meaningful and productive work, and pleasure from the association with capable and enthusiastic individuals. I was aided and sustained by the technical and managerial talent of the civilian and military engineers and scientists who made many significant contributions to the Center's programs. Although the professional development of all personnel has always been of special concern to me, there remains one major goal still to be reached: the establishment of an upper technical career ladder which parallels the managerial one. —Alexis B. Dember

It was heart warming and inspiring to be, so soon after the war, well received by all at NAMTC and in Ventura County. And there was so much interesting work to be done, especially in submarine cruise missile projects. Its importance for the future of western culture was well recognized by us immigrants. An example of this Center's contributions is the concept of thrust vector control on solid propellant rockets, needed so soon afterwards in the Navy's Fleet Ballistic Missile Program.

Most exciting at that time were the missile launchings from surfaced submarines. The biggest surprise for the Fiedler family was the presentation of the Navy Civilian Distinguished Service Award. As always, one has to thank co-workers and boss — in this case, R. H. Helmholz. Later as a member of the PMR Advisory Board, I was happy to visit with friends at the Center. —W. A. Fiedler

The time span 1963-80 witnessed numerous and significant changes at Point Mugu—the organizational consolidation— the very topnotch military and civilian personnel who have reported/detached—Ol' Blue and other Connies, now replaced by P-3 aircraft—the arrival of Antarctic Development Squadron SIX—and the Reserve Forces, now in their beautiful new hangars— the earthquake that scared hell out of us, but really didn't hurt much—the flood in 1980 that did hurt, followed by construction of Dallam's wall—and now visits by President Reagan. That's progress!

—E. J. Fridrich

In my earliest experience with PMTC, I was indeed fortunate to head the staff of the Space and Astronautics Orientation Course, then a segment of NMC. This course served to acquaint the senior officer and civilian personnel of the Navy Department with the military potential of space systems and to stimulate their enthusiasm for the Navy's future in space.

In later assignments with a PMTC tenant command, I served as Operations and Executive Officer of the Navy Astronautics Group who, then as now, operate the Navy Navigation Satellite System. Finally, as PMR Representative at NAVAIR in Washington, I was able to view the continued growth and accomplishments of PMTC over a total span of 13 years. I feel I was part of the "challenge" and I observed the "change." —John J. Gallagher

Reflecting back over 23 years of employment at the Center, I have been provided the opportunity to grow professionally in the field of weapon systems engineering and to stay abreast of airborne weapons technology. During the 1960's, I was deeply involved in design and development of new propulsion systems for air-to-air missiles and high *fraction units for satellite injection. From 1967 to 1973, I helped establish a new function at the Center titled in-service engineering for air-launched weapons. Since 1974, I have served as the Chief Engineer in the F-14/PHOENIX Project Management Office. The single most significant change in weapons technology has been the introduction of reprogrammable embedded digital computers in missiles, avionics, radars, electronic countermeasures, and ground test equipment. This digital capability has opened new vistas in laboratory simulation, instrumentation and data reduction techniques, and complex multi-environment test scenarios that represent the ultimate in battle conditions.*

—G. C. Googins

I have many memories of events, experiences, and people at Point Mugu. One that stands out was demonstrating a need for getting the physical scientists and engineers to communicate with the bioscientists. Towards this goal, a Life Science Department was set up at NMC. Top biological scientists, Naval Reservists, from academia were recruited to put on courses for scientists and engineers. It was anticipated that they would thus be better able to assist and participate in such projects as instrumenting porpoises and developing capsules for physiological monitoring of a monkey in space.

By putting this philosophy of cooperation to work, it also appeared facilities for physical testing could be used for biological testing if requirements were known early enough. Thus the developed facilities would have greater scope of utility and the Government could realize greater dollar value on its investment of funds. Carrying this point further, greater cooperation between academia and the services could save money by cross utilization of Government financial facilities.

—Sidney Goren

In the late 1950's we were always designing new organizational structures for the Naval Missile Center, as if we thought re-organizing would solve all the management problems.

Then a source and solution to some of these problems became clear to many of us. It happened at the infamous Ojai-mixed-Bag-T-group, when Jack O'Brien said, to the effect: A military man comes to Mugu and finds an operating, cliquish, often cantankerous civilian organization and he thinks, "This is a Navy base. They are supposed to work for us." The civilians on the other hand have a major part of their lives invested in the Center and worry about what the military man might do to their Center in the interest of quick results during his short tenure.

This insight into where the other guys were coming from made it easier for us to work together. It showed me a way to look at and understand a lot of other tough management relationships since I left Point Mugu. —T. E. Hanes

[In the opening days] *a small military contingent was assigned to the base as an aircraft squadron and another small group (military) provided the nucleus of what became the Component Test and Engineering Design Department. Then a Chief Scientist, Dr. Royal Weller, was employed. He and his wife, Betty, soon acclimated and an active recruitment program was initiated. Royal gave lectures on "Design of Experiment," "Theory of Failure," etc., but more importantly, he encouraged cooperation between departments. Willi Fiedler, Germany's designer of the V-1, became a close* *friend within a few months of assignment to my organization in the Component Test Department.*

The most outstanding and memorable military officer was Grayson Merrill, who, as Director of Tests, promulgated and maintained the highest standards of engineering. Another notable officer was RADM John Clark. It was he who released SPARROW for Fleet use.

Far and away the most notable Industrial Relations Officer was Norm Newcomb. When we were strapped for satisfactory recruits, he organized and ran a nationwide recruitment program. —Robert H. Helmholz

I came to Point Mugu in July 1961 as a GS-7 mathematician, working in range operations data processing on data reduction software. At that time we were using the Land-Air Integrated Reduction System, LAIRS, with the IBM 7090 computer. One of our big projects was the NIKE-ZEUS launches. Later I worked on the development of the specifications for a new computer and software system to replace the LAIRS. The result of our efforts was the acquisition of the Cyber computers. From that work, I moved into designing tactical software for embedded computers. Presently, I am Director of the Data Processing Service Center-West which is involved with Management Information and Decision Support Systems.

My observation over the years is the growing dependence of the Navy, and indeed the world, on computers and the need for each person to understand their function. The change has been rapid — four generations of computers in thirty years. We have had to adapt rapidly and, because of the extreme flexibility of the tool, the end is not in sight.

—Gwendolyn E. Hunt

In January 1971 the Instrumentation Division of NOL Corona was transferred intact to NMC Point Mugu to become the Data Systems Division of the Laboratory Department. As Head of the new Division, I had the unique experience of participating in an exceptionally smooth and efficient relocation of work effort. It was particularly gratifying to see the hardware output of the Division (which included design, development, fabrication and testing of telemetry, data-reduction, and command/destruct systems) applied directly to the missiles tested at Point Mugu and to improving the capabilities of range operations.

—T. Burr Jackson

My continuous assignment with the Pacific Missile Range from June 1960 until my retirement on 1 November 1970 was the biggest challenge of my 30-year naval career. I was involved in almost all facets of various missile and scientific vehicles, from influencing development through assembly, ground safety, launching, and missile in-flight safety. There were tremendous advances both in the vehicles being processed and the Range's ability to gather reliable data. I was always particularly impressed by the ability and talents of the Civil Service, contractors, and military personnel involved. Of greatest personal satisfaction to me was my involvement in all phases of the successful NIKE-ZEUS program at both Point Mugu and Kwajalein Atoll.

—A. T. Kasehagen

My recollections of the middle part of Point Mugu's history are mainly of the people, starting with my admiration of the German scientists onboard at the time of my arrival and continuing through with amazement at the *mental capabilities and potential of the employees. Because of the nature of my work, I particularly noted the graduates of the various World War II "V" programs and the G.I. Bill, followed by the Junior Professionals (JP's) and the Student Engineering Development (SED) participants. Knowing them was a great experience.* —Andrew E. Kohr

In over thirty years here at Point Mugu there have been many changes — in testing, in technology, in programs, in facilities, and in increased sophistication and complexity of the weapons being tested. Significant events are almost too numerous to mention, but two that stand out include the arrival of the space age and its related technology, and the development of underwater range technology. With all the change that's occurred, however, there's one thing that has remained essentially constant — the quality, professionalism, and dedication of the people who have worked here. Through its entire history, the Center has benefited tremendously from the human side of the equation. In the final analysis, the people have really been the most important part of the evolution and success of the Center.

—K. I. Lichti

The last half of my working career, 1956 to 1974, was spent at Point Mugu in a variety of jobs: in operations, data handling, development, the APOLLO program, and on the Admiral's planning staff. In all that time I never had a bad boss, and that is saying something. This wasn't just luck because, in the course of getting the projects done, I had to cross many lines of authority and knew many supervisors and managers.

It was a pleasure to work with such competent and dedicated teammates over so long a time and on so varied a chain of endeavors. If this high-quality working atmosphere persists, and I feel confident that it does, Point Mugu will continue to be an unusually fine place for highly trained people to work. —James H. Love

Most important in my work at Point Mugu from 1947 to 1973 was being part of an effective team in the Technical Support area, where there was developed mutual respect among engineers, technicians, shop personnel, and clerical personnel. These people worked together in providing support for most of the programs that came to Point Mugu. When I retired I had the satisfaction of knowing that the team with which I worked had significantly contributed in one way or another during the period of greatest growth in missile technology. —Baxter C. Madden, Jr.

In the early days of Point Mugu, the acceleration of scientific, engineering, and technical operations far outpaced development of financial information to support operations. Manual processing of financial data was the largest inhibiting factor. In the early 1960's, local Command and Washington-level authority was obtained to lease a computer system for financial operations. Although this system had a limited capability, it demonstrated the necessity of computer capabilities for timely and more meaningful financial information. Subsequent developments provided for both the technical and financial data to be served by one computer system and this "wedding," so to speak, was the initial action in establishing the computer center concept at Point Mugu.

—John Malbon

The Controls Division holds a fond place in my memory because I had the opportunity of working on many interesting programs (REGULUS SIMS, CROW, HYDRA, SEA SPARROW) with many good people under the outstanding leadership of Joe Rom. This was a particularly good time of learning and growing for me.

The most challenging and rewarding job I have had, however, was the responsibility of designing, building, and operating the F-14A/PHOENIX LIS which included both the F-14 SITS and the AIM-54A PHOENIX missile laboratories. This job stands out because of the fine team of people, the challenge of building a laboratory that was unique in scope and complexity at the time, and because it involved the early development and evaluation of an important Navy program. It is very gratifying for me and for many other people who developed it to see a laboratory which we started in 1966 still providing an important evaluation function for the F-14 weapon system. —Milton R. Marson

I was employed at Point Mugu from March 1951 until July 1975 and was active most of that time in Range Instrumentation. The highlights of my career were the establishment of instrumentation sites at Edwards AFB; Tonopah, Nevada; and Dugway, Utah, for the test and evaluation of the REGULUS II missile; the procurement and implementation of the AN/FPS-16 precision tracking radars; and the establishment of the Pacific Missile Range with instrumentation sites at Point Arguello, the Hawaiian Islands, Johnston Island, the Marshall Islands, and on aircraft and ships. I found this to be a period of great adventure and excitement because it was a period of great technological pioneering. —Richard S. McMullin

During the early 1960's, the Naval Missile Center management worked very hard to involve the Center in the Astronautics Program. This effort resulted in ambitious facility budgets including a 200-foot centrifuge and the establishment of an Astronautics Directorate. Although the facility plans were never approved, the Directorate functioned for several years... I recall one "early days" incident where the Directorate personnel in the life sciences group imported a supply of pure bred mice, the progeny of twenty-five generations of controlled breeding, for use in controlled testing. The mice were housed in an old World War II building, and this led to the failure of the effort when the beach field mice were able to get into the building. —Harold (Hal) D. Munroe

To make sure that the Fleet gets equipment which will be sure to perform as described, under all conditions encountered — that was the challenge on 1 October 1946 — and everybody could get into the act. With missile launchings from the beach and low-flying, slow aircraft close to shore, every employee could watch and emotionally participate in every failure and success. Over the years, the challenge has continued — has even become more difficult in some respects. Unfortunately, the high speeds of aircraft and missiles has moved the action out where few can get the feeling of participation and common purpose which builds and maintains the spirit of an organization.

—Eric Neuron

In the days before Building 761, the Simulation Laboratory was housed in two large adjacent Quonset huts located immediate to the beach and in an area we thought of as "Point Mugu's Last Frontier." The buildings were not well *sealed or insulated, and these conditions made them accessible to all kinds of insects, mice, cats, and other creatures seeking warmth. No one gave much thought to these additional laboratory inhabitants until one cold day a 4½-foot rattlesnake slithered inside. Not being equipped to deal with snakes, we pushed at it with chairs and stools in an effort to remove it, but to no avail. Not to be outdone by a lowly creature, one of the "simulators" picked up a* CO_2 *bottle (fire extinguisher) and froze the poor snake. Later the rattles were prominently displayed to show our ingenuity against all elements.* —Celso S. Ovalle

My tenure at Point Mugu spanned the advent of the space age and the massive development program of the National Pacific Missile Range. Although now no longer totally managed by the Navy, this does not detract from the task of installing instrumentation, vehicular launch, and base support facilities in the broad expanses of the Pacific. It was an enormous challenge, pushing the state-of-the-art, involving heavy work schedules for the dedicated personnel occupied with the planning and development of the range. Combining the excitement of achievement and excellent on-base facilities, it was a high point of my naval career.
—J. J. Pace

During my twenty-one and a half years of service at Point Mugu, I took part in the planning, design, and development of a major national test range. Radio telemetry receiving network planning, design, and implementation took up the earlier years, followed by development of a range instrumentation ship fleet to provide coverage of missile tests beyond the coverage range of land-based sites. The range ship fleet included up to 22 ships, many quite complex, to support Navy, Air Force, and NASA programs. I was happy to contribute to the very important area of missile testing at Point Mugu. —Rayburn (Ray) Perry

When I arrived at Point Mugu in 1958, management systems were largely manual, and management was hard pressed to control the expanding workload. It was even difficult to find out what work had been assigned and who was responsible for it. My job was to develop a workload system for NAMTC. To get information to management without the work and possible errors of constant retyping, I collected project data in a cardex file, photographed the file, and sent copies to managers each month. This crude attempt at automation was gradually augmented to include detailed manpower, workload, financial plans and results—all manually prepared and summarized.

When computers became available, this system was programmed and eventually evolved into one of the first integrated and computerized management information systems. It was described in the April 1968 issue of Data Magazine. *The system was discontinued in 1971 when the Navy installed Naval Industrial Funding at Point Mugu.*
—Paul Perschbacher

On June 9, 1946, I reported to the Pilotless Aircraft Unit, NAS Mojave, as the Laboratory Officer. On July 4th it was on to Point Mugu to begin building laboratories for the Naval Air Missile Test Center, officially established on October 1, 1946. Reverting to civilian status as head of laboratories on January 1, 1947, it was my good fortune to spend the next 24 years guiding the development of many of *the ground testing facilities now comprising much of the Systems Evaluation Directorate.*

As Laboratory Officer, I also participated in the planning and development of the Pacific Missile Range.

The whole experience was most satisfying and rewarding. It was truly the opportunity of a lifetime and one that will always be remembered with pride of accomplishment.

—Ralph H. Peterson

It was a privilege and sometimes a pleasure to play a small part in the formation and subsequent development of PMTC. I came to the organization from the Navy in 1946, having served in a Radio Controlled Aircraft Squadron, STAGRON 2 & 3. In the early days at Point Mugu every event was usually a first. Data collection and reduction were crude and manual operations. Back then one of the most rewarding experiences involved telemetry of the LARK missile. B. Harris, G. Towle, and I were the whole organization on TAD to NOTS. We calibrated the sensors, recorded the flight data, developed the records and manually reduced them to a complete Flight Test Data Package at the rate of two a month. This was the birth of Range Instrumentation Data Systems, a far cry from the computerized automatic data systems in use today.

— W. B. Peterson

During the period between February 1954 and March 1957, I served as Officer-in-Charge of Guided Missile Unit TEN (GMU-10), developing and testing the then-secret CORVUS missile system in conjunction with the Naval Ordnance Laboratory, Corona. During this period, the development and testing of the missile system proved extremely successful, but in subsequent years, due to lack of funds and changes in Navy requirements, the project was deleted from the list of programs at NAMTC.

—A. P. Pomatti

My favorite memories of the years spent at Point Mugu relate to participation in the formation of what is now the Electronic Warfare Division and the establishment of the associated programs. The minimal funding and equipment available, plus the reluctance of missile project sponsors and contractors to cooperate and support investigations of the vulnerability of their systems to countermeasures, made it a challenging job. The outstanding support of VX-4 and the Marine Air Detachment led to the demonstration of system vulnerability and ultimate incorporation of counter-countermeasure capabilities. Throughout the years the Division operated on the leading edge of technology, utilizing the current output of university research and development, and resulting in the accomplishment of many firsts in the field of electronic warfare. The continued growth and development of the Division and the current recognition of the role of Electronic Warfare has been extremely rewarding.

—E. Norris Proctor

I reflect on my fifteen years at Point Mugu with great satisfaction and gratitude for being able to work with so many dedicated and outstanding personnel. My most rewarding experiences were development of advanced concepts in the Electronic Warfare Division, as Deputy Missile Test Officer, and as Technical Director of the Pacific Missile Range during the challenge to meet deadlines for the buildup of ships, aircraft, and downrange stations. Scoring the impact of the first ICBM's fired into the Pacific was a *highlight. The objectivity and spirit of military-civilian teamwork throughout the organization paved the way for so many technical achievements.* —Stanley R. Radom

It was my good fortune from 1957 to 1975 to participate in several major efforts and organizational changes at Point Mugu. The most significant was the transformation from NAMTC to the Pacific Missile Range, which encompassed an area from Utah to the Indian Ocean. I was assigned by RADM Monroe to organize and direct the RAM-12 group which performed the preliminary systems design and geographical layout for PMR.

It was my privilege to serve in several responsible capacities in the Chief Scientist's Office for NAMTC and PMR, including a period as Acting Chief Scientist. I especially enjoyed my nine years as Operations Research Officer in NMC. My final assignment before retirement was as a member of the 20-Mule Reorganization Team that planned the changes from PMR/NMC to PMTC.

I look back upon 18 years at Point Mugu that were filled with challenging and rewarding experiences in teamwork with dedicated and competent professionals. I am grateful and proud that I was there. —William M. Simpson

I came to NAMTC in 1956 as a Junior Professional and after several assignments, I went to Flight Test where I remained until 1965. At that time I became a Program Manager, and my primary involvement has been with the SPARROW. When I came we were launching the SPARROW I, II, and III. The first two are now long gone, but SPARROW III AIM-7, in its several models, has continued as a major effort at Point Mugu.

Some of the highlights I took part in were the Bureau of Inspection and Survey (BIS) Trials on the F-3H with SPARROW II; TOPGUN, in which I headed the missile evaluation group during competition between twelve Fleet squadrons firing SPARROW; and the BIS Trials on the new F-4, again as Head of the SPARROW III evaluation team.

In Foreign Military Sales, I've participated in evaluating the SPARROW on the Italian F-104S aircraft and went to Italy as PMTC representative evaluating the ASPIDE (Italian version of SPARROW). I also helped set up the U.K.'s SKYFLASH program. —Henry Sandoval

Not much was known about the effects on living things of those first airborne missile control radars in the early 1950's. Students in the classrooms had great fun holding their hands in front of the antenna and feeling the heat generated by the 250-watt-average power output. But it was more fun to point the antenna out the window at flocks of birds flying in straight lines. What happened? Those birds instantly started flying in circles. Are some of us being bombarded by these radars today?

One of the urgent needs of the Navy at Point Arguello in the early 1960's was searchlights for missile night operations. Man, did they react when two dozen surplus World War II searchlights and generators rolled in on flat cars. Why? A few weeks earlier I noticed a surplus equipment sign on a Washington, D.C., Navy building and innocently asked if there were any free searchlights. I envisioned them to be small and hand-portable units, and so I asked for two dozen. When they arrived, the caller on the phone pleaded for no more — they didn't know where to store those 48 four-wheeled trucks. —Hal Skoog

The days spent at Point Mugu were always fun and a challenge. In the very early days it was exciting to walk the halls of Building 6-2 and know that a small cadre of experts on all phases of missiles, from rockets to guidance, worked there. As Mugu grew to meet the challenges, changes were needed; components, yes, but with a system view. Early work with our nation's first satellite, VANGUARD, and the Point Arguello Facility are two of Mugu's contributions to the space program.

The CROW (Creative Research On Weapons) R&D missile, our country's first solid-fuel integral rocket ramjet, an in-house concept converted to hardware and then flight tested, furnished excellent training for technicians and engineers. In the process, the CROW yielded many patents.

Flexibility and challenge have always made Point Mugu, our Navy, and our country strong. Thanks for a rewarding 25 years. —E. Q. Smith

I am proud to have been a part of the Navy and the Naval Missile Center. Looking back I would still enter the Electronic Engineering profession and be involved in either the development or testing of weapons for defense.

One area in which I was engaged was the development of the tactical probe, which, in my estimation, if pursued, would have provided the Fleet a reconnaissance capability at the Commanders' finger tips.

I have been given an opportunity to be concerned with a wide assortment of job experiences during my 28 years at Point Mugu and I am grateful. —Tony Solferino

When I arrived at NAMTC, I was made Assistant Project Officer, then Project Officer on the Navy LOON. I worked closely in launching it from the USS CUSK and USS CARBONERO. I was also the first Project Officer on the REGULUS.

Later I returned to Point Mugu as Director, Pacific Missile Range, and at the end of this tour when I retired, I received the Meritorious Service Medal Citation. I succeeded in resolving many funding and technical problems. Under my guidance, a three-dimensional tactical range was developed for use by the antisubmarine forces in tactical training and weapon system evaluation. During a four year period, the Range experienced an unprecedented growth from 160 programs in 1965 to 300 programs and over 3,000 live missile firings in 1969. I also directed PMR's efforts on several classified programs including the Lockheed SR-71/D-21 drone project and the subsequent B-52/D-21 drone project.

—William G. Stearns, II

My twenty-two years at Point Mugu have left me with fond memories. Though we, as managers, were faced with everyday irritations and headaches, a decade of absence has given me perspective in realizing some of the virtues of the place: the year-round climate, ideal for working and raising a family; the people I worked with and the bosses I worked for — competent, honest in their dealings with others, real "pros"; and the technical environment where opportunities and challenges abounded.

To develop the last point just a bit, I think the technical opportunity and challenge is so diverse and so vast at Mugu that, if fully realized by the outside world, it would bring on professional envy. If I had the chance to do it over again at Point Mugu, I'd do it! And I'd recommend it to others.

—Donald F. Sullivan

During the 1970's, I found myself completely engrossed in underwater projects with the Navy's Submarine Development Group Deep Submersible Vehicles — SEA CLIFF and TURTLE. The project that stands out most vividly was the recovery and replacement of hydrophone 4-7 off PMRF, Barking Sands, in 1971. This project exemplifies the spirit, attitude, and expertise of so many people in the Range Directorate. The thirty-day crash project involved several Navy activities, contractors, and inter-department personnel. It was a delicate high-priority project that challenged all of us in planning, preparation, logistics, and hardware development. I feel it could only have been accomplished by dedicated team effort. —Carl E. Svanberg

In 1960, PMR management, especially Admiral Monroe, Mr. Holmquist, and Mr. Radom, became convinced that for the future of the Range, it was essential to establish an "in-house" computer processing capability second to none.

The available assets were some 120 contractor and 40 civil service personnel. I was recruited to establish a nationwide recruiting and training program for scientists, engineers, mathematicians, programmers, management information, and operating personnel. At its high point the Test Data Division included 203 civil service and 250 contractor personnel and the best computers available. Geographically they were scattered all over the Pacific (Point Mugu, Arguello, Kwajalein, and Johnston Island).

The most surprising experience probably was having a scientific paper accepted and listed for presentation at the Navy Science Symposium and then receiving a message from Washington that "the paper will not be presented, and the authors will not attend." —Charles J. Thorne

Since I came to Point Mugu in the late 1950's, I've been involved with computers and seen a rapid change from relatively primitive first generation equipment to today's fourth generation computers. In terms of core memory and physical size, the advances in just over twenty years have been almost unbelievable. I also remember that in the past it was difficult to make the transition from one generation computer to the next. Now, due to advances in technology, the changeover can be made much easier.

Some of the programs I remember best were providing real-time data processing for range safety on the NIKE-ZEUS missile and supporting the Mercury flights and early satellite launches. —Ben Torres

During my sixteen years at Point Mugu, I was fortunate to work in two different and very interesting areas, technical and employment. In the first, I was employed in Technical Support as a model maker, then moving on into Shop Instructor, quality control, and eventually Head of Tool Control and Maintenance.

My involvement with employment began in 1973 when I was selected to head the newly established Hispanic Employment Program, the first such program in the Department of the Navy Over the years, I also participated in a number of firsts: the opening of an employment information office in the Colonia section of Oxnard, the production of a motion picture about the Hispanic Employment Program, our participation in CETA, and the inauguration of the Summer Employment Engineering Program.

In 1978, I moved to Civilian Personnel and I'm now involved in another first—the establishment of the Navy Employment Information Center. —Robert Q. Valles

In 1975, we achieved a "first"; receiving, recording, and simultaneously retransmitting telemetry data from a Navy EC-121K Super Constellation instrumentation aircraft via satellite to earth. Our budget was so low (actually nil) that we had to borrow equipment and use a broomstick for an antenna mast and a makeshift television antenna to transmit the signal.

We were highly successful. Professional satellite engineers came to inspect our real-time retransmission system. Upon seeing our contrivance they immediately funded a more sophisticated system which we subsequently designed and built. This was a dual-purpose antenna system to retransmit and receive, and had elevation and azimuth control. This same satellite transmission system was in use until 1979 when the EC-121K aircraft was decommissioned.

—Ed Vasquez

In reflecting on twenty-two years at Point Mugu, six significant events come to mind. First is the change from a massive 1958-62 PMR buildup to the divestment of Eniwetok, Kwajalein, and Point Arguello. Second was an unsuccessful campaign to consolidate target life-cycle efforts at the Naval Missile Center under the banner of "threat simulation." The threat simulation concept and name stuck. Third was the formative years of the software support movement. I can recall being instructed in 1973 to think in terms of a department.

Fourth was the consolidation of NMC and PMR into PMTC. The fifth item is related to the controversial experiment in matrix management. Sixth, I am proud to be associated with the emergence of electronic warfare as a major PMTC mainstream function. Through these years of change, wins, and losses, the best part is the friendships which came of it all.

—R. J. Warnagieris

As the first Chief Scientist of the Pacific Missile Test Center, I served from 1949 to 1957. After leaving I was Chairman of the Advisory Board for a time. During this period there was a great deal of rivalry between the Bureau of Aeronautics and the Bureau of Ordnance. Perhaps the most significant event during this period was the development of the SIDEWINDER missile under Bill McLean at Inyokern. Another important concept was the formation of the Senior Scientist Group to promote cooperation between Naval Technical Field Activities.

—R. Weller

Lucille (Derwin) Cook and I came to Point Mugu in the summer of 1961 as the first female engineering majors in the Student Engineering Development (SED) program. Our student assignments here related primarily to computer programming since most of the engineering labs did not have facilities for women.

Following graduation from UCLA, Lucille expanded her association with computers, completed a Master's Degree in Computer Science, and is now Task Engineer for Electronic Warfare Software Support. After graduating from UCB, I spent a short stint as an engineer with the Navy's Porpoise Program, worked fifteen years developing electro-optical systems, and I am now Project Engineering Manager for Electro-Optical and Infrared Systems Development . Both Lucille and I have been active in Equal Opportunity committees and are heartened by the increased potential we see for new women professionals at PMTC.

—Pam (Hutchcraft) Wilke

APPENDIX IV

CHRONOLOGY

COMMANDER, NAVAL AIR MISSILE TEST CENTER

CAPT A. N. Perkins	October 1946 — January 1947
CAPT A. B. Scoles	January 1947 — April 1947
CAPT R. S. Hatcher	April 1947 — June 1949
CAPT E. W. Parish, Jr.	June 1949 — August 1949
CAPT D S. Fahrney	August 1949 — October 1950
CAPT J. N. Murphy	October 1950 — June 1952
CAPT E. M. Condra	June 1952 — October 1954
CAPT J. E. Clark	October 1954 — September 1955
CAPT D. G. Donaho	September 1955 — June 1957
CAPT J. C. Alderman	July 1957 — October 1957
RADM J. P. Monroe	October 1957 — December 1958

COMMANDER, PACIFIC MISSILE RANGE

RADM J. P. Monroe	June 1958 — August 1961
RADM J. E. Clark	August 1961 — September 1965
RADM R. N. Sharp	September 1965 — April 1968
RADM M. W. White	April 1968 — June 1969
RADM H. S. Moore	June 1969 — April 1972
CAPT J. A. Rapp	April 1972 — June 1972
CAPT W. W. Fleming	June 1972 — August 1972
RADM W. WM. Harnish	August 1972 — June 1974
RADM J. M. Thomas	June 1974 — April 1975

COMMANDING OFFICER, NAVAL MISSILE CENTER

CAPT C. H. S. Murphy	December 1958 — July 1959
CAPT W. H. Sweeney	August 1959 — February 1961
CAPT K. C. Childers	February 1961 — September 1964
CAPT C. O. Holmquist	September 1964 — August 1967
CAPT J. C. Rickets	August 1967 — June 1969
CAPT L. A. Hopkins	June 1969 — February 1971
CAPT E. E. Irish	February 1971 — June 1973
CAPT I. N. Schwarz	June 1973 — August 1975

COMMANDER, PACIFIC MISSILE TEST CENTER

RADM J. M. Thomas	April 1975 — September 1975
CAPT I. N. Schwarz	September 1975 — May 1976
RADM D. M. Altwegg	May 1976 — October 1977
CAPT J. C. Weaver	October 1977 — July 1979
RADM F. H. Baughman	July 1979 — January 1982
RADM E. Barrineau	January 1982 — August 1982
CAPT R. F. Crater	August 1982 — September 1982
RADM J. B. Wilkinson	September 1982 — July 1984
RADM J. R. Wilson, Jr.	July 1984 — May 1986
RADM R. C. Gentz	May 1986 — May 1988
CAPT S. L. Vernallis	May 1988 — September 1988
RADM G. H. Strohsahl, Jr.	September 1988 —

CHIEF SCIENTISTS AND TECHNICAL DIRECTORS

Naval Air Missile Test Center

CDR Grayson Merrill, Technical Director	1946 — 1949
Dr. Royal Weller, Chief Scientist	1949 — 1957
Mr. J. P. Maxfield, Chief Scientist (Acting)	1957 — 1958
Dr. A. B. Focke, Chief Scientist	1958 — 1959

Pacific Missile Range

Mr. Robert H. Helmholz, Chief Scientist (Acting)	1960
Mr. Robert S. Schairer, Chief Scientist	1961
Dr. Gerhard W. Braun, Chief Scientist	1962 — 1965
Dr. William M. Simpson, Chief Scientist (Acting)	1965
Mr. Stanley R. Radom, Technical Director	1963 — 1965
Mr. W. L. Miller, Technical Director	1965 — 1975

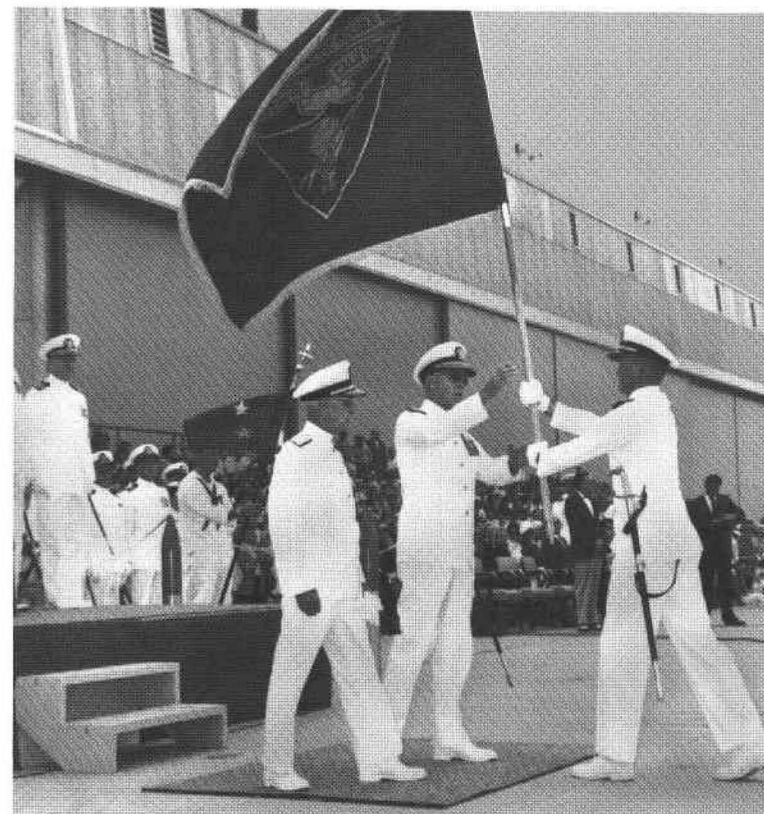
Naval Missile Center

Mr. Donald Sullivan, Technical Director	1961 — 1972
Mr. Thad Perry, Technical Director	1973 — 1975

CAPT E. W. Parish, Jr., RADM Baker, and CAPT Fahrney in 1950.

Pacific Missile Test Center

Mr. W. L. Miller, Technical Director (Acting)	1975 — 1976
Mr. Thad Perry, Technical Director	1976 — 1982
Mr. K. I. Lichti, Technical Director	1982 — 1985
Mr. W. R. Hattabaugh, Technical Director	1985 — 1989
Dr. R. J. Warnagieris, Executive Director	1989 —



Change of Command, 1961: RADM J. E. Clark (l.) and RADM J. P. Monroe (r.).

BIBLIOGRAPHY

CHAPTER 1

Fahrney, Rear Admiral Delmar S., "The Birth of Guided Missiles," *Naval Institute Proceedings,* December 1980

Fahrney, Rear Admiral Delmar S., unpublished manuscript

"Final Report on ASM-N-2(BAT),"Technical Report NAMTC TR-44, 3/26/49

"Final Report on PTV-N-2 (GORGON IV)," Technical Report NAMTC TR-40, 12/14/48

"KAN-2 (LITTLE JOE)," Technical Report NAMTC TR-10, 3/25/47

"Launching of the KUW-1 LOON from an XM-1 Catapult," Technical Report NAMTC TR-17, 7/1/47

Menken, Arthur, *History of the Pacific Missile Range,* 30 June 1959

NAMTC Historical Report — 1 October 1946 to July 1949, Vol. 1

"Noise and Vibration Measurements in KAY-1 (LARK)," Technical Report NAMTC TR-12, 4/1/47

"The MISSILE," 7/21/68

United States Naval Air Missile Test Center History - 1 October 1946 to 1 October 1956

CHAPTER 2

"Interim Report on LOON Program from 1 January 1948 to 1 March 1949," Technical Report NAMTC TR-5, 4/26/48

"Interim Report on LOON Program to 1 January 1948," Technical Report NAMTC TR-28, 4/26/48

Menken, Arthur, *History of the Pacific Missile Range,* 30 June 1959

NAMTC Historical Report - 1 October 1946 to July 1949, Vol. 1

United States Naval Air Missile Test Center History - 1 October 1946 to 1 October 1956

CHAPTER 3

Menken, Arthur, *History of the Pacific Missile Range,* 30 June 1959

NAMTC Historical Report - 1 October 1946 to July 1949, Vol. 1

Oxnard Press Courier, November 11, 1949

"Progress Report on Project XSSM-N-8 (REGULUS)," Technical Report NAMTC TR-89, 7/1/52

United States Naval Air Missile Test Center History - 1 October 1946 to 1 October 1956

CHAPTER 4

"Interim Summary Progress Report, XAAM-N-4 (ORIOLE)," Technical Report NAMTC MT-23-53, 10/28/53

Menken, Arthur, *History of the Pacific Missile Range,* 30 June 1959

NAMTC Historical Report - 1 Jan 1951 to 1 July 1951

NAMTC Historical Report - 1 July 1952 to 31 Dec 1952

"NAMTC REGULUS Assault Missile Evaluation Program," Technical Report NAMTC MT-07-53

"Report on Status of SPARROW III Weapon System," Technical Report NAMTC MT-11-55, 4/26/55

United States Naval Air Missile Test Center History — 1 October 1946 to 1 October 1956

CHAPTER 5

Menken, Arthur, *History of the Pacific Missile Range,* 30 June 1959

"Objectives of the Navy Technical Evaluation of XASM-N-7 (BULLPUP) Weapon System," Technical Report NAMTC DT-01-57, 1/11/57

"Plan for SPARROW III/F3H-2 Weapon System Technical Evaluation," Technical Report NAMTC TMR-103, 10/31/56

"REGULUS II-Grayback," Technical Film Report (MP-4849) BUAER 17-58 1959 NMC

"REGULUS I/Submarine TROUNCE 1A Weapon System Phase B T&E Program, 1 Dec 1955 to 31 May 1956," Technical Report NAMTC MT-06-57, 3/22/58

CHAPTER 6

Menken, Arthur, *History of the Pacific Missile Range,* 30 June 1959

Pacific Missile Range General Development Plan, Vol. 1, PMR-MP-59-08, 1/1/59

"PMR Manual, Vol. 1, Introduction to the Pacific Missile Range," Technical Report PMR-MP-60-07, 12/1/60

CHAPTER 7

"Final Report on CORVUS (XASM-N-8) Development Testing at the U.S. Naval Missile Center," Technical Report NMC-TR-61-02, 12/28/61

*History of the Pacific Missile Range, Fiscal Year 1960,*PMR-MP-60-07, 12/1/60

CHAPTER 8

"High Altitude Rocketry at NMC," publication

History of the Pacific Missile Range and Naval Missile Center, Calendar Year 1961, PMR-MP-62-4-17, April 1962

History of the Pacific Missile Range, First Half Fiscal Year 1961

History of the Pacific Missile Range, Fiscal Year 1960, PMR-MP-60-21

CHAPTER 9

History of the Naval Missile Center, Calendar Year 1963

"KDA-2 as an Operational Target," Technical Report NMC-TR-62-23

"Program Plan KD2B-1 Navy/AF Expendable Target System," Technical Report NMC TM-60-09, 3/7/60

CHAPTER 10

History of the Pacific Missile Range, Calendar Years 1962—3

CHAPTER 11

History of the Naval Missile Center, Calendar Years 1964—6

CHAPTER 12

History of the Pacific Missile Range, Calendar Years 1966, 1967, and 1968

CHAPTER 13

"F-14 Shipboard Suitability Test," Technical Film Report MP-038 029 74

"F-14A Weapons Loading Evaluation," Technical Film Report, MP-721220 3545

BIBLIOGRAPHY (Continued)

History of the Naval Missile Center, Calendar Years 1964 and 1966

History of the Pacific Missile Range, Calendar Years 1965, 1966, 1967, 1968, 1969, 1970, 1971, 1972 and 1973

History of the Pacific Missile Test Center, Calendar Years 1975, 1976, 1977, 1978, 1979, and 1980

Naval Missile Center Command History, 1974

"Six on Six," Technical Film Report MP-297 3669 73

CHAPTER 14

History of the Pacific Missile Range, Calendar Years 1969, 1970, 1971, 1972, and 1973

CHAPTER 15

"Counter-Countermeasures in the Laboratory," NMC publication

"Environmental Simulation at the Naval Missile Center, publication

History of the Pacific Missile Range Calendar Years 1968, 1969, 1970, and 1971

"Total Environment," (Environmental Facilities at the Naval Missile Center) Technical Film Report MP-18909

CHAPTER 16

"A System for Obtaining Physiologic Data During Flight," Technical Memo NMC-TM-62-36, 10/31/62

"Application of Sea Launch to Vertical Probes," Technical Memo NMC-TM-62-54, 12/6/62

"Exposure of Human Subjects to 100 Percent Oxygen at Simulated 34,000 Feet Altitude for 5 Days," Technical Memo NMC-TM-62-7, 4/6/62

"Dolphins that Joined the Navy," Technical Film Report MN-10199

Historical Highlights of the U.S. Naval Missile Center, Calendar Year 1964

History of the Naval Missile Center, Calendar Years 1963 and 1965

History of the Pacific Missile Range, Fiscal Year 1960

History of the Pacific Missile Range, First Half Fiscal Year 1961

History of the Pacific Missile Range and Naval Missile Center, Calendar Year 1961

History of the Pacific Missile Range, Calendar Year 1962

"HYDRA-IRIS," notes from Code 0930 file

"HYDRA-SANDHAWK," Technical Film Report 71MP-18472

"HYDRA-SHARK—A Sea Launched Polar Sounding Rocket," Technical Memo NMC-TM-61-51, 2/9/62

Robinson, C.A., Jr., "Alternate MX Basing Concepts Weighed," *Aviation Week and Space Technology*, 10/27/80

"Sea Launch of Large Solid Propellant Rockets," Technical Memo NMC-TM-60-17, 4/19/60

"Tuffy the Sea Teacher," Technical Film Report MN-11318

CHAPTER 17

History of the Pacific Missile Range, Calendar Years 1968, 1969, 1970, 1971, and 1972

CHAPTER 18

History of the Pacific Missile Test Center, Calendar Year 1975

CHAPTER 19

History of the Pacific Missile Test Center, Calendar Years 1975, 1976, 1977, 1978, 1979, and 1980

"PMTC Ties the Pieces Together," publication

"Production Acceptance Test and Evaluation—Ready Missile Test Facility," publication

CHAPTER 20

History of the Pacific Missile Test Center, Calendar Years 1978, 1979, and 1980

CHAPTER 21

"AN/DLQ-3B Countermeasure Set," Technical Television Production

History of the Pacific Missile Test Center, Calendar Years 1977, 1978, 1979, and 1980

"Old Crow Electronic Warfare," publication

CHAPTER 22

"Barking Sands Underwater Range Expansion," Technical Film Report

History of the Pacific Missile Test Center, Calendar Years 1977, 1978, 1979, and 1980

"Mobile Sea Range," Technical Film Report

"Optical Signature Program III," Technical Film Report

APPENDIX I

Data Base File Code 0930

"Fact Sheet," Naval Air Reserve Unit (NARU), Point Mugu, CA

"Global Navigation by Satellite," Navy Astronautics Group publication

History of Air Development Squadron FOUR (VX-4) Summary Report, 15 September 1952 to 30 June 1959

History of Antarctic Development Squadron SIX (VXE-6), May 1977

History of the Naval Missile Center, Calendar Years 1963, 1964, 1965, 1966, 1967, and 1968

History of the Pacific Missile Range, Fiscal Year 1960

History of the Pacific Missile Range and Naval Missile Center, Calendar Year 1961

History of the Pacific Missile Range, Calendar Year 1962

History of the Pacific Missile Range, Calendar Years 1969, 1970, 1971, 1972, and 1973

"South for the Summer," VXE-6 file

"Welcome Aboard," Naval Air Reserve, Point Mugu, CA publication

APPENDIX II

Career Development Division extracts, Code 0410 files

History of the Pacific Missile Center Center, Calendar Years 1975, 1976, 1977, 1978, 1979, and 1980

"PMTC Handicapped Program," Slide Presentation

ACRONYMS AND ABBREVIATIONS

ACLS	Automatic Carrier Landing System
ADP	Automatic Data Processing
AEC	Atomic Energy Commission
AEW	Airborne Early Warning
AFB	Air Force Base
AFC	Area Frequency Coordinator
ALVRJ	Air Launched Low Volume Ram Jet
AMRAAM	Advanced Medium Range Air-to-Air Missile
ARPA	Advanced Research Project Agency
ASW	Anti-Submarine Warfare
ATDS	Airborne Tactical Data System
AVR	Aircraft Rescue Vessel
AWC	Airborne Weapon Change
BARSTUR	Barking Sands Tactical Underwater Range
BIS	Bureau of Inspection and Survey
BOA	Broad Ocean Area
BODS	Barking Sands Operational Display System
BSURE	Barking Sands Underwater Range Expansion
BuAer	Bureau of Aeronautics
BuMed	Bureau of Medicine
BuOrd	Bureau of Ordnance
CBC	Construction Battalion Center
CCMP	Computer Centralization and Modernization Program
CDT	Contractor Development Test
	Command Destruct Transmitter
CIWS	Close In Weapon System
CNO	Chief of Naval Operations
COMASWGRU	Commander Anti-Submarine Warfare Group
COTAR	Correlated Orientation Tracking and Ranging
CTE	Contractor Test and Evaluation

CVAC	Consolidated-Vultee Aircraft Company
DDG	Guided Missile Destroyer
DLG	Guided Missile Frigate
	Guided Missile Destroyer, Leader
DOD	Department of Defense
DPSC	Data Processing Service Center
DSARC	Defense Systems Acquisition Review Council
EAM	Electronic Accounting Machine
EATS	Extended Area Test System
ECCM	Electronic Counter-Countermeasures
ECM	Electronic Countermeasures
EDM	Engineering Development Model
EELS	Electronic Emitter Locating System
EEO	Equal Employment Opportunity
EW	Electronic Warfare
FTS	Flight Test Simulation
FTV	Flight Test Vehicle
FWP	Federal Women's Program
GLAT	Government Lot Acceptance Testing
GEOS	Geodetic Earth Orbiting Satellite
HARM	High Performance Anti-Radiation Missile
HEP	Hispanic Employment Program
HP	Handicapped Program
ICBM	Intercontinental Ballistic Missile
ICAP	Improved Capability Program
IFF	Identify Friend or Foe
IFPDAS	In-Flight Physiologic Data Acquisition System
IRIG	Inter-Range Instrumentation Group
IRBM	Intermediate Range Ballistic Missile
ISSSMD	Imaging Seeker Surface-to-Surface Missile Demonstration
ITCS	Integrated Target Control System
JATO	Jet Assisted Take Off

JP	Junior Professional
JTE	Joint Technical Evaluation
LEIP	Logistic Engineering Improvement Program
LIS	Laboratory Integration System
LST	Landing Ship, Tank
MCEB	Military Communications-Electronics Board
MAD	Marine Air Detachment
METEOR	Marine Testing of Electro-Optical Radiation
MTI	Moving Target Indicator
MOTU	Mobile Optical Tracking Unit
MSR	Mobile Sea Range
NAF	Naval Air Facility
NAMU	Naval Air Modification Unit
NAMTC	Naval Air Missile Test Center
NBS	National Bureau of Standards
NMC	Naval Missile Center
NMFPA	Naval Missile Facility, Point Arguello
NNSS	Navy Navigation Satellite System
NOLO	No Live Operator
NOTS	Naval Ordnance Test Station
NTDS	Navy Tactical Data System
NTE	Navy Technical Evaluation
NWC	Naval Weapons Center
OASIS	Operational Automated Scheduling Information System
OPEVAL	Operational Evaluation
OPTEVFOR	Operational Test and Evaluation Force
OSP	Optical Signature Program
PAM/FM	Pulse Amplitude Modulation/Frequency Modulation
PATE	Production Acceptance Test & Evaluation
PAU	Pilotless Aircraft Unit
PBX	Private Branch Exchange
PDAS	Photo Data Analysis System
PIC	Program Identification Code
PIDS	Program Identification Data System
PIP	Product Improvement Program
PMG	Project Management Group
PMR	Pacific Missile Range
PMRF	Pacific Missile Range Facility
PMTC	Pacific Missile Test Center
PPI	Plan Position Indicator
PRT	Product Reliability Test
PVL	Production Verification Launch
RAYDAC	Raytheon Digital Automatic Computer
RCC	Range Commanders Council
RDCC	Range Display and Control Center
R&M	Reliability and Maintainability
RDT&E	Research Development Test and Evaluation
RMSS	Range Meteorological Sounding System
ROASIS	Range Operations Automatic Scheduling Information System
ROC	Range Operation Control
SCARF	Santa Cruz (Island) Acoustic Range Facility
	Special Committee on Adequacy of Range Facilities
SITS	Systems Integration Test Station
SOFAR	Sound Fixing and Ranging
TAWS-PEP	Total Airborne Weapon System Performance Evaluation Program
T&E	Test and Evaluation
TASM	Tomahawk Anti-Ship Missile
TECHEVAL	Technical Evaluation
TLAM	Tomahawk Land Attack Missile
TSS	Telecommunication Switching System
WAFC	Western Area Frequency Coordinator

MILITARY NOMENCLATURE

In the Joint Electronics Type Designation System (JETDS), formerly called the "AN" system, nomenclature for electronic equipment consists of a name, followed by a type number.

Table 17 — Set or Equipment Indicator Letters*

1st Letter (Type of Installation)		2nd Letter (Type of Equipment)		3rd Letter (Purpose)	
A	Piloted aircraft	A	Invisible light, heat radiation	A	Auxiliary assemblies (not complete operating sets used with or part of two or more sets or sets series) (inactivated, do not use)
B	Underwater mobile, submarine	B	Pigeon (do not use)	B	Bombing
C	Air transportable (inactivated, do not use)	C	Carrier	C	Communications (receiving and transmitting)
D	Pilotless carrier	D	Radiac	D	Direction finder, reconnaissance, and/or surveillance
		E	Nupac (inactivated, do not use)	E	Ejection and/or release
F	Fixed ground	F	Photographic**		
G	General ground use (includes two or more ground-type installations)	G	Telegraph or teletype	G	Fire control or searchlight directing
				H	Recording and/or reproducing (graphic meteorological and sound)
		I	Interphone and public address		
		J	Electromechanical or inertial wire covered		
K	Amphibious	K	Telemetering	K	Computing
		L	Countermeasures	L	Searchlight control (inactivated, use "G")
M	Ground, mobile (installed as operating unit in a vehicle which has no function other than transporting the equipment)	M	Meteorological	M	Maintenance and/or test assemblies (including tools)

1st Letter (Type of Installation)		2nd Letter (Type of Equipment)		3rd Letter (Purpose)	
		N	Sound in air	N	Navigational aids (including altimeters, beacons, compasses, racons, depth sounding, approach, and landing)
P	Pack or portable (animal or man)	P	Radar	P	Reproducing (inactivated, use "H")
		Q	Sonar and underwater sound	Q	Special, or combination of purposes
		R	Radio	R	Receiving, passive detecting
S	Water surface craft	S	Special types, magnetic, etc., or combination of types	S	Detecting and/or range and bearing, search
T	Ground, transportable	T	Telephone (wire)	T	Transmitting
U	General utility (includes two or more general installation classes, airborne, shipboard, and ground)				
V	Ground, vehicular (installed in vehicle designed for functions other than carrying electronic equipment, etc., such as tanks)	V	Visual and visible light		
W	Water surface and underwater combination	W	Armament (peculiar to armament, not otherwise covered)	W	Automatic flight or remote control
		X	Facsimile or television	X	Identification and recognition
		Y	Data processing	Y	Surveillance (search, detect, and multiple target tracking) and control (both fire control and air control)
Z	Piloted and pilotless airborne vehicle combination				

EXAMPLE

FPS-16 = Fixed, Radar, Detecting and/or Range and Bearing, Search

*Adapted from MIL-STD-196C, "Joint Electronics Type Designation System," 22 April 1971 and Notice 1, 20 April 1972

**Not for U.S. use except for assigning suffix letters to previously nomenclatured items.

INDEX

COMMENTS

Readers are encouraged to send comments and additions to this technical history to the Visual Communications Division, care of Division Head, Code 0130, Pacific Missile Test Center, Point Mugu, CA 93042-5000. These comments and additions will be considered for use in future editions of the Technical History.

AFTERWORD

Thirty-four years of testing and evaluation have been chronicled. LOON, LARK, REGULUS, and many other missiles and target systems are now just names on yellowing test records. They served their purpose in their time, contributed to our national defense, then made way for better things to come. But they are worth remembering. The effort they represent—the testing of each weapon, target, and electronic system—undergirds our present and future work.

The history of the Pacific Missile Test Center does not end here, nor is there any foreseeable end to our mission. As long as America needs a strong defense, we will have a vital part to play. When a weapon goes to the Fleet, it must be dependable. There is no place for second best when providing for our nation's defense.