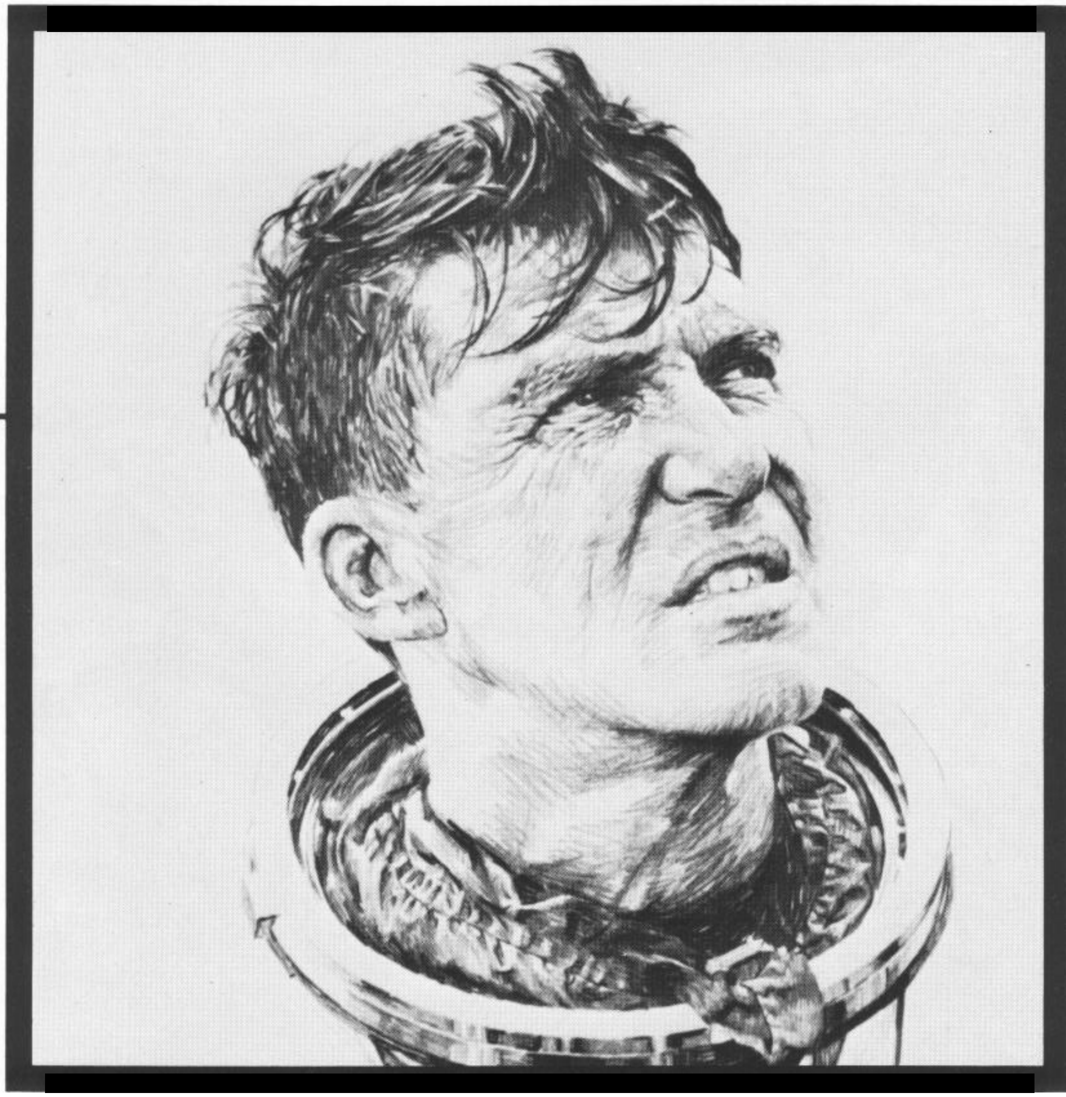
SPACE

AND THE UNITED STATES NAVY

prepared by Naval Aviation NEWS *editorial staff*

DEFINITION OF SPACE

For purposes of this treatment, the term "space" will refer to those altitudes beyond the 30 kilometer level, or the outer one percant of the Earth's upper atmosphere.



FRONT COVER *painting of Captain Alan Shepard by Commander Ted Wilbur, courtesy National Air and Space Museum, Smithsonian Institution*

ABOVE *drawing of Captain Wally Schirra by Paul Calle, courtesy NASA*

SPACE-
and the
UNITED STATES NAVY

by COMMANDER TED WILBUR

CONTENTS

NAVAL AVIATION NEWS

Prepared by
the Editors of
NAVAL AVIATION NEWS

A Publication of the Chief of Naval Operations
November 1970

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price $1.75

"Roger; liftoff and the clock is started.... Yes, sir, reading you loud and clear. This is *Freedom 7.*"

These words, which I was privileged to speak a few seconds after liftoff in *Freedom 7* on May 5, 1961, marked America's first step in its manned space flight program. At the successful completion of the mission, this country had accumulated one-quarter of a man-hour in space.

Eight years and two months later, after we had achieved thousands of man-hours in space, Neil Armstrong completed "one giant leap for mankind" as he stepped from the spacecraft *Eagle* onto the moon.

The intervening years have been marked by hard work, intense research and precise planning by hundreds of thousands of Americans in government and industry. The utilization of space truly has been a national effort; the talents of the military services have been invaluable through these years. The United States Navy has played a particularly important part in the development and final realization of that enterprise.

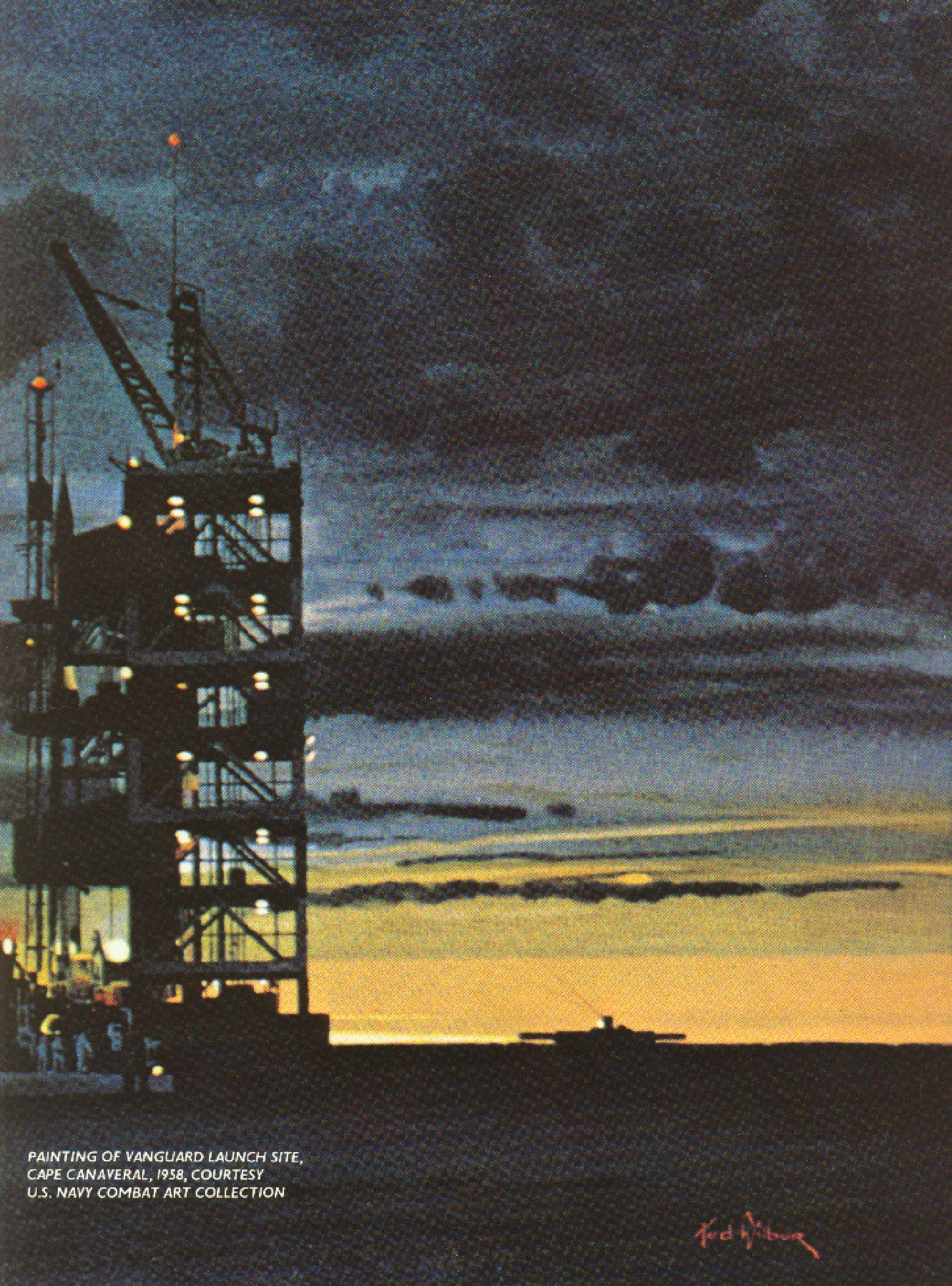
There is yet a long way to go. Eventually Americans will visit other planets in our solar system. More immediately we will man space stations, pilot space shuttles to visit these stations on a regular schedule, and investigate the distant planets and the solar system with unmanned spacecraft.

The United States has established its lead as a spacefaring nation. I, for one, as a Naval Aviator, am honored to have been in at the beginning and feel fortunate to have a continuing role in this great effort.

I am continually proud of the fine support the Navy has provided over the years of the space program.

Alan B. Shepard, Jr.

Captain Alan B. Shepard, Jr., USN
NASA Astronaut



PAINTING OF VANGUARD LAUNCH SITE, CAPE CANAVERAL, 1958, COURTESY U.S. NAVY COMBAT ART COLLECTION

ONCE A FIGHTER PILOT...

He hadn't changed much. Thinner, maybe even a little gaunt. Or was it the light? He stood in the green dimness of the control room, a maroon sweater draped casually on his form. The last of the "Original Seven" glanced up at Houston's huge Lunar Module simulator, then at the banks of flickering consoles. The room was cool. An air-conditioning system droned monotonously off in some distant place. His gaze shifted to the surrounding engineers and he murmured a few words. Finally, we shook hands and I told him what we needed. "Okay," he said, "you can get a few pictures now before this training session. We'll talk later."

Talking to Captain Alan Shepard is a revealing experience. He exhibits two distinct sides. On one hand he is serious and completely logical. Persuasive. But he counterpoints his forcefulness with injections of humor and wit.

On May 5, 1961, I watched from the deck of the USS *Lake Champlain* as he was brought aboard following his historic sub-orbital flight in *Freedom 7*. The carrier's crew gave him a tremendous ovation. A couple of hours later, America's First Man in Space hopped aboard my C-l *Trader*, and we were off to Grand Bahama Island where he would undergo an extensive debriefing and physical examination. No sooner had I cleared the bow than he was out of his seat in the cabin and up into the cockpit, with that big wide grin spread across his face. Shouting above the noise of the COD's engines, he described his morning's monumental adventure, and it was easy to see he had been on top of the world, literally.

National Geographic photographer Dean Conger was on board, too, and, after a series of pictures were taken, I pointed up ahead to where the Bahamas were coming into view. By then it was mid-afternoon and, as usual, tall build-ups were forming over each island. I commented to Shepard that it would be a shame to spoil his day by running into a batch of bad weather. (The strip at Grand Bahama has no instrument facility.) He looked the situation over thoughtfully, then laughed: "Swell! Let's divert to Nassau and pitch a liberty!"

Unfortunately, we made it into GBI in good shape.

The Manned Spacecraft Center in Houston has been described by some writers as cathedral or monastic, a sanctified place wherein astronauts preside as high priests. It doesn't hit *me* that way; rather, it is a geometric setup, neat and quiet. In the middle of the complex there is a duck pond surrounded by carefully trimmed walkways. To get from one building to another you have to make a few right angle turns to avoid walking on the grass. Most people follow the Center's obvious rules of the road.

But when Alan Shepard came out of the LM simulator that afternoon, and I suggested we go over to the pond to get some pictures of him with a watery background, it was interesting to observe how he got there. In a straight line. Over bushes, through a garden, across the lawns and up and down a few grassy banks. It was characteristic.

Visiting with Captain Shepard was originally part of a two-fold mission: I needed some current studies of him in order to do a painting for the National Air and Space Museum; and, at the same time, it seemed a good opportunity to gather some fresh impressions of our astronauts for the readers of *Naval Aviation* News. But something else came of it — this special treatment of Space and the Navy.

It had been said that Alan Shepard is the "intellectual" of the astronauts. He has his own ideas about that. But as Vice Admiral Tom Connolly, DCNO(Air) — who knew him well as a test pilot — puts it, "Alan Shepard is one of the sharpest pilots and officers I ever met. He really has it. There was never a doubt in my mind that he had all the makings for eventually becoming an admiral."

Shepard's own view of his Navy experience focuses on flying. "Operating from carriers at night," he says, "was the hardest kind of flying I've ever done — or ever expect to do. I've said for a long time it's what separates the men from the boys." Today he flies T-38's or the LLTV (lunar landing training vehicle) — Bell's Flying Bedstead. Only, you don't fly that one in terms of hours, just minutes. The weird machine provides the pilot with the same thrust and ratio vectors as he gets with the lunar module.

Since that memorable day in May of 1961, Shepard's life has been a long series of successes — and frustrations. As America's first space hero, he rode the crest of a national publicity wave. Of that experience a few things stand out in his mind. Like the time he waited, all silvery suited up and ready to go, just inside Hangar S at the Cape. On the other side of the door were the reporters, anxious to see which

Alan Shepard
as photographed by
JOC James Johnston

Once a Fighter Pilot

Above, Shepard carves a pair of crude sandals – one of his activities during survival exercises for the Mercury astronauts in the Nevada desert – training for the possibility of a land recovery.

At left, the jubilant astronaut cracks jokes on his way to Grand Bahama island. Above, the first American in space accepts congratulations from President Kennedy. The other six astronauts are in background.

of the three "finalists" (Glenn, Grissom or Shepard) would emerge and make his way out to the loxed-up *Mercury Redstone*. Months of training lay behind and now the moment was at hand. The tension built as he waited with growing impatience for the word to open the door and face the crowd. Instead, the flight was cancelled. He had to wait three more days to start the whole thing again.

The subsequent triumph threw him into the spotlight. He now says he wishes he had a dollar for every picture that was taken of him — because then he could retire. (Actually, investments in banking and real estate have made him more than financially sound.) "In the beginning," he states, "there was a lot of glamour and excitement. It was new to the public. But there really wasn't that much to it. John Glenn went through a lot more than I did."

When Shepard went to the White House to receive NASA's Distinguished Service Medal, he recalls that President Kennedy was nervous and dropped it. From the background came the voice of the President's wife saying, "Pick it up, Jack." Mr. Kennedy retrieved the medal, handed it to Shepard, and declared: "This decoration has gone from the ground up."

Months later, in a similar ceremony for John Glenn, as the President was about to bestow the award again, Shepard whispered to him, "Don't drop it!" Mr. Kennedy broke up over that one.

During the years that followed, Alan Shepard became known as "Hard Luck Al." He was a backup pilot for the final *Mercury* shot (MA-9) and then tried relentlessly to get approval for one last solo flight for himself. The capsule had already been completed. (MA-l0 was named *Freedom 7-II* and is now stored in the National Air and Space Museum in mint condition.) At a White House dinner, after checking with NASA's James Webb, Shepard asked Mr. Kennedy for approval of MA-l0. It was to be an extra flight of protracted duration. The President deferred the question, saying that the decision would be up to NASA. MA-10 never went.

When the *Gemini* program started, he was scheduled again. Then ear trouble developed and Shepard was grounded. "The difficulty," he says, "was termed Meniere's syndrome — a form of dizziness. The problem is not considered very significant for an earthbound person, but it sure can finish you as a pilot. I convinced myself it would eventually work itself out. But it didn't.

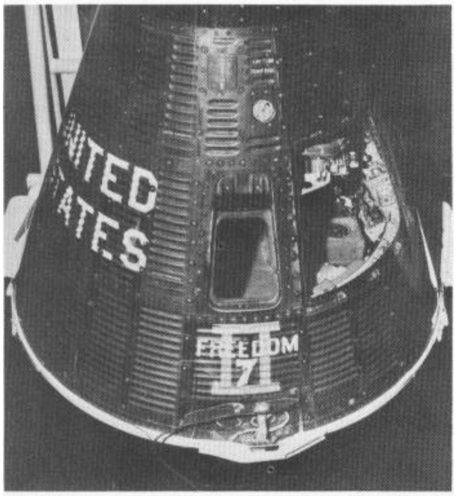
"Tom Stafford had told me about Dr. House, out in Los Angeles, who could perform an operation on this particular kind of inner ear trouble. At first it sounded a little risky but, in 1968, I finally decided on having it done.

"With NASA's permission, I went out to California. In order to keep the whole business quiet, Dr. House and I agreed that I should check into the hospital under an assumed name. It was the doctor's secretary who came up with it. So, as Victor Poulis, I had the operation and six months later my ear was fine."

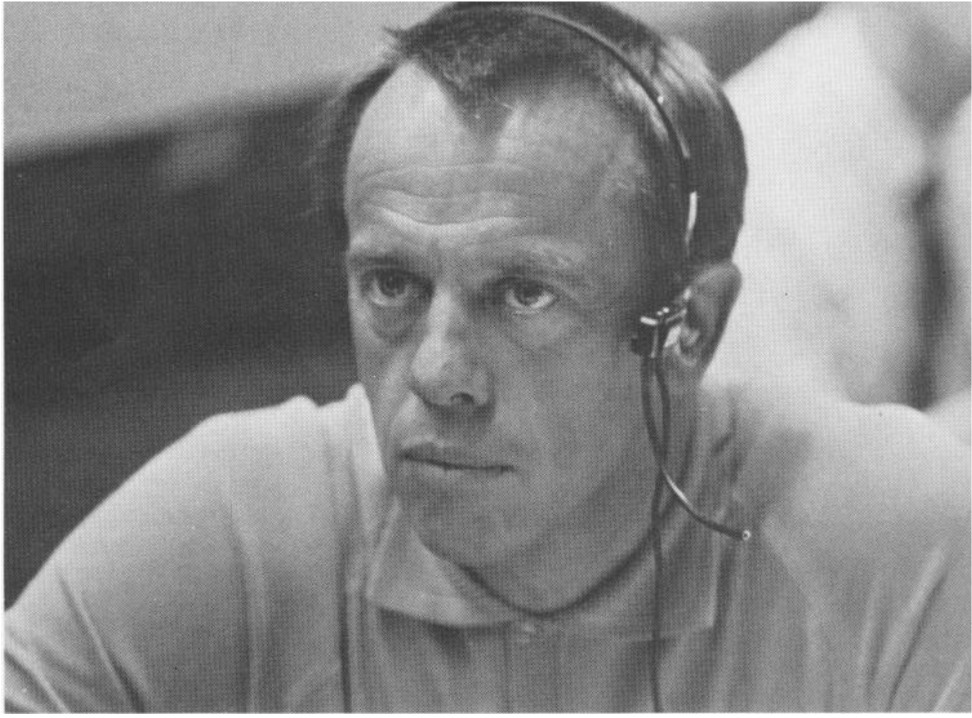
In the meantime, Shepard had accepted the position as Chief of the Astronaut Office, becoming a major guiding force in the training, conduct and assignment of the other astronauts. The performance of this duty required a certain amount of apparent detachment which has at times been misinterpreted as aloofness. There are those who consider Shepard cool or even unfeeling. Reporters and associates alike comment on his ability to control the mood of a meeting or conversation.

But what really lies beneath his demeanor, and what is naturally overlooked or misunderstood by those outside the environment, is the basic fact that he is an aviator — a test pilot — and that he functions in a very similar fashion to, and responds to the responsibilities of, a typical commanding officer of an elite squadron.

Shepard is proud of his Navy background and, be-



Freedom 7-II, above, never flew. It is now stored in the Smithsonian Institution. At right, Shepard monitors communications at Mission Control in Houston as he sweats out the safe return of Apollo 13.



cause of this, is well aware of its contributions to the space program over the years — largely little known facts or unrecognized achievements by Navy scientists and men. For example, during *Mercury,* Shepard himself was involved with the planning for recovery operations of the capsules and pilots. Tracking and locating where his major interests and numerous aids were developed and employed to insure success — UHF and HF radio beacons, fluorescent dye markers, high intensity lights and special Navy depth bombs *(Sofar*)* that explode beneath the ocean surface below the floating spacecraft, sending sound waves through the water to shore stations thousands of miles away.

As he spoke of these things, and of the "spinoffs" of the program which are so beneficial to the public, the original idea of doing a "close-up" for *Naval Aviation News* began to expand into a larger concept. The end result of that thinking is this special edition. It is not meant to be a detailed technical history but, instead, a broad-brush view of just some of the individuals of the Navy who have, each in his own way, helped extend the reach of Man beyond the confines of this planet — men who have also stimulated progress in the pursuit of a better life here at home.

Effort has been made to avoid a "rehash" of familiar material. Much of the information presented concerns fairly obscure Navy men who worked behind the scenes. It is largely about imagination, persistence, success, failures and accomplishments.

To this end, Alan Shepard stands as a symbol. The story of how he fought to overcome the obstacles to his return to space is not surprising to those who have known him for years. His record at Admiral Farragut Academy reveals early leadership potential (and a genius-level IQ of 145). After graduation from Annapolis in 1944, he was assigned to the destroyer USS *Cogswell* before going on to Corpus Christi and Pensacola. In the interim he took civilian flying lessons to better prepare himself for his future. Designated a Naval Aviator in 1947, he joined Fighter Squadron 4B (VF-4B) and then VF-42, flying *Corsairs* from the USS *Franklin D. Roosevelt.* He had test pilot training at Patuxent River and remained there from January 1951 until July 1957 — a period interspersed with duty in VF-193, a night fighter squadron flying F2H *Banshees.*

Of that tour he recalls an incident, while operating off the USS *Oriskany,* when he had difficulty finding the ship. His radio had failed and it was one of those nights when things began to go so wrong — the edge of panic seeped in. He considered his situation and thought: "Shape up, Al! You're never going to get anywhere if you just sit out here and start worrying about it." So, keeping his thinking machine on the move, he worked out the problem and made it back to the ship okay. It was a principle he has consistently applied, as have thousands of successful aviators.

The fact that the 47-year-old astronaut has hung on to the program with such tenacity prompts a question: *Why?* The others of his original group have each gone their separate ways but, over the years, he has continued to maintain an arduous training schedule. He certainly hasn't done it for the money, and there were all manner of alternatives he could have pursued with a high degree of success.

In answer to that question, the commander of the forthcoming *Apollo 14*, Captain Alan Bartlett Shepard, Jr., grins. And then he says, "Once a fighter pilot, what else can a fighter pilot do?"

*Sound Fixing and Ranging

— COMMANDER TED WILBUR, 1970

Considering that it is traditional for sailing men to study the sun and stars — a necessity if they are to navigate desolate seas with any assurance of success — it could be said that the United States Navy has always had an interest in space. It could also be pointed out that the Navy established its base of space technology, the Depot of Charts and Instruments — later renamed the U. S. Naval Observatory and Hydrographic Office — over 140 years ago. Among its duties was the preparation of celestial charts and spatial information.

To Leave the Earth

"It looks like a good day to set an altitude record." And, with that, Lieutenant Pat Bellinger, Naval Aviator #8, climbed into a Curtiss AH-3 pusher and soon found himself at 6,200 feet over Annapolis, claiming the first unofficial world's altitude record for seaplanes. The date was Friday the 13th, June 1913. (Always one to push his luck, Pat went on, the next year, to become the first Naval Aviator to be shot at. Over the many years of his full life, he happily pursued adventure.)

Because seaplanes were not yet a *recognized* category, his feat was never set down in the record books. But it represents the manifest desire of early Naval Aviators to join others of their kind in reaching out from earth to climb ever higher toward outer space.

Bellinger challenged the heavens again in 1915, making it to 10,000 feet over Pensacola in a Burgess Dunne AH-10 — a vehicle to which modern sweptback wings can trace their ancestry, Later that same year, Lieutenant "Caswell" Saufley flew in an AH-14 to 11,975 feet and, in 1916, successively to 16,010 and 16,072 feet. Shortly afterwards, he crashed to his death while setting an endurance record of eight hours and 51 minutes over Santa Rosa Island, off Pensacola.

Some years passed before there was any official differentiation between land and sea planes by the accepted authority, the Federation Aeronautique Internationale (FAI). By 1923, however, when the categories had expanded to 42, including seaplanes with various payloads, the Navy's Bureau of Aeronautics was credited with 22 out of the 33 world records then held by the United States. And by the end of the Twenties, the books showed that out of some 100 competitive events involving altitudes, flight duration, distance and speed, Americans held over one-third the honors, including the coveted absolute altitude record for Class C landplanes. In the latter category, two Naval Aviators had emerged to gain this honor: Lieutenant C. C. Champion (appropriately enough) and Lieutenant Soucek — whose first name was Apollo.

In 1927, the Navy had a unique airplane, the diminutive Wright *Apache*. Its purpose was to fly higher than any other machine — to probe the chilling secrets of the blue above the earth. Not a war plane, its lines were conventional. Still, it was a fighter. Its adversary? — *air*. Two basic elements made up the Apache project: the airplane and the man who flew it, Both needed *air,* in an environment where the "breath of life" was, literally, rare,

A reciprocating, gasoline-driven engine needs air, with its high content of oxygen, to function. So does a man. The engine of the *Apache* was a Pratt & Whitney *Wasp,* a radial engine of the type Naval Aviation (with considerable wisdom and foresight) had put its money on. But it had a few improvements attached: Scintilla magnetos, a special Stromberg carburetor, "BG" spark plugs, and a "Rootes-type" *supercharger* — manufactured by the Allison Engineering Company. (A supercharger can, by various means, increase the volume of air inducted by an engine — a useful item in situations where you don't have much to begin with,)

A man is more delicate; you can't just pump him up with a Rootes blower. So, early in the game, it was learned that a certain amount of extra oxygen could be carried and administered in a fairly simple flask-and-tube

There are those who believe the matter should stop right there. After all, they argue, it is a Navy's business to sail its ships upon *terrestrial* waters — and not become involved with grandiose notions about seas of space. But if we contemplate the motives of that unknown man in ancient times who first hacked and whittled out a log and then paddled into the unknown, we can more easily understand his modern counterpart. The tools have improved; the ponds are larger. But *he* is still the same old *restless* fellow.

for the Oceans of Space

Lieutenant Patrick N. L. Bellinger, Naval Aviator No. 8, at the controls of a Curtiss AH-3 pusher-type seaplane. Bellinger was the first Naval Aviator to be shot at — in 1914.

fashion. What was not fully understood was the effect on a human body of low atmospheric pressure at high altitude. It was thought that inhalation of oxygen by the pilot would be sufficient for survival. The facts refuted this hopeful theory.

On the morning of July 25, 1927, Lt. Carleton C. Champion took off from the Anacostia Naval Air Station in Washington, D.C., in an attempt to break the existing landplane altitude record of 37,569 feet, then held by Lieutenant John A. Macready, U.S. Army. The 425-hp. *Apache* climbed to a height registered as 47,000 feet on the cockpit altimeter when two cylinder heads on the Pratt & Whitney Wasp engine suddenly blew off. Parts of the broken engine hurtled past Champion's head, tearing pieces from the plane's wings. As he ducked, the rubber oxygen tube popped from his mouth. He passed out within a few seconds, and the *Apache* rolled over, uncontrolled. As the plane fell towards denser air, Champion awakened in a semiconscious state and found his machine falling and afire. Groping around, he found the lost tube, righted the plane and went into a series of sideslips and dives to blow out the flames. The strain of these maneuvers further tore up the engine. Still half conscious, he glided to a cornfield, having fought four fires on the way down. An official examination of the instruments showed that Lt. Champion had actually reached a height of 38,419 feet, a new record.

In spite of the victory, obvious physiological problems had yet to be overcome. Champion's successor saw the need for a face mask which would ensure that oxygen, *under pressure*, would reach the lungs.

The man named Apollo (he was called "Sockem" Soucek by his friends) won his wings in 1924 and three years later found himself assigned to the *Apache* project. As a member of the Power Plants Division of the Bureau of Aeronautics in Washington, Soucek shuffled papers for a year before he ever saw the research plane, which was then undergoing a complete overhaul. But from all the technical correspondence and plans he was handling, he became intimate with every detail of the Wright machine. A consuming desire to fly it prompted Soucek to ask his boss, Admiral William A. Moffett, if he could step into Champion's shoes. The visionary leader of Naval Aviation gave the go-ahead and Apollo Soucek prepared to venture out beyond all men.

One part of the training bears examination — a contrast to today's multi-million-dollar space flight simulators (described later in this publication). In order to test an individual's capacity to function at high altitudes, the subject would be placed in a gradually rarefying atmosphere where, under the scrutiny of flight surgeons, he would attempt to do a number of things, all at once. There was a panel of little lights; if one came on, punching a switch beneath would put it out. On the side was an ammeter and a knob. Turning the knob at the proper rate would keep the meter's needle zeroed. With both hands thus occupied, attention was given to the feet: by pumping furiously on a pedal, the irritating whine of a supercharger-like device could be diminished.

Apollo did fine on this curious exercise — for a while. But as the air within the chamber grew thinner, confusion limited his ability to play the "one-man-band." After what seemed an eternity he was too exhausted to go on. The lights flashed, the needle had run amuk, the screaming noise pierced his ears. But only 25 minutes had actually passed and Sockem was deemed "qualified to go to an altitude of 28,000 feet without oxygen!"

Although an understanding of the need for pressurization in flight suits and cockpits was yet to come, the requirement for oxygen at altitude was well known. The method of applying it was interesting. Of his self-designed breathing device Apollo said, "I obtained the necessary parts from the naval hospital, from the air station and from local drug stores."

The apparatus consisted of oxygen flasks in the *Apache's* open cockpit, rubber tubing to the mouth, "a clothes pin-like gadget to clamp the nostrils shut," and a tube attached to a hot water bottle, "thus enabling the operator to breathe normally — almost."

Before attempting his assault on the altitude record, Soucek made five familiarization flights in the little plane, each time flying higher than before. He discovered that his limit was about 33,500 feet; beyond that his goggles frosted over and he couldn't see the instruments. This seemingly insurmountable problem (which also induced the fear of "frozen eyeballs") was eventually solved by Apollo's brother, Zeus. The younger man, a Naval Aviator attached to the Naval Aircraft Factory in Philadelphia, flew down to Anacostia with a special set of electrically heated goggles he had made. The lenses, a standard, pilot's type, were equipped with a wire element which was attached to an eight-volt, rheostat-controlled storage battery. In principle, this arrangement later proved excellent, the only objectionable feature being the weight of the battery, eight pounds. "That isn't much on an ordinary airplane," said Apollo, "but in one where ounces mean reduced height, the addition of extra pounds is most undesirable." As it turned out, Zeus arrived too late; his brother had already taken off.

Above 25,000 feet the temperature drops as low as 89 degrees below zero. Experience from the Arctic, dating back to 1913, indicated that a proper flying suit, if made from the right material (caribou skin), need weigh no more than nine pounds and yet would provide complete comfort. The user was advised, however, to refrain from wearing any clothing underneath. The fur suit was to be worn next to the skin. Therefore, Soucek's attire consisted of: a caribou suit; a nutria fur-lined helmet/face mask; fleece-lined, vented goggles; lambskin boots; two pairs of muskrat mittens ("the second pair makes one's hands rather clumsy"); golf stockings; and an athletic supporter.

"The golf stockings and jockey strap," said Soucek, "were in a sense unnecessary refinements. By wearing them I violated the underwearless doctrine. They provided no additional warmth and were worn for civilized purposes only."

On May 8, 1929, the *Apache* was fueled with 40 gallons of gas, while the flight surgeon packed Soucek's nose and ears with Vaseline-coated cotton wads. Then the suit was donned, "the ends of the trouser legs wrapped around and gripped in place by the clamping effect of the boot tops." His nose clip was attached and the helmet put on. "The pilot must see to it," Soucek later advised, "that the assistants do not draw up the helmet and neck piece straps too tightly; the entire clothing regalia should fit loosely in order that blood circulation not be retarded. Over-zealous helpers are apt to draw up any slack strap very firmly in order to make the grotesque looking pilot appear as shipshape as possible."

After a run of less than 75 feet, the *Apache* leapt into the air and climbed smoothly. It was an uneventful flight to 38,000 feet, the engine and oxygen systems of the little research plane functioning perfectly. Thereafter, progress lessened. "At this height, the frost began to appear on the goggles" and, by the time he reached 40,000 feet, engine rpm had dropped, "About 40 minutes had elapsed since leaving the ground . . . I periodically felt weak. Frost now covered the inside of the goggles. But I knew that a record was within my grasp, so I decided not to return until I had gone as high as I could.

"I pushed the goggles up on my forehead and placed my head as low as I could in the open cockpit. To my surprise, I felt no excruciating pains (from frozen eyeballs) whatever. Instead, the new visibility was encouraging. I could discern colors on the ground; the earth presented a beautiful sight — perfectly natural but greatly reduced in size. I thought I was over the city of Washington, but was mistaken as subsequent events disclosed.

Lieutenant Carleton C. Champion at the time of his harrowing but record-breaking flight to 34,419 feet in July 1927. During his descent, Champion successfully fought four fires.

At left, Lt. R. C. Saufley, Naval Aviator No. 14, smiles in this 1915 photo. Saufley established several world's altitude records before crashing to his death at Pensacola the following year.

"Soon the skin around my eyes began to hurt, but my eyes themselves did not pain. Fearing the results of frozen skin, I pulled the goggles back down. Then I could not see the instruments, much less the horizon or any reference point."

Soucek was flying blind, barely. The *Apache* became extremely hard to handle; it was near its stalling point. The grease in the control system had become stiff, causing difficulty in movement of the stick — "it required every bit of strength I had to lift a wing. I attempted to use my knees on the stick and my right hand to hold the goggles away from my eyes about an inch."

To make matters more difficult, Soucek had to operate the emergency oxygen valve with the same, heavily be-mittened hand while his left was employed exclusively for the throttle

LT. APOLLO SOUCEK, SUITING UP AND READY TO GO

'. . . our last record will serve only to sharpen the keen edge of foreign competition.'

and supercharger valves. As a safety precaution in case of blackout, those controls were tensioned with a bungee cord. To keep them open required a constant forward pressure. The fatigue began to tell.

"The plane dropped off in a right spin. Removing the goggles entirely, I grabbed the stick with my right hand and released the throttle and supercharger controls from my left. Both levers immediately closed. The spin cost 2,000 feet of altitude; to regain that, plus a few additional feet, did not appear at that time to be possible. Besides, I was somewhat alarmed to find myself over Chesapeake Bay." It took 25 minutes to get back to Anacostia and land — where it was found that eight gallons of fuel remained in the *Apache's* tank. But the Navy pilot had set a new world's altitude record.

Although Apollo Soucek went on to greater heights, his comments on that particular flight are noteworthy. "It was valuable. Something was gained. In the Navy, we enter research work such as altitude flying for a definite purpose; records are secondary matters that are useful only as goals for which we strive. The *Apache* is a flying laboratory; the height she attained proved the experiments were based on correct formulas. The equipment in some parts of the plane and its power-plant is just a step in advance of what will appear on standard aircraft of tomorrow.

"It is natural to suppose that men in foreign countries will go beyond the mark set by the *Apache;* our last record will serve to only sharpen the keen edge of foreign competition.

"Many people have congratulated me on my successful effort. Some of my friends and acquaintances have been most enthusiastic in their expressions: however, I fear that some of my more intimate friends do not think very highly of my spiritual standing, More than one of them has remarked, 'Well, I suppose that's about as close to heaven as you'll ever get!'

"A remark like that causes one to think and wonder about his past life. But I'm not so sure that heaven is such a desirable place, after all, if conditions are anything like those I experienced above 40,000 feet."


WRIGHT
APACHE
S.NAVY

Soucek's predictions were correct; two weeks after the flight just described, a German pilot did better. Other records were set, including some by Soucek, but it had become apparent that aircraft of that time could not truly provide the sealed, pressurized environment for the safe study of the upper atmosphere. The answer lay in balloons.

Settle Up - Settle Down

It was one of those rare, crisp, clear mornings in the District of Columbia, when I knocked on his door, a half-hour early. A man in a robe greeted me, saying, "I was in the shower. Come in and get comfortable. I'll make some coffee when I come down." Vice Admiral Settle (Ret.) went back upstairs to complete his ablutions.

The house was in an attractive, northwest Washington neighborhood. Looking out the window of the dining room, I could see the sloping, wooded yard and then, gazing upward, follow the lines of tall trees, their leaves almost blanking out the blue sky overhead, It was a curious setting; the sylvan scene was somehow incongruous. For, as I thumbed through the scrapbooks he had left on the table — two marvelous, meticulously maintained albums with green leatherette covers and gold inscriptions stating simply: "Campaign I" and "Campaign II" — I reflected on the fact that the friendly, unassuming man upstairs, who lived in a house surrounded by trees, had once been the focal point of the beginnings of the Race for Space.

In 1927, when Captain Hawthorne Gray of the U.S. Army lost his life due to oxygen failure in an open balloon basket at 42,000 feet, a young Naval Aviator decided to build a better vehicle. The airship officer, Thomas ("Tex") Settle, working with C. P. Burgess of the Bureau of Aeronautics, came up with a design for a sealed cylinder, about seven feet long, in which a man with a life support system and instruments could ride into the stratosphere. He called it "The Flying Coffin," When Settle showed the proposal to Admiral Moffett, the Bureau's Chief ordered its construction at the Philadelphia Naval Aircraft Factory.

But about this time there was another of the ever recurring "tight money" situations. As a result, budget problems forced the cancellation of a number of research projects, including The Flying Coffin. Nevertheless, the idea persisted. In Europe, physicist August Piccard developed it into a spherical gondola and, by 1932, had made balloon ascensions to 53,000 feet.

The following year, Piccard made a lecture tour in the United States. Suggesting that a new flight be made at the Century of Progress Exposition in Chicago, he succeeded in acquiring the necessary backing. The National Broadcasting Company and the *Chicago Daily News* would be co-sponsors. Goodyear would provide the balloon; Dow Chemical, the gondola; and Union Carbide, the hydrogen. Scientists Arthur Compton and Robert Millikan offered equipment to study cosmic rays. For an American pilot, the Navy brought forth the only man in the world licensed to fly all types of aircraft, "lighter-than-air" specialist Lieutenant Commander Tex Settle.

The ascent from Soldier Field was planned for August 1933. Although the gondola was designed for two men, it was decided that in the interest of saving weight, Settle would fly solo. Once again, the "Lone Eagle" concept came into play and LCdr. Settle became a page-one excitement to millions of Depression-ridden Americans. Radio and newspapers followed every step of the preparations until, on the night of August 4, tens of thousands of people jammed into Soldier Field to watch the spectacular takeoff. As searchlights played, the 600,000 cubic foot "A Century of Progress" — the largest balloon in the world — was gradually inflated from a nearby stack of 700 steel hydrogen cylinders. By two in the morning, the 105-foot-diameter balloon, straining at the lines gripped by a score of Navy men, Photographs from the Settle Collection

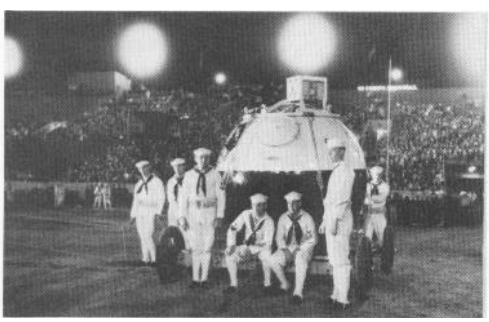
LCdr. "Tex" Settle looks on as a University of Chicago scientist checks special instrument and flight equipment prior to assault on the world altitude record. Below, the scene at Soldier Field, Chicago, on the night of August 4, 1933 as 125,000 cubic feet of inflammable hydrogen gas mushrooms the gigantic balloon up over the assembled crowd.

'...may both

A CENTURY OF PROGRESS AT AKRON

loomed above the crowd. Then utter silence fell as Settle announced he was going to test the gas release valve, a critical control. He pulled the cord, which went up through the folds, and then let go. To his dismay, a shrieking hiss persisted far too long. The valve was not closing properly; somewhere above, the cord was binding. Flight was impractical. Yet, to rip the bag and release the hydrogen in the midst of the crowd was a more dangerous alternative. Settle made his decision: "Let's go!"

Rivetted by searchlight beams, A Century of Progress rose to 5,000 feet in the pre-dawn Chicago darkness. Settle worked the cord again. This time the valve remained fully open and the balloon fell toward the railroad yard. Ballast was dumped to lessen the rate of descent. The 15-minute flight ended ignominiously with a crash across the railroad tracks. A morning paper headlined the event: "SETTLE UP! SETTLE DOWN."



There is something about the demise of an aerial machine that *does something* to people. The souvenir hunter emerges. Crowds have been known to rummage through wreckage, their apparent objective being to make off with whatever is portable. At times, even tattered human flesh has had a peculiar appeal. If the wreck is remote, the finder has opportunity to even *toy* with it. A case is recalled where a farmer leisurely bulldozed over the remains (including the pilot) of a plane which had crashed in his field. The scheme was to hide it from searchers and then sell the metal as junk, later.

But, when in a pack, a dog works fast to get a bone. So, when Tex Settle crawled out of his gondola in the middle of downtown Chicago at an early morning hour, he was naturally concerned by the sight of the mob which was stomping all over his limp balloon. Puffing on cigarettes, a few were already cutting up the fabric, oblivious to the presence of explosive hydrogen. It wouldn't take them long to get to the instruments.

Fortunately, the Marines arrived. As part of the launch crew, they had observed the fall of the balloon and Major C. L. "Mike" Fordney and four of his men had taken a bearing and followed by automobile. The ensuing operation "to keep the peace" until reinforcements arrived was fortunately successful and was noted with cryptic praise by an appreciative press. The bag was saved, would be repaired, and Settle would try again. But an the next attempt, regardless of weight considerations, he would have a partner to help: Maj. Fordney.

As work progressed at a comfortable pace, word suddenly came from across the seas that a foreign attempt was being made on the high altitude record. On September 30, 1933, a sealed-cabin balloon named the "USSR," manned by three Soviet aeronauts, achieved a height of 62,230 feet! Although Russia was not a member of the FAI and therefore did not qualify for official recognition, the record was a challenge.

Sensing a potential for disproportionate publicity if another attempt were made from Soldier Field, Settle shifted operations to Akron, Ohio. In spite of the move and the relative privacy afforded by the Goodyear zeppelin dock, newspapers continued to give the preparations major treatment — making much of the competitive characteristics of the Russian and American craft. News-hungry reporters devoured every bit of information they could get, and sensational accounts of the supposed "effects of cosmic rays" splashed across the Sunday supplements.

our countries continue to contest the heights.'

Vice Admiral Settle gently stirred his coffee, his eyes lingering on the towering trees beyond the window. "The fruit fly experiment," he said, "was interesting. I read this morning, in the paper, a short article about the *Apollo 12* astronauts who observed the effect of cosmic rays on a human being — they saw little flashes of light, even when their eyes were closed. In a way, the cosmic rays are still mysterious. They certainly were in 1933, and much more was made of them.

"Back then, there was a belief that cosmic rays might affect the gender of a living creature. Since the reproductive cycle of the fruit fly is rather quick, it was decided to install a number of these insects in the gondola for the flight into the stratosphere — into that region where they would be bereft of normal sky protection. The jars were prepared, each with an air hole, of course, and each containing what was claimed to be a virgin fruit fly. Where this notion came from, I can't imagine. For, as bad weather moved in, and the flight was repeatedly delayed, the jars were constantly full of tiny offspring. Noting the concern about this particular experiment, the reporters speculated. And, somehow, the idea developed that a man at high altitude, bombarded by the dreaded rays, might come back — as a woman!

"Confronted with this strange proposition of the Press, I struggled for a reply that would satisfy. I told them, in a very knowing manner, that if, upon return, Maj. Fordney and I discovered ourselves not to be as we had left, we would immediately go back up, get another dose, and be ourselves again.

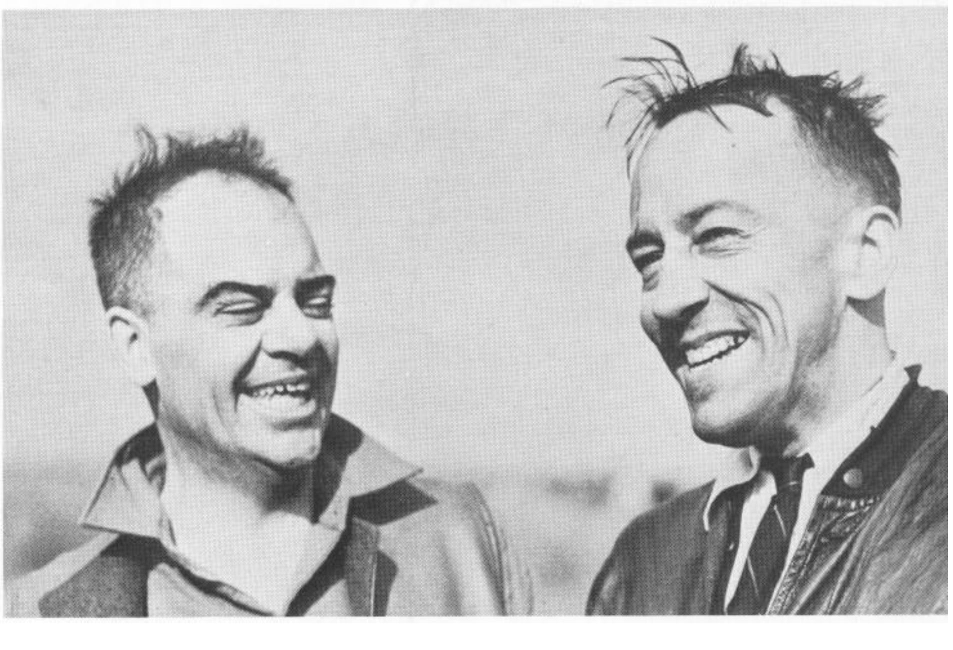
"But then they asked, 'What if one of you is more susceptible and changes before the other?' Mmm. I said, 'In that case, upon observation of such phenomenon, the unchanged one will quickly don a parachute and bail out, returning as rapidly as possible to the safety of Earth. The other, continually exposed to the strange rays, will wait until the cycle makes full turn and then follow suit.' I almost had them believing it."

On November 17, the balloon, A Century of Progress, manned by a Naval Aviator and a Marine, arose from the Ohio landscape to an altitude of 61,237 feet — a new, official world's record — yet still short, by almost 1,000 feet, of the actual Russian mark. The Soviets were magnanimous in their praise of Settle's achievement, but part of one of the congratulatory messages gave clue to their intent: ". . . may both our countries continue to *contest the heights* in every sphere of science and technique."

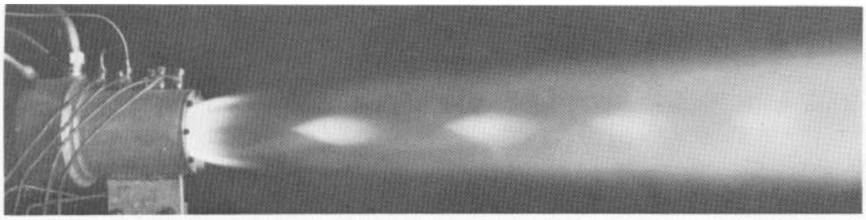
On January 30, 1934, the *Osoaviakhim* made it to 72,182 feet before plunging back to Earth in a crash which killed its three crew members. It was said that the Russian balloon may have iced up. The time of year was a factor, too. Some reports claimed that Stalin, against advice, had ordered the dangerous flight in conjunction with the 17th Communist Party Congress then being held in Moscow. He had pointed to heaven and said, "Go!"

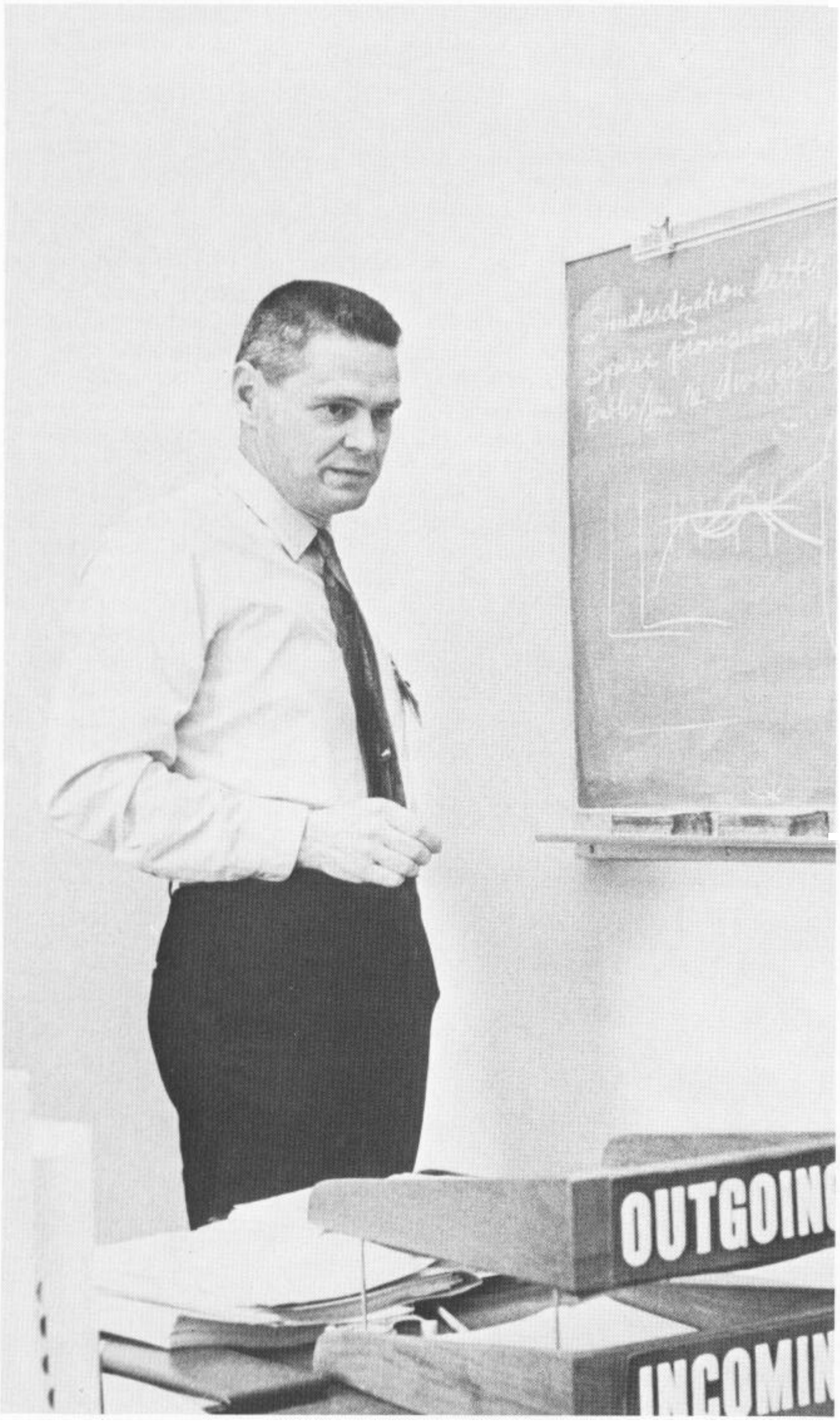
The competition went on, but the Russians' worthiest opponent had left the arena. LCdr. Settle went off to China to take command of the Yangtze River gunboat, *Palos*. After a long and distinguished career in both the air and surface Navy, he finally retired from active duty, as a vice admiral, in 1963.

Thomas G. W. Settle, Class of '15, sipped his coffee and, with a sparkle in his eyes, thought back on an adventure that earned him the Harmon International League of Aviators Medal and the Count de la Vaux Medal. The flight was termed "another victory for the American eagle" by the FAI but, as far as Tex Settle is concerned, it was the starting flag of the Race for Space.



MIKE FORDNEY AND TEX SETTLE





Photograph by JOC James Johnston

TRUAX/GODDARD

Navy

Just inside the main gate of the Naval Ship Research and Development Center on the banks of the Potomac in Carderock, Md., there is a small white building that has a temporary look about it. You get the feeling that someday you might come back and find it gone — a reasonable estimate, because the man who works within is on the move. He always has been. That is the way it is with *rocketeers* — if you are lucky, you may discern a little patch of scorched earth some place and know that one has been there. It is about all they leave behind — that, and an idea. You begin to suspect they are not of this world.

The thing that immediately strikes you about Bob Truax is his energy — and youth. He speaks, and you find yourself on the edge of your chair. He looks, and you see a fire in his eyes. He moves — an equation suddenly appears on the blackboard — and you notice that his hands are constantly in motion. He might have been an actor. Instead, he is *the* rocket pioneer of the Navy — a distinction shared with Dr. Robert Goddard and a few others.

In order to put the work of Captain Robert Truax, USN (Ret.), in perspective, it is necessary to go back a bit and observe that there were three recognized progenitors of our modern space age. The first was a Russian, Konstantin Ziolkovsky, whose proposal for spaceships was published in 1903. Dr. Robert H. Goddard followed with the classic, "A Method of Reaching Extreme Altitudes," in 1919. Then, in 1923, the German, Dr. Hermann Oberth, published his study, "The Rocket into Interplanetary Space."

Goddard was the only one to personally put his theory into practice, starting about 1914 when he was a physics instructor at Clark University in Worcester, Massachusetts. In July of

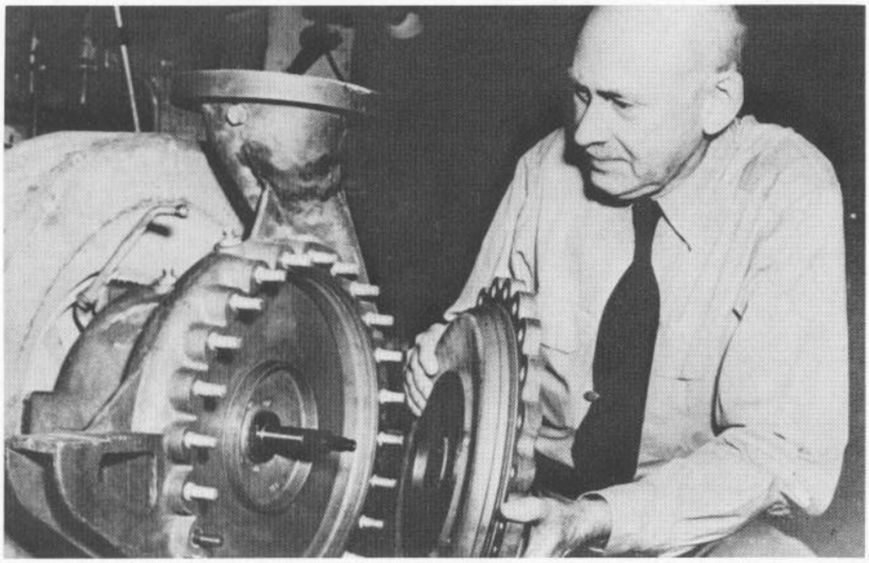
Rocket Pioneers

that year, while recovering from pulmonary tuberculosis, he was granted a patent, the first of more than 200 over his lifetime. During World War I, one of his developments was the prototype of the World War II bazooka. The war ended shortly after he demonstrated the remarkable antitank hand weapon — too late for that conflict, but useful in the next. His "A Method of Reaching Extreme Altitudes" was quietly released, in limited distribution, by the Smithsonian Institution in January 1920. Then all hell broke loose.

The paper had been aimed at scientific circles, but conjectures on its last pages — especially one dealing with a rocket shot to the moon — had been seized upon by the popular press and sensationalized.

At a time when everyone *knew* that rockets could not operate in the vacuum of space — and that Jules Verne had been a *fiction* writer — Goddard became the target of public ridicule. For a while, he tried to explain his hypothesis; each time he was misquoted and humiliated. Even as he tried to withdraw from the limelight, the hecklers followed and Sunday supplements portrayed him as the "Mystery Professor." The articles were complete with wild illustrations of mad preparations for his lunar trip. Branded a crackpot, Goddard dropped from public view. Privately continuing his work on rockets and space navigation, he guardedly stored his notes in a file labeled "Formulae for Silvering Mirrors."

While the average American made sport of the man with a *new idea,* the European reaction to Goddard was seriously receptive. His Smithsonian paper found acceptance, and among those who entered into correspondence was a mathematics student at the University of Heidelberg, Hermann Oberth. The young gentleman was engaged in a pursuit similar to Goddard's. In the years to come, Oberth would write a textbook on space flight and become associated with Wernher von Braun and the place called Peenemuende. When "Herr Wernher" was being interrogated about the development of the V-2 rocket by a U.S. technical team in Germany after WW II, he said, "I don't know why you ask these questions of me when it is you who have the teacher who expounded the technology that has made the V-2 possible."



Captain Robert C. Truax, opposite page, front runner in early Navy rocket experiments, led the way in development of reaction motors for aircraft and missiles. Above, his wartime civilian associate, Dr. Robert H. Goddard, examines a turbo pump from a captured German V-2 rocket. Dr. Goddard worked, under contract, for the Navy at the Experiment Station, Annapolis.

Goddard was not so thin-skinned as to be truly disheartened by his own countrymen's derision in the early Twenties. He *knew* he was right (the philosophical advantage of a thinking man). In 1926, he launched the world's first liquid-cooled rocket from a farm near Auburn, Massachusetts. More shots followed, until, on July 17, 1929, he got one off with history's first rocket-borne instrument payload — a barometer, thermometer and camera. Unfortunately, a rocket has one especially obnoxious characteristic — noise, and a great deal of it. This particular one caused neighbors to assume an airplane had crashed. Shortly thereafter, he was enjoined by a Massachusetts fire marshal to cease and desist. A friend came to the rescue. Colonel Charles Lindbergh suggested to the Guggenheim family that Goddard's work was worth support. Former Naval Aviator Daniel Guggenheim agreed. The financing resulted in the building of a rocket experimental station near Roswell, N.M. There Goddard was able to make substantial progress.

Robert Goddard's publicity had not gone unnoticed by American scientists. Not long after the base at Roswell was established, the American Rocket Society (ARS) was formed. A hard core of "rocket enthusiasts," finding Dr. Goddard too remote (and uncommunicative), patterned their own organization after Berlin's Vercin für Raumschiffart — the German Interplanetary Society. Soon, thunderous, fiery birds were arcing skyward from such unlikely places as Marine Park on Staten Island, while, in a garage in Alameda, California, violent experiments with combustible powders were being conducted by a youngster named Truax.

"The first rocket I ever built," says the bright-eyed man, moving his hands in a manner reminiscent of a sculptor's, "was, I guess, when I must have been in high school. I was a *Popular Mechanics* fan and, in the early Thirties, there was a splash made. Dr. Goddard was doing a little bit, and the German Rocket Society and the American Rocket Society were just then getting formed. So, every so often, they'd make the *Popular Mechanics*-type magazine. It was far out. Anyway, I got the bug to the extent of wanting to go out and build what I'd been reading about."

Bob Truax looked at the sky and clouds outside his small office. "I guess it just appealed to me. So, I started making rockets. Made gunpowder rockets. Mixed up black powder in the basement and put in a little glue to make a sort of solid propellant.

'It was more an accident than anything else that I didn't kill somebody!'

At right, the first gasoline/oxygen rocket engine built by Truax in 1938. Below, Midshipman Truax with members of British Interplanetary Society in England Noted space writer, Arthur C. Clarke, is at far right.

Some of them burned fairly decently. But others. . . . Well, for instance, I found that Sparklett cylinders (used to make carbonated water), when filled with smokeless powder, do *not* make very good rockets. They explode and send steel all over the place. Once, I blasted the door of my Dad's garage with flying metal particles.

"But then I made one with a toothpowder can which I stuffed full of nitrate film. *That* makes a pretty good rocket." Truax leaned back, chuckling. "The only trouble is that after working fairly well for a while, it came apart, and sent these streamers of flaming celluloid all over my backyard and I had to run around stamping out the fires.

"Well, with the Depression and all, money was tight, so I went to the Naval Academy and, after a while, started to build myself a rocket over in the Steam Engineering Building where they had lathes and other such stuff. I had it finished by 1937 — just the combustion chamber, a rather sophisticated, cooled, liquid-propellant type — and I took it over to the head of the Marine Engineering Department and asked if I could set it up in the foundry and run it. And he said, 'Why don't you take your. . . . rocket and get the hell out of here!" So, I took it across the [Severn] river to the Experiment Station."

At this point, Midshipman Truax found himself subjected to an interrogation by several other heads of departments, whose concern was primarily safety. Young Truax adroitly applied a principle he would never forget — always have an answer. Spouting physics to physics instructors, he made an impression. Captain Cox, C. O. of the Experiment Station, finally said, "Well, fellows, what do you say we give him a chance?"

As Truax recalls, "Once the boss had spoken, it became a grand idea.

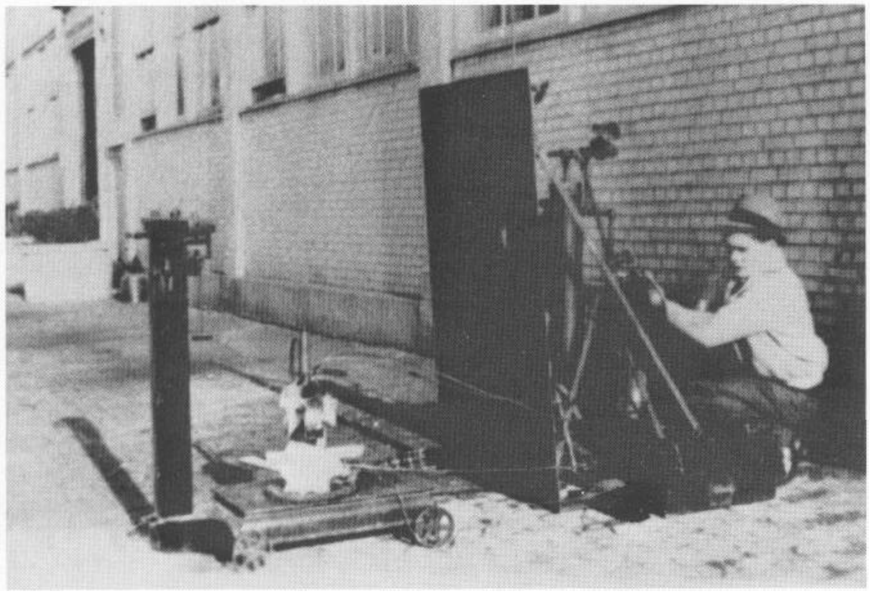
"I never found out what my budget was; it was sufficient for my needs. And they even assigned a little welder to me — Sugar Evans — who was a whiz with a torch when I had to cut up boiler plates and pipes."

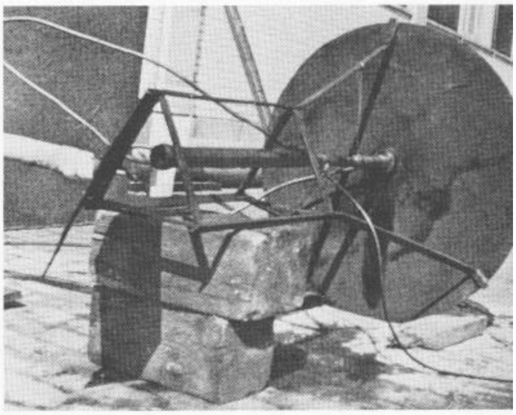
Since spare time is rather limited at Annapolis, Truax decided to stay at the Experiment Station over his Christmas leave (1937) in order to get his rocket going. "I had ten days. One problem was that I needed gasoline and liquid oxygen for fuel. Gasoline was easy, but lox was like the atomic bomb! So, I settled on compressed air. It was more an accident than anything else that I didn't kill somebody!

"But the rocket worked and attracted attention. I remember the workmen would come out of the building during lunch hour to where I was set up and sit around eating their lunches and watch the crazy kid running his rocket. It made a godawful racket — only 25 pounds of thrust — but enough to drive you batty! They'd throw rocks at it, at the exhaust, and watch them go up in the air. Two big guys got a plank and tried like the devil to hold it in the jet. Quite a time they had!

"Perhaps the only real good that came out of the Annapolis thing was the write-up I did in late Spring of 1939 for the Naval Academy *Log.* The technical reports were published by the ARS (American Rocket Society) but went largely unnoticed. However, the *Log* article came to the attention of Commander A. B. Vosseller. He was a 'big boat' (patrol plane) man, and they apparently were having trouble with the PBY-2's. The *Catalinas* were underpowered for certain conditions. So he dropped me a note along about graduation time and said, 'Before you go out to the fleet, why don't you drop in and talk to me?' Vosseller was head of the Plans Division of the Bureau of Aeronautics (BuAer).

"Having an idea of what he wanted to talk about, I ran up to Washington, where he pointed out the problem by saying, 'Do you think you can put a rocket on an airplane?' Well, I just happened to have a little analysis, as applied to the PBY, in my pocket. Then, what he did was suggest I submit a patent paper on my JATO (Jet Assisted TakeOff) unit — and that he would use it as a vehicle to get me assigned to the Bureau and to get





At left, young Truax adjusts his compressed air/gasoline rocket. Above is his regeneratively cooled engine on its test stand. Truax devoted most of his spare time and leave periods to these experimental operations.

a project started, actually develop it!

"It took a little time. I put two years in the carrier *Enterprise* (CV-6) and a destroyer before I was finally ordered to BuAer. The job was to set up a project for JATO's for the PBY. Because the term 'rocket' was always associated with crackpots, I was the 'jet propulsion' man. I worked up a scheme estimated to cost $65,000. My boss, Commander Bolster, thought this

amount was more than BuAer was ready to put into such a venture, but suggested that I take my proposition to Commander L. C. Stevens, the head of the Experiments and Development Branch. Without any haggling at all, Cdr. Stevens, a particularly forward-looking officer, told me to write out a project order for that amount. I could have kicked myself for not having asked for $165,000.

"Well, that done, and with an urge to get my hands a little dirty — I just couldn't sit up there in Washington and be a bureaucrat — I went back down to the Experiment Station at Annapolis to run the thing. From the Bureau files, I had selected Bill Schubert, Jim Patton and Ray Stiff, all Reserve ensigns, to lend a hand. Several months later, the Bureau set up Dr. Goddard in a facility we had established at Annapolis."

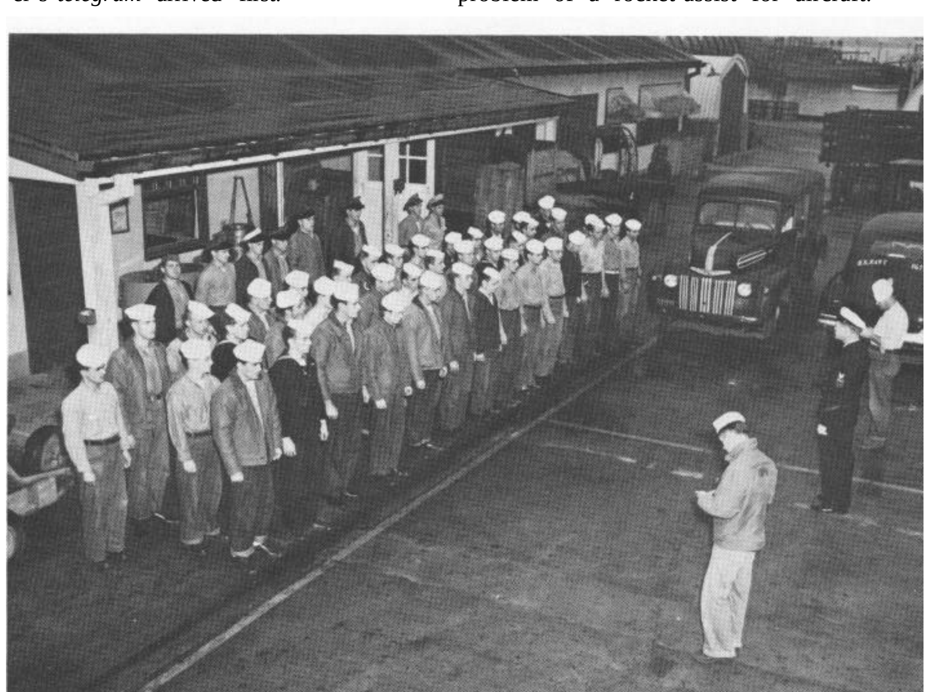
It is a point of interest that Goddard, in the years leading up to World War II, had offered his services several times to the government, and that he had been rejected. Perhaps the "crackpot" image preceded him. Then too, his previous rough treatment at the hands of the Press, which resulted in a *secretive* method of operation, probably branded him as an eccentric outside his small circle. But two military men, an Army flyer named Boushey, and a Naval Aviator, Lieutenant Fink Fischer, did all they could to bring recognition to Dr. Goddard, Both men were interested in the development of rocket-assisted takeoffs for airplanes and eagerly sought to recruit Goddard for this purpose. One story has it that at a point when the war was imminent and a rocket research program seemed to have some possible merit, both Captain Boushey and Fink Fischer simultaneously went after the famous rocketeer. Boushey sent an airmail letter. But Fink Fischer's *telegram* arrived first.

Captain Truax recalls, "In 1942, just before I left the Bureau and went back to the Experiment Station at Annapolis, Dr. Goddard walked in. During the year before, when the international situation had been getting tense, the Guggenheims had recommended that he work for the government as he had in WW I. He had been doing some contract work for the Navy out in New Mexico, and now, here he was in Washington!

"He astonished me a little when he said he thought the rocket had come to the point where it needed engineering treatment, as opposed to the laboratory type of effort, and he needed someone to be his chief engineer. I said, Who do you have in mind,' and he answered, 'How about you?' That was what surprised me. Goddard had been engaged as a private contractor using government facilities. His work and the Navy's were to be separately administered but co-located. As a result, Goddard became Director of Research on Jet Propulsion, at Annapolis, while I was officer in charge of the Navy people. Both efforts were supported by BuAer as Project TED 3401, and Goddard's assignment was the same as mine — to build a JATO for the PBY *Catalina.*"

Others were also at work on the problem of a rocket-assist for aircraft.

One of the BuAer projects at Annapolis was a radio-controlled flying wing. This particular version made one successful free flight, dropped from plane.



At right, the Navy crew at morning muster at the Experiment Station. Dr. Goddard's office and shop were located in the right half of building.

The Army Air Corps, with the help of a former collaborator of Goddard's, Dr. C. N. Hickman, sponsored a program at the Guggenheim Aeronautical Laboratory at Cal Tech (GALCIT). Captain Homer Boushey, working out of Wright Field, conducted a series of tests in mid-1941, using rockets to thrust an *Ercoupe* into the air. Solid propellants were used in both locales, and Dr. Hickman's work was paralleled by the Navy's Bureau of Ordnance at Indian Head, Md. The smokeless powder used in these experiments burned at an uncontrollable rate (some would explode), a factor which made them impractical for service use. Although the British development of extruded cordite was an improvement — Lt. Fischer made successful takeoffs in a Brewster F2A-3 *Buffalo* on May 26, 1942, using British antiaircraft rockets (which spewed burning particles over the tail of the fighter) — the Navy's main program was concentrated on development of a long duration, cooled rocket motor.

"We were asked," Truax continues, "to build either a restartable unit or one that had an idling period. This really threw Goddard a curve because none of his prior work had been directed toward meeting such a requirement. I had decided, long before, that liquid oxygen was not a tractable propellant for military application. Needed was something which could be stored in a tank for a long time and not evaporate. Goddard was of a different mind; liquid oxygen was his baby, and he figured it would be all right.

"My first plan was to use nitric acid as the oxydizer and gasoline as the fuel. This combination proved very hard to ignite. In an effort to find a fuel that would ignite spontaneously on contact with nitric acid, we tried numerous chemicals. Turpentine worked well, but aniline proved best and became standard in rockets for many years.

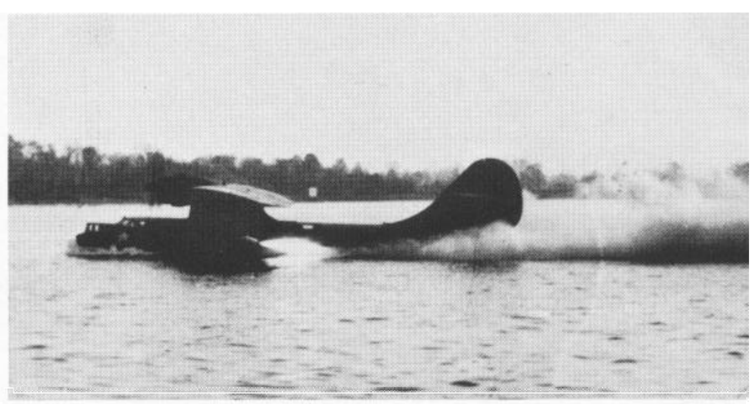
"I can remember Goddard, looking out his window, watching one of my test runs, a look of absolute amazement on his face, because here we were, turning on, turning off, turning on, repeatedly. And there Goddard was, having such a devil of a time with his non-spontaneous propellants.

"He'd have to fire his with either a spark plug or a squib (a pyrotechnic device fitted in the nozzle). But with first ignition, the squib, of course, would be blasted out or, in the case of the spark plug, the tip would be burned off. In either case, this meant he couldn't light off a second time — and that was the requirement. He tried all kinds of arrangements to protect the spark plug. I remember looking at his unit, and it just had tubing in every direction — spaghetti around and under and over. Very complex compared to the self-igniting system.

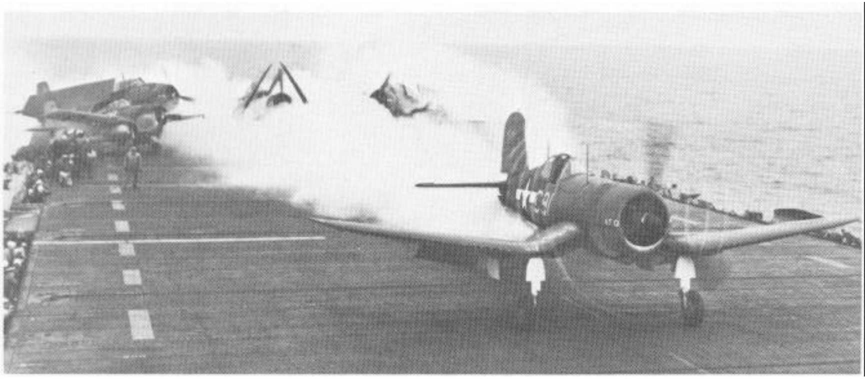
"The requirement itself proved eventually to be unnecessary for JATO and had the unfortunate effect of making Dr. Goddard's problem much more difficult.

"At any rate, by the time Fink Fischer came down from Washington to join us in 1942, we had developed a thrust chamber — a full size, 1,500-pound thrust chamber, working regeneratively, without requiring any extra coolant. It was, I decided, time for me to go off to flight training and become a Johnny-come-lately Naval Aviator."

The work Lt. Truax had done on controls and propellant feed systems had led his group to the discovery of the spontaneously igniting chemicals so widely used later. But the bulk of Dr. Goddard's experimentation at that time still was centered on gasoline and liquid oxygen. On August 1, 1942, a *Catalina* flying boat was delivered to the group at the Annapolis Experiment Station. The flying boat was modified to accommodate Goddard's installation. The unit was very complex, with numerous



Truax and his staff are shown at left during a visit from Dr. Van Karman (in white coat) of Cal Tech. Above, JATO units light off during 1942 PBY tests in Severn River. Craft made one successful takeoff prior to mishap.



An F4U-1 Corsair starts takoff run on USS Altamata (CVE-18) in 1944 after widespread acceptance of JATO units for fleet use.

thermocouples and safety relays. As a result, the test runs conducted in September by Lt. Fischer were only partially successful. Salt spray and the vibration of the PBY kept shorting out the relays, thus shutting down the unit. After five unsuccessful attempts, Fischer, in a desperate effort to get the plane into the air, had the special safety thermostatic cutoff switch removed. He was making sure the JATO unit would keep running throughout a complete takeoff. On the sixth test, the plane took off satisfactorily. Unfortunately, during the seventh run, vibration loosened a liquid oxygen line; the resultant fire seriously damaged the aft end of the airplane.

Nevertheless, further development work culminated in successful flight tests of a JATO-equipped *Catalina* by May 1943. Tests performed with this and other aircraft made it evident that JATO could reduce a takeoff run by 33 to 60 percent — or permit greatly increased payloads. One of the project test pilots, Marine Lieutenant William L. Gore, engineered a remarkable demonstration of JATO potential when he decided to "sell" it to the Pacific Fleet. It was not an easy task.

As previously mentioned, the Army Air Corps had gone to some lengths to develop a JATO capability of its own.

Capt. Bill Gore hung around, probing for a chink in the armor

Asphalt potassium perchlorate JATO was demonstrated in 1943 on F4F-3.

In spite of considerable success, the Army changed its mind around 1943. In view of the long runways at its disposal, the need for JATO dissipated, and they dropped the project. In the Navy, too, there were those with similar feelings — as Bill Gore found out.

Gore was a long time rocket enthusiast. As an enlisted man and aviator in the Marine Corps, he had built a radio-controlled model dirigible propelled by the powder of Roman candles. His official paper on the use of JATO for flying boats and carrier aircraft eventually resulted in his assignment to the rocket desk in BuAer and promotion to a commissioned grade. He had been Fischer's copilot on the early PBY test and had put on his own show in an F4F *Wildcat.* Now he was out for big game, the Commander, Fleet Air Wing Two — Rear Admiral John Dale Price.

If any man could put JATO on Navy airplanes, Admiral Price would have to be that man. As Gore recalls, it took him three days to fly a PBM *Mariner* from Annapolis to Kaneohe Bay, Oahu, in the Hawaiian Islands. Then for the next five days, he cooled his heels outside the Admiral's office until it became evident he was not exactly welcome. But after that 6,000-mile trip, the Marine Aviator took a risky chance; he finally burst into Admiral Price's office and exclaimed, "I'm here, Sir, to sell you rockets!"

The Admiral quietly replied, "I'm trying to fight a war and what does Washington send me? A guy with a rocket." And then, with mounting vigor, "We don't need *rockets.* We need *airplanes!* Get the hell out of here!"

As a famous man once said, "Nothing succeeds like persistence. . . ." Bill Gore hung around Oahu, probing for a chink in the armor. And then he thought of the solution — a *contest.*

Arranging to put on a demonstration of comparative takeoffs between an ordinary PBM and one equipped with JATO, Gore set a time, knowing the Admiral would come out to watch, if only for the sport of it. As an added inducement, it was stipulated that each plane would be loaded with ten tons of sandbags. The opposing pilot was one who also shared the Admiral's disdain for rockets, so he was bound to do his best.

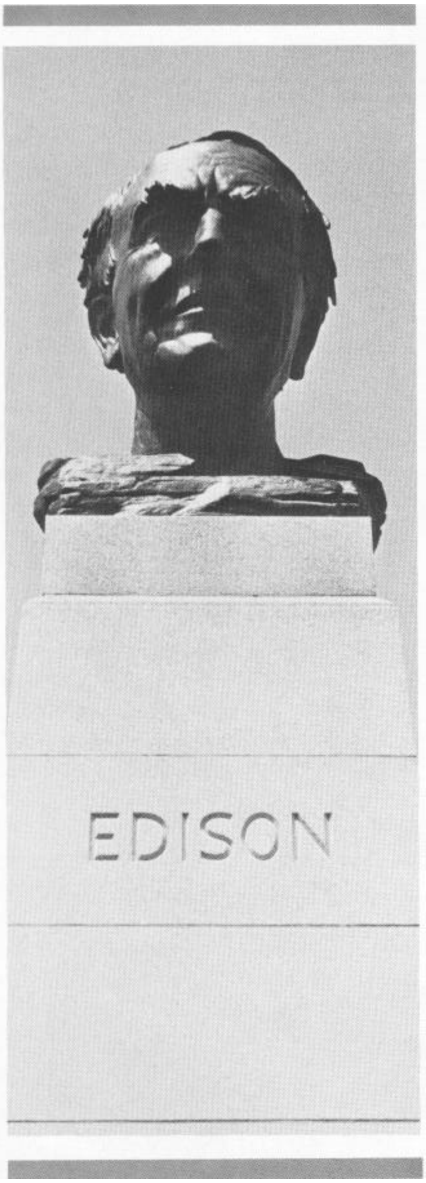
The night before the contest, Gore told his crew chief to have 20,000 pounds of sand put in each PBM. The next morning, sure enough, the Admiral was on the seawall watching as the seaplanes taxied in the bay. At the signal, Gore cut in his rockets and sailed into the air. The Admiral could hardly believe it, especially since the other flying boat was still thundering about, unable to even get airborne! It turned out that Gore's crew chief had loaded the other plane's sand in its stern, far aft of its center of gravity; there was *no* way it could fly.

But Admiral Price had seen JATO. "I want that on every plane in the Navy," he said, and from then on, he was JATO's strongest supporter.

The liquid propellant JATO units of 1943 were reliable and worked well. However, their inherent handling difficulties and the fact that they were impossible to service in forward areas led to the switch to solid propellant units. By the end of the war, it was claimed that more than 3,000 lives had been saved because of its use. It also played a part in unique salvage operations, several times enabling downed flying boats to take off from extremely shallow waters. The most remarkable case concerned a JATO-equipped, four-engined PB2Y-5 *Coronado* that had been forced down in desert sand south of the Salton Sea in California. A ditch 2,000 feet long was bulldozed out, filled with water, and the seaplane floated. From this narrow ditch, it made a successful JATO takeoff and returned to its home base.

But the chief result of the Truax/Goddard liquid propellant JATO program at Annapolis was that it laid the groundwork for the use of rocket power in Navy guided missiles.

NRL



'a place to sift ideas'

While young Robert Goddard was antagonizing New England neighbors with his noisy contraptions in I915, another visionary gentleman was penning a far-reaching proposal for the *New York Times Magazine*. In July of that year, Thomas A. Edison went on record as saying the Navy should have its own scientific staff to sift the ideas of our inventive nation; that it should have its own laboratory, indigenous to the Naval Establishment, in which the ideas or inventions could be tested and adapted to the special needs of the Navy.

Secretary of the Navy Josephus Daniels wasted no time. American involvement in the War to End All Wars was imminent, and the myriad problems of readying a fleet for the conflict were beginning to inundate the former publisher. He immediately contacted Edison, asking that the Wizard recruit a technical advisory group composed of leading scientists in various fields. They would screen the hundreds of inventions submitted to the Navy, determining which had merit and which were crackpot notions. With typical enthusiasm and energy, Edison rounded up 24 of the biggest names in the scientific-engineering community. These luminaries, operating under the title Naval Consulting Board of the United States, drew up a proposal for a research laboratory to be located either at Annapolis or in southwest Washington, D.C. Edison, on the other hand, had a strong, personal preference for Sandy Hook, at the mouth of New York harbor. Other considerations (one of which was the war itself) had a tendency to bog the committee down, so it was not until 1920 that the elite group was to assemble for the purpose of witnessing the ground breaking for the laboratory.

The formal dedication of the Naval Experimental and Research Laboratory on July 2, 1923, was equally impressive; Franklin D. Roosevelt, Assistant Secretary of the Navy, was the principal speaker. Edison was not present at the ceremony, which took place at the Bellevue Magazine in southwest Washington. As a matter of fact, he never visited the lab. (Some said he might have, had it been located on Sandy Hook.)

Nevertheless, Edison sent a recommendation which was followed to the letter — that the research institution be headed and administered by naval officers, and that the scientific work be placed in the hands of civilians. By the end of the first year, the few scattered radio research groups (and one in water sound study at Annapolis) had been scooped up and deposited at the Washington facility — four officers and 92 civilians. They were off and running. And four decades later, there were four of the original plank-owners still aboard.

The accomplishments of the Naval Research Laboratory (NRL), as it later came to be named, range far and wide. Many of its members were destined for greatness in diverse fields. The NRL list of inventions and achievements is lengthy — too long for this confined perusal of Navy space-related activities. Therefore, most of our observations will be interwoven with other stories throughout this book. One fact, however, warrants our attention at this point: NRL invented radar.

As has already been noted, significant achievements are not easily come by — fun to look back on, perhaps, but at those moments of actual pursuit, elusive goals sometimes existing only in the form of dreams or, possibly more often, nightmares. If one is lucky, he may even have one of those remarkable "accidents" which open up new avenues. But, it still boils down to a *thinking* man's game. Such was the case with radar.

Back in the early Twenties, the terror of the German U-boat was still fresh in people's minds. War from beneath the sea had become an awesome reality. At the same time, radio was just coming into its own. President Harding had broadcast the 1922 dedication of the Lincoln Memorial in Washington, using a transmitter built and installed by an NRL man, L. A. Gebhard. Commerical programs were beginning to make their first impact on the American life. Wireless had made itself indispensable to the fleet as far back as '17 and '18, and now new objectives were established.

Greater range, round-the-clock communication, more channels (with increased stability) — these were goals of NRL, the little group which had become the recognized leader in American radio development. Because the small Navy organization was of modest means, the eager scientists often resorted to a form of bird-dogging. They sniffed over new discoveries and applied them to their own use. Lacking the wherewithal to make components themselves, they often prodded the radio industry into *making* them.

This is not to say that NRL did not do impressive radio research on its own. The NRL-developed, Taylor-Hulbert wave-propogation theory revolutionized prior thinking on how radio waves travel. And the Laboratory designed some very ingenious gadgetry — guidance circuitry for the first successful radio controlled aircraft (1924), and later, for target drones. As for prototype development, many an NRL breadboard (simplified design) model was translated into specifications for standard equipment used throughout the fleet. An example was the radio direction finder and airborne radio for the giant dirigible, *USS Shenandoah*. It was this practice of bird-dogging the new discoveries, combined with in-house research where necessary, that led NRL to radar.

While still at the Anacostia Aircraft Radio Laboratory in 1922, A. H. Taylor and Leo Young noticed the interference caused by a ship passing in the river between their radio transmitter and a receiver on the other side. This was a curious phenomenon, of great interest to the two scientists. Here was a discovery that somehow seemed important.

After the consolidation with NRL, L. A. Gebhard designed the equipment (used by Breit and Tuve of the Carnegie Institution) which measured, by *radio pulses,* the height of the ionosphere. Then, in 1930, NRL scientists observed continuous-wave radio reflections, in the form of "beats," from an aircraft in flight. Now they really had their hands on something. At that point, Taylor determined that intensive research should be undertaken by the Radio Division.

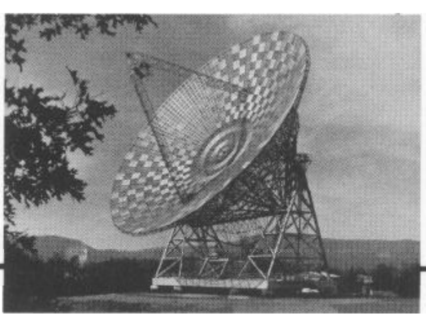
By the following year, complete plans for an *aircraft early warning* system had been worked out on paper. At the time, the system seemed probably more applicable to Army needs, but the Navy work continued. Taylor assigned the task of actually building a pulse system to Leo Young and another promising engineer, Robert M. Page. In 1934, the continuous-wave system was demonstrated to members of Congress. Then Page succeeded in building, for the first time anywhere in the world, a transmitter and receiver that could detect aircraft by radio pulses.

Shipboard installations were constantly improved until, in extensive sea trials during fleet maneuvers in 1939, radar's practicability was proven. Its possibilities were immense, not only for aircraft warning but for navigation and gunfire control. A particularly effective demonstration involved *night* destroyer attacks on major fleet units.

By 1941, nineteen NRL radar models were in use aboard naval ships. That same year, Page developed the plan-position indicator — the familiar radarscope with the round face and the sweeping hand.

All this had been accomplished by a handful of dedicated men in naval research. By soliciting the help and cooperation of the American radio industry, they had come up with a workable system which enabled an operator to "see" in the dark, eventually over great distances. And if any object could be seen — regardless of weather conditions or *through a vacuum* such as space — there were a number of directions toward which the information could be applied. Most important, the invention and development of radar — the system of Radio Detection And Ranging — opened the door for *accurate measurement* and *tracking assessment.*

Without radar, today's space program would be impossible.



NRL'S 150-FOOT STEERABLE ANTENNA

ROCKET POWER

While Americans scratched in the budget barnyard, the German effort moved ahead in giant strides

Robert Collins Truax completed his flight training on June 1, 1943. Designated a Naval Aviator, he received orders to Patrol Squadron 101, then operating out of Perth, Australia. Since the unit was flying PBY's, he considered the assignment an opportunity to test JATO units in an *operating* environment.

But, as an aeronautical engineering officer with *rocket experience* and with "things booming in the JATO business," his orders were suddenly cancelled and he found himself back at the Experiment Station, Annapolis.

In reality, the previous work of the Truax/Goddard team on JATO had met fruition. The Aerojet Engineering Corporation had assumed the reins, and all kinds of JATO units were being prepared for fleet use. Truax shifted his sights to *guided missiles.*

The Germans were ahead of us. So, too, were the Russians, for that matter. We now realize they had test flown a rocket powered interceptor in May 1942 (then they had dropped the project as being relatively *impractical).* It was in 1926, inspired by the works of Goddard and Oberth, that Johannes Winkler started the development of liquid propellant takeoff assistance devices in Dessau, Germany. With hindsight, it is noteworthy that most of the subsequent German work on rocket motors had a strong resemblance to Dr. Goddard's inventions, particularly the innards of the horrendous V-2. While their wartime JATO work more or less fell by the boards (probably for the same reason that the Army Air Corps had lost interest), much activity was generated around the weapons known as guided missiles,

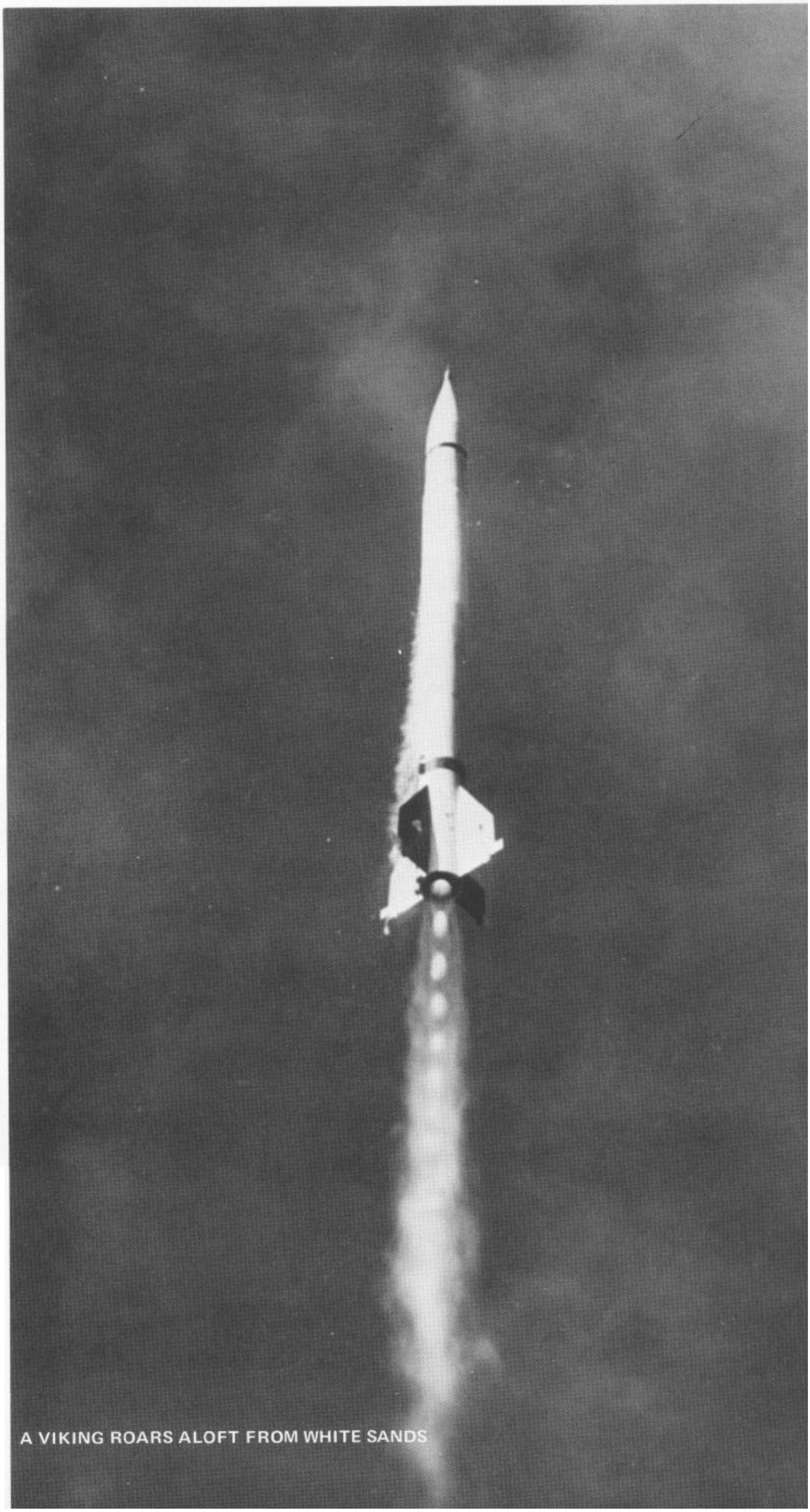
Whereas American interest was, by comparison, limited to a miniscule scratching about in the budget barnyard by a few perceptive visionaries, the German effort was moving ahead in giant strides. Their Army's Peenemuende Center and luftwaffe boss Goering's laboratory at Trauen were lavishly furnished and were undoubtedly the world's most modern rocket research centers. Before the war's end, V-2's were being produced in large numbers, rocket-powered missiles were being used against Allied bombers, and developments in the rocket field promised the Germans an opportunity to actually hit America with exotic weapons.

Though German rocket development was outstanding, it did not meet Hitler's goal. It was a monumental gamble — that failed. The odds were right; the plays were wrong. In some instances, lack of time was a factor. Military expediency led the Germans to accept some untried and not-so-good ideas, in order to "get something into the air" and working against their enemy.

Goering originally established the Trauen facility, giving it almost unlimited powers, simply because the Peenemuende laboratory was a political threat to his air force. He was afraid Dornberger and von Braun might come up with something that would win the war and he, and *his* people, would have had no part in it. He eventually closed down Trauen when "routine" setbacks at Peenemuende led him to believe it was no longer a threat to his Luftwaffe's prestige. Actually, at that time (late 1942), Trauen was ahead of Peenemuende development, and its longer range program was far more promising.

The ME-163B V2 rocket plane, first flown in 1943, was fast, yet it was abandoned because of the danger in its operation; it had a tendency to explode on landing. The *Natter*, half piloted aircraft, half guided missile, had only one operational test. The pilot was killed and the *Natter* was ash-canned.

When the first German radio-controlled bombs (the HS-293 and the Fritz-X) began to hit Allied ships in the Mediterranean, an emergency call went out to the U.S. Navy; NRL responded, on a crash basis. Two destroyers, equipped with signal-analysis gear recorded the German missiles' guidance signals and brought back the data. Within 12 weeks, NRL scientists had built a countermeasure.



A VIKING ROARS ALOFT FROM WHITE SANDS

This equipment not only jammed the German signals but, on several occasions, *took over* control of the weapons and diverted them harmlessly into the sea. Allied bombing of land-based support facilities also helped slow down the German operation, but this, and the jamming technique, only served to stimulate the enemy's counterthinking.

Their analysis of attacks performed in the Mediterranean and Bay of Biscay indicated that more naval ships would have been sunk or damaged had the "mother" aircraft involved been carrying conventional bombs rather than pilotless aircraft. Hence, German emphasis shifted to antiaircraft missiles — guided "flak" — and surface-to-surface weapons.

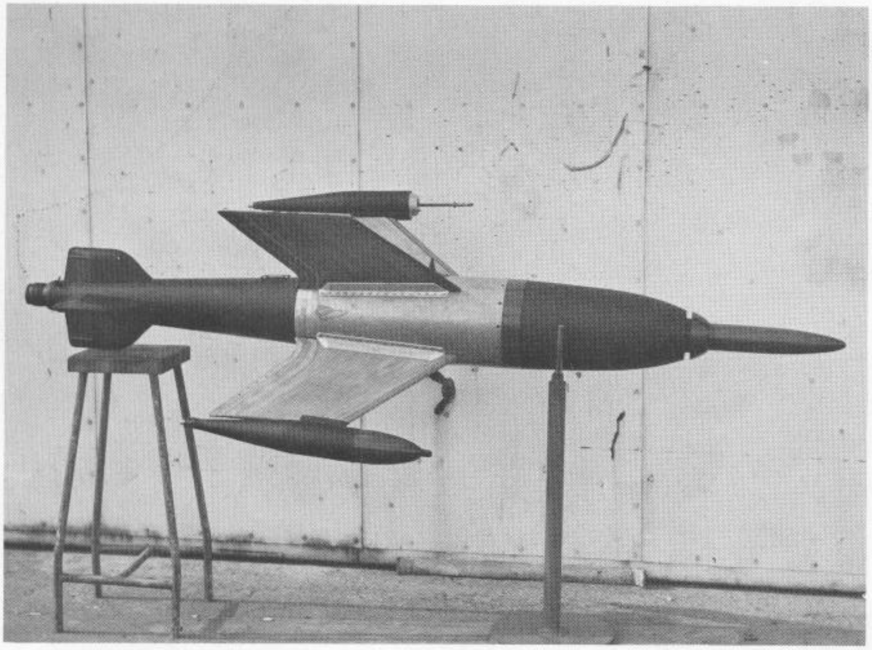
Twelve individual projects were carried through to full development for operational use; the majority were rocket propelled. Of these, the V-2 (A-4), and *Enzian* are probably best known. The A-9/A-10 combination, with a pressurized cockpit for a human pilot, was designed to strike American cities. Fortunately for the U.S., Germany's time ran out.

Back at his Annapolis station, Lt. Truax studied intelligence reports which revealed the advancements in the German missile field. He was also familiar with U.S. Navy efforts to produce an effective air-to-surface missile. *Glombs* and *Glimps* were being developed, and the Bureau of Ordnance (BuOrd) was moving ahead on the *Pelican/Bat* program. But these devices were only *glider* bombs. It was the route the Germans would soon discard.

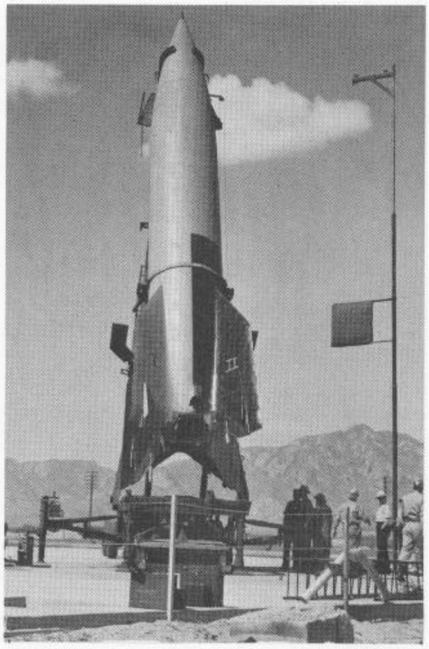
Luckily, in a 1941 memorandum, "Summary and Recommendations for a Jet Propulsion Program" (remember, in those days it was judicious to call a rocket a jet), Truax had urged development of guided missiles. The memo had made the rounds, and, in October 1943, he was asked to build the engine for the *Gorgon*, an ambitious BuAer design for a television guided, pilotless aircraft.

"The *Gorgon* paved the way for expanded Navy activity in the missile business," Truax says. "They had come up with this air-to-air thing powered by two small 9.5-inch jet engines. In effect, they were scale models of what was actually our first turbojet engine. But, small as they were, they cost $11,000 each! The boys in the Bureau said, 'We can't afford *that!'* So they asked me for a *rocket."* Truax grins as he recalls, "We put it together in about 45 days, and it went into production at Reaction Motors. Some 80 or 90 of them were built by early 1944.

"About that time," he continues, "the kamikazes were giving us fits in the Pacific, so everyone began looking around for a *surface-to-air* missile.



German X-4 was a liquid-propelled, rocket-powered, wire-guided missile designed for air-to-air operations. Emphasis on this type of weapon eventually dissipated. In the case of the radio-controlled glide bombs, HS-293 and Fritz-X, an Allied strike destroyed all aircraft modified to carry the missiles. Fuel shortages precluded replacement by the Luftwaffe.



Above, German V-2 is erected for launch at White Sands. Weapon proved possibility of rocket propulsion for space flight. Director of engineering, von Braun, was jailed by Gestapo on sabotage charge: he talked too much about rockets for future space travel — instead of weapons. Hitler released him after being pursuaded the young professor had been carried away by the program.

Now, BuAer and BuOrd sort of competed with each other; BuAer called them pilotless aircraft and BuOrd called them guided missiles. It turned out BuOrd had the best term. Anyway, BuOrd put their money on the Johns Hopkins people who had developed the VT (proximity) fuse, and said, 'Look, we need a surface-to-air missile,' and then BuAer decided to do the same, and they went out to industry and begin to let contracts for the *Lark*. When it came to propulsion, they decided on rockets, Down they came to Annapolis and told us what they needed. So, we took the basic *Gorgon* engine design and came up with a prototype for the twin engine *Lark*. They liked it and turned it over to Reaction Motors for production.

"We did *our* part very quickly, but we paid somewhat for our speed. You see, we had a fellow in our group who was an expert at making thrust chambers. He could take a sketch, without any tolerances or anything else, and just *put the unit together*. Then, when the Navy said to Reaction Motors 'We need 100 of them,' Reaction Motors would say, 'OK, where are the drawings?' And we'd have to say, 'Drawings? Drawings? What drawings?' So, then they'd have to cut the thing apart to see how it was made . . . and try to *duplicate* it!

"Actually, it worked out fine in the long run, though. The *Lark* got its engines. Unfortunately," and here Truax winces a little, "the development time, instead of being 90 days (or some ridiculous figure we were hoping for) — as a counter to the kamikazes — turned out to be considerably more. I think we knocked down the first airplane target after 1950."

On December 7, 1941, the day of Pearl Harbor, the United States had no rocket weapons. At the time the war ended, the American rocket budget was 13 million. We had found German development included advanced homing devices: infrared, acoustic, electromagnetic (radio) and television. They had an accurate velocity measurement system which made use of the Doppler effect. And telemetering was employed to its full extent.

In the case of the V-2, it is inconceivable that the Germans considered the weapon to be an end in itself, or that, with all its complexities, it was developed (at a cost of billions and manufactured in great quantity with the highest priority) merely to deposit 750 kilograms of explosive on Great Britain. These were men *looking to the stars.*

But that singular man, the one who had been the prime mover — the inspired genius who laid the groundwork for all development in modern rocketry and space flight — did not

A BAT MISSILE IS RELEASED FROM AN SB2C HELLDIVER live out the war. Dr. Robert Goddard died on August 10, 1945.

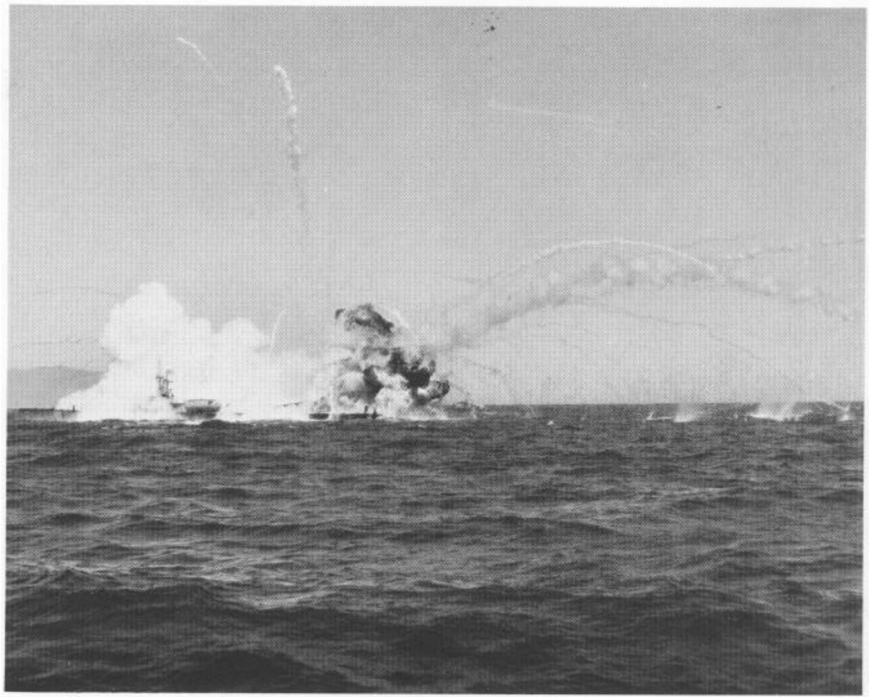
His 214 patents covered every basic aspect of rocket design, construction and operation. Goddard had shown the way; his few followers would now be joined by others in the new technology.

Along with the fairly limited wartime indulgence in rocketry, "pilotless aircraft" provided a proving ground for the men with bigger dreams. After Goddard's early experience with the lunatic image, his acolytes took heed. You might not encourage a "trip to the moon," but you could certainly solicit support for seemingly bizarre methods of hitting the enemy — or so it seemed in the 1944-1945 period.

The relatively primitive ASM-2 *Bat* did reasonably well. So did the equivalent German glided, guided bombs (they even sank a battleship with two Fritz-X's). Then there was the Navy's Project *Anvil,* not quite in the context of this story, but interesting as a review of the thinking of the time.

Anvil was the conversion of two Navy PB4Y's to "drones." Not only had we discerned the German effort to develop long-range guided missiles of their own, we had also detected elaborate precautions for insuring a high degree of security.

It was decided to try to hit the exotic German weapons — with an American exotic weapon. The scheme was actually straightforward, and not particularly hazardous. With the Heligoland missile training base as a target, the plan was for a plane, loaded with high explosives and a remote radio-control system, to be taken off and established on level flight long enough for the controlling aircraft to take over. Then the plane's explosive cargo would be armed and the crew would bail out, leaving further journey of the drone to the skill of the controlling plane's pilot. His job was to guide, from a distant, secure position, the television-equipped, lethal bomber down through the anticipated flak, onto its target. The operation was plausible — an opportunity to throw a wrench into the German missile operation, without loss of American life.



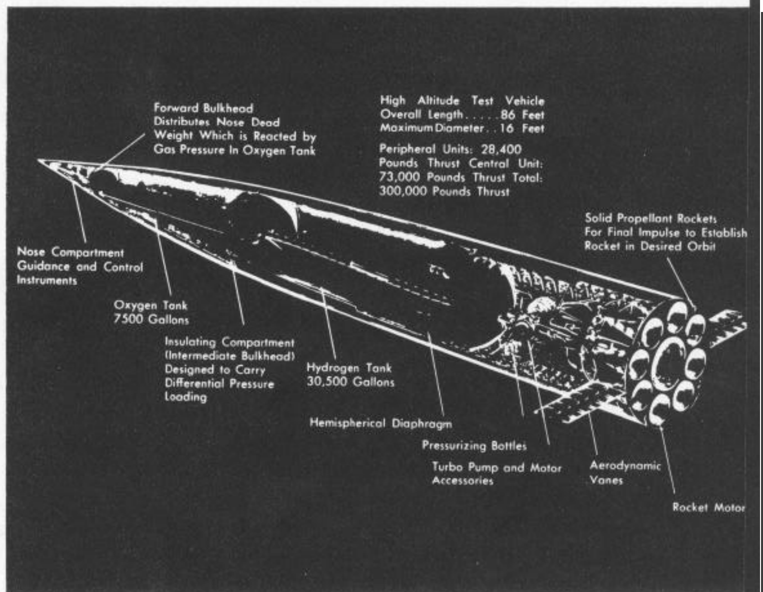
In the fall of 1944, the first PB4Y exploded prematurely while still over England, before reaching its crew-bailout point.* Operation of the second bomber was successful; the Heligoland target was hit on September 3, 1944. No further work was done with the PB4Y (and other) assault drones since the Army was working on a parallel program. But the Navy efforts with pilotless aircraft contributed to the development of guidance components and design criteria for the more sophisticated missiles of the postwar period.

*The pilot was Lt. Joseph Kennedy, the older brother of President John Kennedy.

One result of the Navy's growing experience and expanding interest in rocket propulsion and guidance systems was the report of November 6, 1945, "Feasibility of Space Rocketry," by Commander Harvey Hall and Lieutenant Robert DeHavilland. They were members of a group assigned by BuAer to make a study of future rocket applications. "That report," says Truax, "represents the first United States space program. It proposed that a project be set up for the purpose of constructing and launching an *earth satellite* for scientific purposes."

The satellite project, called HATV (High Altitude Test Vehicle), consisted of a single stage, liquid oxygen/hydrogen rocket capable of achieving an orbit around the earth. The stainless steel craft was to have nine individual motors producing thrust of up to 300,000 pounds at altitude. Inde-

On opposite page, a V-l explodes during 1948 attempt to launch the missile from a submarine, the USS Cusk (SS-348). These experiments paved the way for the Regulus program.



At left, a dummy Viking after launch from USS Norton Sound (AV-11). Above, the 1945 Navy HATV concept, the first U.S. satellite proposal. In 1958, the Navy offered Project Mer, a plan to send a man into orbit in a collapsible pneumatic glider, boosted by a giant launch vehicle.

pendent studies confirmed the vehicle's feasibility. An orbit date in the early Fifties seemed reasonable.

However, cost estimates ran as high as $8,000,000, far more than the Navy would have for such a research endeavor. The BuAer group decided to speak to the Army Air Force about a possible joint effort. At the first meeting, which took place on March 7, 1946, in Washington, the Navy's rocket progress was laid out and the plan for a joint Army Air Force/Navy experimental satellite program was presented. The Army representatives at the meeting were impressed; they agreed to discuss it with their superiors up the line. A few days later, Cdr. Hall was informed that the Army Air Force would not support the Navy satellite program.

Instead, the Army Air Force had asked the West Coast RAND (Research ANd Development) group to come up with a study on the *feasibility of an earth satellite* and, on May 12, RAND presented their report. It was called "Preliminary Design of an Experimental World-Circling Spaceship." In June, another BuAer/AAF meeting was held at which it was pointed out that the AAF (armed with the *brand new* RAND study) was on an equal level with the Navy's position. End of joint project.

The RAND report was a well conceived document. It contained recommendations that were improvements over (and more ambitious than) the Navy's HATV concept. But most remarkable were its two prophetic conclusions: that a satellite with appropriate instrumentation could be one of the most potent scientific tools of the 20th century, and that a United States satellite would inflame the imagination of the world. "To visualize impact," the study stated, "one can imagine the consternation and admiration that would be felt here if the United States were to discover, suddenly, that some other nation had already put up a successful satellite,"

The aeronautical board of the War Department made no decision regarding which service would have jurisdiction of the program, if at all. But the Chief of Naval Operations provided enough money to the BuAer group to keep the project alive. Then LCdr. Truax arrived back on the Washington scene in September 1946.

Since the end of the war, he had been moving about out West. "Once the war was over," Truax says, "people began to complain about the noise at Annapolis, and I was given to understand that my group would have to vacate the Experiment Station. So I picked up my troops, bag and baggage, and went out to California, first to Mohave (the pilotless aircraft unit), and then to Point Mugu where we became the Propulsion Laboratory of the Naval Air Missile Test Center. Shortly after, I was ordered back to the Bureau to head up the rocket desk."

Truax took charge of the development of the engines for Hall's HATV project. But during the following year, a number of events took place which were to have a bearing on the Navy's future role in space. The U.S. Air Force came into being as a separate service in July 1947 and, in September the Department of Defense was created, replacing the War Department. The initial Air Force emphasis was placed on strategic bombers and air-breathing missiles rather than satellite programs. This gave Truax and the BuAer group a clear field — for a while. In 1948, because of its lack of military value, funding for HATV was cut off by the Joint Research and Development Board. Harvey Hall went back to civilian life.

To Bob Truax, who had also championed the satellite proposal, the death of HATV was a blow — softened somewhat by the NRL *Viking* program.

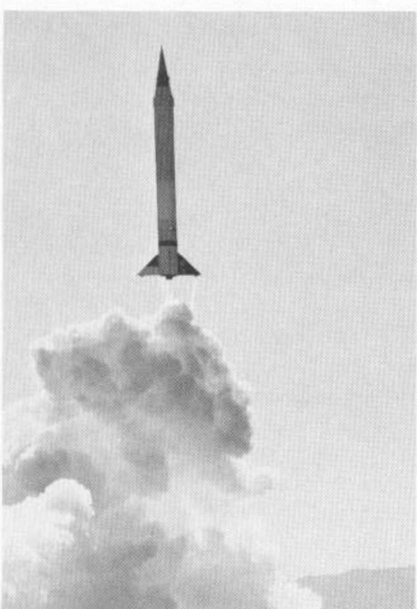
At war's end, NRL had turned its attention to a question which was an outgrowth of the work done by Soucek, Settle and others so many years before: What lies above us in that vast upper area which contains less than one percent of the earth's atmosphere? In 1945, some of the captured German V-2's were put to use as high altitude research vehicles. But, because the ex-weapon was relatively complicated, in limited supply and unsuitable for extended high altitude test programs, it was decided that a completely new, smaller, and more economical *sounding* rocket was needed.

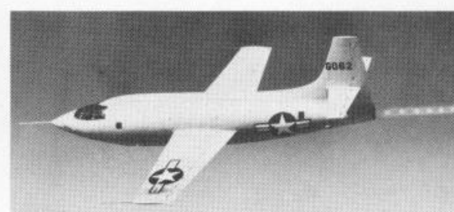
Originally proposed as the *Neptune,* the 45-foot *Viking* emerged. Designed to carry a 500-pound instrument payload, it was used primarily for upper air research. Bob Truax supervised development of its power plants.

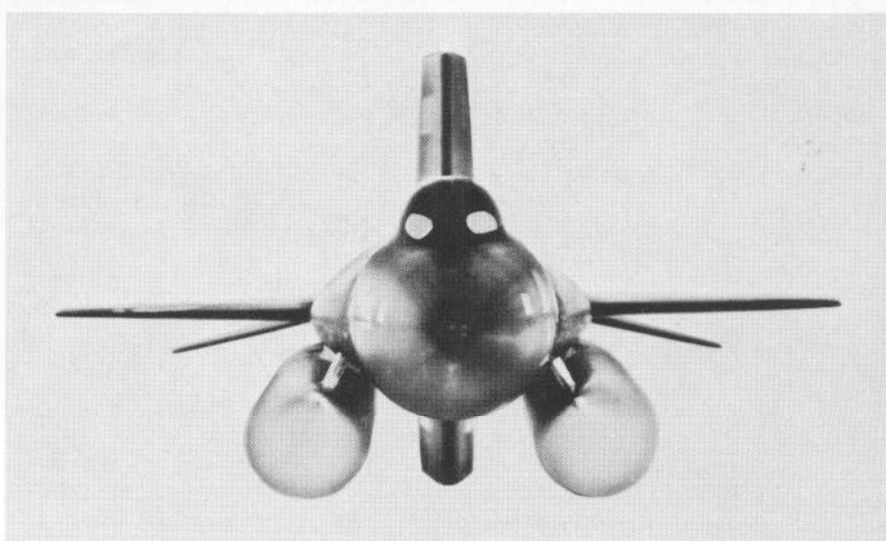
And while he was at it, he "monitored" the power plants which were used in the X-1 (the first piloted aircraft to exceed the speed of sound) and the D-558-2 (the first to hit Mach 2) and wrote an interesting proposal for a ballistic missile. "At this time," says Truax, "I completed study for a long-range (1,100 mile) missile for fleet use and succeeded in getting a BuAer endorsement on it. The missile program was rejected by CNO (Chief of Naval Operations) but development of the *engine* for such a missile was initiated and it ended up in the X-15.

"Well, a desk in Washington wasn't really my idea of the best place to build a rocket," Truax admits. "So, I looked around a little bit, and decided that a place up in New Jersey — Lake Denmark — looked promising. Although it was only 35 miles from New York City, the location was in a comparatively wild, hilly region where noisy activity could be conducted without bothering nearby residents.

"And, it was a matter of economics. Test and evaluation take a whale of a lot of money. If a government finances construction of expensive test facilities on a contractor's property, it commits itself to continuing contracts. So, instead, the Navy had a philosophy at that time of doing all testing of contractor-developed engines, both recip-







Above, the successful Viking. Other craft with engines bearing the Truax stamp are depicted at right: the D-558-2, as it drops from a P2B; the Bell X-1, designed for 1,700 miles per hour; and the exotic X-15, shown here with extra propellant tanks.

rocating and gas turbine. I decided we should do the same for rocket engines and I got the facility authorized. Its mission was to furnish high quality test stands and so forth to contractors and other government activities with inadequate facilities of their own. We could also test and evaluate engines and propellants to assure BuAer that contract specifications were being met. Commander Dayton Seiler, my predecessor in the Bureau job, was ordered in as officer in charge and I went along as his exec."

The station was ideally located, and before Truax arrived, there was already one rocket manufacturer on the premises, Reaction Motors, Inc.

RMI had produced the first commercial rocket engine in the United States. The small firm had its spiritual origin in New York City's Greenwich Village, where many a genius (and not a few crackpots) have been known to flourish. There, in 1937, a young man named James Wyld discovered that a pantry was an inferior place to operate a rocket. Seeking others of his kind, he teamed up with three fellow-members of the American Rocket Society (ARS) and eventually roosted in the backwoods New Jersey town of Wanaque. Upon testing a dandy little engine of Wyld's — it could fit in the palm of a hand and delivered 200 horsepower — the group incorporated and decided to sell it to the Navy.

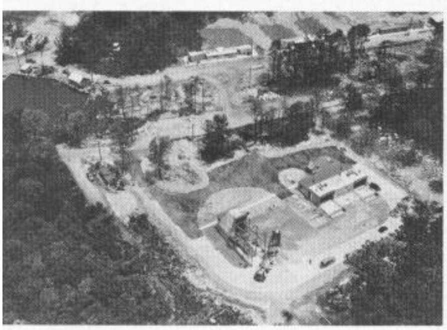
Lieutenant Fink Fischer was on the 1941 Bureau desk when the four-man company presented their invention. Fischer, of course, knew a good thing when he saw it, especially a rocket; a development contract was let. Now subsidized, the little company set up headquarters in Pompton Lakes (behind a storefront window which said "Pat's Tailor Shop") and immediately proceeded to disturb the peace.

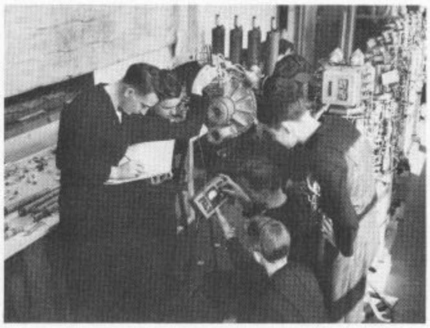
Because operation of an item such as a 6,000-pound thrust rocket engine has a tendency to irritate an average man — it shakes the ground, cracks sidewalks, breaks dishes and induces flabby eardrums — a $50,000 lawsuit (exactly ten times the amount of their Navy backing) was initiated against RMI. Off they moved, and throughout the war they kept on moving, yet incredibly managing to manufacture liquid propellant airplane rocket engines (X-l, D-558), JATO units and engines for the *Gorgon* and *Lark*.

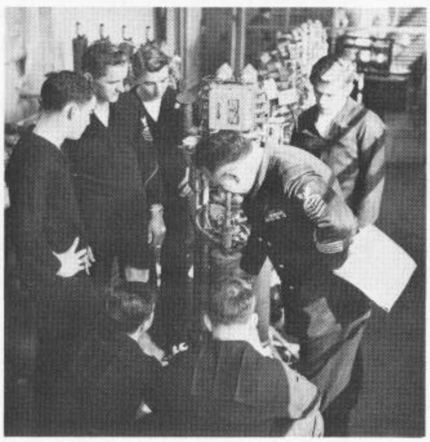
The Naval Ammunition Depot at Lake Denmark provided a haven where noise and hazard had been a way of life since the Revolutionary War. So, when it was eventually decided to inactivate it as a depot in the postwar period, BuAer selected the location as a site for its rocket activity. Reaction Motors had finally found a home.

What was the facility called? "Well," says Truax, "it started out as the Naval Aeronautical Rocket Laboratory, paralleling the Naval Turbine Laboratory, but then some people said, 'Oh, no! We're only going to do *testing* up there. (They knew that Truax always liked to get into *development* work.) It will be called the Naval Air Rocket Test Station.' So, that was the change in the name.

"Only trouble was, that came out NARTS — which is pretty close to NUTS. Not exactly the image we wanted."







JOC JAMES JOHNSTON

At left, Bob Truax, Fred Durant and Dayton Seiler were early members of the NARTS group at Lake Denmark. The facility offered many advantages for noisy activity. Durant, above, is now director of astronautics for the National Air and Space Museum.

VANGUARD

The Naval Air Rocket Test Station lasted ten years. During that period, its scientists were active in the screening of a number of monopropellants, fuels and oxydizers for auxiliary and prime power plants. Their work included evaluation of high energy fuels with an eye toward the feasibility of safe handling aboard ships at sea.

The in-service responsibility for the burgeoning liquid propellant rocket program had rested largely with NARTS until 1956, when BuAer began to divide its interest in such work between the Naval Air Missile Test Center (NAMTC) at Point Mugu, for flight test and evaluation, and NARTS, for static test and development. (BuOrd, meanwhile, had been given cognizance of all solid propellant work.)

In 1960, NARTS was disestablished and its facilities were turned over to the Army. The Lake Denmark work which had been started by LCdr. Truax in 1948 had been completed. And Truax himself had long since left the scene. During the early Fifties, he had taken opportunity to broaden his knowledge. To his B.S. in mechanical engineering, he added a B.S. in aeronautical engineering and, in 1953, topped them off with a master's degree in nuclear engineering. It was during these years that he also found time to make a number of ardent appeals for an American space flight and satellite program — the development of astronautics. Whether addressing his comembers of the ARS, speaking at the Congress of the International Astronautical Federation in Europe or writing articles, he hammered again and again with his theme: *We can have space flight in our time.*

Truax and his associates were by no means alone in their thinking. As has already been remarked, Soviet rocket technology was far more advanced than was generally believed by most Americans. The Russians actually had a history of remarkable progress in rocket development. In 1936, they were testing multistage rockets and in 1940 were starting mass production of the small military rocket called *Katyusha,* which was widely used throughout the war. Their first experimental rocket-powered fighter was designed in 1939 and was delivered for flight testing in October 1941. While their *practical* technology as applied to weapons of the V-2 nature was inferior, their *theoretic* status was on a par with Peenemuende's.

Contrary to popular belief, practically all the *leading* German rocket men ended up in the United States. What the Russians *did* get were hundreds of German workers and ordinary engineers, to add to their own already well developed core of rocket technology. As a result, by 1948, there were at least two Soviet projects drawn up for long-range rockets. One, the TT-1, was a three-stage liquid rocket designed for high altitude and *orbital* flight.

For the space dreamers of the world, 1948 was a year of ups and downs. Because of "political readjustments," the Soviet satellite project was sidetracked, for a while. Here in the United States, the Navy's HATV was cancelled. But studies continued. Rear Admiral Dan Gallery applied his persuasive powers to a revival of the idea of a joint Air Force/Navy earth satellite vehicle — to no avail. Secretary of Defense James Forrestal then issued an unfortunate statement to the Press referring to independent satellite studies by the three services. Angry reaction from home and abroad was immediate; here, because *secrecy* had been compromised, and from the Soviet Union, which denounced "madman Forrestal's earth satellite" as an "instrument of blackmail."

This then was the prevailing atmosphere in which Truax and his rocketeer associates tried to promote flight into space. Fortunately, their arguments found opportune support in 1954. For in that year, plans were being made for the Third International Polar year of the 1957-1958 period of expected sunspot activity. Meetings, in Europe, of the International Scientific Committee resulted in an expanded program for the International Geophysical Year (IGY) – one which would include the launching of small satellite vehicles for scientific purposes. Interest was aroused in both the U.S. and Russia.

On July 29, 1955, President Eisenhower announced that the United States would launch "small, unmanned, earth-circling satellites" as a part of the U.S. contribution to IGY.

Obviously, it was not an overnight decision. During the early NRL *Viking* experiments at White Sands, N.M., the concept of an "ideal rocket" for high-altitude research began to evolve with the accumulation of experience. And with the use of smaller, lightweight measurement payloads, the requirement for a smaller, less expensive rocket resulted in development of the highly reliable *Aerobee* series. An NRL study in 1954 indicated the feasibility of successfully placing a satellite in

orbit, using a vehicle based on the *Viking* as a first stage and the *Aerobee* as the second.

At about the same time, a Naval Aviator attached to the Office of Naval Research, Commander George Hoover, sought to enlist the aid of Wernher von Braun in a joint Army/Navy satellite program. Although Dr. von Braun's Army rocket people in Huntsville, Alabama, were more interested in the dream of putting up a huge space station, they could see a tiny satellite as a step in that direction. They agreed to support Cdr. Hoover in a project called *Orbiter,* based on the Army's *Redstone* booster and small, solid propellant *Loki* rockets.

When the Air Force tossed its hat into the ring with a proposal for an *Atlas/Aerobee-Hi* vehicle, it appeared the time had come for serious government evaluation — and a decision.

The Committee on Special Capabilities was set up within the Department of Defense, under the chairmanship of Dr. Homer Stewart. After some time the Stewart Committee chose the NRL proposal. Project *Vanguard* would have three missions: place in orbit at least one satellite during the 1957-1958 IGY, accomplish a *scientific* experiment in space, and *track* the flight to demonstrate that the satellite had actually attained orbit.

Vanguard actually started on September 9, 1955, when the Navy was authorized to proceed with the NRL proposal. A contract was awarded to the Martin Company for the building of enough launch components to comprise 16 vehicles. Two of these would be the older *Vikings* which would be used for crew training and testing of the third stage. NRL's Dr. John Hagen was named director, and a young engineer named Paul Walsh became his deputy. Milt Rosen who had put together the original proposal would be technical director, and a handful of other *Viking* men would make up the operational team.

One of the first problems was selection of a launch site. White Sands, where testing of the *Viking* and *Aerobee* had been done, was out of the question due to the danger, to populated areas, of falling pieces from the multistage launch vehicle. Of various other more appropriate sites, Cape Canaveral was chosen as being most economical. The Air Force was already building up the Florida complex and the Army's *Redstone* missile program was there. When Dr. Hagen suggested a sharing of facilities, the Army demurred on the basis that nothing could be allowed to interfere with the U.S. ballistic missile program. (The Army's *Jupiter-C* was also coming into being.) Dr. Hagen then managed to find enough money in the emergency fund of the Secretary of Defense to permit construction of *Vanguard's* own launch complex on the Cape. As a dividend, the block house and launch pad would be made available (after *Vanguard)* for future use in other programs.

To furnish the site, the entire *Viking* launch complex at White Sands, including tanks, plumbing, electrical hardware and gantry, was knocked down, shipped to Cape Canaveral and reassembled.

In purpose, the satellite program, under the direction of the National Commitee for IGY, was strictly a scientific venture, part of an overall plan to extend knowledge in the field of geophysics. It was a tri-service industry endeavor. Army teams, trained by NRL, operated most of the tracking stations where IGY scientists would extract data from the satellite itself as it circled the earth. The Air Force provided the launching site and the Navy was responsible for the design, construction, testing, and launch of the satellite itself,

By July 1957, the program encompassed the use of six preliminary rocket systems for test purposes, to be followed by six complete rocket guidance-and-control systems. Following the successful launch of an actual satellite, the next task would be to follow the little "moon" and to predict its future orbits by tracking.

The minitrack system of radio angle tracking was developed at NRL under the direction of Roger Easton. Easton recalls that, "The minitrack system was designed to enable scientists, for the first time, to follow the launching, direction of launch, and movement of multistage rockets; and to localize the time of arrival of the satellite over any given ground location within six minutes.

"Minitrack used established radio interferometric principles, A beam of radio energy is sent to receiving antennas on the ground as the transmitter-

Dr. John P. Hagen, head of the NRL Vanguard task force, had mountains of problems to overcome.

Dr. J. Paul Walsh was Hagen's deputy, is now superintendent of NRL's Ocean Technology Division.

The minitrack system of tracking was developed by Roger Easton, shown above with Vanguard satellite,

equipped satellite approaches and passes by overhead. By comparing the path length from the transmitter to one antenna with the path length from the transmitter to the next antenna, and so forth, it is possible to locate the satellite in its orbit, determining its angular position by radio phase-comparison methods. Similar measurements with another set of antennas, at right angles to the first set, help to fix the satellite accurately. Essentially, we had to create ten minitrack antenna stations across the world."

To this Dr. Hagen adds, "Captain Win Berg was the senior naval officer assigned to the team. He did an outstanding job in getting international cooperation. Minitrack stations were located and arranged for by groups from many countries eager to share in the operation. Many foreign nationals were brought to NRL where they took an intensive training course in the principles of radio tracking."

The status of *Vanguard* in September 1957 was roughly this: Test Vehicle Zero (TV-O) had been successfully launched, proving the capabilities of the pad complex and down-range facilities. The flight of TV-l, which at that time was the second stage, demonstrated successful trajectory, control and upper atmosphere ignition. Constant checkout difficulties in the hangar slowed progress on TV-2 but, towards the end of the month, it was being readied on the launch stand. However, on October 4, 1957, the Soviet Union announced it had put an earth satellite in orbit.

Suddenly, the *Vanguard* scientific program, which had been moving along at an unhurried pace while its scientists and engineers were ironing out the bugs inherent in the launching of *any* new rocket, found itself spotlighted as the losing contender in a space race with Russia. The NRL *Vanguard* operation, which consisted of only 15 staff people out of a 180-man team, began to feel the effects of national disappointment. That prophetic conclusion of the 1946 RAND report had become a reality.

As could be expected under the circumstances, there was a good bit of speculation as to reasons for the "failure," even though there had really been no such thing. The project, which had been a fairly open operation all along (largely ignored by the Press as an uninteresting American scientific experiment) became a "U.S. Navy folly."

The pressure was on; if *Vanguard* could not be our "vanguard in space," at least it would be second. A White House statement said so. On October 23, TV-2 was successfully launched. But TV-2 was only another systems check not the complete rocket, so no one cared. TV-3 was the one to watch — the one with the satellite — the one which would salvage some semblance of national pride. (A three-pound NRL satellite would be an emaciated answer to the 200-pound Russian *Sputnik*, but, at least it would be *something.)*

On November 3, TV-3 was on the pad; December 4 was the launch target date. The lengthy countdown procedure was started under an ever-increasing goldfish-bowl atmosphere. Press conferences in Washington and myriad newspaper accounts began to whip up a national "satellite fever." The members of the Press were not permitted, of course, on the actual site; no matter, they somehow kept tabs on every small detail of the activities at the *Vanguard* complex. On the scheduled day of launch, the beaches and balconies around Cocoa Beach sprouted a fantastic display of long-range photographic equipment. Roads in the vicinity of the Cape were clogged with cars, area motels bulged with reporters and correspondents from here and abroad. This was the day America would go into orbit.

Out on the pad, things began to go wrong. Loose plugs, leaks, sticking valves — and finally fatigue — beset the weary crew. The countdown had reached T (ignition time) minus 50 minutes shortly before 9:00 p.m., when weather forecasts indicated excessive winds for proper takeoff. The test was scrubbed.

On December 6, TV-3 finally rose off the launch stand — about two feet, before toppling over in a tremendous explosion that shook the blockhouse.

VANGUARD

As the flame and smoke cleared away, the *Vanguard* crew in the firing room could see, through the six-inch thick glass window, the forlorn little silver satellite lying where it had fallen in the smoldering debris, undamaged and beeping merrily away. It was an excruciating scene.

A few weeks before, perhaps with a sense of foreboding about *Vanguard*, the Secretary of Defense had ordered the Army to enter the satellite contest. So now, as the *Vanguard* crew cleaned up the mess of TV-3 and prepared the TV-3 B.U. (back-up) rocket, they could look over and watch Dr. von Braun's people busily setting up their *Jupiter-C*. Thus it was that on January 31, 1958, they had a ringside seat for the launch of the Western World's first satellite, *Explorer I*. NRL minitrack stations confirmed von Braun's achievement.

On February 4, the TV-3 B.U. made a beautiful takeoff. At 60 seconds into the flight, a wire separated in the guidance system and the 72-foot rocket tumbled through the sky, exploding in a fiery blob.

TV-4 was wheeled out. The work went on, still subjected to frustrating setbacks and impossible predicaments. As an example, on the night of March 7, when the countdown reached T minus 35 seconds, the switch was thrown that would cause the helium umbilical cord to disconnect and drop from the side of the rocket. But nothing happened. A hold was called and the crew stared, through bloodshot eyes, at the frost-coated umbilical-draped bird. It couldn't go anywhere with that attached. Well, they could send a man up on the arm of a "cherry picker," and he could yank the umbilical out! They had resorted to this procedure once before, and now it was standard practice to have the little motorized crane standing by.

It was standing by, all right, but the union man who drove and operated the machine was not. No one had *told* him to. And there was no other qualified operator.

It took two tantalizing hours to move the 100-foot gantry back to the simmering rocket where the engineers could loosen the stuck umbilical. About then high winds set in. Another scrub.

TV-4 was launched on March 17, 1958. Its performance was flawless; *Vanguard I* went into an orbit that will endure for more than 2,000 years. The next day, Dr. Wernher von Braun made a speech:

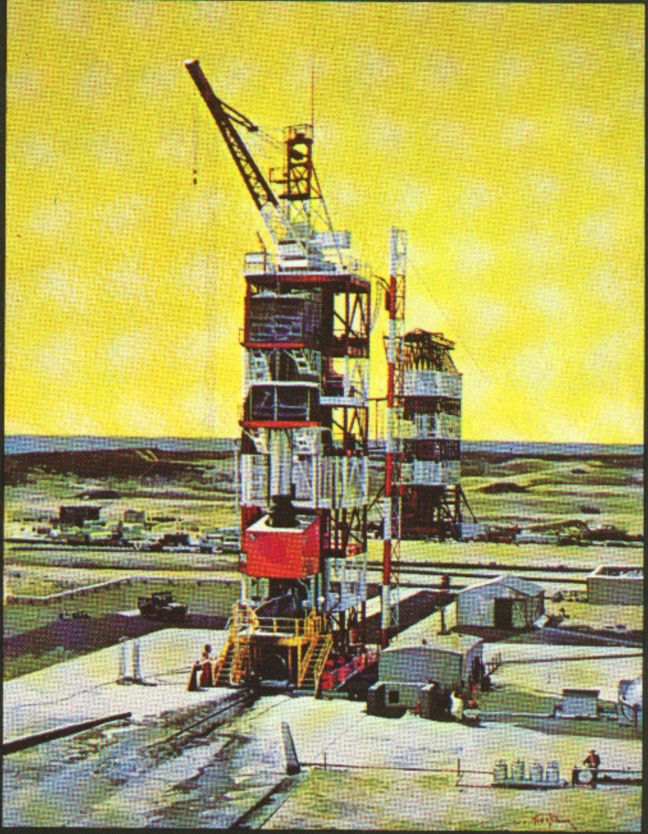
"Let me first express to you, and to whomever may be present from the Navy, my most heartfelt congratulations on the most wonderful success of our friends of the *Vanguard* project.

"Some of you, inspired by what you have read in the papers, may think that we have always had a very strong competitive feeling toward the *Vanguard* program. This is not exactly the case. We have always felt, at the Army Ballistic Missile Agency, that the *Vanguard* vehicle was an advanced design, compared to our own, and we were too much 'space men' in our hearts and too little interested in interservice problems not to wish the advanced *Vanguard* missile and its crew a full success in their endeavor.

"We were honestly and gravely concerned about the time schedule on which the *Vanguard* program was planned. After all, two years ago, when that program was initiated, the *Vanguard* constituted a brand new approach for the design of a satellite vehicle, whereas our own proposal essentially involved the utilization of existing sets of hardware for this particular accomplishment.

"Any such thing as successfully designing and developing a three-stage missile, with three brand new and unproven stages, on a time schedule of two years was absolutely unheard of, and when I say at this moment that I want to congratulate our friends of the *Vanguard* program on their fabulous success, I really mean it. What was done by the *Vanguard* group in these two years is absolutely unprecedented – the development of such a missile in such a short time is something that has never, never been done before."

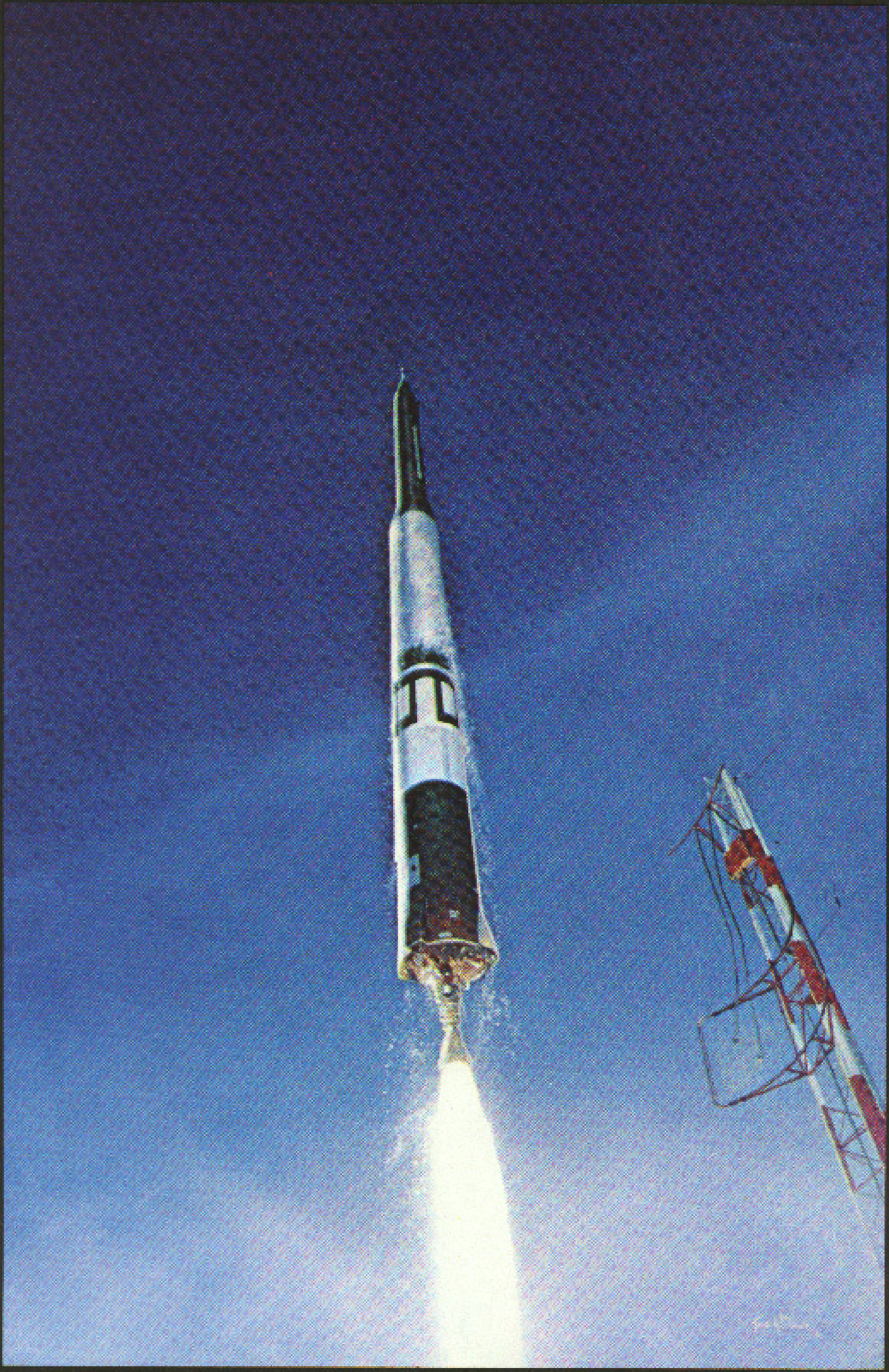
VANGUARD



VANGUARD GANTRY
CAPE CANAVERAL
NOVEMBER 1958

a selection of paintings of the Vanguard Project by Commander Ted Wilbur

HANDLING OF WHITE INHIBITED FUMING NITRIC ACID REQUIRED PROTECTIVE CLOTHING. ABOVE, VANGUARD 1 IS MATED TO ROCKET



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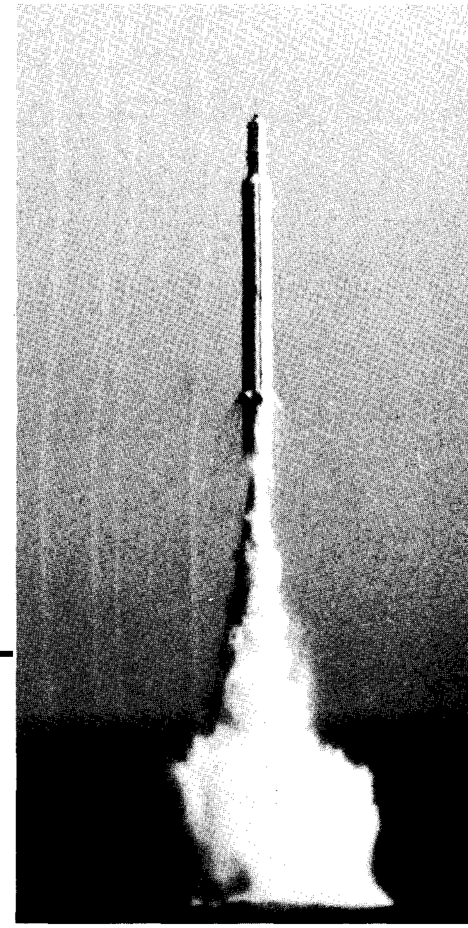
THE DEMISE OF VANGUARD TV-3

ROCKET POWER

New Directions



A 40-foot Hydra vehicle is blasted out of the sea, demonstrating that a firing system can withstand a marine environment and that a water-launched rocket can be stabilized in the open sea.

Bob Truax did not share in the belated success of *Vanguard I.* He had not agreed, in 1954, with the original configuration of the vehicle, namely, the combination of the *Viking* and *Aerobee* rockets and the addition of a solid third stage. "In the long run," he says, "practically everything was changed. The first stage engine was changed from the RMI to a General Electric. This required a change of propellants from lox and alcohol to lox and gasoline. The *Aerobee* was then found to be too small and had to be increased in size. As time went on, it became a program of changes. My only connection with the ultimate *Vanguard* was the second stage, which used the same general class of propellants as the old JATO units."

Truax had championed the United States experimental, scientific satellite program loud and clear. Once the cause had been picked up (largely because the Central Intelligence Agency had become aware of Russian progress in development of a satellite program), he had moved on to other fields. For example, when he received the Legion of Merit (in 1958, at the time of *Vanguard),* he was cited, somewhat belatedly, for his services in pioneering and advancing the Navy's efforts in the field of guided missiles and rockets. But, in addition, he was further cited for his "performance of duty while assigned to the Bureau of Aeronautics from June 11, 1953, to June 21, 1955." During that time, Commander Truax independently made a study titled "A Means for Making the Guided Missile Submarine a Primary Naval Weapon."

Truax's study had contained most of the elements of the U.S. Navy's current fleet ballistic missile program — an interesting subject to be examined later in this treatment.

When, after two years of badgering by Truax, BuAer gave an apparently final "no" to his proposition for a submarine-launched ballistic missile, the impatient Commander offered his services to Trevor Gardner, the Air Force assistant secretary who was building up a ballistic missile team under General Schriever in Inglewood, California. Truax was received enthusiastically by the now famous Western Development Division and was immediately placed in charge of creating a new missile — subsequently known as the *Thor* IRBM.

Once this program was underway, Truax began to hear rumors that the Air Force space program, an outgrowth of the old RAND study, was going to be transferred to General Schriever's WDD. Though the study was still in the paper stage, Gen. Schriever had ruled that if the project was ever to use any of his ICBM hardware, he was going to control the program.

Truax became Deputy Director, Weapons System 117L — the Advanced Reconnaissance System. This became the *Discoverer, Midas, Samos* program. "For a long time," says Truax, "it was the entire Air Force space program."

The concept of the satellite surveillance system had its origins in the 1946 RAND report. In the intervening years, it had barely escaped the obliteration suffered by many other programs. General Schriever had it transferred to the Ballistic Missile Division and, as Project 1115, it began to grow. As is now we11 known, it was a reconnaissance system –from space. *Samos,* for instance, was capable of taking pictures from a 300-mile orbit.

Truax originally had been loaned to the Air Force for a period of two years. At the Air Force's request, this loan was extended an additional year. After that, since a transfer of some kind was apparently unavoidable, Gen. Schreiver arranged to have Truax (now a Captain) assigned to the newly formed Advanced Research Projects Agency, with the hearty concurrence of the latter.

In May 1958, he reported to ARPA as the project officer on the Advanced Reconnaissance System. Then, as his retirement approached, he returned to his old home, the Bureau of Aeronautics, for his final months on active duty. His boss there was Captain Thomas F. Connolly, who was heading up the Pacific Missile Range. "After I arrived back at the Bureau," Truax recalls, "Capt. Connolly said, 'Bob, I know you are about to retire, but before you go, I'd like you to do something more for us. I'd like you to do a paper on the Pacific Missile Range and what you think we should do with it; and I'd like you to do a study on the Navy in Space — what its potential is — and what you think the Navy's policy should be.'

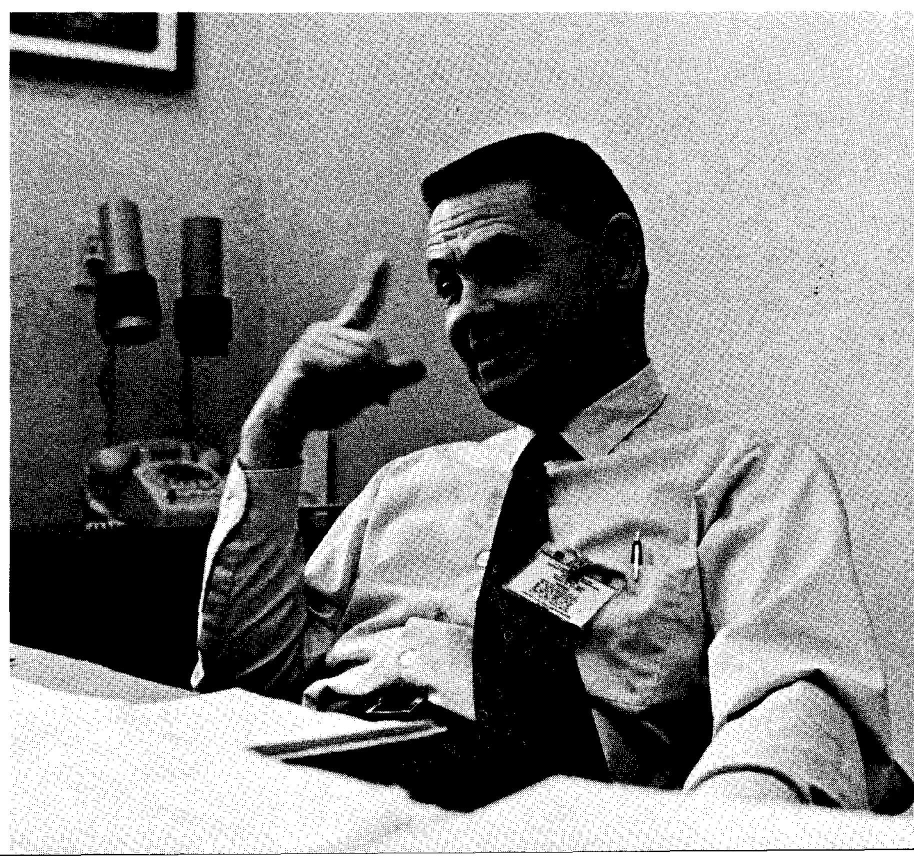
"Well, he liked my report so well he had it duplicated. I think every admiral in the Navy got a copy."

On the basis of Captain Truax's report, the Connolly Committee on the Navy's use of space and the science of astronautics was formed in April 1959. The resultant classified study established the Navy's future directions and its role in the Space Age.

Bob Truax retired from active duty in June 1959, after a remarkable career of rocket pioneering, testing, development, and farsighted planning. Today, as he applies the same talents, and same singleness of purpose, to another infant field — research and development of Surface Effect Ships — some of the ideas he proposed over a decade ago are still being "discovered."

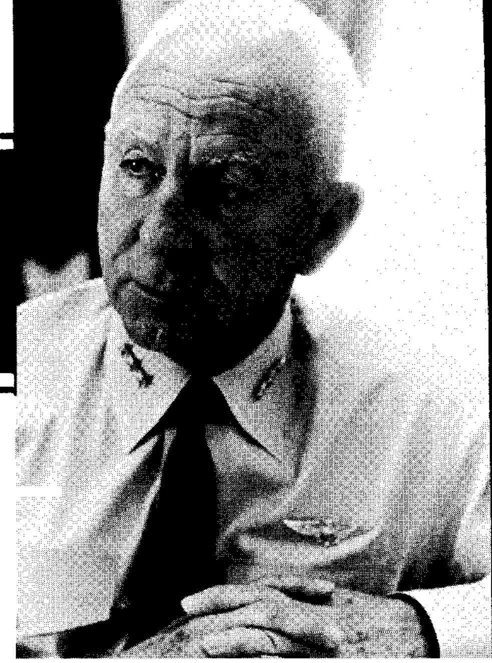
A few days ago, he called us and said, "Hey, you know that old study on the externally stowed missile that I let you borrow? Well, they're kicking the idea around up there and I want to let them read my paper." We got the file over to his little white building within the hour.

Robert C. Truax will always be a Rocketeer.



JOC JAMES JOHNSTON

The Navy's



VICE ADMIRAL THOMAS F. CONNOLLY

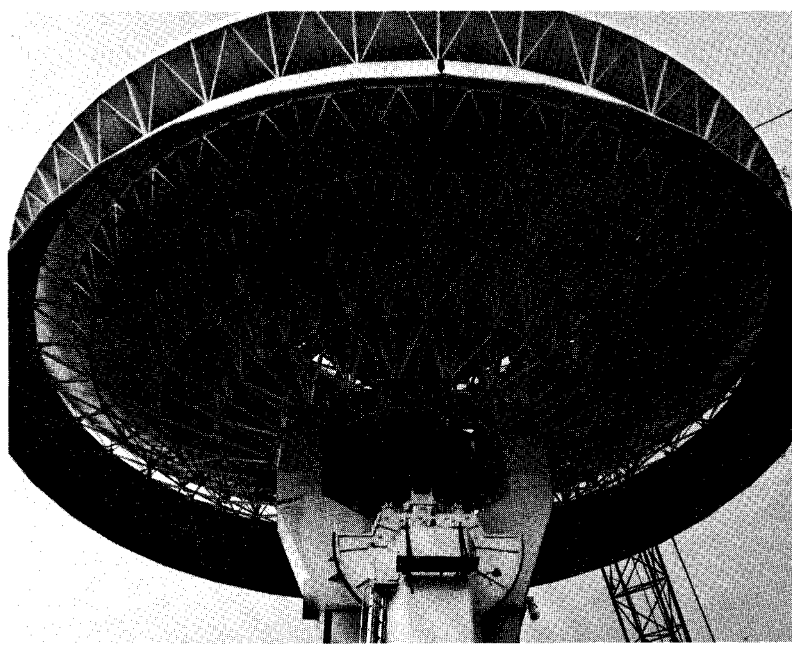
THE BOSS OF NAVAL AVIATION

Vice Admiral Thomas F. Connolly frowned. He had glanced out a window of his fourth floor Pentagon office and had noted the Washington smog drifting by. His gaze shifted to the spotless white model of the lunar module on his desk; then his eyes moved over to a similar, impeccable model of an aircraft. The miniatures seemed almost to glow against the polished wood surface. His expression mellowed.

On the wall behind his chair was a large R. G. Smith oil painting, one of the finest pictures of an aircraft carrier ever done. In it, the USS *Enterprise* looms out of a murky, morning haze on the South China Sea; a group of Navy fighters is flashing by the nuclear carrier, down low. Towering clouds rise above, dominating the scene. Toward the top of the picture, the air begins to clear and a view of blue space beyond can be observed.

It is an appropriate setting for the Deputy Chief of Naval Operations (Air) — the boss of U.S. Naval Aviation. But, at the moment, Admiral Connolly was thinking back to that time in the late Fifties when things began to *move* in space. "Missilery — ballistic missilery — had come on with a very great rush. The United States realized that the Soviets were building enormous rockets and would soon have an intercontinental capability. So," said Admiral Connolly, "we moved out very sharply in that period.

"I had just come into the Bureau from command of a carrier and found that an effort was being made to find a flag officer to take charge of the Pacific Missile Range, which, together with the Atlantic Missile Range and the White Sands Missile Range constituted the national ranges for ballistic missile firing and testing. For some reason, they just couldn't find an admiral for the job; so, although I was only a captain, I *was* an aeronautical engineer with missile experience, and I ended up with the assignment. It was decided to make me an assistant chief



The 60-foot directional antenna atop Laguna Peak at the Navy Astronautics Group Headquarters, Point Mugu, Calif., is landmark for motorists on Pacific Coast Highway.

of BuAer — for Pacific Missile Range affairs.

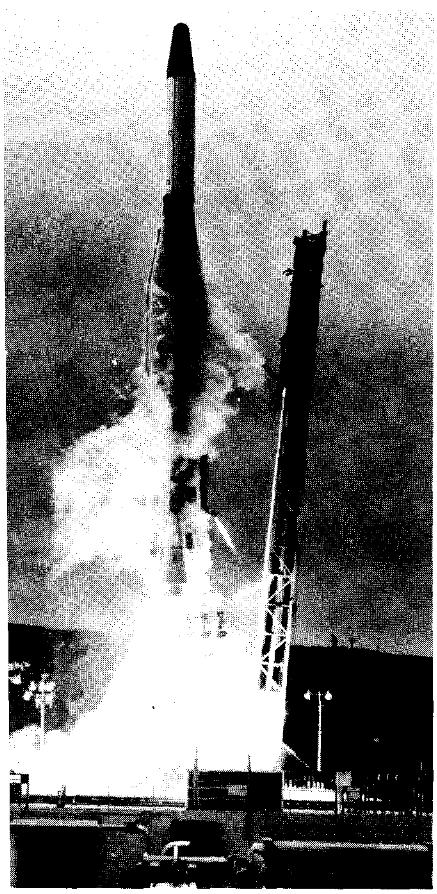
"In a very short time I could see that if the needs of the Navy were to be met, the job would have to be 'for Pacific Missile Range *and Astronautics.*' There was no good agency within the Navy capable of handling the possibilities of space with respect to *naval* military missions. So, we had to make that provision for 'astronautics.' For the next year or so I did what I could from the Washington end to help out Admiral Monroe and his people at the Pacific Missile Range (PMR). It grew into a fine operation."

The Naval Missile Center at Point Mugu, California, was the nucleus around which the Pacific Missile Range was developed. During WW II, it had become clear that if the nation's guided missile program was to pro-

Role in Space

REFLECTS ON THE ORIGINS OF THE NAVY PROGRAM

gress, the Navy would have to have a test range based on naval requirements. The result of this decision was the establishment of the Naval Air Missile Test Center in 1946. The original sea test range was only 75 by 150 nautical miles.



An Atlas/Burner II blasts off, carrying into space two Navy satellites: the Lidos for geodesy, and the ionospheric Orbis Cal.

As the national missile program gained momentum, the need for increased range capacity grew critical; "Mastery of Space" takes *space*. And money. Fifteen million dollars in construction were expended by 1961, and the range encompassed more than 10,000 miles. Major projects completed were MILS (missile impact location systems) buildings at Hawaii, Eniwetok, Midway and Wake Islands. New construction at Point Mugu included a hangar, sea-level climatic laboratory, instrumentation buildings, mess halls, BOQ's and storage facilities. One of the significant developments was the Life Sciences Department where experiments were conducted on animals and men in multiple stress environments and where "space journeys" were made by flight surgeons and Naval Aviators, with and without full pressure suits, in a ground-based "space ship," in order to study the effects of breathing pure oxygen at high altitude.

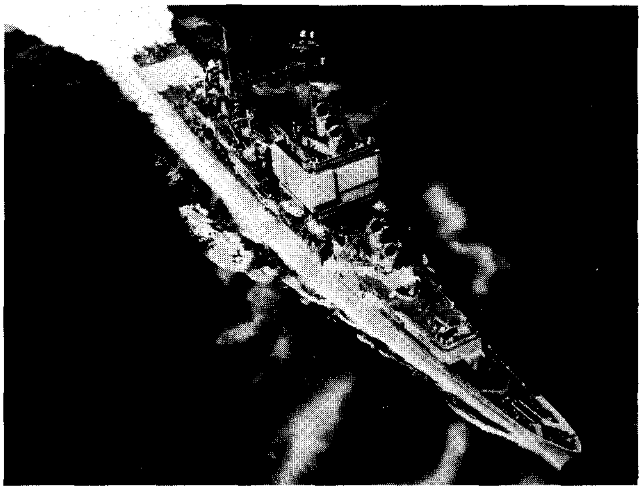
"We were tremendously spurred on by this new area of endeavor," the Admiral continued. "Although there was some criticism by a few agnostics and those who were constantly vying for the dollar, we received a great deal of support — from Admiral Burke, who was Chief of Naval Operations; Admiral Russell, the Vice Chief; and Admiral Pirie, DCNO (Air).

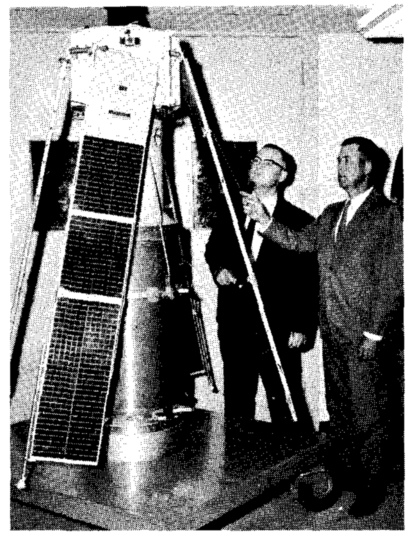
"Ten thousand people," Admiral Connolly said, "staffed the huge PMR complex which comprised five different ranges. It was a very fast moving and highly successful operation, not only capable of handling the ballistic missile firings of both the Air Force and the Navy, but also of doing the job with the shorter range weapons. With our excellent radar coverage, we could really do the shots that covered long distances and, at the same time, meet the national need. This evolved into Space: the Polar Orbit Range was developed for southward launchings from the Naval Weapons Facility at Point Arguello.

"As the size and range of the missiles increased, it became possible to build a *fractional orbiting* missile. That is what a ballistic missile really is. Well, with the Office of Naval Research and NRL being the first to get going with an earth satellite — the little *Vanguard* 'grapefruit' — we had learned a lesson. *Vanguard* went through a lot of growing pains and difficulties before it showed that it worked just as it was supposed to. Drawing on that experience, we asked the Johns Hopkins people to come up with a *navigational* satellite concept. It was aptly dubbed *Transit,* and was the first *real* attempt on the part of the Navy to make sure, from beginning to end, that an earth satellite would work for us. My office had the responsibility for its advancement. In all of this, we had the close cooperation of the Department of Defense, the Army, the Air Force and the then-young NASA."

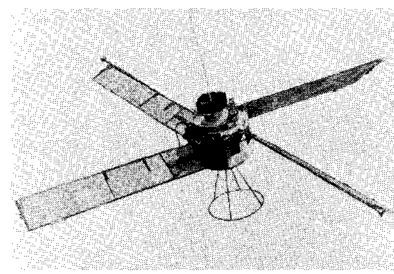
Admiral Connolly leaned forward. "But, where does the Navy *go* in space? Right then, we decided that we had better find out what was *solid* — what our legitimate prospects were for the future. I gathered up the best people I could get my hands on — Bob Truax, Win Berg, Bob Freitag, and a lot of others — and then, one by one, we called in every branch of scientific and industrial endeavor connected with space and had them lay out their programs. This constituted the so-called 'Connolly Committtee' and resulted in the study known as 'The Navy in the Space Age'."

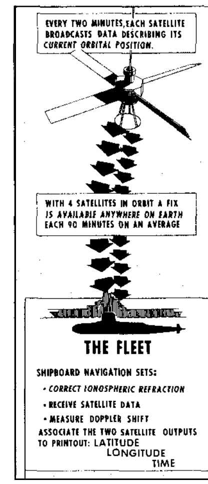
The Navy's Role in Space





The Navy Navigation Satellite, developed by Johns Hopkins University scientists is powered by solar cells and batteries. System was used in world cruise of USS Long Beach.





THE FINAL RECOMMENDATION OF THE COMMITTEE WAS: GET TO WORK!

The committee's report became the master plan for U.S. Navy space programs; Its chairman became a Rear Admiral, and Assistant to the Chief of the newly formed Bureau of Weapons, for PMR and Astronautics. The stated policy of the new organization was that the Navy would pursue research and technological developments necessary to enhance its ability to conduct operations in space which were in support of roles and missions assigned to the Navy. It would work in partnership with the other services and would vigorously support national civilian space programs.

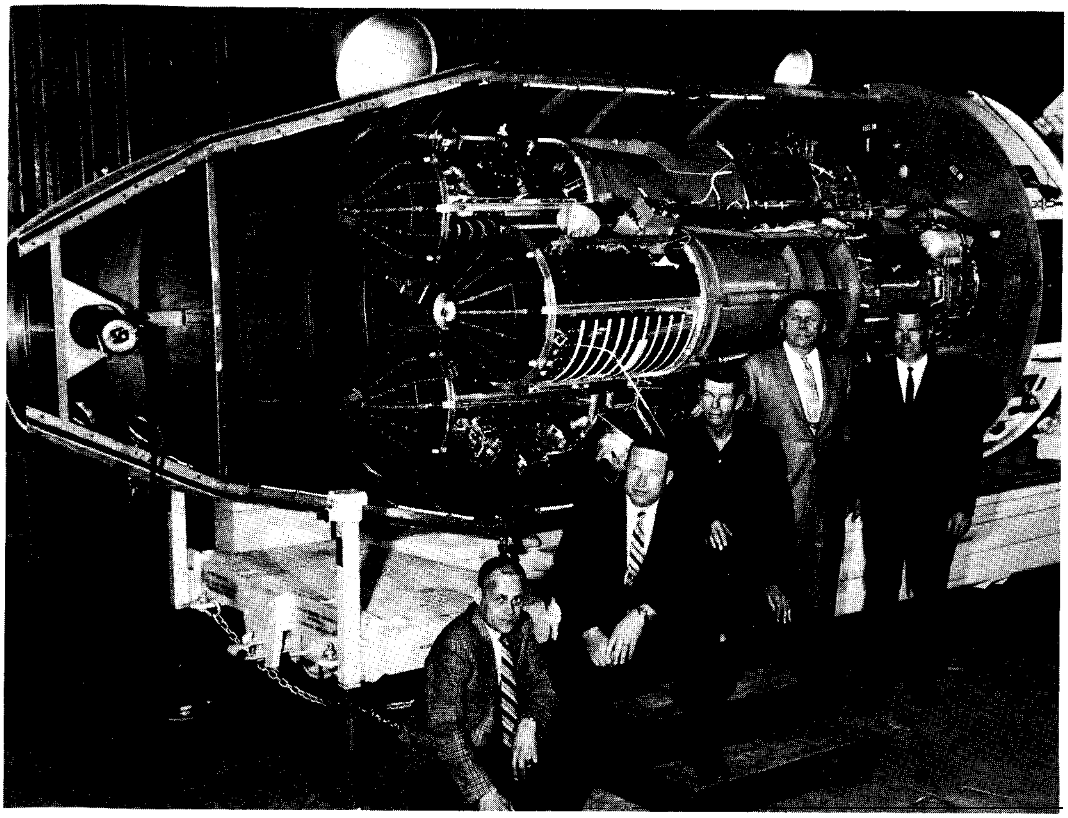
"Our basic objectives of ten years ago," said Admiral Connolly, "are essentially the same today, with a few refinements added. *Reliability* is a long, drawn out, painstaking matter that can't be solved by enthusiasm alone. The final recommendation of our committee had been to GET TO WORK! And that's what we have been doing over the years. Now we have that *reliability.*

"After we had determined just what was *solid* for the Navy, the lineup looked like this: Communications, Geodesy, Navigation, Weather Forecasting and Surveillance, but not necessarily in that order.

The NRL minitrack system of the *Vanguard* satellite program was pointed out by Admiral Connolly as the forerunner of the present Navy Space Surveillance System, commonly known as NavSpaSur. It may be recalled that minitrack was designed by Roger Easton to locate satellites which *transmitted* on a fixed frequency. But what about a *quiet Sputnik?* Needed was a detection system to locate and track *all* man-made objects in space.

A new plan was submitted to ARPA, approved, and by early 1959, NRL's NavSpaSur was operational. The system was similar to minitrack but used a high-powered, continuous wave transmitter to illuminate the satellite by radio. Reflected energy data from the target would then be obtained from various receiver sites and the object could be pinpointed. When the system became fully computerized, it took only seconds for analysis of a satellite detection to get to the headquarters of the Naval Weapons Laboratory at Dahlgren, Virginia, and thence to the North American Air Defense Command (NORAD) for further consideration. By 1970, more than 5,000 orbiting objects have been observed by NavSpaSur.

"Navigation," said Admiral Connolly. "With a satellite, you have your own star. Only, instead of just putting out visible light as an ordinary star does — a light that cannot be seen through clouds — *our* star would put out radio signals that could be picked up at any time. And, since we could accurately fix the position of any satellite, at any time, a ship could use our star to get a very accurate fix on its own location as *Transit* orbited by.



The triple OV-1 was product of joint effort by Air Force, NRL, Navy Space System Activity, Convair, and other personnel. Among results was better understanding of HF radio propagation.

"We, and other people," the Admiral continued, "foresaw that space *communications* would be a great aid. NRL was, even then, bouncing signals off the moon. They were using the moon as a *reflection* device in order to send a message from here in Washington to our station in Hawaii. This, of course, led to the ComSat organization which is both federally and industrially financed. This is how we get live TV shows, instantly, all over the world.

"Geodesy. This meant the ability to locate things on the ground. Even in our modern day and age, there are still a great many places on the face of the earth that the charts show to be in such and such a spot, when they are actually many miles away. The world's maps had been put together by acceptance of surveys done by various entities. Soviet maps, Chinese maps, Indian, British, French and even going back to old Portuguese and Italian maps. All have inaccuracies. So, geodesy was a thing we could do with satellites.

"And, finally," the chairman of the

THE OBJECTIVES OF TEN YEARS AGO ARE ESSENTIALLY THE SAME TODAY.

Connolly Committee said as he glanced over at the window, "we had weather forecasting — the surveillance of the earth and the movement of its cloud formations."

Vice Admiral Connolly reached over to pick up a paper which an aide had brought in. He examined it, signed it, and sat back, thoughtfully. "We found a lot of ancillary uses for our space program. For example, it wasn't contemplated in the beginning, but we found we could use the very accurate navigational positioning derived from *Transit* to put in the inertial guidance platforms of our aircraft. If you have precise knowledge of exactly where you are at the moment of launch from a carrier, you can do a very precise navigational job in getting to a target, all-weather.

"I think it has been absolutely fantastic to see what has come out of the *disciplines* of space. In order to have a successful vehicle that can go into space and take men to the moon and back, *quality* equipment had to be created. Equipment that no one had dreamed of before. If it hadn't been for that quality and the built-in redundancy of the systems, we never would have gotten our *Apollo 13* boys back home."

Admiral Connolly has been described by the Press in various ways, most often as "peppery." The description didn't fit as he got up and walked to the window. "I really think that the space program has brought the world together. In these terrible times, I think that the success of the manned space flight program, more than anything else, has kept alive a certain warm respect for, and trust of, the United States."

He gazed out the window at the milky sky. "It looks like it might clear up. But, you never can be sure. . . ."

Speaking of Weather...

From Polar Fronts to Solar Storms

The threat of the German zeppelin in World War I hastened the formation of the Naval Weather Service. It was apparent that the Allied Aviation Forces in Europe needed environmental support in order to combat this new threat. Thus, at the suggestion of the Commander, U.S. Naval Forces in Europe, initial steps were taken to form a special meteorological group to meet the needs of Naval Aviation. The requests for this service soon spread beyond those of aviation and, by war's end, the embryonic Naval Weather Service consisted of over 200 officers and men.

In 1919, the Naval Aerological Service was literally pigeon-holed in the Bureau of Navigation when the weathermen found themselves located in the Photography and Pigeon Section. After two years of molting with the bird people, the Naval Aerological Service was transferred to the newly formed Bureau of Aeronautics.

One of the key figures in the development of the Naval Weather Service was Francis W. Reichelderfer. As a naval officer and aviator, Reichelderfer was a triple threat man, qualified in balloons, dirigibles and multi-engine aircraft. As a meteorologist, he was a pioneer in developing aviation weather services and, from 1922 to 1928, supervised the reorganization of the Navy's weather service. It was during this period that he came across some research done by the Norwegian, Bjerknes. The Norwegian's theory, still valid today, dealt with the concept of air masses and frontal systems and observed that most "weather" occurs at the boundaries between large bodies of air which have differences of temperature and humidity. In 1925, Reichelderfer introduced the Norwegian papers on air mass analysis and techniques throughout the Navy's meteorological community. The concept has been important to the development of meteorology.

After many notable achievements, Cdr. Reichelderfer was transferred to the inactive list in 1938. He then became Chief of the Weather Bureau, a position which he held until 1963.

The Naval Weather Service's climb into space began on the wings of the 1917 airplane. Wing-mounted meteorological instruments provided a profile of the atmosphere through which the plane flew. By 1939, the balloon-borne radio transmitter, meteorological instrument package had become the routine method of obtaining upper air soundings. It is still used today. (Helium-filled balloons frequently attain altitudes in excess of 100,000 feet and provide information on the atmosphere.)

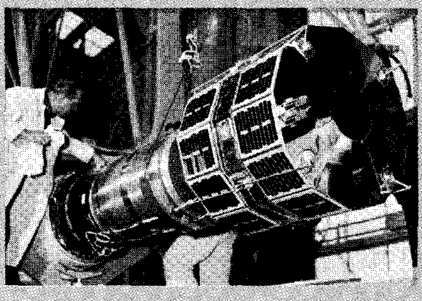
In 1954, a small group of Navy

SOLRAD

The problem of not receiving a routine radio broadcast may soon be resolved through the pioneer efforts of a dedicated group of Navy scientists and a satellite called *Solrad*. For those who have been denied hearing the opening game of the baseball or football season while making a Pacific or Atlantic transit, the aggravation becomes a personal thing. Operationally, it is a serious matter.

Most radio transmissions rely heavily on that electrified atmospheric shell, the ionosphere, which owes its existence to the influence of the sun on the various components of the atmosphere. Since the earth is not bathed in the same even flow of sunshine, there are variations in the levels and density of the ionosphere that surrounds it. These detached and sporadic layers of varied ionic composition are, in part, brought about by the disassociation of molecular oxygen and the heating of the atmosphere.

In general, the state of the ionosphere is sufficiently reliable to allow continuous communications, although radio frequencies employed have to be shifted. All this is true until some unknown triggers solar activity. The most common form of solar activity, the one that creates the greatest ionospheric disturbance, is the solar flare. Compared to hydrogen bomb explosions, the solar flare on the sun's surface is of such magnitude as to make man's effort appear minutely inconsequential. Photographs of solar flares depict flaming bases leaping hundreds of thousands of miles outward from the sun's surface. The energy involved exerts a great deal of influence on the earth's ionosphere and may be a serious hazard to man in space. Although Old Sol appears to be a benevolent and reliable orb that brings spring flowers and glowing summer tan, he can really be cantankerous at times.



Initially, the solar research conducted by Navy scientists of NRL was accomplished by the use of intermeteorologists joined with their colleagues from the Weather Bureau and Air Force to form the Joint Numerical Weather Prediction Unit at Suitland, Maryland. A year later, the group was routinely making operational computer forecasts. In 1959, the Navy established the Fleet Numerical Weather Central at Monterey, California, to support fleet meteorological and oceanographic needs.

To support the environmental service needs of the forces' effort, data from ships at sea and island and land stations are used. In addition, Navy aircraft are used for meteorological and oceanographic observations. The VW-l *Typhoon Trackers* and the VW-4 *Hurricane Hunters* of the Pacific and Atlantic, respectively, fly the tropical storm watch.

However, the Navy's need for new and sophisticated weaponry and support of naval communications will force the Naval Weather Service to extend beyond the fringes of the earth's atmosphere. With satellites and other space traveling vehicles, the need for space weather reports is becoming as important as routine ship weather forecasts. Over the past two decades, man has learned much about space environment, but the focal point of space environment is the sun.

The sun is not just a quiet, orange ball that rises in the east and sets in the west. Frequent storms rage across it, spraying large volumes of gas, and electric energy fields, into space. Fortunately, not all the blasts from these storms strike the earth. But when they do they cause all kinds of communications' blackouts. This happens because most radio systems depend upon the electrified blanket, the ionosphere, that surrounds the earth at an altitude of 60 to 300 miles. When a solar magnetic storm is taking place, the increased electrical flow from the sun to the earth overcharges the ionosphere and can light up the polar regions like a neon tube — the aurora borealis.

In mid-1973, the Naval Weather Service will make a quantum jump into space when *Solrad-Hi* will be launched on a *Titan. Solrad,* a contraction of solar radiation, is a sun monitoring system made up of three 24 x 30-inch satellites that will be placed in a circular orbit at an altitude equal to 20 earth diameters. The satellites are being fabricated by Navy scientists at NRL. *Solrad-Hi* is also the first solar satellite system able to continuously monitor the sun and have a real-time readout capability.

In order to make use of these observations of the sun, the researchers at NRL and the Naval Weapons Center, Corona, California, are in the process of developing techniques to forecast the sun's activity and its influence on Navy communications. Once these prediction methods are established and translated into computer programs, the Naval Weather Service will begin providing this information on a routine basis. It is presently planned to issue these forecasts from the Fleet Weather Facility at Suitland.

As man becomes more sophisticated, so do his military systems. The problems of space environment forecasting will be staggeringly difficult, but then, so are those of air masses and fronts.

— LCDR. NEIL F. O'CONNOR

mittent rocket probes and by monitoring with ground-based sounders. The advent of satellites, however, added a new dimension to the research effort and has made possible the measurement of many additional parameters. Satellites have greatly enhanced the progress of NRL's solar research, which began in 1949. For the past decade, the Navy has been operating satellites on the fringes of outer space. The satellites used for monitoring solar radiation are *Solrads.* The first SR-1 was launched in June 1960 and has been followed each year by an improved model fabricated by NRL scientists. The Navy's *Solrad* program, with its single U.S.-based ground station, is recognized by the Department of Defense as an example of a space science effort which has high operational utility. Unlike other satellites that have multi-purpose space functions, *Solrad's* principal mission is to monitor all aspects of the sun's activity.

Operation of the *Solrad* system epitomizes cost effectiveness. Telemetered data from the satellite are received at the NRL Tracking and Data Acquisition Facility at Blossom Point, Maryland, where they are relayed by dataphone to the Solrad Data Operations Center, at NRL near Washington, D.C. The stored digital telemetry data are then converted into operationally useful message formats and transmitted to many users. The Naval Communications Command utilizes the data in formulations of Navy alerts to all communicators. Outside the Navy, *Solrad* data are furnished on a routine basis to the Environmental Services Space Disturbance Forecast Center at Boulder, Colorado, and the USAF Solar Forecast Center on Cheyenne Mountain, Colorado.

Future plans call for continued development of forecasting models and techniques and for placing three small solar monitoring satellites in an orbit at an altitude of 20 earth radii (about 70,000 nautical miles). At this altitude and with extended deployment of the three monitoring devices, continuous coverage of solar activity will make real-time continuous transmission of data to the single existing ground station a reality. Forecasts of solar activity are expected to be as readily available as daily forecasts of weather. It is expected that the Naval Weather Service, with its worldwide centers and computer facilities, will be responsible for the dissemination and interpretation of the forecasts for Navy users. Armed with this information, the communicator will be able to select those radio frequencies which will allow him to best avoid solar interference. Thus, the day of the lost broadcast may soon come to an abrupt halt, thanks to the efforts of NRL scientists.

LCdr. O'Connor is a frequent contributing editor to Naval Aviation News.

ROCKET POLITICS

and Robert F. Freitag

Photograph by JOC James Johnston


U.S NAVY
POLARIS

Captain Robert F. Freitag, USN (Ret.), is probably the only officer in the Navy to be awarded the Legion of Merit for being a salesman.

This man, Admiral Connolly emphatically states, was a tremendous motivator. "He was cited for being that one person in the Navy most responsible for bringing the *Polaris* concept into an approved status so that the program could be set up and started. Bob Freitag was a personal crusader — a real stem-winder. He devoted his entire career to the furtherment of rocketry and missilery and was the chief stimulator of not only *Polaris* but also the Pacific Missile Range and the Navy's space programs."

Freitag never had a day of sea duty. He was neither inventor nor pioneer. He did not wear the wings of a Naval Aviator but most of his assignments were in the Bureau of Aeronautics. Paradoxically, as a middle grade officer, he moved in high level, senior Navy and national circles, exerting a profound influence. How this was accomplished, largely in the complex environs of Washington, is best answered by the man himself.

ROCKET POLITICS- *and Robert F. Freitag*

Bob Freitag speaks softly, with economy of words. "Let me explain," he says, "the background of the ballistic missile program; it has a direct relation to the present space program. Without one, the Navy wouldn't have the other."

Polaris was an outgrowth, Freitag points out, of our post-World War II interest in missile weaponry. How he became involved was pretty much by accident. As a youngster, Lindbergh's solo flight across the Atlantic had stimulated his desire for a career in aviation. But with prospects of higher monetary return, he accepted advice that he should take engineering law in college. Then, threatened with the pre-war draft, he switched to aeronautical engineering, an immune curriculum which would enable him to complete his studies. It wasn't easy; because of his part-time job managing a soda fountain, it took him more than five years to earn his degree at the University of Michigan. But just prior to graduation in 1941, he was approached by Captain Lyle Davidson, an enterprising naval officer who was making his own personal effort to recruit promising, upcoming engineers for the Navy. Although Freitag's grades were not the best, the captain offered him an ensign's commission and postgraduate work at the Massachusetts Institute of Technology — an attractive inducement, especially since the young man had recently married.

The aeronautical engineering program did not involve pilot training but, thinking beyond his first desire, which was to fly, Freitag applied himself assiduously to his studies at MIT. Imbued with a feeling of responsibility toward the Navy, he was at the top of his seven-day-a-week Navy class. His reputation for superior performance as an engineer reached new proportions after he was assigned to BuAer as an aerodynamicist. Throughout the war years he was consistently rated by his superiors as "outstanding" and "the finest engineer they had ever worked with."

Upon the cessation of hostilities, Freitag was faced with the problem of choosing a career. Either he could stay in the Navy with the inevitability of having to go to sea periodically; or he could go into industry and concentrate solely on engineering. Being of a practical nature, he decided to accept a job as Chief of Aerodynamics for Aero-Products Propellers.

The postwar Navy was also aware of the value of specialization in certain fields. Thus, when the AEDO (Aeronautical Engineering Duty Only) program was initiated, he quickly returned to active duty where his first assignment was to join the Naval Technical Mission in Europe.

Early in 1945, the Joint Chiefs of Staff had ordered forces in Europe to preserve and take under control "records, plans, documents, papers, files and scientific, industrial and other information and data belonging to . . . German organizations engaged in military research." An immense collection process was soon underway, with particular emphasis on rocket and missile technology. Along with tons of reports, documents, data and notes, Allied forces gathered up nearly 100 V-2's, complete with production machinery and associated equipment. They also managed to dismantle a huge supersonic wind tunnel which was then shipped to the Naval Ordance Laboratory in Maryland for use in rocket development. General Dornberger, von Braun and the leading rocket technologists of Germany voluntarily turned themselves over to the Americans in Austria.

The job of the Naval Technical Mission in Europe was to sift out what might be useful to the United States. In that capacity, Freitag was primarily interested in supersonic wind tunnels, but he had also been tasked to interview the German rocket people. It was an opportunity for enlightenment. By the time he returned home, LCdr. Freitag was not only an expert on guided missiles but he had also decided to devote his energy to their future naval development.

As Assistant to the Director of the Guided Missile

Division, in 1948, he planned the Navy's experimental work with the captured German equipment and the guided missile programs which included *Viking* and *Aerobee*, an evolution which would progress into the *Sparrow, Rigel* and *Regulus* weapons.

"During this 1948-1949 period," says Freitag, "while on another assignment to Europe, I became deeply involved with a joint Army, Navy, Air Force effort — coordinated with the British — to evaluate the Soviet missile program. It soon became apparent to me that the Soviets were going like the devil on *ballistic* missile development. While we in this country were doing almost nothing along those lines. My interest expanded very rapidly beyond the 'pilotless aircraft' concept, which had been our main concern, to the idea of selling ballistic missiles to the Navy.

"The first thing to be done was to take what we had — the relatively small NRL *Viking* — and see if we could make a weapon version of it. By 1952, it looked pretty promising. Meanwhile, I had a tour of duty at Cape Canaveral where I became even more convinced that ballistic missiles were in our future. It was during this tour at Cape Canaveral in 1951 that I first became acquainted with Wernher von Braun when the Army missile team launched the *Bumper Rocket*, a V-2 modified by adding a second stage WAC rocket. So, upon my return to Washington, I got myself assigned to the surface-launched missile branch, and it was there that I began to work with Captain Grayson Merrill and Bob Truax. I had known them both over the years but this was the first time we were actually able to work together."

In 1953, Freitag's primary assignment was "to look after the *Regulus* program." Truax was working on advanced planning for future missilery. Both men, along with Capt. Merrill and NRL's Milt Rosen, were convinced of the superior potential of the ballistic missile. The weapon version of the *Viking* had been turned down eventually in favor of smaller missiles, but the *Viking* had at least demonstrated the feasibility of successful launches from the rolling deck of a ship at sea, as well as many of the very advanced techniques of rocketry required for ballistic weapons such as gimbaled rocket engines for control and guidance, a separable nose cone for payload development and lightweight, efficient structures. Many of the very early techniques of today's space systems originated in the early *Viking* research, including much instrumentation, payload design and space photography. As far back as 1947, Truax had submitted a paper on surface-launched missiles; now he was trying to convince people that ballistic missiles could be fired from the sea itself.

The *Regulus* was an air-breathing pilotless aircraft and, although Freitag was able to guide the program to a successful conclusion, including deployment of operational missiles aboard aircraft carriers, cruisers and submarines, there were obvious drawbacks to its combat potential. Truax, meanwhile, prepared a new study entitled "A Means for Making the Guided Missile Submarine a Primary Naval Weapon," which pointed up the shortcomings of the thinking at that time.

The original plan for *Regulus* involved the use of three submarines for two missiles — one which surfaced and launched the *Regulus* missiles while the other two provided radio guidance. Within the *Regulus* program, an advanced inertial guidance system was under development which eliminated the need for the two guidance submarines and provided greater security by eliminating the need for radio transmission that could be intercepted or jammed. Still, both Truax and Freitag reasoned, a much greater improvement could be achieved by utilizing ballistic missiles which could be launched under water to avoid detection of the launching submarine and which could fly at extreme altitudes and hypersonic speeds and prevent interception by active defenses.

"During the war," Truax states, "the Germans had proposed a towed submersible barge from which a V-2 would be launched. It was a very cumbersome thing — with liquid oxygen, only one missile per sub, and it had to be towed around. It was very unhandy. As bad as the *Regulus*. What was needed was an increase in the ratio of warhead payload to submarine weight. The ballistic rocket was the answer. It is very dense — a pressure vessel that can be exposed to sea pressure without a lot of protection. You could plaster the missiles — a great many of them — all along the outside of the submarine. Once released from the side of the sub, a missile would rise to the surface, much like a buoy, and from there it could be fired on command. You would have a tremendous increase in payload, secret mobility, and economy (because no elaborate launch pads or facilities were required). The disadvantage was a reduction of submarine speed as long as the missiles were attached."

And, as Truax puts it, "At that time, just the *idea* of putting a missile on a submarine — let alone the notion of putting a nuclear warhead on an underwater missile —

was considered pretty kooky! We didn't get very far with it."

By 1954, while the Air Force was moving ahead with its ICBM's and the Army was developing its *Redstone,* the Navy was engaged in an internal *reappraisal* regarding the proper role of the missile in naval operations. In a complete turnabout from the earlier period, BuOrd was advocating a winged missile (pilotless aircraft), known as *Triton,* while BuAer was thinking in terms of ballistic trajectory rockets, a somewhat paradoxical reversal of their traditional experience and roles. Some officers questioned the assignment of missile priorities in view of the state of the art and budgetary considerations, while others called for a diversified research and development program with emphasis on the ballistic type missile.

It was in this unsettled atmosphere that Cdr. Freitag and a civilian BuAer scientist, Abraham Hyatt, decided to take the initiative. "We knew the Russians were moving real fast," states Freitag. "So we looked at all the different efforts that were going on and put them together in a study for a ship-launched ballistic missile. There were three key men who gave us tremendous support throughout this episode. They were Rear Admiral Bill Schoech, chief of R&D in BuAer; Captain A. B. Metsger, head of the Guided Missiles Division; and Rear Admiral Jim Russell, Chief of BuAer — who later really put his career on the line for this operation.

"The study was completed in late 1954 at just about the time that the presidential committee on weapons systems, chaired by Dr. James Killian, president of MIT, came out with a major recommendation that ballistic missiles be developed: ICBM's — IRBM's — and (almost as an afterthought) sea-launched missiles. Commander Pete Aurand was involved with the Killian Committee and it was because of his efforts that the policy statement included *that* final item. As a result, for the first time we were able to start getting the attention of key Department of Defense and Navy personnel."

The fleet ballistic missile (FBM) enthusiasts in the Navy did not have easy sailing, even on their own waters. While launchings from cargo (or "Q") ships were practical, *submarine* operation was the elusive goal. Ballistic missiles of the time were either of short range or would prove too large (100 feet long) for easy handling aboard a submarine. Then, too, there was the question of who would have cognizance of the program, BuOrd or BuAer? The Killian Committee had lent support to the Freitag/Hyatt study, but not until there was an improved degree of miniaturization in electronics could there be a viable FBM system. Needed, too, was a solid propellant of sufficient specific impulse. None was in existence; nor was there a suitable navigational system, an accurate guidance system or an acceptable fire-control system. It was argued, logically, and with good cause, that the FBM would be a continuous drain on Navy funds — to the great detriment of other equally important programs. Therefore, in July of 1955, BuAer was ordered to cease and desist in the matter of the FBM.

Nevertheless, the gears of the Freitag/Hyatt motor were already meshing. Letters had previously been sent out to 22 aerospace contractors and laboratories requesting ideas on solutions to the myriad problems of launching a 1,500-mile rocket from a submarine beneath the surface of the sea — a rocket with a nuclear warhead that would strike an 'inland target with pinpoint accuracy. Detailed design proposals were soon forthcoming, not only from industry but also from NRL, the Naval Air Missile Test Center, the Army Redstone Arsenal and the Naval Ordnance Test Station. The FBM program, they said, *was feasible.*


JOC James Johnston

"Then a fortuitous thing happened," says Freitag. "Admiral Russell and Captain Tom Moorer* had already convinced the Assistant Secretary of the Navy for Air, James H. Smith, of the importance of the FBM, and they apprised him of its controversial nature. So, when Admiral Burke was named to take the reins as the Chief of Naval Operations, former Naval Aviator Smith immediately briefed him on the problem. The first thing Admiral Burke did was rescind the order which had restricted BuAer's work on the FBM. As I recall, he was sworn in on a Friday and on Sunday Russell and Metsger were already going over the plan with him. Then he just said, 'Go! Full speed!' and he told BuAer to get the thing sold — internally and externally."

Freitag, who had by now established the firm base of practicality rather than conjecture and who had successfully enlisted the necessary support of his own organization, embarked upon a selling campaign aimed at convincing those outside the Navy. Of particular significance was the strong support Freitag had enlisted in the Bureau of Ships. There, under the leadership of Commander "Red" McQuilkain, feasibility studies of ballistic missile launch ships and submarines as well as ship navigation and fire-control systems were evolved which further reinforced the feasibility of the concept. "Once Admiral Burke had said 'Go,' there was no more conflict between BuAer and BuOrd. It was 'all shoulders to the wheel,' and we worked like hell.

*Admiral Thomas H. Moorer is now Chairman of the Joint Chiefs of Staff.

"But, at about that time, a tentative Defense Department decision was made in response to the Killian report: The Air Force would develop ICBM's (5,000-mile range); both the Air Force and the Army would develop IRBM's (1,500-mile range) — the Air Force would be prime and the Army would be back-up. Navy was out!

"The factor was that the Navy had just been given the satellite project, *Vanguard,* an endeaver believed to have tied up all of Navy's capability — we were presumed to be too busy developing *Vanguard* to have anything to do with an IRBM. The Army was kept in business because, with von Braun's team at Huntsville, they had a *capability* (although no real requirement). In essence, the Air Force appeared to have the ballistic missile market cornered."

Curiously, the DOD decision did recognize the validity of the Navy's *requirement* for the FBM — which was a form of IRBM. The door was still open and Bob Freitag rushed through — all the way to Huntsville where he spent three days with his old acquaintance, Dr. von Braun.

"I proposed to von Braun," states Freitag, "a very simple proposition. He could see that the Navy requirement made a lot of sense. We knew the United States wouldn't be able to stay in Turkey and Italy and other places forever with our rocket weapons — we were just drawing fire to those countries. But if we put the launch platforms *at sea,* we would still have all the advantages. So, I suggested that he redesign his missile for shipboard operation, which in essence meant putting a fourth gimbal on the guidance platform to take care of pitch and roll. We (Navy) would take care of shipboard installation — all the fire control – but he (Army) would have the rocket. In effect, with his brains and our good looks — our *requirement* and his *capability* — we would have something we could work with."

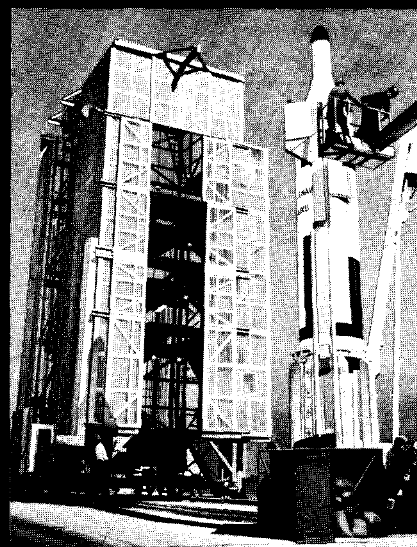
The Navy had been working with von Braun for a few years. Commander Hoover had generated enthusiam for Project *Orbiter* prior to the *Vanguard* decision. "*Orbiter,*" says Freitag, "was essentially the *Explorer,* which was finally launched two years later. It was a matter of taking a *Redstone* and putting more stages on it.

"Well, von Braun accepted. He said, 'I will support it and take it through Army channels and you can take it through Navy channels.' Then, when I got back to Washington, Admiral Russell said, 'Fine,' and it went on up the line."

Somewhat to the surprise of the Pentagon, the Army and the Navy had formed an alliance for a fleet ballistic missile. In effect, the Department of Defense was confronted with a counterproposal to its directive. Two of the services had planned a logical *joint* ballistic missile program. Under the circumstances it was difficult to say no. The *Polaris* program was underway.

POLARIS DEVELOPMENT

The development of *Polaris* (which had first been named *Thor* – no relation to the Air Force missile) is a separate story in itself. The original Army/Navy concept actually was to be a modified *Jupiter.* Its size (58 feet in length) and the fact that its lower stage utilized cryogenic propellants (both features being undesirable), prompted the Navy's Special Projects office to investigate the potential of less volatile fuels. The ultimate Navy goal remained one of underwater launch from submarines and



Cdr. Ted Wilbur

the storable solids were most conducive to success in this regard. Size remained a problem, and size of the rocket was dictated by the warhead weight and propellant efficiency. A bold gamble that warhead weights could be dramatically reduced during the *Polaris* development lifetime needed to be taken to fully exploit the FBM potential. With the support of Dr. Edward Teller and others of the Atomic Energy Commission this gamble was taken. As a consequence, not only did the eventual breakthrough on solid propellants and smaller warheads* permit a much smaller missile (the *Polaris A-1* was about 28 feet), but it also brought about the dissolution of the Army-Navy partnership which had served the basic purpose of getting the initial FBM approval.

*It was the reduction in warhead size that permitted the lower performing solids to be used. The performance of solids was later improved so that payload/weight ratio approached that of liquids. Today, solid rockets are heavier than their liquid counterparts.

During the early development period, Commander Freitag stayed on in the Office of the Chief of Naval Operations, "just across the street" from BuAer, where he helped with the organization of the *Polaris* program. A nationwide industry team was called in. Top management attention was secured and many industrial contractors (in addition to those in the Navy and NRL) were welded together in a cohesive team. "It was through this fantastic type of operation," says Freitag, "that I came to know the right people — the ones who would prove to be so helpful later on."

A POLARIS MAN

Captain Roger Boh, then a lieutenant commander, was a Naval Aviator assigned to Polaris as a test conductor at Cape Canaveral under missileer K.C. "Casey" Childers (now Naval Air Systems Command Representative, Atlantic). A fighter pilot and engineer, Boh applied his talents to development of the spectacular weapon at a time when there was much White House interest. "At the time of a launch, I don't imagine my feelings were much different from Alan Shepard's when he was sitting on top of the Mercury/Redstone. The first five shots were failures. One went straight up and came straight down. Two blew up on the pad, and a second stage missed us by one-fourth mile. Lots of snakes came out of the bushes." Capt Boh is now assigned to F-4 project office.


JOC JAMES JOHNSTON

With one arm up to the shoulder blade in *Polaris,* he then busied the other by stirring the pot wherein the space stew simmered — and *applications* bubbled. Fifteen years of experience in the ways of the Navy — and, for that matter, the Army, Air Force and industry — came to the fore as Freitag set his sights on space. Long ago he had learned the few basic rules of making progress in an organization: dedication (with humor); understanding (especially of the opposition); and flexibility. (There is more than one way to get aboard. If you think about it, it doesn't always have to be a *left-hand* pattern....) Now, he was rapidly becoming a virtuoso of the art, and *variety* was the keynote of his repertoire. As he maneuvered from individual to group to committee, he employed all manner of tactics, subtle, direct and circumventive — but he never lost sight of his goal: the U. S. Navy in space.

For Step Two of the master plan, he advanced the idea of building up the Missile Test Center at Point Mugu as a counterpart of the Atlantic Missile Range. "The idea of having a Pacific Missile Range (PMR) was, first, to have a targeting area for ICBM's and IRBM's, and also to have a launching base for polar orbiting *satellites.* At that time, it was believed that Cape Canaveral was unsuitable for certain satellite vehicles because of safety problems; the falling stages would represent a danger.*

"The planning operation," Bob Freitag recalls, "put me right on the Army circuit, the Air Force circuit and the then-new NASA circuit. During that entire course of time (approximately two years) I made over 200 presentations — up and down every hall, in and out of offices, stopping people in passageways, doing everything I could think of — just trying to make this thing go.

"Because of this perseverance, we were able to convince the Secretary of Defense that we had to have a range on the West Coast to do the training and also the operations. What I am speaking of here was a long drawn-out series of Department of Defense reviews. A team had been formed of Army, Navy, Air Force and DOD people for the purpose of inspecting all facilities for missile operations — and even aircraft flight testing — in order to determine what the optimum range configuration should be. This committee, which was called the Special Committee on Adequacy of Range Facilities, finally recommended: a West Coast range (PMR) which would be basically under the Navy; the mid-continent land range at White Sands, which consolidated the White Sands/Alamogordo area into one good range; and the East Coast range under the Air Force."

According to Cdr. Freitag's thinking, especially during the 1957-1959 period — after the Russians had launched their *Sputniks* and *Explorer* had been so successful, and then, of course, the Navy had its *Vanguard* — it was time that consideration be given to satellites from an operational standpoint. "There were items coming along such as *Transit, SynCom* and *Tiros,* weather satellites and so forth, but it seemed as though the Navy always ended up working for someone else. *Vanguard* was working for the IGY; and *Transit,* which was generated by the Navy/Johns Hopkins Applied Physics Lab, was being run by the Advanced Research Projects Agency (ARPA) group.

"There were also," Freitag reflects, "many people within the Navy who were content with that situation. Fortunately, Tom Connolly was on the scene, as assistant for plans to the Chief of BuAer. I had known him back during World War II when he was a VP (flying boat) pilot and then at Flight Test at Patuxent River and, of course, later at TPT (Test Pilot Training), but now I had the opportunity to work directly with him. Because of his position, I knew that he was the best man to convince that the business of testing at PMR was not only important for our flight test aspirations — but that it was also probably going to provide a real opportunity for space.

"He spent a lot of time looking over my proposition and finally agreed with it. In order to give it proper focus, I

*It is still true.

recommended a plan that ultimatelv resulted in what is now known as the Connolly Report. Admiral Russell, who was then Vice Chief of Naval Operations, also gave his support. I had explained to him that the same sort of ingredients existed in the space question of that year (1959) as had existed in 1955 with ballistic missiles."

Freitag pointed out to Admiral Russell the need to educate all the appropriate offices at the same time: OpNav, BuShips, ONR (Office of Naval Research), practically everyone in the Washington Navy. "We had to get the really good key people together; otherwise, we would be forever trying to get off top dead center."

Admiral Russell bought it; Freitag was told to write up the charter. Two days later, with Admiral Burke's blessing, Russell signed it.

Captain Thomas F. Connolly was named chairman of the 1959 *ad hoc* committee on astronautics. Members of the twenty-man board included, along with Freitag, Truax and Berg, representatives of various key divisions of OpNav, BuShips, BuOrd, BuAer, BuMed, ONR, NRL and PMR. Not only did the group examine what was going on in space and sort out what was important, but they "equated their findings with Navy requirements and set up a program that made sense. In addition, they recommended an organization to execute it.

"It was a rather comprehensive job. Two new sections were established in CNO: OP-54, which was under Admiral Pirie, DCNO(Air), and looked after things like PMR; and OP-76, an office truly responsible for space matters, which is still with us today. And, near the end of the year when BuAer and BuOrd merged to form the Bureau of Weapons (BuWeps), an astronautics division was established to parallel the aircraft division. The Navy was ready to play an integral part in the development and fulfillment of the national effort and particularly of the military space programs.

"However," Freitag continues, "the biggest problem came along in 1961 when, again, the Navy was almost put out of business as far as space was concerned. In that year, a directive was issued which said in effect that the Air Force was to be, with a few minor exceptions, the sole agent for all space programs. If the Navy was to stay in the game, we would have to work through the USAF.

"Well, in the long run, we were able to make this procedure work. In some respects it was a blessing in disguise. For instance, I was among those who at one time were in favor of adding another stage to *Polaris* and making it a launch vehicle. The idea was to create a device for reconnaissance — bomb damage assessment, and so forth – that would be launched from the sea, make one orbit and be recovered. It was a pretty advanced proposal; we called it *Sea Scout*.

"Although it was a good idea," says Freitag, "it probably would have sopped up all the money the Navy had, if we had gotten approval. But, of course, due to the directive we couldn't get it. Instead, we put all our money into payloads — scientific instruments and satellites — and, to get them up there, we used Air Force boosters, which they furnished. It worked out very nicely. A highly effective program

"In retrospect, I often think back to those days of 1955 when we were trying to sell *Polaris,* and one of the big objections was the problem of pinpoint navigation. There were those who said it just couldn't be done. Yet, it was only five years later that an earth satellite, *Transit,* was tested as a navigational system — and the following year it was operational. In only five short years we were using a system that was a hundred times more accurate than anything that had ever been done before. But, back in 1955, there were people who could not even *conceive* of a satellite.

"Well," understates Freitag, "we educated them."

Captain Bob Freitag may have been a "mover behind the scenes," largely unrecognized by the public and the general naval community, but he left a lasting mark on the Navy's future in space. By 1963, practically every Navy space project bore his brand — PMR, *Transit, SpaSur* and ANNA among them. His Operation *Starlight* was an amplification of the Connolly report, but with emphasis on the future ten to twenty years. In his many writings and lectures (some said when the first man would step on the moon, Freitag would be there delivering the speech), he emphasized two points: the value of astronautics and the future outlook for the Navy. The value, he pointed out, often comes from explorative research. "What is experimental today, may become essential tomorrow. In the beginning, there were few who could see the potential of a satellite, just as today there are those who question the exploration of the moon and planets. But the new technology enriches life in this world and makes it easier for us."

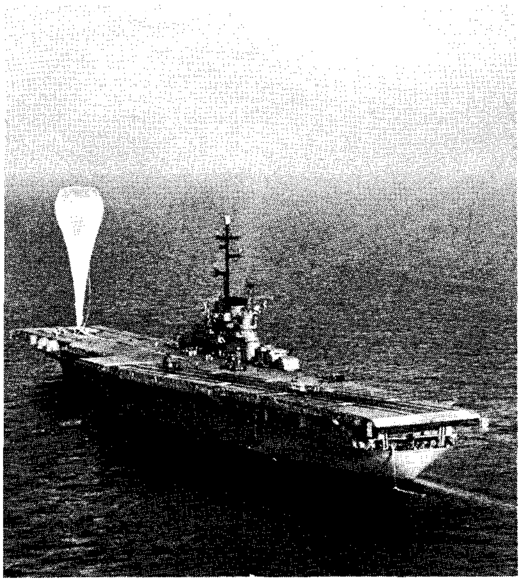
The basic programs which he planned, prodded, pushed, organized and guided still form the nucleus of today's astronautic Navy: communications, surveillance, weather, geodesy, navigation — and support.

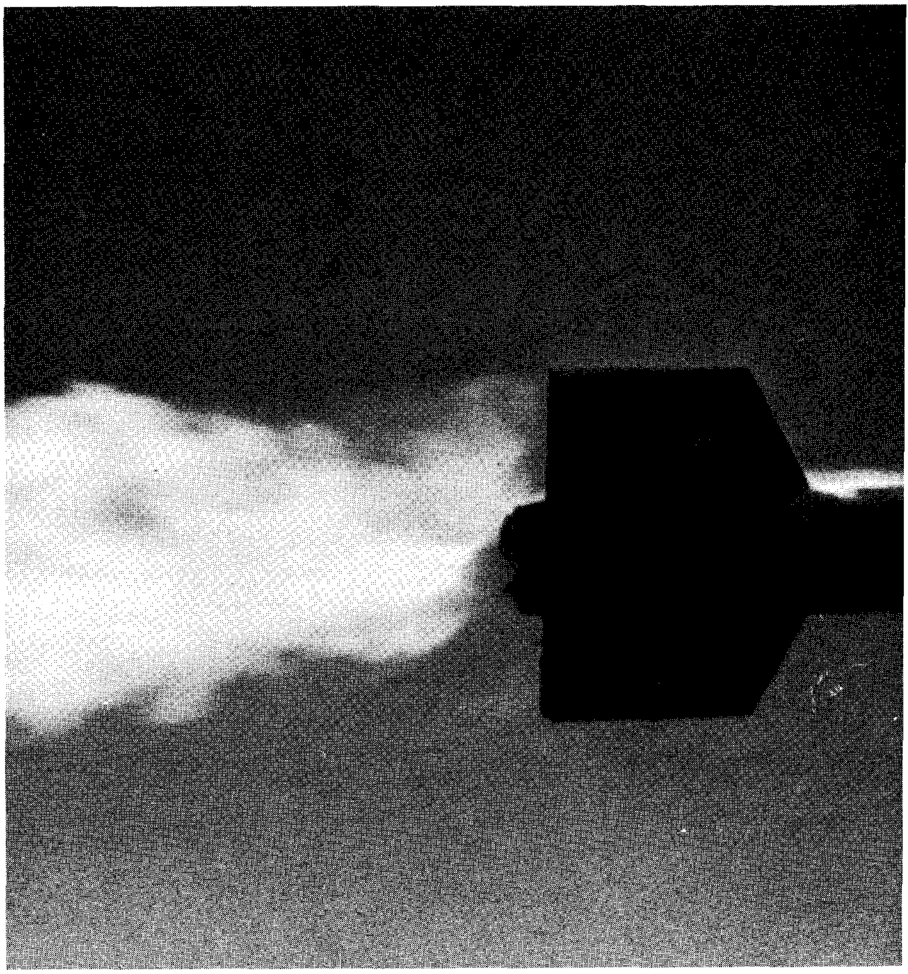
And what of Bob Freitag? In 1963, after 22 years of active duty, he retired from the Navy. It had become obvious that, as a captain, he had reached the highest plateau in his own promotion structure. His particular talents had been devoted more toward innovation and pathfinding than to the acquisition of *command* experience. To the man who had been called "Mister Astronautics of the Navy," Admiral Connolly gave counsel: "Through the years you have been with us, you have given a direction and impetus which has been invaluable. You have done here what had to be done. Now, it is time you devote your energies to the civilian space program where your capabilities can reach their full potential."

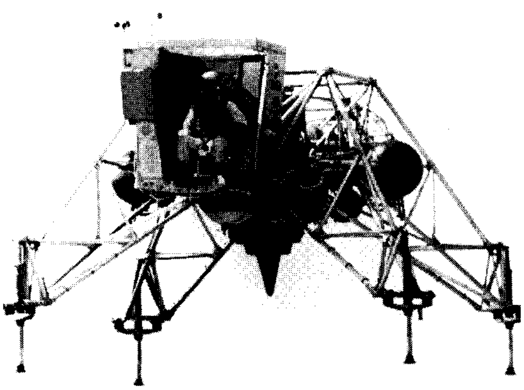
Thus, since 1964, Captain Robert F. Freitag, USN (Ret.), has been Director, Manned Space Flight Field Center Development for NASA. Among his responsibilities — which include liaison with Congress — has been the Manned Space Flight Center at Houston.

Ask Bob Freitag what all this means in the infinite scheme of things and he will probably smile and quietly say, "What good is a newborn baby?"

MANNED





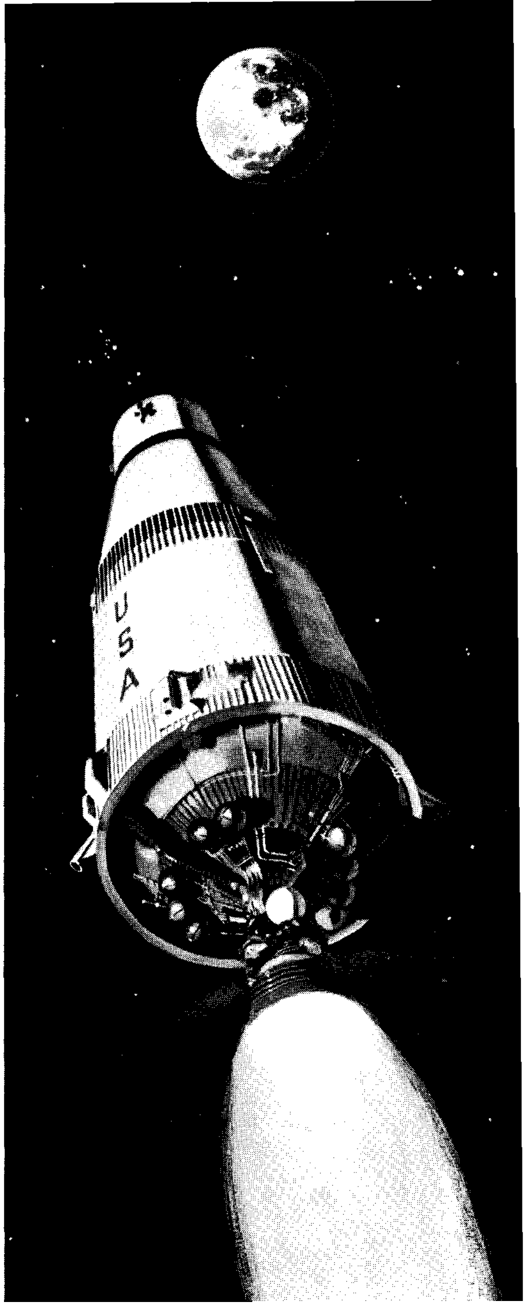


Cdr. Malcolm Ross and LCdr. Victor Prather lift off Antietam enroute to a world record altitude of 21½ miles, set in May 1961. Below, Navy astronaut Charles Conrad, Jr., commander of Apollo 12, operates a lunar landing training vehicle. The X-15 rocket-powered aircraft, right, used to explore the edge of space, benefited from acceleration force studies conducted at the Navy's Medical Acceleration Laboratory.

In 1935 after the record flight of Tex Settle and Mike Fordney, another balloon, sponsored jointly by the Army Air Corps and the National Geographic Society, rose to the then incredible altitude of 72,395 feet. Its sealed gondola manned by Captains A. W. Stevens and O. D. Anderson, *Explorer II* established a mark unchallenged for two decades. Undoubtedly, WW II had a tendency to divert interest in high altitude research experiments. And, too, there were those who felt that the mark set by Stevens and Anderson could not be surpassed by a manned balloon, a conclusion based on the fact that a rubber balloon expands during ascension into the stratosphere — to the point where it finally explodes.

But, at the end of the war, Navy interest began to center on the use of plastics, which do not have the expansion characteristics of rubber. The first plans for a manned balloon flight into the upper atmosphere were made by the Office of Naval Research (ONR) in 1946. At that time, it was realized that a stable platform, from which scientific observations could be made, was

SPACE



needed to gather information on near-space physics, nuclear energy, cosmic radiation and in connection with future high altitude flight. The inherent limitations of conventional aircraft and the rockets and rubber balloons used in high altitude studies precluded their use for carrying observers to the stratosphere.

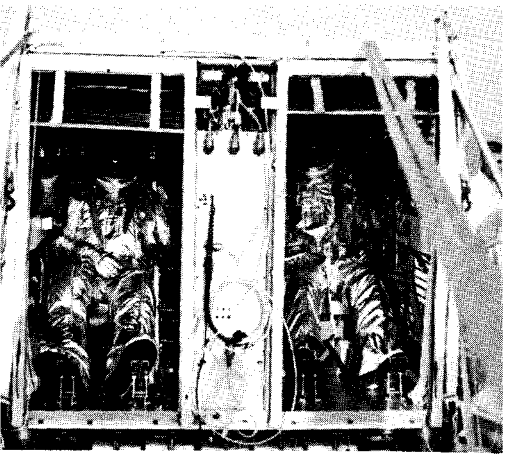
The original project, *Helios,* was named for the Greek sun god. A contract with the University of Minnesota and General Mills, Inc., called for the construction of plastic balloons and a gondola equipped with a battery of scientific instruments. A sealed cabin was to be supported by 100 of the balloons at an anticipated altitude of 100,000 feet for 10 hours.

Dr. Jean Piccard and Mr. O. C. Winzen were among the principals in the project, working along with ONR's Commander George Hoover. Their concept was to use a thin plastic material which permitted a reduction in the weight of the balloon itself to only a fraction of that of a rubber balloon, thereby allowing the plastic cluster to reach a considerably higher altitude.

Because of a lag in technology, the ambitious plan for manned flight was replaced in 1947 by Project *Skyhook,* which involved the use of polyethylene balloons carrying instrument packages to extreme altitudes. Thousands of these balloons were sent into the stratosphere for basic research.

In 1952, a new technique was developed in which meteorological *Deacon* rockets were lifted above 70,000 feet by *Skyhook* balloons. At a fixed altitude, a pressure switch would fire the *Deacon* from an almost vertical position. With the aerodynamic drag of

MANNED SPACE



Ross and Prather, wearirng full-pressure flight suits sit in Stratolab V gondola awaiting hook-up for flight.

lower altitudes thus eliminated, the rocket could achieve a near vacuum ballistic trajectory and attain heights greatly in excess of those reached by surface-level firings. This efficient operation had been proposed by LCdr. Morton Lee Lewis of BuAer in 1949 while conducting *Skyhook* experiments aboard the USS *Norton Sound.*

So successful were the *Skyhook's* that in 1954 plans were laid to entrust the lives of men to a thin film of polyethylene plastic. Project *Stratolab* came into being the following year as a practical, economical method of obtaining fundamental data in the fields of astronomy, astrophysics and physics of the upper atmosphere. During the next six years, five *Stratolab* flights were made, four of which used gondolas originally constructed for the abortive *Helios* project.

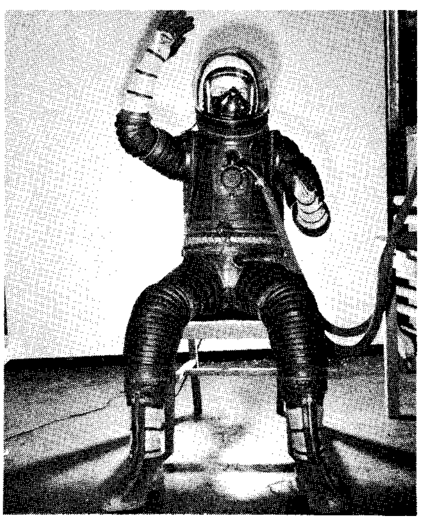
Test equipment included cameras to photograph the formation, growth and decay of contrails created by jet aircraft; special gamma telescopes for cosmic radiation study; and, most important, a wide variety of aeromedical experiments. Captain N. L. Barr of the Medical Corps developed a telemetered (radio-transmitted) version of an electrocardiograph to record the pilots' physiological reactions, heart reactions and respiratory conditions.

In 1956, *Stratolab I,* manned by Lieutenant Commanders Malcolm D. Ross and the above mentioned M. L. Lewis, attained a record altitude of 76,000 feet. As the flights progressed, the altitudes increased until on May 4, 1961, Cdr. Ross and LCdr. Victor A. Prather* (MC), a scientific observer, reached 113,739 feet in *Stratolab V.*

The *Stratolab* experiments made a number of contributions to the manned space flight program. Protons, associated with solar flare activity on the sun, were measured and found to be of such high intensity as to have an ominous import regarding their effects on man in space. This discovery necessitated development of a system whereby solar flare activity could be predicted and monitored.

Telescope astronomy provided a means of obtaining photographs of a quality and resolution heretofore impossible with earth-bound telescopes. Subsequently, an infrared system enabled unprecedented astronomical study.

*It is regrettable that both Lewis and Prather lost their lives in Stratolab-associated accidents: Lewis in a ground accident while testing a balloon gondola suspension system; and Prather at the conclusion of the record Stratolab V. Prather fell from the sling of the recovery helicopter into the sea. Water filled his suit before rescuers could get to him.



MODEL I HIGH ALTITUDE SUIT AT ACEL

The early *Stratolab* gondolas were sealed aluminum balls. *Stratolab V's* balloon hoisted an open, cage-like gondola equipped with adjustable "Venetian blinds" on its side to provide variations of the sun's radiation effects. What made this feature possible were the special full-pressure space suits worn by Ross and Prather.

The Navy *Mark IV* life-support garment had its origins in the early Thirties, not long after the exploits of Soucek and Champion. Pioneer globe-circling aviator Wiley Post requested the B. F. Goodrich Company to fabricate a type of rubber suit that he could wear in an attempt to break the Italian aircraft altitude record of 47,000 feet. Engineer Russ Colley came up with a fairly rigid suit of heavy rubberized cloth, capped with a diver's helmet. (It was stitched together on Mrs. Colley's home sewer; it eventually ruined her machine.)

Such an outfit had a bizarre appearance. One day in 1934, Post made an emergency landing in the desert and, spotting a car that had pulled up on a nearby road, he plodded over to it in his strange suit and helmet, waving at the driver. Post had to chase the frightened man around the car before catching him and convincing him that he was truly of this planet.

Within 20 years, most of the problems of suit maneuverability had been solved. Colley devised swivel joints, rotating bearings and fluted joints. (He had observed a tomato worm in his garden and was inspired by its chenille-like bands expanding and contracting. Thus, the 1952 suit resembled a conglomeration of tomato worms and small rubber tires.)

Its joints allowed neck and shoulders to move in one plane only — but this was progress. Since rubberized fabric tends to take on the flexibility of sheet metal when pressurized, a suit pressure of 3.4 psi (equivalent to atmospheric pressure at 35,000 feet) was selected so as not to destroy mobility in zero-pressure conditions. This pressure also allowed the user to breathe 100 percent oxygen at all times without resorting to fatiguing pressure breathing and at the same

NAVY MARK I FULL-PRESSURE SUIT

time did away with the uncomfortable face mask. The Navy's Air Crew Equipment Laboratory at Naval Base, Philadelphia, meanwhile developed an aneroid pressure suit controller which automatically sensed the cabin altitude and pressurized the suit accordingly — a welcome improvement over the previous manual control system which was annoying if not hazardous.

The lab began working on space equipment well before any object had been placed in orbit. Work began to provide an emergency suit for pilots at 50,000 feet. Step by step the researchers added improvements until they had a garment which would enable man to work outside the earth's atmosphere. Six years and 25 experimental models after Colley's semi-rigid accordion pleats, the Navy and Goodrich developed the *Mark IV* full pressure suit with features that gave it a head start on the space age. Weighing only 20 pounds, it was made from nylon fiber coated with neoprene.

In its development, problems had to be solved in the areas of weight and bulk reduction, ventilation, air and water tightness, mobility, temperature insulation and land/sea survival capability. The *Mark IV* overcame these problems so well that NASA selected a modified version in 1959 and ordered 21 suits for use by the Project *Mercury* astronauts. The NASA "life support garment" added a coating of silver spray as a heat buffer and radiation shield. Picked for its mobility, compactness, reliability and pressure integrity, the suit looked more like a conventional flight suit than its man-from-Mars-appearing predecessors.

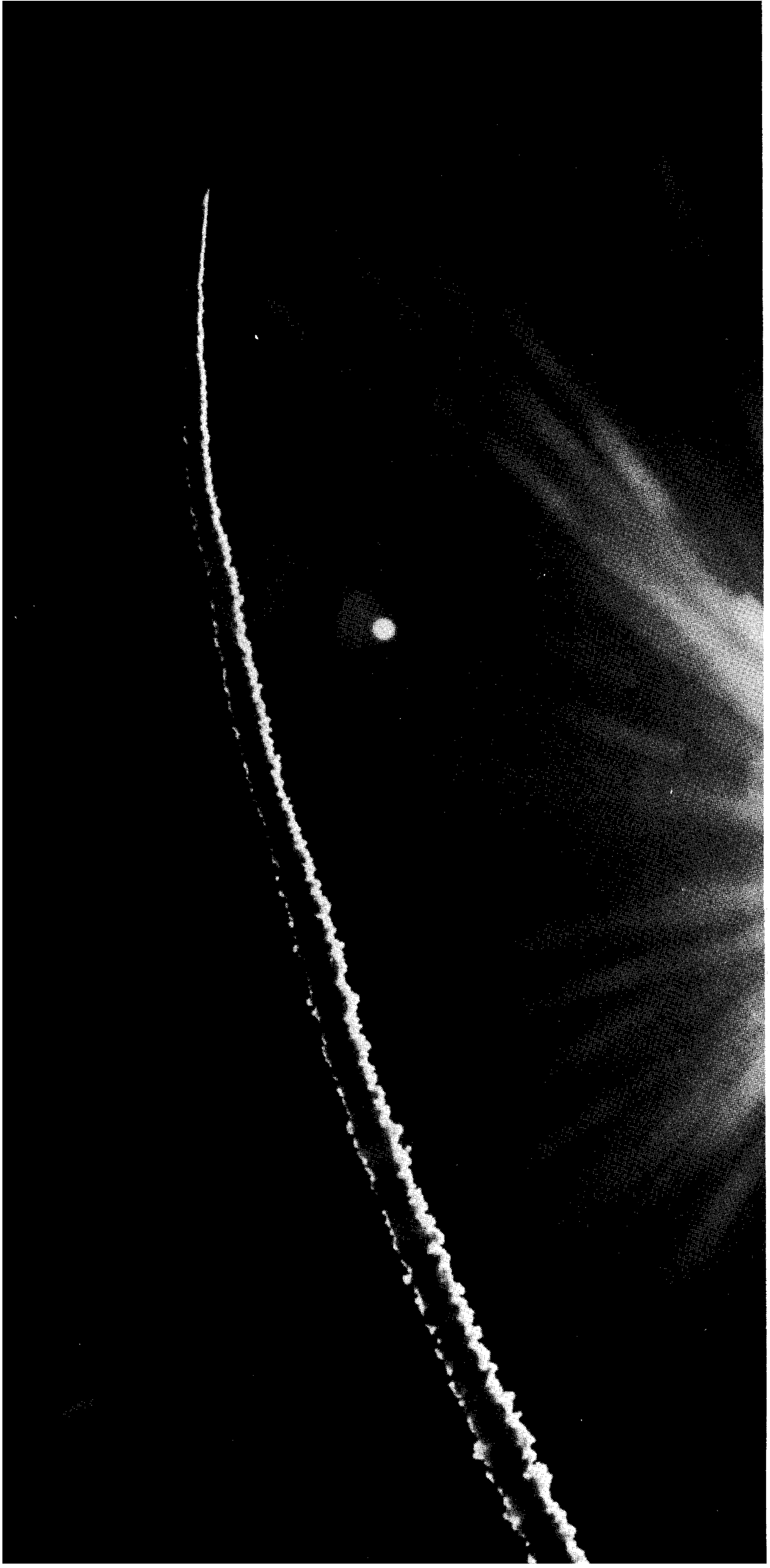
NASA had used the *Mark IV* suit earlier, during its X-15 research project — a forerunner of *Mercury, Gemini* and *Apollo* designed to probe the outer fringes of the earth's atmosphere. The X-15 was an exploratory vehicle used to examine aerodynamic heating, stability and control at high speeds on the edge of space — problems likely to be encountered in manned space flight. LCdr. Forrest S. Petersen, one of the pilots assigned to the X-15 project, wore the suit while reaching the then record altitude of 102,000 feet in the rocket-powered craft. "We found out a great deal about space and equipment," he says. "We learned about reaction controls and how much a man could handle at high speeds. We also learned a lot of lessons and techniques in manufacturing equipment which would withstand the extreme high temperatures caused by friction."

Among other things studied during this initial preparation for space flight were the biological and physical effects of acceleration forces occurring in the X-15. The National Advisory Committee for Aeronautics (NACA), after two years of intensive study of the problems likely to be encountered in manned space flight, submitted a proposal to the Department of Defense for the construction of an airplane capable of the extremely high speeds and altitudes necessary for the desired exploration. The X-15 was designated the test vehicle, and NACA began preparations for its flights by defining the flight profiles needed to gather the needed information. The Navy's Aviation Medical Acceleration Laboratory (AMAL), Johnsville, Pennsylvania, was asked to provide an environment in which man and machine could be subjected to practically all of the actual flight stresses and phenomena caused by acceleration forces.

In order to determine how these factors would affect the pilot's control abilities, AMAL (now the Aerospace

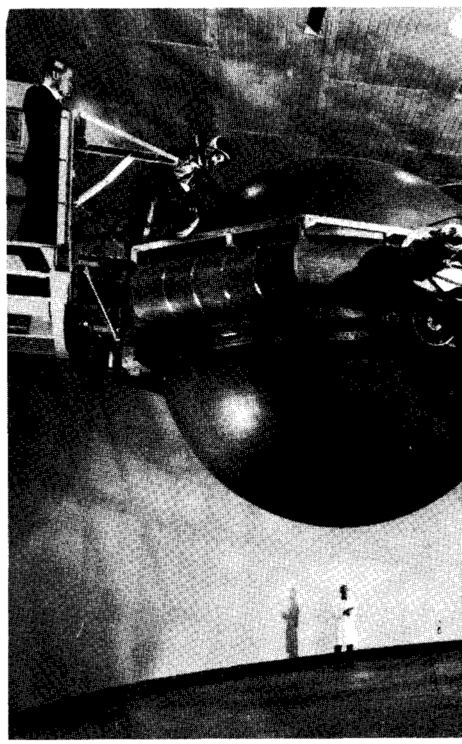
LCdr. Petersen, Navy X-15 pilot, wears Mark IV full-pressure suit later adopted for NASA's space flight program.

Drawing by Paul Calle
Courtesy NASA



Medical Research Department) combined its centrifuge with the Naval Aeronautical Computer Laboratory's (NACL) analog computer to reduce all variables concerning pilot toleration to acceleration forces to known factors. The tests included studies of the pilot's ability — under high G loads — to exercise the precise manual control necessary to keep the X-15 on its exacting flight profile, execution of emergency procedures during uncontrolled gyrations and application of minute corrections necessary to boresight the only safe re-entry corridor.

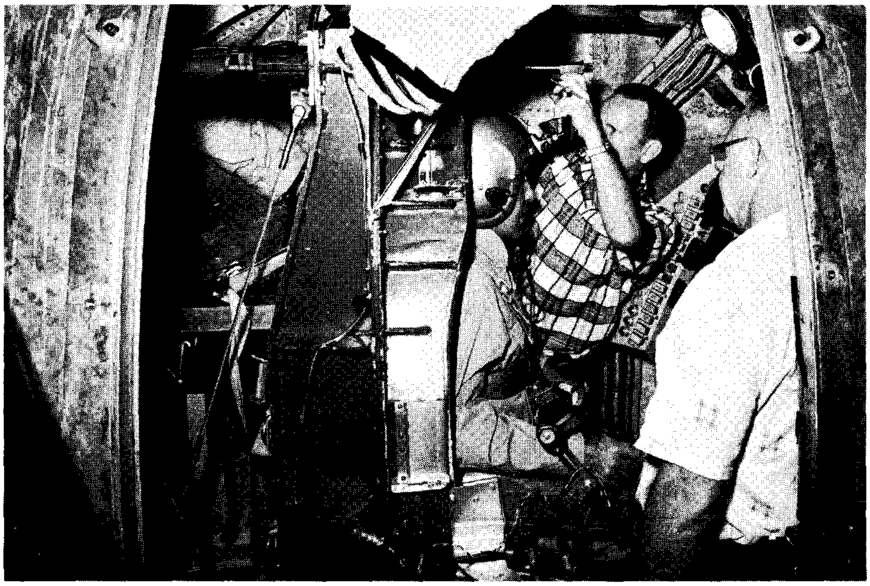
In March 1957, the first centrifuge program was conducted at AMAL to evaluate pilot tolerance, performance and ability to control the aircraft at forces up to 8 G's. By November, a second series was begun to evaluate the pilot's ability under specific flight conditions during exit and re-entry of the atmosphere. In this group of tests, the pilot was able to control the centrifuge through NACL's "closed loop" system linked to its computer which, by processing control signals together with aerodynamic equations, placed the appropriate G forces on the gondola. More tests in the summer of 1958 led to changes in the instrument



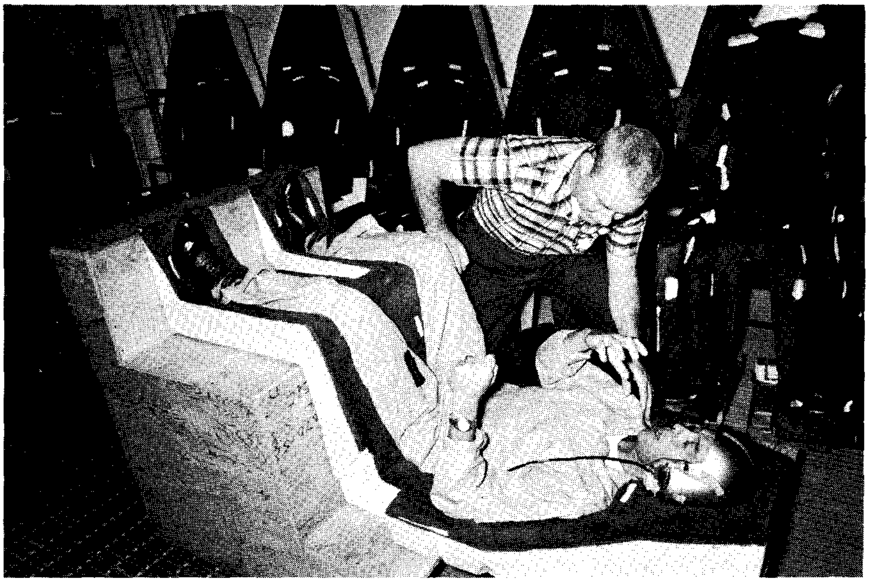
panel and to improvements in the pressure suit.

As the tests for the X-15 project came to an end, NASA (which had by this time absorbed NACA) came forward with new requirements. Data was needed to evaluate three types of proposed spacecraft — the high drag capsule, the high drag variable lift capsule and the glide capsule. Navy, Marine and Air Force pilots were selected to participate in the simulation program — which evolved into the astronaut acceleration simulation training program. The high drag capsule *(Mercury* spacecraft) was the type selected, based in part on the results of some 231 dynamic runs in the centrifuge. These dynamic runs explored problems associated with each type of craft. Further acceleration testing commenced in June 1959 when the centrifuge was used to simulate boost/orbital problems anticipated during the launch phase of manned space vehicles. Pilot physiology and performance of launch and orbital tasks were the subject of the tests, which simulated the effects of two-stage and four-stage accelerations ranging from 3 to 15 G's. These tests aided in the solutions of some basic questions concerning the degree of manual vs. automatic control which would be appropriate in achieving orbital research. The simulation also enabled evaluation of an astronaut contour couch developed at Johnsville in conjunction with NASA's Langley Research Center.

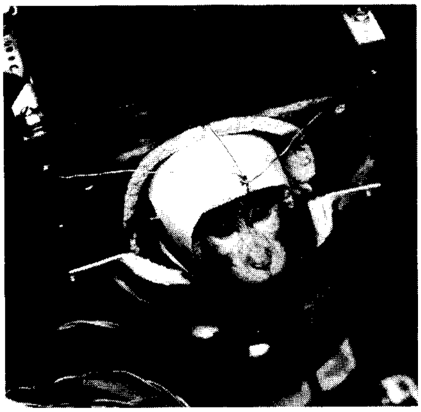
Later that summer, the original seven *Mercury* astronauts began their acceleration training at Johnsville and, for the first time, were able to experience some of the physiological effects of the acceleration they might expect to encounter during launch and re-entry. Using a preliminary test model of the proposed *Mercury* three-axis side-arm control stick and a *Mercury-type* control panel built by the Naval Air Development Center, the seven astronauts made 147 runs in the centrifuge. Participating engineers and scientists made another 98 runs in order to become familiar with the problems of launch and re-entry G forces. In all, the *Mercury* astronauts,



X-15, left, soars upward in quest for space data. Below, Navy centrifuge is prepared for test to study effect of acceleration forces. Wally Schirra is assisted before simulated space flight in centrifuge gondola. His right hand rests on Mercury three-axis control. Alan Shepard, below right, tries acceleration couch at the Aviation Medical Laboratory.



MANNED SPACE



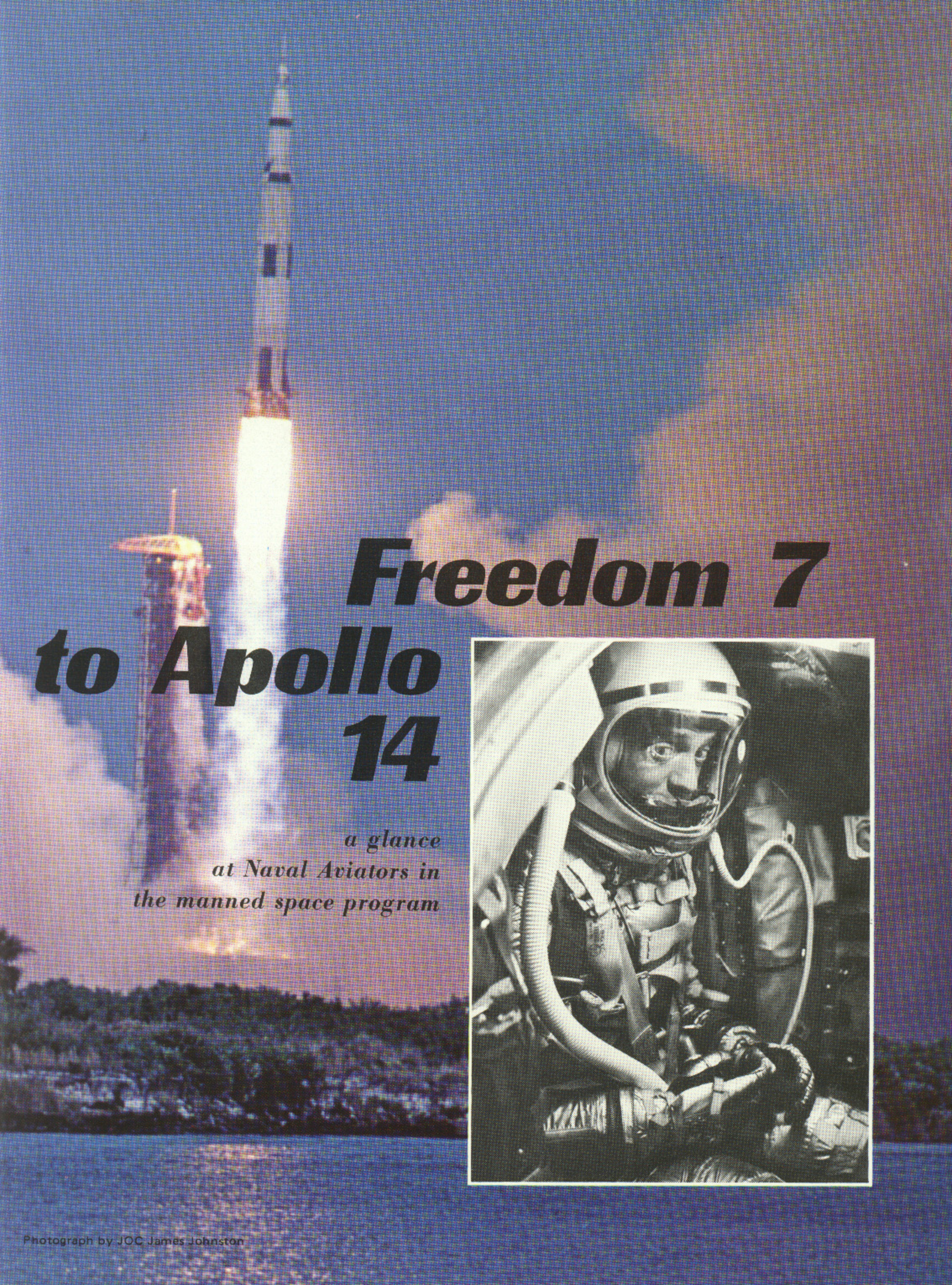
Naval Aerospace Medical Institute bio-pack is fitted on monkey, Able, during early space flight. Richard Gordon, undergoes water survival training at Pensacola, center. Below, UDT members rig Navy-developed flotation gear on Gemini capsule.

between 1959 and 1963, took part in eight acceleration training programs ranging from familiarization and equipment refinement to complete mission runs and continuing refresher training.

While the *Mercury* project was still being readied, other space programs were being serviced by AMAL's centrifuge. They included human engineering studies for use in *Gemini* design, military astronauts' classes from the USAF Aerospace Research Pilots School and feasibility evaluations for NASA's Manned Spacecraft Center. In June 1963, astronaut training for the *Gemini* program began. A wide range of normal and emergency conditions were simulated and a continuing evaluation of the *Gemini* cockpit was conducted. Studies of *Apollo* mission problems started a few months later in September and the following month, initial full-scale *Apollo* simulation runs were commenced to provide early information for preliminary equipment design based on the effects of acceleration on crew performance. Training for astronauts and design evaluation of spacecraft equipment continued throughout the *Gemini* program while preparations were made for the *Apollo* series. In June 1965, AMAL completed its services to the *Apollo* program with a series of tests which evaluated two types of *Apollo* pressure suits and collected data for suit refinement and selection.

NASA also called on the Naval Aerospace Medical Institute (NAMI), Pensacola, Fla., to contribute to the Manned Space Flight program. There a number of NASA-requested studies were conducted over the years, including the effects on man of spatial disorientation, sound and vibration, and prolonged low-grade rotational forces (the latter in connection with problems of providing an artificial gravity in an orbiting space station). Physiological research with small mammals at NAMI produced bio-packs for the primates who preceded man into space. Other research studied the effects of prolonged weightlessness and lack of exercise on an astronaut's cardiovascular system. Additional experiments ranged from the study of cosmic radiations' effect on the ionization of a spacecraft's atmosphere to research into the effects of high and low magnetic fields on man. (The moon's magnetic field is only one-thousandth that of earth.) NAMI studies concerning capsule egress and sea survival led to a decision to develop a flotation device for the re-entry craft. The Naval Air Rework Facility (NARF) at NAS Pensacola got the job of developing and constructing the device. Under the direction of John Staples, a flotation collar was designed and fabricated for use with the *Mercury* capsule. Later, other versions were built in NARF's shops for the *Gemini* and *Apollo* spacecraft. Special recovery equipment for lifting the capsules from the sea was also designed and built by the facility. Not to be left out, one other Pensacola activity joined in advancing the space program. NAS Pensacola's Schools Command assisted by providing water survival training for the astronauts.

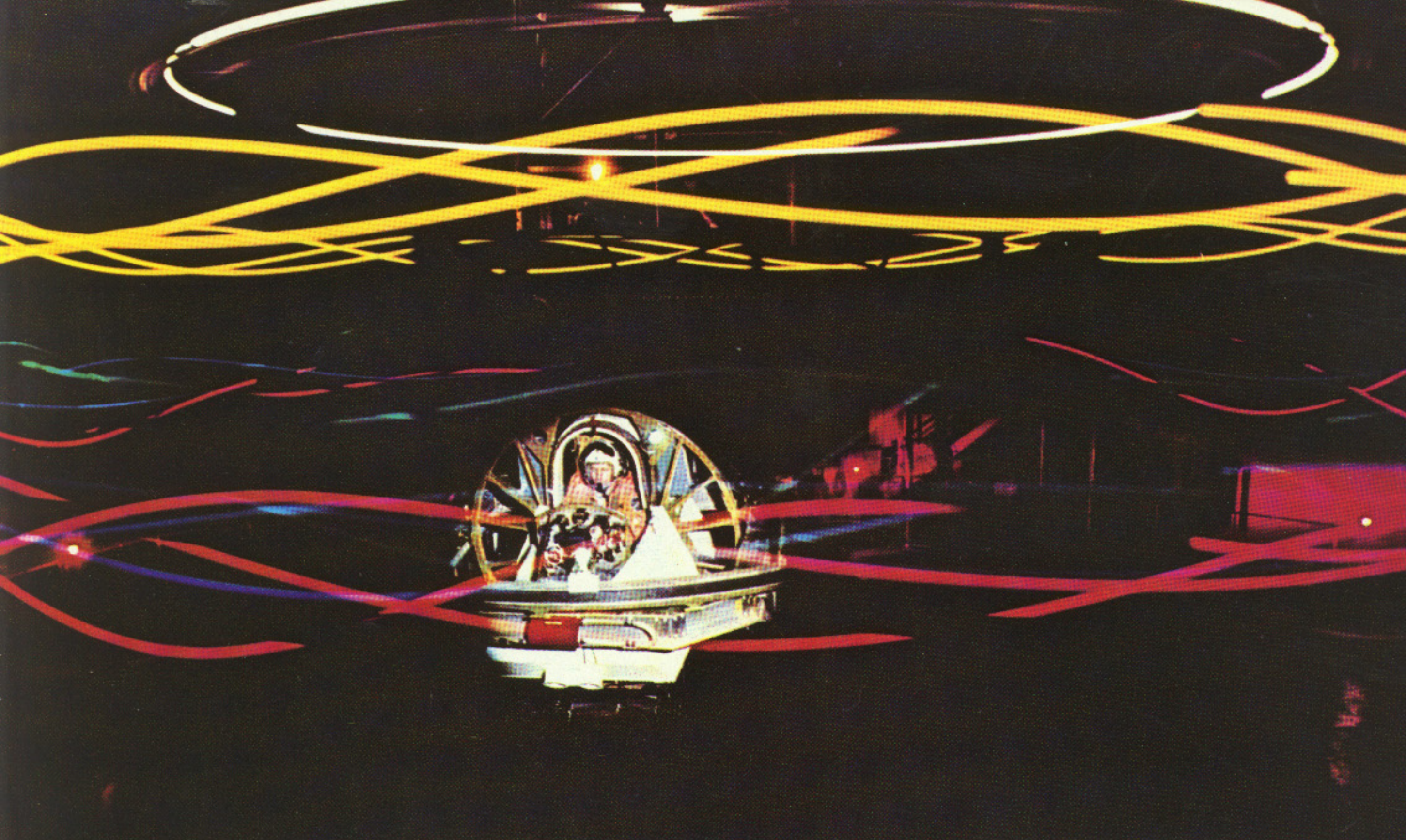
The Navy's Air Crew Equipment Laboratory (ACEL), in addition to its earlier work in developing the *Mark IV* space suit, fitted and trained the astronauts in its use. During the training phase, ACEL's low pressure chamber, also used for the *Mercury* project, was put to use. The capsule was placed inside and the atmosphere was evacuated to near space-like conditions; then various emergencies were simulated, from fire in the capsule to loss of interior air pressure.



Freedom 7 to Apollo 14

a glance at Naval Aviators in the manned space program

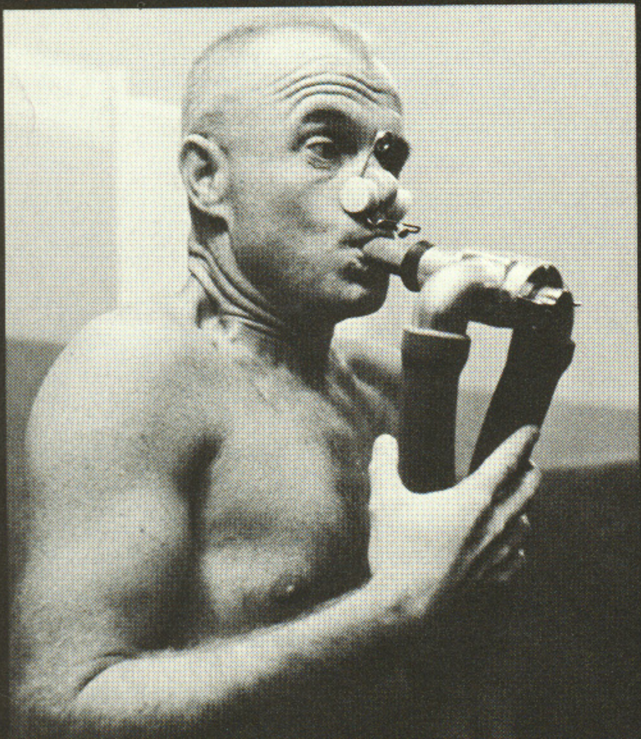
Photograph by JOC James Johnston



Astronauts sharpen their coordination by maneuvering the five-axis simulator at NASA's Ames Research Center, NAS Moffett Field, California, as engineers feed in movements by remote control.

Work, Worries, Winnings and

Full schedules of training and study fill out an astronaut's day. Below, John Glenn as he underwent respiratory test for Mercury. At right, Wally Shirra eyes his hatch being closed on Gemini 6.

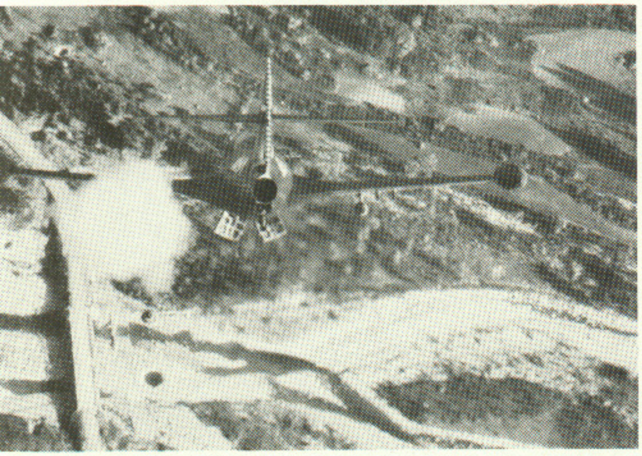


Glenn, the first American to achieve orbital flight, became a popular national hero. Injuries resulting from an accidental fall precluded further flights.

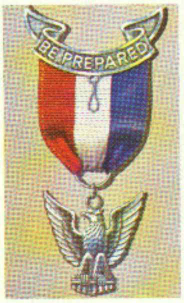
Scott Carpenter had tense moments when his craft overshot recovery area. Glenn, below, returned with a loose heat shield, creating doubts about his safety.

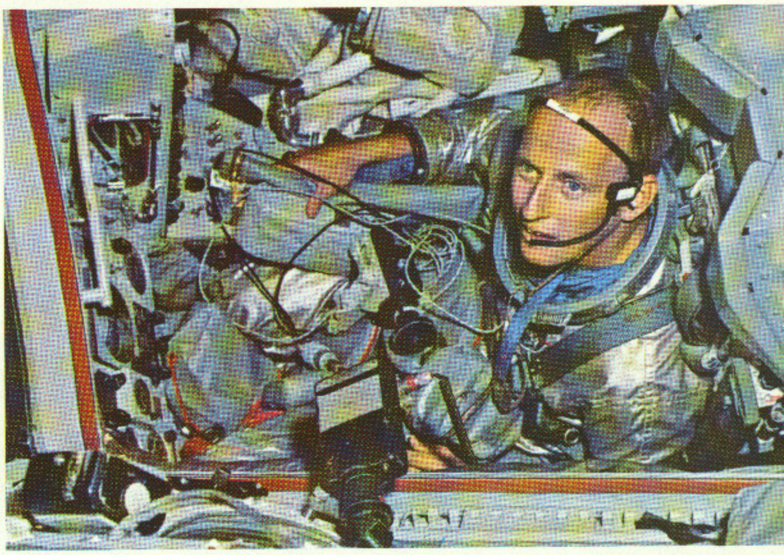
a Near Loss

Jim Lovell practices helicopter lift procedures at the Water Survival School, Pensacola, in the days before the Billy Pugh net. At right, Alan Shepard comes back in style.

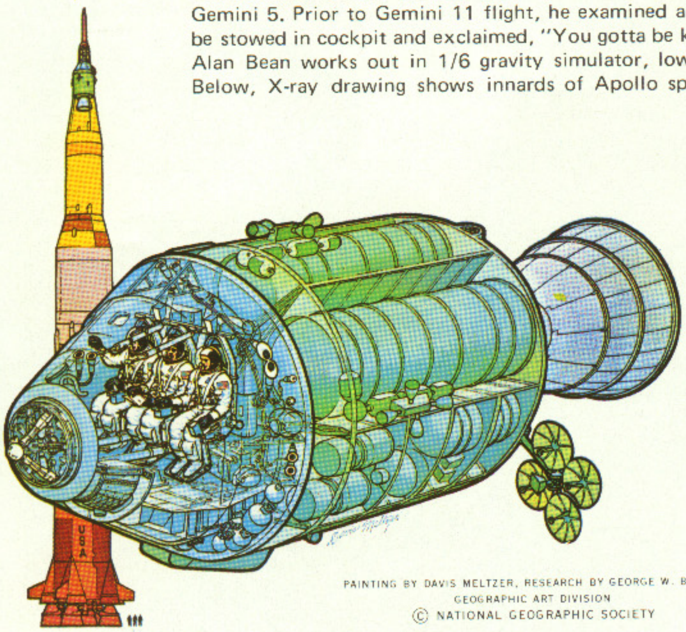


Neil Armstrong, who was shot down in Korea, has long been involved with eagles. Among others, the Air Medal, Apollo 11 emblem, VF-51 insigne and Eagle Scout.

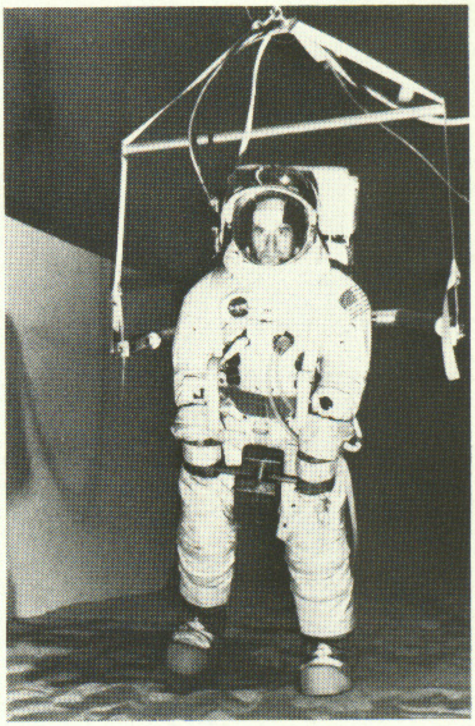




The exuberant Pete Conrad yawns as he is suited up for Gemini 5. Prior to Gemini 11 flight, he examined all gear to be stowed in cockpit and exclaimed, "You gotta be kidding." Alan Bean works out in 1/6 gravity simulator, lower right. Below, X-ray drawing shows innards of Apollo spacecraft.

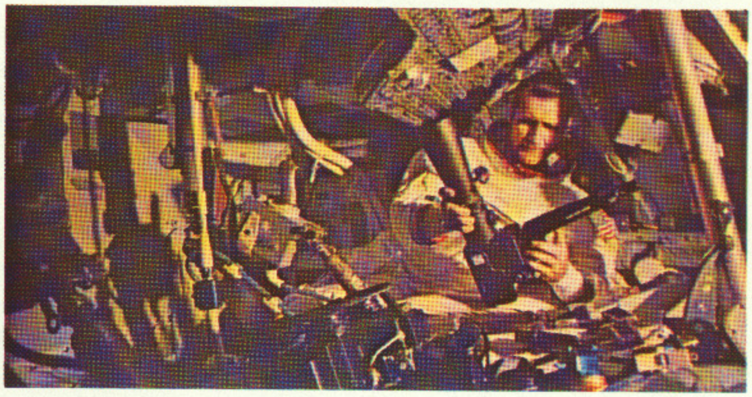


PAINTING BY DAVIS MELTZER, RESEARCH BY GEORGE W. BEATTY
GEOGRAPHIC ART DIVISION

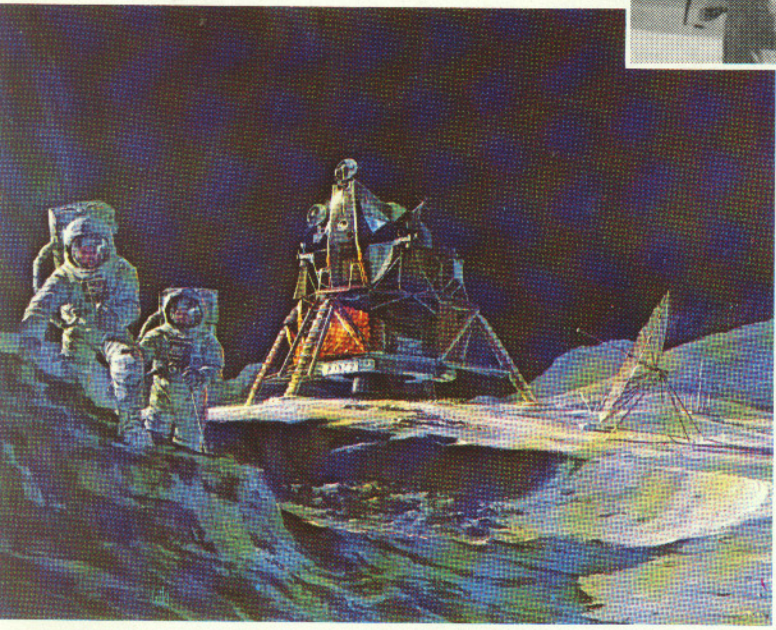


Dick Gordon first flew at Pensacola; became a Red Ripper (VF-11) and F-4 project officer. To win Bendix Trophy in 1962, he drove an F-4 cross country in 2 hours, 47 minutes.

Gordon and Conrad teamed for Gemini 11, achieved altitude record of 850 miles, docked with Agena target, developed techniques valuable for future uses.



Jim Lovell, left, as he appeared at Barin Field in 1953; below, following his 14-day Gemini 7 mission. Below left, his walk on the moon was only an artist's conception as Apollo 13 ran into troubles.



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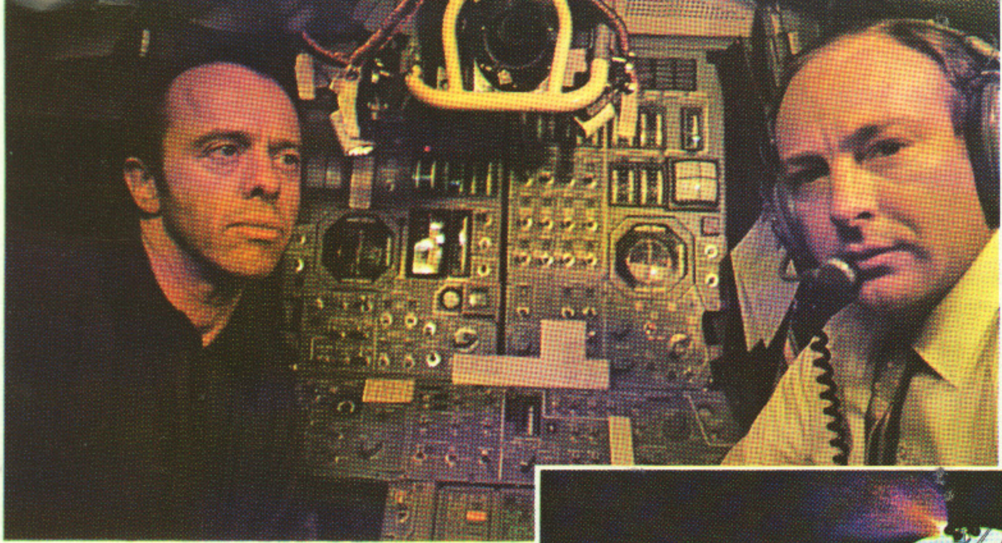

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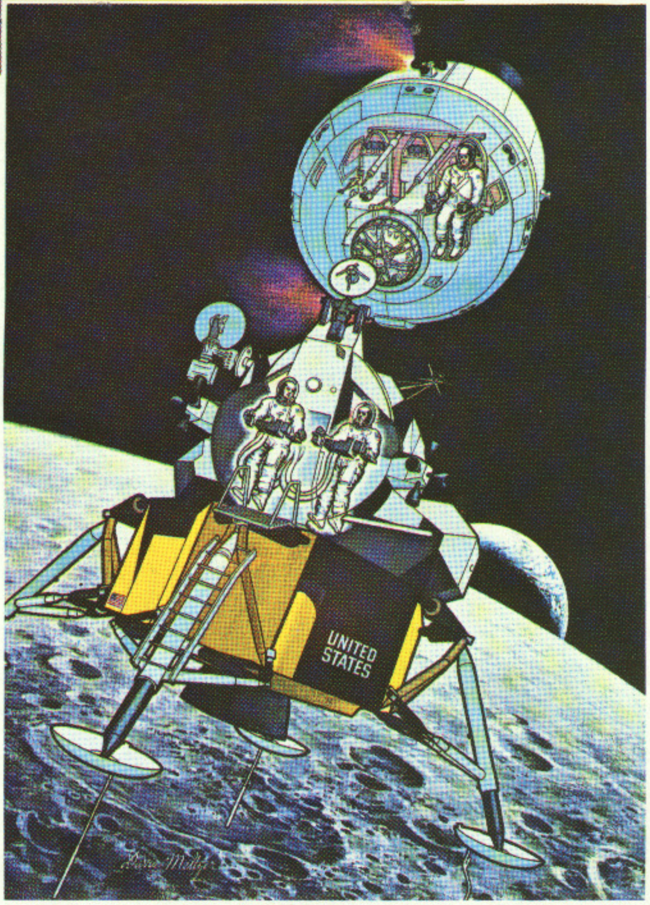
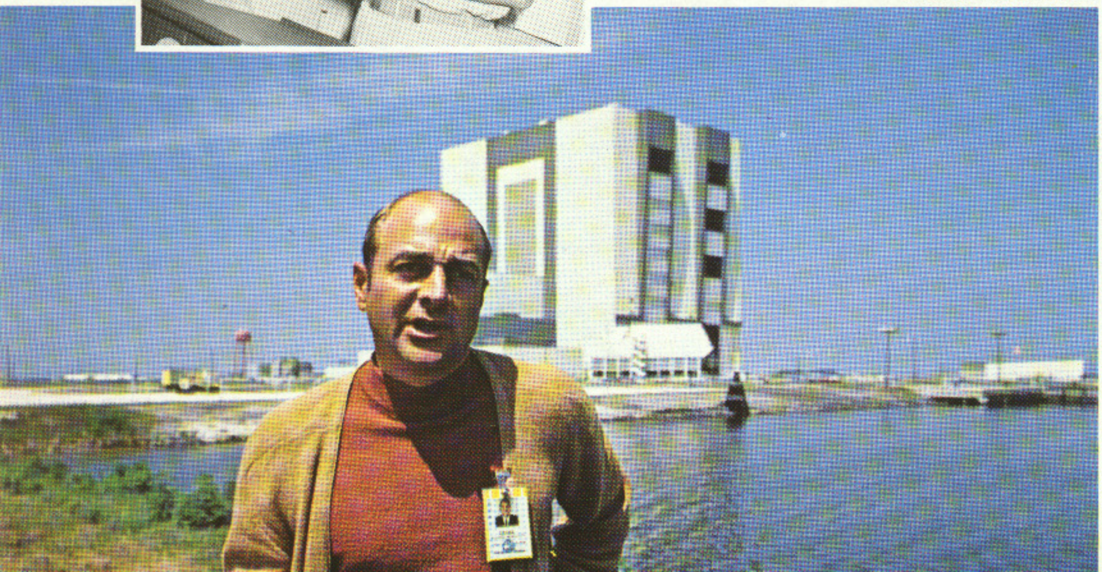


PAINTING BY DAVIS MELTZER, GEOGRAPHIC ART DIVISION © NATIONAL GEOGRAPHIC SOCIETY

Apollo 14 crew members, Shepard and Mitchell, are shown in the lunar module simulator, a far cry from the primitive rig used by Lt. Soucek. The LM sim is built around a closed circuit television system which produces images of the moon's surface in the windows as the crew practices approaches and landings. External cameras pan over moon model in response to the pilots' control. The LM and command module sims enable the astronauts to train for every possible contingency. Shepard and Mitchell will descend to the moon's surface as shown at right, in the artist's rendition, and will spend 34 hours exploring the moon.

JOC James Johnston



Ron Evans, backup command module pilot for Apollo 14, received his letter of acceptance for the space program in 1966 following his final combat mission from the USS Ticonderoga off Vietnam. More recently, he expressed the view that his present work is just an extension of flying: "You have to plan for everything that may go wrong."

SUPPORT FORCES

Drawing by Paul Calle
Courtesy NASA

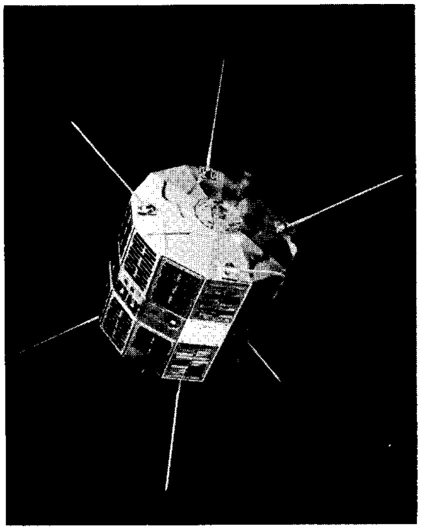
Navy support for the American manned space program does not end with research into the upper atmosphere or development of space-related equipment. Day to day support of the NASA program has been and still is an important service provided by Navy units. Beginning before the launch of a manned spacecraft, a 195-pound Navy satellite in earth orbit detects and measures the intense proton streams sent into space by solar flares. The 30-inch diameter *Solrad* satellite developed by the Naval Research Laboratory, was first used at NASA's request to provide information in support of *Apollo 8*. Since then *Solrad* satellites have telemetered similar data to the Navy's Blossom Point, Md., station to support subsequent *Apollo* flights.

Satisfied that solar radiation presents no obstacle to manned spaceflight, NASA next called on Navy support to tell its launch controllers the precise microsecond at which to launch the spacecraft. Using the ultimate in accuracy — the Naval Observatory's cesium beam atomic clock — NASA controllers are assured of conducting launch, in-flight control and recovery, with the utmost exactness.

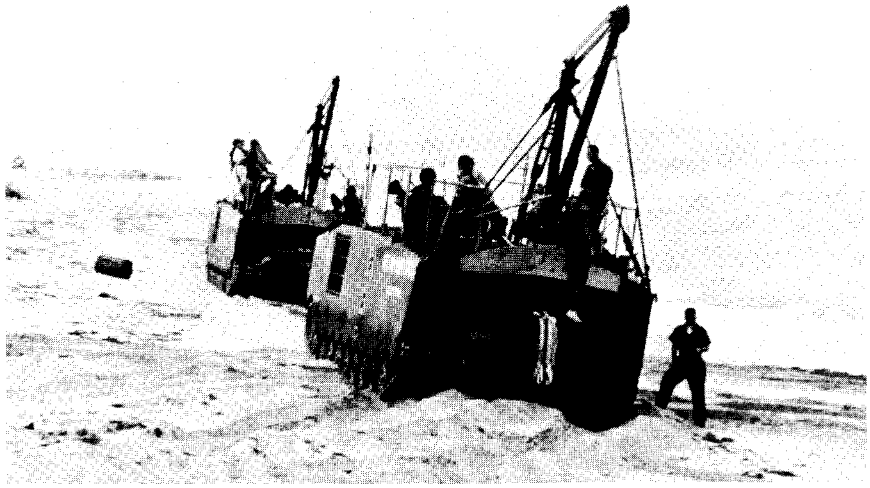
As the astronauts lie strapped to their couches in the nose of the launch vehicle awaiting blast-off, they may be comforted by the knowledge that should anything go wrong during lift-off and they are forced to use the emergency escape system to blast clear of an errant booster, the U. S. Marine Corps is standing by on the beach. The Marines manning two amtrac retrievers 6,000 yards from the launch pad are among those nearest to the spacecraft. If *Apollo's* escape system deposits the capsule in the surf or on the beach, the amtracs will rush to rescue the astronauts. Though, fortunately, the Marines have not been called on, they have been on duty for every major space flight since 1965 when NASA first requested that they provide support for the *Gemini* program.

Should an emergency occur further

SUPPORT FORCES



Navy's earth orbiting SOLRAD satellite relays solar activity data for NASA use.

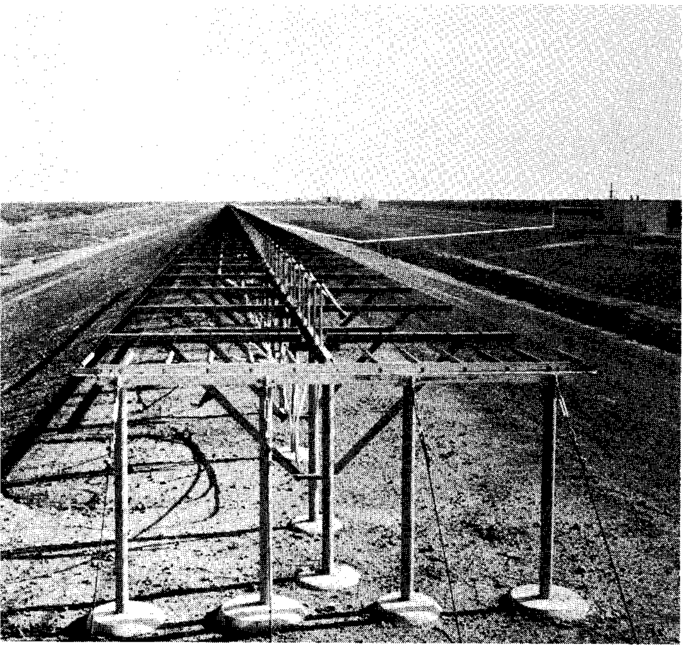


USMC amphibious retriever vehicles stand by on Cape Kennedy beach prior to Apollo launch. Below, RAdm. Davis, TF-130, plans force movements in support of Apollo 13.

into the initial climb toward space, other Navy ships are spotted along the spacecraft's track. In earlier flights this included tugboats and minesweepers equipped with Underwater Demolition Team (UDT) swimmers a few miles offshore. A variety of other naval vessels stretch around the globe along the planned flight path.

To control these naval units, the Navy's Manned Spacecraft Recovery Force, maintains 24-hour surveillance of ships' positions and their readiness condition as well as weather conditions in the primary and contingency recovery areas.

The Commander, Manned Spacecraft Recovery Force is responsible for the training of his force in addition to its control and coordination. Some 200 individual ships and large numbers of naval aircraft have participated in recovery operations since the Navy's first involvement in 1958. The recovery forces are divided into two task forces: TF 140, the Atlantic Recovery Force under control of the Atlantic Recovery Control Center (RCCA) at Norfolk, Va., and TF 130 under control of the Pacific Recovery Control Center (RCCP) at Kunai, Hawaii. Either can handle recovery during any



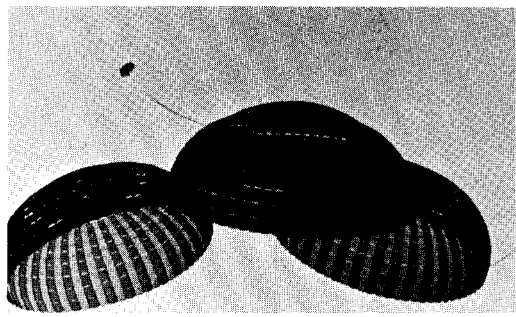
Two-mile-long NavSpaSur transmitter radiates a million watts. Reflected energy detected by receiver sites pinpoints spacecraft.

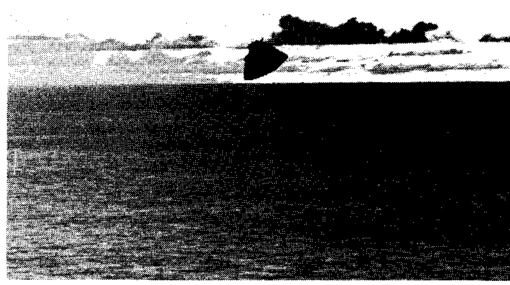
Sea Kings of HS-4 prepare to launch in support of Apollo recovery operation and are on station well in advance of capsule re-entry.

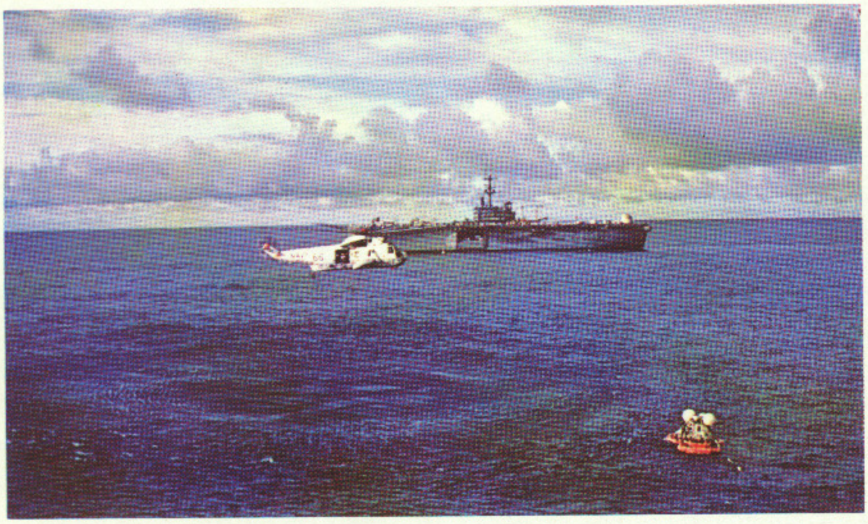
phase of the mission, and each continually moves its forces to maintain the best recovery positions as the spacecraft's ground track shifts during earth orbit. The recovery ships receive up-to-date information from RCCA, RCCP and NASA's Mission Control Center.

Task Force commanders, utilizing the recovery control centers' complex communications system, are able to maintain voice contact with all ships and aircraft in the recovery force. The Navy communications satellite system, now part of the Defense Satellite Communications Systems (DSCS), contributes to this network of control. In addition, DSCS maintains constant communication with the spacecraft. And, as mentioned previously, the Navy assists NASA, in another way, in maintaining accurate information about a spacecraft. The Naval Space Surveillance System (NavSpaSur) developed for DOD's Advanced Research Project Agency is capable of tracking and identifying space vehicles orbiting the earth. Part of NORAD since 1961 NavSpaSur, through use of its three transmitting and six receiving stations in the southern United States, is able to determine azimuth and zenith angles used to fix the position of passing spacecraft.

Below, at sea, spread across thousands of miles of ocean, the ships and aircraft of the Manned Spacecraft Recovery Force wait. Destroyers, aircraft carriers and assorted auxiliaries, together with helicopters, carrier-based fixed-wing and land-based patrol aircraft, all there to perform specific missions, remain at the ready for the moment when they will play their part in man's venture into space. As re-entry time draws near, the ships take up their final positions, aircraft are launched and all eyes turn skyward in an attempt to detect the telltale streak of flame marking re-entry. When it comes, and radar and visual contact are made, the recovery ship (normally an aircraft carrier) and its helicopters move toward the exact splashdown point. Should splashdown occur outside the planned area, longer-ranging S-2 *Trackers*, E-1 *Tracers* and P-3 *Orions* are on station waiting to spot the floating capsule, mark its position and radio its coordinates. This seldom occurs, and it is most likely that the first on the scene will be one of the recovery carrier's airborne helicopters.





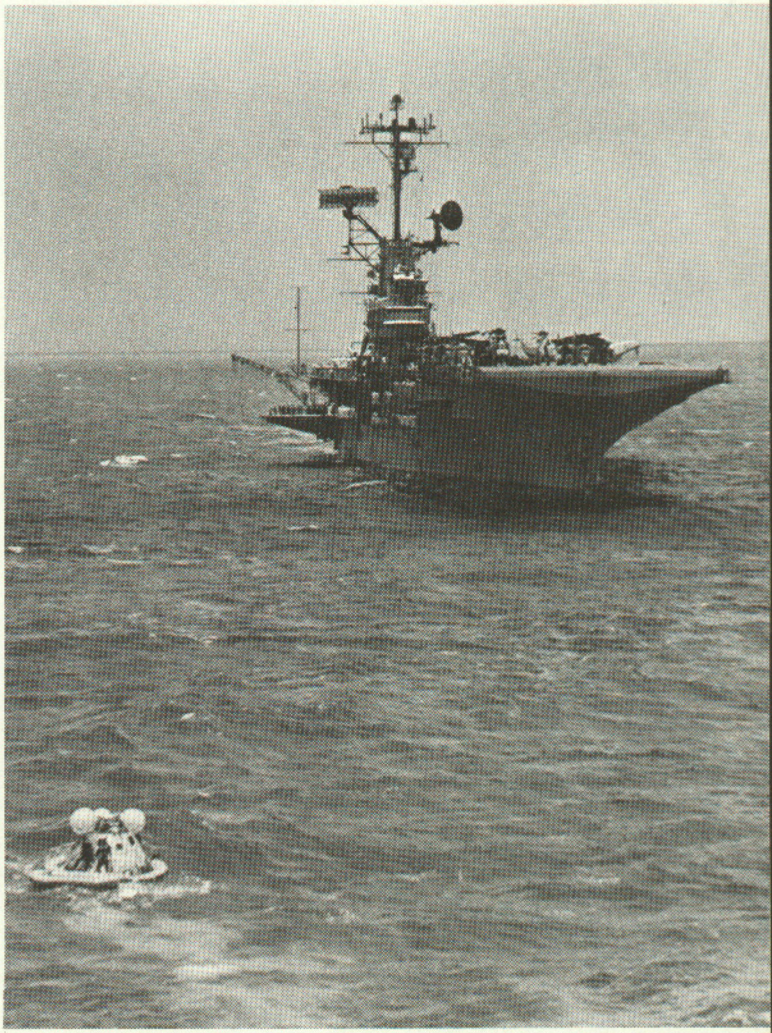


Sea King and Iwo Jima stand by Apollo 13 capsule after its eventful flight, top. UDT swimmer, center, prepares to jump in support of Apollo 10 training. Princeton appears in background. All-Navy crew of Apollo 12, Conrad, Gordon and Bean, bottom photo, wait pickup.

SUPPORT FORCES

The historic *Apollo 11* flight serves as an example of a typical recovery operation – beginning with flight deck control aboard *Hornet* (CVS-12) announcing, "Flight crews, man your aircraft." Aircrews of Helecopter Antisubmarine Squadron Four climbed into their SH-3D *Sea Kings* and headed for their assigned positions, one a mile up range and one a mile down range of *Hornet*, with the primary recovery and "Photo One" helicopters circling at 1,000 feet a short distance out. *Apollo 11's* re-entry was first spotted by the crew of an E-1A of Carrier Airborne Early Warning Squadron 111, Det. 12, as a "white burning trail." As the capsule's parachutes deployed and it descended to the ocean, HS-4 's #53 moved into position near splashdown. When the capsule was in the water, #53 immediately marked the position with a dye marker as Photo One came to a hover at 40 feet, 100 feet to one side. Swimmer helo #64 approached next and dropped three swimmers of UDT-11 into the water. The swimmers attached and inflated the Navy-designed flotation collar, then deployed sea anchors and life rafts, and made voice contact with the astronauts inside. Helicopter #66 then made a pass and dropped Lt. Hutleburg, officer in charge of the UDT team, and on its next pass, lowered the biological isolation garments to him in a Billy Pugh net. Lt. Hutleburg opened the capsule and passed three of the garments to the astronauts, waited for them to enter the raft for helo-lift to *Hornet*, and then entered the spacecraft to execute decontamination procedures. A fourth B. I. garment was lowered for his use.

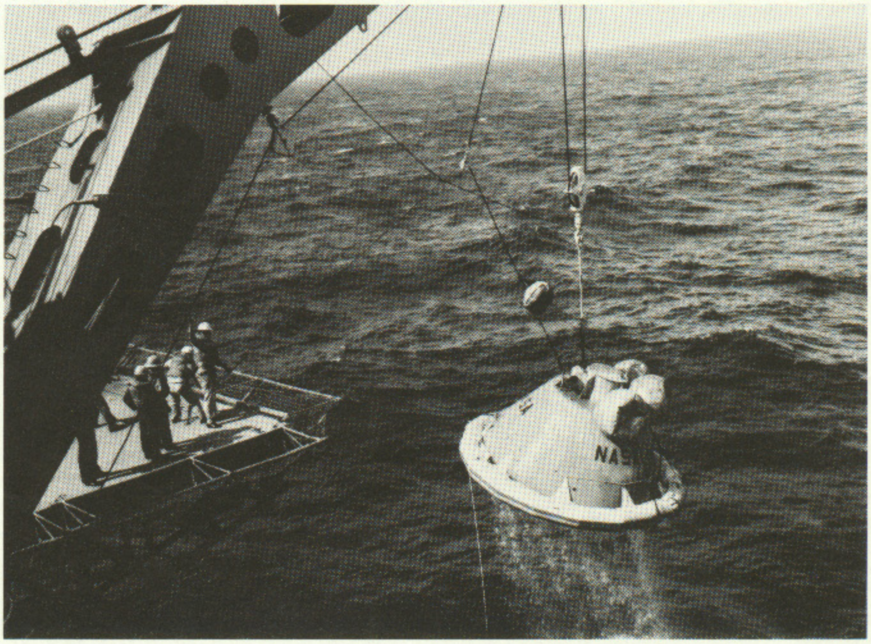
Meanwhile, the astronauts arrived on elevator #2 and were lowered to the hangar deck where their Mobile Quarantine Facility awaited them. While television cameras and the eyes of the world followed the astronauts, the Navy's job continued. The UDT swimmers remained with the capsule,



Captain James Lovell, above, is greeted aboard Wasp after his Gemini 12 flight. While all eyes are on the astronauts, Hornet, at right, prepares to complete its task by recovering Yankee Clipper.

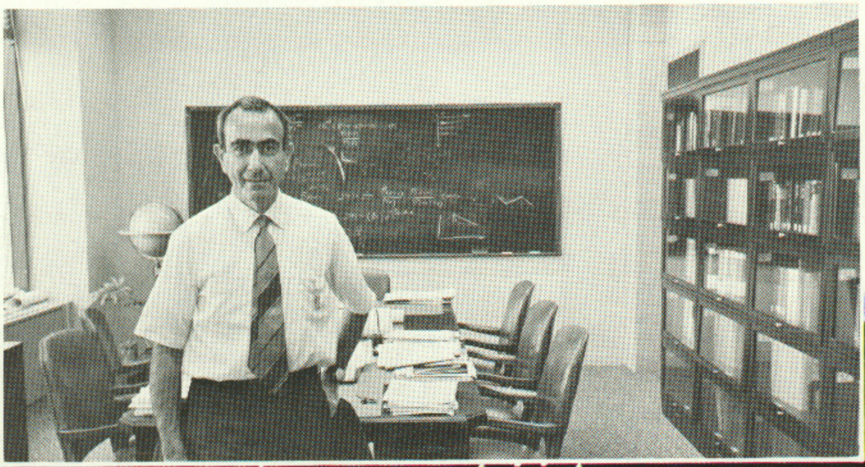
preparing it for recovery. As *Hornet* drew alongside, retrieval lines were fixed to the men in the water who attached them to the spacecraft and then removed the sea anchors and boarded their rafts to wait for completion of the recovery operation. With the space capsule safely aboard, the recovery ship set course to deliver its cargo to a port designated by NASA.

Between space shots, the recovery forces are not idle. They continue to maintain readiness through continued training and receive assignments to other duties. Following the *Apollo 11* recovery, HS-4 embarked on *Bennington* (CVS-20) as part of Carrier Antisubmarine Air Group 59 for a WestPac deployment. Other ships and aircraft returned to ASW training, patrol duties and the regular chores required of fleet units.



The Jewels of Isabella

JOC James Johnston



In 1953, Commander Bob Truax put it this way: "The new horizons opened to science by space travel in all its aspects would amply justify the cost. Astronomers would certainly love to have an observatory beyond the atmosphere, and the physicists would be ecstatic over a high vacuum laboratory of infinite size. For all their enthusiasm, however, scientists are in general

a poverty-stricken lot — and I am talking about a project that would cost a great deal of money . . . .

"If we allow events to take their natural course, we will probably have space travel eventually . . . but you and I would very likely not be alive to see it. I, for one, am not content to let the matter rest thus. To me, one of the greatest thrills of living is the emotional lift, the sense of wonder and awe that comes from witnessing, first-hand, great human achievements. If the majority of Americans feel the same way, the arguments of immediate utility are unnecessary . . . .

"If the people of this country just *want* to, they can provide the 'jewels of Isabella,' opening a new Age of Exploration that will make the discoveries of Columbus seem tame by comparison.... Landings on the moon and journeys to the nearer planets may well come within our lifetime — but these things will happen only if we act *now.*

"The cost of even a satellite station has been estimated at upwards of a billion dollars — a staggering sum. But, look, take the billion dollars and spread it over a period of ten years of the station's usefulness. Divide this by approximately fifty million taxpayers and we have just two dollars per taxpayer per year. Two bucks — a pint of cheap whiskey. Wouldn't you give that up each year for a ringside seat at one of the greatest adventures on which mankind has ever embarked? To me there can only be one answer. A pig, rooting in the mud, would pass by a diamond for a half rotten potato, but if the people of this country would do the equivalent, then the pioneering spirit of our forefathers is indeed dead, and decadence has truly begun."

Bob Truax's 1953 cost estimate really wasn't too far off. For example, the fiscal '71 budget for NASA is $3.6 billion. In terms of the federal budget, it represents 1.7 percent of the total — roughly $17 per person in one year. Since the Manned Space Program uses about one-third of NASA's funding, it costs the average American less than $6 to have man walk on, and *investigate,* the moon!

Compare this with $400 per person we spend on social actions — federal expenditures for education, health, housing, social security and veterans benefits — or with the $35 per person on alcoholic beverages, $17 on tobacco or $16 on cosmetics.*

When we consider that each of us is spending nearly 25 times as much each year on the human resources programs than on space, it becomes clear that even if we had no space program — even if every dollar spent on space were spent on health or housing or education — the impact on those programs would hardly be noticeable.

*Statistics provided by George M. Low of NASA in May, 1970.

But, even more important, where would we be today had we not undertaken to meet the challenge of space? What have been the benefits — the "spinoffs?"

As a result of space technology, man is beginning to learn how to solve problems that have beset him throughout history — hunger, sickness, social ills, crime and pestilence. If you ask the people at NASA, they will identify more than 3,000 spinoffs from space that are of benefit to mankind. Most of these have been applied in the highly technical fields of medicine, electronics, astronomy, geophysics, meteorology and oceanography.

On the Navy side of the coin, let us examine a sampling of space-related contributions which have resulted in the betterment of mankind.

Foremost among these is the Navy navigation satellite system, often referred to as *Transit,* which actually came about because of the curiosity of two young scientists at Johns Hopkins University's Applied Physics Laboratory (APL). In 1957, Drs. W. H. Guier and G. C. Weiffenbach found that when tracking the first Russian *Sputnik,* they were able to fix its position by measuring the Doppler shift of its signal. An idea occurred that if the reverse would be true, signals from the satellite could be used for precise positional fixes on the earth. As a result, the Navy navigational satellite system became operational in 1964. (The USS *Long Beach* employed the system on a round the world cruise that year.)

In 1967, Vice President Humphrey announced that the government was releasing the system, designed originally for Navy ships, for commercial shipping. Since that announcement, the history of the system has been well marked. The Navigation Satellite Set *(Navset)* was used by the *SS Manhattan* on her legendary voyage through the Northwest Passage. The *Queen Elizabeth II* has used it since her maiden voyage. It is employed by the *Glomar Challenger* and several other oceanographic research ships, and cable-laying and rescue vessels.

Navset, which provides data for computing a navigation position, costs only $12,000 per unit. Its accuracy pro-

DR. FRIEDMAN AND THE CRAB NEBULAE

vides a tolerance of one-tenth of a nautical mile, a fact which accounts for the remarkable positioning of naval ships involved in recovery of manned space flights. According to Captain C. J. Seiberlich, commanding officer of the USS *Hornet,* "Had Navset not been aboard, the navigation problem in the South Pacific recovery of *Apollo 12* would have been considerable.

The Johns Hopkins APL, which works largely under Navy contract, also developed *thin wafer-type* solar cells for use in satellites. Their heat pipe, which transfers heat immediately from the nuclear power unit of a satellite to any other of its parts while maintaining uniform temperature is now being used commercially in cooking utensils.

Johns Hopkins' scientists more recently created a new rechargeable cardiac pacemaker to treat patients requiring artifically generated electrical heart-triggering pulses. The problem of reliably powering remote electrical devices of minimum weight and size was intensively studied for spacecraft applications. Current versions of these tiny (one inch, two ounce) nickel-cadmium cells require recharging every 18 months. The Hopkins team hopes to extend this to 20 years or longer.

Manned space flight obviously requires precision in timing. Not only did the Naval Observatory develop the atomic clock,but observatory personnel have provided the star charts astronauts use in navigation and visual orientation.

The list of Navy contributions and their applications is too lengthy for complete coverage in this general treatment. But it is worth our time to take one last look at certain activities of the Naval Research Laboratory. Obviously, such NRL work as that done on environmental systems for *Polaris* submarine crews had its carry-over into similar systems for spacecraft. More fascinating, however, is their actual space research program.

NRL pioneered solar rocket astronomy with the V-2's in 1946, and today the program is still one of the foremost in the country. The list of NRL space research firsts is voluminous: ultraviolet spectra beyond the atmospheric, cutoff, detection of X-rays from the sun and associated high altitude photography, the solar radiation satellites *(Solrads),* and so forth.

In an effort to reduce the huge mass of technical achievements and goals down to layman's terms, a visit was made to NRL's space research director, Dr. Herbert Friedman.

Dr. Friedman joined NRL in 1940 and since then has conducted or directed programs devoted to measurements of ultraviolet, X-ray and high-energy radiations. Thinking back on the earlier days he recalls, "The V-2 gave us a vehicle for sun research. One result of the subsequent work is that we can now predict solar flares — and therefore communications blackouts — which have a direct bearing on our manned space shots.

"Beginning with the simplest forms of ultraviolet and X-ray photometers, we have progressed to moderately large telescopes, image converters and high resolution spectrographs in the present generation of rockets. After having spent so much of the early years in the study of the sun, it was only natural to look further out — to see what could be done with more distant places.

"One result of this deep space research is the supporting evidence of the 'big bang' theory that the universe was created billions of years ago by the explosion of a fireball."

Dr. Friedman and the Navy astronomers contend that at one time all the matter for a potential universe was contained in a primordial fireball, a tremendous single atom of 10 billion degrees temperature. This condition existed only a second, then exploded into stars, galaxies and planets. The radiation from the blast still pervades deep space and this echo of creation is yet detectable by radio astronomy. The evidence was obtained by an X-ray telescope carried on an *Aerobee* rocket 102 miles above the White Sands range.

"There have been," states Dr. Friedman, "some totally unexpected surprises in this work. For instance, we had some slight clues that since the sun is an X-ray source we might find stars with a somewhat higher output. But what we have found are stars within the galaxy with a *billion* times the sun's X-ray output!

"When we look at external galaxies now we detect X-ray and radio-wave emissions so powerful that it becomes difficult to explain the radiation mechanism on the basis of conventional nuclear physics. It becomes a borderline question of whether there is enough energy in nuclear fusion available to produce the emissions we are now looking at. We find that some of these are 100 times more powerful than the X-ray *spectrum* and so one has to look for other, possibly *unimaginable,* mechanisms.

"But so much data is pouring in that we believe the answers will come. This fundamental research, this looking for answers without really knowing what the questions are, is necessary. Who would have thought 30 years ago that from nuclear physics would come atomic power, and from atomic physics the laser, or that from solid-state physics, transistors and molecular circuitry.

"The first phase of exploratory science is behind us. Now we have a level of technological sophistication that permits us to move ahead in space research with far greater economy."

Navy goals in space are a mixture of the search for scientific knowledge, applications for national defense and peaceful benefits to mankind, and the sheer human adventure of man — that same old *restless* man — trying to escape the cradle of his surroundings.

As Dr. Friedman and others have declared, "Ultimately the yield of new knowledge will far overshadow all the more obvious benefits of space technology."

Dawn on the Atlantic off the Kennedy Space Center. Photograph by JOC James Johnston

☆ U.S. GOVERNMENT PRINTING OFFICE : 1970 O—397-454

The author gratefully acknowledges the professional assistance of Mr. Clarke Van Vleet, Historian, DCNO (Air); LCdr. Paul Mullane, Editor, Naval Aviation News; and Chief Journalist James A. Johnston.

Naval Aviation
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