# Man in Space

National Historic Landmark Theme Study

By

Dr. Harry A. Butowsky

National Park Service

Department of the Interior

May 1984

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# Man in Space

## A National Historic Landmark Theme Study
## Introductory Essay

The Man in Space National Historic Landmark Theme Study has been prepared for the Congress and the Secretary of the Interior's Advisory Board in partial fulfillment of the requirements of P.L. 96-344. The purpose of the Theme Study is to evaluate all resources which relate to the theme of Man in Space and to recommend certain of those resources for designation as National Historic Landmarks.

The Man in Space Theme Study considered resources relating to the following general subthemes:

A. Technical Foundations before 1958
B. The Effort to Land a Man on the Moon
C. The Exploration of the Planets and Solar System
D. The Role of Scientific and Communications Satellites

The Theme Study considered the Space Program in an integrated fashion. In any given space mission thousands of scientists, technicians, and other support personnel were necessary to insure success. These support personnel performed vital work in a variety of ways using support facilities in many parts of the country. None of these personnel in all likelihood comprehended all aspects of each space mission, yet all were vital to the success of the program. Since individual missions lasted over many years and involved a wide variety of resources and people only a few managers at the National Aeronautics and Space Administration (NASA) were able to see all of the facets of the space program. It was this coordination, cooperation, and collaboration that enabled NASA to successfully manage the American Space Program. The theme study follows this same approach and attempts to identify, inasmuch as is possible, the surviving resources of those that were necessary to accomplish the goals of landing a man on the moon and exploring the earth, planets and solar system.

### General Background

NASA's origins can be traced to World War I and the realization that although America had invented the airplane we had fallen behind in the technology of aeronautical research. In 1915 President Woodrow Wilson signed into law a Bill establishing the National Advisory Committee for Aeronautics (NACA) to remedy this situation. NACA began work in 1920 with the establishment of its first field office—the Langley Memorial Aeronautical Laboratory in Hampton, Virginia.

As the years passed and significant wind tunnel research was accomplished at Langley, NACA perceived the need for additional research facilities. In 1939 NACA established its second field center--the Moffett Field Laboratory, in California, later called the Ames Research Center. Like Langley, Ames was primarily devoted to wind tunnel testing needed to support the growing American aircraft industry.

In 1940 NACA established its third field center, in Cleveland, Ohio—the Lewis Research Center. The purpose of Lewis was also to support aeronautical research with special emphasis on the development of newer, more efficient engines.

By the late 1940s NACA also had established two flight test centers--the Auxiliary Flight Research Center at Wallops Island, Virginia and the NACA Muroc Flight Test Unit at Edwards, California, later renamed the Dryden Flight Research Center.

Also established during these early years were the U.S. Naval Research Laboratory in Washington, D.C., and the Guggenheim Aeronautical Laboratory at the California Institute of Technology, later called the Jet Propulsion Laboratory. Both of these centers were soon concerned with research involving rocket technology.

After the Second World War the interest of the Army in rockets as battlefield weapons led to the importation of many German scientists who had worked on the German V-2 program. This group, led by Dr. Werner von Braun, was first stationed at Fort Bliss, Texas, and later reassigned to the U.S. Army Redstone Arsenal, in Huntsville, Alabama. The army group at the Redstone Arsenal eventually evolved into the George C. Marshall Space Flight Center.

After the launch of Sputnik 1 and the much publicized failure of the American Vanguard Rocket, Congress passed the National Aeronautics and Space Act of 1958 that brought into being the National Aeronautics and Space Administration (NASA) and the modern American Space Program.

When NASA began business on October 1, 1958, the process of consolidating the many pieces of the American Space Program was initiated. By 1963, when the process was completed, NASA consisted of the following field centers:

Ames Research Center, Moffett Field, California: Ames continued its work in furthering aeronautical research using its fine wind tunnel complex. Its role in the Space Program was limited to the management of the Pioneer series of Spacecraft; space environmental physics; simulation techniques; gas dynamics at high speeds; configuration, stability, structures, and guidance and control of aeronautical and space vehicles; and biomedical and biophysical research.

Hugh L. Dryden Flight Research Center, Edwards, California: Dryden supported flight testing of general aviation and high performance aircraft and spacecraft; flight operations and flight systems; and structural characteristics of aeronautical and space vehicles.

Goddard Space Flight Center, Greenbelt, Maryland: Goddard developed from the Naval Research Laboratory after its transfer to NASA in 1958. The role of Goddard is in the scientific research of space with unmanned satellites; research and development of meteorological and communications satellites; and tracking and data acquisition operations. The Goddard Space Flight Center also manages the Goddard Institute for Space Studies in New York City which conducts research in astrophysics, planetary physics, and atmospheric physics.

George C. Marshall Space Flight Center, Huntsville, Alabama: Marshall developed from the U.S. Army Redstone Arsenal rocket program under Dr. Werner von Braun. After the transfer of Dr. von Braun and his group to NASA, Marshall continued to work in the research and development of launch vehicles and systems to launch manned and unmanned spacecraft; development and integration of payloads and experiments for assigned space flight activities; and application of space technology and supporting scientific and engineering research. Marshall is most famous for the development of the Saturn family of rockets. Marshall also managed the Michoud Assembly Facility in New Orleans, Louisiana where the giant Saturn V rocket first stage was built and the Slidell Computer Facility in St. Tammany Parish, Louisiana, which handled computer data processing for both Michoud and the National Space Technology Laboratories.

Jet Propulsion Laboratory, Pasadena, California: The Jet Propulsion Laboratory was transferred to NASA from the U.S. Army in 1958 and developed into NASA's primary center for the exploration of the moon, planets, and solar system. JPL also manages the Goldstone Tracking Station which is responsible for the tracking and data acquisition systems necessary to communicate with spacecraft exploring deep space. JPL is operated for NASA under contract with the California Institute of Technology.

John F. Kennedy Space Center, Florida: The Kennedy Space Center in cooperation with Cape Canaveral Air Force Station supports major NASA launches. All moon flights originated from Launch Complex 39 at this site. The Kennedy Space Center also manages the NASA Western Test Range Operations Office at Vandenberg, California, which was responsible for the integration, test, checkout, and launch of unmanned light and medium vehicles and the White Sands Test Facility in Las Cruces, New Mexico, which supported developmental and operational tests of spacecraft propulsion and power generating systems.

Langley Research Center, Hampton, Virginia: Langley was the first NACA field installation and thus the oldest NASA center. Through the use of its fine complex of wind tunnels and other facilities Langley supports research in aeronautical and space structures and materials; advanced concepts and techniques for future aircraft; aerodynamics of re-entry vehicles; and space environmental physics, and improved supersonic flight capabilities. Langley has also provided major support for most aspects of the Space Program including Projects Mercury, Gemini, Apollo, the Space Shuttle, and the Viking Project.

Lewis Research Center, Cleveland, Ohio: Lewis is another of the original NACA field offices that was transferred to NASA in 1958. Lewis was responsible for power plants and propulsion; high energy propellents; electric propulsion; aircraft engine noise reduction; engine pollution reduction; and data bank research information in aerospace safety. The most significant achievement of Lewis was in pioneering research that led to the development of hydrogen as a rocket engine fuel and in the development and testing of new materials for spacecraft and aircraft. Lewis also manages the Plum Brook Operations Division at Sandusky, Ohio, where many of its larger testing facilities are located.

Lyndon B. Johnson Space Center, Houston, Texas: The Johnson Space Center was created after the formation of NASA to manage the American Manned Space Program. Johnson pioneered in research and development of manned spacecraft systems;

development of astronaut and crew life support systems; development and integration of experiments for space flight activities; and application of space technology, and supporting scientific, engineering, and medical research. Johnson was recently designated as the lead NASA center in the development of the manned space station.

Wallops Flight Center, Wallops Island, Virginia: Wallops was another of the original NACA field installations that transferred to NASA in 1958. Wallops was responsible for launch facilities and services to other NASA installations which conduct suborbital, orbital, and space probe experiments with vehicles ranging from small rockets to the Scout four-stage solid fuel rocket.

National Space Technology Laboratories, Bay St. Louis, Mississippi: The National Space Technology Laboratories (Mississippi Test Facility) was responsible for static test firing of large space and launch vehicles such as the Saturn V rocket.

Former NASA Installations

In addition to the above existing NASA installations there were two facilities that no longer exist:

Electronics Research Center, Cambridge, Massachusetts: The Electronics Research Center was responsible for conducting research and developing advanced technology in the area of space and aeronautical electronic components. It was closed in 1970.

Nuclear Rocket Development Station, Jackass Flats, Nevada: The Nuclear Rocket Development Station was responsible for conducting full-scale ground tests of nuclear reactors, engines, and flight stages for the nuclear rocket program. It was closed in 1974.

United States Air Force Facilities:

Cape Canaveral Air Force Station, Brevard County, Florida: Cape Canaveral Air Force Station contains some of the earliest facilities associated with rocket experimentation and space exploration as well as active space-age installations for current military and NASA programs. Cape Canaveral is best known for its association with Projects Mercury, Gemini, and Apollo as well as the launch site for most satellites and deep space probes during the early years of the American space program.

Edwards Air Force Base, Edwards, California: Edwards Air Force Base is the site of the Air Force Flight Test Center which conducts new and follow-on testing of aircraft and related avionics and weapons systems. Edwards is also the home of the Air Force Rocket Propulsion Laboratory and the Air Force Test Pilot School. Edwards is presently the primary landing site for the Space Shuttle.

Vandenberg Air Force Base, Lompoc, California: Vandenberg Air Force Base is the site of the 1st Strategic Aerospace Division, Western Space and Missile Test Center, Space and Missile Test Organization, and the Shuttle Activation Task Force. Vandenberg conducts missile crew training, and operates testing and launch facilities for the Strategic Air Command.

Contractor Sites:

In addition to the above NASA and USAF installations there were many contractor facilities that were important in the space program. These facilities were not visited during the course of this theme study. It is not known what contractor facilities associated with the early years of the American Space Program survive. Additional facilities associated with Robert Goddard, the U.S Army White Sands Test Sites, and space hardware now in the collection of the Smithsonian Institution will be visited and assessed during Phase II of the Man in Space Theme Study.

Recommendations:

A. National Advisory Committee for Aeronautics Wind Tunnels

1. Variable Density Tunnel (Langley Research Center)
2. Full Scale Tunnel (Langley)
3. Eight-Foot High Speed Tunnel (Langley)
4. Unitary Plan Wind Tunnel (Ames Research Center)

These sites are recommended for designation as National Historic Landmarks because they represent the fine technological base of aeronautical research facilities created by the National Advisory Committee for Aeronautics. It was on this base that the National Aeronautics and Space Administration would build to create the success of the American Space Program. The Variable Density Tunnel was the first wind tunnel in the world to use the principle of variable density air pressure to test scale model aircraft. The Full Scale Tunnel was the first full scale tunnel in NACA's inventory and contributed mightily to the design of an entire new generation of aircraft in the 1930s and 1940s. The versatility of the Full Scale Tunnel is demonstrated by the fact that today, 53 years after its construction, it is still a major research tool in NASA's inventory and is being used to design a new generation of aircraft. The Eight-Foot High Speed Tunnel is important because it was the first tunnel to employ a slotted throat design which gave aircraft designers accurate data on airframe performance in the transonic range. The Unitary Plan Wind Tunnel is significant because it represents the continuing effort of NACA to update its wind tunnel inventory to provide the American aircraft and aerospace industry with the most advanced testing facilities in existence in the world. The Unitary Plan Wind Tunnel was extensively used in designing new generations of aircraft that eventually led to the Space Shuttle of today. These wind tunnels represent only a small fraction of the more than 65 wind tunnels currently in NASA's inventory.

B. Rocket Engine Development Facilities

5. Rocket Engine Test Facility (Lewis Research Center)
6. Zero-Gravity Research Facility (Lewis)
7. Spacecraft Propulsion Research Facility (LeRC Plum Brook Operations Division)

These sites are recommended for designation as National Historic Landmarks because they represent the important role of the Lewis Research Center in developing hydrogen as a fuel for the Centaur and Saturn V rockets. The Rocket Engine Test Facility pioneered in the technology necessary to handle hydrogen

as a rocket fuel, the Zero-Gravity Research Facility investigated the physics of handling liquids in a zero-gravity environment, and the Spacecraft Propulsion Research Facility enabled engineers at Lewis to hot fire full scale Centaur engines in simulated space conditions. The development of the Centaur and Saturn Rockets was crucial to both the manned and unmanned space programs of the United States.

C. Rocket Engine Test Stands

8. Redstone Test Stand (George C. Marshall Space Flight Center)
9. Propulsion and Structural Test Facility (Marshall)
10. Rocket Propulsion Test Complex (National Space Technology Laboratories)

These facilities are recommended for designation as National Historic Landmarks because they represent the role of the Marshall Space Flight Center in the building and testing of actual space flight rockets. Before any rocket is allowed to fly and be used on a manned mission it is first tested by firing in a static test stand to verify its flight status. The Redstone Test Stand was the first facility of this type built at Marshall by Dr. Werner von Braun. The Redstone test stand tested the Mercury/Redstone missiles used to launch Alan B. Shepard and Gus Grissom on their first space launches. The Propulsion and Structural Test Facility was important in the testing of the Saturn 1B vehicle and represents the evolution of test stand technolgy from the days of the Army Redstone Missile to the Solid Rocket Boosters used on the Space Shuttle today. The Rocket Propulsion Test Complex was used by Marshall to test and man-rate all Saturn V rockets used in the Apollo Program.

D. Rocket Test Facility

11. Saturn V Dynamic Test Stand (Marshall)

This facility illustrates another facet of the building and testing and man-rating of the Saturn V Rocket. After every Saturn V was tested on the firing stand it was brought to the Dynamic Test Stand for mechanical and vibrational tests to determine its structural integrity. This process was part of the extensive ground testing program for the Saturn V Rocket and it is a primary reason for the success of the American manned space program. Tests conducted here gave NASA and industry engineers their last chance to detect and correct any flaws in the fully assembled Saturn V.

E. Rockets

12. Saturn V Space Vehicle

At this time the only rocket recommended for designation as a National Historic Landmark is the Saturn V at the Alabama Space and Rocket Museum. This vehicle is one of only three remaining Saturn Vs in the country. It was selected to represent the class of Saturn V rockets because of its integrity and association with its site--the George C. Marshall Space Flight Center. All three stages of the vehicle and the instrument ring are intact. The vehicle is well maintained and in a good state of preservation. This Saturn V was the original test vehicle used in dynamic testing of the Saturn support facilities at the Marshall Space

Flight Center. While not intended to fly itself, this Saturn V was a working vehicle with all of its parts intact, and prepared the way for all the Saturn Vs that did fly and were lost after having completed their missions.

F. Launch Pads

13. Space Launch Complex 2 (Vandenberg Air Force Base)

Space Launch Complex 2W at Vandenberg Air Force Base is recommended for designation as a National Historic Landmark because it is the finest remaining example of a 1950s-era launch complex in the country. All facilities associated with the site are intact. The blockhouse retains the original electronic equipment. The only modifications to the site over the years involved changing from the Thor to the Delta Rockets. Since the Delta is descended from the Thor Rocket, modifications were minor.

G. Apollo Training Facilities

14. Lunar Landing Research Facility (Langley)
15. Rendezvous Docking Simulator (Langley)
16. Lunar Landing Training Vehicle (Alabama Space and Rocket Center)
17. Neutral Buoyancy Space Simulator (Marshall)

These facilities are recommended for designation as National Historic Landmarks because of their association with training programs necessary to prepare American astronauts to land on the moon. The Lunar Landing Research Facility and the Lunar Landing Training Vehicle represent two different philosophies within NASA on how to fly the last 150 feet to the lunar surface. The Lunar Landing Research Facility employed a mock Lunar Excursion Module attached to a fixed facility while the Lunar Landing Training Vehicle was a free flying vehicle used to replicate Lunar Excursion Module flight dynamics here on Earth. Both methods were used to train Apollo Astronauts. The Rendezvous Docking Simulator is the only surviving trainer that Gemini and Apollo Astronauts used to practice rendezvous and docking techniques needed to link the Lunar Excursion Module and the Command and Service Module in Space. The ability to link these two vehicles in space was critical to the success of the Lunar Orbit Rendezvous technique for landing on the moon. The Neutral Buoyancy Space Simulator was used to familiarize Apollo astronauts with the dynamics of zero gravity while operating outside of the Apollo Spacecraft.

H. Apollo Hardware Test Facility

18. Space Environment Simulation Laboratory (Lyndon B. Johnson Space Center)

The Space Environment Simulation Laboratory is important because it was used to man-rate and test the integrity of the Apollo Command and Service Module, Lunar Module, and spacesuits under simulated space conditions here on Earth. This testing was essential to the safety and well being of the Apollo astronauts.

I. Unmanned Spacecraft Test Facilities

19. Spacecraft Magnetic Test Facility (Goddard Space Flight Center)
20. Twenty-Five-Foot Space Simulator (Jet Propulsion Laboratory)

These facilities are recommended for designation as National Historic Landmarks because they illustrate the extensive ground support testing facilities needed to accomplish the American unmanned space program--the exploration of the near and deep space environment. The Spacecraft Magnetic Test Facility represents the role of the Goddard Space Flight Center in the American space program. This facility, the only one of its type in NASA's inventory, enables NASA to determine and minimize the magnetic movement of even the largest unmanned spacecraft and thereby eliminate unwanted torques due to the interaction of the spacecraft with the Earth's magnetic field. The Twenty-Five-Foot Space Simulator is the only NASA facility capable of producing the true interplanetary conditions of cold, high vacuum, and intense solar radiation coupled with a large test chamber that can accommodate large space vehicles. Both of these facilities have contributed to the success of the American unmanned space program and represent the technological sophistication of the support facilities necessary to accomplish that program.

J. Tracking Stations

21. Pioneer Deep Space Tracking Station (Goldstone Tracking Station)

The Pioneer Deep Space Tracking Station is recommended for designation as a National Historic Landmark because it was the first antenna to support NASA's unmanned exploration of deep space. The technological achievements necessary to track deep space vehicles were first demonstrated and put into use at this site. The Pioneer Station was later joined by dozens of additional tracking stations around the world. This site illustrates the role of Goldstone and the NASA tracking system in the American Space Program.

K. Mission Control Centers

22. Space Flight Operations Facility (JPL)
23. Apollo Mission Control (Johnson)

These sites are recommended for designation as National Historic Landmarks because they are the very heart and soul of both the American Manned and Unmanned Space Programs. The Space Flight Operations Facility at the Jet Propulsion Laboratory represents the role and achievement of JPL in the American effort to explore the moon, planets, and solar system: Projects Viking, Voyager, Pioneer, Ranger, and Mariner opened new worlds for exploration and human understanding. The Space Flight Operations facility is the symbol of this effort and the facility at the Jet Propulsion Laboratory is the one most closely associated with this effort. Apollo Mission Control at the Lyndon B. Johnson Space Flight Center represents the role and achievement of Johnson in the American manned spaceflight program. It was to Apollo Mission Control that Neil Armstrong reported his famous words that man had first landed on the moon in July 1969.

L. Other Support Facilities

24. Rogers Dry Lake (Edwards Air Force Base)

Although a natural resource the Rogers Dry Lake is recommended for designation as a National Historic Landmark because of its association with flight testing of advanced aircraft that opened the way to space. The natural attributes of clean air, isolated location, ideal weather, proximity to variable terrain, and the large surface of the dry lakebed provided a natural laboratory in which to flight test aircraft that were on the cutting edge in aviation and aerospace technology. As a resource the Rogers Dry Lake has contributed as much to the American aircraft and aerospace effort as any manmade facility. Starting in 1947 with the flight of the Bell X-1, the first plane to break the sound barrier, to the landing of the Space Shuttle Columbia in 1981, the Rogers Dry Lake has been the scene of some of the most important developments in the history of aviation.

Previously Designated Sites

Cape Canaveral Air Force Station was designated a National Historic Landmark on April 16, 1984. Launch Complex 39 at the Kennedy Space Center was listed on the National Register of Historic Places on May 24, 1973.

Summary

The 24 recommended resources contained in this phase of the Man in Space Theme Study represent only a small fraction of the technological resources that were necessary to support the American space program. They are recommended for designation as National Historic Landmarks because they represent the best and most important surviving examples of this technology. Due to the rapid change of the space program and evolving technologies, support facilities simply do not survive or survive in a greatly altered state. The efforts to land a man on the moon, investigate the near Earth environment, and explore the planets and solar system were supported from a technological base that reflected a depth and variety of support facilities that were unprecedented in American history. Many of these resources have long since been destroyed, abandoned or altered to meet the changing demands of the space program. The 24 facilities reflected in this theme study are but a fraction of this resource base. They are the best, most intact, and most important resources that have survived. Their variety and range reflect the much larger technological base that provided the foundation of the space program. It is hoped that this selection will survive to interpret for future generations the early years of the American space program.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS WIND TUNNELS

1. Variable Density Tunnel (Langley Research Center)
2. Full Scale Tunnel (Langley)
3. Eight-Foot High Speed Tunnel (Langley)
4. Unitary Plan Wind Tunnel (Ames Research Center)

NPS Form 10-900
(7-81)

**United States Department of the Interior**
**National Park Service**

# National Register of Historic Places Inventory—Nomination Form

For NPS use only
received
date entered

See instructions in *How to Complete National Register Forms*
Type all entries—complete applicable sections

## 1. Name

historic Variable Density Tunnel

and/or common Variable Density Tunnel

## 2. Location

street & number Langley Research Center ___ not for publication

city, town Hampton ___ vicinity of congressional district

state Virginia code 51 county Hampton code 650

## 3. Classification

| Category | Ownership | Status | Present Use | |
|---|---|---|---|---|
| ___ district | X public | ___ occupied | ___ agriculture | ___ museum |
| ___ building(s) | ___ private | ___ unoccupied | ___ commercial | ___ park |
| X structure | ___ both | ___ work in progress | ___ educational | ___ private residence |
| ___ site | **Public Acquisition** | **Accessible** | ___ entertainment | ___ religious |
| ___ object | ___ in process | X yes: restricted | ___ government | ___ scientific |
| | ___ being considered | ___ yes: unrestricted | ___ industrial | ___ transportation |
| | | ___ no | ___ military | X other: Abandoned |

## 4. Owner of Property

name National Aeronautics and Space Administration (NASA)

street & number

city, town Washington ___ vicinity of state D.C. 20546

## 5. Location of Legal Description

courthouse, registry of deeds, etc. National Aeronautics and Space Administration (NASA)

street & number Real Property Management Office Code NXG

city, town Washington state D.C. 20546

## 6. Representation in Existing Surveys

title None has this property been determined eligible? ___ yes ___ no

date ___ federal ___ state ___ county ___ local

depository for survey records

city, town state

# 7. Description

| Condition | | Check one | Check one |
|---|---|---|---|
| ___ excellent | ___ deteriorated | ___ unaltered | _X_ original site |
| _X_ good | ___ ruins | _X_ altered | ___ moved date _____ |
| ___ fair | ___ unexposed | | |

**Describe the present and original (if known) physical appearance**

The Variable Density Tunnel (VDT) is in Building 582 in the East Area of the Langley Research Center.[1] The VDT was constructed during the period from 1921 to 1923 at the direction of the National Advisory Committee for Aeronautics (NACA).

The tank of the VDT was built by the Newport News Shipbuilding & Dry Dock Co., of Newport News, Virginia. It is capable of withstanding a working pressure of 21 atmospheres. It is built of steel plates lapped and riveted according to the usual practice in steam boiler construction, although, because of the size of the tank and the high working pressure, the construction is unusually heavy. Entrance to the tank is gained through an elliptical door 36 inches wide and 42 inches high. The tank and its contents weigh 100 tons and are supported by a foundation of reinforced concrete.[2] The tank is 34.5 feet long and 15 feet in diameter with interior steel walls 2 1/8 inches thick. To minimize tank volume and the quantity of structural steel required (85 tons), an annular flow scheme was adopted. The test section was made 5 feet in diameter to match the National Advisory Committee for Aeronautics (NACA) Wind Tunnel No. 1. The maximum air velocity was 50 MPH at a pressure of 20 atmospheres.

The VDT was partially destroyed by fire in 1927. The interior of the tunnel was damaged but the exterior pressure tank remained intact. The tunnel was rebuilt and was operational again by 1930.

By the 1940s the tunnel was obsolete by the standards of the day and was gutted. The VDT continued to serve the needs of NACA and was used as a pressure tank to support the operation of the Vertical Wind Tunnel and the Low Turbulence Wind Tunnel. The VDT continued to serve in this capacity until it was declared potentially unsafe for further operations in 1978. Additional modifications during this time included the removal of the viewing platform and porthole from the tunnel.

The basic structure of the tunnel remains intact. At the present time there are no plans for the use of the Variable Density Tunnel.

# 8. Significance

| Period | Areas of Significance—Check and justify below | | | |
|---|---|---|---|---|
| ___ prehistoric | ___ archeology-prehistoric | ___ community planning | ___ landscape architecture | ___ religion |
| ___ 1400–1499 | ___ archeology-historic | ___ conservation | ___ law | X science |
| ___ 1500–1599 | ___ agriculture | ___ economics | ___ literature | ___ sculpture |
| ___ 1600–1699 | ___ architecture | ___ education | ___ military | ___ social/ humanitarian |
| ___ 1700–1799 | ___ art | X engineering | ___ music | ___ theater |
| ___ 1800–1899 | ___ commerce | ___ exploration/settlement | ___ philosophy | ___ transportation |
| X 1900– | ___ communications | ___ industry | ___ politics/government | X other (specify) Aeronautical Research |
| | | ___ invention | | |

**Specific dates** 1921-1940 **Builder/Architect** Max Munk

**Statement of Significance (in one paragraph)**

The Variable Density Tunnel was the first facility to establish NACA as a technically competent research organization. The tunnel was a technological quantum jump that rejuvenated American aerodynamic research which in time led to the best aircraft in the world.[3]

The success of the Wright Brothers airplane was followed by a technological backward slide by the American aircraft industry. British, French, and German designers soon surpassed the Wright Brothers and other American aircraft builders. By World War 1 the United States had slipped into a position of technological inferiority compared to the European designers.

To support their aircraft industry European designers built major wind tunnels to test new theories and to discover better methods of building aircraft. To regain for America the technological leadership in the field of aircraft design and manufacture, President Woodrow Wilson signed into law a bill establishing the National Advisory Committee for Areonautics (NACA) March 3, 1915.

The responsibility of NACA, as the new agency was called, was to "supervise and direct the study of the problems of flight, with a view to their practical solution...." The act also provided for the construction of research facilities and a laboratory site near Hampton, Virginia. Thus the Langley Research Center came into being in 1917.

Originally called Langley Memorial Aeronautical Laboratory, later just Langley Aeronautical Laboratory, NACA Langley immediately set about the problem of building a wind tunnel to conduct aeronautical research. Because of the lack of experience in this area Langley first constructed NACA Wind Tunnel No. 1, a low speed tunnel with no return circuit for air passing through the test section. Although useful as a learning tool, this tunnel was obsolete by the standards of the day and produced no significant findings.

In June 1921 NACA's Executive Committee decided to leapfrog European wind tunnel technology and build a tunnel in which pressures could be varied. This concept was strongly advocated by Max Munk, a NACA technical assistant, who was familiar with European wind tunnel design from his days at Gottingen. The purpose of the Variable Density Tunnel, that Munk advocated, was to solve the problem of applying experimental results obtained from scale model aircraft to full size aircraft. Almost all wind tunnel tests at the time were, and still are, performed on scale model aircraft because of the expense involved in constructing full scale wind tunnels.

In a classic set of experiments, Osborne Reynolds (1842-1912) of the University of Manchester demonstrated that the airflow pattern over a scale model would be the same for the full scale vehicle if certain flow parameters were the same in both cases. This factor, now known as the Reynolds number, is a basic parameter in the description of all fluid-flow situations, including the shapes of flow patterns, the ease of heat transfer, and the onset of turbulence.[4]

In 1921 all wind tunnels were operating at normal atmospheric pressure using scale models. This meant that experimental results using these wind tunnels were open to question because the Reynolds number obtained did not match those encountered in using full scale aircraft. Thus the Reynolds number of a 1/20-scale model being tested at operational flight velocities in an atmospheric wind tunnel would be too low by a factor of 20. NACA engineers realized that since the Reynolds number is also proportional to air density that a solution was possible by testing 1/20-scale models at a pressure of 20 atmospheres. The Reynolds number would be the same in the wind tunnel as in actual flight.[5]

This was the significance of the Variable Density Tunnel. The VDT, for the first time, placed in the hands of NACA engineers a research tool superior to that found anywhere else in the world. The VDT was able to predict flow characteristics of test aircraft models more accurately than any other tunnel then in existence. The VDT quickly established itself as a primary source for aerodynamic data at high Reynolds numbers.

The result of this research led to the publication of NACA Technical Report 460 in which aerodynamic data for 78 related airfoil sections were presented. Information contained in this report eventually found its way into the design of such famous aircraft as the DC-3, B-17 and the P-38.

The VDT established NACA as a technologically competent organization and led to the production of superior American aircraft that have dominated the airways of the world since that time. All modern Variable Density Tunnels now in operation are but an extension of the original ideal first formulated and put into operation by Max Munk in 1921 with the construction of the original Variable Density Tunnel at Langley.

Footnotes

1. Much of the material in Sections 7 and 8 of this report has been adapted from Donald D. Baals and William R. Corliss, Wind Tunnels of NASA (Washington, D.C.: National Aeronautics and Space Administration, 1981), pp. 9-17.

2. Elton W. Miller, The Variable Density Wind Tunnel of the National Advisory Committee for Aeronautics Part II, Technical Report No. 227, (Washington, D.C.: National Advisory Committee for Aeronautics, 1925), pp. 411-412.

3. Baals, 17.

4. Ibid., 3.

5. Ibid., 15.

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## 9. Major Bibliographical References

See continuation sheets

## 10. Geographical Data

Acreage of nominated property Less than 1 acre.

Quadrangle name Hampton

Quadrangle scale 1:24,000

UMT References

| | Zone | Easting | Northing |
|---|---|---|---|
| A | 18 | 380520 | 4104240 |
| B | | | |
| C | | | |
| D | | | |
| E | | | |
| F | | | |
| G | | | |
| H | | | |

Verbal boundary description and justification

The nominated property includes only the steel tank known as the Variable Density Tunnel.

List all states and counties for properties overlapping state or county boundaries

state code county code

state code county code

## 11. Form Prepared By

name/title Harry A. Butowsky

organization National Park Service date May 15, 1984

street & number Division of History telephone (202) 343-8168

city or town Washington, D.C. 20240 state

## 12. State Historic Preservation Officer Certification

The evaluated significance of this property within the state is:

___ national ___ state ___ local

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89-665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service.

State Historic Preservation Officer signature

title date

For NPS use only

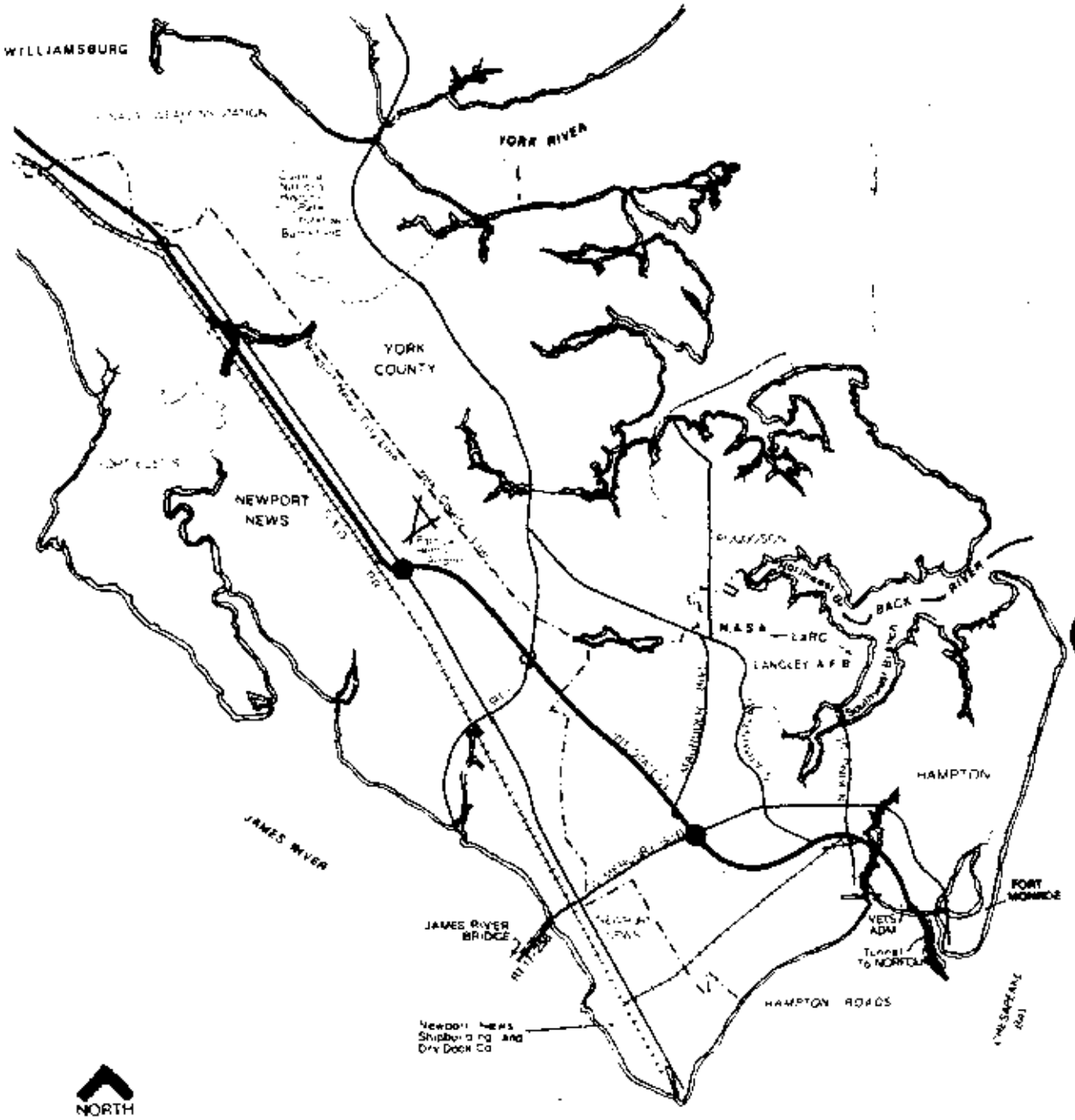
I hereby certify that this property is included in the National Register

date

Keeper of the National Register

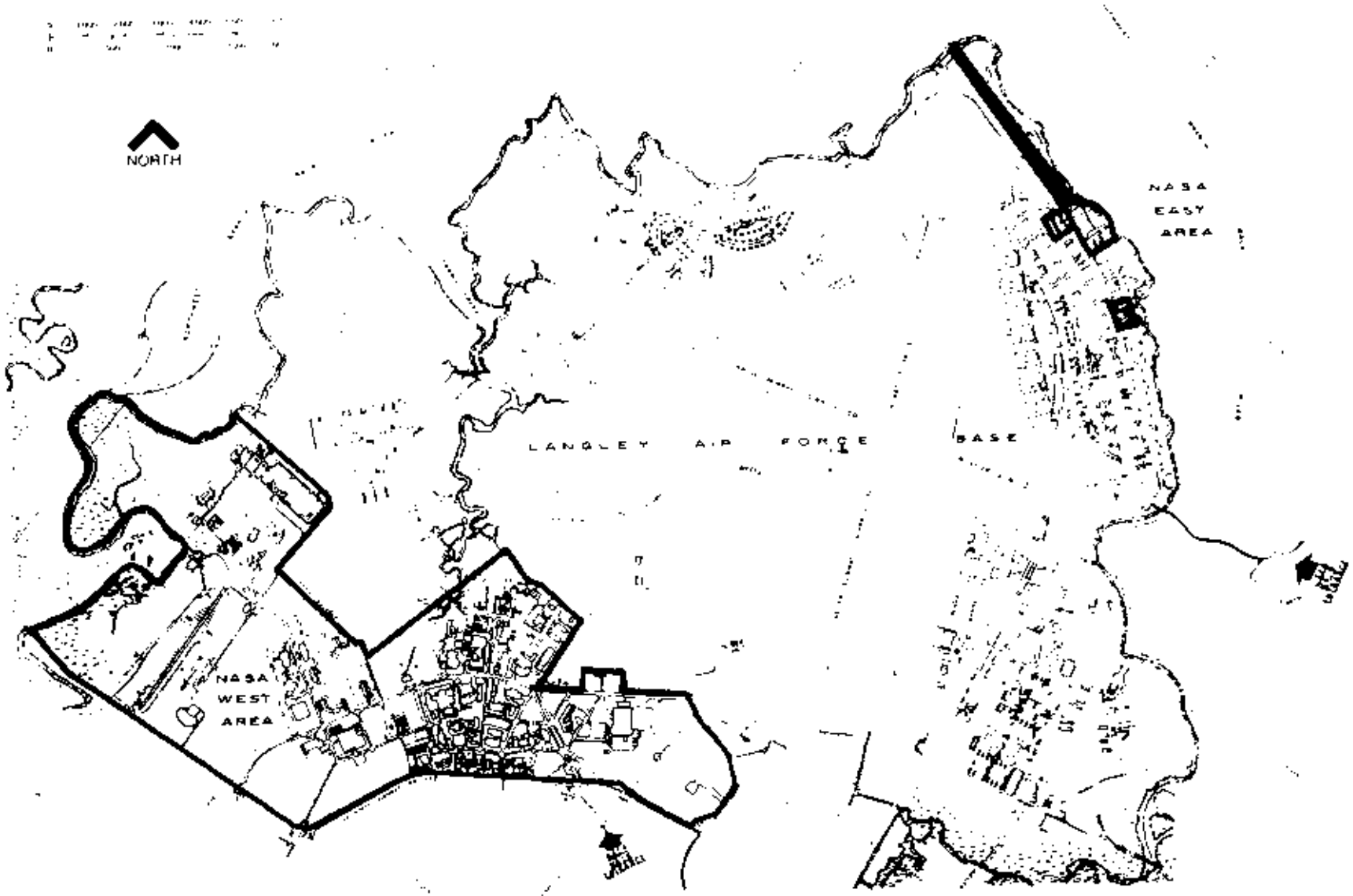
Attest: date

Chief of Registration



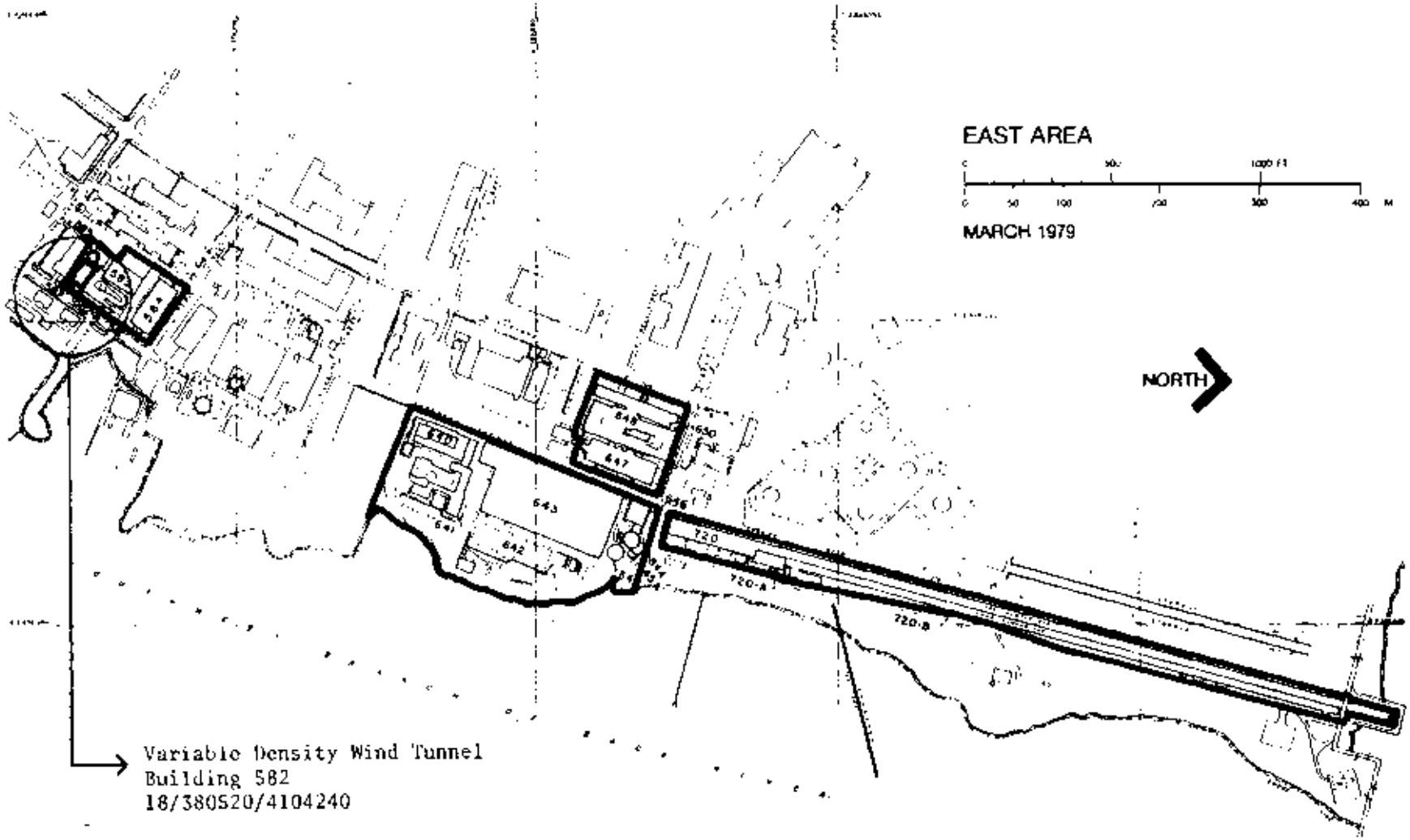

NASA
National Aeronautics and Space Administration
**Langley Research Center**
Hampton, Virginia
23665

**FIGURE 1-1**
**Regional Map**




NASA
National Aeronautics and
Space Administration
**Langley Research Center**
Hampton, Virginia
23665

FIGURE 1-2
**Combined East & West Area**

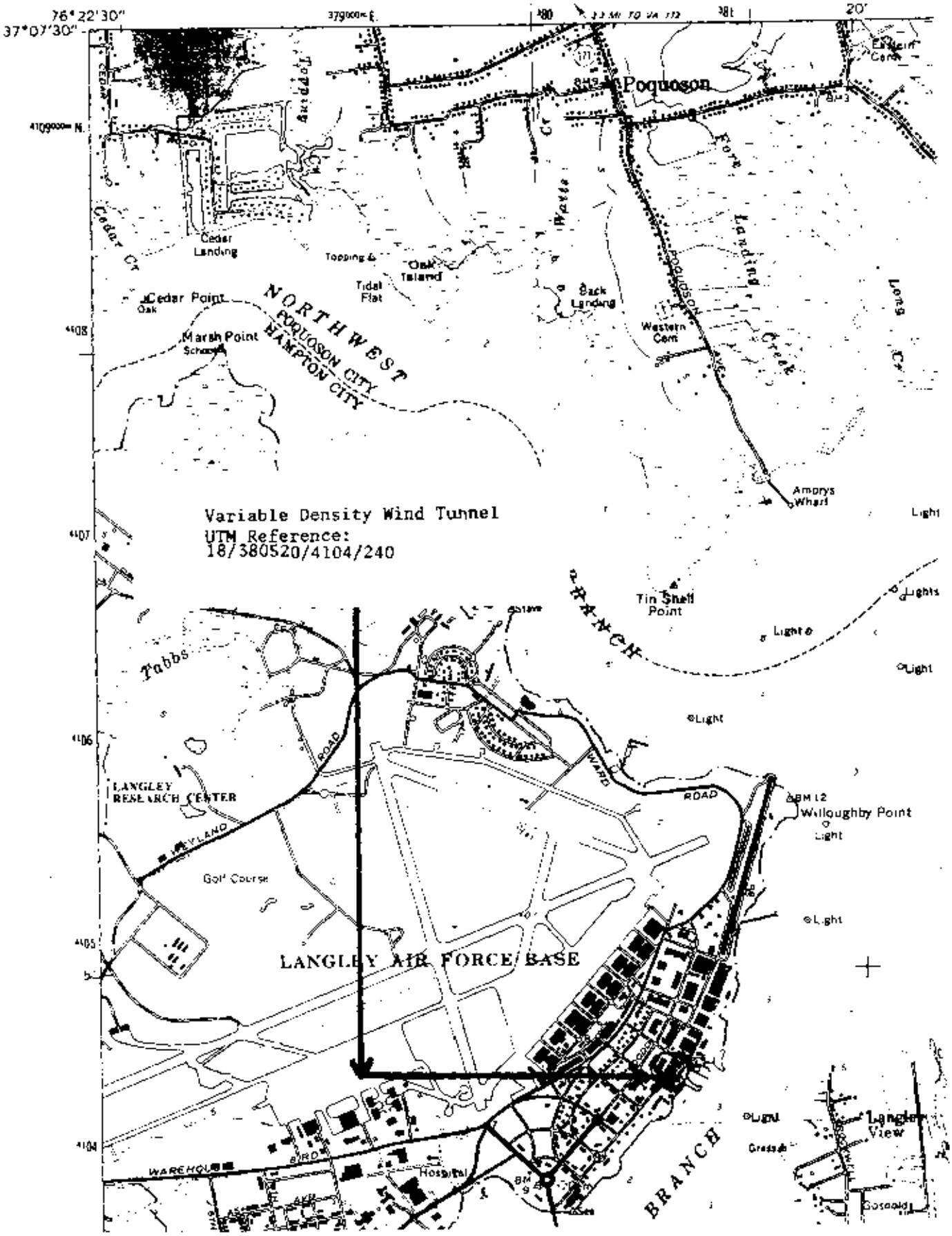



NASA
National Aeronautics and
Space Administration

**Langley Research Center**
Hampton, Virginia
23665

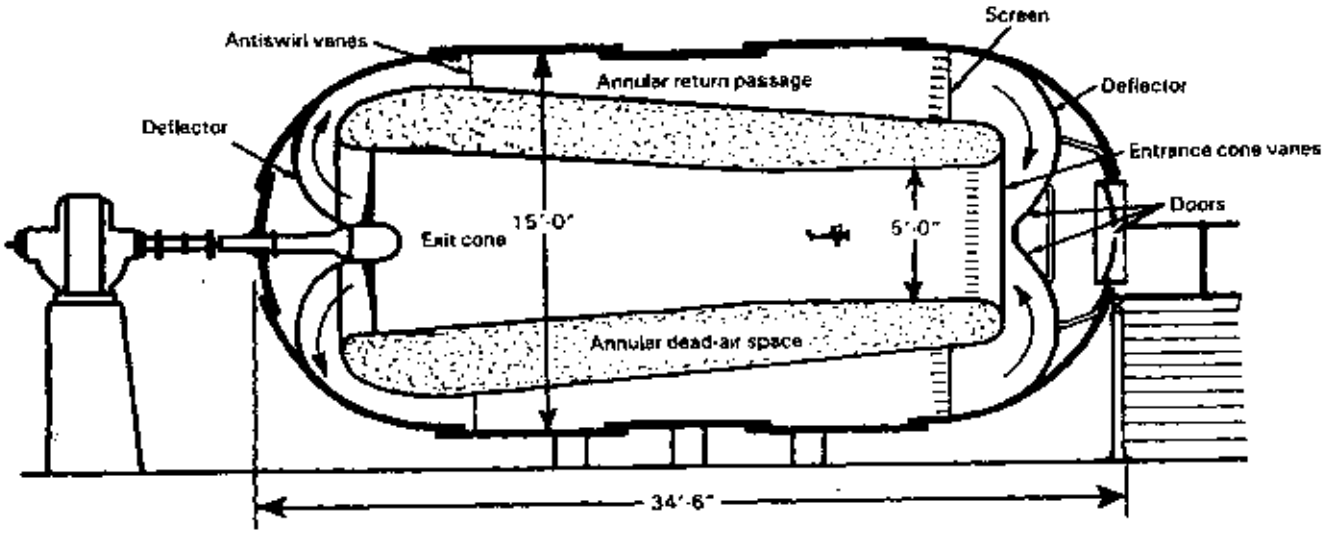
**FIGURE 1-3**
**East Area**

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY




Variable Density Wind Tunnel
UTM Reference:
18/380520/4104/240

Variable Density Tunnel

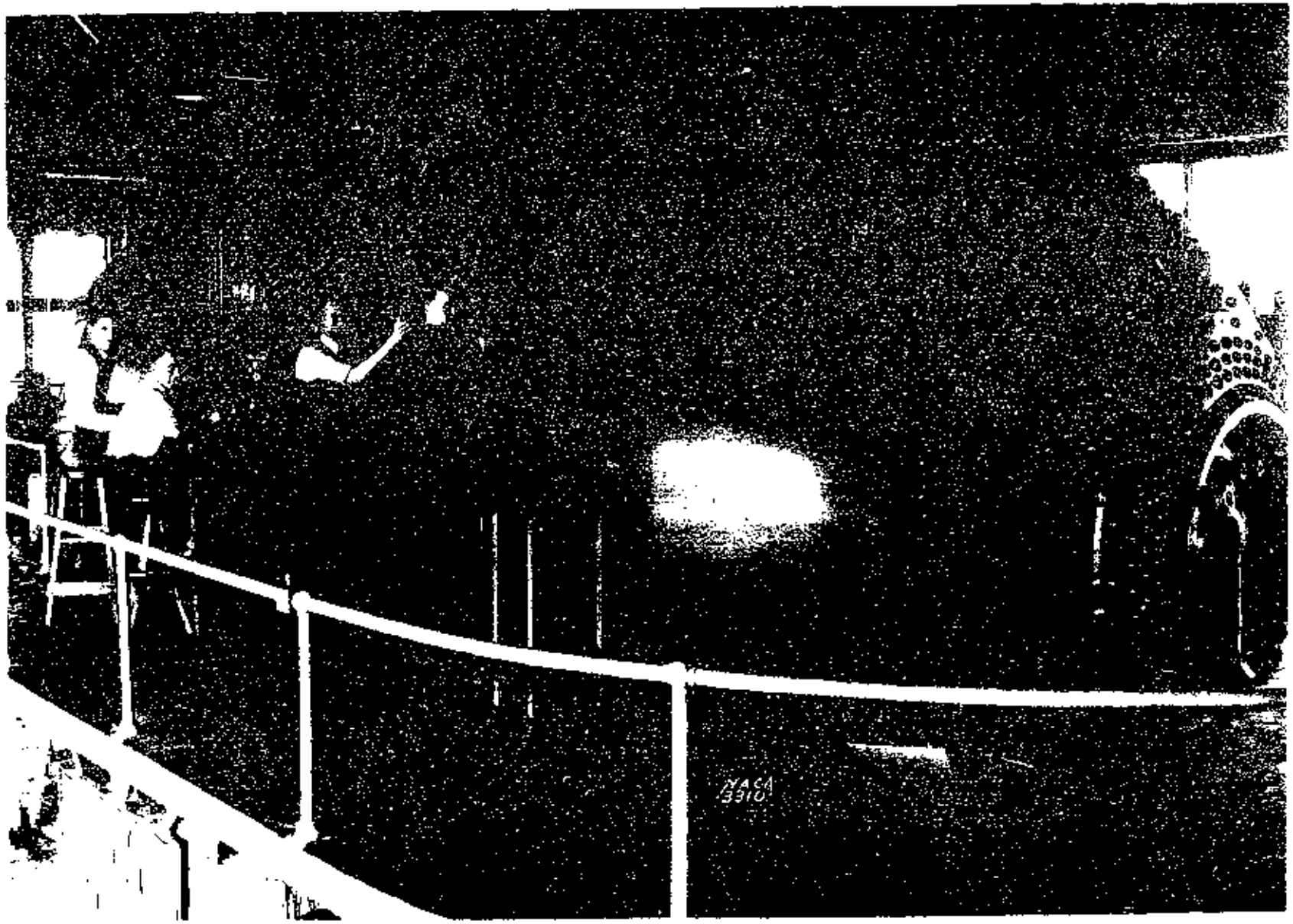



Source: Baals, p. 16.

Identification Key to Pictures

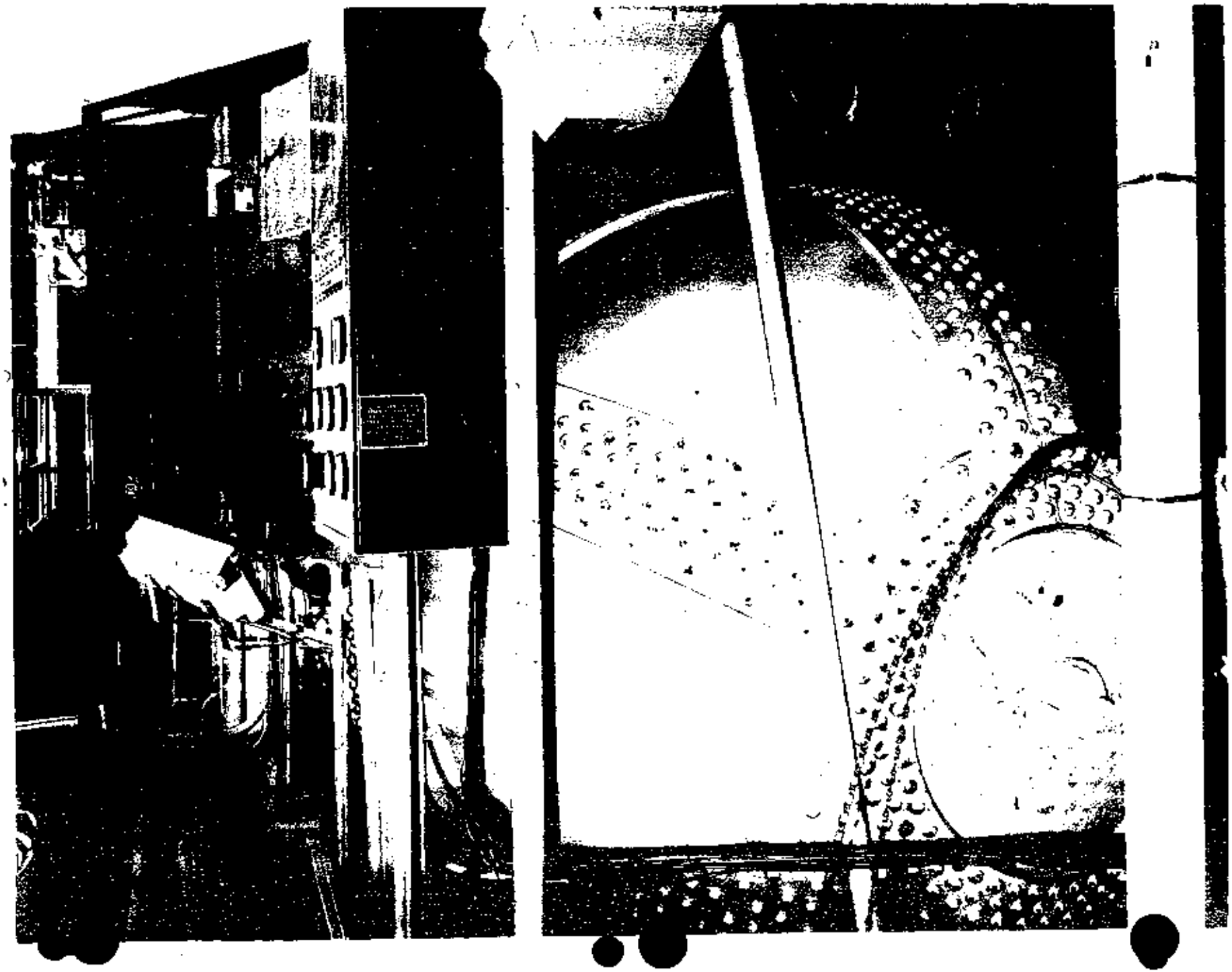
1. Name of Property
2. City and State where located
3. Name of Photographer
4. Date of Photograph
5. Location of Photograph Negative
6. Description of View

1. Variable Density Tunnel
2. Hampton, Virginia
3. NACA
4. 1929
5. NASA, Langley Research Center Archives
6. Exterior view of VDT in Building 582


NASA
3310

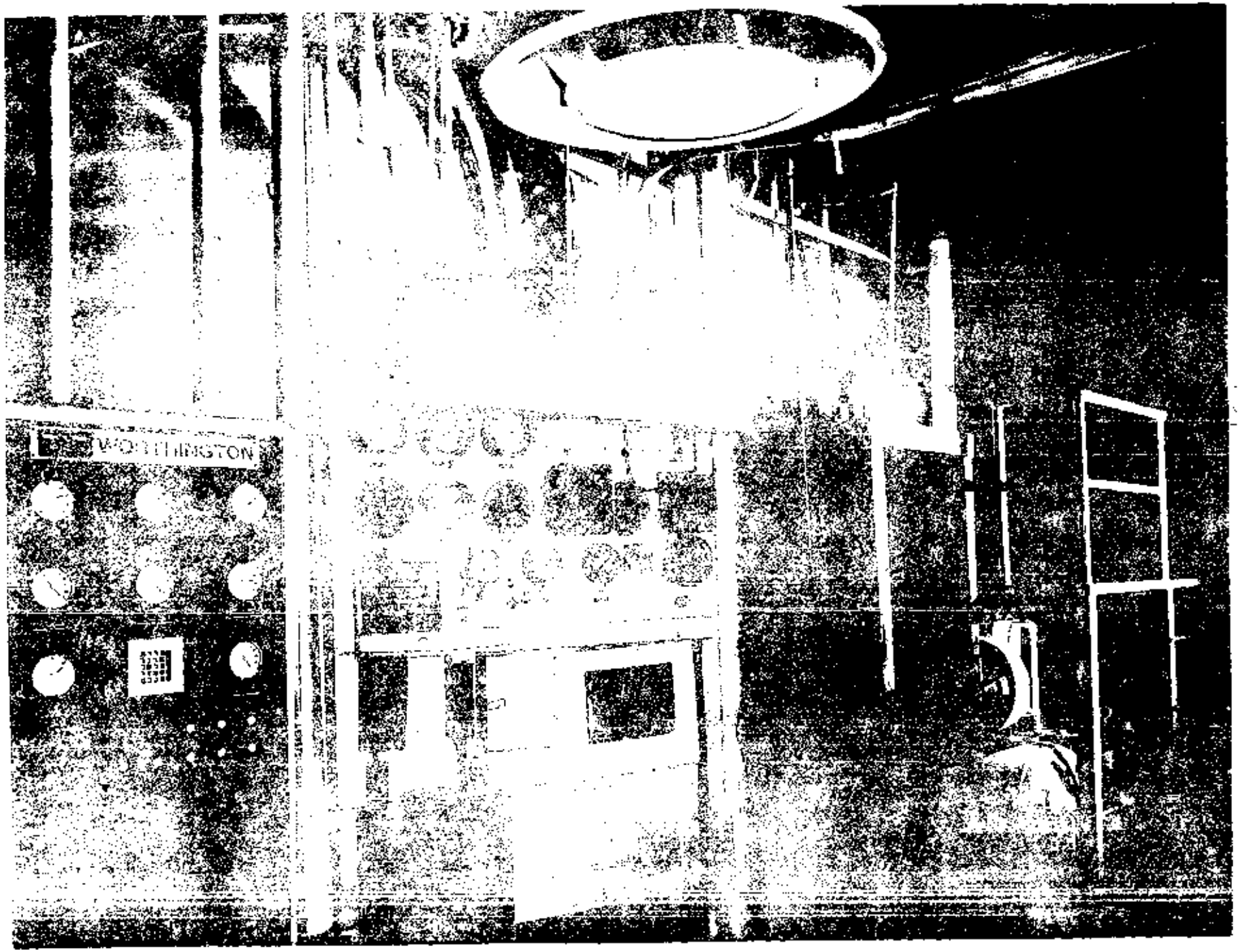
1. Variable Density Tunnel
2. Hampton, Virginia
3. NASA
4. 1984
5. NASA, Langley Research Center Facilities Office
6. Modern exterior view of VDT in Building 582

NASA
L-84-5321



1. Variable Density Tunnel
2. Hampton, Virginia
3. NASA
4. 1984
5. NASA, Langley Research Center Facilities Office
6. Modern exterior view of VDT in Building 582

NASA
L-84-5322



# 8. Significance

| Period | Areas of Significance—Check and justify below | | | |
|---|---|---|---|---|
| ___ prehistoric | ___ archeology-prehistoric | ___ community planning | ___ landscape architecture | ___ religion |
| ___ 1400–1499 | ___ archeology-historic | ___ conservation | ___ law | X science |
| ___ 1500–1599 | ___ agriculture | ___ economics | ___ literature | ___ sculpture |
| ___ 1600–1699 | ___ architecture | ___ education | X military | ___ social/ humanitarian |
| ___ 1700–1799 | ___ art | X engineering | ___ music | ___ theater |
| ___ 1800–1899 | ___ commerce | ___ exploration/settlement | ___ philosophy | ___ transportation |
| X 1900– | ___ communications | ___ industry | ___ politics/government | X other (specify) Aeronautical Research–Space Exploration |
| | | ___ invention | | |

**Specific dates** 1931-Present **Builder/Architect** Smith J. DeFrance

**Statement of Significance (in one paragraph)**

By 1929 the original NACA Langley wind tunnel complex was completed and turning out useful high quality aerodynamic research data. In spite of this achievement NACA engineers realized that there was a gap in their wind tunnel inventory. They needed a full scale wind tunnel.

Although the Variable Density Tunnel gave NACA engineers confidence in scaling up test results from models, several research areas could be explored only with full-scale models or with actual aircraft. The VDT was limited when the aerodynamic characteristics of a complete airplane were desired because it was practically impossible to build a model of the required size that is a true reproduction of a complete airplane. This difficulty is increased by the requirement that the model withstand large forces. Some of the questions that needed to be answered involved solving drag penalties due to external struts, surface gaps, air leaks, and engine cooling insulation. These questions could only be answered by using full scale aircraft. Models simply would not work. Previous experience with the Propeller Research Tunnel, which had a large scale test section, gave NACA engineers the confidence to attempt to build the Full Scale Tunnel.

Under the leadership of Smith J. De France, the design of the Full Scale Wind Tunnel began at Langley in 1929. With funds appropriated before the start of the Depression, NACA was able to buy materials and labor at bargain prices. In addition a large pool of talented but now unemployed aeronautical engineers was available to work on the project. The work progressed quickly and by 1931 the tunnel was complete.

The significance of the Full Scale Tunnel was immediately apparent to NACA engineers. Drag tests in the tunnel indicated surprisingly large performance penalities from external struts and other exposed aircraft parts. This information had been suspected by NACA engineers for some time but with the completion of the Full Scale Tunnel the engineers now had the data needed to correct the problem. Soon a large procession of military aircraft was dispatched to Langley for drag cleanup tests. Before and during World War II practically every high performance aircraft used by the United States was checked out at the Full Scale Tunnel. The tunnel operated 24 hours a day 7 days a week during the war performing drag cleanup tests for the military. For most of the war the Full Scale Tunnel was the only tunnel in the country and in the world capable of performing these tests. The importance of the tunnel was so evident that the United States built an even larger Full Scale Tunnel at the Ames Research Center in 1944.[5]

The Full Scale Tunnel has proved to be a remarkably adaptive research tool. In recent years modern aircraft of all types have been tested in the tunnel. These aircraft include the Harrier VTOL fighter, the F-16, the American supersonic transport, the X-29A-a forward swept wing experimental fighter, the Space Shuttle, the Lunar Landing Test Vehicle, and many others.

Because of its unique performance the Full Scale Tunnel is of singular importance not only in the area of aeronautical research but also in the theme of support facilities that contributed the American victory in World War II. The superiority of American designed and built fighters and bombers was due in no small part to the testing that these aircraft received in the Full Scale Tunnel.

Footnotes

1. National Advisory Committee for Aeronautics, The N.A.C.A. Full-Scale Wind Tunnel-Technical Report 45 (Washington, D.C.: National Advisory Committee for Aeronautics, 1933), pp. 292-93.

2. National Aeronautics and Space Administration, Langley Test Highlights 1982-Technical Memorandum 84655 (Hampton, Va.: Langley Research Center, 1983), p. 3.

   Donald D. Baals and William R. Corliss, Wind Tunnels of NASA (Washington, D.C.: National Aeronautics and Space Administration, 1981), p. 23.

3. Ibid.

4. Langley Facilities Program Development Office, LaRC Data for Facilities Catalogue (Unpublished Internal Memorandum, August 4, 1983), p. 3.

5. Baals, pp. 22-3.

Major Bibliographic References

Anderton, David A. Sixty Years of Aeronautical Research: 1917-1977. Washington, D.C.: National Aeronautics and Space Administration, 1978.

Anderson, John D. Jr. Introduction to Flight: Its Engineering and History. New York: McGraw Hill Book Company, 1978.

Baals, Donald D., and Corliss, William R. Wind Tunnels of NASA. Washington, D.C.: National Aeronautics and Space Administration, 1981.

Characteristics of Nine Research Wind Tunnels of the Langley Aeronautical Laboratory. Washington, D.C.: National Advisory Committee for Aeronautics, 1957.

Gray, George W. Frontiers of Flight: The Story of NACA Research. New York: Alfred E. Knopf, 1948.

Langley Research Center Facilities Program Development Office. LaRC Data for Facilities Catalogue. Hampton, Va., Unpublished Internal Memorandum, August 4, 1983.

Langley Test Highlights 1982-Technical Memorandum 84655. Hampton, Va.: Langley Research Center, 1983.

N.A.C.A. Full Scale Wind Tunnel Technical Report 459. Washington, D.C.: National Advisory Committee for Aeronautics, 1933.

Pope, Alan and Harper, John J. Low-Speed Wind Tunnel Testing. New York: John Wiley & Sons, 1966.

## 9. Major Bibliographical References

See continuation sheets

## 10. Geographical Data

Acreage of nominated property 434 feet x 222 feet

Quadrangle name Hampton

Quadrangle scale 1:24,000

UMT References

| | Zone | Easting | Northing |
|---|---|---|---|
| A | 18 | 380740 | 4104700 |
| B | | | |
| C | | | |
| D | | | |
| E | | | |
| F | | | |
| G | | | |
| H | | | |

Verbal boundary description and justification

The boundary of the Full Scale Tunnel is defined by the outside perimeter of Building 643 in the East Area of the Langley Research Center.

List all states and counties for properties overlapping state or county boundaries

| state | code | county | code |
|---|---|---|---|
| state | code | county | code |

## 11. Form Prepared By

name/title Harry A. Butowsky

organization National Park Service date May 15, 1984

street & number Division of History telephone (202) 343-8168

city or town Washington, D.C. 20240 state

## 12. State Historic Preservation Officer Certification

The evaluated significance of this property within the state is:

___ national ___ state ___ local

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89-665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service.

State Historic Preservation Officer signature

title date

For NPS use only

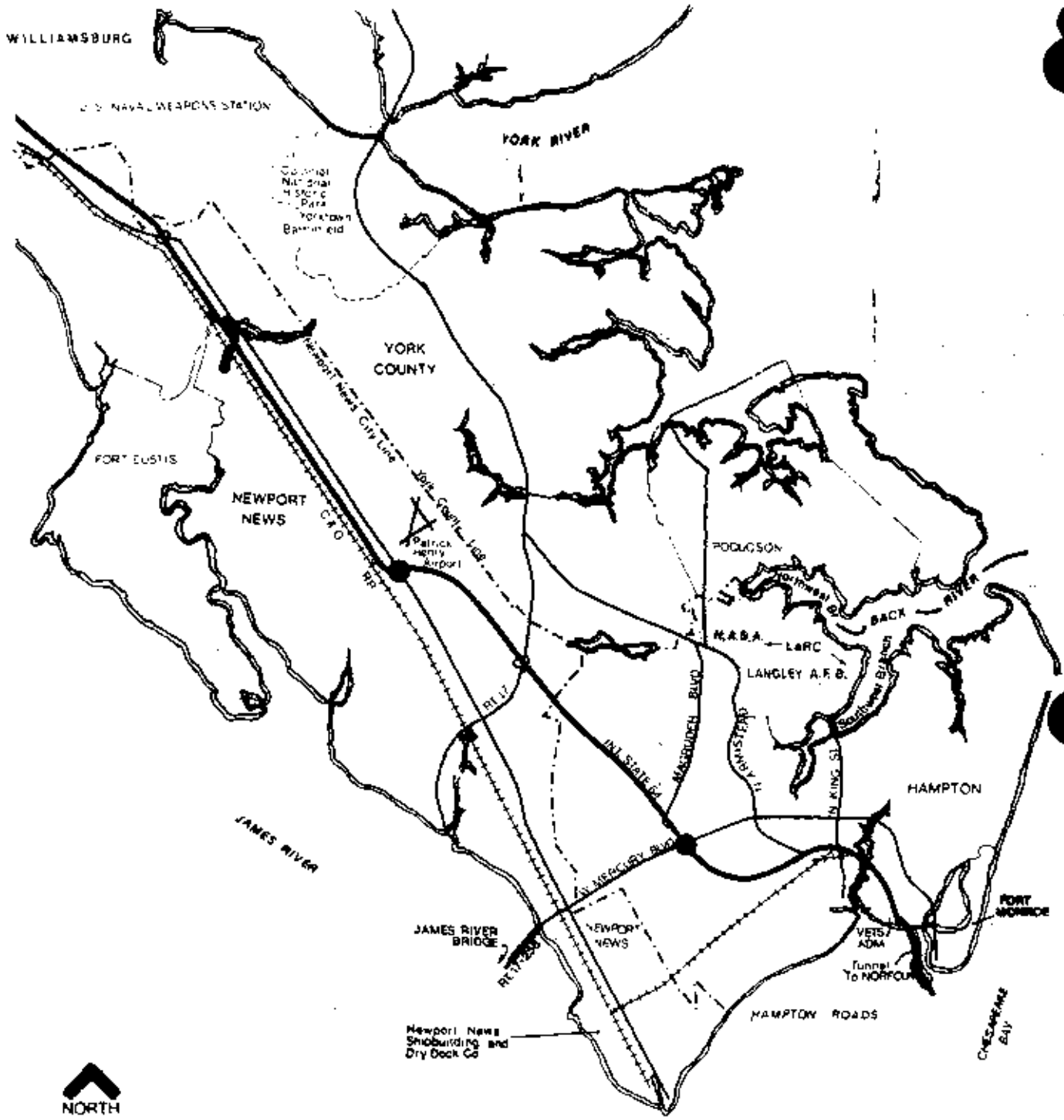
I hereby certify that this property is included in the National Register

date

Keeper of the National Register

Attest: date

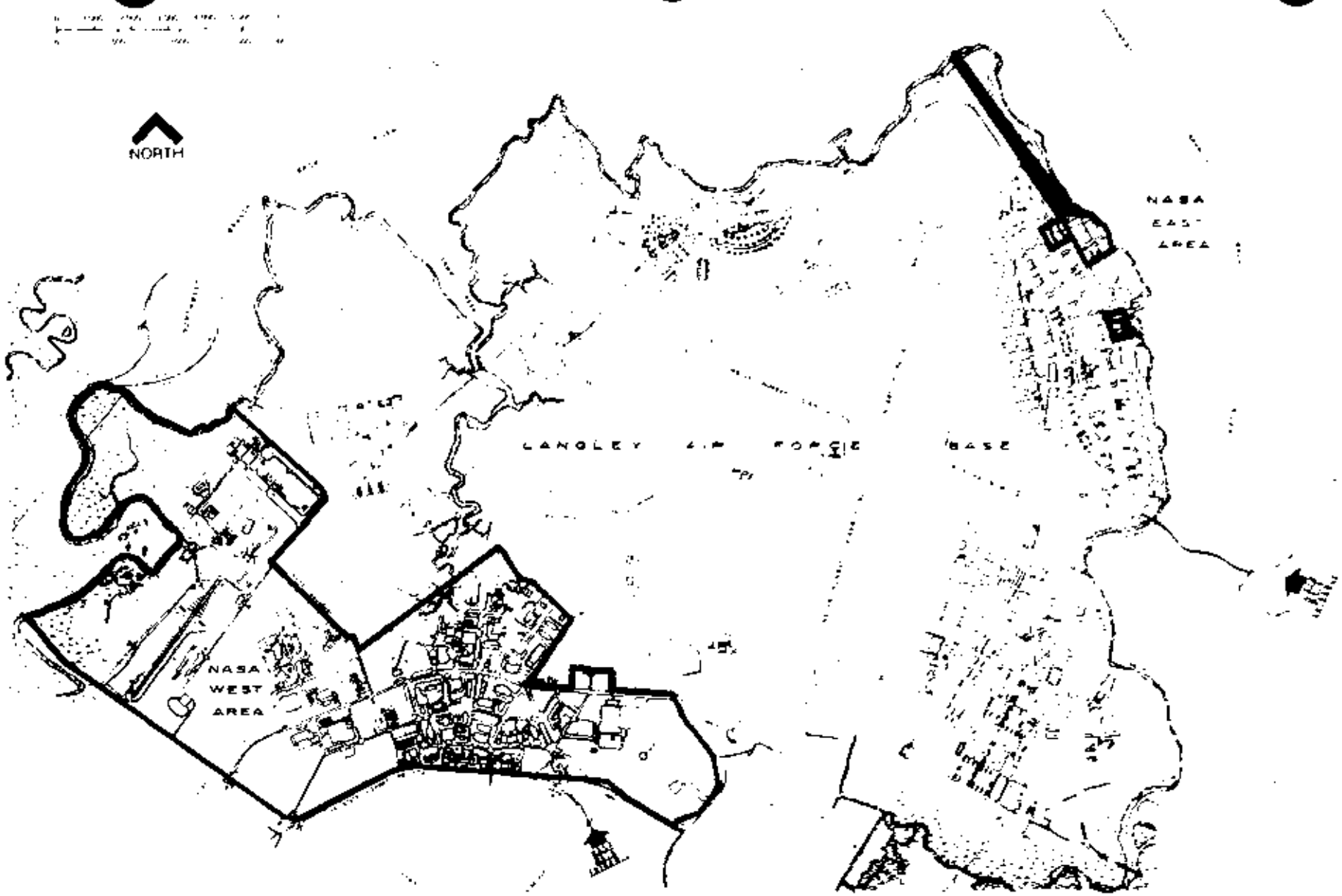
Chief of Registration




NASA
National Aeronautics and Space Administration

**Langley Research Center**
Hampton, Virginia
23665

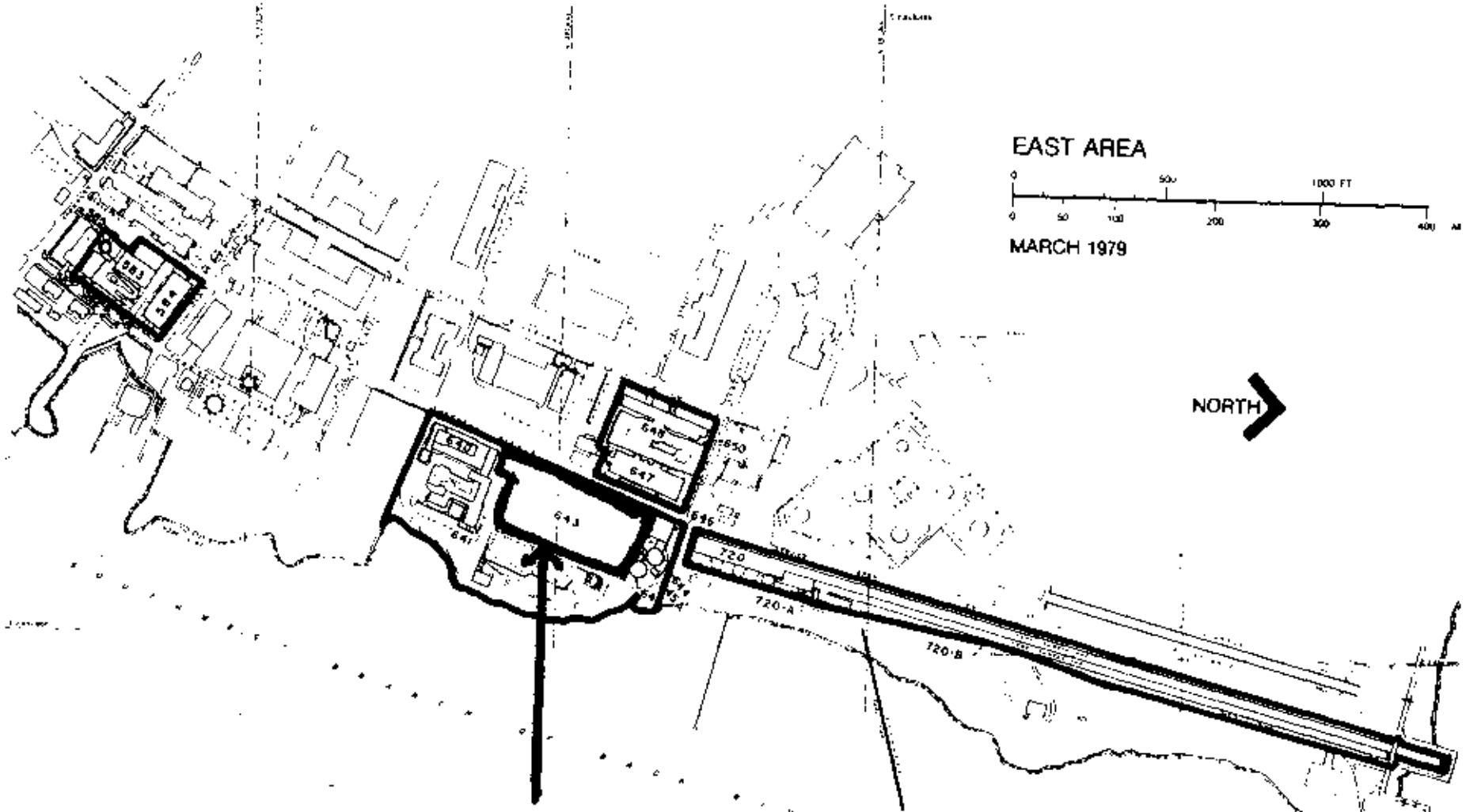
**FIGURE 1-1**
**Regional Map**




NASA
National Aeronautics and
Space Administration

**Langley Research Center**
Hampton, Virginia
23665

**FIGURE 1-2**
**Combined East & West Area**



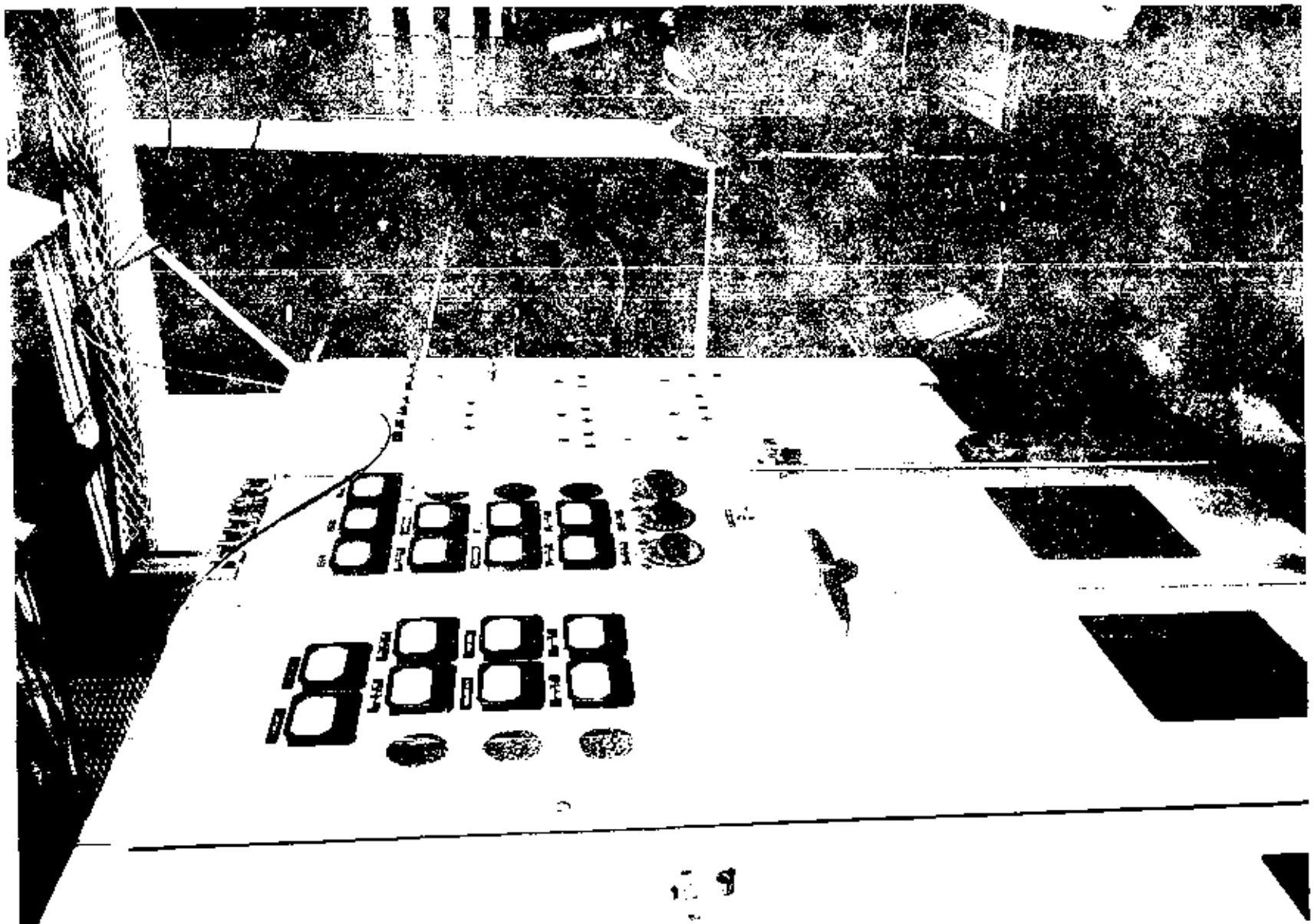

Full Scale Tunnel
Building 643
18/380740/410700

NASA
National Aeronautics and
Space Administration

**Langley Research Center**
Hampton, Virginia
23665

FIGURE 1-3

NASA
L-84-5319



Man in Space Theme Study
Federal Agency Nomination

NPS Form 10-900
(7-81)

United States Department of the Interior
National Park Service

# National Register of Historic Places Inventory—Nomination Form

For NPS use only
received
date entered

See instructions in *How to Complete National Register Forms*
Type all entries—complete applicable sections

## 1. Name

historic Lunar Landing Training Vehicle

and/or common Lunar Landing Training Vehicle

## 2. Location

street & number Alabama Space and Rocket Center ___ not for publication

city, town Huntsville ___ vicinity of congressional district

state Alabama code 01 county Madison code 089

## 3. Classification

| Category | Ownership | Status | Present Use | |
|---|---|---|---|---|
| ___ district | X public | ___ occupied | ___ agriculture | X museum |
| ___ building(s) | ___ private | ___ unoccupied | ___ commercial | ___ park |
| ___ structure | ___ both | ___ work in progress | ___ educational | ___ private residence |
| ___ site | **Public Acquisition** | **Accessible** | ___ entertainment | ___ religious |
| X object | ___ in process | X yes: restricted | ___ government | ___ scientific |
| | ___ being considered | ___ yes: unrestricted | ___ industrial | ___ transportation |
| | | ___ no | ___ military | X other: Exhibit |

## 4. Owner of Property

name National Aeronautics and Space Administration, Smithsonian Institution (On extended Loan to the Alabama Space and Rocket Center

street & number

city, town Washington ___ vicinity of state D.C.

## 5. Location of Legal Description

courthouse, registry of deeds, etc. N/A

street & number

city, town state

## 6. Representation in Existing Surveys

title None has this property been determined eligible? ___ yes ___ no

date ___ federal ___ state ___ county ___ local

depository for survey records

city, town state

# 7. Description

| Condition | | Check one | Check one |
|---|---|---|---|
| X excellent | ___ deteriorated | X unaltered | ___ original site |
| ___ good | ___ ruins | ___ altered | ___ moved date _____ |
| ___ fair | ___ unexposed | | |

**Describe the present and original (if known) physical appearance**

The Lunar Landing Training Vehicle (LLTV) is a free-flight vehicle consisting of a tubular frame on which a crew station, jet engine, lift rockets, attitude control rockets, control electronics, and associated equipment are mounted. The gimbaled jet engine, which is mounted vertically, provides main power for takeoff and supports five-sixths of the weight of the vehicle during simulation of the lunar environment. The remaining one-sixth is lifted by two 500-pound maximum thrust, throttleable lift rockets to simulate the Lunar Module descent engine. The cockpit includes a Lunar Module three-axis attitude control assembly, the throttle for the lift rockets, a horizontal velocity indicator, the altitude-rate tape indicator, and a thrust-to-weight indicator. Although the pilot of the Lunar Landing Training Vehicle was seated because of the necessity for a rocket-propelled ejection seat, the location of the flight instruments and controls relative to the pilot's hand and eyes was similar to that in the actual Lunar Landing Module.

The Lunar Landing Training Vehicle is the third of three such vehicles built for the National Aeronautics and Space Administration. It is in excellent condition and retains all of its original equipment.

# 8. Significance

| Period | Areas of Significance—Check and justify below | | | |
|---|---|---|---|---|
| ___ prehistoric | ___ archeology-prehistoric | ___ community planning | ___ landscape architecture | ___ religion |
| ___ 1400–1499 | ___ archeology-historic | ___ conservation | ___ law | ___ science |
| ___ 1500–1599 | ___ agriculture | ___ economics | ___ literature | ___ sculpture |
| ___ 1600–1699 | ___ architecture | ___ education | ___ military | ___ social/ humanitarian |
| ___ 1700–1799 | ___ art | X engineering | ___ music | ___ theater |
| ___ 1800–1899 | ___ commerce | ___ exploration/settlement | ___ philosophy | X transportation |
| X 1900– | ___ communications | ___ industry | ___ politics/government | X other (specify) Space Exploration |
| | | ___ invention | | |

**Specific dates** 1967–1972 **Builder/Architect** Bell Aerosystems

**Statement of Significance (in one paragraph)**

The value of high-fidelity simulation and training was an accepted part of the Space program. The dependence of this training for the success of every mission and the safety of the crew was crucial because of the nature of space flight. Flight crews are fully committed at lift-off for an entire mission in which a broad number of variables and obstacles must be successfully surmounted. Unlike aircraft which allow for a broad range of training opportunities in actual aircraft under flight conditions, space flight is necessarily limited to ground simulation training before the actual flight. The success of the mission and safety of the crew is dependent on the success of space flight simulation and training available to the astronauts before each actual flight.

The landing of a manned machine, the Lunar Module, on the surface of the moon was crucial to the success of the program. The feat itself could not be practiced before a touchdown was initiated. Therefore it was necessary to devise training aids and simulators here on the Earth to train the astronauts in the techniques and skills necessary to land on the moon. This was the mission and reason for the Lunar Landing Training Vehicle. Its purpose was to simulate lunar landings on the Earth in a controlled and safe environment.

The National Aeronautics and Space Administration ordered three of these vehicles for the use of its Apollo Astronauts. Two Lunar Landing Training Vehicles crashed during flight training excercises.

This vehicle is the third Lunar Landing Training Vehicle ordered by NASA and is the only surviving example of the type. Crews from Apollo 9, 12, 13, 14, 16, and 17 trained on this vehicle. Neil Armstrong, the first man to land on the moon, trained on another Lunar Landing Training Vehicle that crashed during his flight. After Neil Armstrong's crash, NASA suggested dropping training in the Lunar Landing Training Vehicle as too risky, but the astonauts insisted that this training continue in the belief that it accurately forecasted conditions of a Lunar Landing on the moon.

Bibliography

Brooks, Courtney G., Grimwood, James M., and Swenson, Loyd S. Chariots for Apollo: A History of Manned Lunar Spacecraft. Washington, D.C.: National Aeronautics and Space Administration, 1979.

Cortright, Edgar M. ed. Apollo Expeditions to the Moon. Washington, D.C.: National Aeronautics and Space Administration, 1975.

Ertel, Ivan D., Newkirk, Roland W., and Brooks, Courtney G. The Apollo Spacecraft A Chronology. Vol IV. Washington, D.C.: National Aeronautics and Space Administration, 1978.

## 9. Major Bibliographical References

See continuation sheets

## 10. Geographical Data

Acreage of nominated property N/A

Quadrangle name Madison

Quadrangle scale 1:24,000

UMT References

| | Zone | Easting | Northing |
|---|---|---|---|
| A | 16 | 5 0 1 5 2 0 | 3 8 4 0 7 8 0 |
| B | | | |
| C | | | |
| D | | | |
| E | | | |
| F | | | |
| G | | | |
| H | | | |

**Verbal boundary description and justification**

The Lunar Landing Training Vehicle is an object in the collection of the Alabama Space and Rocket Center.

**List all states and counties for properties overlapping state or county boundaries**

| state | code | county | code |
|---|---|---|---|
| state | code | county | code |

## 11. Form Prepared By

name/title Harry A. Butowsky

organization National Park Service date May 15, 1984

street & number Division of History telephone (202) 343-8168

city or town Washington, D.C. 20240 state

## 12. State Historic Preservation Officer Certification

The evaluated significance of this property within the state is:

___ national ___ state ___ local

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89-665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service.

State Historic Preservation Officer signature

title date

For NPS use only

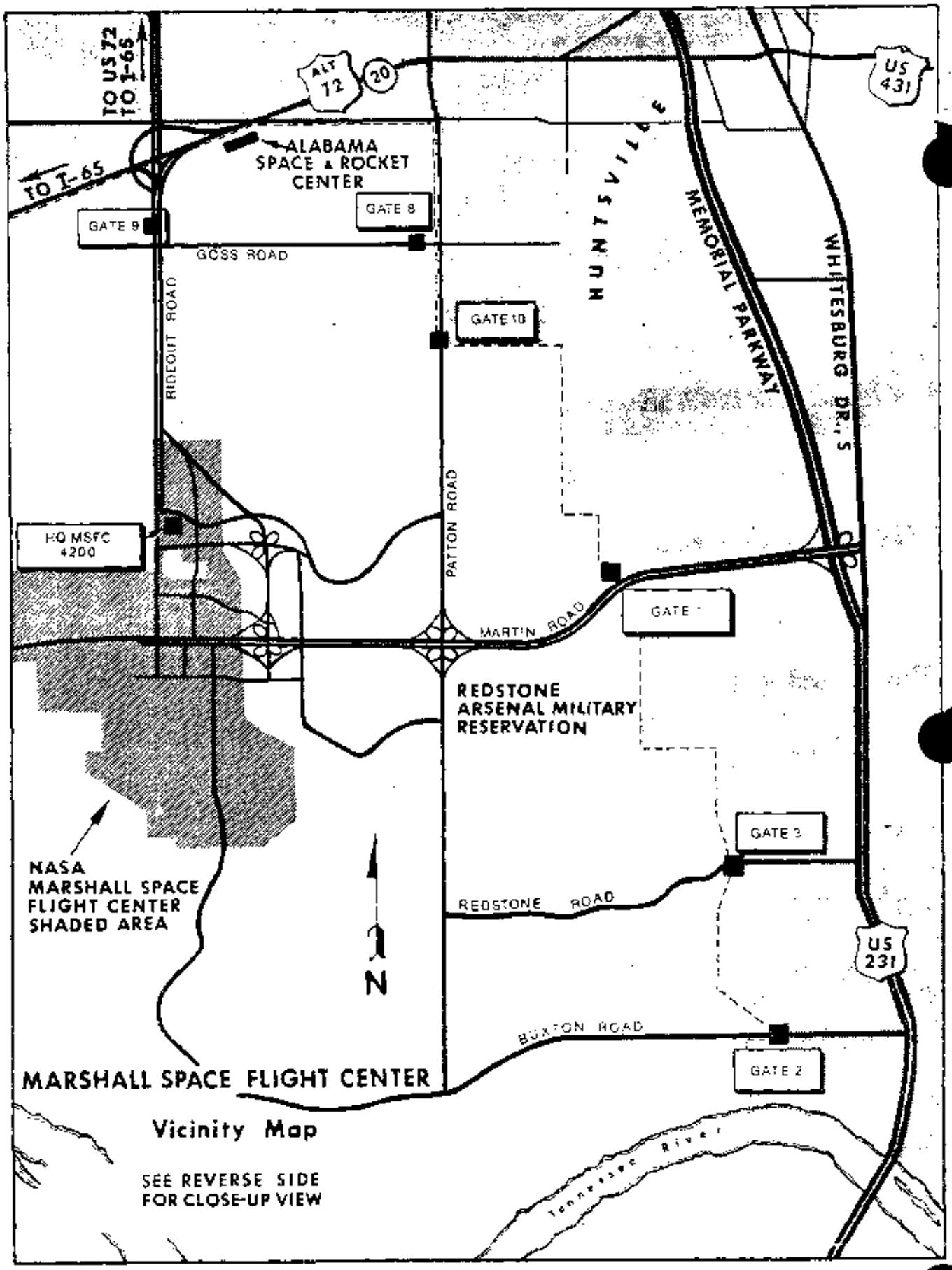
I hereby certify that this property is included in the National Register

date

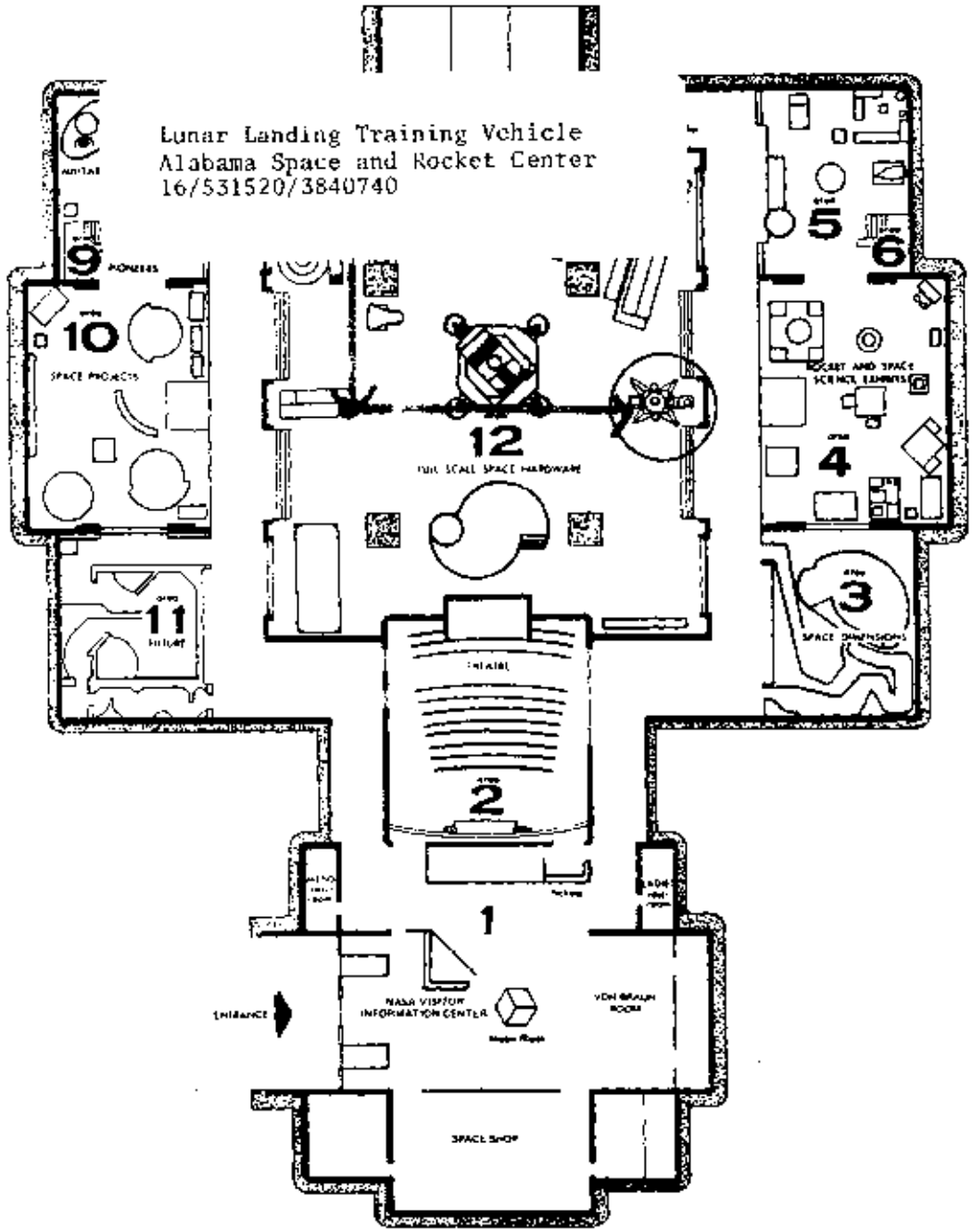
Keeper of the National Register

Attest: date

Chief of Registration

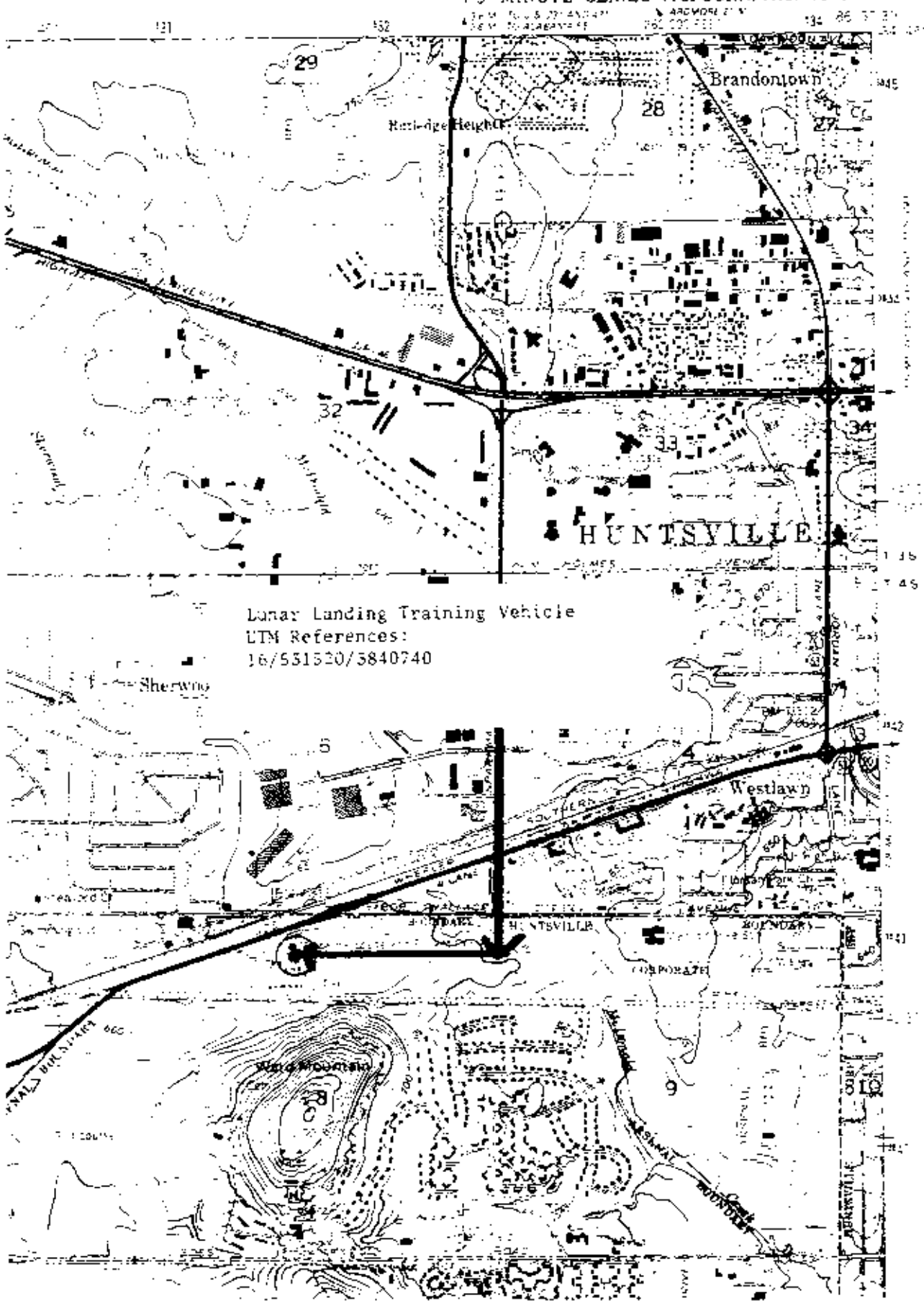

TO US 72
TO I-65
ALT 72
20
US 431
TO I-65
ALABAMA SPACE & ROCKET CENTER
GATE 8
GATE 9
GOSS ROAD
REDOUT ROAD
GATE 10
HUNTSVILLE
MEMORIAL PARKWAY
WHITESBURG DR., S
PATTON ROAD
HQ MSFC 4200
MARTIN ROAD
GATE
REDSTONE ARSENAL MILITARY RESERVATION
GATE 3
NASA MARSHALL SPACE FLIGHT CENTER SHADED AREA
N
REDSTONE ROAD
US 231
BUXTON ROAD
GATE 2
MARSHALL SPACE FLIGHT CENTER
Vicinity Map
SEE REVERSE SIDE FOR CLOSE-UP VIEW
Tennessee River

# YOUR GUIDE TO



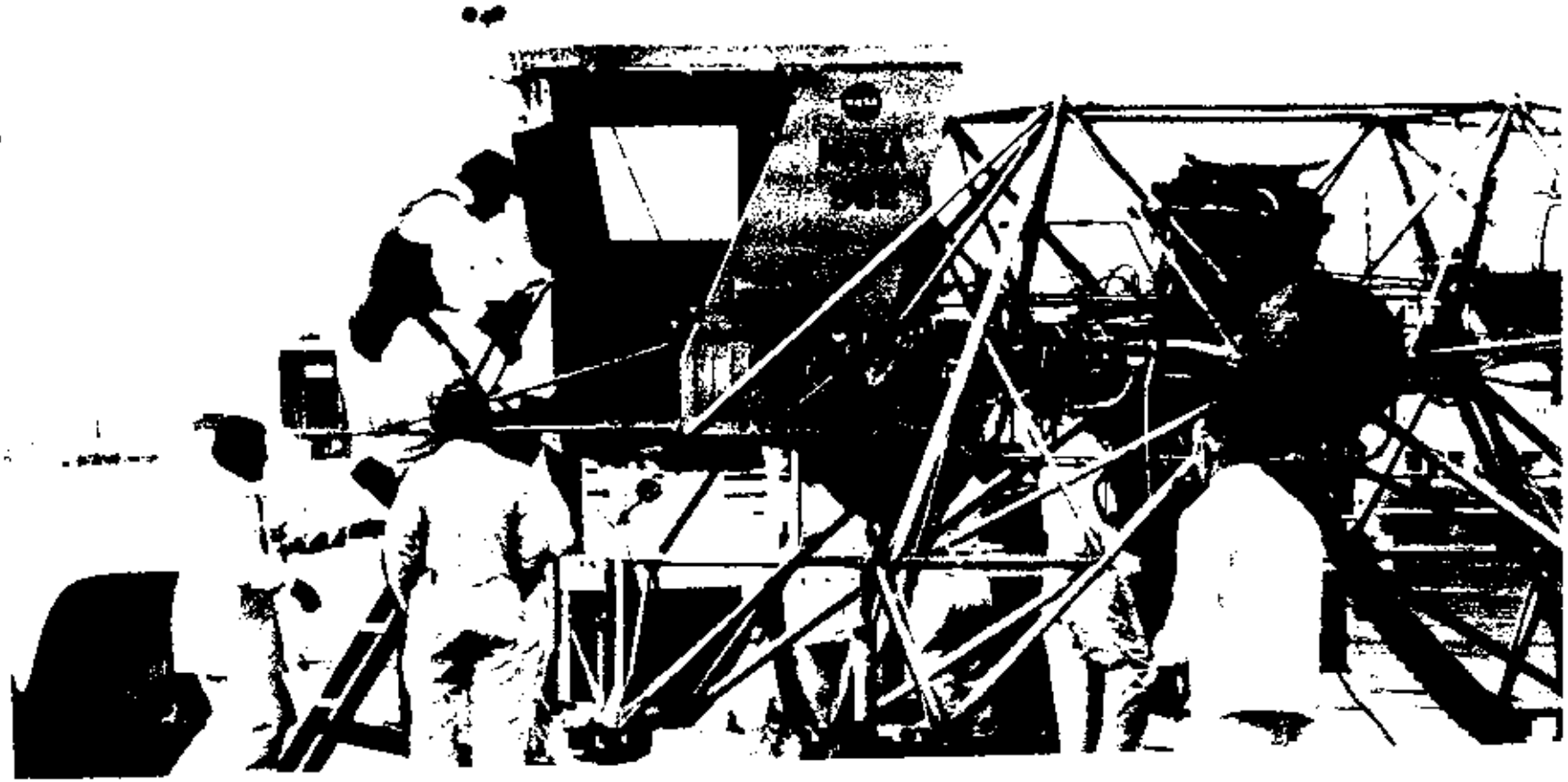

# ALABAMA SPACE & ROCKET CENTER

MADISON QUADRANGLE
ALABAMA - MADISON CO.
7.5 MINUTE SERIES (TOPOGRAPHIC) 7.5-NW

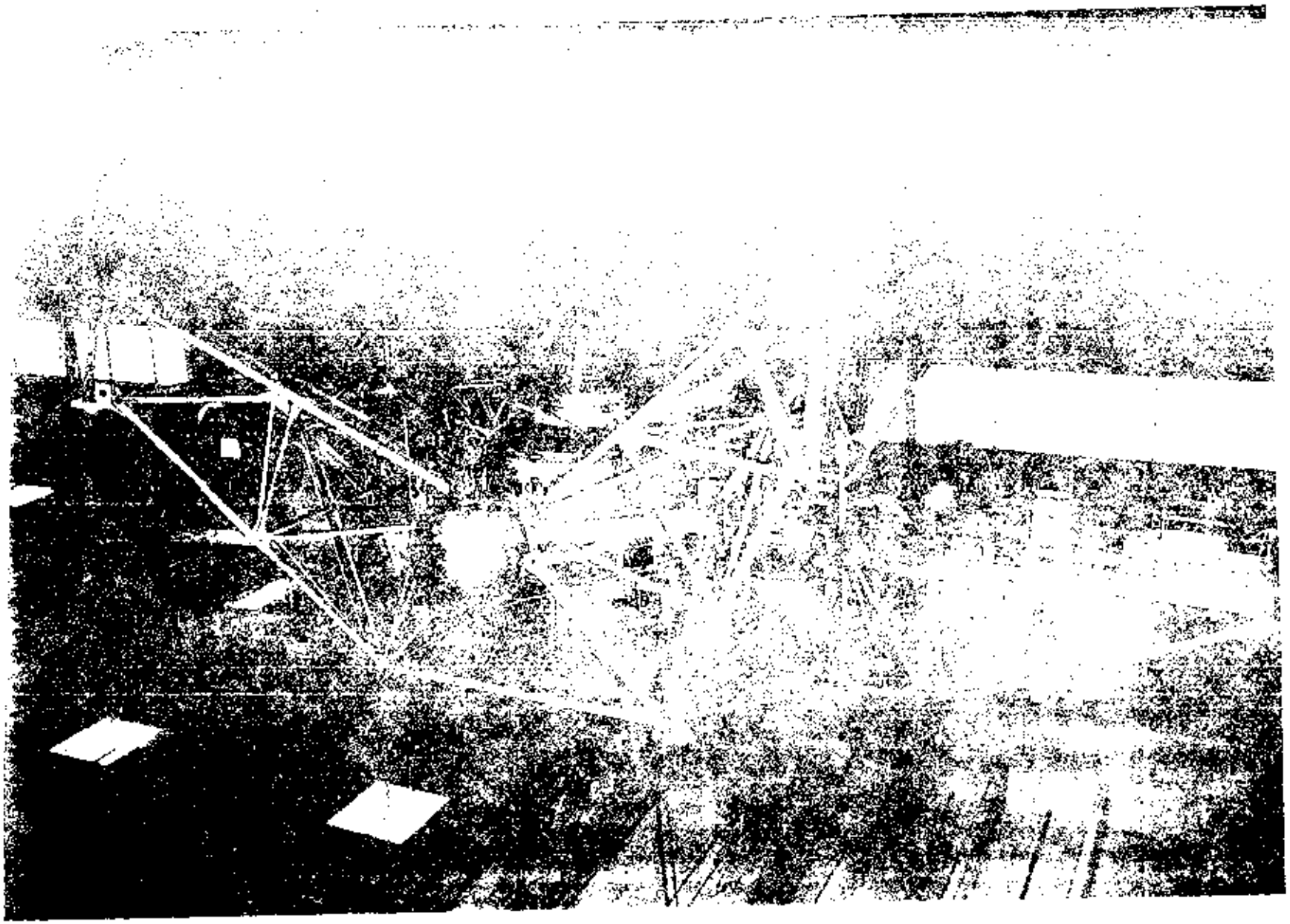


1. Lunar Landing Training Vehicle # 952
2. Huntsville, Alabama
3. NASA
4. 1972
5. Alabama Space and Rocket Center
6. Lunar Landing Training Vehicle with Astronaut John Young at the controls

NASA
S-72-31480



1. Lunar Landing Training Vehicle #952
2. Huntsville, Alabama
3. Alabama Space and Rocket Center
4. 1984
5. Alabama Space and Rocket Center
6. Modern photo of Lunar Landing Training Vehicle on display at the Alabama Space and Rocket Center



NPS Form 10-900
(7-81)

**United States Department of the Interior**
**National Park Service**

# National Register of Historic Places Inventory—Nomination Form

For NPS use only
received
date entered

See instructions in *How to Complete National Register Forms*
Type all entries—complete applicable sections

## 1. Name

historic 30-by 60-Foot Tunnel

and/or common Full Scale Tunnel

## 2. Location

street & number Langley Research Center ___ not for publication

city, town Hampton ___ vicinity of congressional district

state Virginia code 51 county Hampton code 650

## 3. Classification

| Category | Ownership | Status | Present Use | |
|---|---|---|---|---|
| ___ district | X public | ___ occupied | ___ agriculture | ___ museum |
| ___ building(s) | ___ private | ___ unoccupied | ___ commercial | ___ park |
| X structure | ___ both | ___ work in progress | ___ educational | ___ private residence |
| ___ site | **Public Acquisition** | **Accessible** | ___ entertainment | ___ religious |
| ___ object | ___ in process | X yes: restricted | X government | X scientific |
| | ___ being considered | ___ yes: unrestricted | ___ industrial | ___ transportation |
| | | ___ no | ___ military | X other: Aeronautical Research |

## 4. Owner of Property

name National Aeronautics and Space Administration (NASA)

street & number

city, town Washington ___ vicinity of state D.C. 20546

## 5. Location of Legal Description

courthouse, registry of deeds, etc. National Aeronautics and Space Administration (NASA)

street & number Real Property Management Office Code NXG

city, town Washington state D.C. 20546

## 6. Representation in Existing Surveys

title None has this property been determined eligible? ___ yes ___ no

date ___ federal ___ state ___ county ___ local

depository for survey records

city, town state

# 7. Description

| Condition | | Check one | Check one |
|---|---|---|---|
| X excellent | ___ deteriorated | ___ unaltered | X original site |
| ___ good | ___ ruins | X altered | ___ moved date 1931 |
| ___ fair | ___ unexposed | | |

**Describe the present and original (if known) physical appearance**

The Full Scale Tunnel is in building 643 in the East Area of Langley Research Center.

The general arrangement of the Full Scale Tunnel is shown in Appendix 1 at the rear of this report. The tunnel is a double return flow type with an open throat having a horizontal dimension of 60 feet and a vertical dimension of 30 feet. On either side of the test chamber is a return passage 50 feet wide, with a height varying from 46 to 72 feet. The entire equipment is housed in the structure, the outside walls of which serve as the outer walls of the return passages. The over-all length of the tunnel is 434 feet by 222 feet and the maximum height is 97 feet. The framework is on structural steel and the walls and roof are of 5/16-inch corrugated cement asbestos sheets. The entrance and exit cones are constructed of 2-inch wood planking, attached to a steel frame and covered on the inside with galvanized sheet metal as protection against fire.[1]

The test section in the open throat is 30 feet high and 60 feet wide and can accommodate airplanes or models having spans to about 40 feet. The tunnel is powered by two four-blade, 35.5 foot diameter fans, each driven by a 4000-horsepower electric motor. Airflow from the dual propellers is split right and left into two streams; doubling back between the test section and the building's wall, the streams are reunited prior to entering the throat of the test section.

The maximum air-speed of the tunnel is about 100 mph. When this tunnel was first placed in operation in 1931, its maximum air-speed was equal to the top speed of many airplanes then flying. Since then, not only has the maximum speed of airplanes far surpassed that of the tunnel, but transonic and supersonic airplanes operate in realms into which low-speed data cannot be extrapolated. The design of these airplanes, however, has required wing shapes and airfoil sections that sometimes result in poor low speed characteristics. The Full Scale Tunnel is well suited to investigate means of alleviating these low speed problems because full or large scale hardware can be used, and the model or airplane is readily accessible.[2]

In addition to the testing capabilities of extensive flow measurement and visualization for large scale-models, the tunnel is equipped with shielded struts for six-component scale balance testing, and can also be used for free-flight testing of subscale models. These tests are particularly suited to the study of high-angle-of-attack flight dynamics for advanced fighter configurations.[3]

The Full Scale Tunnel was upgraded in 1973 and is scheduled to be upgraded in 1984. Work in both cases primarily involved work done on the electric motors that power the fans. At the current time, principal research for this facility is directed at the study of the low-speed aerodynamics, static and dynamic stability and control, and associated flow characteristics of military, general aviation, and commuter aircraft.[4]

Man in Space Theme Study
Federal Agency Nomination

NPS Form 10-900
(7-81)

United States Department of the Interior
National Park Service

# National Register of Historic Places Inventory—Nomination Form

For NPS use only
received
date entered

See instructions in *How to Complete National Register Forms*
Type all entries—complete applicable sections

## 1. Name

historic Neutral Buoyancy Space Simulator

and/or common Neutral Buoyancy Space Simulator

## 2. Location

street & number George C. Marshall Space Flight Center ___ not for publication

city, town Huntsville ___ vicinity of congressional district

state Alabama code 01 county Madison code 089

## 3. Classification

| Category | Ownership | Status | Present Use | |
|---|---|---|---|---|
| ___ district | X public | ___ occupied | ___ agriculture | ___ museum |
| X building(s) | ___ private | ___ unoccupied | ___ commercial | ___ park |
| X structure | ___ both | ___ work in progress | ___ educational | ___ private residence |
| ___ site | **Public Acquisition** | **Accessible** | ___ entertainment | ___ religious |
| ___ object | ___ in process | X yes: restricted | X government | X scientific |
| | ___ being considered | ___ yes: unrestricted | ___ industrial | ___ transportation |
| | | ___ no | ___ military | X other: Space Exploration |

## 4. Owner of Property

name National Aeronautics and Space Administration (NASA)

street & number

city, town Washington ___ vicinity of state D.C. 20546

## 5. Location of Legal Description

courthouse, registry of deeds, etc. National Aeronautics and Space Administration (NASA)

street & number Real Property Management Office Code NXG

city, town Washington state D.C. 20546

## 6. Representation in Existing Surveys

title Historic Properties Report (Draft) has this property been determined eligible? ___ yes ___ no

date July 1983 X federal ___ state ___ county ___ local

depository for survey records U.S. Army Redstone Arsenal

city, town Huntsville state Alabama

# 7. Description

| Condition | | Check one | Check one |
|---|---|---|---|
| X excellent | ___ deteriorated | X unaltered | X original site |
| ___ good | ___ ruins | ___ altered | ___ moved date _____ |
| ___ fair | ___ unexposed | | |

**Describe the present and original (if known) physical appearance**

The Neutral Buoyancy Simulator is in Building 4705 at the Marshall Space Flight Center in Huntsville, Alabama. A large water tank, 75 feet in diameter and 40 feet deep is the heart of the simulator. The water within the simulator is temperature controlled, continuously recirculated, and filtered. There are four observation levels with portholes to view activities within the simulator. An elevator serves all four observation levels. Special systems are integrated into the tank for underwater audio and video, pressure-suit environmental control, and emergency rescue and treatment. Life support is simultaneously provided by these systems for up to four pressure-suited subjects. Additional systems include data acquisition and recording, underwater lighting, special underwater pneumatic and electrical power operations of motor, valves, controls, and indicators that are required for high fidelity, and functional engineering mockups and trainers.

Adjacent to the Neutral Buoyancy Simulator is a completely equipped test control area for directing, controlling, and monitoring simulation activities in the Neutral Buoyancy Simulator. An annex contains the operating crew dressing and shower area.[1]

# 8. Significance

| Period | Areas of Significance—Check and justify below | | | |
|---|---|---|---|---|
| ___ prehistoric | ___ archeology-prehistoric | ___ community planning | ___ landscape architecture | ___ religion |
| ___ 1400–1499 | ___ archeology-historic | ___ conservation | ___ law | ___ science |
| ___ 1500–1599 | ___ agriculture | ___ economics | ___ literature | ___ sculpture |
| ___ 1600–1699 | ___ architecture | ___ education | ___ military | ___ social/ humanitarian |
| ___ 1700–1799 | ___ art | X engineering | ___ music | ___ theater |
| ___ 1800–1899 | ___ commerce | ___ exploration/settlement | ___ philosophy | ___ transportation |
| X 1900– | ___ communications | ___ industry | ___ politics/government | X other (specify) Space Exploration |
| | | ___ invention | | |

**Specific dates** 1955-Present **Builder/Architect** U.S. Army, NASA

**Statement of Significance (in one paragraph)**

The Neutral Buoyancy Simulator was constructed in 1955 by the Army at the Redstone Arsenal. It was designed to provide a simulated zero-gravity environment in which engineers, designers, and astronauts could perform, for extended periods of time, the various phases of research needed to gain first hand knowledge concerning design and operation problems associated with working in the zero-gravity environment of space. Because of this capability to support research and testing of operational techniques and materials needed to successfully performed manned space missions the Neutral Buoyancy Simulator contributed significantly to the American manned space program especially Projects Gemini, Apollo, Skylab, and the Space Shuttle. The Neutral Buoyancy Simulator is a facility that is unique within the NASA inventory of training facilities. Until the mid-1970s, when an additional facility was constructed at the Johnson Space Flight Center to support the Space Shuttle Program, this facility was the only test facility that allowed astronauts to become familiar with the dynamics of body motion under weightless conditions.

The Neutral Buoyancy Simulator is on the NASA public tour of the Marshall Space Flight Center and is interpreted to the public.

Footnotes

1. George C. Marshall Space Flight Center Master Plan (Washington, D.C.: National Aeronautics and Space Administration, 1980), p.31.

Bibliography

Brooks, Courtney G., Grimwood, James M., and Swenson, Loyd S. Chariots for Apollo: A History of Manned Lunar Spacecraft. Washington, D.C.: National Aeronautics and Space Administration, 1979.

Draft Historic Properties Report Redstone Arsenal, Alabama with the George C. Marshall Space Flight Center. Silver Spring, Maryland: Building Technology Incorporated, 1983.

Master Plan George C. Marshall Space Flight Center. Washington, D.C.: National Aeronautics and Space Administration, 1980.

Technical Facilities Catalog Vol. III. Washington, D.C.: National Aeronautics and Space Administration, 1974.

## 9. Major Bibliographical References

See continuation sheets

## 10. Geographical Data

Acreage of nominated property: Less than 1 acre

Quadrangle name: Madison

Quadrangle scale: 1:24,000

UMT References

| | Zone | Easting | Northing |
|---|---|---|---|
| A | 16 | 529500 | 3834500 |
| B | | | |
| C | | | |
| D | | | |
| E | | | |
| F | | | |
| G | | | |
| H | | | |

**Verbal boundary description and justification**

The boundary of the Neutral Buoyancy Simulator is defined by the outside perimeter of Building 4705 at the Marshall Space Flight Center

**List all states and counties for properties overlapping state or county boundaries**

state _____ code _____ county _____ code _____

state _____ code _____ county _____ code _____

## 11. Form Prepared By

name/title: Harry A. Butowsky

organization: National Park Service

date: May 15, 1984

street & number: Division of History

telephone: (202) 343-8168

city or town: Washington, D.D. 20240

state: _____

## 12. State Historic Preservation Officer Certification

The evaluated significance of this property within the state is:

___ national ___ state ___ local

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89-665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service.

State Historic Preservation Officer signature _____

title _____ date _____

For NPS use only

I hereby certify that this property is included in the National Register

date _____

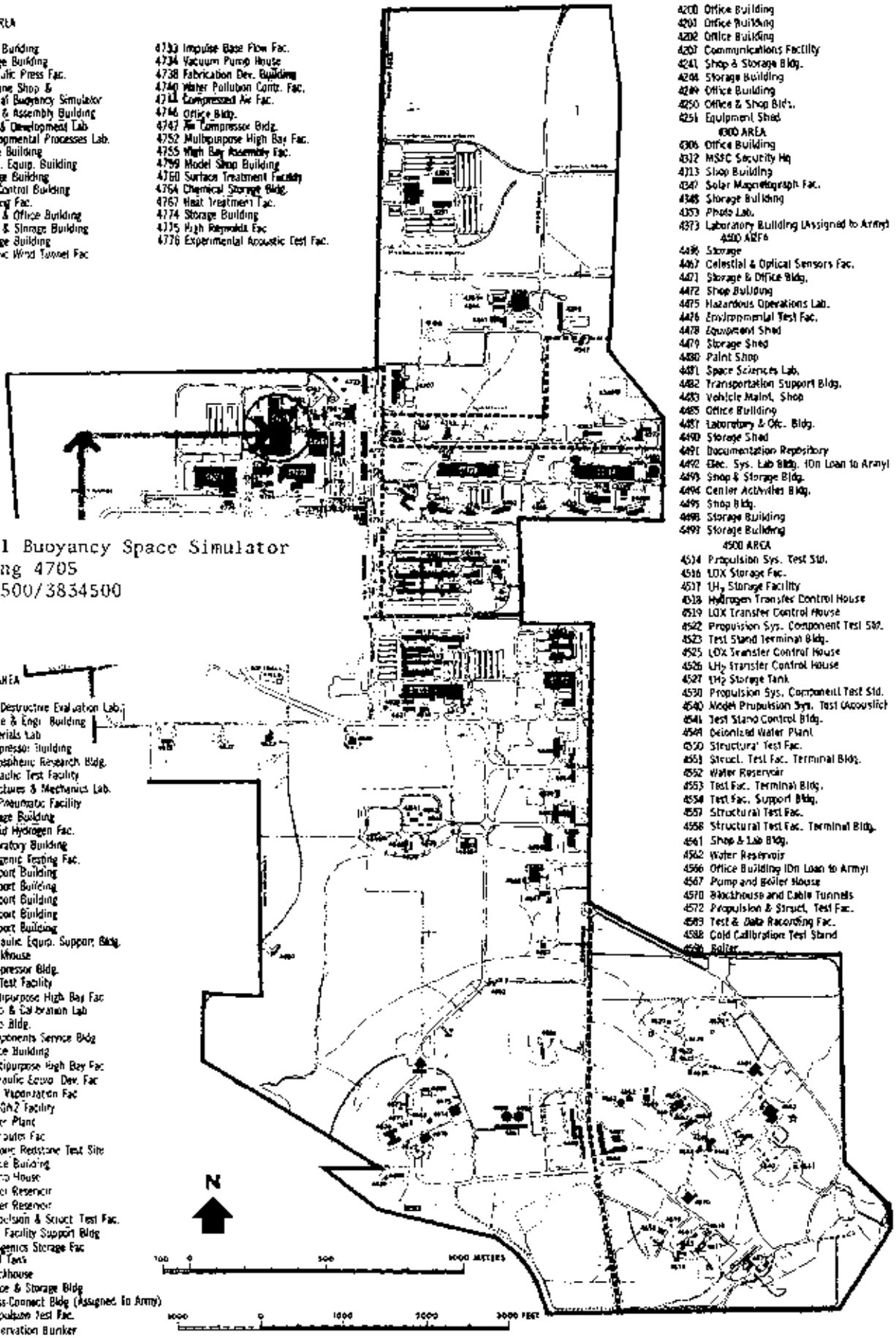
Keeper of the National Register

Attest: date _____

Chief of Registration

# MARSHALL SPACE FLIGHT CENTER, ALABAMA

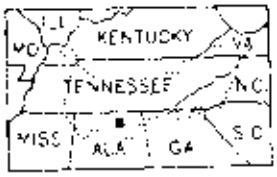
## FACILITIES SITE MAP



Neutral Buoyancy Space Simulator
UTM References:
16/529500/3834500

NASA BDY
FLIGHT CENTER (NASA)
WHEELER NATIONAL WILDLIFE REFUGE
WHEELER LAKE
ELEV 556
Mile 7
Mile 6
Oxidation ponds (sewage)
Chemical
Substation
Microwave tower
Water
Jordan Cem
Moore Cem
Cem
MARSHALL ROAD
MORRIS ROAD
DIGNEY ROAD
OLD MAIL ROAD
FOWLER
REFUGE
BOUNDARY
WHEELER
Indian Creek
TRIANA 7.5-SW R 2W R 1W
FARLEY 9 MI
SCALE 1:24 000

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929



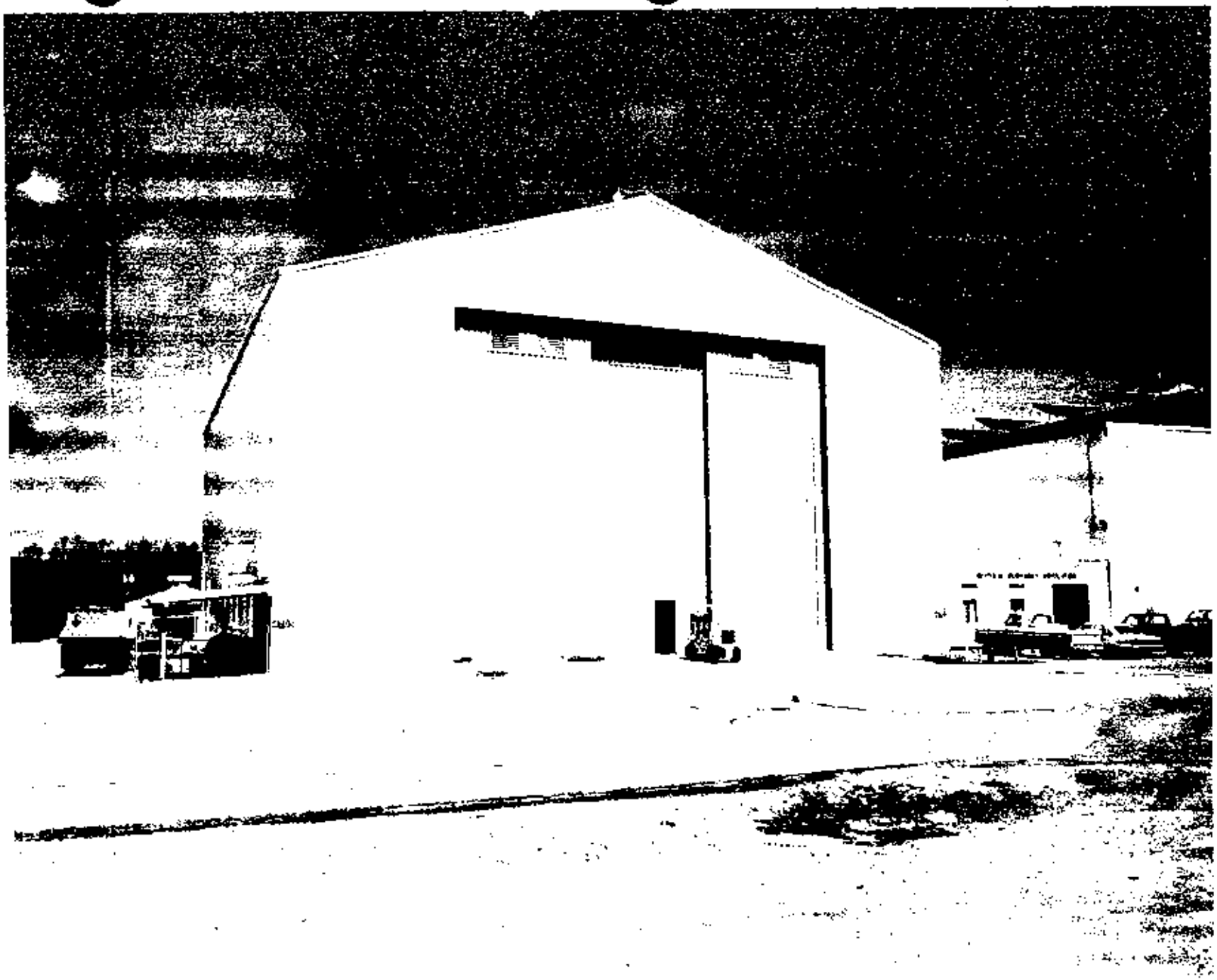
QUADRANGLE LOCATION

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, RESTON, VIRGINIA 22092
NESSEE VALLEY AUTHORITY, CHATTANOOGA, TENN. 37401 OR KNOXVILLE, TENN. 37902
OLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

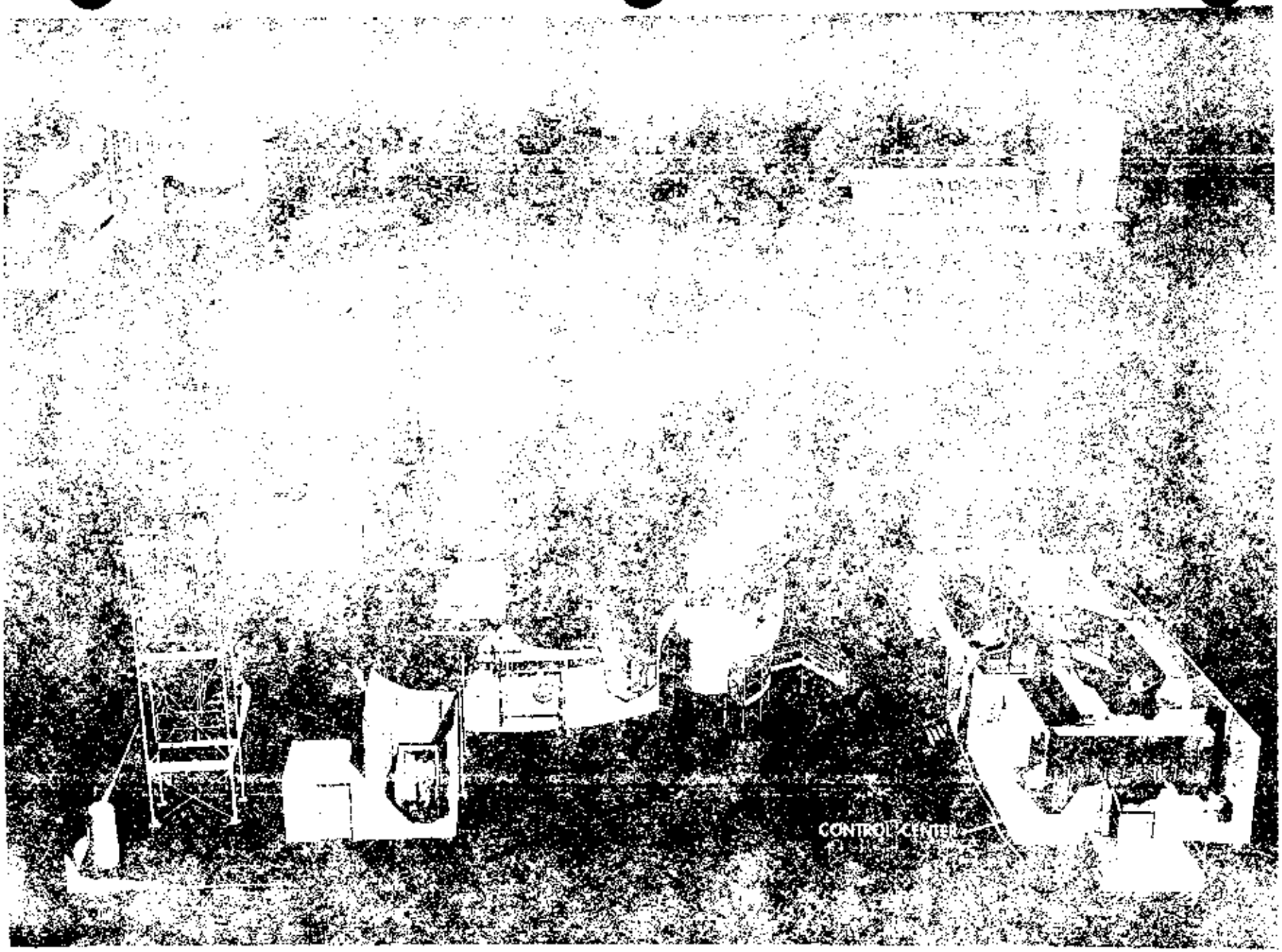
Primary
hard sur
Seconda
hard sur

There may be private inholdings with
of the National or State reservations sh

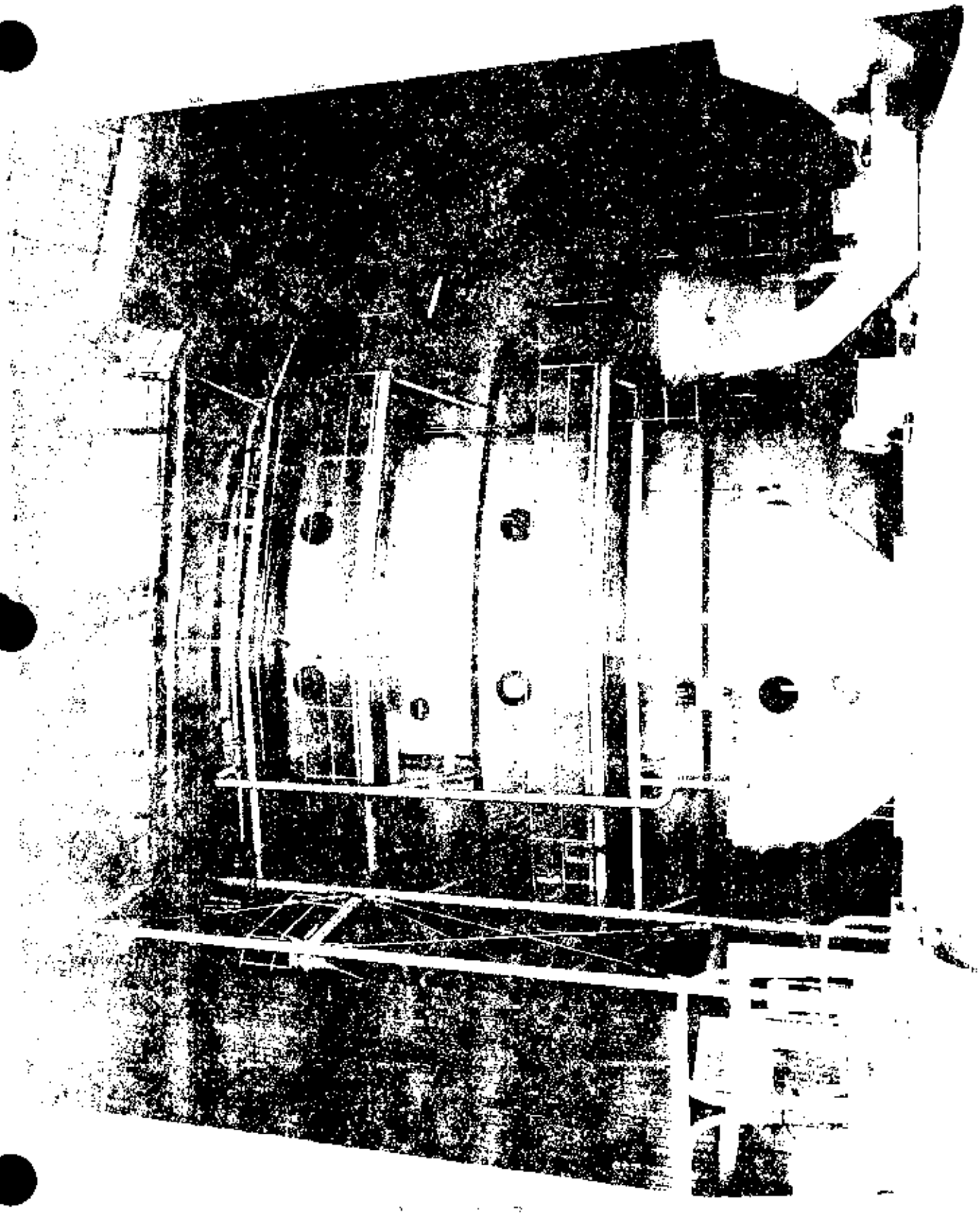
1. Neutral Buoyancy Space Simulator
2. Huntsville, Alabama
3. NASA
4. 1984
5. NASA, Marshall Space Flight Center Facilities Office
6. Exterior View of Neutral Buoyancy Space Simulator



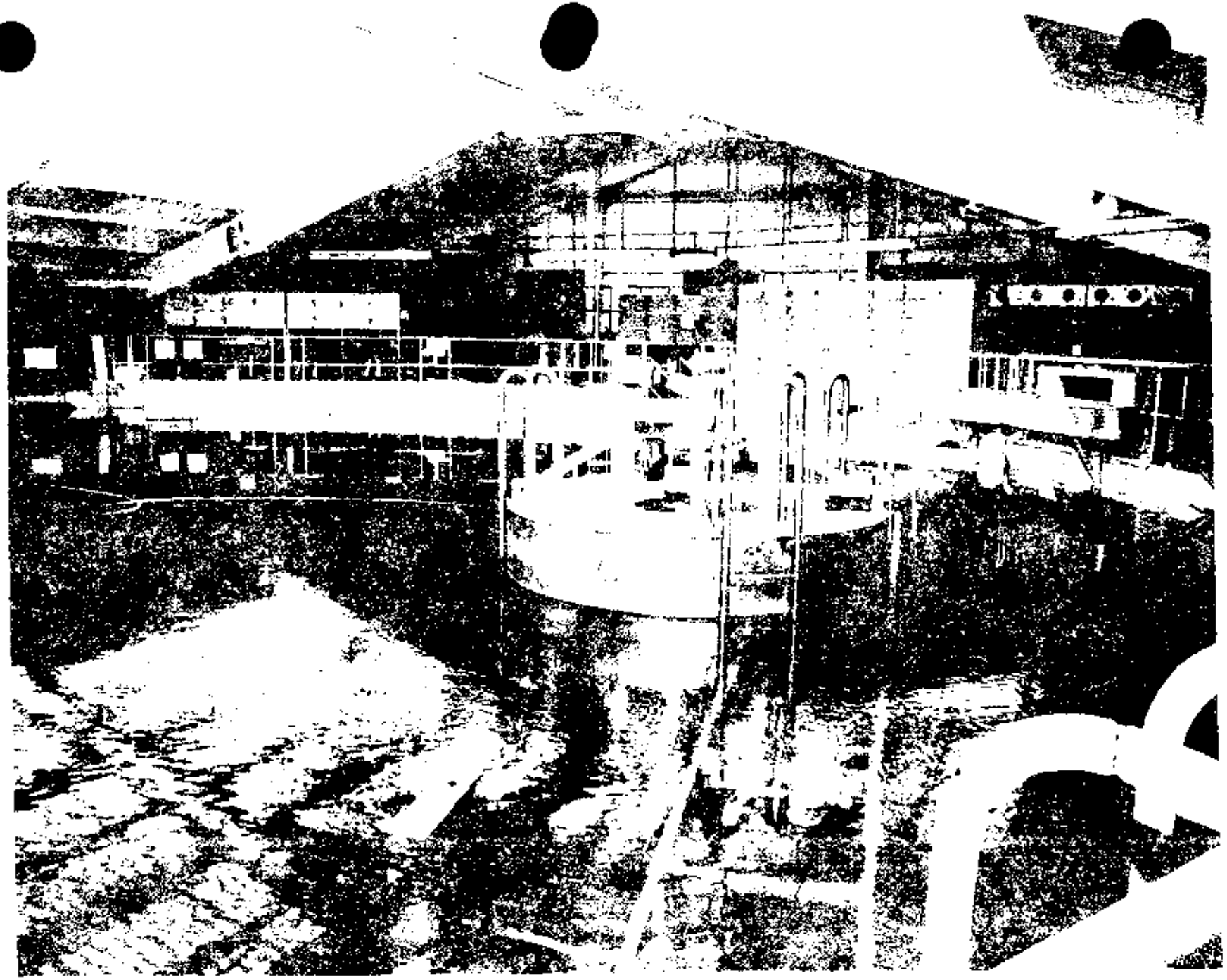
1. Neutral Buoyancy Space Simulator
2. Huntsville, Alabama
3. NASA
4. 1971
5. NASA, Marshall Space Flight Center Facilities Office
6. Cutaway View of facility


CONTROL CENTER

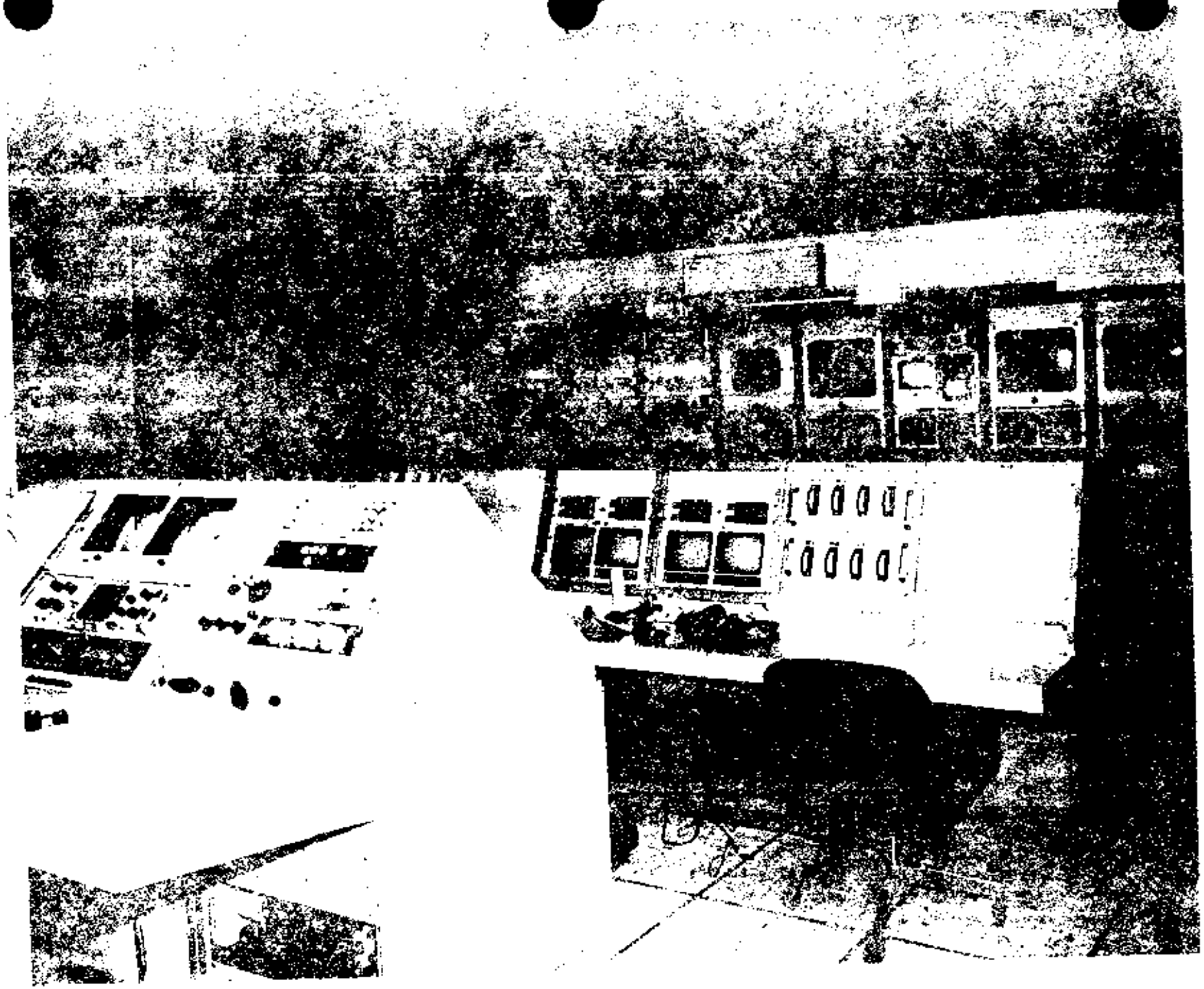
1. Neutral Buoyancy Space Simulator
2. Huntsville, Alabama
3. NASA
4. 1984
5. NASA, Marshall Space Flight Center Facilities Office
6. Exterior View of Water Tank



1. Neutral Buoyancy Space Simulator
2. Huntsville, Alabama
3. NASA
4. 1984
5. NASA, Marshall Space Flight Center Facilities Office
6. Top of Water Tank



1. Neutral Buoyancy Space Simulator
2. Huntsville, Alabama
3. NASA
4. 1984
5. NASA, Marshall Space Flight Center
   Facilities Office
6. Interior View of Control Room



1. Neurtal Buoyancy Space Simulator
2. Huntsville, Alabama
3. NASA
4. 1980
5. NASA, Marshall Space Flight Center Facilities Office
6. Interior View of Water Tank with astronaut and support personnel

## APOLLO HARDWARE TEST FACILITIES

18. Space Environment Simulation Laboratory
(Lyndon B. Johnson Space Center)

Man in Space Theme Study
Federal Agency Nomination

NPS Form 10-900
(7-81)

**United States Department of the Interior**
**National Park Service**

For NPS use only
received
date entered

# National Register of Historic Places Inventory—Nomination Form

See instructions in *How to Complete National Register Forms*
Type all entries—complete applicable sections

## 1. Name

historic Space Environment Simulation Laboratory (SESL)

and/or common Space Environment Simulator Laboratory (SESL)

## 2. Location

street & number Lyndon B. Johnson Space Center ___ not for publication

city, town Houston ___ vicinity of congressional district

state Texas code 48 county Harris code 201

## 3. Classification

| Category | Ownership | Status | Present Use | |
|---|---|---|---|---|
| ___ district | X public | ___ occupied | ___ agriculture | ___ museum |
| ___ building(s) | ___ private | ___ unoccupied | ___ commercial | ___ park |
| X structure | ___ both | ___ work in progress | ___ educational | ___ private residence |
| ___ site | **Public Acquisition** | **Accessible** | ___ entertainment | ___ religious |
| ___ object | ___ in process | X yes: restricted | ___ government | ___ scientific |
| | ___ being considered | ___ yes: unrestricted | ___ industrial | ___ transportation |
| | | ___ no | ___ military | X other: Inactive |

## 4. Owner of Property

name National Aeronautics and Space Administration (NASA)

street & number

city, town Washington ___ vicinity of state D.C. 20546

## 5. Location of Legal Description

courthouse, registry of deeds, etc. National Aeronautics and Space Administration (NASA)

street & number Real Property Management Office Code NXG

city, town Washington state D.C. 20546

## 6. Representation in Existing Surveys

title None has this property been determined eligible? ___ yes ___ no

date ___ federal ___ state ___ county ___ local

depository for survey records

city, town state

# 7. Description

| Condition | | Check one | Check one |
|---|---|---|---|
| X excellent | ___ deteriorated | X unaltered | X original site |
| ___ good | ___ ruins | ___ altered | ___ moved date _____ |
| ___ fair | ___ unexposed | | |

**Describe the present and original (if known) physical appearance**

The Space Environment Simulation Laboratory (SESL) is in building 32 at the Lyndon B. Johnson Space Center (JSC) in Houston, Texas. The SESL contains two large man-rated chambers, instrumentation and data systems, and support facilities.

Chamber A is the largest of the JSC thermal-vacuum test facilities. Its usable test volume and high-fidelity space simulation capabilities are adaptable to thermal-vacuum tests of a wide variety of test articles.

The major structural elements of the chamber are the rotatable floor, the 40 foot diameter access door, and the dual manlocks at the floor level and at the 31 foot level.

The chamber floor, which is 45 feet in diameter, can be rotated by manual control $\pm$ 180° about its vertical axis at continuously variable angular velocities up to a maximum of 0.8 rpm.

Test articles are normally inserted into the chamber by means of overhead cranes and a dolly and track structure that extends from the high-bay area into the chamber. Two 100,000 lb cranes are used outside the chamber and four independently operated 50,000 lb cranes, lowered through removable sections of the top head, are employed inside the chamber.

The dual manlocks provide a means for the test crew to move from ambient air pressure to the thermal-vacuum environment and back. They also provide for the maintenance of rescue crewmen at convenient intermediate pressures during manned test operations. When the inner door is bolted, either of the manlocks can be used as an altitude chamber for independent tests.

In Chamber A, a test article can be irradiated from either the top or the side with high-fidelity solar simulation. The solar simulation modules can be arranged in various dimensional configurations to meet most requirements. This chamber can also generate thermal plasmas simulating those found in low Earth orbit.

Chamber B, the smaller man-rated chamber, has the same basic capability as Chamber A and can accommodate a variety of smaller scale tests more economically and with faster response. Major structural elements of the chamber are the removable top head, the fixed chamber floor, and a dual manlock at the floor level.

The load-bearing floor area is 20 feet in diameter and will support a concentric load of 75,000 lb.

Two rolling bridge cranes with a capacity of 100 000 lb. are used to remove the chamber top and to insert large test articles.

The dual manlock provides easy access to the test articles as well as a means of transporting test crewmen to the test environment and back during manned tests. The manlock can also be used as an altitude chamber for independent tests. In addition, one manlock is equipped with a water deluge system and other features that permit its use for manned operations with oxygen-rich residual atmospheres.

A solar simulation array, mounted on the top head, is modular in design to facilitate changes in location and beam size to accommodate test requirements.

The solar simulation modules are on-axis with xenon lamp sources. The source and collection optics are outside the chamber, with the collimating optics inside the chamber. Solar incident angles other than vertical can be achieved by installing mirrors in the chamber to redirect the solar beam.[1]

Only Chambers A and B are within the boundary of the National Historic Landmark.

# 8. Significance

| Period | Areas of Significance—Check and justify below | | | |
|---|---|---|---|---|
| ___ prehistoric | ___ archeology-prehistoric | ___ community planning | ___ landscape architecture | ___ religion |
| ___ 1400–1499 | ___ archeology-historic | ___ conservation | ___ law | ___ science |
| ___ 1500–1599 | ___ agriculture | ___ economics | ___ literature | ___ sculpture |
| ___ 1600–1699 | ___ architecture | ___ education | ___ military | ___ social/ humanitarian |
| ___ 1700–1799 | ___ art | X engineering | ___ music | ___ theater |
| ___ 1800–1899 | ___ commerce | ___ exploration/settlement | ___ philosophy | ___ transportation |
| X 1900– | ___ communications | ___ industry | ___ politics/government | X other (specify) |
| | | ___ invention | | Space Exploration |

**Specific dates** 1965-Present **Builder/Architect** NASA

**Statement of Significance (in one paragraph)**

The Space Environment Simulation Laboratory (SESL) has a significant association with the manned spacecraft program of the United States. The SESL was designed, built, and used to conduct thermal-vacuum testing for all United States manned spacecraft of the Apollo-era. The large size of both chambers in the SESL meant that full scale flight hardware could be tested for a variety of design and development problems involving such factors as operating temperatures, fluid leak rates, changes in absorptive or emissive properties of thermal coatings and other materials. This testing was absolutely essential to man rate flight hardware. The safety of the astronauts and the success of the manned space program depended on information that resulted from these tests in the SESL.

Since it was constructed in 1965, the SESL has tested all Apollo command and service modules, Apollo lunar modules, spacesuits for extra-vehicular activity, the Skylab/Apollo telescope mount system, various Space Shuttle systems, the Apollo/Soyuz docking module, and various large scale scientific satellite systems such as the parabolic reflector subsystem of the Applications Technology Satellite. The thermal vacuum testing done at the SESL since 1965 has been a significant factor contributing to the success of both the manned and unmanned space program of the United States.

Footnotes

1. Thermal Vacuum Laboratories User Guide (Houston, Texas: Lyndon B. Johnson Space Center, 1981), pp. 4-5.

Bibliography

Brooks, Courtney G., Grimwood, James M., and Swenson, Loyd S. Chariots for Apollo: A History of Manned Lunar Spacecraft. Washington, D.C.: National Aeronautics and Space Administration, 1979.

Brooks, Courtney G., Ertel, Ivan D., and Newkirk, Roland W. The Apollo Spacecraft: A Chronology Vol. IV. Washington, D.C.: National Aeronautics and Space Administration, 1978.

Major Test Facilities of the Engineering and Development Directorate. Houston, Texas: Manned Spacecraft Center, 1966.

Technical Facilities Catalog Vol. II. Washington, D.C.: National Aeronautics and Space Administration, 1974.

Thermal Vacuum Laboratories User Guide. Houston, Texas: Lyndon B. Johnson Space Center, 1981.

## 9. Major Bibliographical References

See continuation sheets

## 10. Geographical Data

Acreage of nominated property Less than 1 acre

Quadrangle name League City

Quadrangle scale 1:24,000

UMT References

| | Zone | Easting | Northing | | Zone | Easting | Northing |
|---|---|---|---|---|---|---|---|
| A | 1 6 | 2 9 7 7 0 0 | 3 2 7 1 7 4 0 | B | | | |
| C | | | | D | | | |
| E | | | | F | | | |
| G | | | | H | | | |

**Verbal boundary description and justification**

The boundary of the Space Environmental Simulation Laboratory is defined by the outside perimeters of both Chambers A and B located within Building 32 at the Lyndon B. Johnson Space Center.

**List all states and counties for properties overlapping state or county boundaries**

state code county code

state code county code

## 11. Form Prepared By

name/title Harry A. Butowsky

organization National Park Service date May 15, 1984

street & number Division of History telephone (202) 343-8168

city or town Washington, D.C. 20240 state

## 12. State Historic Preservation Officer Certification

The evaluated significance of this property within the state is:

___ national ___ state ___ local

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89-665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service.

State Historic Preservation Officer signature

title date

For NPS use only

I hereby certify that this property is included in the National Register

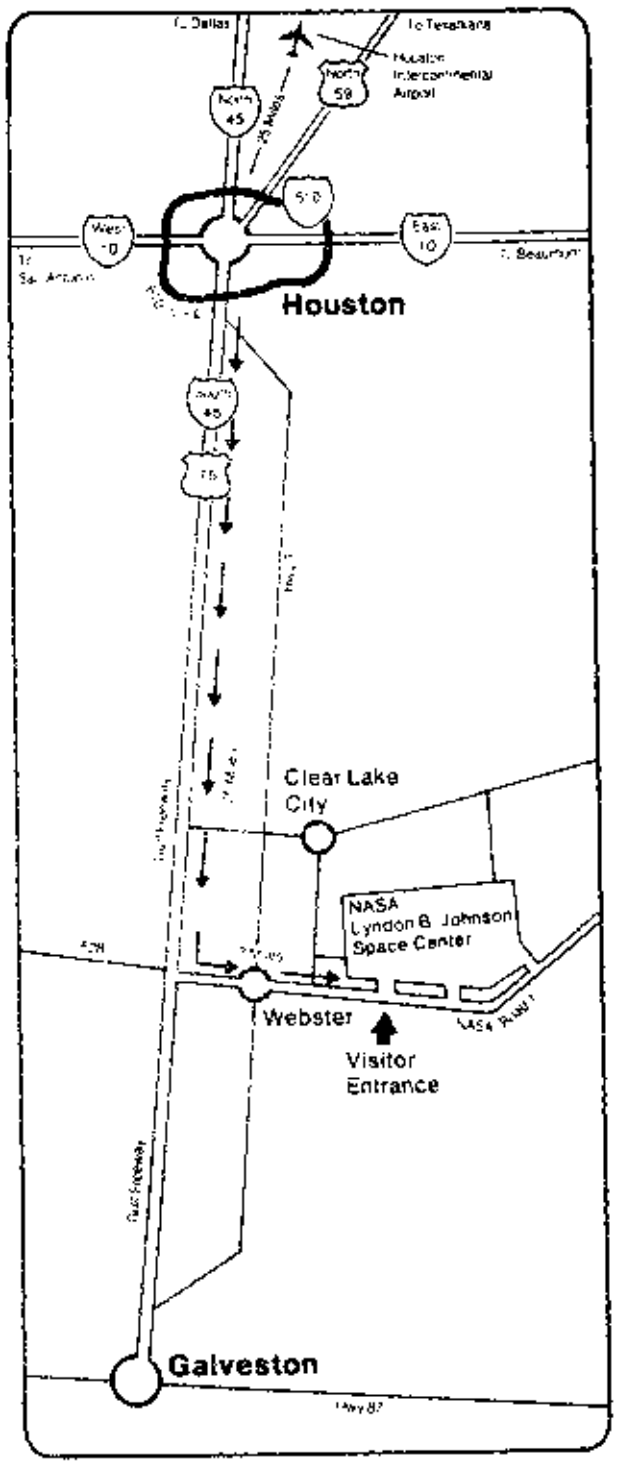
date

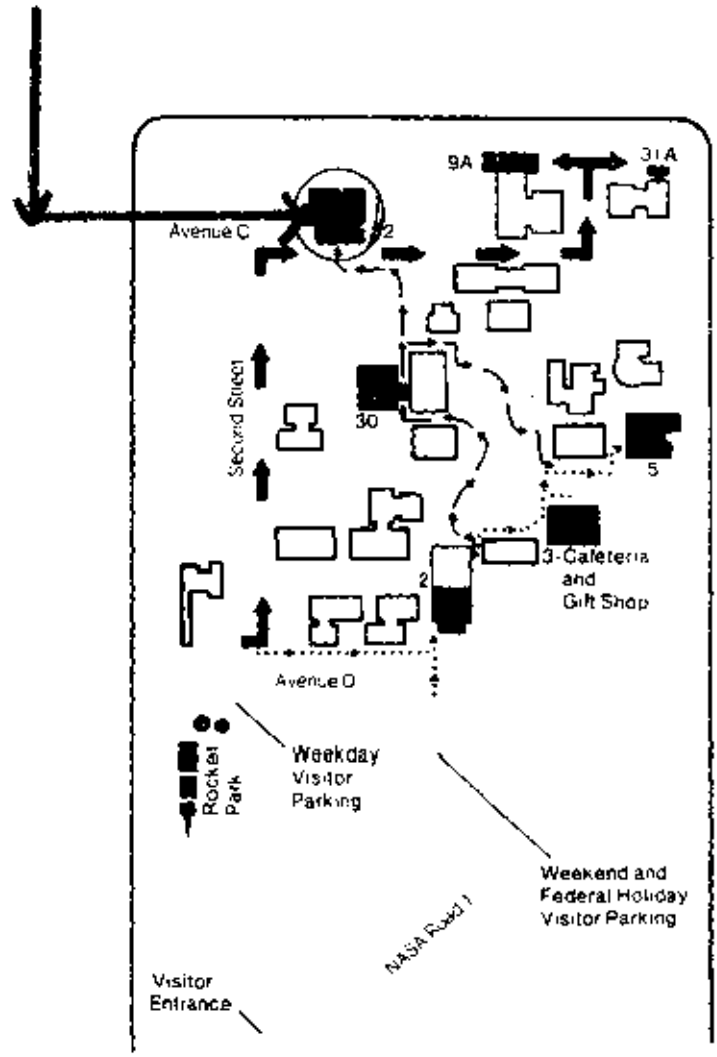
Keeper of the National Register

Attest: date

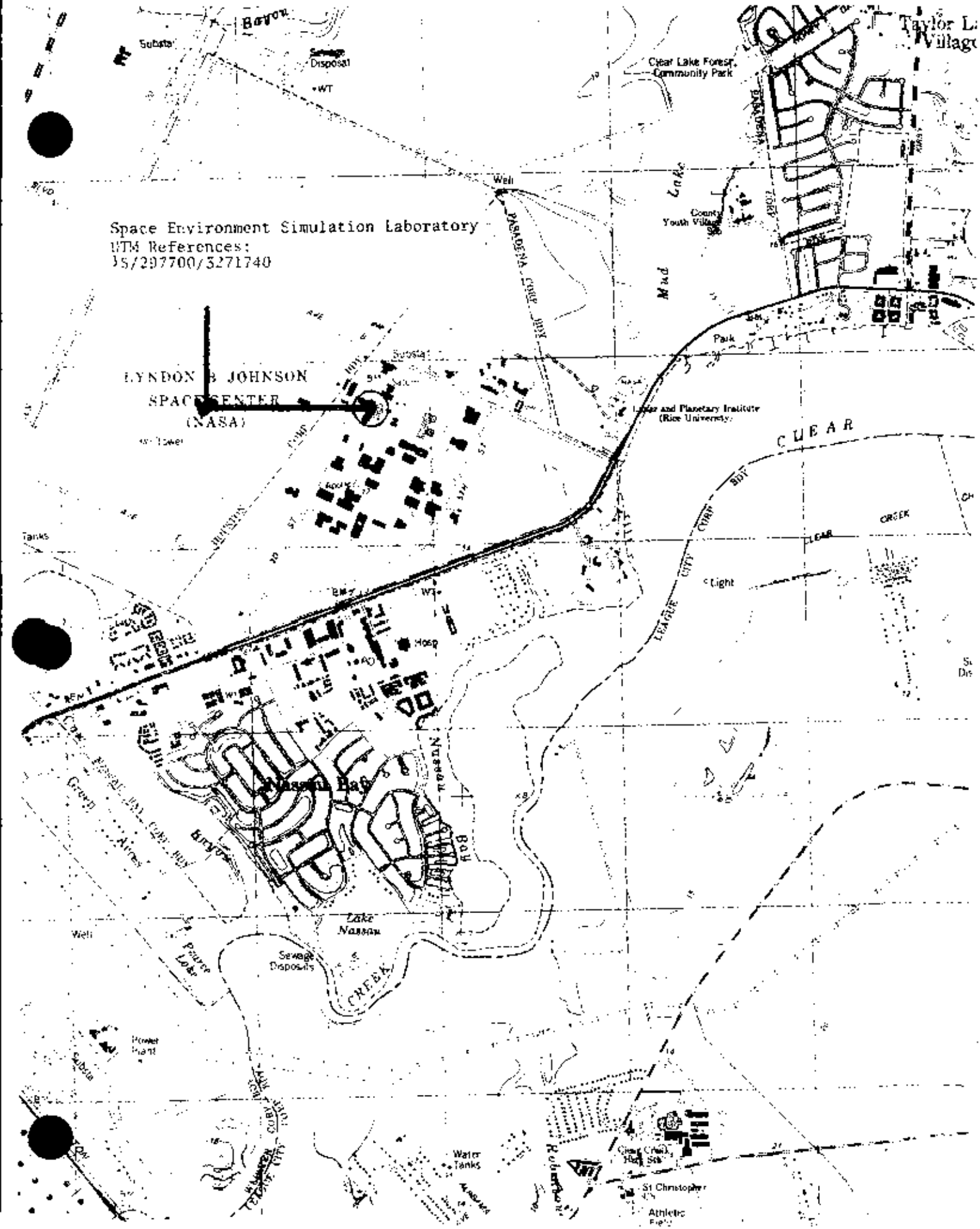
Chief of Registration

Space Environment Simulation Laboratory
Building 32
15/297700/3271740

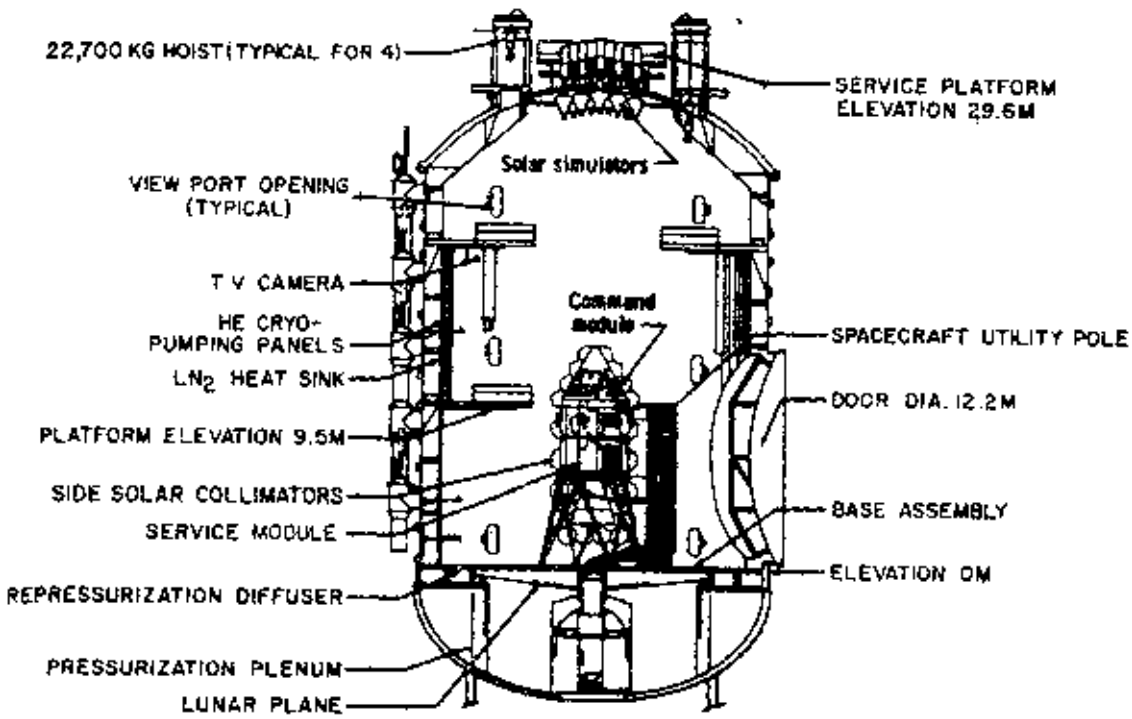



Bldg.
2 - Visitor Center
3 - JSC Cafeteria and Gift Shop
5 - Mission Simulation and Training
9A - Space Shuttle Orbiter Training
30 - Mission Control Center
31A - Lunar Sample Building
32 - Space Environment Simulation Laboratory

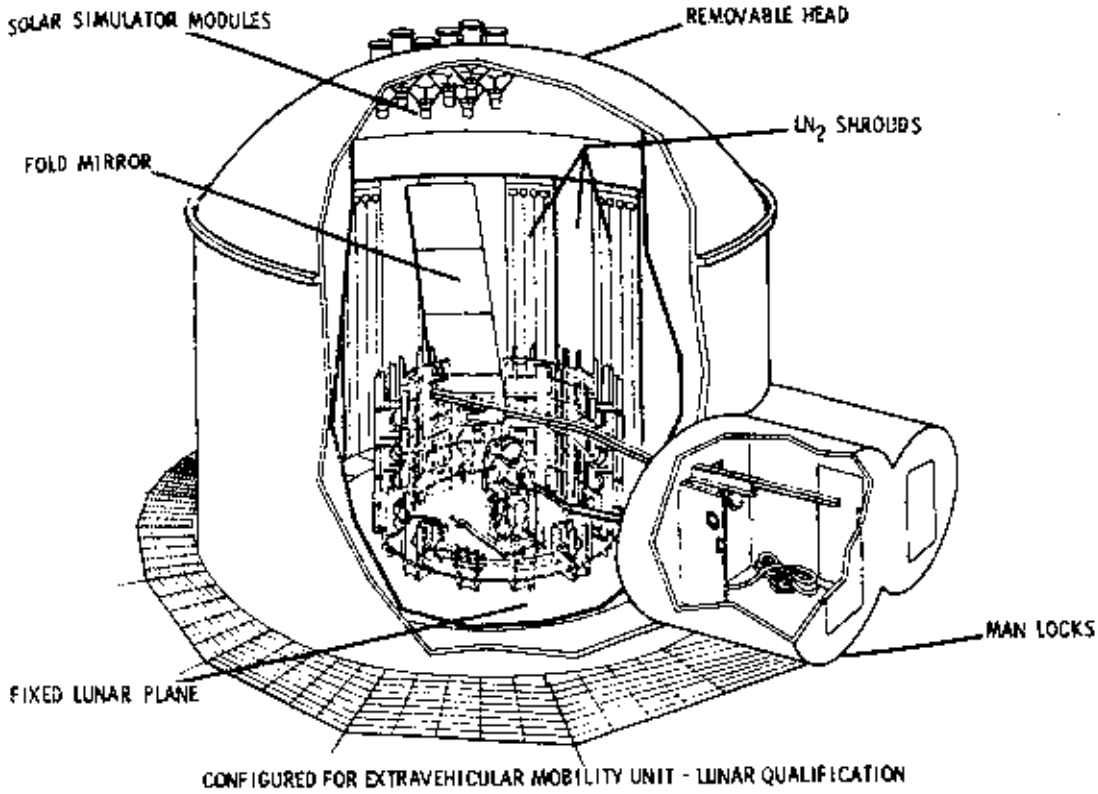

Space Environment Simulation Laboratory
UTM References:
15/297700/3271740
LYNDON B JOHNSON
SPACE CENTER
(NASA)
Clear Lake Forest
Community Park
Mud Lake
County
Youth Village
Park
Lunar and Planetary Institute
(Rice University)
CLEAR
CREEK
Light
Nassau Bay
Lake
Nassau
Sewage
Disposals
Power
Plant
Water
Tanks
St Christopher
Athletic
Field
Well
Disposal
Tanks
Hosp

Space Environmental Simulation Laboratory Chamber A



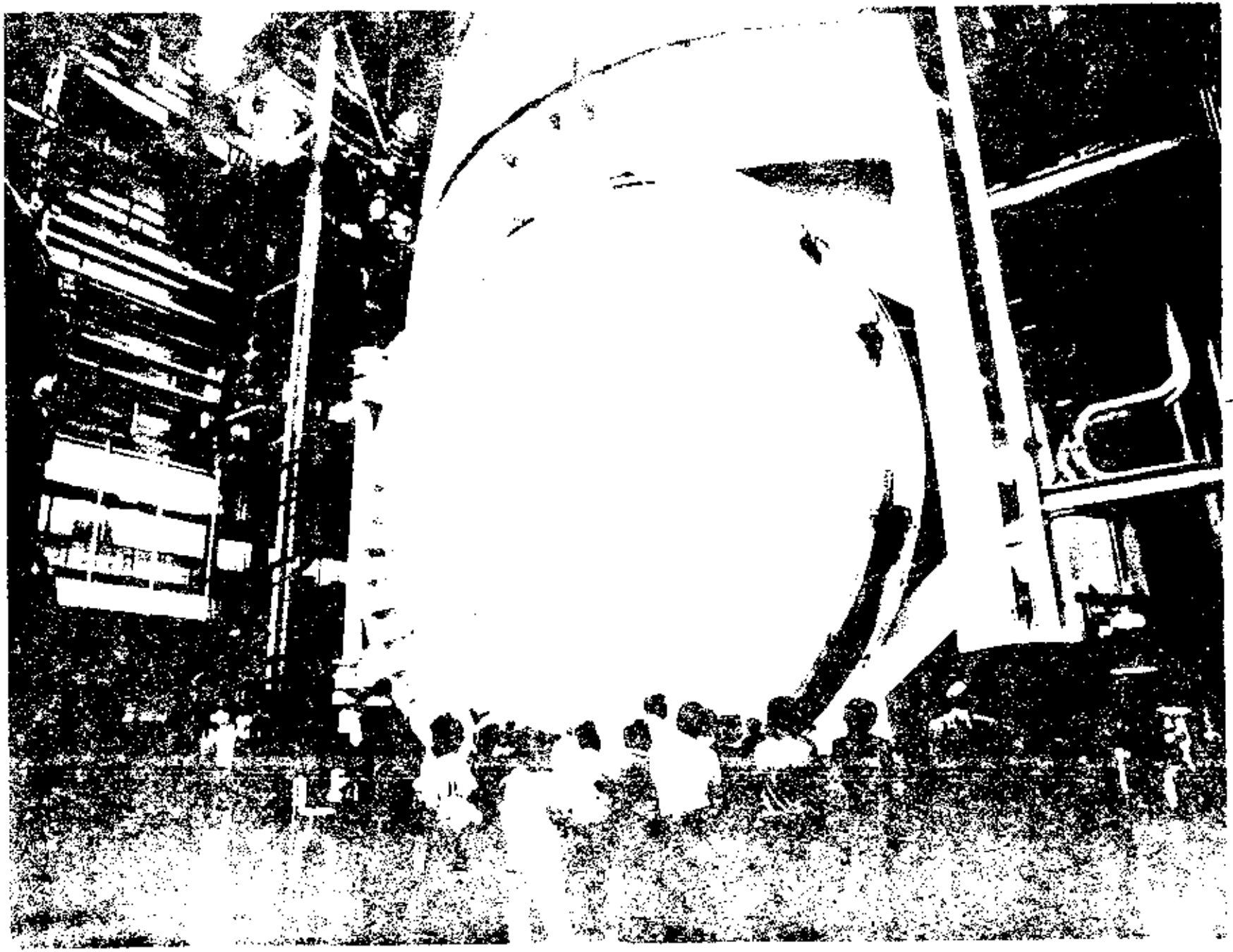

Source: Technical Facilities Catalog Vol. 11, 1974, p. 8-103.

Space Environmental Simulation Laboratory Chamber B

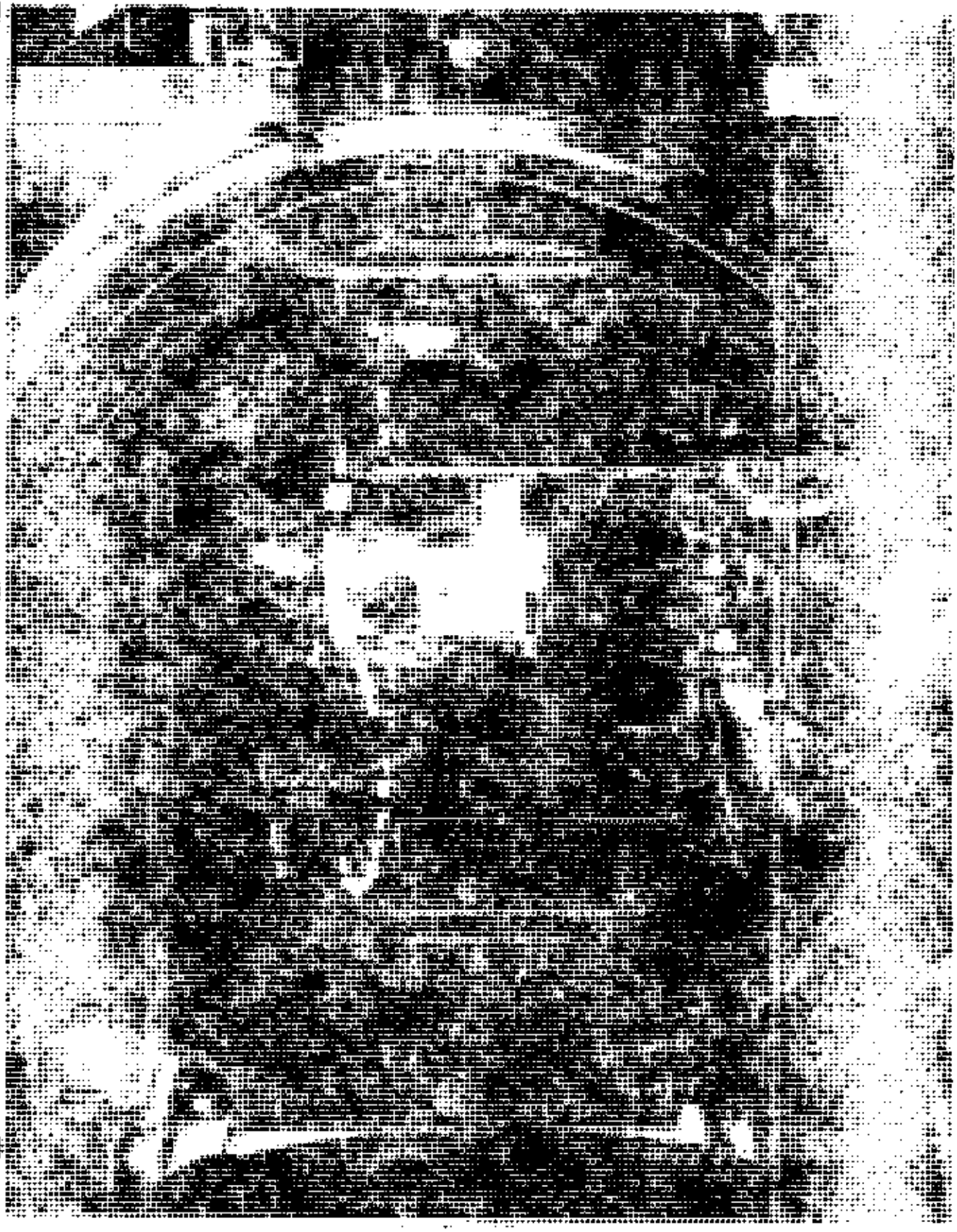



Source: Technical Facilities Catalog Vol. 11, 1974, p. 8-107.

1. Space Environment Simulation Laboratory
2. Houston, Texas
3. NASA
4. 1976
5. NASA, Houston Public Affairs Office
6. Exterior View of Chamber A



1. Space Environment Simulation Laboratory
2. Houston, Texas
3. NASA
4. 1968
5. NASA, Houston Public Affairs Office
6. Interior View of Chamber A with Apollo Spacecraft



1. Space Environment Simulation Laboratory
2. Houston, Texas
3. NASA
4. 1969
5. NASA, Houston Public Affairs Office
6. High-angle interior view of Chamber A showing three astronauts preparing to enter Apollo Spacecraft, 2TV-1.

1. Space Environment Simulation Laboratory
2. Houston, Texas
3. NASA
4. 1969
5. NASA, Houston Public Affairs Office
6. Astronaut James B. Irwin entering Lunar Module Test Article-8 in Chamber B

NASA
S-68-32005

## UNMANNED SPACECRAFT TEST FACILITIES

19. Spacecraft Magnetic Test Facility (Goddard Space Flight Center)

20. Twenty-Five Foot Space Simulator (Jet Propulsion Laboratory)

Man in Space Theme Study
Federal Agency Nomination

NPS Form 10-900
(7-81)

United States Department of the Interior
National Park Service

For NPS use only
received
date entered

# National Register of Historic Places Inventory—Nomination Form

See instructions in *How to Complete National Register Forms*
Type all entries—complete applicable sections

## 1. Name

historic Attitude Control Test Facility

and/or common Spacecraft Magnetic Test Facility

## 2. Location

street & number Goddard Space Flight Center ___ not for publication

city, town Greenbelt ___ vicinity of congressional district

state Maryland code 24 county Prince Georges code 033

## 3. Classification

| Category | Ownership | Status | Present Use | |
|---|---|---|---|---|
| ___ district | X public | ___ occupied | ___ agriculture | ___ museum |
| ___ building(s) | ___ private | ___ unoccupied | ___ commercial | ___ park |
| X structure | ___ both | ___ work in progress | ___ educational | ___ private residence |
| ___ site | **Public Acquisition** | **Accessible** | ___ entertainment | ___ religious |
| ___ object | ___ in process | X yes: restricted | X government | X scientific |
| | ___ being considered | ___ yes: unrestricted | ___ industrial | ___ transportation |
| | | ___ no | ___ military | X other: Space Exploration |

## 4. Owner of Property

name National Aeronautics and Space Administration (NASA)

street & number

city, town Washington ___ vicinity of state D.C. 20546

## 5. Location of Legal Description

courthouse, registry of deeds, etc. National Aeronautics and Space Administration (NASA)

street & number Real Property Management Office Code NXG

city, town Washington state D.C. 20546

## 6. Representation in Existing Surveys

title None has this property been determined eligible? ___ yes ___ no

date ___ federal ___ state ___ county ___ local

depository for survey records

city, town state

# 7. Description

| Condition | | Check one | Check one |
|---|---|---|---|
| _x_ excellent | ___ deteriorated | _X_ unaltered | _X_ original site |
| ___ good | ___ ruins | ___ altered | ___ moved date _____ |
| ___ fair | ___ unexposed | | |

**Describe the present and original (if known) physical appearance**

The Spacecraft Magnetic Test Facility was built in 1966 and consists of a 60-foot square building constructed of nonmagnetic materials, which contains a 42-foot-diameter coil system. The coil, a 3-axis Braunbek system of 4 loops on each axis, provides cancellation of the earth's magnetic field over the central 6-foot-diameter spherical volume, uniform to 0.001% and stable to a half nanotesla. Geomagnetic fluctuations up to 16 Hz and $\pm$ 750 nanoteslas are eliminated by automatic servo-control from 3 remotely-located rubidium magnetometers. The coil can generate a stable artificial field from zero to 60,000 nanoteslas in steps of 0.1 nanotesla. The artificial magnetic vector can be rotated about any axis at rates of zero to 100 rad/sec.

Accessories include nonmagnetic tracks and dollies to transport the test item in and out of the coil system, and an 8 foot-diameter powered turntable at the coil center for positioning the test item, 9 foot-5 inch Helmholtz coils to provide dc and ac field exposure up to $50 \times 10^{-4}$ tesla for perm and deperm treatment, and a sensitive nonmagnetic torquemeter capable of measuring magnetic torques of $10 \times 10^{-7}$ Nm on test items weighing up to 4000 kg.

The coil building is about 2 miles east of the Goddard Space Flight Center. Access is through a truck lock with doors 14 feet by 15 feet high. Material handling is accomplished with a 3-ton monorail hoist in the truck lock and 5000-pound-capacity fixed location hoists on the coil center line and outside the coil. The coil has a 10 foot-3 inch square opening and a clear interior work space 25 feet in diameter x 17 feet-6 inches high. The coil building is air-conditioned to maintain the dew point at 50°F or less. Cleanliness is maintained by passing all air introduced into the building through a bank of HEPA (high-efficiency particulate air) filters. A recirculating air system to maintain a higher degree of contamination control in the work space is available.[1]

# 8. Significance

| Period | Areas of Significance—Check and justify below | | | |
|---|---|---|---|---|
| ___ prehistoric | ___ archeology-prehistoric | ___ community planning | ___ landscape architecture | ___ religion |
| ___ 1400–1499 | ___ archeology-historic | ___ conservation | ___ law | ___ science |
| ___ 1500–1599 | ___ agriculture | ___ economics | ___ literature | ___ sculpture |
| ___ 1600–1699 | ___ architecture | ___ education | ___ military | ___ social/ humanitarian |
| ___ 1700–1799 | ___ art | X engineering | ___ music | ___ theater |
| ___ 1800–1899 | ___ commerce | ___ exploration/settlement | ___ philosophy | ___ transportation |
| X 1900– | ___ communications | ___ industry | ___ politics/government | X other (specify) Space Exploration |
| | | ___ invention | | |

**Specific dates** 1966-Present **Builder/Architect** NASA

**Statement of Significance (in one paragraph)**

The Spacecraft Magnetic Test facility is the only facility in NASA's inventory that makes it possible to determine and to minimize the magnetic movement of even the largest unmanned spacecraft and observatories and thereby reduce unwanted torques due to the interaction of magnetic movement with magnetic vector. The limited evaluation of magnetic control systems is also possible as is the final calibration of precision flight magnetometers in orbital configuration.[2]

Without the use of the Spacecraft Magnetic Test facility and information it provides in the testing of large statellites, the United States would be unable to successfully orbit and maintain the large variety of satellites that have provided information on weather, communications, earth resources and many other fields. The use and operation of this facility is essential to the continuing success of the American Manned and Unmanned Space program. The Spacecraft Magnetic Test facility is unique and is not replicated anywhere else in the United States.

Footnotes

1. Technical Facilities Catalog Vol. 1 (Washington, D.C.: National Aeronautics and Space Administration, October, 1974), p. 5-15.

2. Technical Facilities Catalog Vol. 1 (Washington, D.C.: National Aeronautics and Space Administration, March, 1967), pp. 7-16, 7-17.

Bibliography

Boyle, J.C. Lunar Roving Vehicle Magnetic Test X-325-72. Greenbelt, Maryland: Goddard Space Flight Center, October 1971.

Technical Facilities Catalog Vol. 1. Washington, D.C.: National Aeronautics and Space Administration, March 1967.

Technical Facilities Catalog Vol. 1. Washington, D.C.: National Aeronautics and Space Administration, October 1974.

## 9. Major Bibliographical References

See continuation sheets

## 10. Geographical Data

Acreage of nominated property Less than 1 acre

Quadrangle name Laurel

Quadrangle scale 1:24,000

UMT References

| | Zone | Easting | Northing |
|---|---|---|---|
| A | 18 | 341940 | 4318900 |
| B | | | |
| C | | | |
| D | | | |
| E | | | |
| F | | | |
| G | | | |
| H | | | |

Verbal boundary description and justification

The boundary of the Spacecraft Magnetic Test Facility is defined by the outside perimeter of building 310-20 at the Goddard Space Flight Center.

List all states and counties for properties overlapping state or county boundaries

state code county code

state code county code

## 11. Form Prepared By

name/title Harry A. Butowsky

organization National Park Service date May 15, 1984

street & number Division of History telephone (202) 343-8168

city or town Washington, D.C. 20240 state

## 12. State Historic Preservation Officer Certification

The evaluated significance of this property within the state is:

___ national ___ state ___ local

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89-665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service.

State Historic Preservation Officer signature

title date

For NPS use only

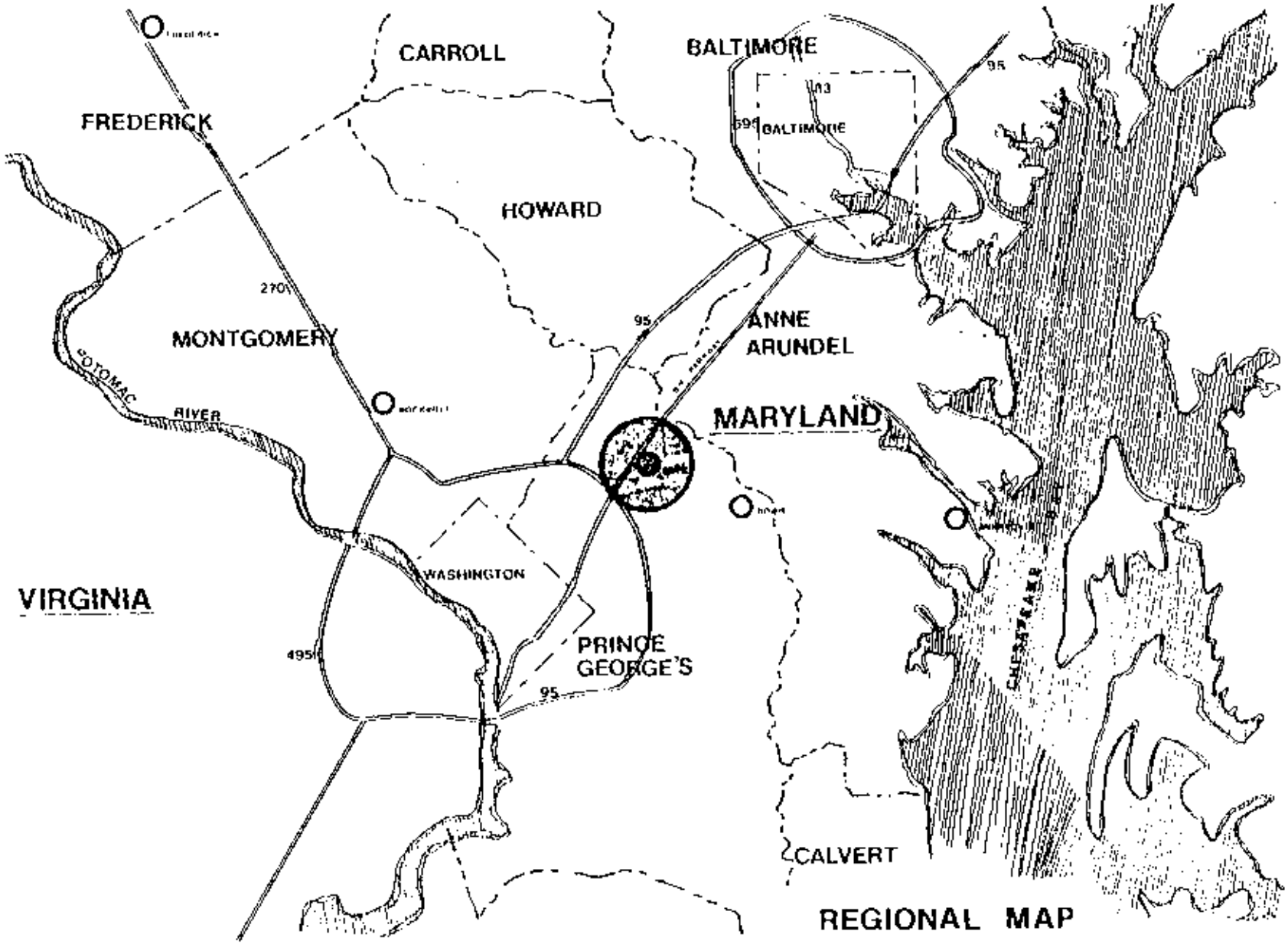
I hereby certify that this property is included in the National Register

date

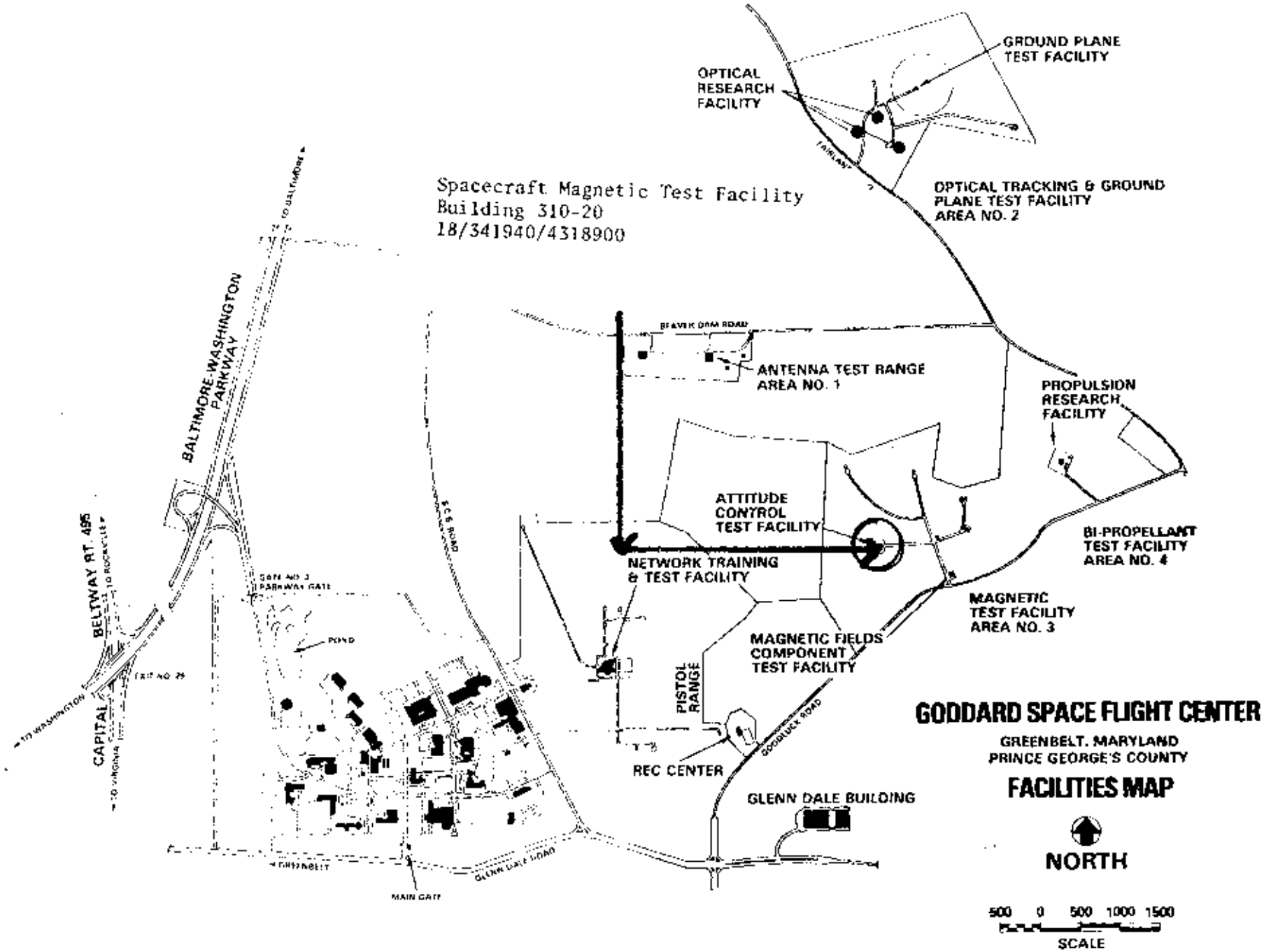
Keeper of the National Register

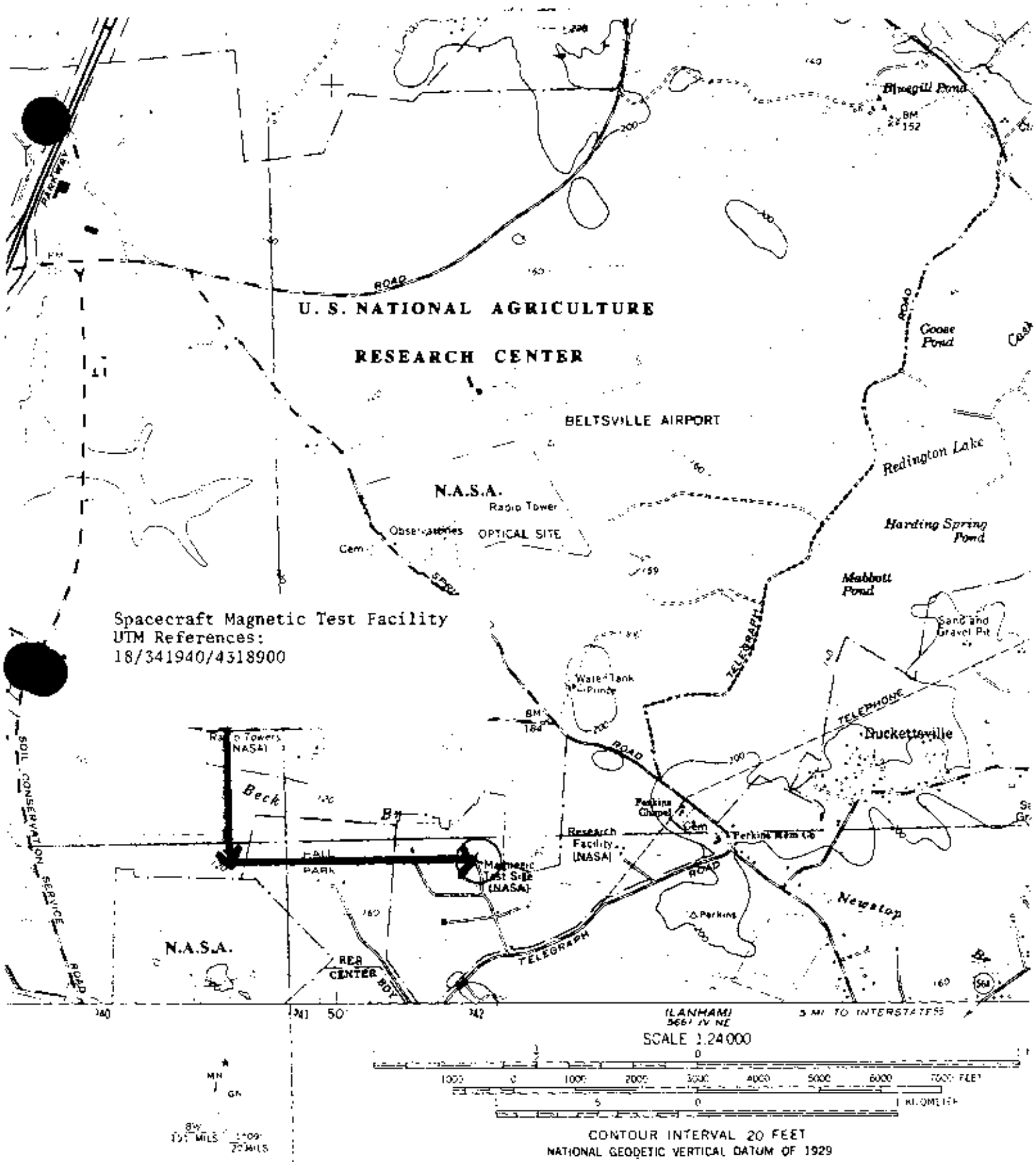
Attest: date

Chief of Registration



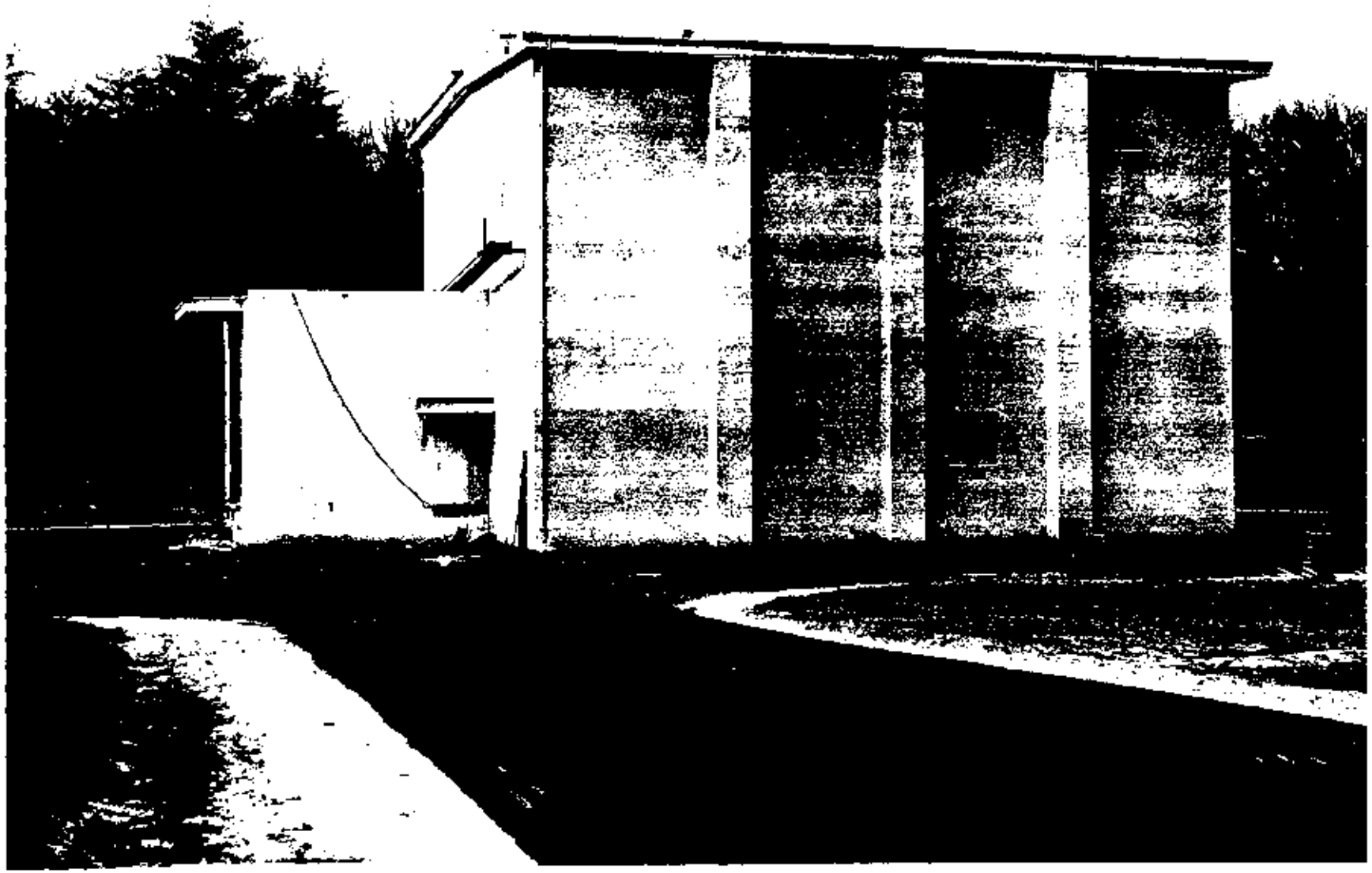

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND 20770


Spacecraft Magnetic Test Facility
Building 310-20
18/341940/4318900
GROUND PLANE TEST FACILITY
OPTICAL RESEARCH FACILITY
OPTICAL TRACKING & GROUND PLANE TEST FACILITY AREA NO. 2
ANTENNA TEST RANGE AREA NO. 1
PROPULSION RESEARCH FACILITY
ATTITUDE CONTROL TEST FACILITY
BI-PROPELLANT TEST FACILITY AREA NO. 4
NETWORK TRAINING & TEST FACILITY
MAGNETIC TEST FACILITY AREA NO. 3
MAGNETIC FIELDS COMPONENT TEST FACILITY
PISTOL RANGE
REC CENTER
GLENN DALE BUILDING
BALTIMORE-WASHINGTON PARKWAY
BELTWAY RT. 495
CAPITAL
POND
MAIN GATE
GOODLUCK ROAD
GLENN DALE ROAD
GOODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND
PRINCE GEORGE'S COUNTY
FACILITIES MAP
NORTH
500 0 500 1000 1500
SCALE




FOR SALE BY U. S. GEOLOGICAL SURVEY, RESTON, VIRGINIA 22092
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

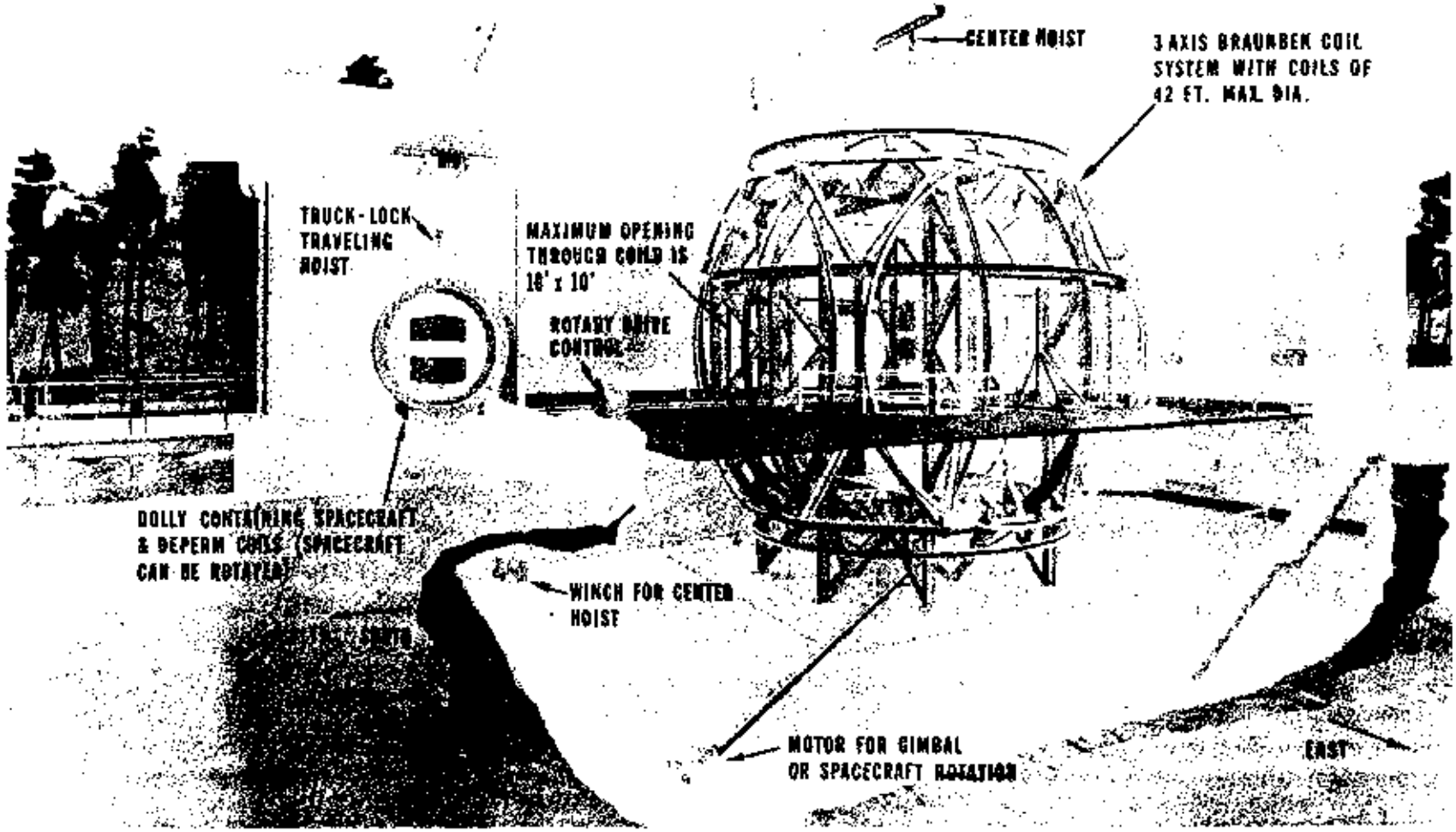
1. Spacecraft Magnetic Test Facility
2. Greenbelt, Maryland
3. NASA
4. 1965
5. NASA, Goddard Space Flight Center Facilities Office
6. Exterior View of Spacecraft Magnetic Test Facility



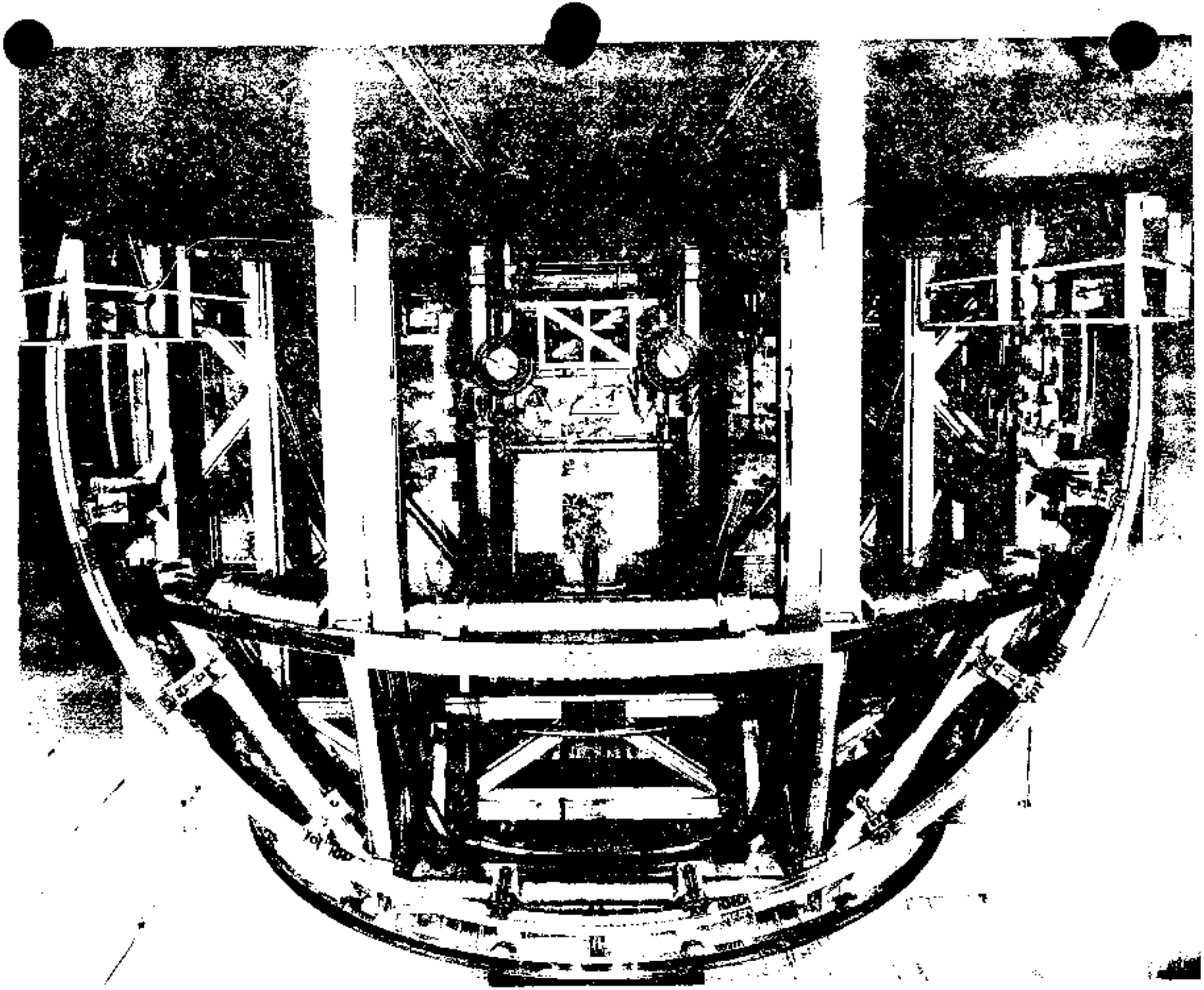
NASA G-65-3748

1. Spacecraft Magnetic Test Facility
2. Greenbelt, Maryland
3. NASA
4. 1971
5. NASA, Goddard Space Flight Center Facilities Office
6. Cutaway View of Spacecraft Magnetic Test Facility

# SPACECRAFT MAGNETIC TEST FACILITY



1. Spacecraft Magnetic Test Facility
2. Greenbelt, Maryland
3. NASA
4. 1971
5. NASA, Goddard Space Flight Center Facilities Office
6. Interior View of Spacecraft Magnetic Test Facility showing Lunar Rover Vehicle Test



Man in Space Theme Study
Federal Agency Nomination

NPS Form 10-900
(7-81)

United States Department of the Interior
National Park Service

# National Register of Historic Places Inventory—Nomination Form

For NPS use only
received
date entered

See instructions in *How to Complete National Register Forms*
Type all entries—complete applicable sections

## 1. Name

historic Twenty-Five Foot Space Simulator

and/or common Twenty-Five Foot Space Simulator

## 2. Location

street & number Jet Propulsion Labortory ___ not for publication

city, town Pasadena ___ vicinity of congressional district

state California code 06 county Los Angeles code 037

## 3. Classification

| Category | Ownership | Status | Present Use | |
|---|---|---|---|---|
| ___ district | X public | ___ occupied | ___ agriculture | ___ museum |
| ___ building(s) | ___ private | ___ unoccupied | ___ commercial | ___ park |
| X structure | ___ both | ___ work in progress | ___ educational | ___ private residence |
| ___ site | **Public Acquisition** | **Accessible** | ___ entertainment | ___ religious |
| ___ object | ___ in process | X yes: restricted | X government | X scientific |
| | ___ being considered | ___ yes: unrestricted | ___ industrial | ___ transportation |
| | | ___ no | ___ military | X other: Space Exploration |

## 4. Owner of Property

name National Aeronautics and Space Administration (NASA)

street & number

city, town Washington ___ vicinity of state D.C. 20546

## 5. Location of Legal Description

courthouse, registry of deeds, etc. National Aeronautics and Space Administration (NASA)

street & number Real Property Management Office Code NXG

city, town Washington state D.C. 20546

## 6. Representation in Existing Surveys

title None has this property been determined eligible? ___ yes ___ no

date ___ federal ___ state ___ county ___ local

depository for survey records

city, town state

# 7. Description

| Condition | | Check one | Check one |
|---|---|---|---|
| _X_ excellent | ___ deteriorated | ___ unaltered | _X_ original site |
| ___ good | ___ ruins | ___ altered | ___ moved date _____ |
| ___ fair | ___ unexposed | | |

**Describe the present and original (if known) physical appearance**

The 25-foot Space Simulator is at the Jet Propulsion Laboratory (JPL) in Pasadena, California. It was built in 1961 to provide high-quality space simulation for testing spacecraft under conditions of extreme cold, high vacuum, and intense, highly uniform collimated solar radiation.[1]

The 25-foot Space Simulator chamber is a stainless-steel cylindrical vessel 27 feet in diameter and 85 feet high; a 15-by 25-foot side-opening access door is provided for test-item loading. A personnel door provides entry through the access door. The minimum operating pressure of the chamber is $5 \times 10^{-7}$ torr. The walls and floor are lined with thermally opaque aluminum cryogenic shrouds controlled over a temperature range of -320° to +200°F by liquid or gaseous nitrogen. The off-axis solar simulation system consists of an array of 37 xenon 20- to 30-kilowatt compact arc lamps, an integrating lens unit, a penetration window, and a one-piece collimator. This provides a simulated solar beam that is reflected down into the test volume by the collimating mirror, which is temperature controlled with gaseous nitrogen through a range of -100° to +200°F.

The test volume of the Simulator, 20 feet in diameter and 25 feet high, can be irradiated by a beam of simulated solar energy selected from a variety of beam sizes and intensities. The maximum beam diameter is 18.5 feet, which can provide intensities up to 2.7 solar constants. With a smaller collimating mirror and different integrating lens unit, a 9-foot diameter beam with intensites up to 12 solar constants can be provided. The spectrum is that of xenon arc lamps, as modified by the simulator optics. A water-cooled douser is provided to simulate eclipse of the sun.

The simulated space environment can be established in about 75 minutes. Test conditions can be terminated and access provided to the test item in about 2 1/2 hours.

A 1000-square-foot clean room facility is available for test article assembly and system test prior to environmental testing. An airlock separates the clean room from the Simulator.

Test article (spacecraft) suspension within the Space Simulator can be provided by a variety of support systems. The chamber has wall-mounted attachment points at three levels, each capable of a 10,000-pound vertical load. These points can be used to attach suspension cables or fixed hardware.

The cooled chamber floor has openings that allow support columns for hardmounted support structure. These columns rest on an isolated seismic mass below the Simulator.

A geosynchronous orbit simulation support system is available, providing one revolution per day with a fast advance and return capability and declination angle change, all possible in a vacuum.

Special test article loading provisions can be accommodated, using either a movable monorail hoist or ramp system within the chamber.

The 25-Foot Space Simulator is still in use by NASA and is likely to remain in use for many years to come.

# 8. Significance

| Period | Areas of Significance—Check and justify below | | | |
|---|---|---|---|---|
| ___ prehistoric | ___ archeology-prehistoric | ___ community planning | ___ landscape architecture | ___ religion |
| ___ 1400–1499 | ___ archeology-historic | ___ conservation | ___ law | ___ science |
| ___ 1500–1599 | ___ agriculture | ___ economics | ___ literature | ___ sculpture |
| ___ 1600–1699 | ___ architecture | ___ education | ___ military | ___ social/ humanitarian |
| ___ 1700–1799 | ___ art | X engineering | ___ music | ___ theater |
| ___ 1800–1899 | ___ commerce | ___ exploration/settlement | ___ philosophy | ___ transportation |
| X 1900– | ___ communications | ___ industry | ___ politics/government | X other (specify) Space Exploration |
| | | ___ invention | | |

**Specific dates** 1961-Present **Builder/Architect** NASA

**Statement of Significance (in one paragraph)**

The 25-Foot Space Simulator has technological capabilities in simulating the environment of space and has strong associations with the unmanned space exploration program of the United States.

The 25-Foot Space Simulator is the only NASA facility capable of producing true interplanetary conditions of extreme cold, high vacuum, and intense solar radiation coupled with a 25 foot-test chamber that can accommodate most modern spacecraft. Its use of a collimating mirror to produce the intense solar radiation of space was the first system of its type when installed in 1966.

This ability to create a true space environment has led engineers and scientists from Europe and Japan to study its many support systems in an attempt to build similar facilities in those countries.

Over the years spacecraft tested in this facility include Ranger, Surveyor, Mariner, Voyager and other spacecraft. The success of the American space program in exploring these planets has not been replicated by any other nation. One of the reasons for this success is the 25-Foot Space Simulator that enables JPL engineers to test their spacecraft in a true space environment and to locate and eliminate any problems before launch.

Footnotes

1. The descriptive material from this section has been taken from the following source. Our Captive Space--JPL Space Simulator Facilities (Pasadena, California: Jet Propulsion Laboratory, 1980). pp. 2-5.

Bibliography

Blaine, J.C.D. The End of an Era in Space Exploration. San Diego, California: American Astronautical Society, 1976.

Koopes, Clayton, R. JPL and the American Space Program. New Haven: Yale University Press, 1982.

Our Captive Space-JPL Space Simulator Facilities. Pasadena, California: Jet Propulsion Laboratory, 1980.

Technical Facilities Catalog Vol. 1. Washington, D.C.: National Aeronautics and Space Administration, 1974.

## 9. Major Bibliographical References

See continuation sheets

## 10. Geographical Data

Acreage of nominated property Less than 1 acre

Quadrangle name Pasadena

Quadrangle scale 1:24,000

UMT References

| | Zone | Easting | Northing | | Zone | Easting | Northing |
|---|---|---|---|---|---|---|---|
| A | 11 | 391940 | 3785060 | B | | | |
| C | | | | D | | | |
| E | | | | F | | | |
| G | | | | H | | | |

Verbal boundary description and justification

The boundary of the Twenty-Five-Foot Space Simulator is defined by the outside perimeter of Building 150 at the Jet Propulsion Laboratory.

List all states and counties for properties overlapping state or county boundaries

| state | code | county | code |
|---|---|---|---|
| state | code | county | code |

## 11. Form Prepared By

name/title Harry A. Butowsky

organization National Park Service date May 15, 1984

street & number Division of History telephone (202) 343-8168

city or town Washington, D.C. 20240 state

## 12. State Historic Preservation Officer Certification

The evaluated significance of this property within the state is:

___ national ___ state ___ local

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89-665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service.

State Historic Preservation Officer signature

title date

For NPS use only

I hereby certify that this property is included in the National Register

date

Keeper of the National Register

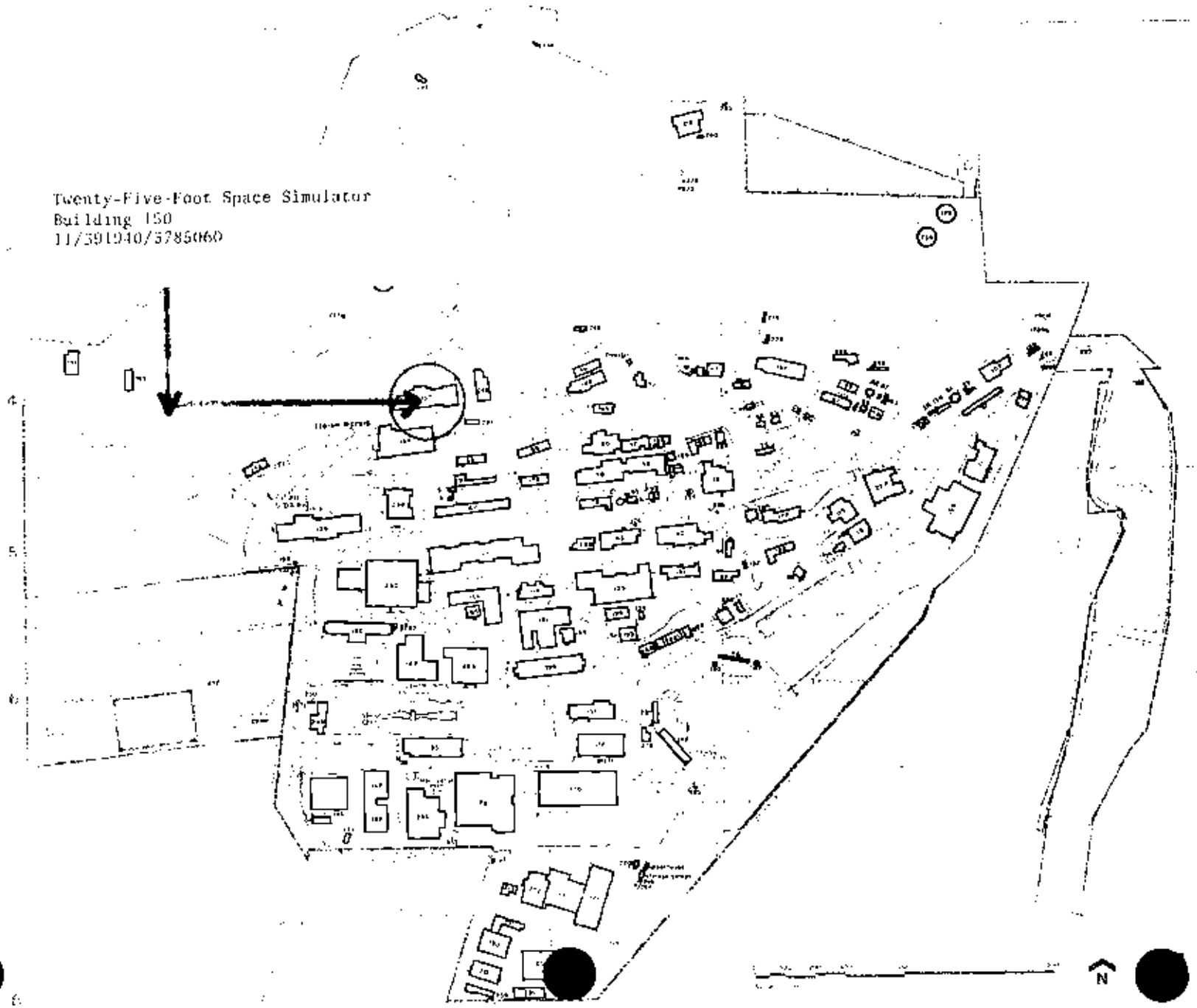
Attest: date

Chief of Registration

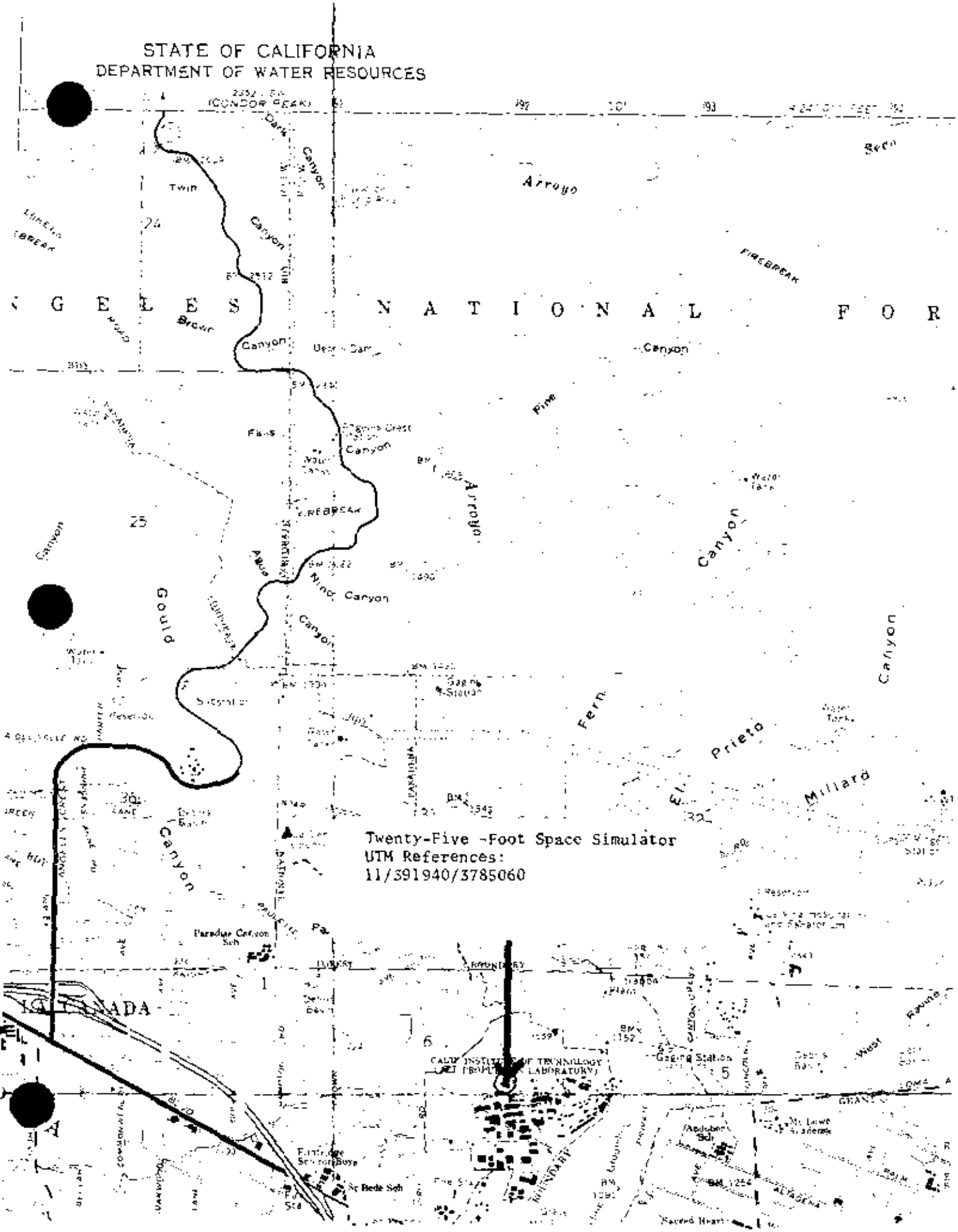
# JET PROPULSION LABORATORY

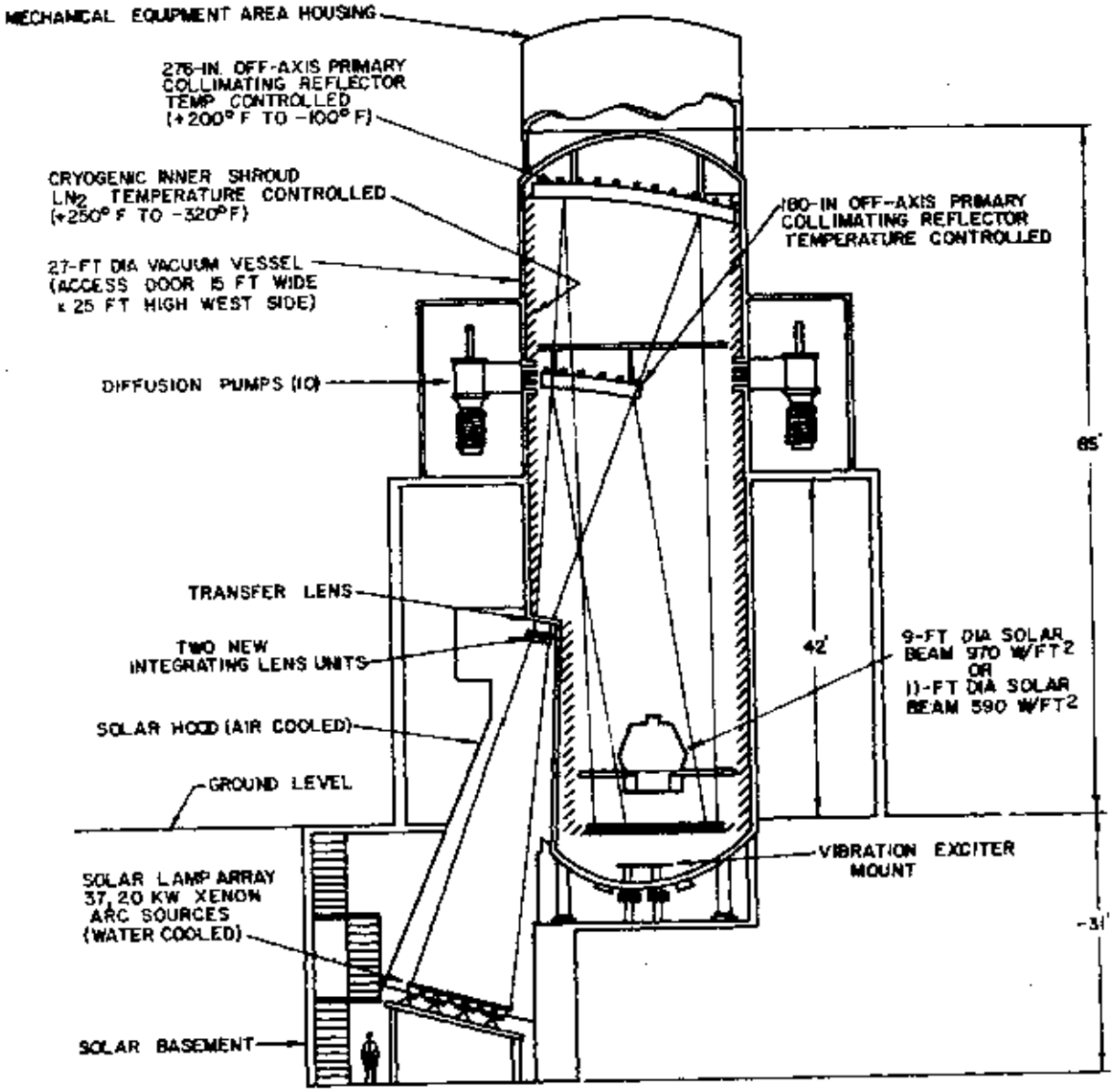
CALIFORNIA INSTITUTE OF TECHNOLOGY

SITE PLAN - FACILITY LOCATIONS



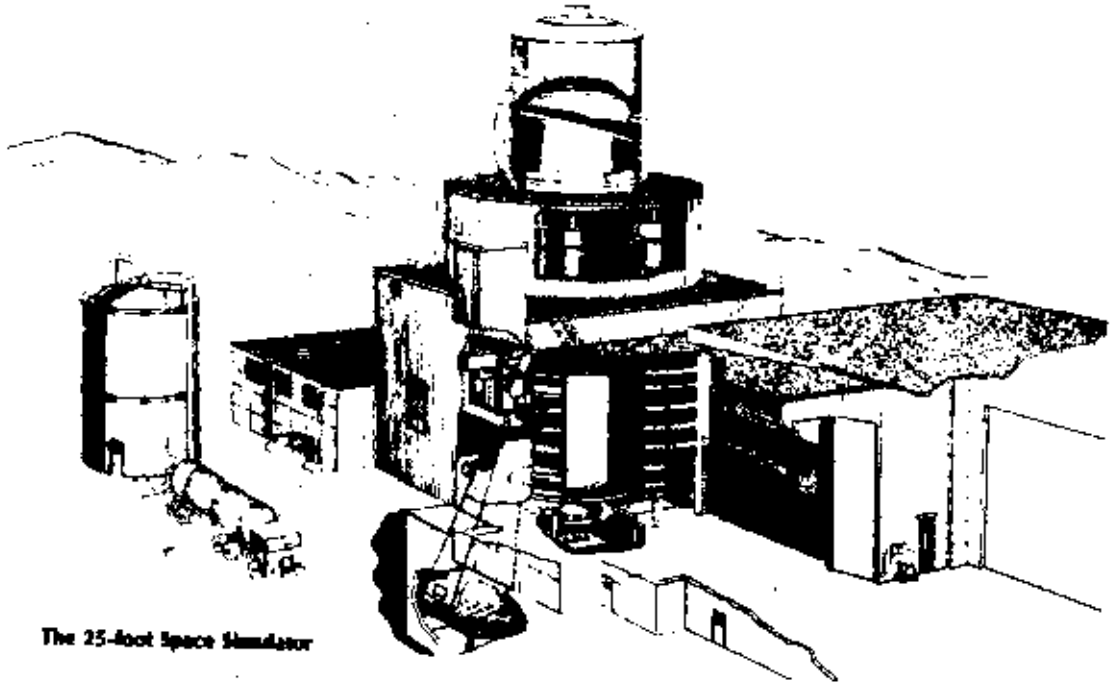
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES






25-FT SPACE SIMULATOR
CROSS SECTION

Source: Technical Facilities Catalog Vol. 1, 1974, p. 6-79.

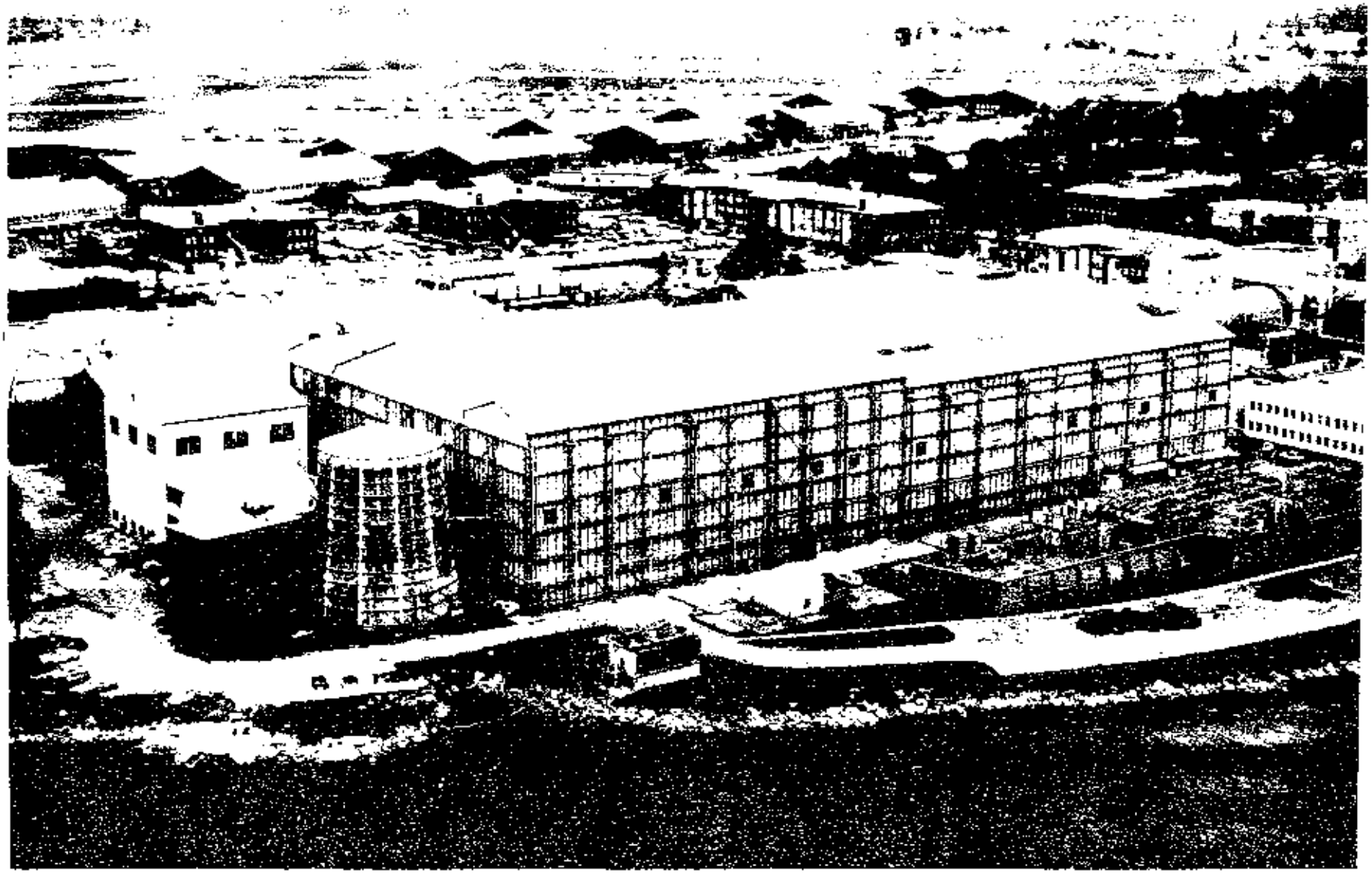


The 25-foot Space Simulator

Source: Our Captive Space-JPL Space Simulator Facilities, p. 2.

1. Twenty-Five-Foot Space Simulator
2. Pasadena, California
3. NASA-JPL
4. 1983
5. JPL Facilities Office
6. Exterior View of Twenty-Five-Foot Space Simulator

NASA
L-81-6016



NPS Form 10-900
(7-81)

**United States Department of the Interior**
National Park Service

# National Register of Historic Places Inventory—Nomination Form

For NPS use only
received
date entered

8

See instructions in *How to Complete National Register Forms*
Type all entries—complete applicable sections

## 1. Name

historic Eight-Foot High Speed Tunnel

and/or common Eight-Foot Transonic Tunnel

## 2. Location

street & number Langley Research Center ___ not for publication

city, town Hampton ___ vicinity of congressional district

state Virginia code 51 county Hampton code 650

## 3. Classification

| Category | Ownership | Status | Present Use | |
|---|---|---|---|---|
| ___ district | ___ public | ___ occupied | ___ agriculture | ___ museum |
| ___ building(s) | ___ private | ___ unoccupied | ___ commercial | ___ park |
| X structure | ___ both | ___ work in progress | ___ educational | ___ private residence |
| ___ site | **Public Acquisition** | **Accessible** | ___ entertainment | ___ religious |
| ___ object | ___ in process | X yes: restricted | X government | ___ scientific |
| | ___ being considered | ___ yes: unrestricted | ___ industrial | ___ transportation |
| | | ___ no | ___ military | X other: Abandoned |

## 4. Owner of Property

name National Aeronautics and Space Administration (NASA)

street & number

city, town Washington ___ vicinity of state D.C. 20546

## 5. Location of Legal Description

courthouse, registry of deeds, etc. National Aeronautics and Space Administration (NASA)

street & number

city, town Washington state D.C. 20546

## 6. Representation in Existing Surveys

title None has this property been determined eligible? ___ yes ___ no

date ___ federal ___ state ___ county ___ local

depository for survey records

city, town state

# 8. Significance

| Period | Areas of Significance—Check and justify below | | | |
|---|---|---|---|---|
| ___ prehistoric | ___ archeology-prehistoric | ___ community planning | ___ landscape architecture | ___ religion |
| ___ 1400–1499 | ___ archeology-historic | ___ conservation | ___ law | X science |
| ___ 1500–1599 | ___ agriculture | ___ economics | ___ literature | ___ sculpture |
| ___ 1600–1699 | ___ architecture | ___ education | X military | ___ social/humanitarian |
| ___ 1700–1799 | ___ art | X engineering | ___ music | ___ theater |
| ___ 1800–1899 | ___ commerce | ___ exploration/settlement | ___ philosophy | ___ transportation |
| X 1900– | ___ communications | ___ industry | ___ politics/government | X other (specify) Aeronautical Research |
| | | ___ invention | | |

**Specific dates** 1936-1956 **Builder/Architect** NACA

**Statement of Significance (in one paragraph)**

The Eight-Foot High Speed Tunnel is a landmark in wind tunnel design. At the time of the construction of the High Speed Tunnel, NACA had only two small high speed tunnels (the 11" and 24" tunnels) to test aircraft design in speeds ranging from Mach 0.5 to Mach 0.9. While useful, these small tunnels had two severe limitations. First, the small size of these tunnels meant than only small scale models could be tested. This meant that test results were suspect if high Reynolds numbers could not be obtained. Second, both tunnels were powered by the rapid blowdown of the VDT and were thus restricted to tests lasting less than a minute.

The Eight-Foot High Speed Tunnel solved both of these problems. It was large enough to accommodate sizeable test models and even complete aircraft parts on occasion. It was also a continuous flow tunnel that could operate almost indefinitely therby giving the engineers sufficient time to run their tests and to check their test results. For the first time NACA engineers had a research tool that could supply high speed test results on a large scale.

Over the years NACA engineers continued to modify and upgrade the Eight-Foot High Speed Tunnel. After the Second World War NACA engineers began to work on improving wind tunnel performance in the transonic range (Mach 0.7 to Mach 1.4). It had long been known that airflow within the test section of a transonic wind tunnel did not represent the actual conditions of free flight. The problem was that the natural pattern of airflow in this range is disturbed and altered by the existence of the walls of the tunnel. This problem became severe in the area of Mach 1 and was known as the tunnel choking effect. Until this problem was solved accurate test results were not possible for transonic tunnels.

Attempts to solve this problem by making smaller models proved unsuccessful when lower Reynolds numbers were obtained. Attempts to eliminated the walls of the tunnel in the area of the test section also proved less than satisfactory. In 1946 Ray Wright at Langley analyzed the potentialities of a partially open or slotted wind tunnel wall. His results suggested that slots occupying about 6 percent of the wall would closely duplicate free-air conditions.[5]

This solution was quickly applied to the Eight-Foot High Speed Tunnel. In February 1950 the tunnel was shut down and slotted walls were added to the test section. The concept worked and NACA now had the first wind tunnel in the world that would give accurate test results in the transonic range. Since all supersonic aircraft would have to fly briefly in the transonic range, knowing what happened to aircraft in this transition zone was critical to the supersonic fighters and bombers being planned in the postwar era. The slotted wall concept was immediately put to work testing the next generation of American aircraft.

After February 1950 the name of the Eight-Foot High Speed Tunnel was changed to the Eight-Foot Transonic Tunnel. Before the tunnel was phased out of operation in 1956 critical tests led to the discovery of the famous Area Rule which dictated that the fuselage of supersonic aircraft should be constricted where the wings are attached and then expanded at their trailing edges. This eliminated the possibility of generating strong shock waves behind an aircraft that can act as a drag on speed.

Many modern wind tunnels are derived from the technology extended or developed at Langley by NACA engineers. The Variable Density Tunnel was the world's first pressurized wind tunnel. The Full Scale Wind Tunnel was exactly that, full scale and thus able to conduct important drag cleanup tests for modern aircraft. The Eight-Foot High Speed Tunnel was the first continuous flow high speed tunnel able to test large models and actual working parts of airplanes. The addition of the slotted throat design was revolutionary for its time and gave accurate wind tunnel data in the transonic range. Many modern wind tunnels incorporate some variation of these features of pressure, large scale, high speed, continuous flow, and slotted throat design. These three tunnels marked the emerging technological superiority of the American aircraft industry. After the Second World War this technology was to provide the base upon which Americans would begin to construct rockets that would eventually fly to the moon and beyond.

Man in Space Theme Study
Federal Agency Nomination

NPS Form 10-900
(7-81)

**United States Department of the Interior**
**National Park Service**

# National Register of Historic Places Inventory—Nomination Form

For NPS use only
received
date entered

See instructions in *How to Complete National Register Forms*
Type all entries—complete applicable sections

## 1. Name

historic Pioneer Deep Space Station

and/or common Pioneer Deep Space Station

## 2. Location

street & number Goldstone Deep Space Communications Complex ___ not for publication

city, town Fort Irwin ___ vicinity of congressional district

state California code 06 county San Bernardino code 071

## 3. Classification

| Category | Ownership | Status | Present Use | |
|---|---|---|---|---|
| ___ district | X public | ___ occupied | ___ agriculture | ___ museum |
| ___ building(s) | ___ private | ___ unoccupied | ___ commercial | ___ park |
| ___ structure | ___ both | ___ work in progress | ___ educational | ___ private residence |
| ___ site | **Public Acquisition** | **Accessible** | ___ entertainment | ___ religious |
| ___ object | ___ in process | X yes: restricted | X government | ___ scientific |
| | ___ being considered | ___ yes: unrestricted | ___ industrial | ___ transportation |
| | | ___ no | ___ military | X other: Inactive |

## 4. Owner of Property

name National Aeronautics and Space Administration (NASA)

street & number

city, town Washington ___ vicinity of state D.C. 20546

## 5. Location of Legal Description

courthouse, registry of deeds, etc. National Aeronautics and Space Administration (NASA)

street & number Real Property Management Office Code NXG

city, town Washington state D.C. 20546

## 6. Representation in Existing Surveys

title None has this property been determined eligible? ___ yes ___ no

date ___ federal ___ state ___ county ___ local

depository for survey records

city, town state

# 7. Description

| Condition | | Check one | Check one |
|---|---|---|---|
| X excellent | ___ deteriorated | X unaltered | X original site |
| ___ good | ___ ruins | ___ altered | ___ moved date _____ |
| ___ fair | ___ unexposed | | |

**Describe the present and original (if known) physical appearance**

The Pioneer Station (DSS 11) was the first deep space station to be constructed in the NASA Deep Space Network. It was built in 1958 and is at the Goldstone Deep Space Communications Complex near the northeast tip of Goldstone Dry Lake approximately 45 miles northwest of Barstow, California.

The Pioneer Station antenna is a 26-meter large-diameter, polar mounted, steerable parabolic dish. The parabolic dish has a surface tolerance of approximately .125 inch and beamwith characteristics (0.1 degree) that permit efficient use of frequencies from 1 to 3 GHz. The antenna structure was designed for closed loop steering control. The 26-meter dish surface was constructed of punched aluminum panels bolted to an open steel framework mounted atop a 62 foot high tower-like polar mount steering mechanism.[1]

The Pioneer Station antenna was patterned after the radio astronomy antennas then in use by the Carnegie Institute of Washington and the University of Michigan. There were significant differences in the design, however. First, the Pioneer antenna incorporated a closed-loop device for automatically pointing the antenna at the space probe. The electrical simplicity of a steerable parabolic reflector made this a good choice for maintaining continuous contact with the spacecraft. Second, to track the space probe automatically, the antenna had to possess an electrical feed capable of utilizing the space probe signal for driving the servo-control system. Third, the antenna had to operate without failure for many continuous hours and without being impaired by wind or temperature. The single significant feature borrowed from the radio astronomy antenna was the design of the gear system that moved the antenna, which was a dual gear arrangement call an hour angle-declination mount. The axis about which the polar, or hour angle gear wheel rotated was parallel to the polar axis of the Earth and pointed precisely, at Polaris, the North Star. This axis provided antenna movement in an East-West direction. The declination gear wheel rotated about an axis parallel to the Earth's equator (perpendicular to the polar axis) and enabled the antenna to move North-South. The gear wheels could be moved either separately or together. Because spacecraft move much like a celestial object in space after traveling several thousand miles from the Earth, it was natural to choose a mount that would steer the antenna from one horizon to the other at a sidereal rate, thus simplifying the mechanical complexity. All of these features were successfully incorporated into the Pioneer Station antenna.[2]

At the present time the Pioneer Station antenna is mothballed and in a standby status. Over the years it has become technologically obsolete and other NASA tracking stations now carry the burden of communicating with the various active space probes.

# 8. Significance

| Period | Areas of Significance—Check and justify below | | | |
|---|---|---|---|---|
| ___ prehistoric | ___ archeology-prehistoric | ___ community planning | ___ landscape architecture | ___ religion |
| ___ 1400–1499 | ___ archeology-historic | ___ conservation | ___ law | X science |
| ___ 1500–1599 | ___ agriculture | ___ economics | ___ literature | ___ sculpture |
| ___ 1600–1699 | ___ architecture | ___ education | X military | ___ social/humanitarian |
| ___ 1700–1799 | ___ art | X engineering | ___ music | ___ theater |
| ___ 1800–1899 | ___ commerce | ___ exploration/settlement | ___ philosophy | ___ transportation |
| X 1900– | ___ communications | ___ industry | ___ politics/government | X other (specify) Aeronautical Research |
| | | ___ invention | | |

**Specific dates** 1936-1956 **Builder/Architect** NACA

**Statement of Significance (in one paragraph)**

The Eight-Foot High Speed Tunnel is a landmark in wind tunnel design. At the time of the construction of the High Speed Tunnel, NACA had only two small high speed tunnels (the 11" and 24" tunnels) to test aircraft design in speeds ranging from Mach 0.5 to Mach 0.9. While useful, these small tunnels had two severe limitations. First, the small size of these tunnels meant than only small scale models could be tested. This meant that test results were suspect if high Reynolds numbers could not be obtained. Second, both tunnels were powered by the rapid blowdown of the VDT and were thus restricted to tests lasting less than a minute.

The Eight-Foot High Speed Tunnel solved both of these problems. It was large enough to accommodate sizeable test models and even complete aircraft parts on occasion. It was also a continuous flow tunnel that could operate almost indefinitely therby giving the engineers sufficient time to run their tests and to check their test results. For the first time NACA engineers had a research tool that could supply high speed test results on a large scale.

Over the years NACA engineers continued to modify and upgrade the Eight-Foot High Speed Tunnel. After the Second World War NACA engineers began to work on improving wind tunnel performance in the transonic range (Mach 0.7 to Mach 1.4). It had long been known that airflow within the test section of a transonic wind tunnel did not represent the actual conditions of free flight. The problem was that the natural pattern of airflow in this range is disturbed and altered by the existence of the walls of the tunnel. This problem became severe in the area of Mach 1 and was known as the tunnel choking effect. Until this problem was solved accurate test results were not possible for transonic tunnels.

Attempts to solve this problem by making smaller models proved unsuccessful when lower Reynolds numbers were obtained. Attempts to eliminated the walls of the tunnel in the area of the test section also proved less than satisfactory. In 1946 Ray Wright at Langley analyzed the potentialities of a partially open or slotted wind tunnel wall. His results suggested that slots occupying about 6 percent of the wall would closely duplicate free-air conditions.[5]

This solution was quickly applied to the Eight-Foot High Speed Tunnel. In February 1950 the tunnel was shut down and slotted walls were added to the test section. The concept worked and NACA now had the first wind tunnel in the world that would give accurate test results in the transonic range. Since all supersonic aircraft would have to fly briefly in the transonic range, knowing what happened to aircraft in this transition zone was critical to the supersonic fighters and bombers being planned in the postwar era. The slotted wall concept was immediately put to work testing the next generation of American aircraft.

After February 1950 the name of the Eight-Foot High Speed Tunnel was changed to the Eight-Foot Transonic Tunnel. Before the tunnel was phased out of operation in 1956 critical tests led to the discovery of the famous Area Rule which dictated that the fuselage of supersonic aircraft should be constricted where the wings are attached and then expanded at their trailing edges. This eliminated the possibility of generating strong shock waves behind an aircraft that can act as a drag on speed.

Many modern wind tunnels are derived from the technology extended or developed at Langley by NACA engineers. The Variable Density Tunnel was the world's first pressurized wind tunnel. The Full Scale Wind Tunnel was exactly that, full scale and thus able to conduct important drag cleanup tests for modern aircraft. The Eight-Foot High Speed Tunnel was the first continuous flow high speed tunnel able to test large models and actual working parts of airplanes. The addition of the slotted throat design was revolutionary for its time and gave accurate wind tunnel data in the transonic range. Many modern wind tunnels incorporate some variation of these features of pressure, large scale, high speed, continuous flow, and slotted throat design. These three tunnels marked the emerging technological superiority of the American aircraft industry. After the Second World War this technology was to provide the base upon which Americans would begin to construct rockets that would eventually fly to the moon and beyond.

## 9. Major Bibliographical References

See continuation sheets

## 10. Geographical Data

Acreage of nominated property Less than 1 acre

Quadrangle name Hampton

Quadrangle scale 1:24,000

UMT References

| | Zone | Easting | Northing |
|---|---|---|---|
| A | 18 | 380760 | 4104620 |
| B | | | |
| C | | | |
| D | | | |
| E | | | |
| F | | | |
| G | | | |
| H | | | |

Verbal boundary description and justification

The boundary of the Eight-Foot High Speed Tunnel is defined by the outside perimeter of Building 641 in the East Area of the Langley Research Center.

List all states and counties for properties overlapping state or county boundaries

state code county code

state code county code

## 11. Form Prepared By

name/title Harry A. Butowsky

organization National Park Service date May 15, 1984

street & number Division of History telephone (202) 343-8168

city or town Washington, D.C. 20240 state

## 12. State Historic Preservation Officer Certification

The evaluated significance of this property within the state is:

___ national ___ state ___ local

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89-665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service.

State Historic Preservation Officer signature

title date

For NPS use only

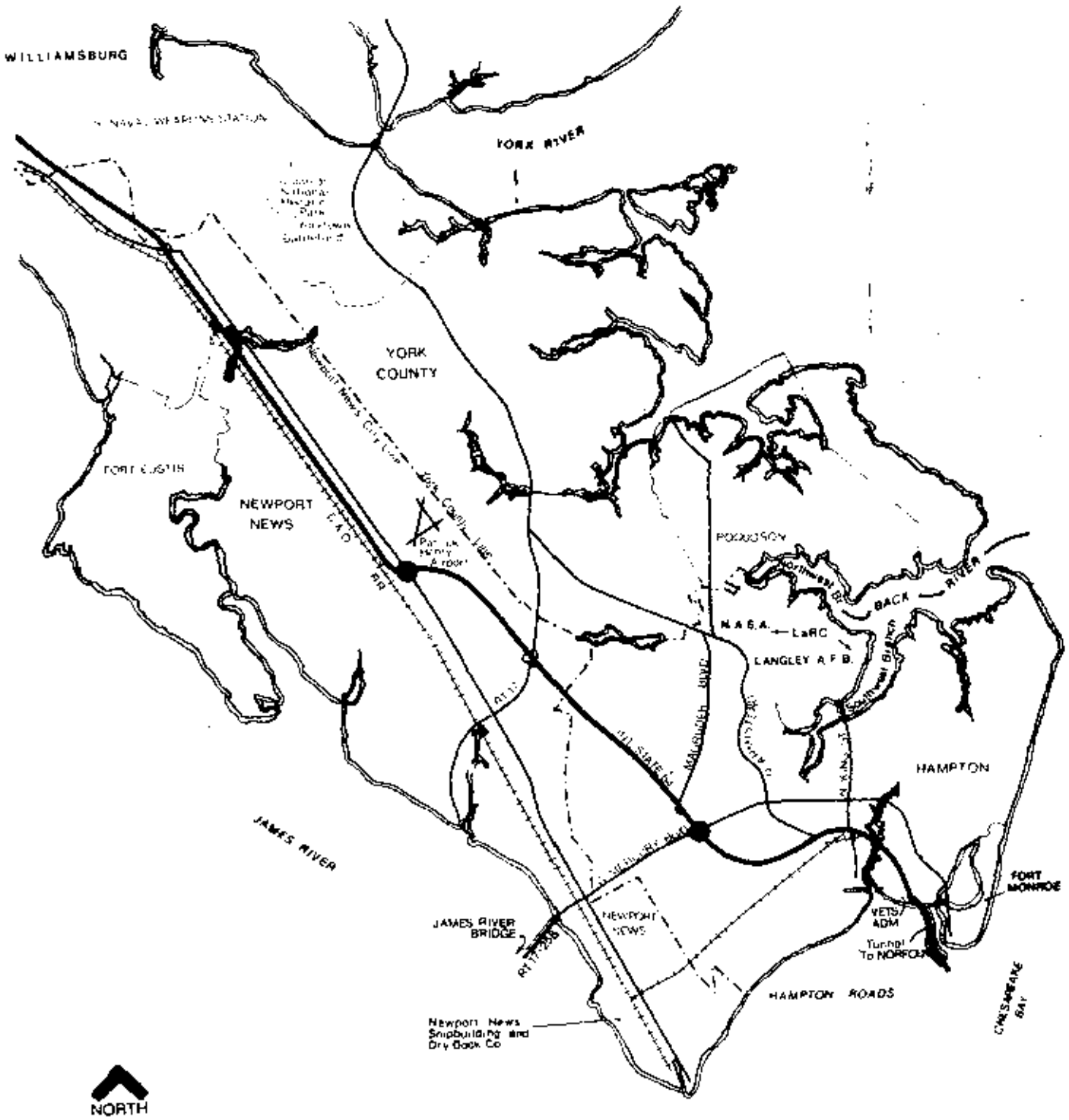
I hereby certify that this property is included in the National Register

date

Keeper of the National Register

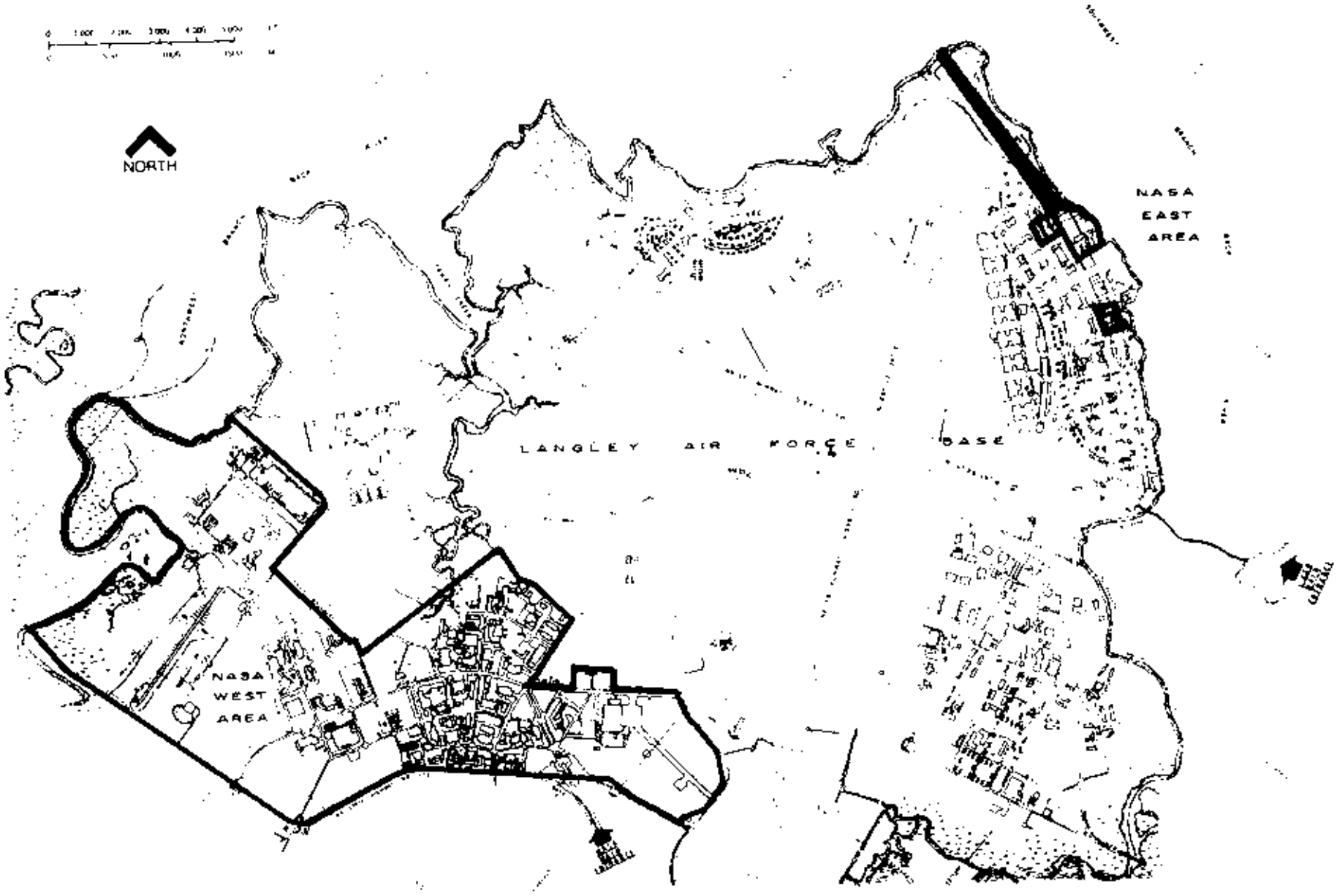
Attest: date

Chief of Registration




NASA
National Aeronautics and Space Administration
**Langley Research Center**
Hampton, Virginia
23665

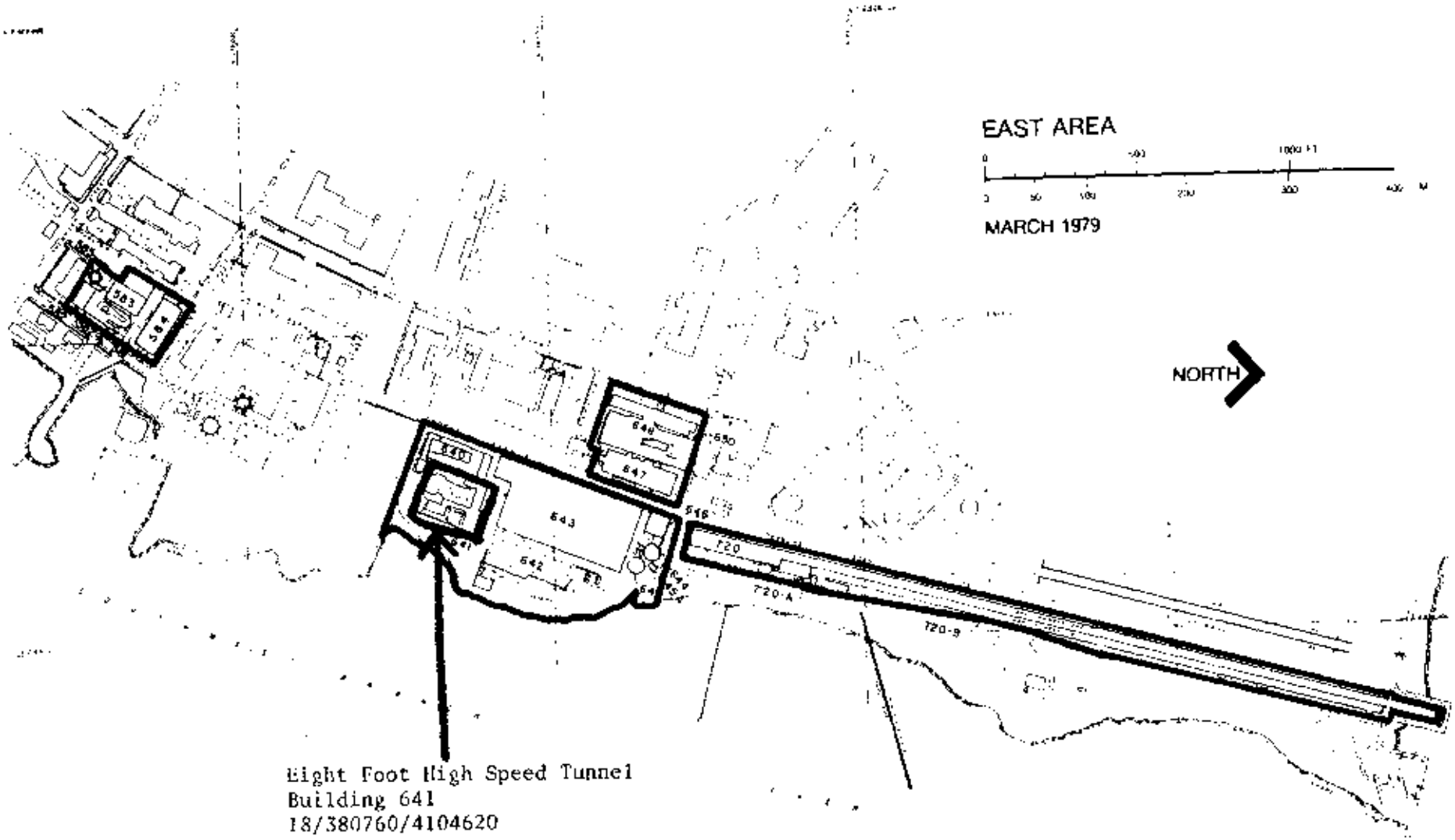
**FIGURE 1-1**
**Regional Map**




NASA
National Aeronautics and
Space Administration

**Langley Research Center**
Hampton, Virginia
23665

**FIGURE 1-2**
**Combined East & West Area**



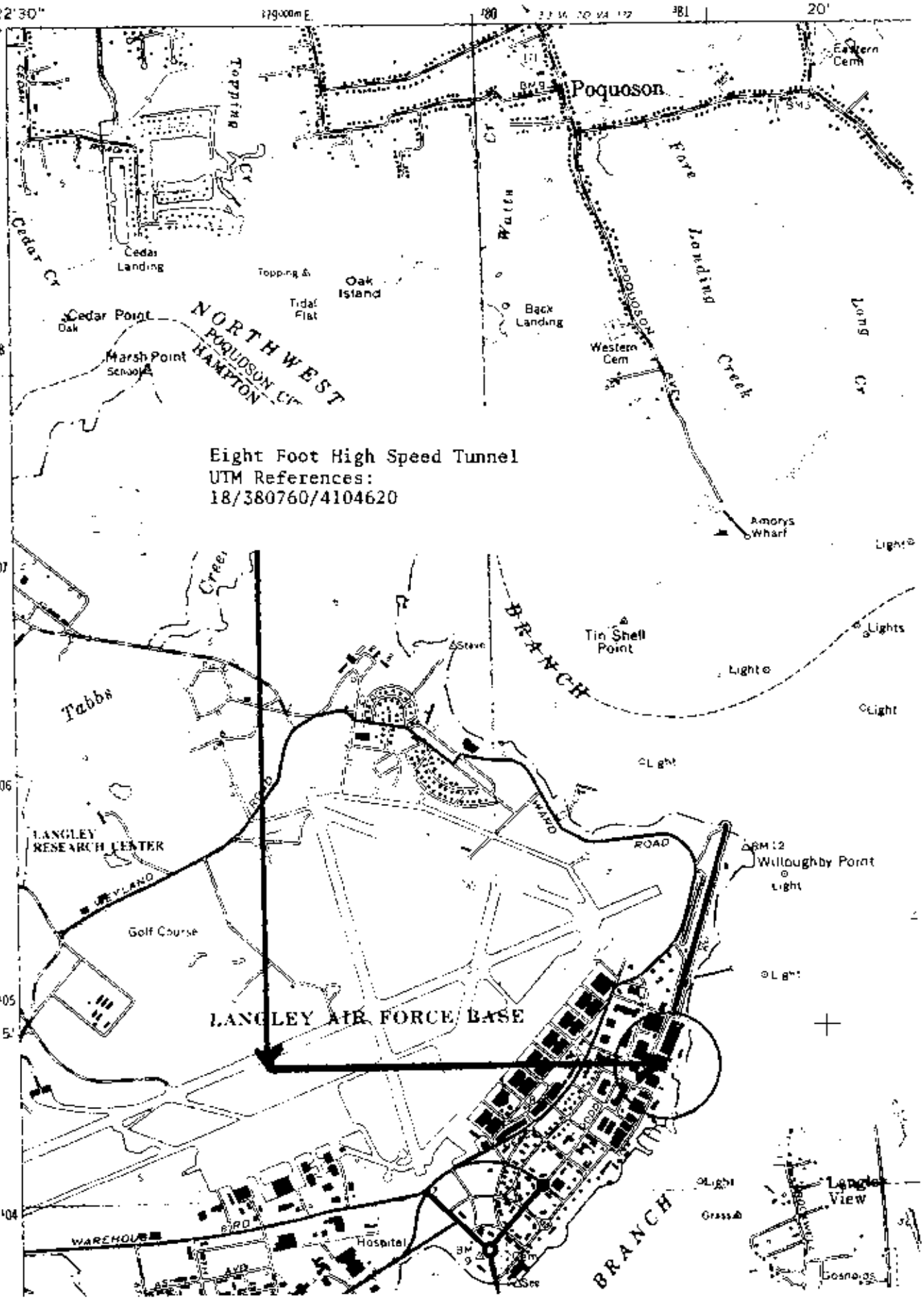

National Aeronautics and Space Administration

**Langley Research Center**
Hampton, Virginia
23665

**FIGURE 1-3**
**East Area**

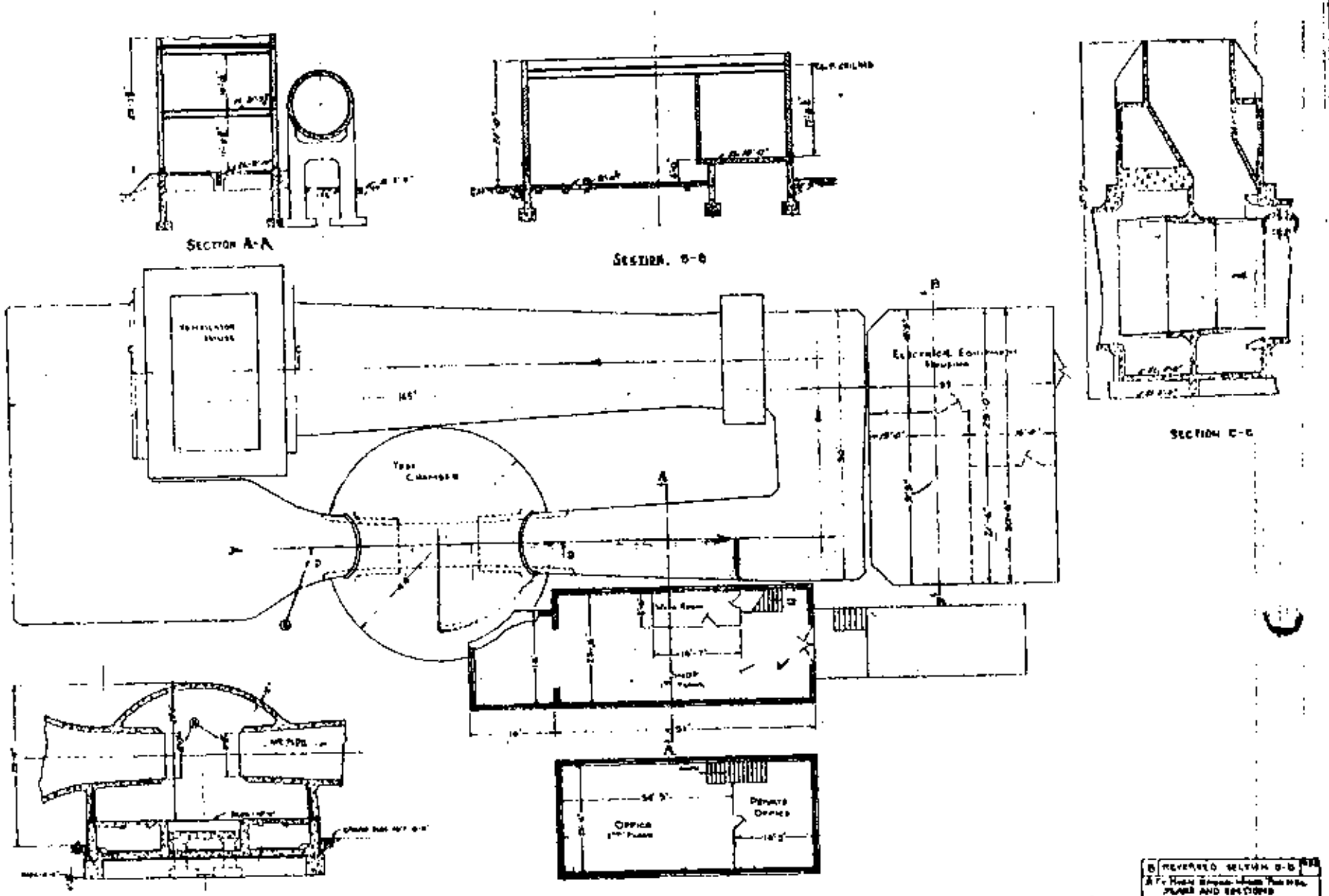
5728 III NW
(POQUOSON WEST)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY




Eight Foot High Speed Tunnel
UTM References:
18/380760/4104620

Eight-Foot High Speed Tunnel




Source 8-Foot High Speed Tunnel Internal Memorandum, (Langley Field, Va.: National Advisory Committee for Aeronautics, June 30, 1939)

Footnotes

1. Information taken for the description of the Spacecraft Propulsion Research Facility was derived from the following sources:

   Plum Brook Station (Cleveland, Ohio: Lewis Research Center, No Date), p.16.

   Spacecraft Propulsion Research Facility "B-2" (Cleveland, Ohio: Lewis Research Center, May 1972), pp. 1-17.

   Technical Facilities Catalogue Vol. 1 (Washington, D.C.: National Aeronautics and Space Administration, 1974), pp. 4-89., 4-90.

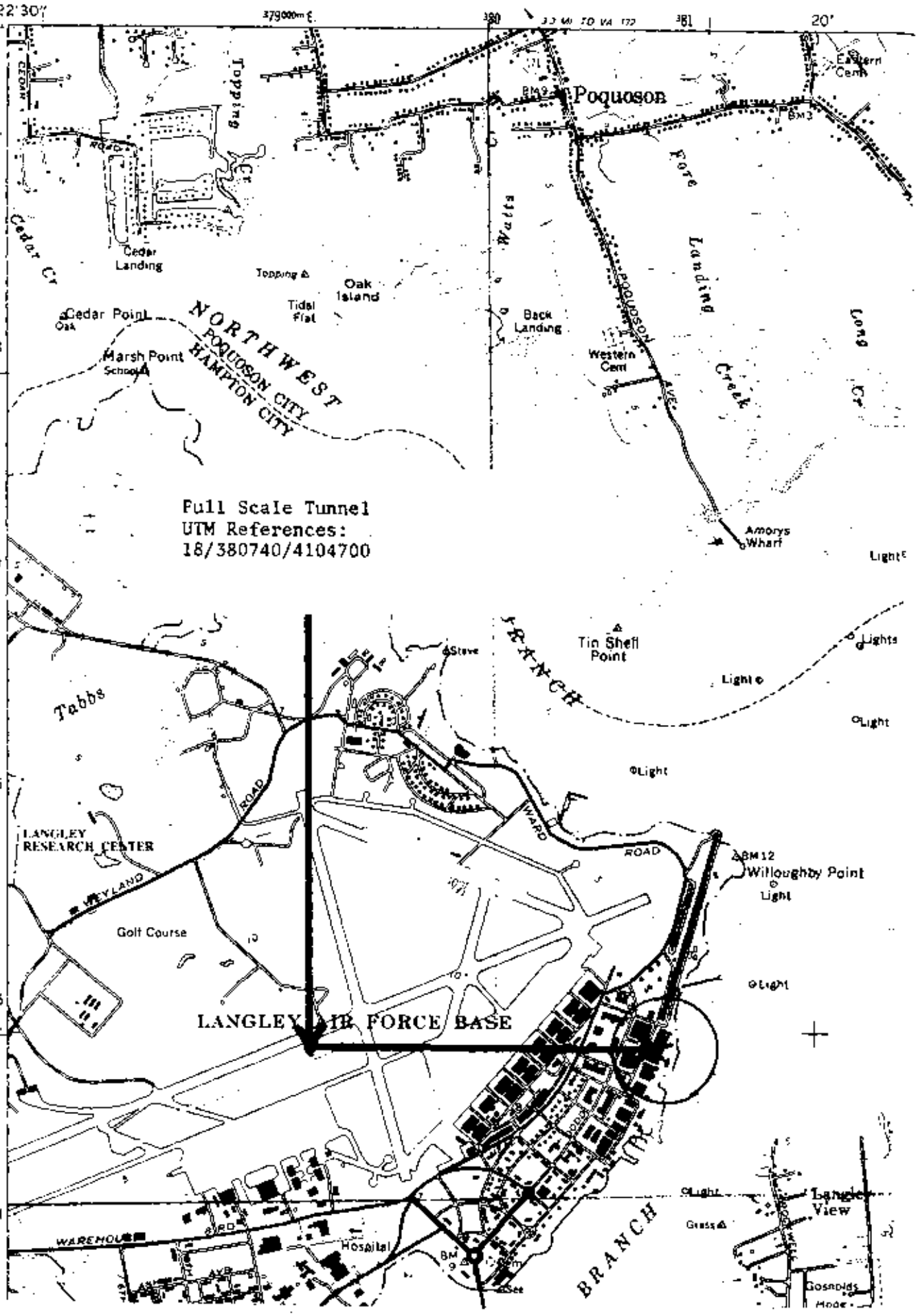
Bibliography

Plum Brook Station. Cleveland, Ohio: Lewis Research Center, No date.

Spacecraft Propulsion Research Facility "B-2". Cleveland, Ohio: Lewis Research Center, 1972.

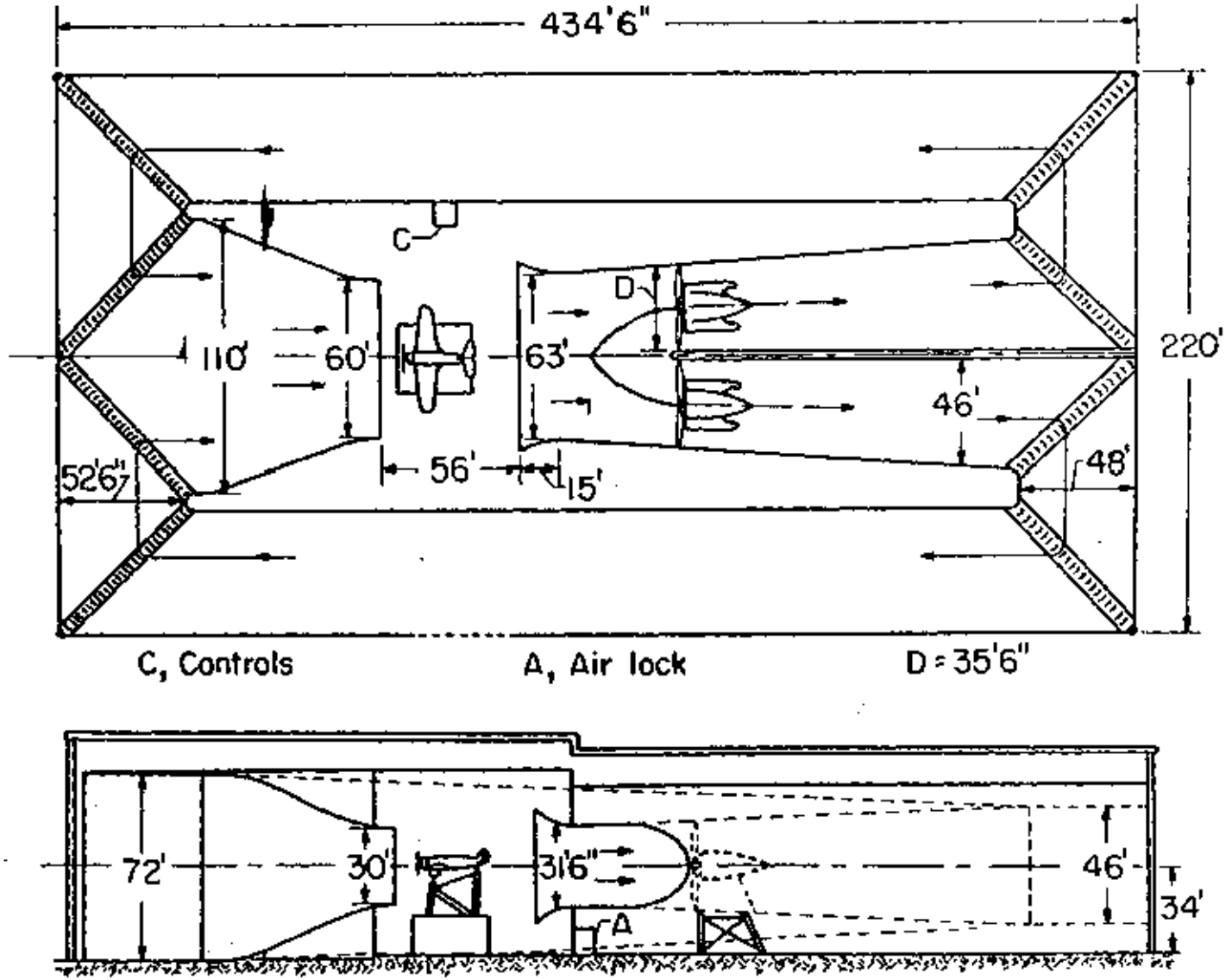
Technical Facilities Catalog Vol. 1. Washington, D.C.: National Aeronautics and Space Administration, 1974.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY



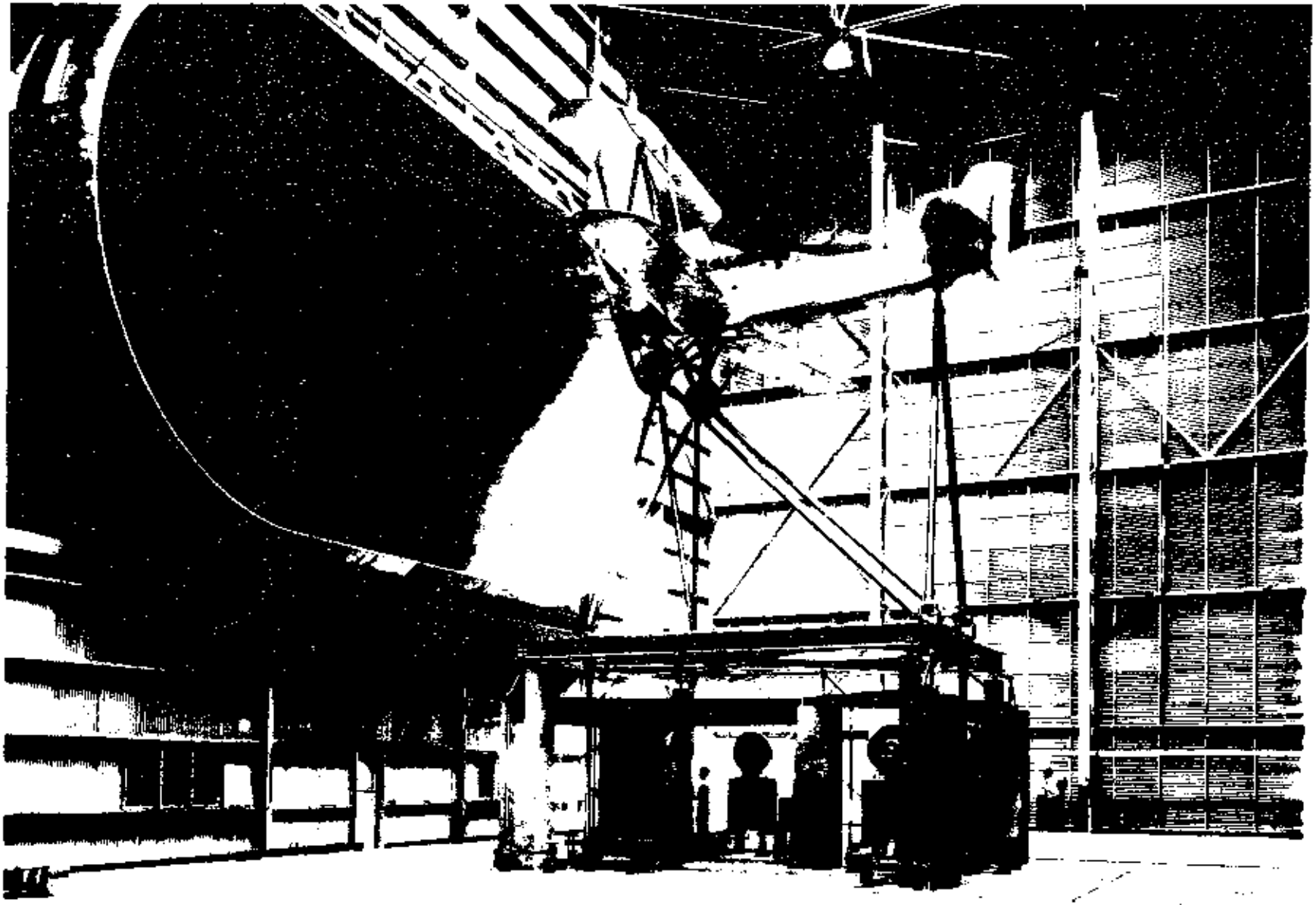
Appendix 1

Plan and elevation sketch of the Langley full-scale tunnel.



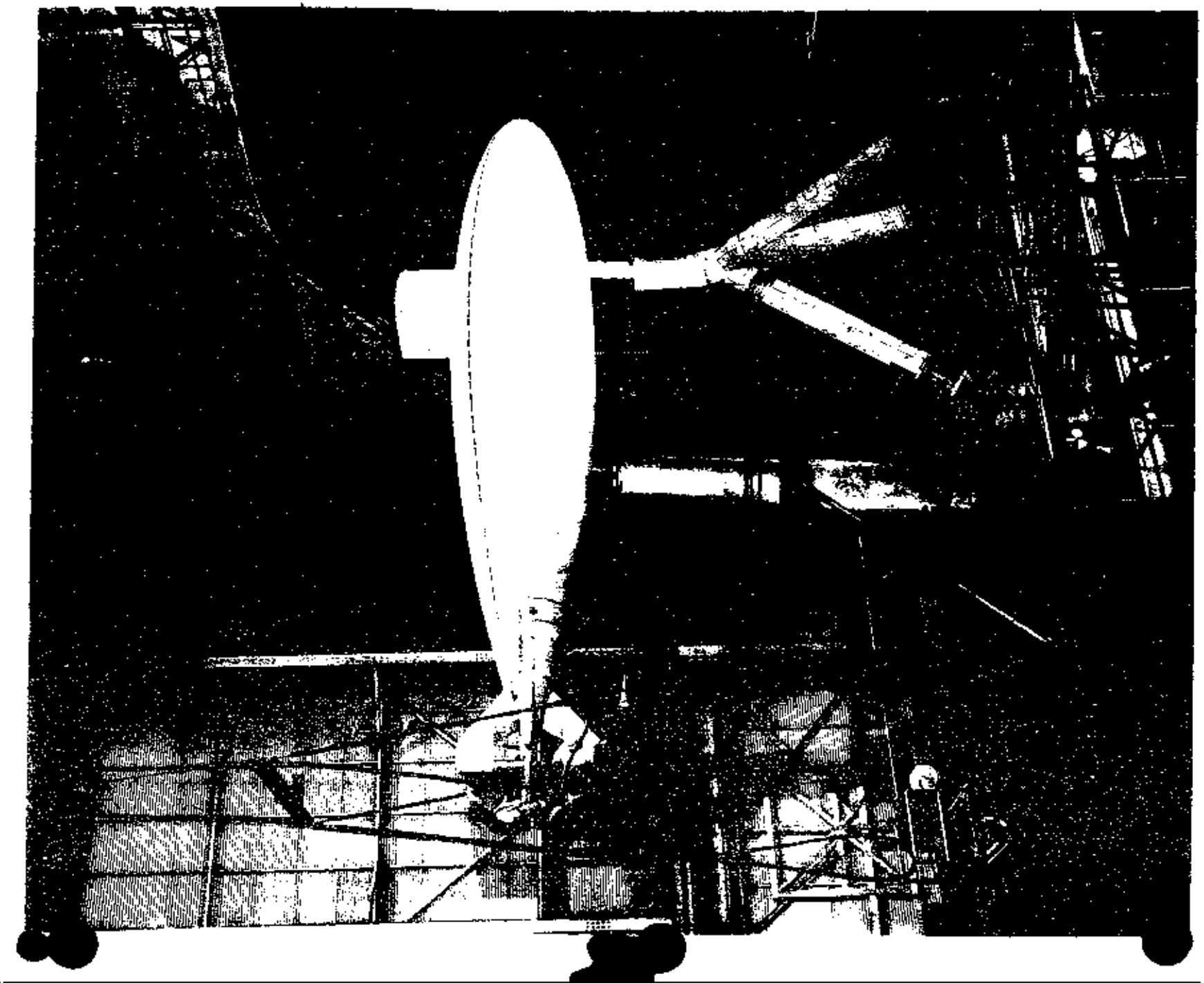

Source Characteristics of Nine Research Wind Tunnels of the Langley Aeronautical [illegible]ratory (Washington, D. C.: National Advis[illegible]tee for Aeronautics [illegible]), p. 99.

1. Full Scale Tunnel
2. Hampton, Virginia
3. NACA
4. 1931
5. NASA, Langley Research Center Archives
6. Interior view of test section with Vought 03U-1 Airplane



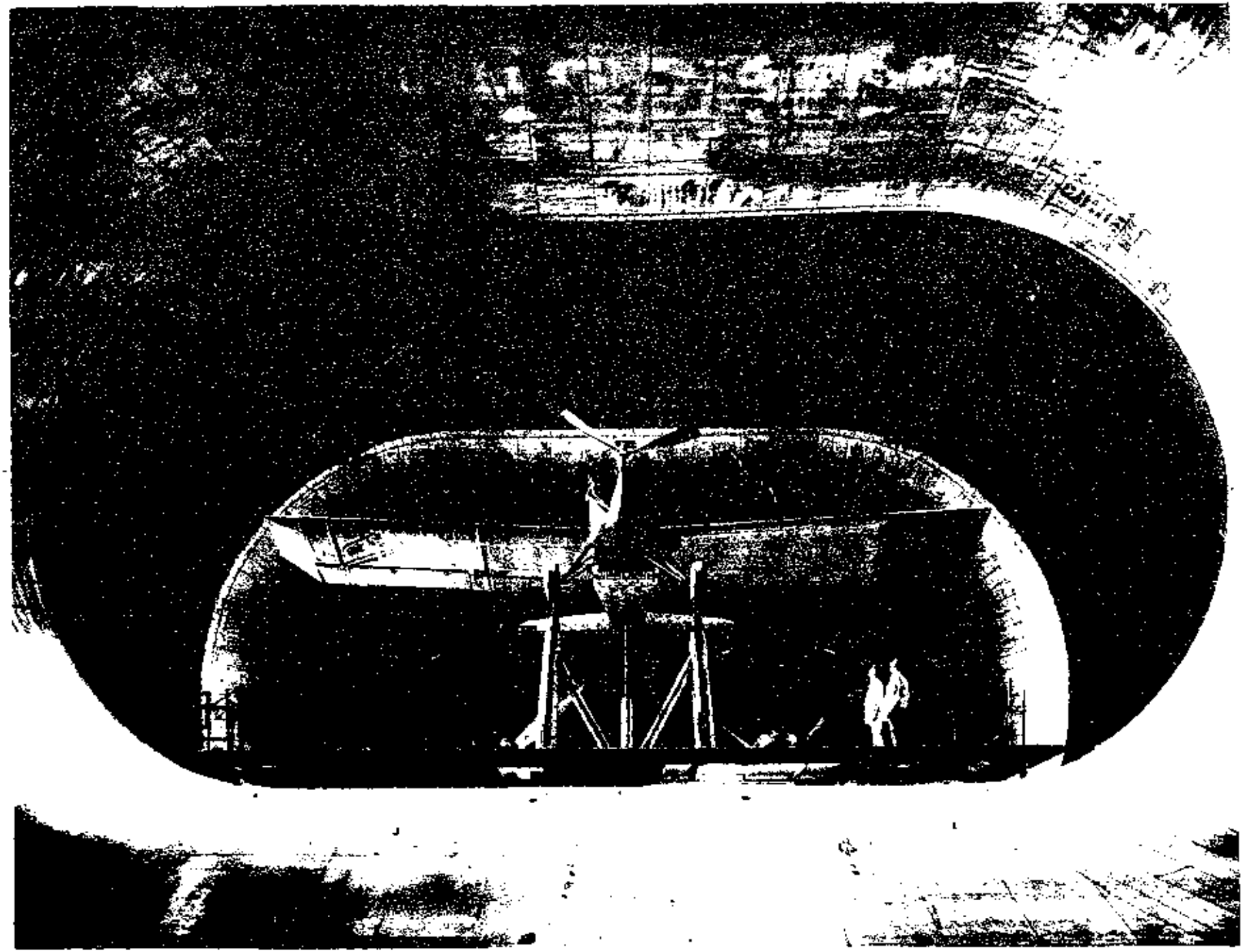
1. Full Scale Tunnel
2. Hampton, Virginia
3. NACA
4. 1950
5. NASA, Langley Research Center Archives
6. Interior view of test section with submarine Albacore

NACA
LAL 64789



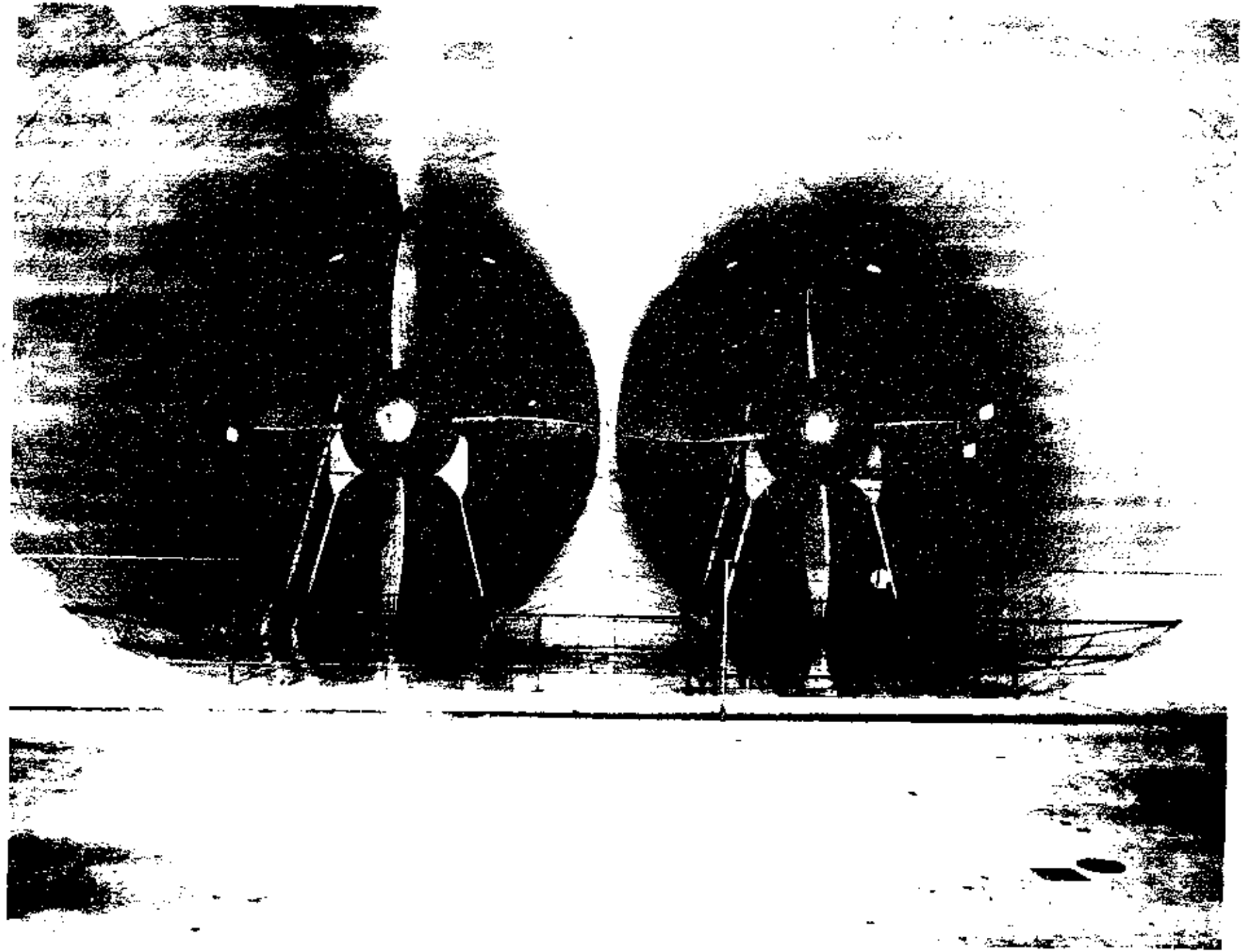
1. Full Scale Tunnel
2. Hampton, Virginia
3. NASA
4. 1978
5. NASA, Langley Research Center Facilities Office
6. Modern interior view of test section

NASA
L-78-3568

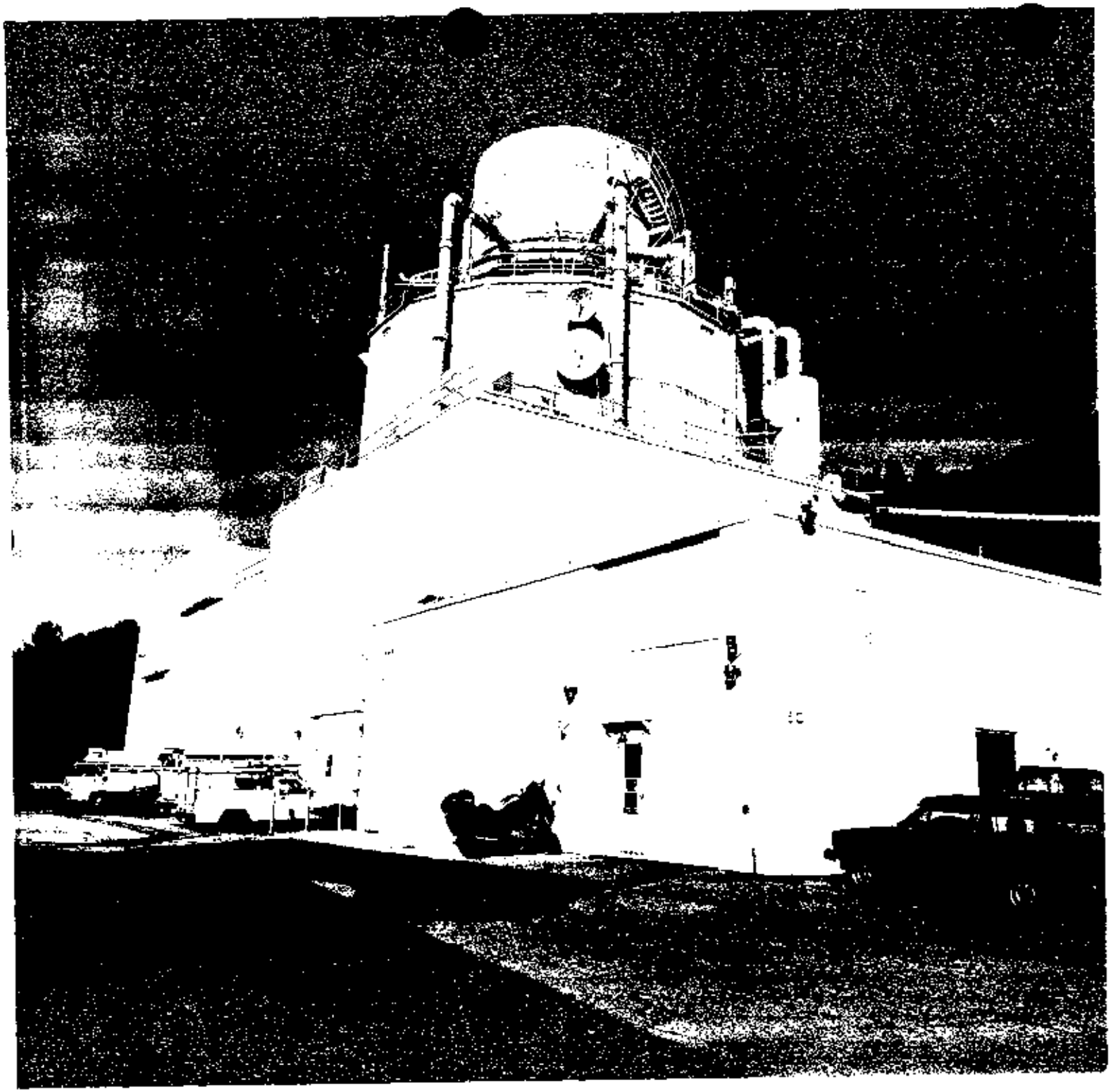


1. Full Scale Tunnel
2. Hampton, Virginia
3. NASA
4. 1983
5. NASA, Langley Research Center Facilities Office
6. Modern view of the two four-blade fans that power the Full Scale Tunnel

NASA
L-83-8,156



1. Full Scale Tunnel
2. Hampton, Virginia
3. NASA
4. 1981
5. NASA, Langley Research Center Facilities Office
6. Exterior view



1. Twenty-Five-Foot Space Simulator
2. Pasadena, California
3. NASA-JPL
4. 1981
5. JPL Facilities Office
6. Interior View of Twenty-Five-Foot Space Simulator with test article

## TRACKING STATIONS

21. Pioneer Deep Space Station (Goldstone Tracking Station)

1. Unitary Plan Wind Tunnel
2. Moffett Field, California
3. NASA
4. 1984
5. NASA, Ames Research Center Facilities Office
6. Exterior view - The Unitary Plan Wind Tunnel is in the center of the photograph

Unitary Plan Wind Tunnel Bldg. N-227

NASA Ames Research Center
Moffett Field, CA

ROCKET ENGINE DEVELOPMENT FACILITIES

5. Rocket Engine Test Facility (Lewis Research Center)

6. Zero-Gravity Research Facility (Lewis)

7. Spacecraft Propulsion Research Facility
(LeRC Plum Brook Operations Division)

Man in Space Theme Study
Federal Agency Nomination

NPS Form 10-900
(7-81)

**United States Department of the Interior**
**National Park Service**

For NPS use only

received

date entered

# National Register of Historic Places Inventory—Nomination Form

See instructions in *How to Complete National Register Forms*
Type all entries—complete applicable sections

## 1. Name

historic Rocket Engine Test Facility

and/or common Rocket Propulsion Test Facility

## 2. Location

street & number Lewis Research Center ___ not for publication

city, town Cleveland ___ vicinity of congressional district

state Ohio code 39 county Cuyahoga code 035

## 3. Classification

| Category | Ownership | Status | Present Use | |
|---|---|---|---|---|
| ___ district | X public | ___ occupied | ___ agriculture | ___ museum |
| ___ building(s) | ___ private | ___ unoccupied | ___ commercial | ___ park |
| X structure | ___ both | ___ work in progress | ___ educational | ___ private residence |
| ___ site | **Public Acquisition** | **Accessible** | ___ entertainment | ___ religious |
| ___ object | ___ in process | X yes: restricted | X government | X scientific |
| | ___ being considered | ___ yes: unrestricted | ___ industrial | ___ transportation |
| | | ___ no | ___ military | X other: Space Exploration |

## 4. Owner of Property

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## 5. Location of Legal Description

courthouse, registry of deeds, etc. National Aeronautics and Space Administration (NASA)

street & number Real Property Management Office Code NXG

city, town Washington state D.C. 20546

## 6. Representation in Existing Surveys

title None has this property been determined eligible? ___ yes ___ no

date ___ federal ___ state ___ county ___ local

depository for survey records

city, town state

# 7. Description

| Condition | | Check one | Check one |
|---|---|---|---|
| X excellent | ___ deteriorated | ___ unaltered | X original site |
| ___ good | ___ ruins | X altered | ___ moved date _____ |
| ___ fair | ___ unexposed | | |

**Describe the present and original (if known) physical appearance**

The Rocket Engine Test Facility (RETF) Complex is an integrated stand-alone test facility dedicated to the testing of full scale rocket thrust chambers. The complex is at the south end of the Lewis Research Center (LeRC), Cleveland, Ohio, and occupies approximately ten acres of land. The complex includes two major buildings with extensive support services. The RETF (Building 202) is used for sea level testing of vertically mounted rocket thrust chambers and space simulation testing of horizontally mounted rocket engines. The Rocket Operations Building (ROB) (Building 100) is located one-quarter mile north of RETF and contains the facility remote control room, a shop area, and general office space. This unique test complex has high pressure capabilities, the ability to test with a wide variety of rocket propellants, and space simulation capabilities for large area ratio rocket nozzle tests.

The RETF was completed in the fall of 1957 at a cost of $2-1/2 million to test hydrogen-fluorine and hydrogen-oxygen rocket thrust chambers. The facility test capabilities have been significantly upgraded since it was built.

Facility Systems

The RETF consists of a 1325 square foot test cell containing two test stands, pressurized propellant run tanks and propellant flow line systems, and a rocket exhaust gas treatment combination scrubber and silencing muffler. A 4800 square foot shop service building and 16 large volume high pressure (4000 to 6000 psi) gas storage bottles are adjacent to the test cell. The support systems include permanent on-site bulk storage dewars for cryogenic liquid hydrogen, liquid oxygen, and liquid nitrogen and a large water reservoir; all are connected to the test cell by permanent pipelines. Four small buildings including a pump house, helium compressor shelter, liquid hydrogen pump-vaporizer shelter, and an observation blockhouse are part of the test complex.

Both the high thrust (20,000 lb) vertical test stand and the low thrust (to 1000 lb) horizontal stand exhausts discharge into the common scrubber muffler system for toxicity and sound control. The scrubber system and facility foundations are designed to accommodate rocket engines up to 100,000 lb. thrust while the present engine mounting and plumbing, controls and instrumentation limit testing to a maximum of 20,000 lb. thrust. The scrubber system consists of a 100-foot long horizontal tank, 25 feet in diameter containing six water spray banks connected to a vertical stack 20 feet in diameter (which necks down to 6 feet in diamenter) by 118 feet high. During a run, water from the reservoir tank flows to the exhaust scrubber at a rate of 50,000 gallons per minute. The

hot gases, emerging from the rocket nozzle at velocities of 9000 to 12,000 feet per second and temperatures of about 6000°F, are met with a drenching spray of water and quickly cooled to steam temperature and slowed to a velocity of about 25 feet per second. Additional water sprays condense the steam, and noncondensable exhaust gas emerges from the stack below 160°F and a velocity of about 20 feet per second. Water from the scrubber is ducted to a detention tank for treatment and then discharged to the ground water system.

The 1984 modifications provide a space simulation test capability for the study of extremely large area ratio nozzles (to 1000:1) on small, low thrust rocket engines. The modifications include a large vacuum tank which houses the rocket engine, a long, water cooled diffuser section into which the hot engine exhaust is funneled, an inter-cooler for cooling the exhaust gases, and two gas ejectors to provide the pumping necessary to maintain the low vacuum environment during testing.

Nine individual propellant systems comprised of run dewars and tanks with working pressure ranging from 1500 to 6000 psi are operational and permanently connected to the test stands with stainless steel, vacuum, or liquid nitrogen jacketed pipelines. These systems provide the capability to test the thrust chamber without the need for high pressure rocket turbomachinery and pumps. The separate propellant systems are integrated to support a particular rocket technology program on an as-required basis. Hydraulic, variable position valves control both the pressurant gas flow to the run tanks and the propellant flow to the rocket chambers under tests.

The primary liquid hydrogen, liquid oxygen, cooling water, and hydrocarbon propellant systems are rated at 5000 psi working pressure. Currently, gaseous hydrogen at 4000 psi, gaseous helium at 6000 psi, and gaseous nitrogen at 3000 psi are being stored. A nominal 500,000-gallon water storage reservoir supplies the scrubber and muffler as well as providing a source of water for the 650 gal/min and 1400 gal/min (at 450 psi) pumps and for cooling the rocket altitude simulation system. On-site bulk storage of liquid nitrogen (28,000 gallons) liquid oxygen (2,000 gallons), and liquid hydrogen (18,000 gallons) support the Rocket Engine Test Facility. On-site gas-pumping equipment in service at RETF supply gaseous hydrogen at 4000 psi, gaseous helium (automated) at 6000 psi, and gaseous nitrogen (automated) at 3000 psi to the various gas bottle farms.

A flare stack, at the top of the scrubber stack, provides the facility with the capability for open air burnoff of non-regenerative hydrogen, discharged from thrust chambers at rates up to 5 pounds per second.

In the test cell integral $CO_2$ and water deluge fire suppression systems and strategically located concrete blast walls aid in damage control if a rocket chamber fails under test. Hydrogen gas detectors are throughout the facility to warn of potentially hazardous hydrogen leaks.

Control and Instrumentation

The RETF test stands are remotely controlled from the well equipped control room in ROB. Manual, automatic timed, and computer electrical units control the facility instrumentation, data acquisition, hydraulic servo systems, valve operation, and the rocket engine operation from that location. Solid state, programmable flow controllers and sequence timers provide automatic propellant flow control, remote sequence timing, and automatic premissive and cut-off control for the rocket engine under tests. Facility safety monitoring is also provided.

Data are processed through a 200 channel high speed (31K Hz) digitizer multiplexer data acquisition system and fed by a direct digital data link to the Lewis Research Center central data system (IBM 3033 TSS and Cray 1-S computers). This system provides on-line data reduction capabilities to the control room via hardcopy terminals and CRTs located at ROB. Analog data systems provide "quick look" test data through four oscillograph recorders. System pressures are displayed on panel meters in the control room for facility remote control. Closed circuit television systems and a sound monitoring system provide real time data necessary for the remote control of rocket tests. A facility intercommunication system, and emergency communication system, and two independent telephone systems all provide the communications network necessary for safe rocket test operations.[1]

# 8. Significance

| Period | Areas of Significance—Check and justify below | | | |
|---|---|---|---|---|
| ___ prehistoric | ___ archeology-prehistoric | ___ community planning | ___ landscape architecture | ___ religion |
| ___ 1400–1499 | ___ archeology-historic | ___ conservation | ___ law | X science |
| ___ 1500–1599 | ___ agriculture | ___ economics | ___ literature | ___ sculpture |
| ___ 1600–1699 | ___ architecture | ___ education | ___ military | ___ social/ humanitarian |
| ___ 1700–1799 | ___ art | X engineering | ___ music | ___ theater |
| ___ 1800–1899 | ___ commerce | ___ exploration/settlement | ___ philosophy | ___ transportation |
| X 1900– | ___ communications | ___ industry | ___ politics/government | X other (specify) Space Exploration |
| | | ___ invention | | |

**Specific dates** 1957-Present **Builder/Architect** NACA

**Statement of Significance (in one paragraph)**

The Rocket Engine Test Facility (RETF) is nationally significant because of its contribution in the development of the lighweight, regeneratively cooled hydrogen engine. The RETF was built in 1956 by the National Advisory Committee for Aeronautics (NACA) at the Lewis Research Center for the purpose of sea level testing of vertically-mounted rocket engines. The construction and use of the RETF was the next logical step in the continuing mission of the Lewis Research Center in the field of aircraft propulsion systems.

The Lewis Research Center was from the beginning of its history a propulsion center for the National Advisory Committee for Aeronautics. It was from this early work which bridged the transition from reciprocating engines to newer gas turbine jet engines that Lewis made its early mark for NACA. In the years immediately before the creation of NASA in 1958 technical personnel at Lewis begin to experiment with the possibilities of using hydrogen as a rocket fuel. Hydrogen was a desirable fuel because of its low weight and high specific impusle. It was a powerful fuel that appeared to hold promise in the development of high performance rocket engines. Hydrogen was also a dangerous fuel to handle due to the possibility of explosion and the need to use exotic oxidizers such as flourine and oxygen.

By the late 1950s researchers at Lewis became convinced that the desirability of using hydrogen-oxygen as a fuel for upper stage rockets was not only desirable but practicable. This data on the use of liquid hydrogen-oxygen combination developed at Lewis in the RETF was rapidly put to use by NASA contractors in developing liquid hydrogen rockets for the American Space Program.

The specific accomplishments that resulted from this work at the RETF were the development of the RL-10 engine for the Centaur rocket, the J-2 engine for the Saturn rocket, and hydrogen-oxygen engines currently used by the Space Shuttle. The development of the technology needed to handle liquid hydrogen-oxygen cannot be overestimated. The use of the Centaur and Saturn rockets have made possible the American exploration of space in both the manned Apollo program and the unmanned program to explore the planets and the solar environment. The technology used to build the Centaur, Saturn, and current Space Shuttle rockets can be directly attributed to the work of the Lewis Research Center in the RETF in its effort to support the continuing propulsion needs of NASA for its many space programs and missions.

The RETF is an active NASA facility that is now engaged in research to improve rocket technology programs in support of the Advance Space Shuttle, Orbit Transfer Vehicles, and the newly announced Space Station Project.

Footnotes

1. Wayne Thomas, "Description of the Rocket Engine Test Facility" (Unpublished Report, Lewis Research Center, 1984), pp. 1-4.

Bibliography

Bilstein, Roger E. Stages to Saturn. Washington, D.C.: National Aeronautics and Space Administration, 1980.

Sloop, John L. Liquid Hydrogen as a Propulsion Fuel, 1945-1959. Washington, D.C.: National Aeronautics and Space Administration, 1978.

Technical Facilities Catalog Vol. 1. Washington, D.C.: National Aeronautics and Space Administrative, 1974.

Thomas, Wayne. "Description of the Rocket Engine Test Facility." Unpublished Report, Lewis Research Center, 1984.

## 9. Major Bibliographical References

See continuation sheets

## 10. Geographical Data

Acreage of nominated property Less than 1 acre

Quadrangle name Lakewood

Quadrangle scale 1:24,000

UMT References

| | Zone | Easting | Northing | | Zone | Easting | Northing |
|---|---|---|---|---|---|---|---|
| A | 17 | 427510 | 4583800 | B | | | |
| C | | | | D | | | |
| E | | | | F | | | |
| G | | | | H | | | |

Verbal boundary description and justification

The boundary of the Rocket Engine Test Facility is shown as the green line on the accompanying map entitled "National Aeronautics and Space Administration, Lewis Research Center."

List all states and counties for properties overlapping state or county boundaries

| state | code | county | code |
|---|---|---|---|
| | | | |
| state | code | county | code |

## 11. Form Prepared By

name/title Harry A. Butowsky

organization National Park Service date May 15, 1984

street & number Division of History telephone (202) 343-8168

city or town Washington, D.C. 20240 state

## 12. State Historic Preservation Officer Certification

The evaluated significance of this property within the state is:

___ national ___ state ___ local

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89-665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service.

State Historic Preservation Officer signature

title date

For NPS use only

I hereby certify that this property is included in the National Register

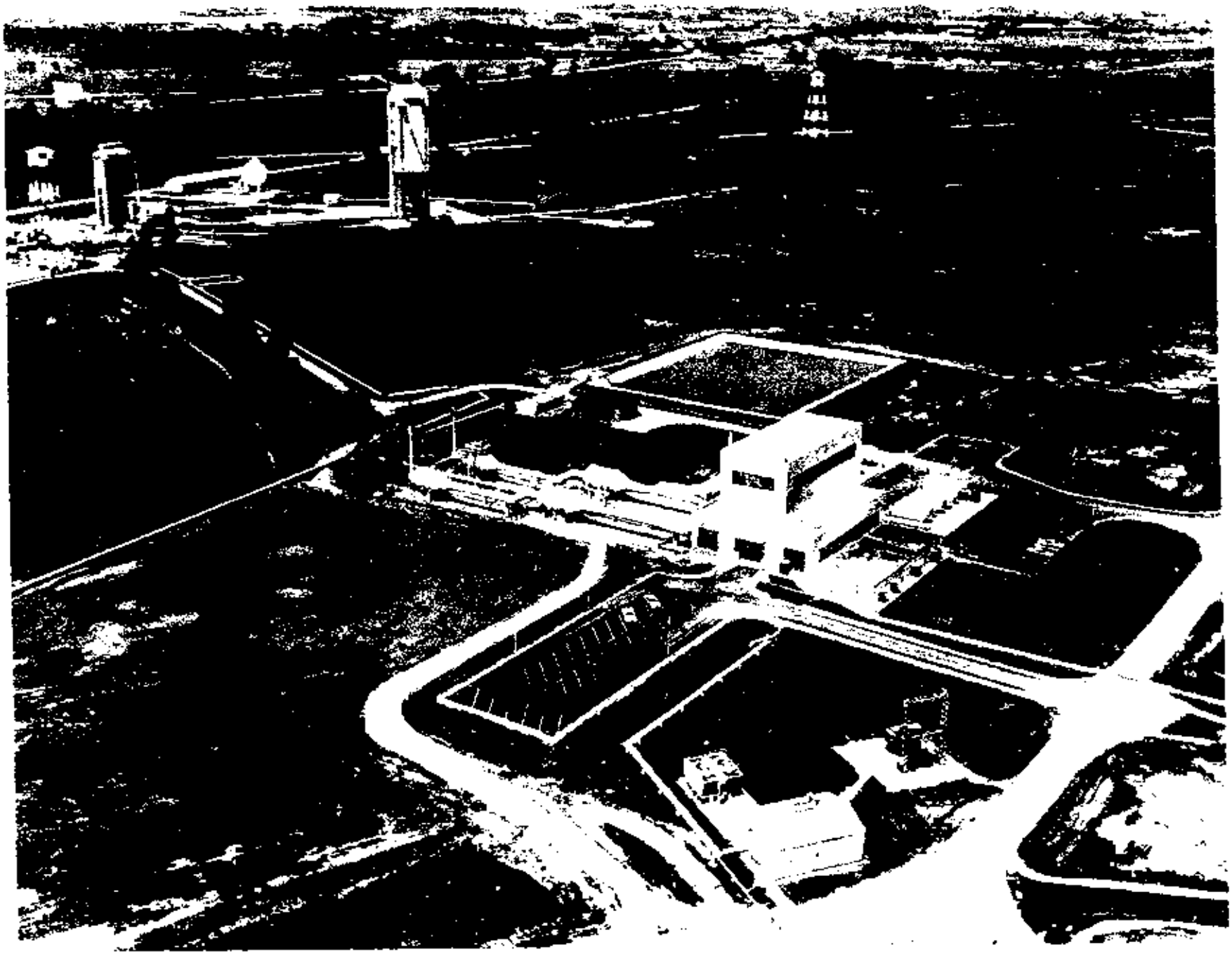
date

Keeper of the National Register

Attest: date

Chief of Registration

NASA
C-69-1922



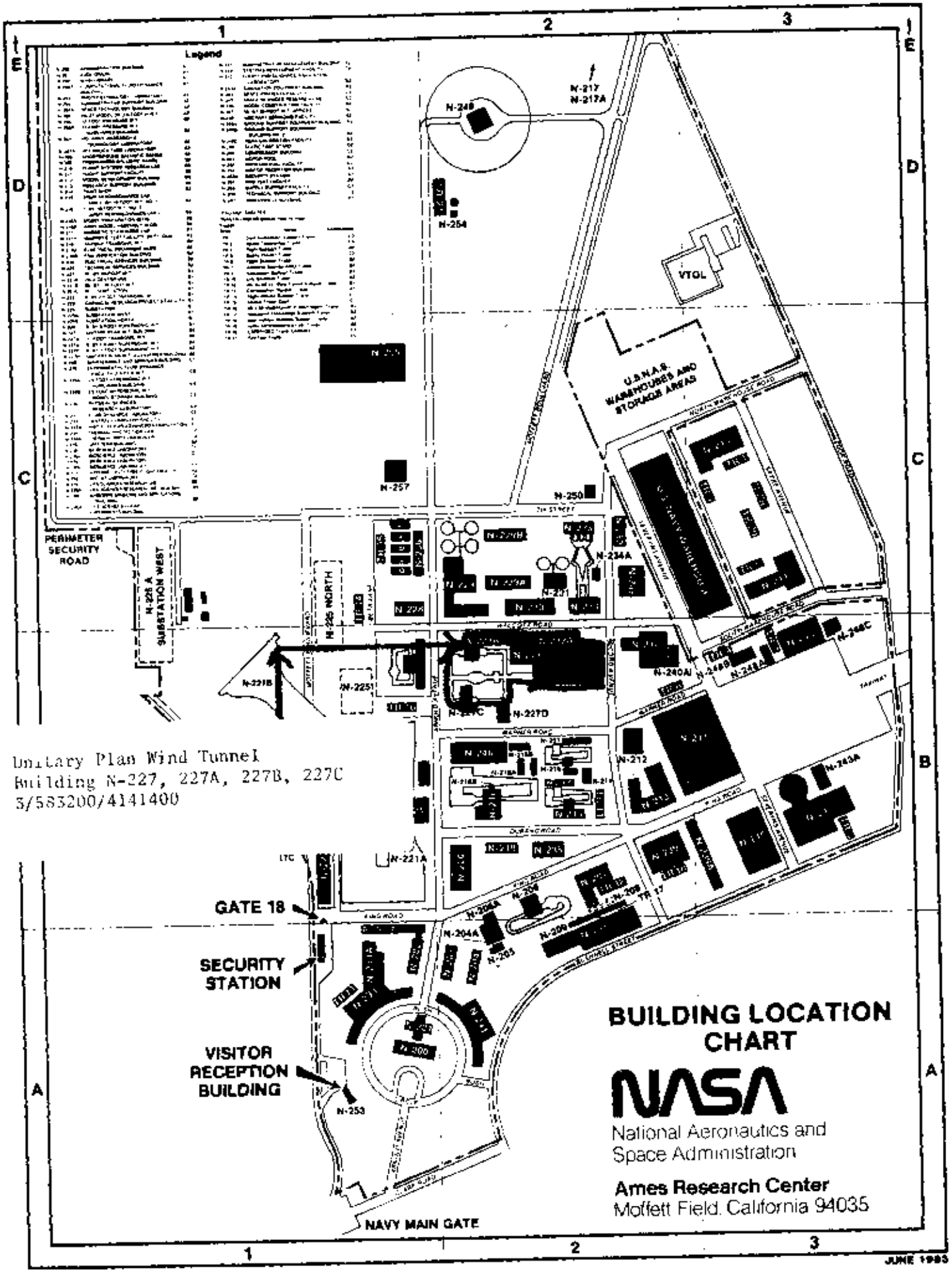
1. Spacecraft Propulsion Research Facility
2. Sandusky, Ohio
3. NASA
4. 1981
5. NASA, Lewis Research Center Facility Office
6. Cutaway view of the facility

## ROCKET ENGINE TEST STANDS

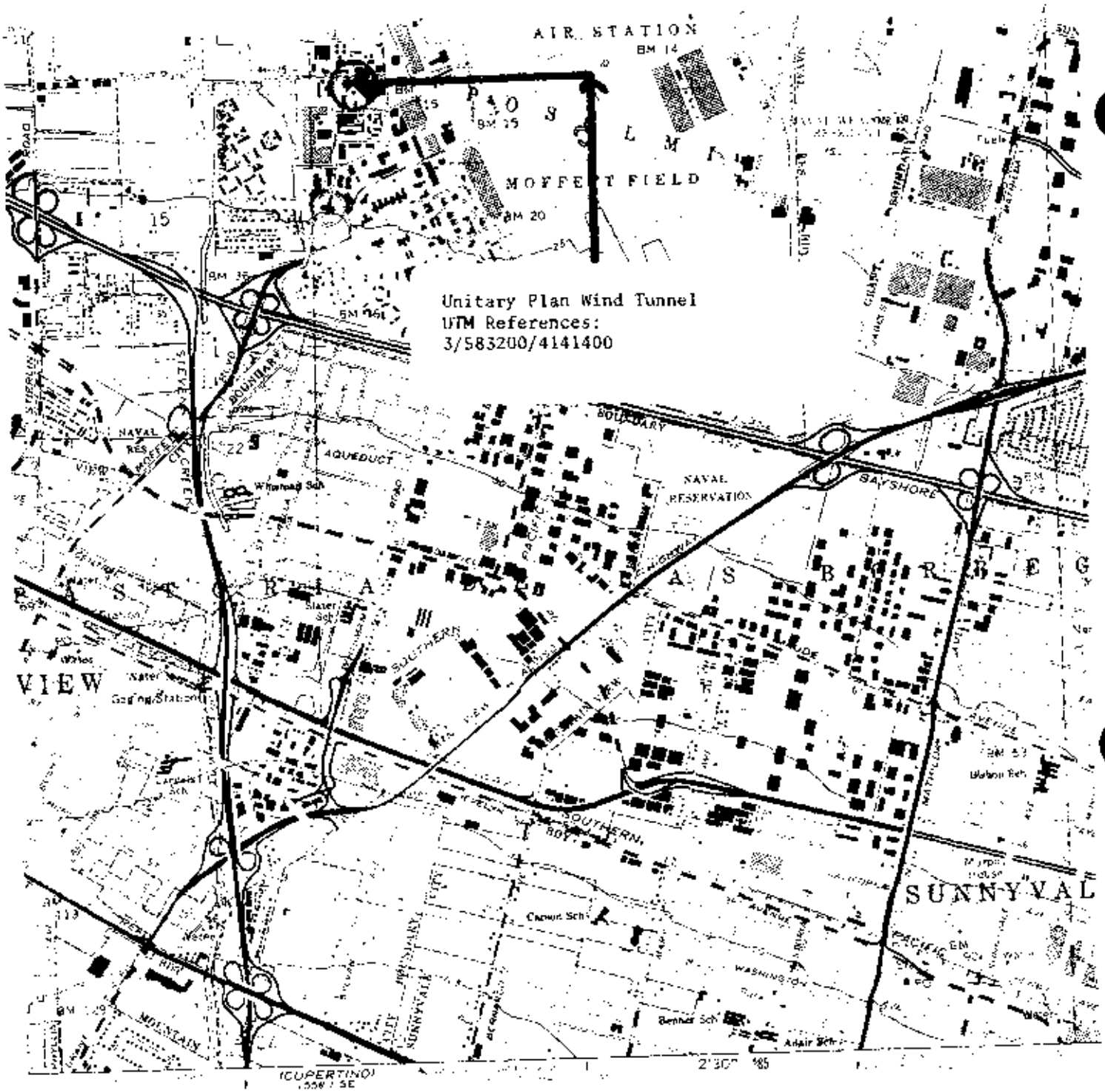
8. Redstone Test Stand (George C. Marshall Space Flight Center)

9. Propulsion and Structural Test Facility (Marshall)

10. Rocket Propulsion Test Complex (National Space Technology Laboratories)



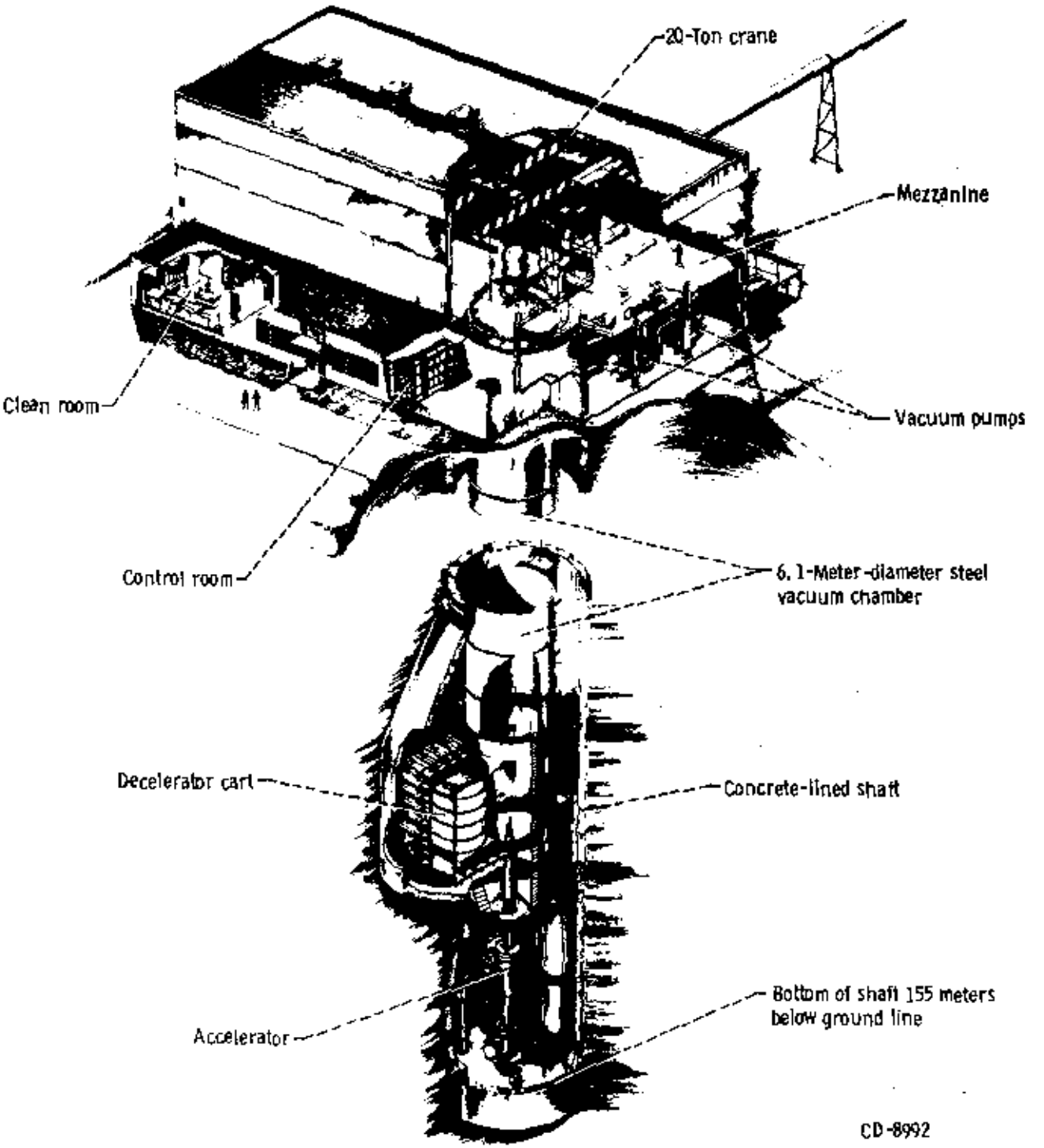

Unitary Plan Wind Tunnel
Building N-227, 227A, 227B, 227C
3/583200/4141400




THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
LE BY U. S. GEOLOGICAL SURVEY DENVER, COLORADO 80225, OR RESTON VIRGINIA 22092
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

QUADRANGLE LOCATION

# LEWIS RESEARCH CENTER ZERO-GRAVITY FACILITY




CD-8992

NPS Form 10-900
(7-81)

**United States Department of the Interior**
**National Park Service**

For NPS use only
received
date entered

# National Register of Historic Places Inventory—Nomination Form

See instructions in *How to Complete National Register Forms*
Type all entries—complete applicable sections

## 1. Name

historic Spacecraft Propulsion Research Facility

and/or common Spacecraft Propulsion Research Facility

## 2. Location

street & number Lewis Research Center Plum Brook Station ___ not for publication

city, town Sandusky ___ vicinity of congressional district

state Ohio code 39 county Erie code 043

## 3. Classification

| Category | Ownership | Status | Present Use | |
|---|---|---|---|---|
| ___ district | X public | ___ occupied | ___ agriculture | ___ museum |
| ___ building(s) | ___ private | ___ unoccupied | ___ commercial | ___ park |
| X structure | ___ both | ___ work in progress | ___ educational | ___ private residence |
| ___ site | **Public Acquisition** | **Accessible** | ___ entertainment | ___ religious |
| ___ object | ___ in process | X yes: restricted | ___ government | ___ scientific |
| | ___ being considered | ___ yes: unrestricted | ___ industrial | ___ transportation |
| | | ___ no | ___ military | X other: Inactive |

## 4. Owner of Property

name National Aeronautics and Space Administration (NASA)

street & number

city, town Washington ___ vicinity of state D.C. 20546

## 5. Location of Legal Description

courthouse, registry of deeds, etc. National Aeronautics and Space Administration (NASA)

street & number Real Property Management Office Code NXG

city, town Washington state D.C. 20546

## 6. Representation in Existing Surveys

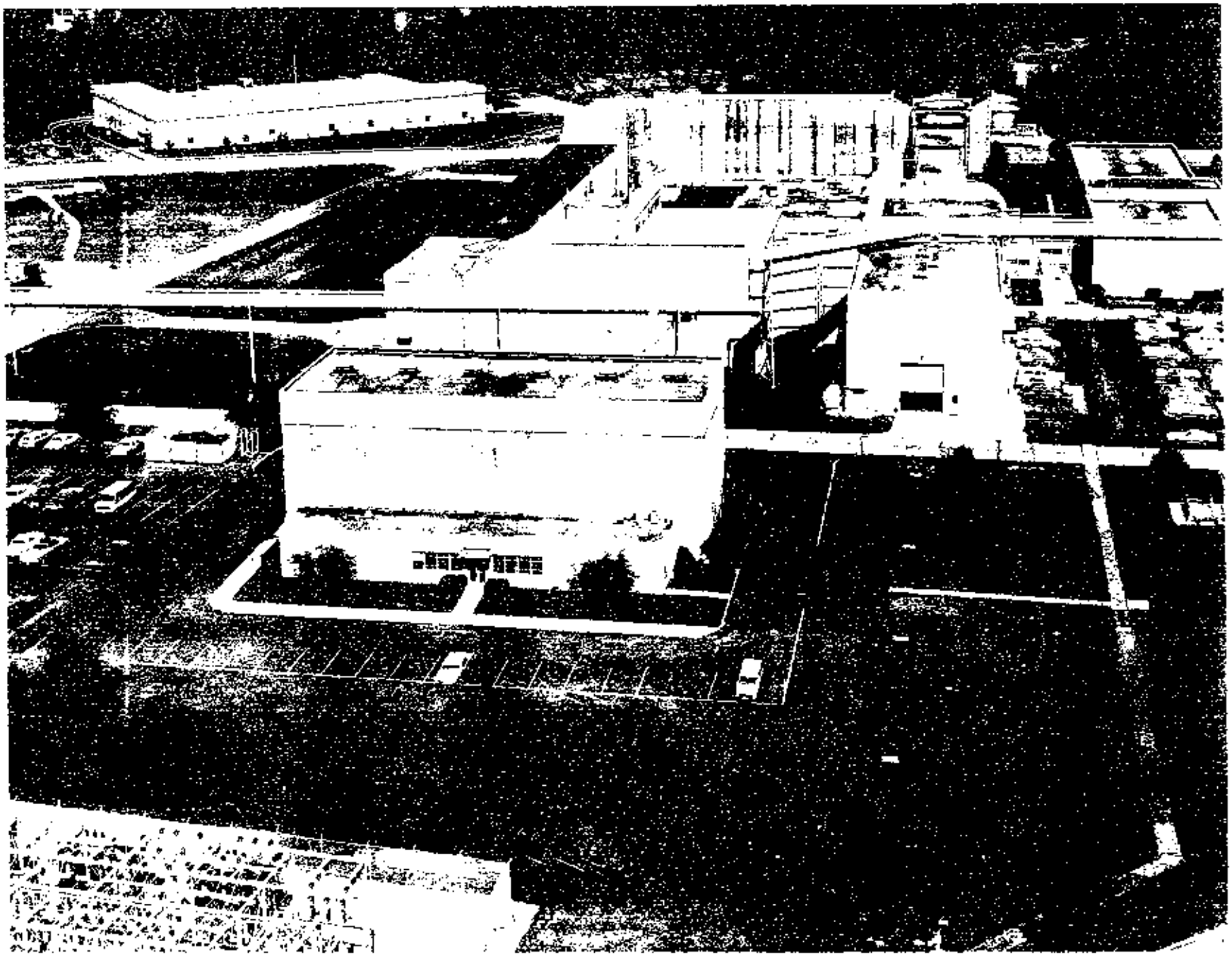
title None has this property been determined eligible? ___ yes ___

date ___ federal ___ state ___ county ___

depository for survey records

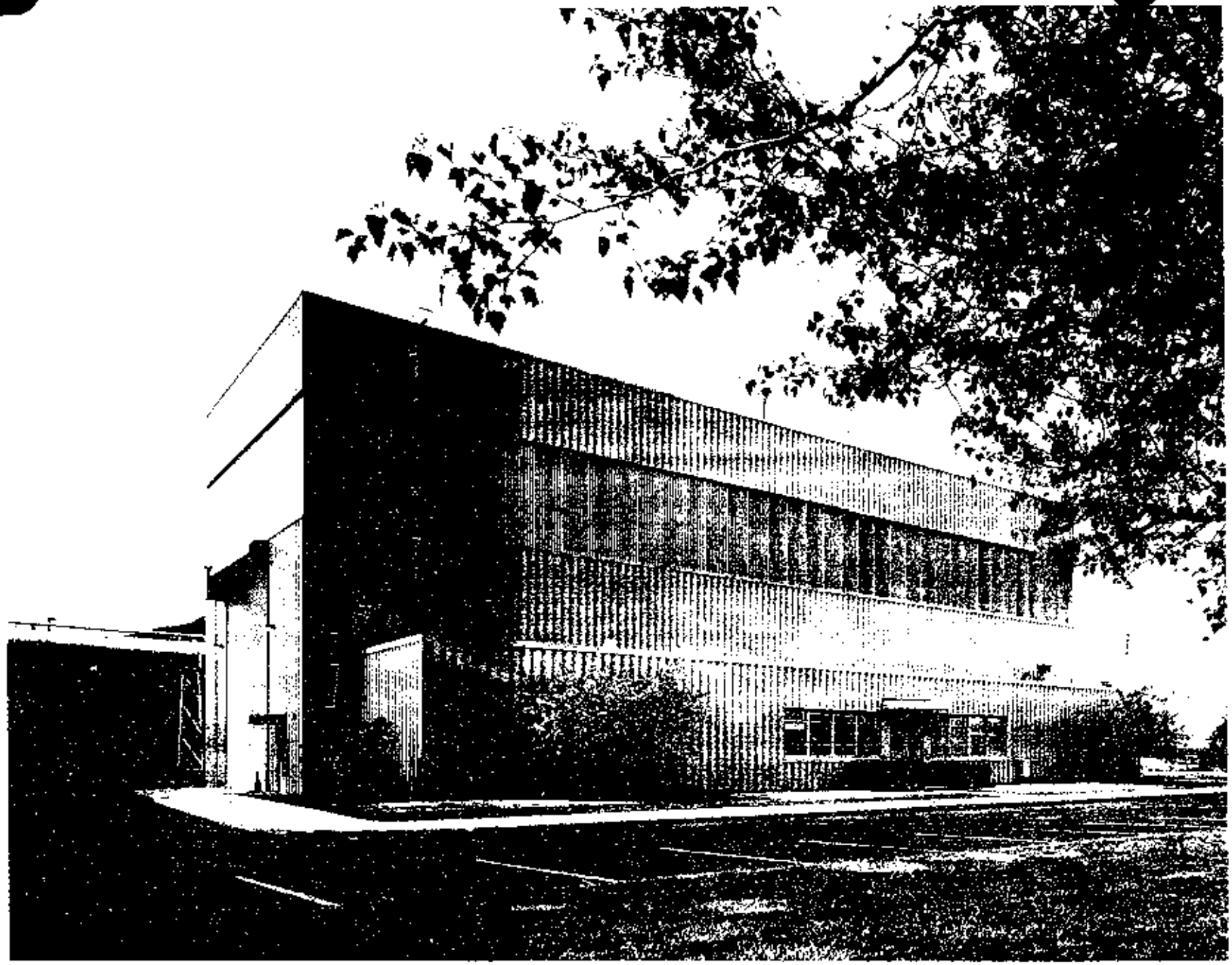
city, town state

NASA
C-82-3033



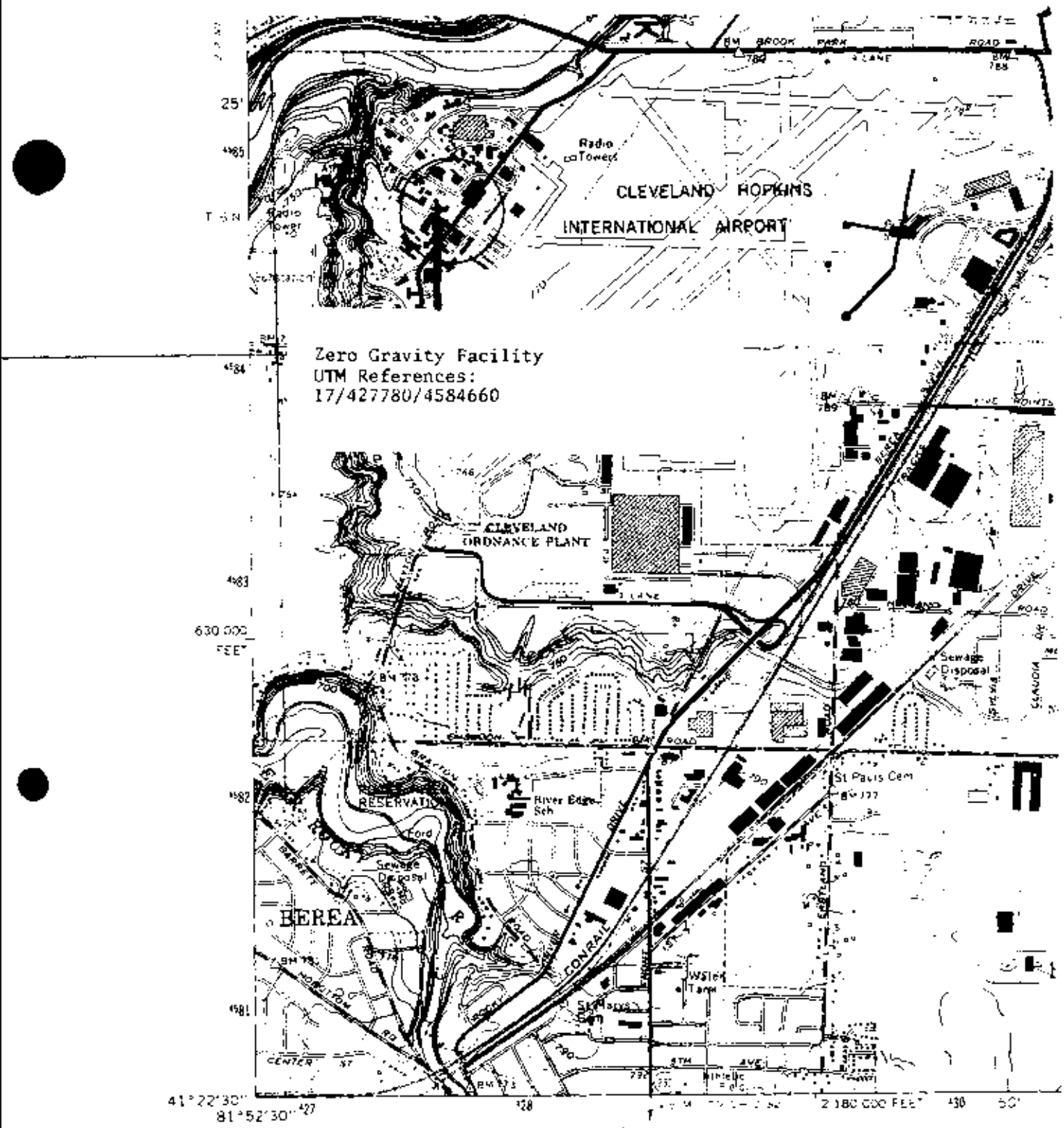
1. Zero Gravity Research Facility
2. Cleveland, Ohio
3. NASA
4. 1982
5. NASA, Lewis Research Center Facilities Office
6. Cutaway section of the facility

NASA
C-82-3565



1. Zero Gravity Research Facility
2. Cleveland, Ohio
3. NASA
4. 1982
5. NASA, Lewis Facilities Office
6. Exterior View

1. Zero Gravity Research Facility
2. Cleveland, Ohio
3. NASA
4. 1982
5. NASA, Lewis Research Center Facilities Office
6. Exterior View




Mapped, edited, and published by the Geological Survey
Revised in cooperation with State of Ohio agencies

Control by USGS, USC&GS, and Cleveland Regional Geodetic Survey

Topography by photogrammetric methods from aerial photographs taken 1959. Horizontal control by plane table surveys 1962. Revised from aerial photographs taken 1962. Field checked 1963

Selected hydrographic data compiled from U. S. Lake Survey Chart 35 (1969). This information is not intended for navigational purposes

Polyconic projection. 1927 North American datum
10,000-foot grid based on Ohio coordinate system, north zone
1000-meter Universal Transverse Mercator grid ticks, zone 17, shown in blue

Fine red dashed lines indicate selected fence and field lines where generally visible on aerial photographs. This information is unchecked

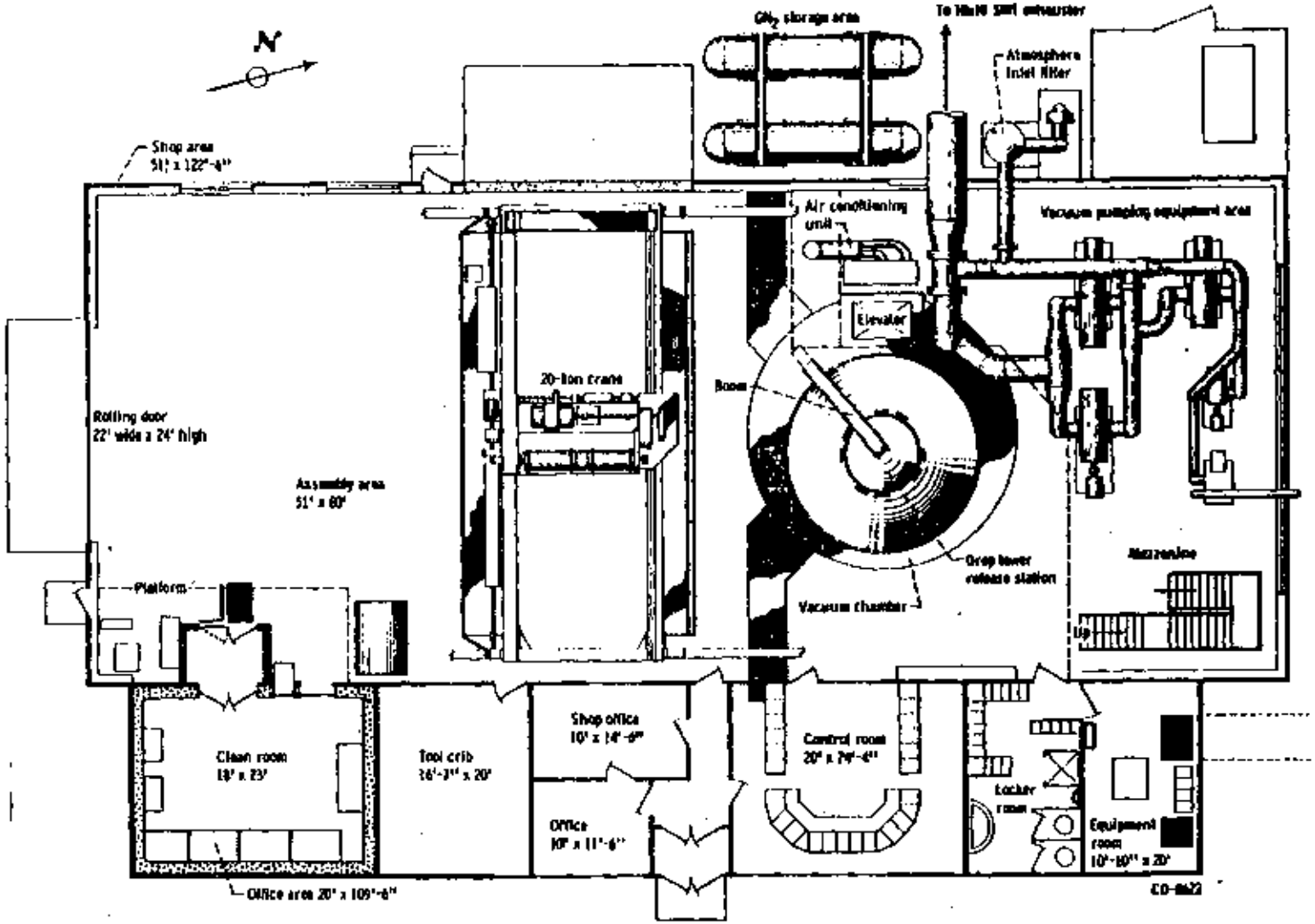
Red tint indicates areas in which only landmark buildings are shown

**There may be private inholdings within the boundaries of the National or State reservations shown on this map**

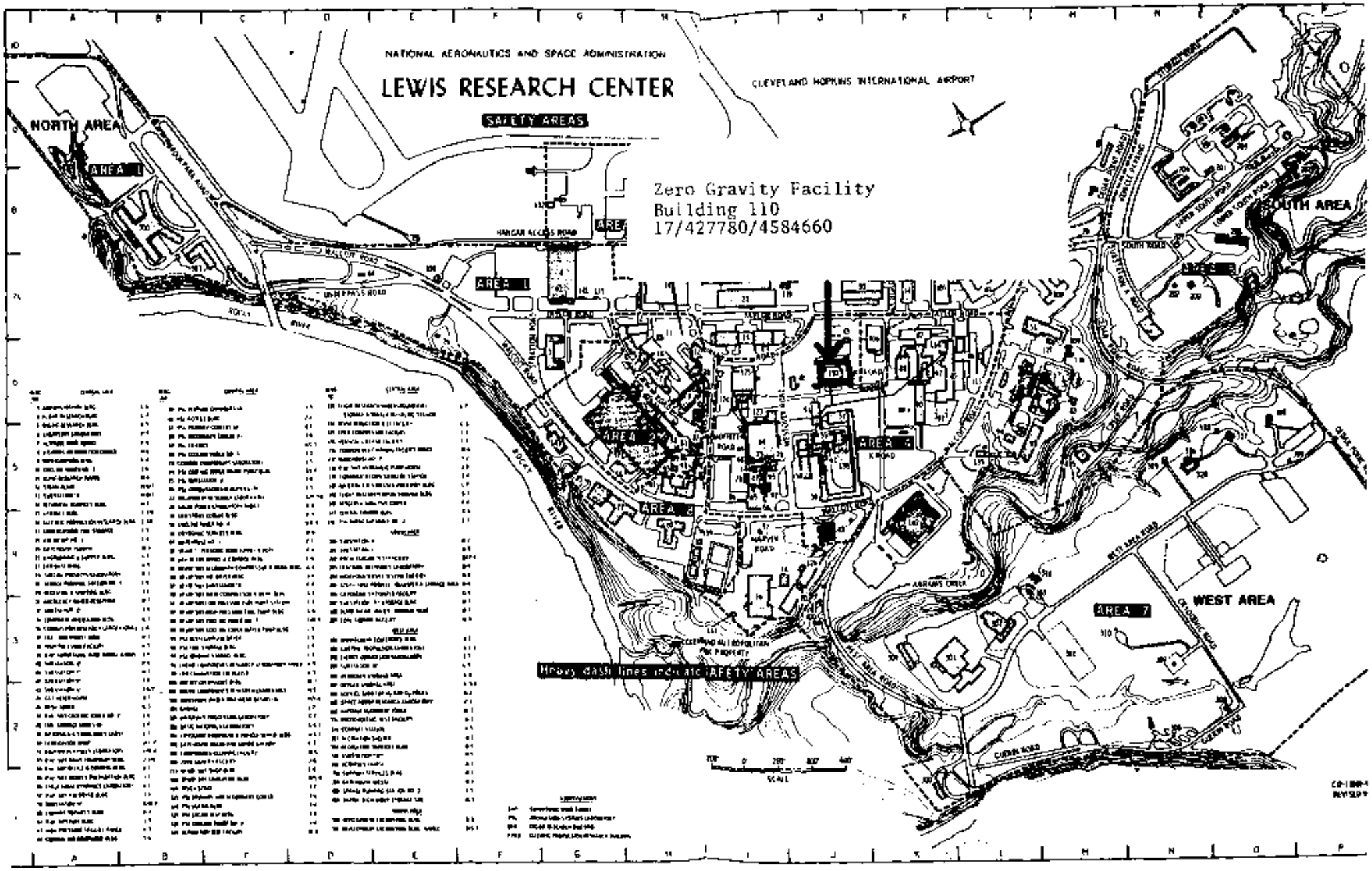
UTM GRID AND 1973 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

Entire area lies within the Connecticut Western Reserve. Dotted land lines established on private subdivisions [illegible]

Zero Gravity Research Facility Floor Plan




Source: Zero Gravity Research Facility, op. cit., figure 5.


NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LEWIS RESEARCH CENTER
CLEVELAND HOPKINS INTERNATIONAL AIRPORT
SAFETY AREAS
NORTH AREA
AREA 1
Zero Gravity Facility
Building 110
17/427780/4584660
HANGAR ACCESS ROAD
AREA 2
AREA 3
AREA 4
AREA 5
AREA 6
AREA 7
SOUTH AREA
WEST AREA
ROCKY RIVER
ABRAMS CREEK
Heavy dash lines indicate SAFETY AREAS
SCALE

# 9. Major Bibliographical References

See continuation sheets

# 10. Geographical Data

Acreage of nominated property Less than 1 acre

Quadrangle name Lakewood

Quadrangle scale 1:24,000

UMT References

| | Zone | Easting | Northing | | Zone | Easting | Northing |
|---|---|---|---|---|---|---|---|
| A | 17 | 427780 | 4586660 | B | | | |
| C | | | | D | | | |
| E | | | | F | | | |
| G | | | | H | | | |

**Verbal boundary description and justification**

The boundary of the Zero-Gravity Facility is shown as the green line on the accompanying map entitled "National Aeronautics and Space Administration, Lewis Research Center."

**List all states and counties for properties overlapping state or county boundaries**

| state | code | county | code |
|---|---|---|---|
| | | | |
| state | code | county | code |

# 11. Form Prepared By

name/title Harry A. Butowsky

organization National Park Service date May 15, 1984

street & number Division of History telephone (202)343-8168

city or town Washington, D.C. 20240 state

# 12. State Historic Preservation Officer Certification

The evaluated significance of this property within the state is:

___ national ___ state ___ local

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89-665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service.

State Historic Preservation Officer signature

title date

For NPS use only

I hereby certify that this property is included in the National Register

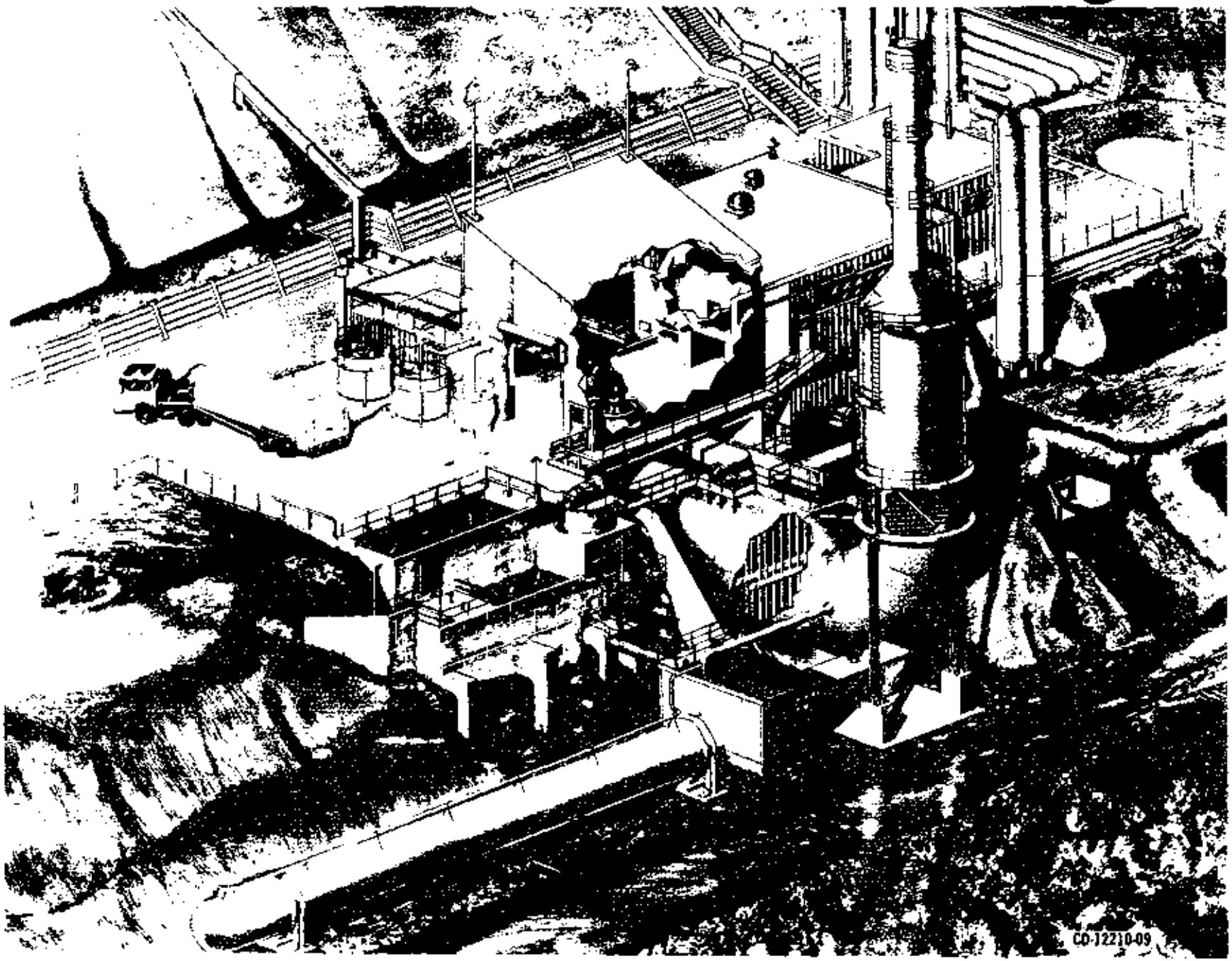
date

Keeper of the National Register

Attest: date

Chief of Registration

NASA
C-78-1725



1. Rocket Engine Test Facility
2. Cleveland, Ohio
3. NASA
4. 1976
5. NASA, Lewis Research Center Facilities Office
6. Rocket Engine Test Cell

# 7. Description

| Condition | | Check one | Check one |
|---|---|---|---|
| X excellent | ___ deteriorated | X unaltered | X original site |
| ___ good | ___ ruins | ___ altered | ___ moved date _____ |
| ___ fair | ___ unexposed | | |

**Describe the present and original (if known) physical appearance**

The Spacecraft Propulsion Research Facility is at the Plum Brook Station of the Lewis Research Center. This facility is designed for hot firings of full-size space vehicles in an environment simulating conditions at an orbital altitude of 100 miles.[1] The major elements that support this facility are a test building, an equipment building, a three stage exhaust system, a waste treatment retention pond, a propellant oxidizer and fuel storage area, an electrical substation, a refrigeration system and a service building.

The Spacecraft Propulsion Test Building is more than 70 feet high and extends 176 feet below grade. The below-grade spray chamber is 67 feet by 119 feet in diameter and holds 1,750,000 gallons of water. A 2.5-million-gallon retention pond is northeast of the test building. The three-stage steam ejectors are in the back of the test building and an 11 foot diameter duct connects them to the spray chamber. The vacuum test chamber is a stainless steel cylinder that can accommodate space vehicles up to 22 feet in diameter and 50 feet high. Two 6 foot 6 inch access openings are provided at the top and bottom of the test chamber. Five 8 inch viewports are provided at the top, center, and bottom of the test chamber for TV monitors. The test chamber is provided with a 27 foot access door for test spacecraft articles. The heat sink of space is simulated by a Liquid Hydrogen cold wall (maintained at $-320^0$F) consisting of copper tube-in-strip panels surrounding the inside wall and top dome of the test chamber. Twelve columns of quartz infrared lamps spaced along an arc of the inside wall of the test chamber simulate thermal radiation and heat from the sun.

In operation, an entire vehicle can be vacuum "soaked" to the proper environmental space conditions in preparation for engine test firing. With the $-320^0$F cold walls and $5 \times 10^{-8}$-torr vacuum, rocket engines can be ignited in the chamber under space conditions. As chamber pressure builds up because of the exhaust gas, an 11 inch diameter valve opens in 0.4-second to connect the chamber to a steam ejector system. Two parallel steam ejectors remove the engine exhaust products from the chamber while maintaining a moderate vacuum level. Three large dump tanks are in the exhaust spray chamber to receive propellants in an emergency situation.

The exhaust system includes a 250,000-gallon-per-minute water spray system for cooling the rocket exhaust. The spray system water is recirculated through the 1.75-million-gallon catch basin under the chamber.

# 8. Significance

| Period | Areas of Significance—Check and justify below | | | |
|---|---|---|---|---|
| ___ prehistoric | ___ archeology-prehistoric | ___ community planning | ___ landscape architecture | ___ religion |
| ___ 1400–1499 | ___ archeology-historic | ___ conservation | ___ law | ___ science |
| ___ 1500–1599 | ___ agriculture | ___ economics | ___ literature | ___ sculpture |
| ___ 1600–1699 | ___ architecture | X education | ___ military | ___ social/ humanitarian |
| ___ 1700–1799 | ___ art | ___ engineering | ___ music | ___ theater |
| ___ 1800–1899 | ___ commerce | ___ exploration/settlement | ___ philosophy | X transportation |
| X 1900– | ___ communications | ___ industry | ___ politics/government | X other (specify) Space Exploration |
| | | ___ invention | | |

**Specific dates** 1968 **Builder/Architect** NASA

**Statement of Significance (in one paragraph)**

The Spacecraft Propulsion Research Facility's significance rests in its association with the development of the Centaur Rocket. This facility is the only one in NASA's inventory that can hot fire a large rocket while simulating the vacuum, cryogenic temperatures, and thermal radiation of space. The duplication of this space environment was crucial to the development of the Centaur Rocket which was designed to fire from Earth Orbit to send vehicles to explore the planets and Solar System. The Centaur upper stage rocket has launched some of America's most important space probes including the Pioneer, Viking and Voyager Spacecraft. The successful development and use of the Centaur was due in large measure to data that was collected from successful test firings of Centaur engines in this facility.

The importance of the Spacecraft Propulsion Research Facility is in its unique technical capabilities and its association with the Centaur research and development program. At the present time this facility is maintained by NASA on a standby status.

## 9. Major Bibliographical References

See continuation sheets

## 10. Geographical Data

Acreage of nominated property Less than 1 acre

Quadrangle name Madison

Quadrangle scale 1:24,000

UMT References

| | Zone | Easting | Northing |
|---|---|---|---|
| A | 16 | 511300 | 3810310 |
| B | | | |
| C | | | |
| D | | | |
| E | | | |
| F | | | |
| G | | | |
| H | | | |

Verbal boundary description and justification

The boundary of the Propulsion and Structural Test Facility is defined by the outside perimeter of Building 4572 at the Marshall Space Flight Center.

List all states and counties for properties overlapping state or county boundaries

state code county code

state code county code

## 11. Form Prepared By

name/title Harry A. Butowsky

organization National Park Service date May 15, 1984

street & number Division of History telephone (202) 343-8168

city or town Washington, D.C. 20240 state

## 12. State Historic Preservation Officer Certification

The evaluated significance of this property within the state is:

___ national ___ state ___ local

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89-665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service.

State Historic Preservation Officer signature

title date

For NPS use only

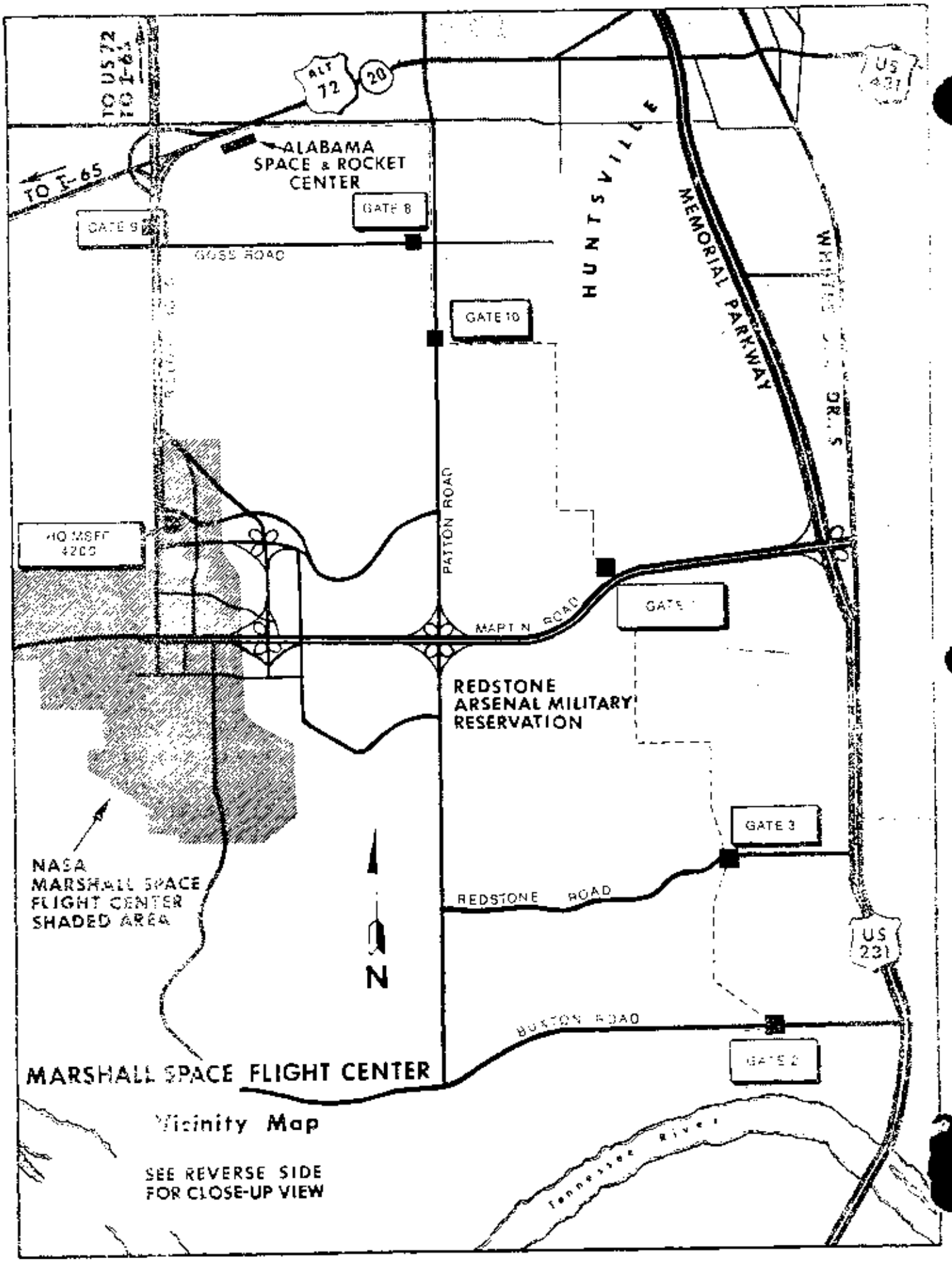
I hereby certify that this property is included in the National Register

date

Keeper of the National Register

Attest: date

Chief of Registration


TO US 72
TO I-65
ALT 72
20
US 431
TO I-65
ALABAMA SPACE & ROCKET CENTER
GATE 8
GATE 9
GROSS ROAD
HUNTSVILLE
MEMORIAL PARKWAY
GATE 10
PATTON ROAD
HQ MSFC 4200
MARTIN ROAD
REDSTONE ARSENAL MILITARY RESERVATION
GATE 3
NASA MARSHALL SPACE FLIGHT CENTER SHADED AREA
REDSTONE ROAD
N
US 231
BUXTON ROAD
GATE 2
MARSHALL SPACE FLIGHT CENTER
Vicinity Map
SEE REVERSE SIDE FOR CLOSE-UP VIEW
Tennessee River

Recovery System - After the experiment vehicle has traversed the total length of the vacuum chamber, it is decelerated in a 12-foot diameter, 20-foot deep container which is centered on the vertical axis of the chamber and filled with small pellets of expanded polystyrene. The deceleration rate (averaging 32 g) is controlled by the flow of pellets through the area between the experiment vehicle and the wall of the deceleration container. This deceleration container is mounted on a cart that is retracted prior to utilizing the 10-second mode of operation. In this mode of operation, the cart is deployed after the experimental vehicle is projected upwards by the pneumatic accelerator.

This facility is in active service supporting present space shuttle experiments.

# 8. Significance

| Period | Areas of Significance—Check and justify below | | | |
|---|---|---|---|---|
| ___ prehistoric | ___ archeology-prehistoric | ___ community planning | ___ landscape architecture | ___ religion |
| ___ 1400–1499 | ___ archeology-historic | ___ conservation | ___ law | X science |
| ___ 1500–1599 | ___ agriculture | ___ economics | ___ literature | ___ sculpture |
| ___ 1600–1699 | ___ architecture | ___ education | ___ military | ___ social/ humanitarian |
| ___ 1700–1799 | ___ art | X engineering | ___ music | ___ theater |
| ___ 1800–1899 | ___ commerce | ___ exploration/settlement | ___ philosophy | ___ transportation |
| X 1900– | ___ communications | ___ industry | ___ politics/government | X other (specify) Space Exploration |
| | | ___ invention | | |

**Specific dates** 1966-Present **Builder/Architect** NASA

**Statement of Significance (in one paragraph)**

The Zero-Gravity Facility is significant because it is the only such facility in NASA's inventory that can study the behavior of liquids in a low gravity environment. A knowledge of the characteristics of liquids in a space vehicle is important to design engineers. Information concerning liquid sloshing which can change the center of mass of a space vehicle and thus effect vehicle stability and control is absolutely essential to the successful performance of liquid high energy space vehicles such as the Centaur and Saturn upper stages. The study of the effects of liquid sloshing on the performance of upper stage liquid rockets was therefore essential to the successful completion of the objectives of the American Space Program.

The Zero-Gravity Facility is the only such facility of its type in the world and is directly linked to the development of the Centaur and Saturn upper stage rockets, which have transported Americans to the moon and sent American space vehicles such as the Viking, Voyager, and Mariner spacecraft to the planets. Research and data developed here involving the physics of liquids in a zero-gravity environment was indispensible to the successful development of these high energy liquid fueled rockets.

Footnotes

1. The descriptive material in this section was taken from the following source: Thomas Labus, Natural Frequency of Liquids in Annular Cylinders under Low Gravitational Conditions, NASA Technical Note D-5412, (Washington, D.C.: National Aeronautics and Space Administration, September 1969), pp. 22-4.

Bibliography

Labus, Thomas L. Natural Frequency of Liquids in Annular Cylinders under Low Gravitational Conditions. NASA Technical Note D-5412. Washington, D.C.: National Aeronautics and Space Administration, September 1969.

National Aeronautics and Space Administration. Technical Facilities Lewis Research Center. Cleveland, Ohio: Lewis Research Center, No Date.

National Aeronautics and Space Administration. Zero Gravity Research Facility. Cleveland, Ohio: Lewis Research Center, September 1966.

Petrash, Donald A. and Corpas, Ellias L. Zero Gravity Facility for Space Vehicle Fluid Research. Reprinted from the 1973 Proceedings of the 19th Annual Meeting of the Institute of Environmental Sciences. No place of publication, No date.

Federal Agency Nomination

NPS Form 10-900
(7-81)

**United States Department of the Interior**
**National Park Service**

For NPS use only

received

date entered

# National Register of Historic Places Inventory—Nomination Form

See instructions in *How to Complete National Register Forms*
Type all entries—complete applicable sections

## 1. Name

historic Propulsion and Structural Test Facility

and/or common Solid Motor Structural Test Facility

## 2. Location

street & number George C. Marshall Space Flight Center ___ not for publication

city, town Huntsville ___ vicinity of congressional district

state Alabama code 01 county Madison code 089

## 3. Classification

| Category | Ownership | Status | Present Use | |
|---|---|---|---|---|
| ___ district | X public | ___ occupied | ___ agriculture | ___ museum |
| ___ building(s) | ___ private | ___ unoccupied | ___ commercial | ___ park |
| X structure | ___ both | ___ work in progress | ___ educational | ___ private residence |
| ___ site | **Public Acquisition** | **Accessible** | ___ entertainment | ___ religious |
| ___ object | ___ in process | X yes: restricted | X government | X scientific |
| | ___ being considered | ___ yes: unrestricted | ___ industrial | X transportation |
| | | ___ no | ___ military | X other: Space Exploration |

## 4. Owner of Property

name National Aeronautics and Space Administration (NASA)

street & number

city, town Washington ___ vicinity of state D.C. 20546

## 5. Location of Legal Description

courthouse, registry of deeds, etc. National Aeronautics and Space Administration (NASA)

street & number Real Property Management Office Code NXG

city, town Washington state D.C. 20546

## 6. Representation in Existing Surveys

title Historic Properties Report (Draft) has this property been determined eligible? ___ yes ___ no

date July 1983 X federal ___ state ___ county ___ local

depository for survey records U.S. Army Redstone Arsenal

city, town Huntsville state Alabama

# 7. Description

| Condition | | Check one | Check one |
|---|---|---|---|
| X excellent | ___ deteriorated | ___ unaltered | X original site |
| ___ good | ___ ruins | X altered | ___ moved date _____ |
| ___ fair | ___ unexposed | | |

**Describe the present and original (if known) physical appearance**

The Solid Rocket Motor Structural Test Facility (Building # 4572) was constructed in 1957. It is in the East Test Area of the Marshall Space Flight Center. This facility is a two-position test stand with a concrete foundation, reinforced concrete load frame, and steel structural frame. The test stand is 175 feet high and 20 feet x 30 feet at its base. The support shop, office space, and terminal room occupy 13,360 square feet of area. The test stand is equipped with a 100-ton overhead crane and a 45-ton gantry crane (Building #4573). Control and instrumentation are provided by the East Test Area Blockhouse and Cable Tunnels (Building #4570), with connections to the computer-controlled data acquisition system in the Structures and Mechanics Laboratory.

One position of the test stand can static fire 1.6-million pounds of thrust stages for engines utilizing LOX/kerosene propellants and can accommodate stages 82 feet x 22 feet. The other position has been modified to accommodate solid rocket booster static testing. Modifications included enlarging and enclosing the west flame trench to accept the test booster.

The Solid Rocket Test Facility is active and is expected to provide continued support to the development and testing of new advanced rocket motors and vehicles for years to come.

# 8. Significance

| Period | Areas of Significance—Check and justify below | | | |
|---|---|---|---|---|
| ___ prehistoric | ___ archeology-prehistoric | ___ community planning | ___ landscape architecture | ___ religion |
| ___ 1400–1499 | ___ archeology-historic | ___ conservation | ___ law | ___ science |
| ___ 1500–1599 | ___ agriculture | ___ economics | ___ literature | ___ sculpture |
| ___ 1600–1699 | ___ architecture | ___ education | X military | ___ social/humanitarian |
| ___ 1700–1799 | ___ art | X engineering | ___ music | ___ theater |
| ___ 1800–1899 | ___ commerce | ___ exploration/settlement | ___ philosophy | ___ transportation |
| X 1900– | ___ communications | ___ industry | ___ politics/government | X other (specify) Space Exploration |
| | | ___ invention | | |

**Specific dates** 1957-Present **Builder/Architect** U.S. Army

**Statement of Significance (In one paragraph)**

The Solid Motor Structural Test Facility was built by the United States Army in 1957 to support testing of the Redstone and other rockets then under development by the Army Ballistic Missile Agency at Redstone Arsenal. After the establishment of the National Aeronautics and Space Administration the Solid Motor Structural Test Facility was transferred to NASA's George C. Marshall Space Flight Center within the boundaries of the Redstone Arsenal. During the next few years the Marshall Space Flight Center became the primary NASA Center responsible for the development of large launch vehicles and rocket propulsion systems. During the 1960s, under the leadership of Dr. Werner von Braun, the Marshall Space Flight Center developed the Saturn Family of launch vehicles. The Saturn I was the launch vehicle for the Pegasus meteoroid detection satellite. The Saturn I-B was used for Apollo spacecraft development and orbital maneuvers and for the Skylab and Apollo-Soyuz missions. The Saturn V was the launch vehicle for the Earth orbital missions and eventual moon landing missions.

The Solid Rocket Motor Structural Test Facility is one of the oldest rocket motor test facilities at the Marshall Space Flight Center. It has supported testing of the Army Redstone Rocket, the Saturn S-1B vehicle, and F-1 engine of the Saturn I-C vehicle employed in the Apollo program. After the completion of the Saturn development program one position of the test stand was modified to accommodate static testing for the Solid Rocket booster currently used in the Space Shuttle Program. The Solid Rocket Motor Structural Test Facility, through its continual use and development over the years since 1957, has played a part in the testing of every important rocket developed by the Redstone Arsenal and later the Marshall Space Flight Center. Through its continual use and modification to meet the demands of new programs, it is illustrative of the primary mission assigned to the Army Ballistic Missile Agency and the George C. Marshall Space Flight Center--the development of large launch vehicles and propulsion systems needed to support the American Space Program. The launch of the Apollo missions to the moon were spectacular, but without the support provided by the Marshall Space Flight Center and the years of testing of rocket boosters at the Solid Rocket Motor Test Facility, the American Space Program would never have succeeded.

Bibliography

Bilstein, Roger B. Stages to Saturn: A Technological History of the Apollo Launch Vehicle. Washington, D.C.: National Aeronautics and Space Administration, 1980.

Brooks, Courtney G., Grimwood, James M. and Swenson, Loyd S. Chariots for Apollo: A History of Manned Lunar Spacecraft. Washington, D.C.: National Aeronautics and Space Administration, 1979.

Draft Historic Properties Report Redstone Arsenal, Alabama with the George C. Marshall Space Flight Center. Silver Spring, Maryland: Building Technology Incorporated, 1983.

Technical Facilities Catalog Vol. III. Washington, D.C.: National Aeronautics and Space Administration, 1974.

NPS Form 10-900
(7-81)

**United States Department of the Interior**
National Park Service

# National Register of Historic Places Inventory—Nomination Form

For NPS use only
received
date entered

See instructions in *How to Complete National Register Forms*
Type all entries—complete applicable sections

## 1. Name

historic Zero Gravity Research Facility (B-2)

and/or common Zero Gravity Research Facility

## 2. Location

street & number Lewis Research Center ___ not for publication

city, town Cleveland ___ vicinity of congressional district

state Ohio code 39 county Cuyahoga code 035

## 3. Classification

| Category | Ownership | Status | Present Use | |
|---|---|---|---|---|
| ___ district | X public | ___ occupied | ___ agriculture | ___ museum |
| ___ building(s) | ___ private | ___ unoccupied | ___ commercial | ___ park |
| X structure | ___ both | ___ work in progress | ___ educational | ___ private residence |
| ___ site | **Public Acquisition** | **Accessible** | ___ entertainment | ___ religious |
| ___ object | ___ in process | X yes: restricted | X government | X scientific |
| | ___ being considered | ___ yes: unrestricted | ___ industrial | ___ transportation |
| | | ___ no | ___ military | X other: Space Exploration |

## 4. Owner of Property

name National Aeronautics and Space Administration (NASA)

street & number

city, town Washington ___ vicinity of state D.C. 20546

## 5. Location of Legal Description

courthouse, registry of deeds, etc. National Aeronautics and Space Administration (NASA)

street & number Real Property Management Office Code NXG

city, town Washington state D.C. 20546

## 6. Representation in Existing Surveys

title None has this property been determined eligible? ___ yes ___ no

date ___ federal ___ state ___ county ___ local

depository for survey records

city, town state

# 7. Description

| Condition | | Check one | Check one |
|---|---|---|---|
| X excellent | ___ deteriorated | X unaltered | X original site |
| ___ good | ___ ruins | ___ altered | ___ moved date _____ |
| ___ fair | ___ unexposed | | |

**Describe the present and original (if known) physical appearance**

The Zero Gravity Research Facility is at the Lewis Research Center in Cleveland, Ohio. It is the only know facility of its size in the free world capable of performing tests in a reduced gravity environment. It has successfully supported researchers involved in the Manned Space Program (Mercury, Gemini and Apollo), and the Centaur Program. Most research tests involve behavior of components, systems, liquids, gases, and combustion when under the influence of reduced gravity or low acceleration environments.[1]

This facility consists of a concrete-lined, 28-foot diameter shaft that extends 510-feet below ground level. A steel vacuum chamber, 20-feet in diameter and 470-feet high, is contained within the concrete shaft. The pressure in this vacuum chamber is reduced to 13.3 newtons per square meter ($1.3 \times 10^{-4}$atm) before use.

The ground-level service building has, as its major elements, a shop area, control room, and a clean room. Assembly, servicing, and balancing of the experiment vehicle are accomplished in the shop area. Tests are conducted from the control room, which contains controls for the "pump down" of the vacuum chamber, the experiment vehicle pre-drop checkout, release and the data retrieval system. Those components of the experiment that are in contact with the test liquid are prepared in the facility's clean room. The major elements of the clean room are an ultrasonic cleaning system and a laminar-flow work station for preparing those experiments requiring more than normal cleanliness.

Mode of Operation - The Zero-Gravity Facility has two modes of operation. One is to allow the experiment vehicle to free fall from the top of the vacuum chamber, which results in a nominal 5.15 seconds of free fall time. The second mode is to project the experiment vehicle upwards from the bottom of the vacuum chamber by a high-pressure pneumatic accelerator on the vertical axis of the chamber. The total up and down trajectory of the experiment vehicle results in a nominal 10 seconds of free fall time.

In either mode of operation, the experiment vehicle falls freely; that is, no guide wires, electrical lines, are connected to the vehicle. Therefore, the only force acting on the freely falling experiment vehicle is due to residual-air drag. This results in an equivalent gravitational acceleration acting on the experiment, which is estimated to be of the order of $10^{-5}$ g or better.

## Bibliography

Ames Research Facilities Handbook. Moffett Field, California: National Aeronatuics and Space Administration, 1982.

Baals, Donald D., and Corliss, William R. Wind Tunnels of NASA. Washington, D.C.: National Aeronautics and Space Administration, 1981.

Hartman, Edwin P. Adventures in Research: A History of Ames Research Center 1940-1965. Washington, D.C.: National Aeronautics and Space Administration, 1970.

Technical Facilities Catalog Vol. 1 Washington, D.C.: National Aeronautics and Space Administration, 1974.

## 9. Major Bibliographical References

See continuation sheets

## 10. Geographical Data

Acreage of nominated property: Less than a acre

Quadrangle name: Mountain view

Quadrangle scale: 1:24,000

UMT References

| | Zone | Easting | Northing |
|---|---|---|---|
| A | 03 | 583200 | 4141400 |
| B | | | |
| C | | | |
| D | | | |
| E | | | |
| F | | | |
| G | | | |
| H | | | |

Verbal boundary description and justification

The boundary of the Unitary Plan Wind Tunnel is shown as the green line on the accompanying map entitled "Building Location Chart, NASA, Ames Research Center."

List all states and counties for properties overlapping state or county boundaries

state _____ code _____ county _____ code _____

state _____ code _____ county _____ code _____

## 11. Form Prepared By

name/title: Harry A. Butowsky

organization: National Park Service date: May 15, 1984

street & number: Division of History telephone: (202) 343-8168

city or town: Washington, D.C. 20240 state: _____

## 12. State Historic Preservation Officer Certification

The evaluated significance of this property within the state is:

___ national ___ state ___ local

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89-665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service.

State Historic Preservation Officer signature

title _____ date _____

For NPS use only

I hereby certify that this property is included in the National Register

Keeper of the National Register date _____

Attest:

Chief of Registration

The Ames Unitary Plan Wind Tunnel Complex is a landmark in the development of conventional wind tunnels and represents the continuing effort of the National Advisory Committee on Aeronautics to provide the American Aircraft and Aerospace industries with the best research facilities possible to insure the technological superiority of the industry. It provides the logical crossover point from NACA to NASA and has contributed equally to both the development of advanced American aircraft and manned spacecraft.

Footnotes

1. Ames Research Facilities Handbook (Moffett Field, California: National Aeronautics and Space Administration, 1982), p. 14.

2. Ibid., 16.

3. Ibid., 18.

4. Ibid., 20.

5. Donald D. Baals and William R. Corliss, Wind Tunnels of NASA (Washington, D.C.: National Aeronautics and Space Administration, 1981), pp. 66-67.

6. Ibid.

7. Ibid.

# 7. Description

| Condition | | Check one | Check one |
|---|---|---|---|
| X excellent | ___ deteriorated | ___ unaltered | X original site |
| ___ good | ___ ruins | ___ altered | ___ moved date _____ |
| ___ fair | ___ unexposed | | |

**Describe the present and original (if known) physical appearance**

UNITARY PLAN FACILITY

The Unitary Plan Facility is a unique system of wind tunnels comprised of three test sections: an 11-by 11-Foot Transonic Tunnel (Mach 0.40 to 1.40), a 9-by 7-Foot Supersonic Tunnel (Mach 1.55 to 2.50), and an 8-by 7-Foot Supersonic Tunnel (Mach 2.45 to 3.45), all capable of operating at variable stagnation pressures. The major common element of the tunnel complex is its drive system, consisting of four intercoupled electric motors that can provide 134.23 MW (180,000 hp) continuously.[1]

11-BY 11-FOOT TRANSONIC WIND TUNNEL

The 11-by 11-Foot Transonic Wind Tunnel is a closed-return, variable density tunnel with a fixed geometry, ventilated throat, and a single-jack flexible nozzle. Airflow is produced by a three-stage, axial-flow compressor powered by four wound-rotor, variable-speed, induction motors. For conventional steady-state tests, models are generally supported on a sting. Internal strain-gage balances are used to measure forces and moments. A schlieren system is available for studying flow patterns, either by direct viewing or by photographs, as well as a system for obtaining 51 X 101 cm (20 X 40 in.) shadowgraph negatives.[2]

9-BY 7-FOOT SUPERSONIC WIND TUNNEL

The 9-by 7-Foot Supersonic Wind Tunnel is a closed-return, variable-density tunnel equipped with an asymmetric, sliding-block nozzle. The test section Mach number can be varied by translating, in the streamwise direction, the fixed contour block that forms the floor of the nozzle. Airflow is produced by an 11-stage, axial-flow compressor powered by four variable-speed, wound-rotor, induction motors. For conventional, steady-state tests, models are generally supported on a sting. Internal strain-gage balances are used to measure forces and moments. A schlieren system is available for studying flow patterns, either by direct viewing or by photographs, as well as a system for obtaining 51 X 51 cm (20 X 20 in.) shadowgraph negatives.[3]

8-BY 7-FOOT SUPERSONIC WIND TUNNEL

The 8-by 7-Foot Supersonic Wind Tunnel is a closed-return, variable-density tunnel equipped with a symmetrical, flexible-wall throat (the side walls are positioned by a series of jacks operated by hydraulic motors). The upper and lower surfaces are fixed. Airflow is produced by an 11-stage, axial-flow compressor powered by four variable-speed, wound-rotor, induction motors. For conventional, steady-state tests, models are generally supported on a sting. Internal strain-gage balances are used to measure forces and moments. A schlieren system is available for studying flow patterns, either by direct viewing or by photographs, as well as a system for obtaining 51 X 51 cm (20 X 20 in.) shadowgraph negatives.[4]

# 8. Significance

| Period | Areas of Significance—Check and justify below | | | |
|---|---|---|---|---|
| ___ prehistoric | ___ archeology-prehistoric | ___ community planning | ___ landscape architecture | ___ religion |
| ___ 1400–1499 | ___ archeology-historic | ___ conservation | ___ law | X science |
| ___ 1500–1599 | ___ agriculture | ___ economics | ___ literature | ___ sculpture |
| ___ 1600–1699 | ___ architecture | ___ education | X military | ___ social/ humanitarian |
| ___ 1700–1799 | ___ art | X engineering | ___ music | ___ theater |
| ___ 1800–1899 | ___ commerce | ___ exploration/settlement | ___ philosophy | ___ transportation |
| X 1900– | ___ communications | ___ industry | ___ politics/government | X other (specify) Aeronautical Research Space Exploration |
| | | ___ invention | | |

**Specific dates** 1955-Present **Builder/Architect** NACA

**Statement of Significance (in one paragraph)**

The Ames Unitary Plan Wind Tunnel is significant because it represents the continual development of superior technical aeronautical research facilities after the end of the Second World War. These research facilities formed the foundation upon which the National Aeronautics and Space Administration would draw in 1958 to launch the American effort to land a man on the moon.

Since the construction of the Variable Density Wind Tunnel at Langley in 1921 the National Advisory Committee on Aeronautics (NACA) had built an impressive variety of technical research facilities upon which the American aircraft industry was based. These technical facilities had enabled the American aircraft industry to produce the airplanes that dominated the skys in both commerical and military applications. By 1945 the American lead in this field seemed to be evaporating. The technological achievements of the German missiles and jet aircraft indicated a lag in American aeronautical research. To assume technological leadership, the Federal Government proposed a coordinated national plan of facility construction that would encompass not only NACA, but the Air Force, industry, and universities as well. This plan, known as the Unitary Plan Act, passed Congress on October 27, 1949, and resulted in the construction of an entire new series of wind tunnel complexes to support the American Aircraft industry.[5]

The Ames Unitary Plan Wind Tunnel Complex was a product of this legislation. Construction of the facility began in 1950-1951 and lasted until 1955. Because no one wind tunnel could meet all of the demands for additional research facilities simulating the entire range of aircraft and missile flight, NACA chose to build the Ames tunnel with three separate test sections drawing power from a common centralized power plan. The transonic test section spanned 11 x 11 feet, while the two supersonic sections were smaller: 9 x 7 feet and 8 x 7 feet. Giant valves 20 feet in diameter supplied air from one supersonic leg to another.[6]

The American west coast aircraft industry quickly capitalized on the Ames Unitary Plan Wind Tunnel Complex. The famed Boeing fleet of commercial transports and the Douglas DC-8, DC-9, and DC-10 were all tested here. In addition such military aircraft as the F-111 fighter, the C-5A transport and the B-1 bomber were tested. In addition to aircraft, in the 1960s and 1970s almost all NASA manned space vehicles including the Space Shuttle were tested in the Ames Unitary Plan Wind tunnel complex.[7]

Footnotes

1. Much of the material in Section 7 and 8 of this report has been adapted from Donald D. Baals and William R. Corliss, Wind Tunnels of NASA (Washington, D.C.: National Aeronautics and Space Administration, 1981), pp. 25-8.

2. Ibid., 25.

3. Ibid., 26.

4. George W. Gray, Frontiers of Flight: The Story of NACA Research (New York: Alfred A. Knopf, 1948). pp. 42-43.

5. Baals, pp. 62-63.

Bibliography

Anderton, David A. Sixty Years of Aeronautical Research: 1917-1977. Washington, D.C.: National Aeronautics and Space Administration, 1978.

Anderson, John D. Jr. Introduction to Flight: Its Engineering and History. New York: McGraw Hill Book Company, 1978.

Baals, Donald D., and Corliss, William R. Wind Tunnels of NASA. Washington, D.C.: National Aeronautics and Space Administration, 1981.

Berkes, John D. The High Speed Frontier. Washington, D.C.: National Aeronautics and Space Administration, 1981.

Gray, George W. Frontiers of Flight: The Story of NACA Research. New York: Alfred E. Knopf, 1948.

# 7. Description

| Condition | | Check one | Check one |
|---|---|---|---|
| ___ excellent | ___ deteriorated | X unaltered | X original site |
| ___ good | ___ ruins | ___ altered | ___ moved date _____ |
| ___ fair | ___ unexposed | | |

**Describe the present and original (if known) physical appearance**

The Eight-Foot High Speed Tunnel is a single-return atmospheric pressure tunnel with an 8-foot diameter closed-throat test section. The tunnel became operational in 1936 and at that time had a maximum speed of Mach 0.75 driven by an 8,000-horsepower electric motor/fan.

The design of the Eight Foot High Speed Tunnel was complicated by two problems.[1]

The first problem involved the effect discovered in 1738 by the Swiss mathematican Daniel Bernoulli who observed that as the velocity of flow in a duct is increased by constricting the cross sectional area, the static pressure of the fluid drops. In wind tunnel design, this means that the air pressure in the chamber containing the high-velocity test section will be lower than in the rest of the tunnel. Thus, for the tunnel, the test chamber had to withstand a powerful, inwardly directed pressure.[2]

One method to solve this problem would have been to construct a welded steel pressure vessel around the test section. In an effort to solve the pressing unemployment problem then existing as a result of the Depression, NACA engineers decided to use locally available unskilled labor and build the entire tunnel of reinforced concrete. An igloo-like structure around the test sections was built with walls 1 foot thick. The igloo was essentially a low pressure chamber--just the opposite of the VDT. Operating personnel in the igloo were subjected to pressures that were the equivalent of 10,000 feet altitude and had to wear oxygen masks and enter through airlocks.[3]

The second new problem that was created had to do with the mechanical energy that the 8,000-horsepower fan added to the airstream. NACA engineers calculated that this additional heat would cause the temperature within the tunnel to rise ten degrees per second until it reached the stage at which the amount of heat seeping through the concrete walls would equal the input of heat from the fan. Before this would happen the temperature within the tunnel would reach several thousand degrees.

The task of providing a cooling system was given to Russell G. Robinson who devised a ventilating tower that periodically allowed a small amount of heated air to escape in exchange for fresh cool air. This system proved to be sucessful and was accomplished with a loss of only one percent of power. This same principle was later applied to many other high speed tunnels.[4]

The Eight-Foot High Speed Tunnel was repowered in 1945 to 16,000-horsepower. By 1950 a slotted throat design was added to the test section that enabled the tunnel to be operated as a transonic tunnel. In 1953 the tunnel was repowered to 25,000-horsepower to yield a speed of Mach 1.2. A schlieren apparatus was also added to the test section of the tunnel to increase the capability for visual flow studies.

The Eight-Foot High Speed Tunnel was deactivated in 1956 and is now abandonded in place. The original test section of the tunnel is used for storage.

NASA
L-84-5317

NPS Form 10-900
(7-81)

Man in Space Theme Study
Federal Agency Nomination

**United States Department of the Interior**
**National Park Service**

For NPS use only

received

date entered

# National Register of Historic Places Inventory—Nomination Form

See instructions in *How to Complete National Register Forms*
Type all entries—complete applicable sections

## 1. Name

historic Unitary Plan Wind Tunnel

and/or common Unitary Plan Facility

## 2. Location

street & number Ames Research Center ___ not for publication

city, town Moffett Field ___ vicinity of congressional district

state California code 06 county Santa Clara code 085

## 3. Classification

| Category | Ownership | Status | Present Use | |
|---|---|---|---|---|
| ___ district | X public | ___ occupied | ___ agriculture | ___ museum |
| ___ building(s) | ___ private | ___ unoccupied | ___ commercial | ___ park |
| X structure | ___ both | ___ work in progress | ___ educational | ___ private residence |
| ___ site | **Public Acquisition** | **Accessible** | ___ entertainment | ___ religious |
| ___ object | ___ in process | X yes: restricted | X government | X scientific |
| | ___ being considered | ___ yes: unrestricted | ___ industrial | ___ transportation |
| | | ___ no | ___ military | X other: Space Exploration |

## 4. Owner of Property

name National Aeronautics and Space Administration (NASA)

street & number

city, town Washington ___ vicinity of state D.C. 20546

## 5. Location of Legal Description

courthouse, registry of deeds, etc. National Aeronautics and Space Administration (NASA)

street & number Real Property Management Office Code NXG

city, town Washington state D.C. 20546

## 6. Representation in Existing Surveys

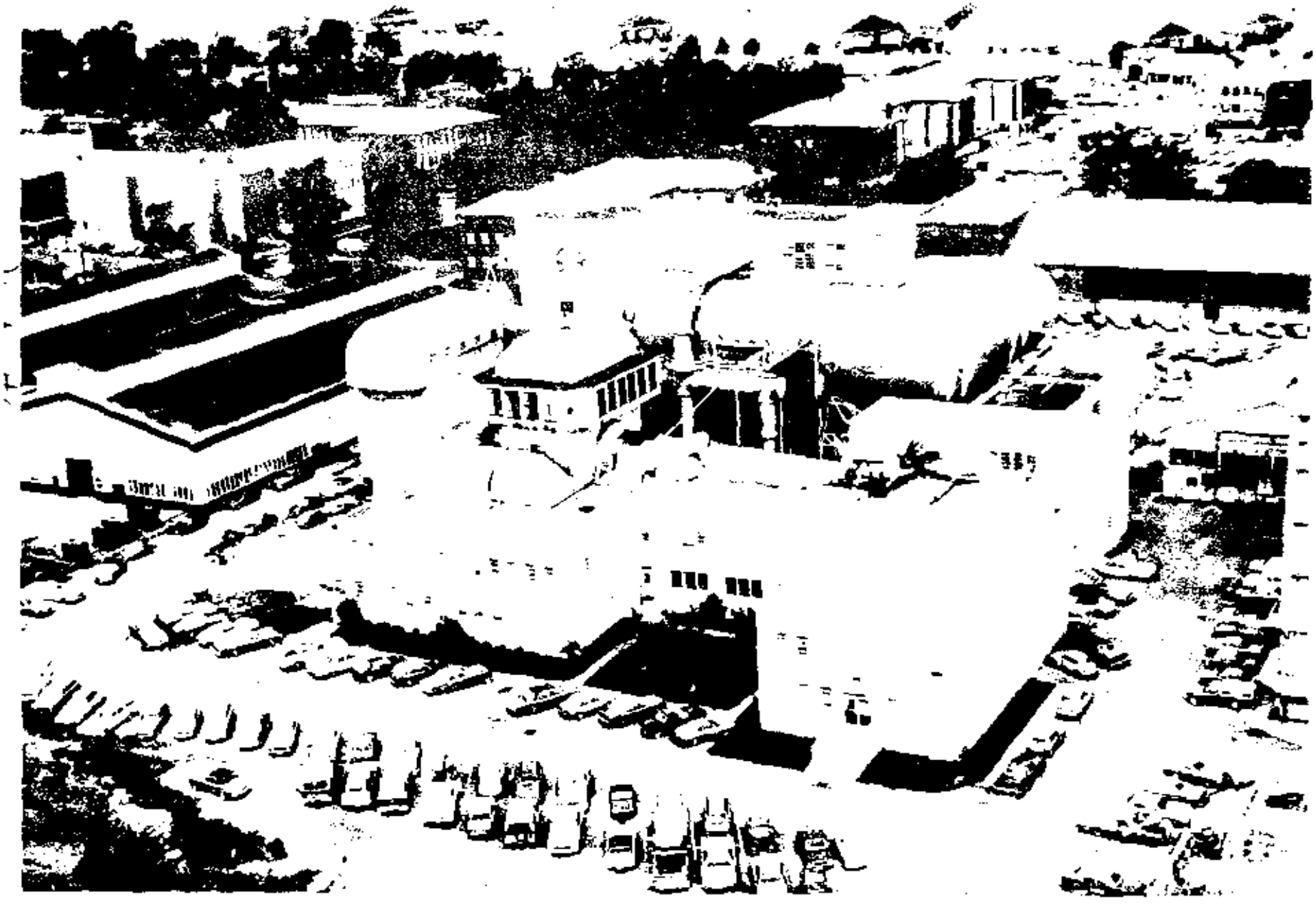
title None has this property been determined eligible? ___ yes ___ no

date ___ federal ___ state ___ county ___ local

depository for survey records

city, town state

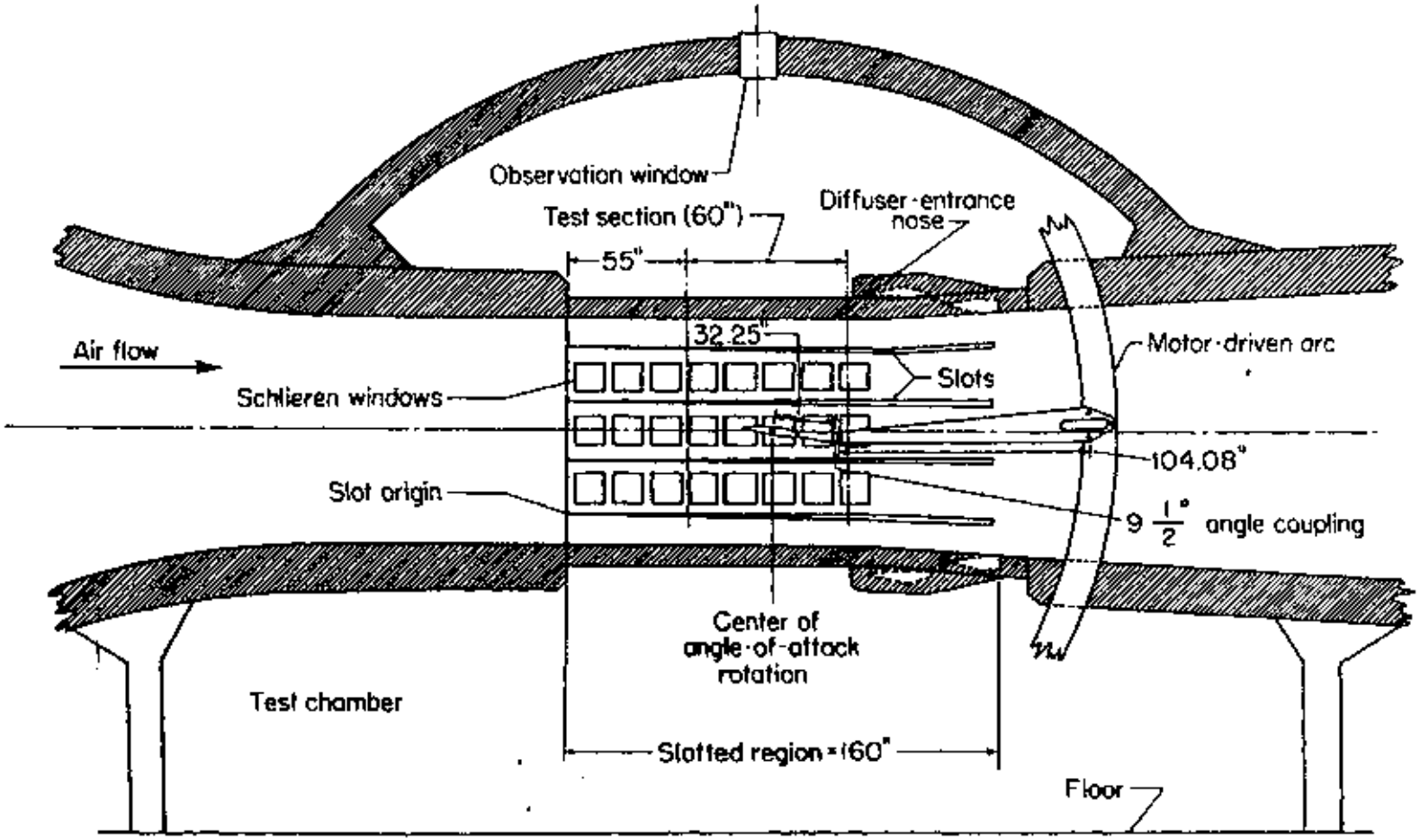
NASA
L-81-6014



1. Rendezvous Docking Simulator
2. Hampton, Virginia
3. NASA
4. 1984
5. NASA, Langley Research Center Facilities Office
6. Exterior view of ventilating tower

Eight-Foot High Speed Tunnel

Test Section




Source Characteristics of Nine Research Wind Tunnels of the Langley Aeronautical Laboratory (Washington, D.C.: National Advisory Committee for Aeronautics, 1957), p. 21.

1. Eight-Foot High Speed Tunnel
2. Hampton, Virginia
3. NASA
4. 1981
5. NASA, Langley Research Center Facilities Office
6. Exterior View

## 9. Major Bibliographical References

See continuation sheets

## 10. Geographical Data

Acreage of nominated property Less than 1 acre

Quadrangle name Kimball

Quadrangle scale 1:24,000

UMT References

| | Zone | Easting | Northing |
|---|---|---|---|
| A | 17 | 359180 | 4580660 |
| B | | | |
| C | | | |
| D | | | |
| E | | | |
| F | | | |
| G | | | |
| H | | | |

**Verbal boundary description and justification**

The boundary of the Spacecraft Propulsion Research Facility is defined by the outside perimeter of Building 3211 at the Plum Brook Station of the Lewis Research Center.

**List all states and counties for properties overlapping state or county boundaries**

state code county code

state code county code

## 11. Form Prepared By

name/title Harry A. Butowsky

organization National Park Service date May 15, 1984

street & number Division of History telephone (202) 343-8168

city or town Washington, D.C. 20240 state

## 12. State Historic Preservation Officer Certification

The evaluated significance of this property within the state is:

___ national ___ state ___ local

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89-665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service.

State Historic Preservation Officer signature

title date

For NPS use only

I hereby certify that this property is included in the National Register

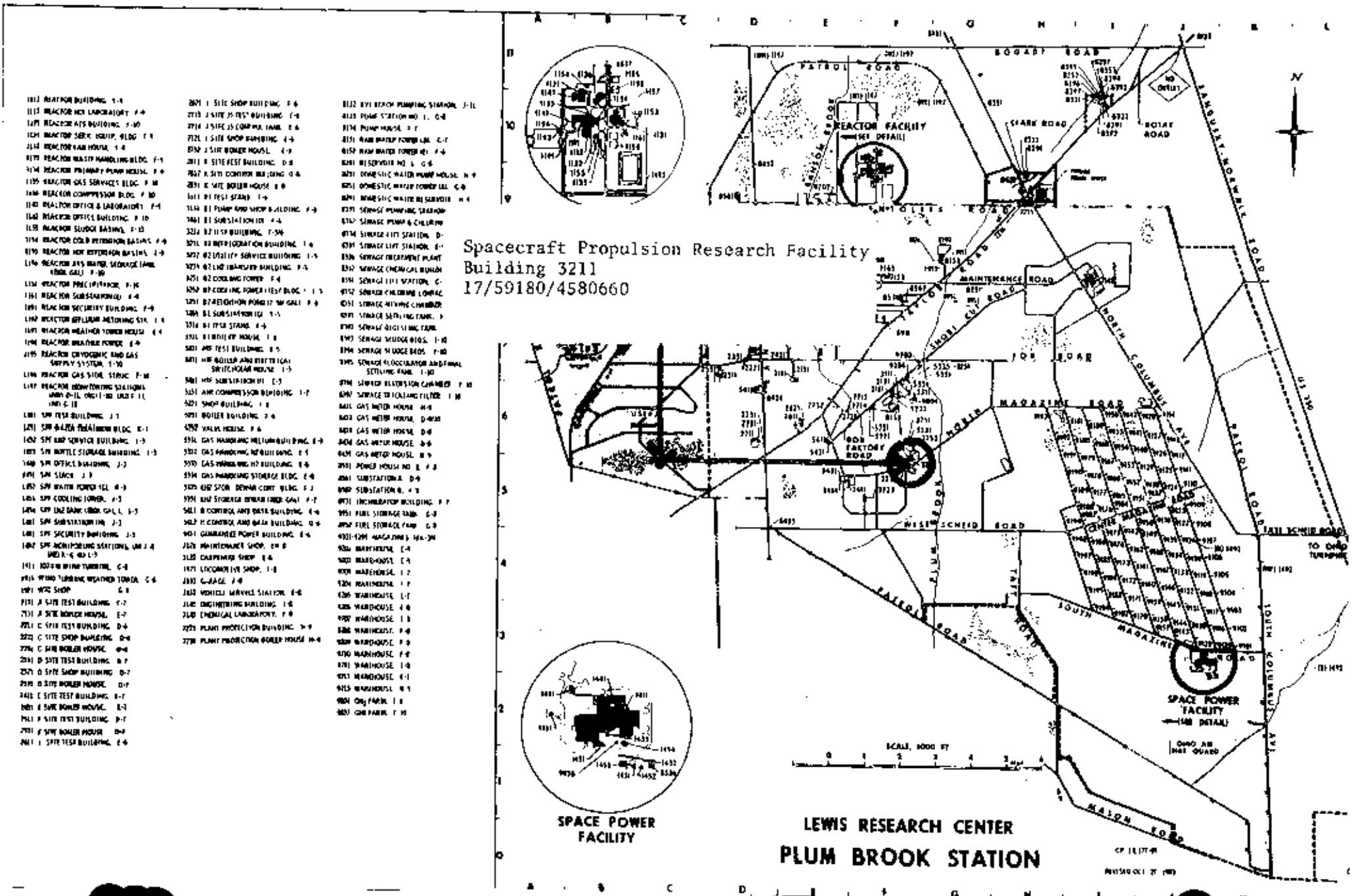
date

Keeper of the National Register

Attest: date

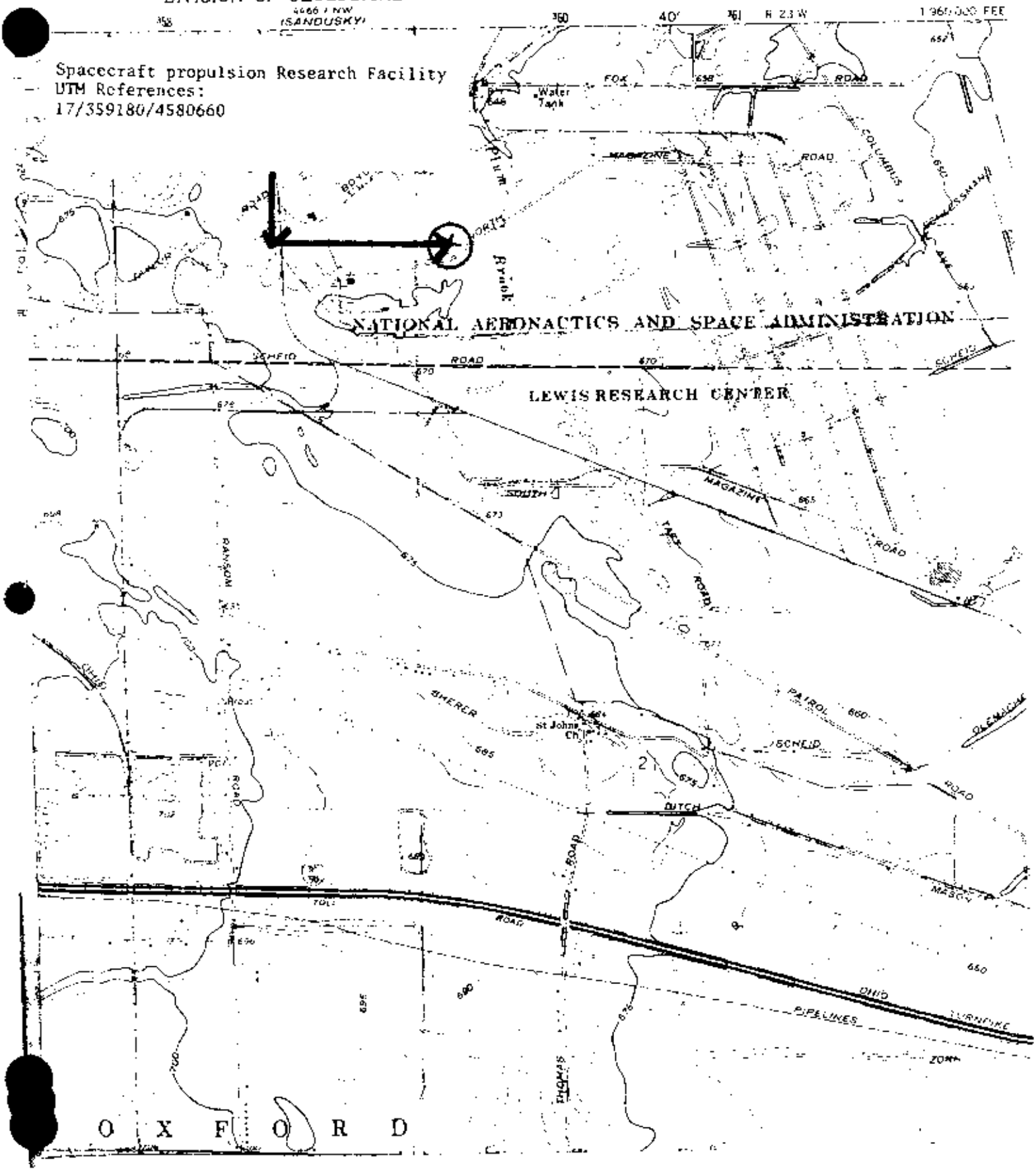
Chief of Registration

Spacecraft Propulsion Research Facility
Building 3211
17/59180/4580660



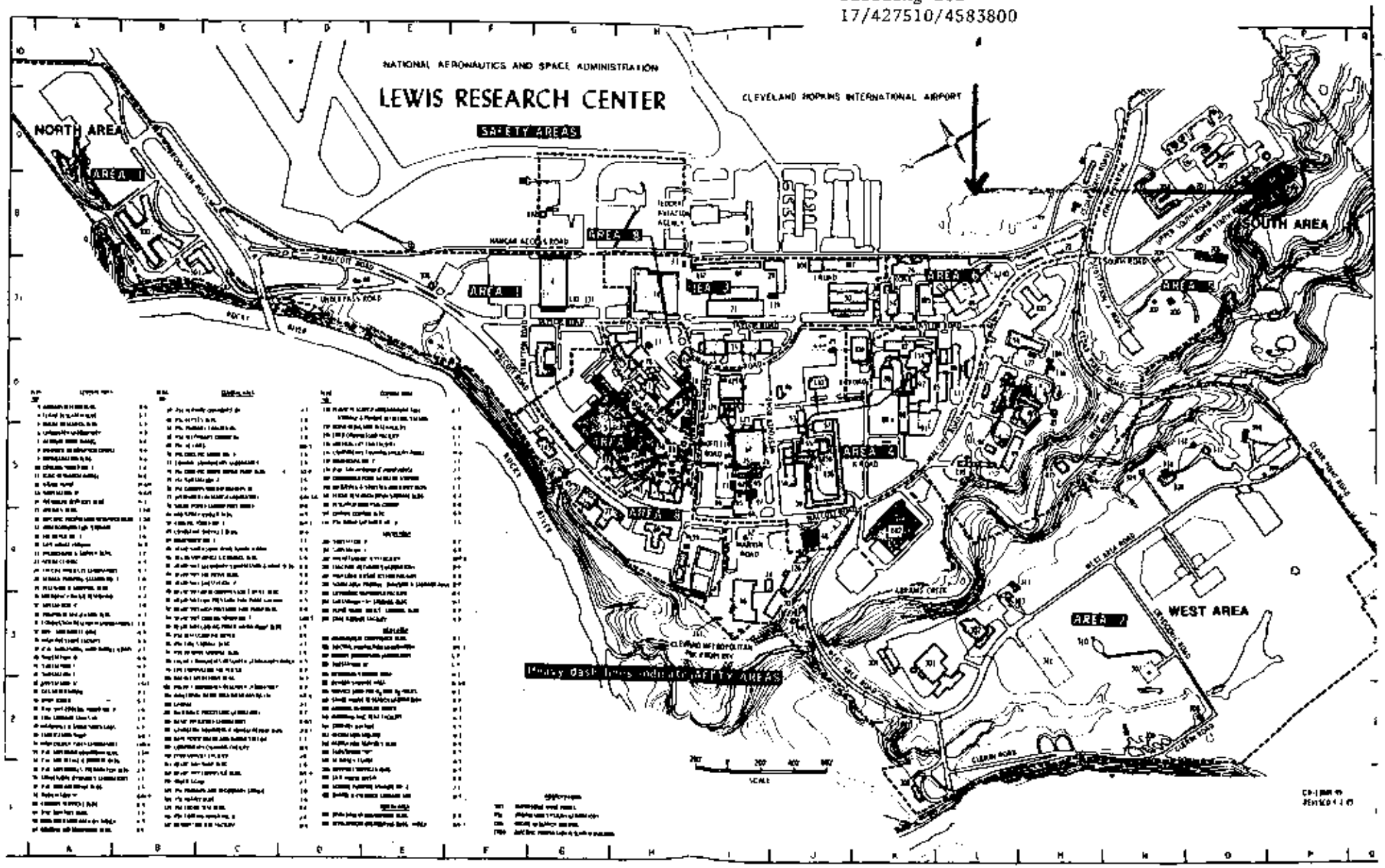
STATE OF OHIO
DEPARTMENT OF HIGHWAYS
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGICAL SURVEY

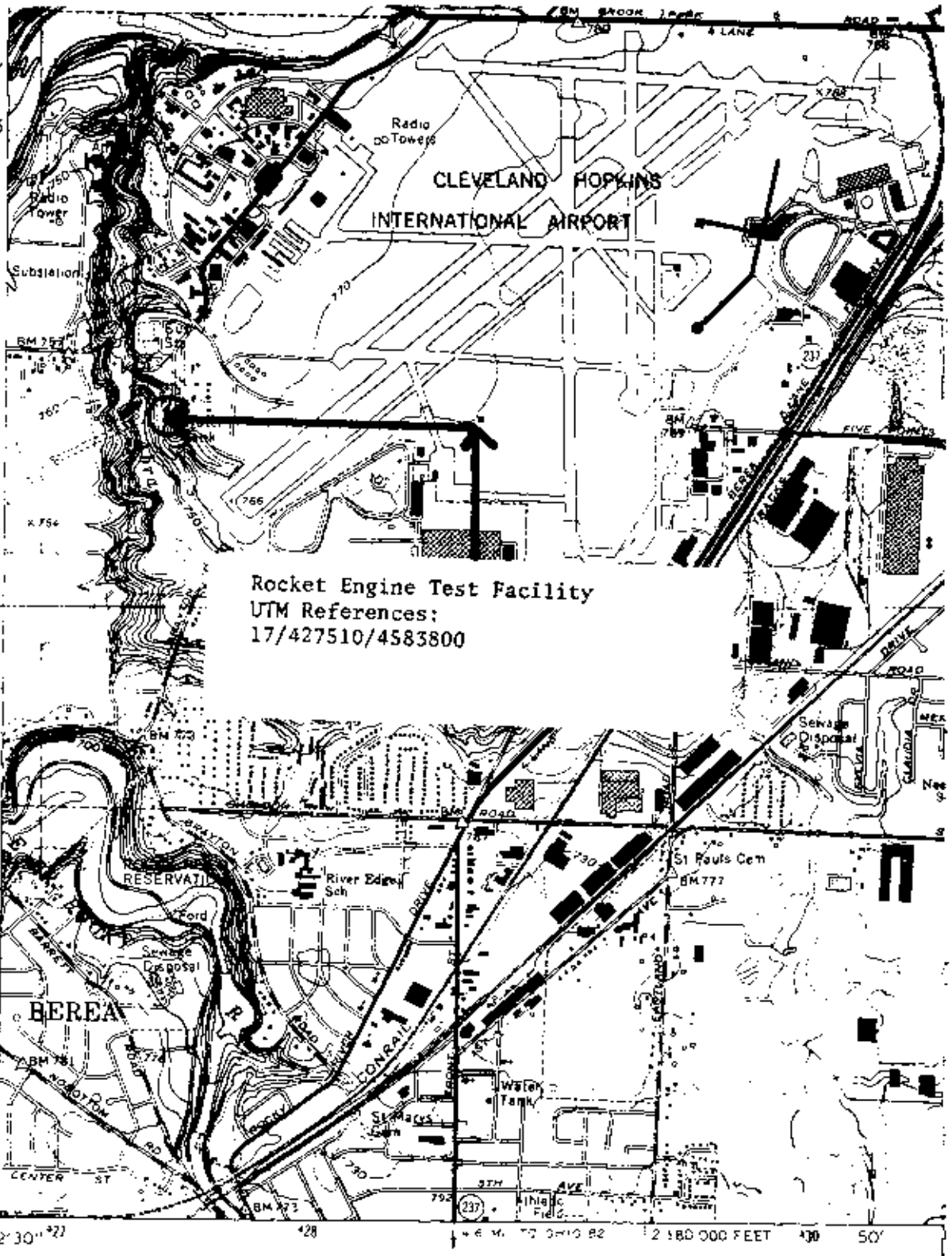
Spacecraft propulsion Research Facility
UTM References:
17/359180/4580660



1. Spacecraft Propulsion Research Facilty
2. Sandusky, Ohio
3. NASA
4. 1969
5. NASA, Lewis Research Center Facilities Office
6. Aerial View

Rocket Engine Test Facility
Building 202
17/427510/4583800






Macpec, edited, and published by the Geological Survey
Revised in cooperation with State of Ohio agencies

Control by USGS, USC&GS, and Cleveland Regional Geodetic Survey

Planimetry by photogrammetric methods from aerial photographs taken 1962. Topography by plane table surveys 1963. Revised from aerial photographs taken 1962. Field checked 1963

Selected hydrographic data compiled from U. S. Lake Survey Chart 35 (1959). This information is not intended for navigational purposes

Polyconic projection. 1927 North American datum
10,000-foot grid based on Ohio coordinate system, north zone
1000-meter Universal Transverse Mercator grid ticks, zone 17, shown in blue

Fine red dashed lines indicate selected fence and field lines where generally visible on aerial photographs. This information is unchecked

Red tint indicates areas in which only landmark buildings are shown

There may be private inholdings within the boundaries of the National or State reservations shown on this map

Entire area lies within the Connecticut Western Reserve
Dotted land lines established by private subdivision of Connecticut Western Reserve

MN
GN
5°
89 MILS
0°32'
10 MILS

UTM GRID AND 1979 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

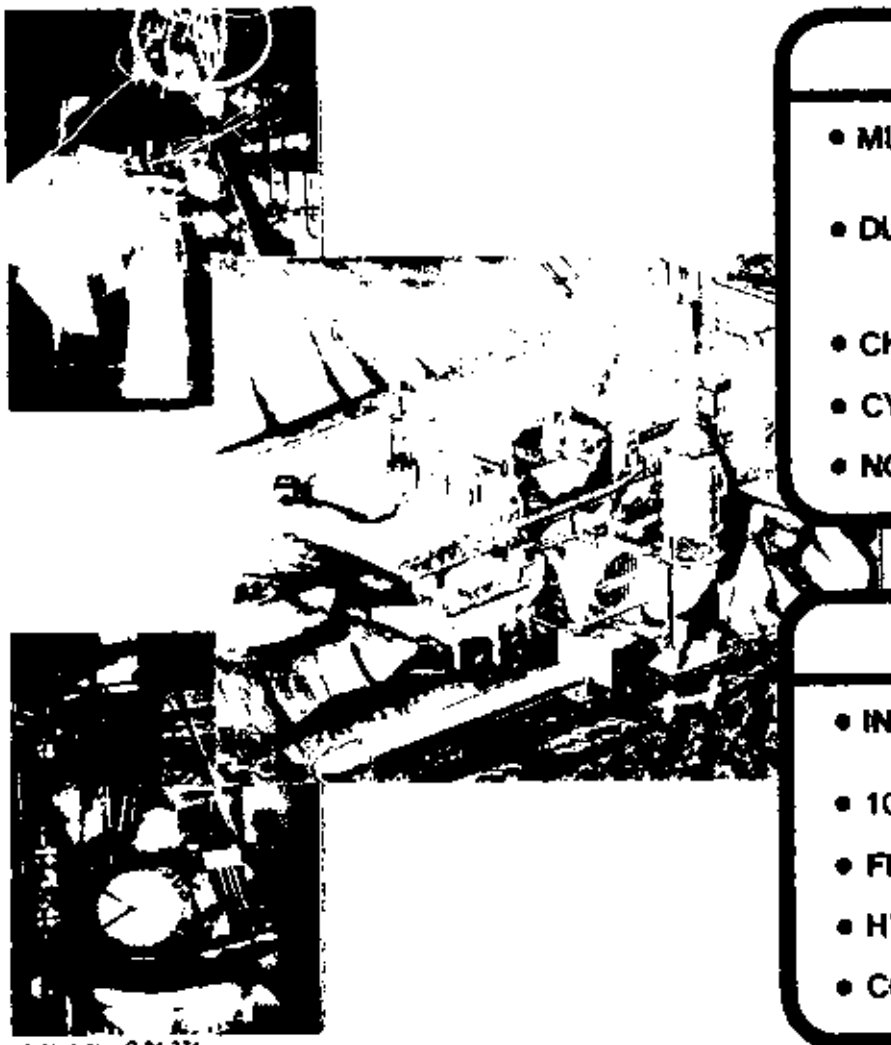
1. Rocket Engine Test Facility
2. Cleveland, Ohio
3. NASA
4. 1981
5. NASA, Lewis Research Center Facilities Office
6. Interior, exterior views and capability statement

NASA
C-81-371

Lewis Research Center

NASA

# ROCKET ENGINE TEST FACILITY



## CAPABILITIES

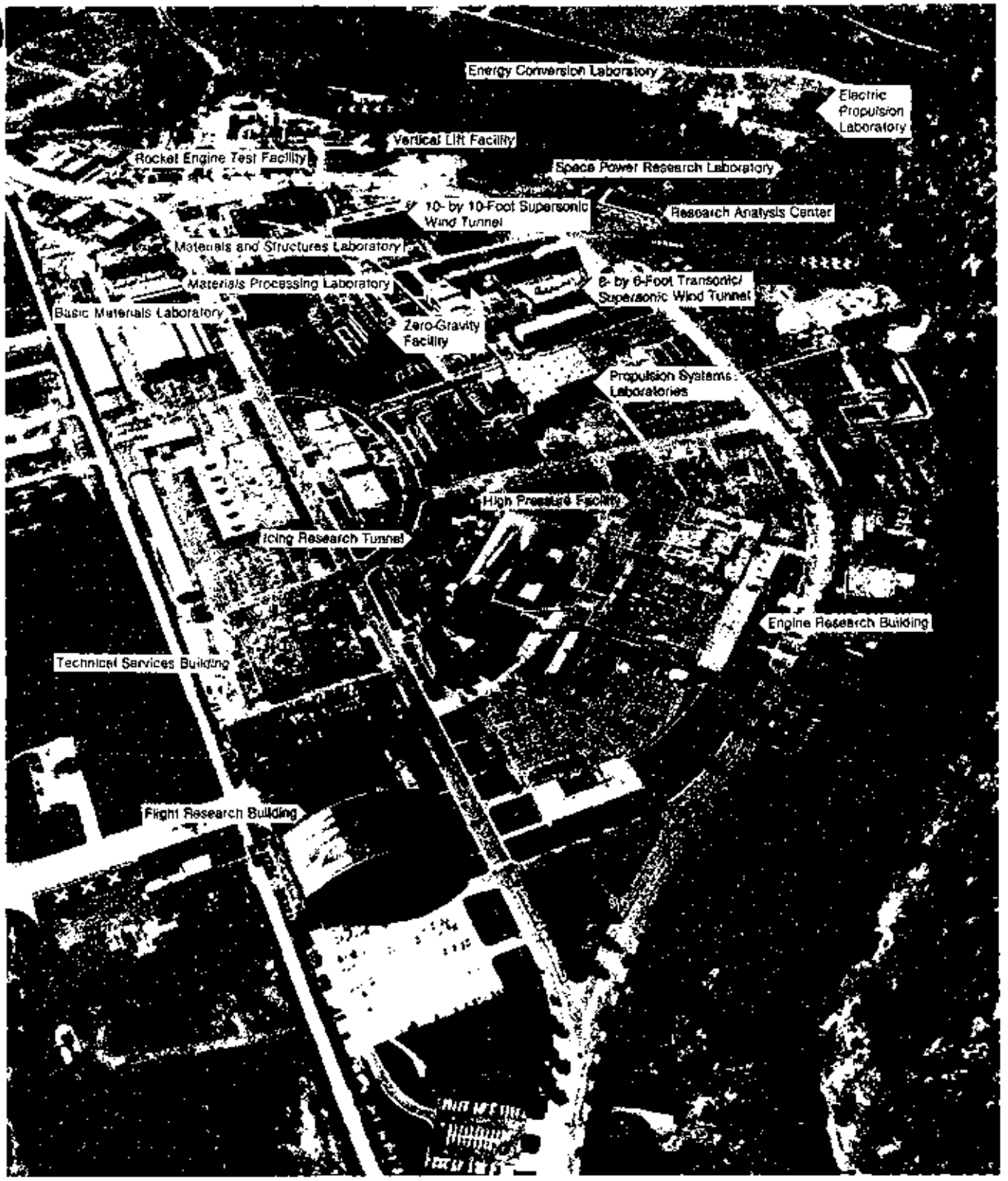
- MULTI-PROPELLANT–$LH_2$, $LO_2$, $N_2O_4$, $N_2H_4$, RP-1
- DUAL TEST POSITIONS
  - –100 to 1000 LBS THRUST
  - –1500 to 50,000 LBS THRUST
- CHAMBER PRESSURE– to 4000 PSIA
- CYCLIC TEST–200 TESTS PER DAY
- NOISE AND CHEMICAL TREATMENT

## PROGRAMS

- INJECTOR TECHNOLOGY FOR RL-10, J-2 AND SSME
- 100,000 THRUST CHAMBER LIFE TESTS
- FIRST LOX COOLED ENGINE
- HYDROGEN COOLING TECHNOLOGY
- COMBUSTION STABILITY TECHNOLOGY

0100 2-81 C-81-371

1. Lewis Research Center
2. Cleveland, Ohio
3. NASA, Lewis
4. 1983
5. NASA, Lewis Research Center Facilities Office
6. Aerial View


Energy Conversion Laboratory
Electric Propulsion Laboratory
Vertical Lift Facility
Rocket Engine Test Facility
Space Power Research Laboratory
10- by 10-Foot Supersonic Wind Tunnel
Research Analysis Center
Materials and Structures Laboratory
Materials Processing Laboratory
8- by 6-Foot Transonic/ Supersonic Wind Tunnel
Basic Materials Laboratory
Zero-Gravity Facility
Propulsion Systems Laboratories
High Pressure Facility
Icing Research Tunnel
Engine Research Building
Technical Services Building
Flight Research Building

1. Rocket Engine Test Facility
2. Cleveland, Ohio
3. NASA
4. 1982
5. NASA, Lewis Research Center Facilities Office
6. Exterior View

NASA
C-82-3055

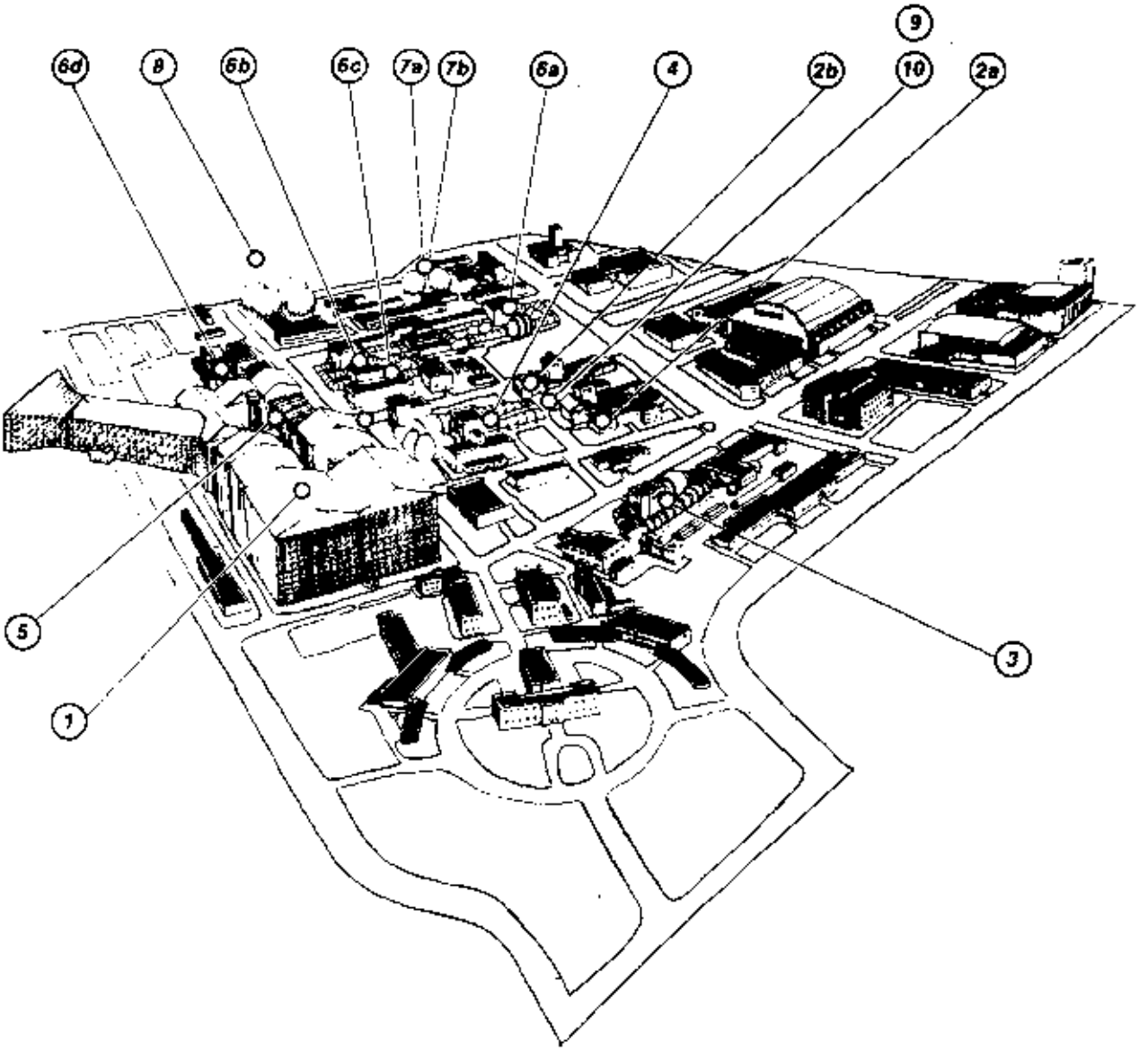
1. Rocket Engine Test Facility
2. Cleveland, Ohio
3. NASA
4. 1978
5. NASA, Lewis Research Center Facilities Office
6. Cutaway view of the facility

6. *UNITARY PLAN FACILITY*

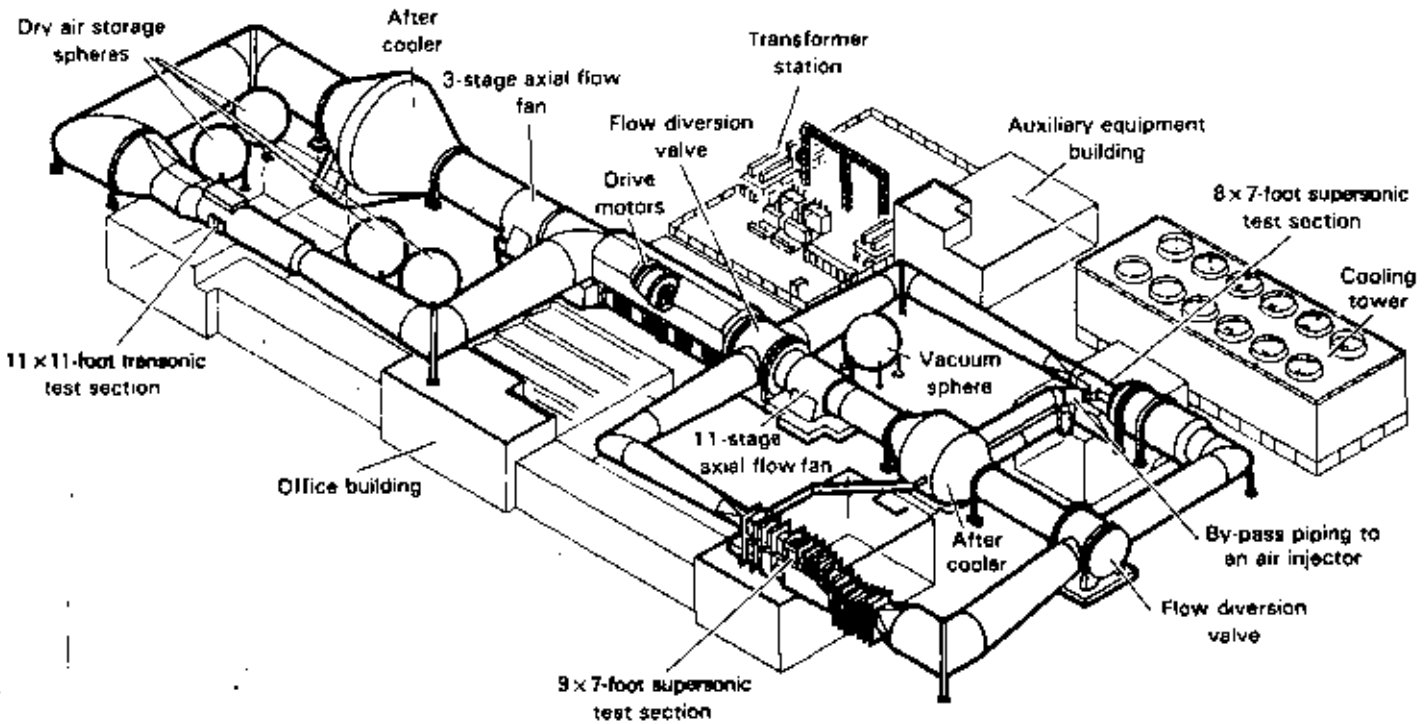
6a. *11-BY 11-FOOT TRANSONIC WIND TUNNEL*

6b. *9-BY 7-FOOT SUPERSONIC WIND TUNNEL*

6c. *8-BY 7-FOOT SUPERSONIC WIND TUNNEL*

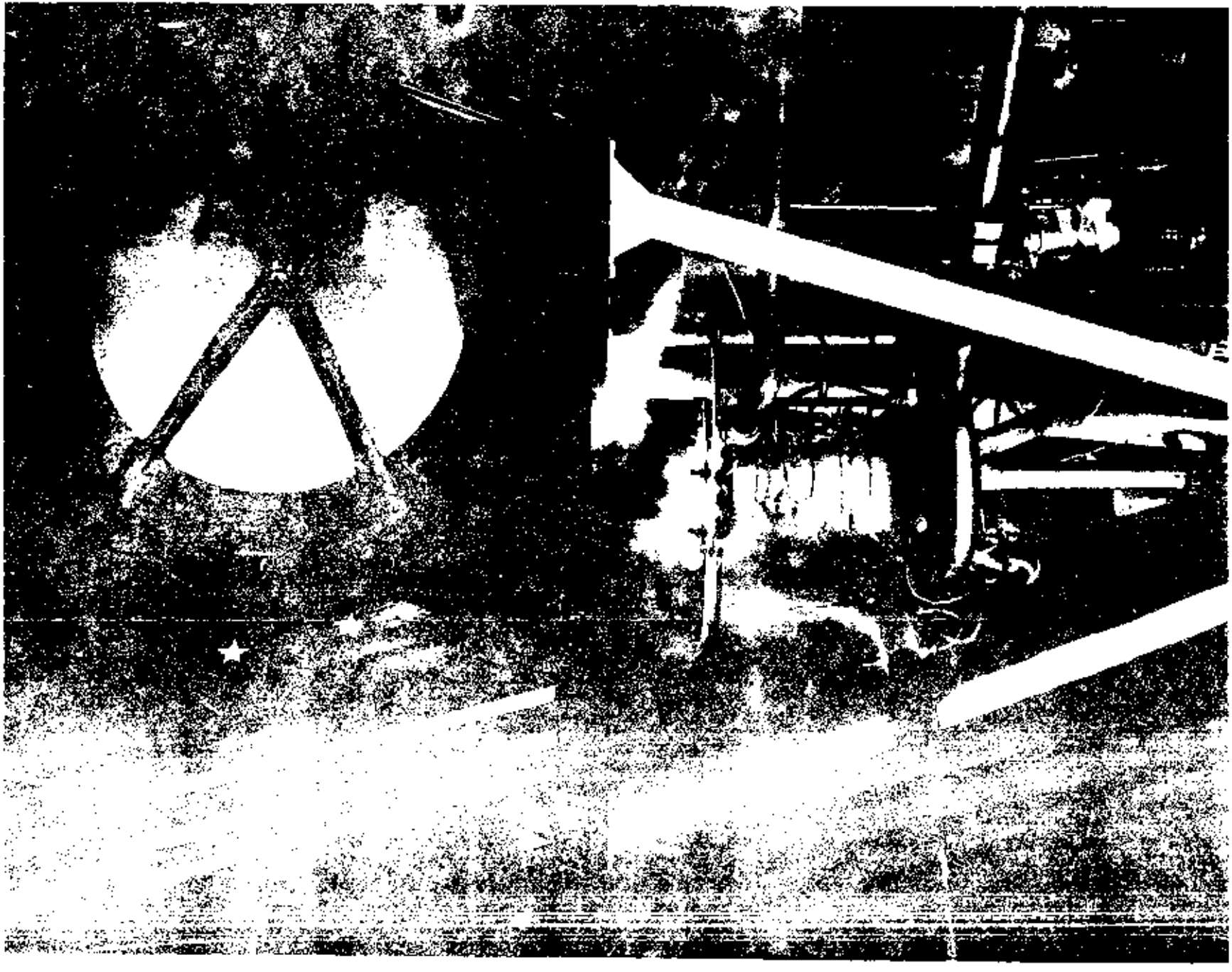


Ames Unitary Plan Wind Tunnel




Source: Baals. p. 68

NASA
C-76-866



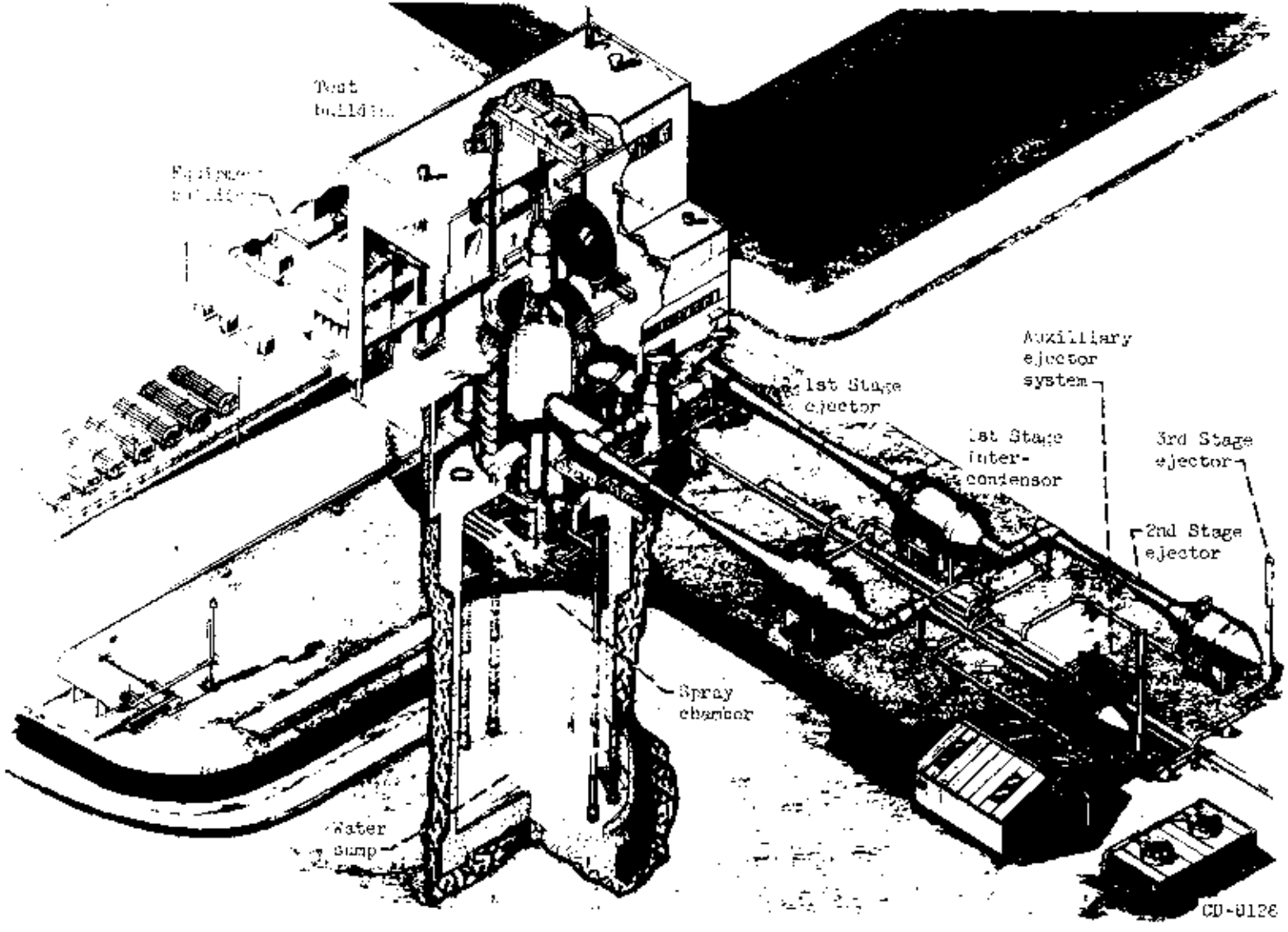



Figure 4. - Cutaway view of Spacecraft Propulsion Research Facility.

Man in Space Theme Study
Federal Agency Nomination

NPS Form 10-900
(7-81)

**United States Department of the Interior**
National Park Service

For NPS use only

received

date entered

# National Register of Historic Places Inventory—Nomination Form

See instructions in *How to Complete National Register Forms*
Type all entries—complete applicable sections

## 1. Name

historic Redstone Test Stand

and/or common Interim Test Stand

## 2. Location

street & number George C. Marshall Space Flight Center ___ not for publication

city, town Huntsville ___ vicinity of congressional district

state Alabama code 01 county Madison code 089

## 3. Classification

| Category | Ownership | Status | Present Use | |
|---|---|---|---|---|
| ___ district | X public | ___ occupied | ___ agriculture | X museum |
| ___ building(s) | ___ private | ___ unoccupied | ___ commercial | ___ park |
| X structure | ___ both | ___ work in progress | ___ educational | ___ private residence |
| X site | **Public Acquisition** | **Accessible** | ___ entertainment | ___ religious |
| ___ object | ___ in process | X yes: restricted | ___ government | ___ scientific |
| | ___ being considered | ___ yes: unrestricted | ___ industrial | ___ transportation |
| | | ___ no | ___ military | X other: Abandoned |

## 4. Owner of Property

name National Aeronautics and Space Administration (NASA)

street & number

city, town Washington ___ vicinity of state D.C. 20546

## 5. Location of Legal Description

courthouse, registry of deeds, etc. National Aeronautics and Space Administration (NASA)

street & number Real Property Management Office Code NXG

city, town Washington state D.C. 20546

## 6. Representation in Existing Surveys

title National Register Inventory has this property been determined eligible? X yes ___ no

date May 13, 1976 ___ federal X state ___ county ___ local

depository for survey records

city, town state

# 7. Description

| Condition | | Check one | Check one |
|---|---|---|---|
| X excellent | ___ deteriorated | X unaltered | X original site |
| ___ good | ___ ruins | ___ altered | ___ moved date _____ |
| ___ fair | ___ unexposed | | |

**Describe the present and original (if known) physical appearance**

The Redstone test stand is a steel frame structure made from salvaged materials. The stand is 75 feet tall and 33 by 22 feet at its base. There is an external stair and two working platforms. An asbestos-sided gable roofed shed is found at the top of the structure.

The blockhouse for the test stand was used for observations and for receiving telemetered data during the tests. The blockhouse is constructed from three surplus chemical steel tanks covered by a mound of dirt. There are metal doors on the east side of the blockhouse, observation windows, and a roof observation post. The three tanks contain 1,500 square feet of usable space for the test engineers. The initial construction cost of the Redstone test stand in 1953 was $25,000. The Redstone test stand is in excellent physical condition.[1]

# 8. Significance

| Period | Areas of Significance—Check and justify below | | | |
|---|---|---|---|---|
| ___ prehistoric | ___ archeology-prehistoric | ___ community planning | ___ landscape architecture | ___ religion |
| ___ 1400–1499 | ___ archeology-historic | ___ conservation | ___ law | ___ science |
| ___ 1500–1599 | ___ agriculture | ___ economics | ___ literature | ___ sculpture |
| ___ 1600–1699 | ___ architecture | ___ education | X military | ___ social/ humanitarian |
| ___ 1700–1799 | ___ art | X engineering | ___ music | ___ theater |
| ___ 1800–1899 | ___ commerce | ___ exploration/settlement | ___ philosophy | ___ transportation |
| X 1900– | ___ communications | ___ industry | ___ politics/government | X other (specify) Space Exploration |
| | | ___ invention | | |

**Specific dates** 1958-1961 **Builder/Architect** U.S. Army

**Statement of Significance (in one paragraph)**

The Redstone test stand is the oldest static firing facility at the Marshall Space Flight Center. It was constructed by the Ordnance Guided Missile Center at Redstone Arsenal and was transferred to NASA in 1960. It was the first test stand in the United States to accommodate the entire launch vehicle for static tests (previous test stands in this country had accommodated the engine only) and was an important facility in developing the Jupiter C and the Mercury-Redstone vehicles that launched the first American satellite and the first American manned spaceflight. The test stand was also used to develop the "manrated" launch procedures vital to manned space flights and the acceptance firing criteria which were made in launch pneumatics, thrust measurement, propellant fuel procedures, and launch ignition procedures during various tests at this facility.

The basic Redstone missile for which the stand was a major test site had its origin in 1950 when the Ordnance Guided Missile Center began study of a 500-mile-range rocket. The Redstone medium range ballistic missile that evolved from a five-year research and development program was 70 inches in diameter and 69 feet long. Its power was rated at 75,000 pounds thrust.

From this test program, other versions of the Redstone evolved, including the Jupiter C and the Mercury/Redstone.

The Jupiter C was the basis for a detailed proposal for an orbiting earth satellite. This proposal designated "A Minimum Satellite Vehicle Based Upon Components Available From Missile Development of the Army Ordnance Corps," was prepared in 1955. It stated that the Army could launch a satellite within a short time using hardware then available.

After the USSR opened the space age, in October 1957, by orbiting Sputnik 1, the Army Redstone team led by Dr. Werner von Braun was directed to attempt a satellite launch. The feat was accomplished on January 31, 1958, by adding a single solid rocket motor as a fourth stage to the Jupiter C and attaching a scientific payload at its forward end.

NASA requested ten Redstones for its first manned program, Mercury. For Mercury, the Redstone propellant tank was lengthened by 6 feet (same as the Jupiter C) and the standard Redstone engine thrust was increased to 78,000 pounds thrust. This vehicle became known as Mercury/Redstone, and nine of them were tested in the Redstone test stand. Two of the Mercury/Redstone vehicles were eventually used to carry men into space. By that time, the space program had grown, and more sophisticated test sites were necessary.

The site was phased out of the active test program in 1961 and all usable equipment removed.[2]

The Redstone test stand was listed on the National Register of Historic Places as being nationally significant in 1976. It was also designated as an Alabama historic engineering landmark in 1979.

Footnotes

1. Draft Historic Properties Report Redstone Arsenal, Alabama with the George C. Marshall Space Flight Center (Silver Spring, Maryland: Building Technology Incorporated, 1983), p. 34.

2. Harry Butowsky et. al., Man in Space Reconnaissance Survey (Denver: Denver Service Center National Park Service, 1981), pp. 60-61.

Bibliography

Butowsky, Harry A. et.al. Man in Space Reconnaissance Survey. Denver: National Park Service, 1981.

Draft Historic Properties Report Redstone Arsenal, Alabama with the George C. Marshall Space Flight Center. Silver Spring, Maryland: Building Technology Incorporated, 1983.

Floyd, Warner W. "National Register of Historic Places Inventory Redstone Test Stand." Montgomery, Alabama: Alabama Historic Commission, 1976.

Swenson, Loyd S. Jr., Grimwood, James M., and Alexander, Charles C. This New Ocean: A History of Project Mercury. Washington, D.C.: National Aeronautics and Space Administration, 1966.

## 9. Major Bibliographical References

See continuation sheets

## 10. Geographical Data

Acreage of nominated property Less than 1 acre

Quadrangle name Madison

Quadrangle scale 1:24,000

UMT References

| | Zone | Easting | Northing | | Zone | Easting | Northing |
|---|---|---|---|---|---|---|---|
| A | 16 | 530 583 | 3832160 | B | | | |
| C | | | | D | | | |
| E | | | | F | | | |
| G | | | | H | | | |

Verbal boundary description and justification

The boundary of the Redstone Test Site is defined by the black circle on the accompanying map entitled "Marshall Space Flight Center, Alabama, Facilities Map."

List all states and counties for properties overlapping state or county boundaries

| state | code | county | code |
|---|---|---|---|
| | | | |
| state | code | county | code |

## 11. Form Prepared By

name/title Harry A. Salowsky

organization National Park Service date May 15, 1984

street & number Division of History telephone (202)343-8168

city or town Washington, D.C. 20240 state

## 12. State Historic Preservation Officer Certification

The evaluated significance of this property within the state is:

___ national ___ state ___ local

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89-665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service.

State Historic Preservation Officer signature

title date

For NPS use only

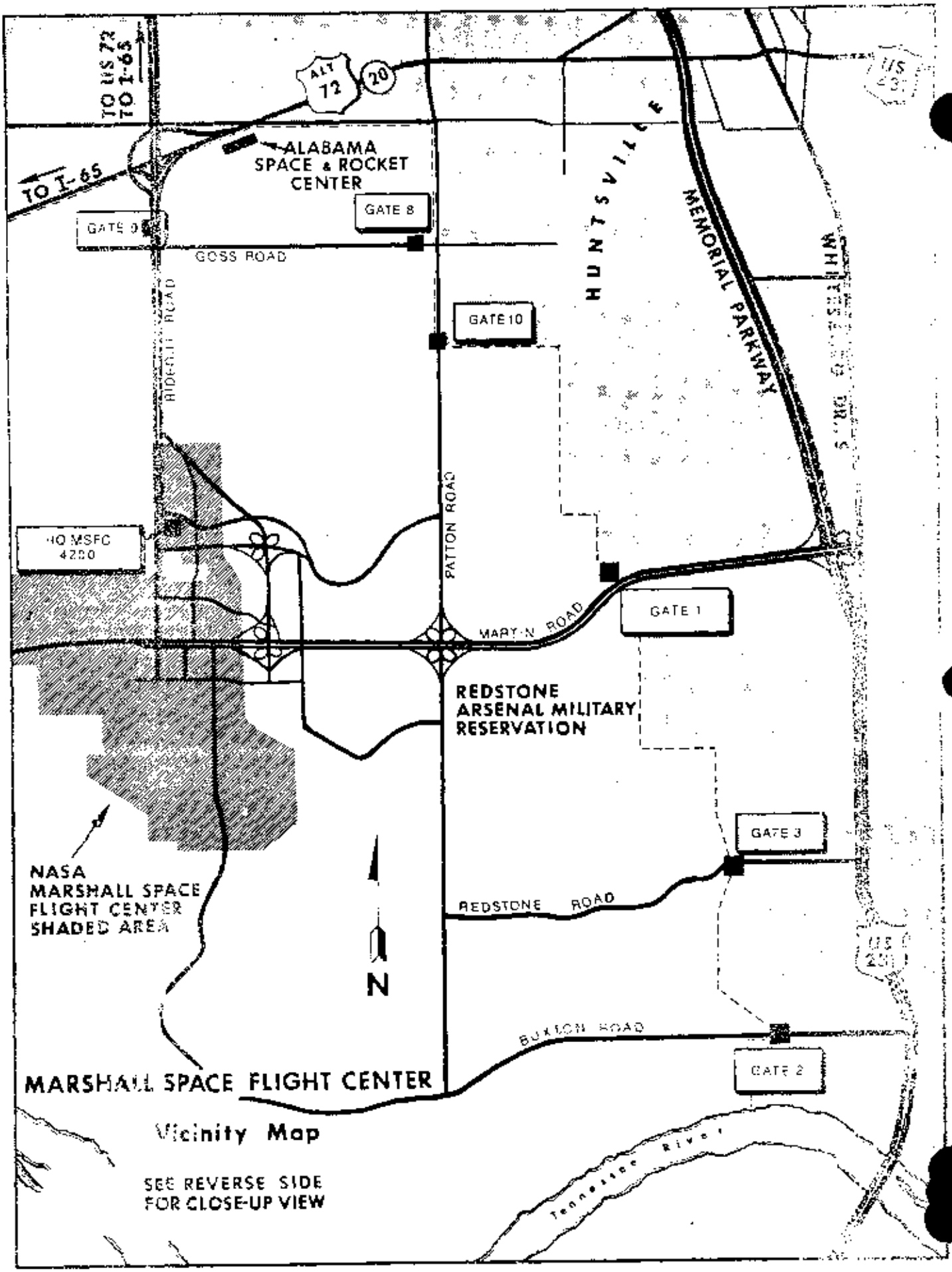
I hereby certify that this property is included in the National Register

date

Keeper of the National Register

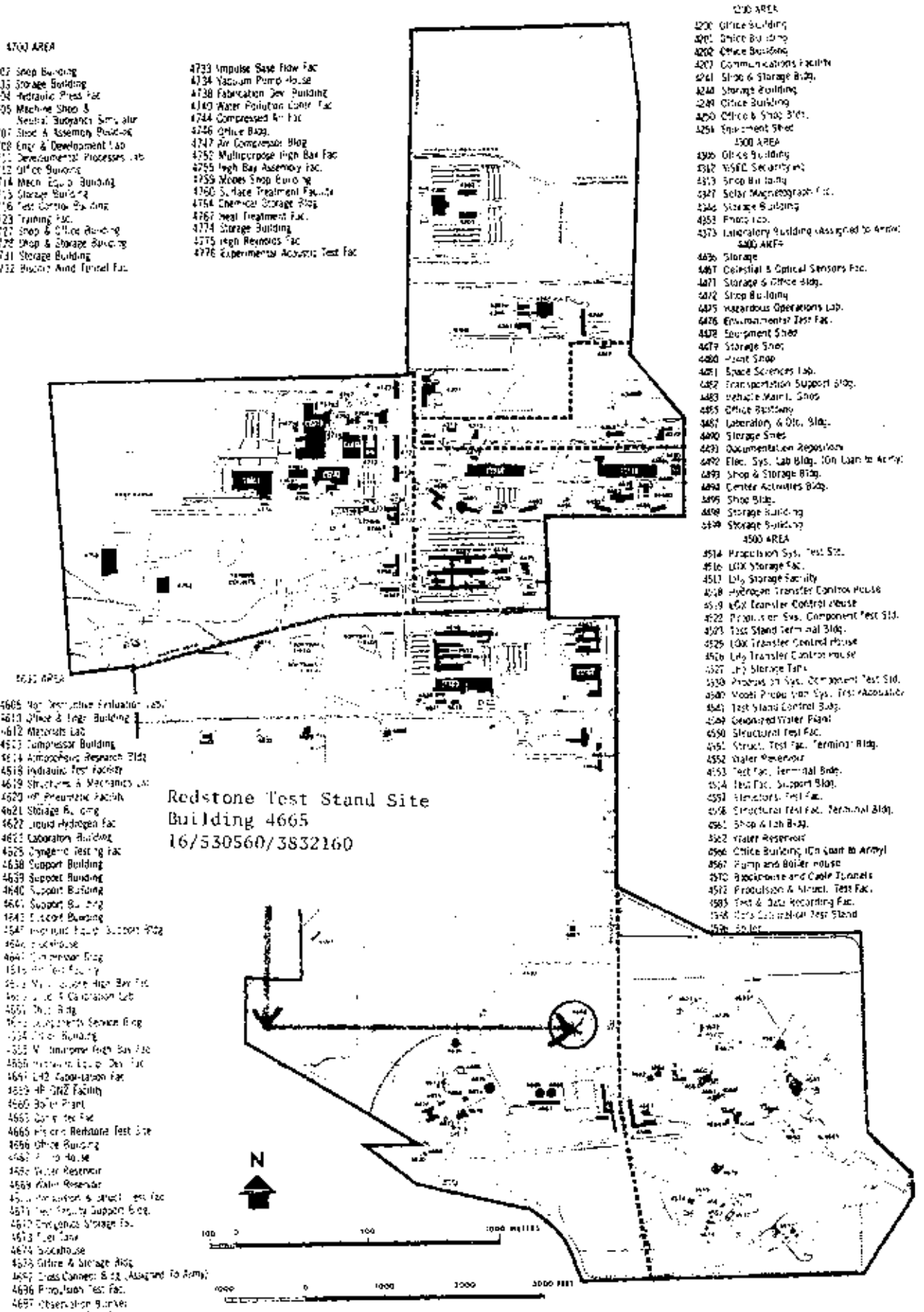
Attest: date

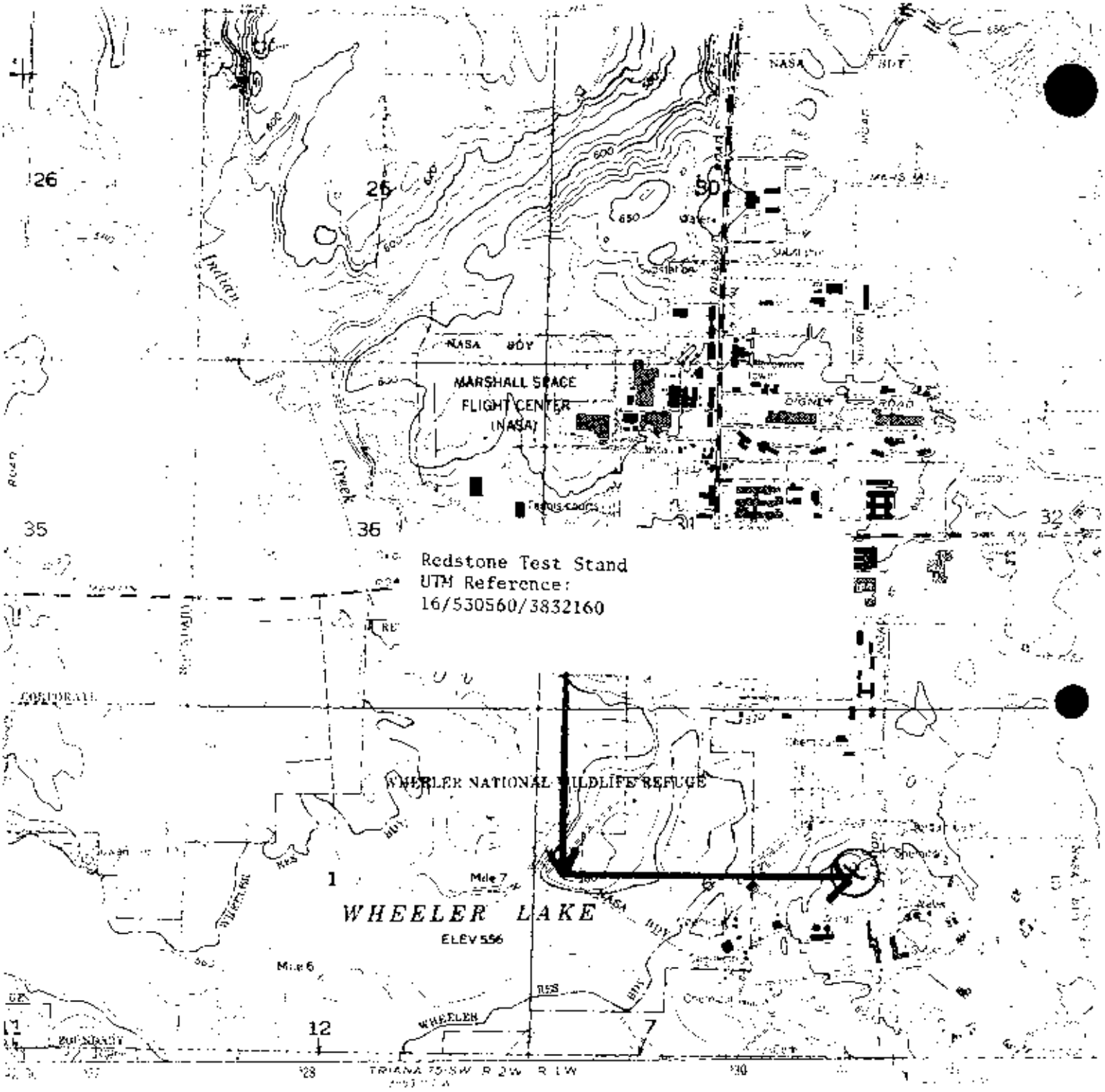
Chief of Registration


TO US 72
TO I-65
ALT 72
20
US 231
TO I-65
ALABAMA SPACE & ROCKET CENTER
GATE 8
GATE 9
GOSS ROAD
HUNTSVILLE
MEMORIAL PARKWAY
WHITESBURG DR S
GATE 10
RIDEOUT ROAD
PATTON ROAD
HQ MSFC 4200
GATE 1
MARTIN ROAD
REDSTONE ARSENAL MILITARY RESERVATION
GATE 3
NASA MARSHALL SPACE FLIGHT CENTER SHADED AREA
REDSTONE ROAD
N
US 231
BUXTON ROAD
GATE 2
MARSHALL SPACE FLIGHT CENTER
Vicinity Map
SEE REVERSE SIDE FOR CLOSE-UP VIEW
Tennessee River

# MARSHALL SPACE FLIGHT CENTER, ALABAMA

## FACILITIES SITE MAP





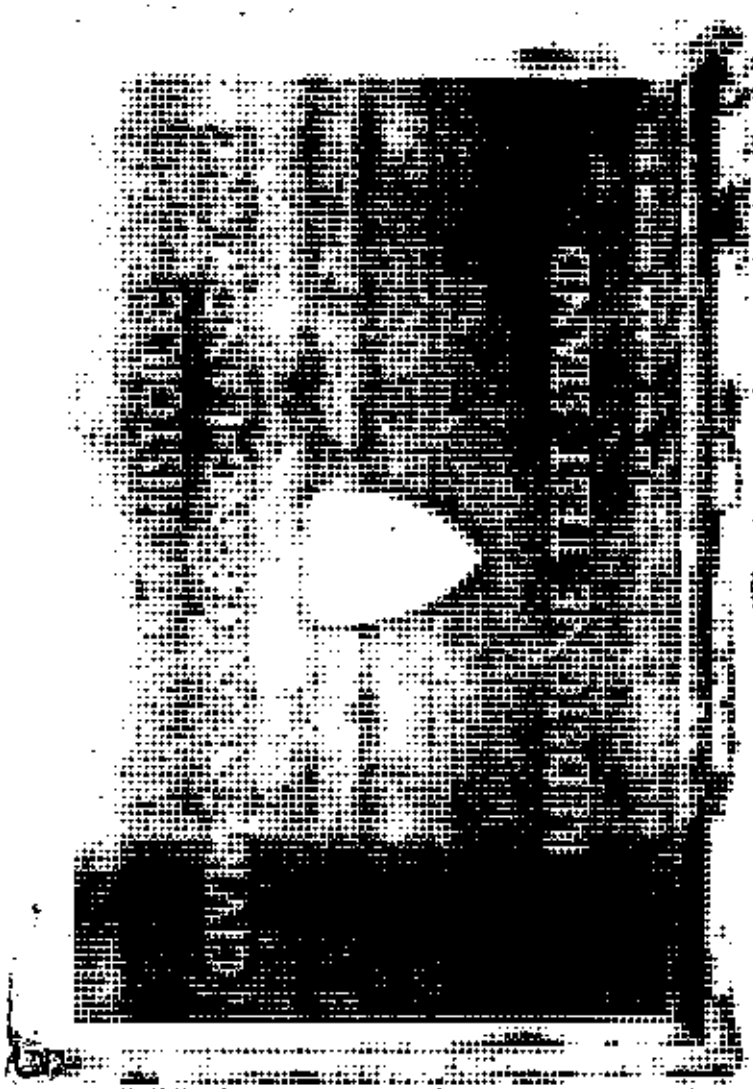

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U.S. GEOLOGICAL SURVEY, RESTON, VIRGINIA 22092
AND BY U.S. TENNESSEE VALLEY AUTHORITY, CHATTANOOGA, TENN. 37401 OR KNOXVILLE, TENN. 37902
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

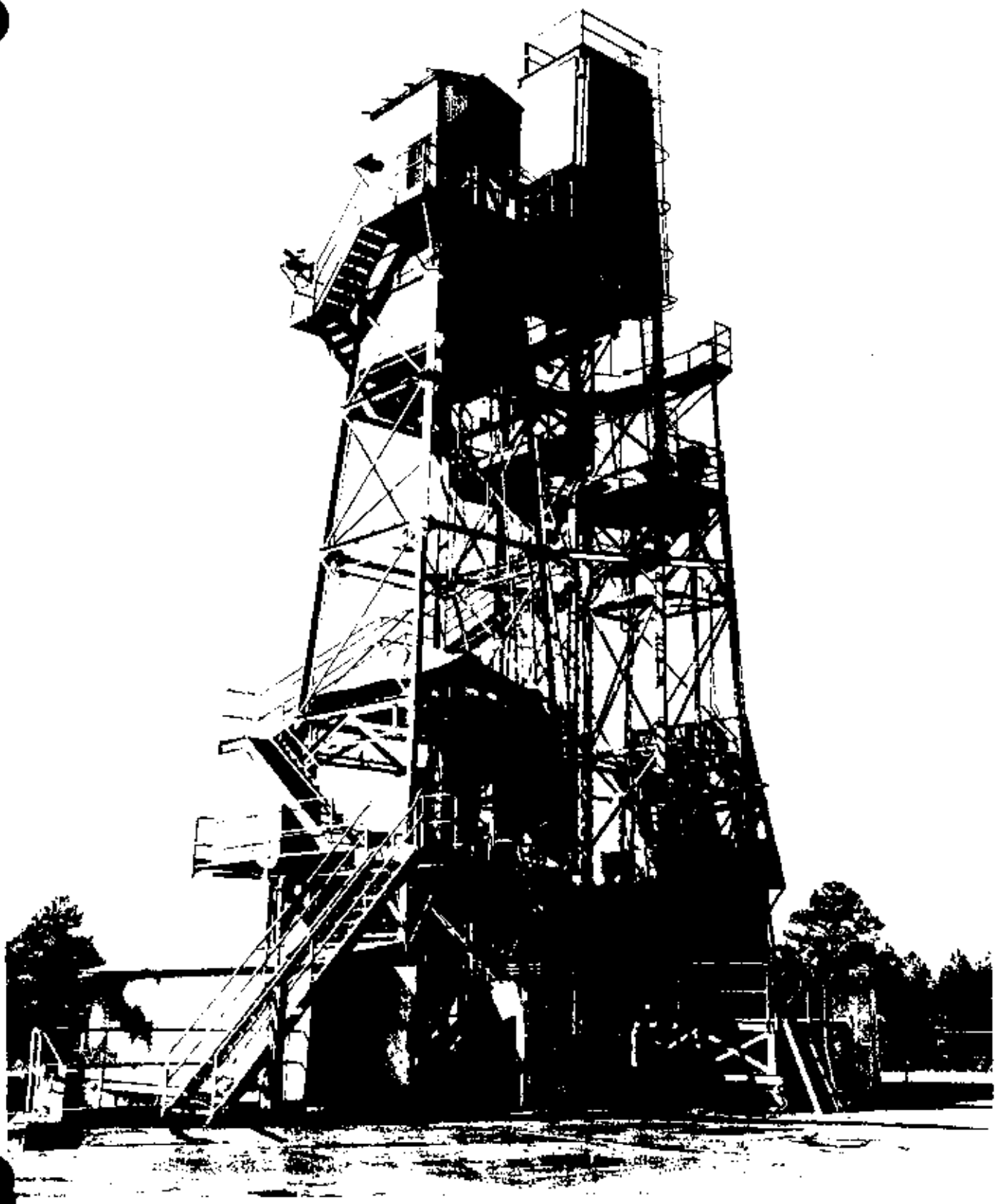
1. Redstone Test Stand
2. Hunstville, Alabama
3. NASA
4. 1984
5. NASA, Marshall Space Flight Center Facilities Office
6. Historic Redstone Test Stand Site Sign

ADDED TO NATIONAL REGISTER OF HISTORICAL PLACES. 1976

1. Redstone Test Stand
2. Huntsville, Alabama
3. NASA
4. 1984
5. NASA, Marshall Space Flight Center Facilities Office
6. Redstone Test Stand Marker

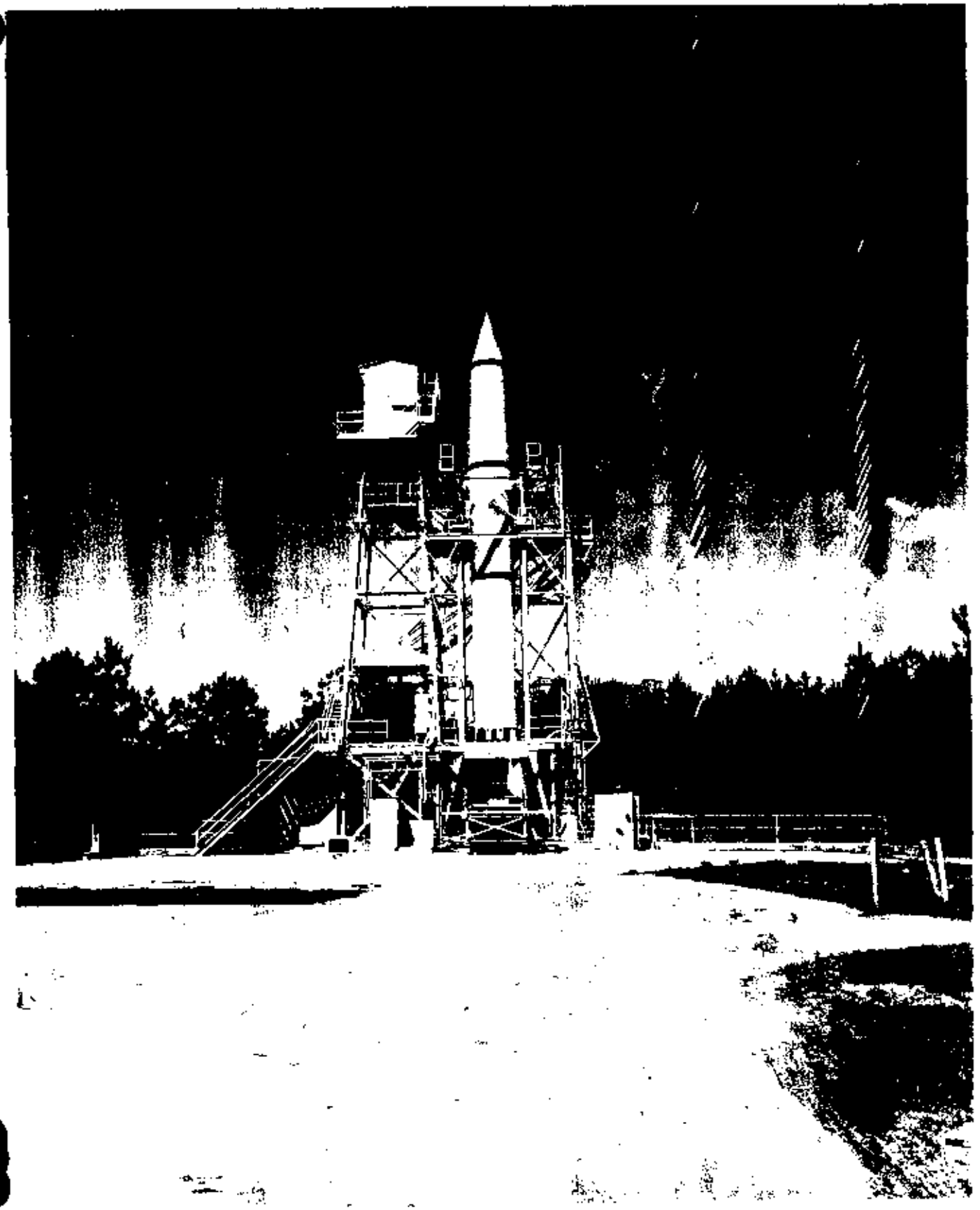


1. Redstone Test Stand
2. Huntsville, Alabama
3. NASA
4. 1961
5. NASA, Marshall Space Flight Center Facilities Office
6. Exterior View



Interim Test Stand

1. Redstone Test Stand
2. Huntsville, Alabama
3. NASA
4. 1984
5. NASA, Marshall Space Flight Center Facilities Office
6. Exterior View



1. Blockhouse for the Redstone Test Stand
2. Huntsville, Alabama
3. NASA
4. 1984
5. NASA, Marshall Space Flight Center Facilities Office
6. Exterior View of Blockhouse

# MARSHALL SPACE FLIGHT CENTER, ALABAMA

## FACILITIES SITE MAP

4700 AREA

4702 Shop Building
4703 Storage Building
4704 Hydraulic Press Fac
4705 Machine Shop &
Neutral Buoyancy Simulator
4706 Shop & Assembly Building
4709 Engr & Development Lab
4711 Developmental Processes Lab
4712 Office Building
4714 Warm Space Building
4715 Storage Building
4716 Test Control Building
4723 Training Fac
4727 Shop & Office Building
4728 Shop & Storage Building
4731 Storage Building
4732 Bisonic Wind Tunnel Fac

4733 Impulse Base Flow Fac
4734 Vacuum Pump House
4738 Fabrication Dev Building
4740 Water Pollution Contr Fac
4744 Compressed Air Fac
4745 Office Bldg.
4747 Air Compressor Bldg
4752 Multipurpose High Bay Fac
4755 High Bay Assembly Fac
4759 Model Shop Building
4760 Surface Treatment Facility
4764 Chemical Storage Bldg.
4767 Heat Treatment Fac
4774 Storage Building
4775 High Reynolds Fac
4776 Experimental Acoustic Test Fac

4200 AREA

4200 Office Building
4203 Office Building
4205 Office Building
4201 Communications Facility
4241 Shop & Storage Bldg.
4244 Storage Building
4245 Office Building
4246 Office & Shop Bldg
4251 Equipment Shed

4300 AREA

4306 Office Building
4312 Security Security
4313 Storage Building
4347 Motor Magnetic Fac.
4348 Storage Building
4353 Photo Lab.
4375 Laboratory Building (Assigned to Army)

4400 AREA

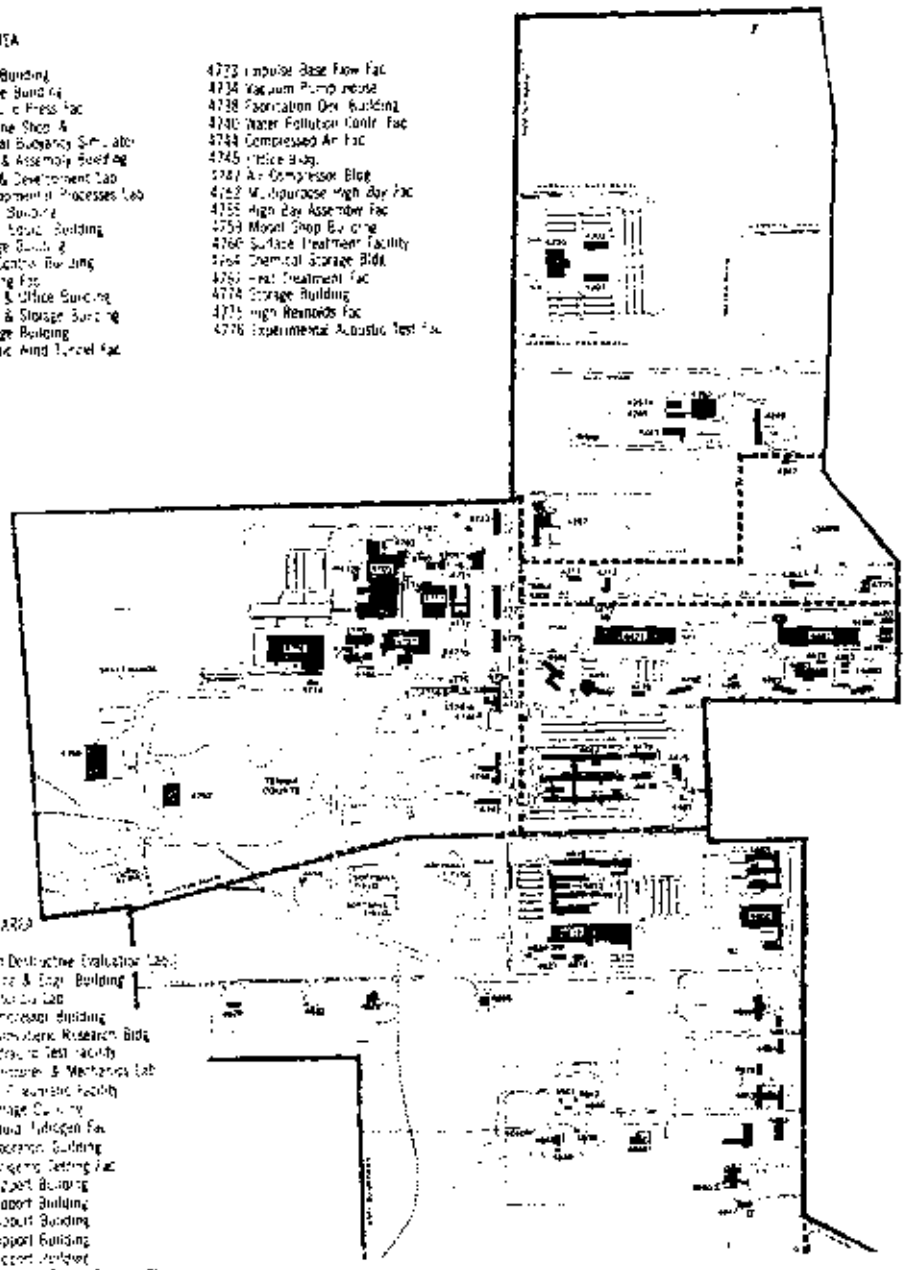
4406 Storage
4467 Chemical & Optical Sensors Fac.
4471 Storage & Office Bldg.
4472 Shop Building
4475 Hazardous Operations Lab.
4476 Environmental Test Fac.
4478 Equipment Shed
4479 Storage Shed
4480 Paint Shop
4481 Space Sciences Lab
4482 Transportation Support Bldg.
4483 Vehicle Maint. Shop
4485 Office Building
4487 Laboratory & Off. Bldg.
4491 Storage Shed
4491 Documentation Repository
4492 Elec. Sys. Lab Bldg. (On loan to Army)
4493 Shop & Storage Bldg.
4494 Center Activities Bldg.
4495 Shop Bldg.
4498 Storage Building
4499 Storage Building

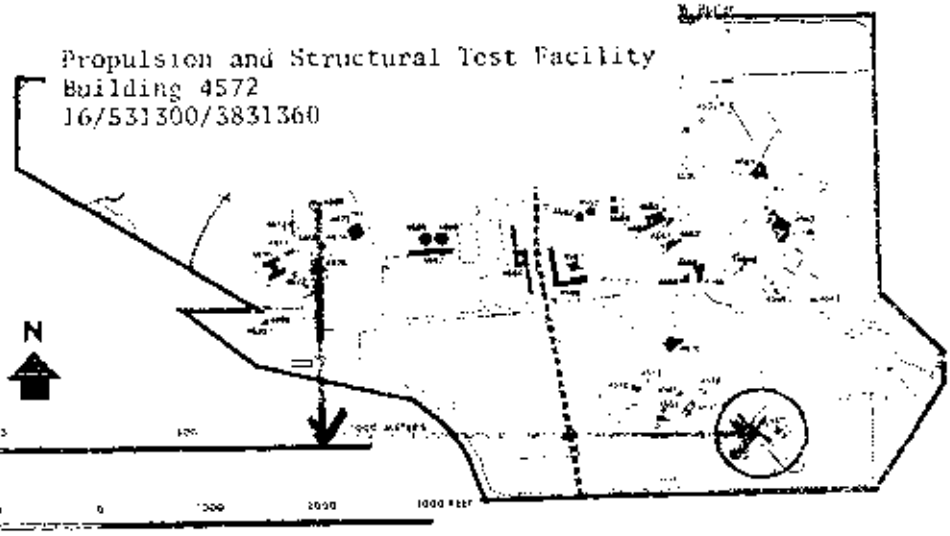
4500 AREA

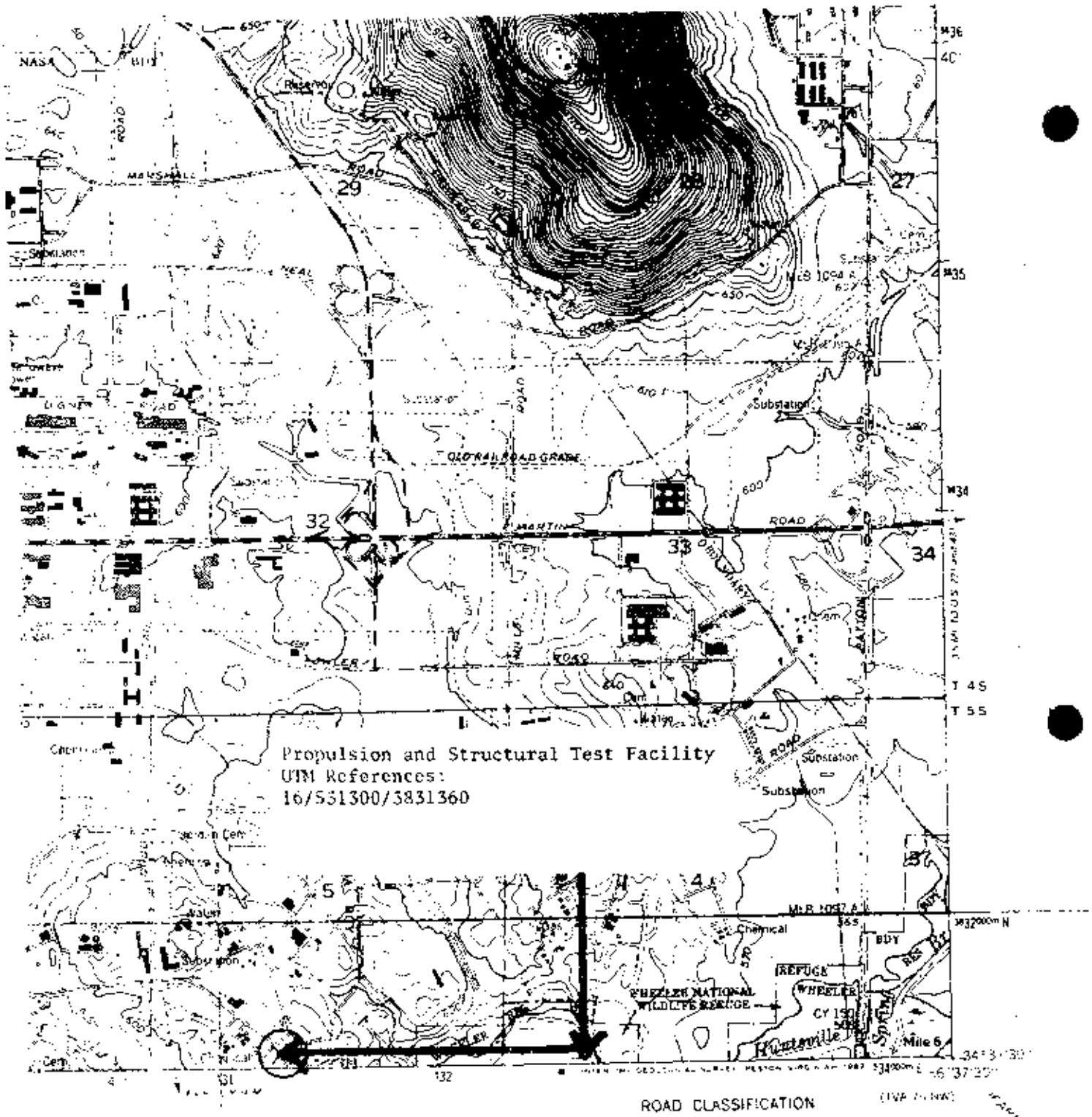
4514 Propulsion Sys. Test Std.
4516 LOX Storage Fac.
4517 LH2 Storage Facility
4518 Hydrogen Transfer Control House
4519 LOX Transfer Control House
4522 Propulsion Sys. Component Test Std.
4525 Test Stand Terminal Bldg.
4525 LOX Booster Control House
4526 LH2 Transfer Control House
4527 LH2 Storage Tank
4530 Propulsion Sys. Component Test Std.
4540 Model Propulsion Sys. Test (Acoustics)
4545 Test Stand Control Bldg.
4549 Demineralized Water Plant
4550 Structural Test Fac.
4551 Struct. Test Fac. Terminal Bldg.
4552 Water Reservoir
4553 Test Fac. Terminal Bldg.
4554 Test Fac. Support Bldg.
4557 Structural Test Fac.
4558 Structural Test Fac. Terminal Bldg.
4561 Shop & Lab Bldg.
4562 Water Reservoir
4566 Office Building (On Loan to Army)
4567 Pump and Boiler House
4570 Blockhouse and Cable Tunnels
4572 Propulsion & Struct. Test Fac
4583 Data & Data Reduction Fac.
4586 Cold Calibration Test Stand

4600 AREA

4612 Non Destructive Evaluation Lab.
4614 Office & Engr Building
4617 Hydraulic Lab
4618 Compressor Building
4619 Aerodynamic Research Bldg
4620 Structure Test Facility
4624 Dynamics & Mechanics Lab
4627 Pneumatic Facility
4629 Storage Building
4631 Liquid Hydrogen Fac
4633 Laboratory Building
4635 Engineering Testing Fac
4636 Support Building
4639 Support Building
4640 Support Building
4641 Support Building
4642 Support Building
4645 Electrical Equip. Support Bldg
4646 Blockhouse
4647 Compressor Bldg.
4648 HP Test Facility
4649 Multipurpose High Bay Fac
4651 Shop & Calibration Lab
4654 Shop Bldg.
4655 Components Service Bldg
4656 Office Building
4665 Multipurpose High Bay Fac
4656 Hydraulic Equip. Dev. Fac
4657 LH2 Vaporization Fac.
4659 HP GN2 Facility
4660 Boiler Plant
4663 Computer Fac
4665 Atomic Resistance Test Set
4666 Office Building
4667 Pump House
4668 Water Reservoir
4669 Propulsion & Struct. Test Fac
4671 Test Facility Support Bldg.
4672 Cryogenics Storage Fac
4673 Fuel Tank
4674 Blockhouse
4678 Office & Storage Bldg
4682 Cross-Connect Bldg (Assigned To Army)
4696 Propulsion Test Fac.
4697 Observation Bunker








ROAD CLASSIFICATION

Primary highway all weather hard surface

Light-duty road all weather improved surface

Secondary highway all weather hard surface

Unimproved road fair or dry weather

Interstate Route U. S. Route State Route

INDEX TO ADJACENT QUADRANGLES

37902

There may be private inholdings within the boundaries of the National or State reservations shown on this map

MADISON, ALA.

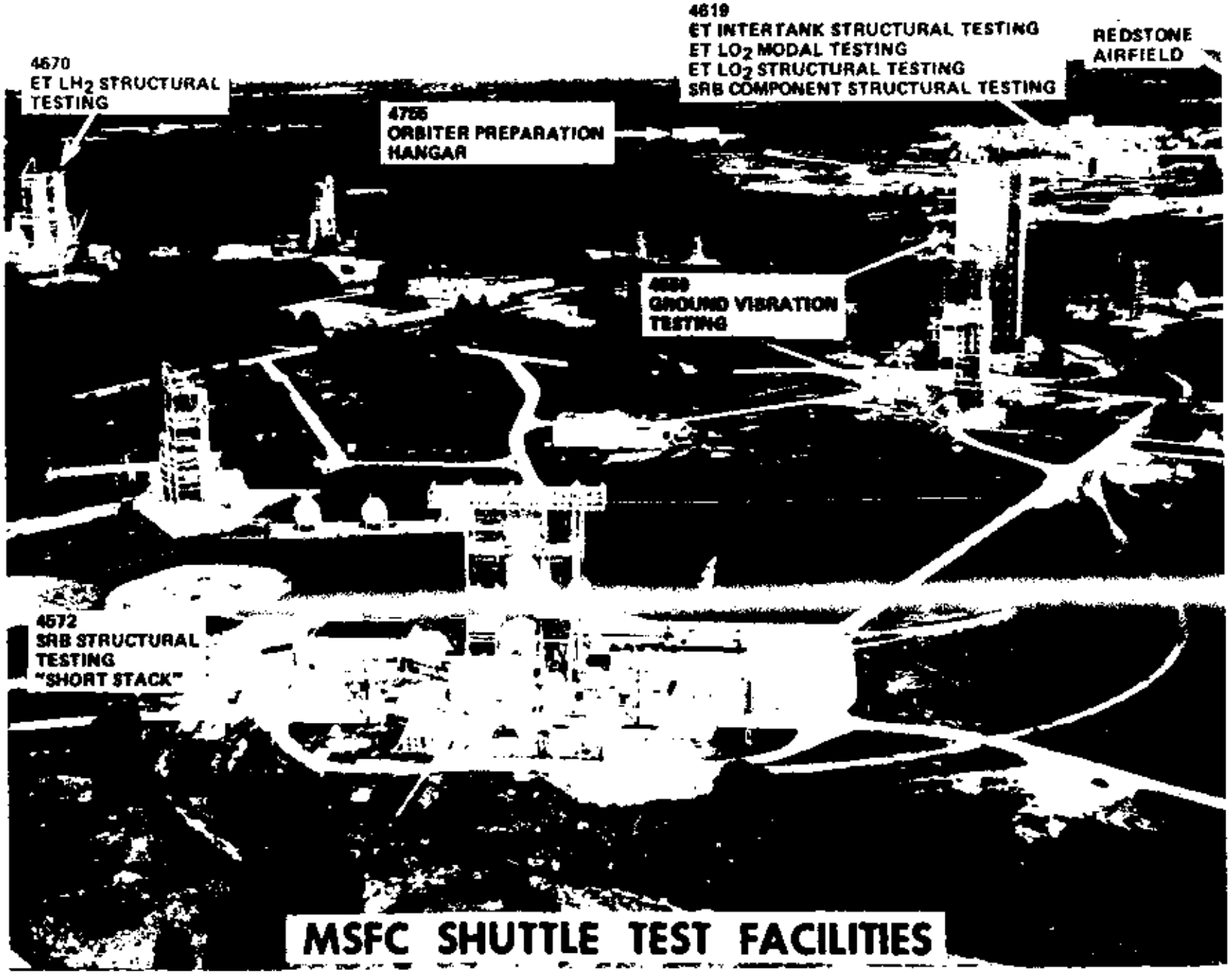
N3437.5-W8637.5

1975

PHOTOREVISED 1982

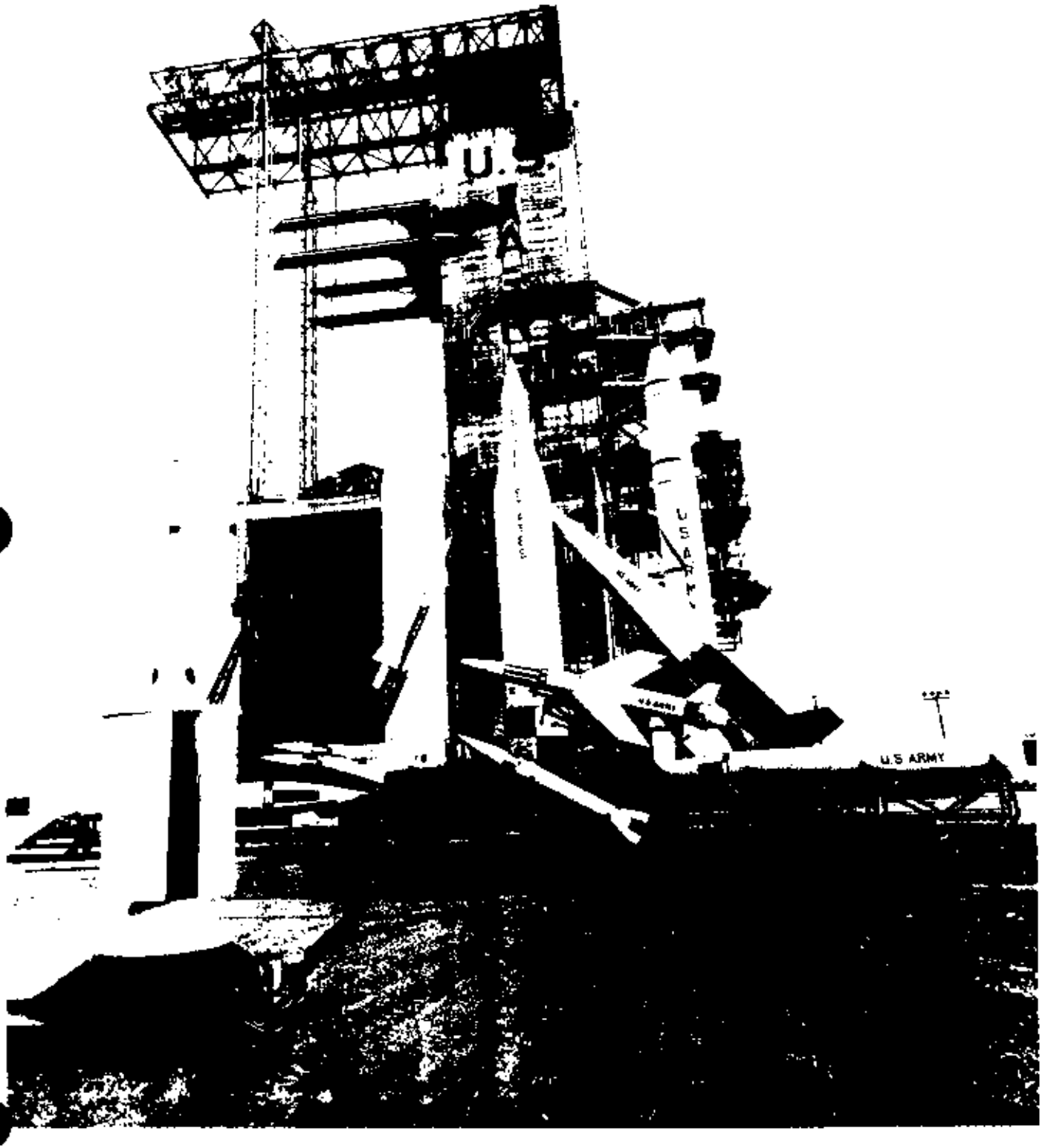
DMA 3553 II NW-SERIES V844

1. Propulsion and Structural Test Facility
2. Huntsville, Alabama
3. NASA
4. 1982
5. NASA, Marshall Space Flight Center Facilities Office
6. Aerial View of MSFC Shuttle Test Facilities showing location of Propulsion and Structural Test Facility



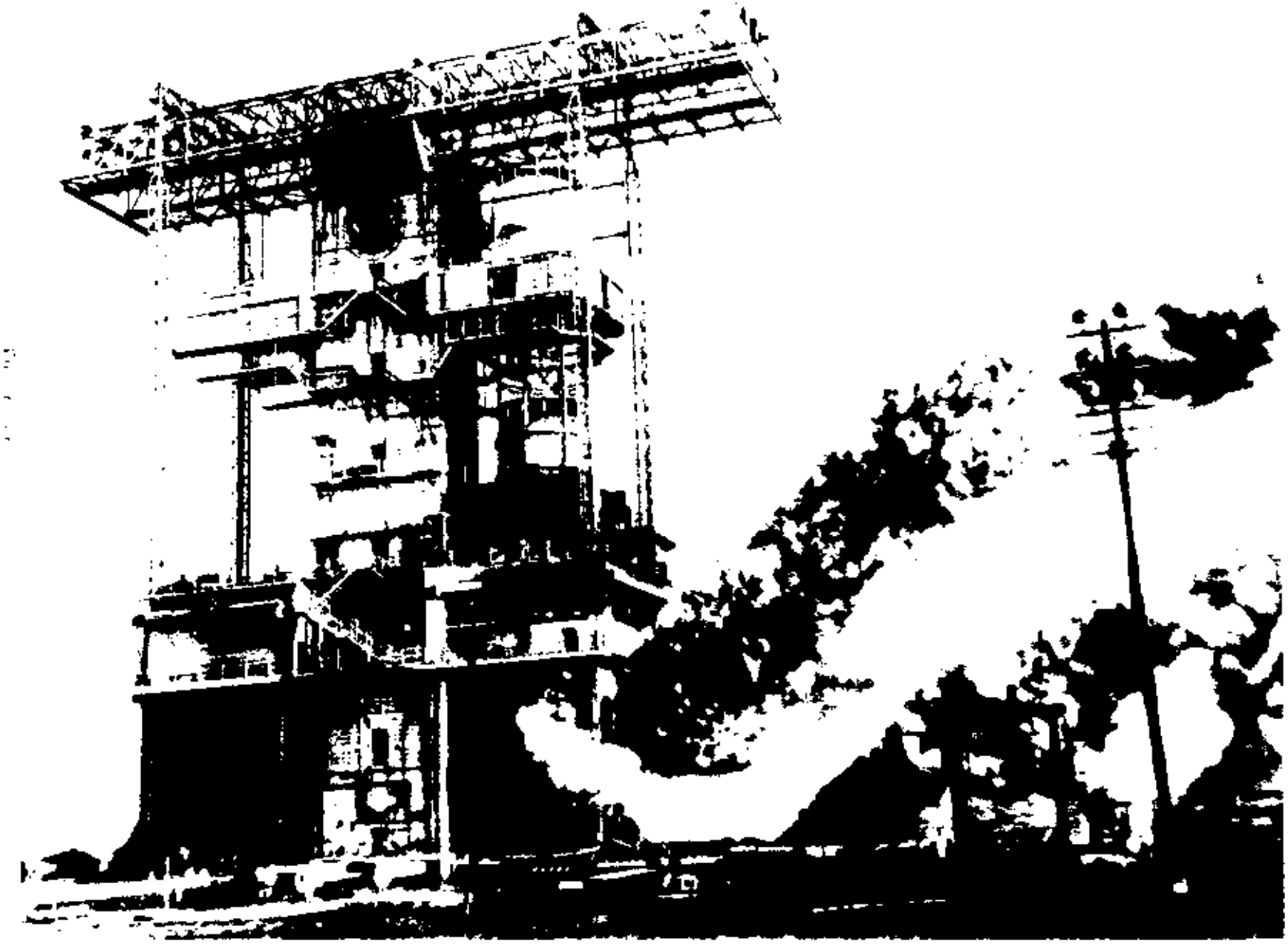

MSFC SHUTTLE TEST FACILITIES

1. Propulsion and Structural Test Facility
2. Huntsville, Alabama
3. NASA
4. 1960
5. NASA, Marshall Space Flight Center Facilities Office
6. Exterior View prior to transfer of facility to NASA

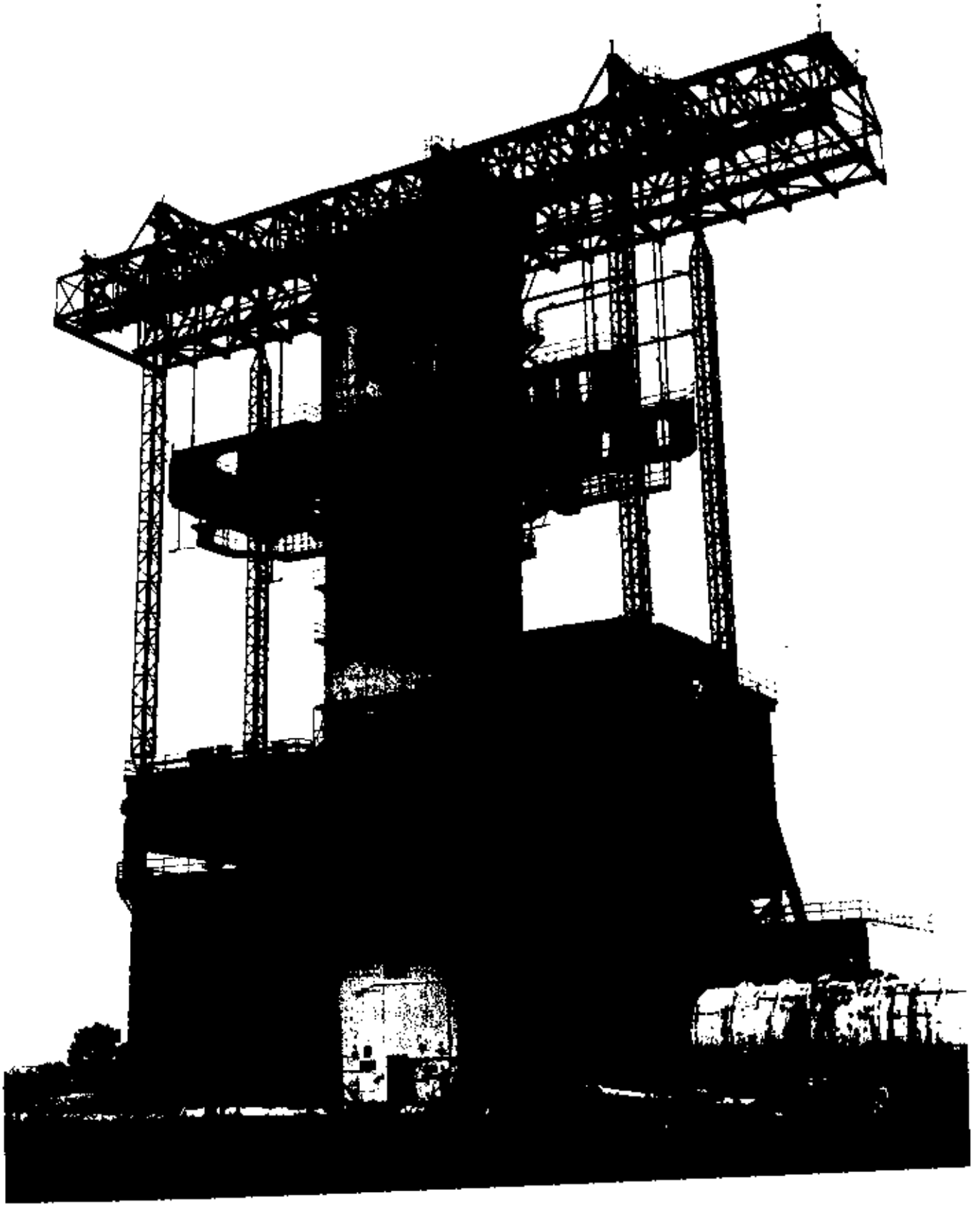

U.S.
U.S ARMY

1. Propulsion and Structural Test Facility
2. Huntsville, Alabama
3. NASA
4. 1966
5. NASA, Marshall Space Flight Center Facilities Office
6. S-1C Propulsion System Firing

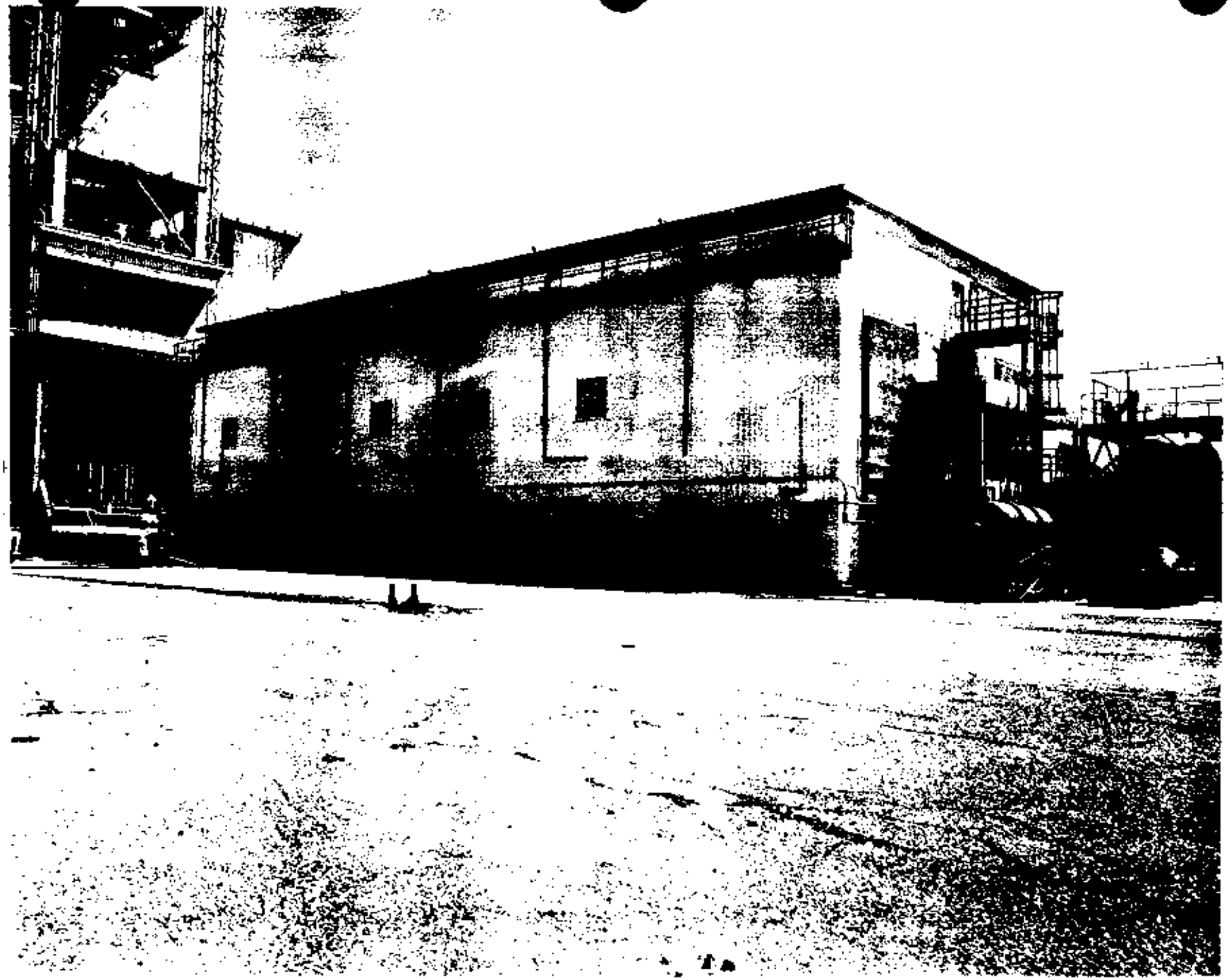
# S-IC PROPULSION SYSTEM FIRING (SINGLE F-1 ENGINE)-MSFC



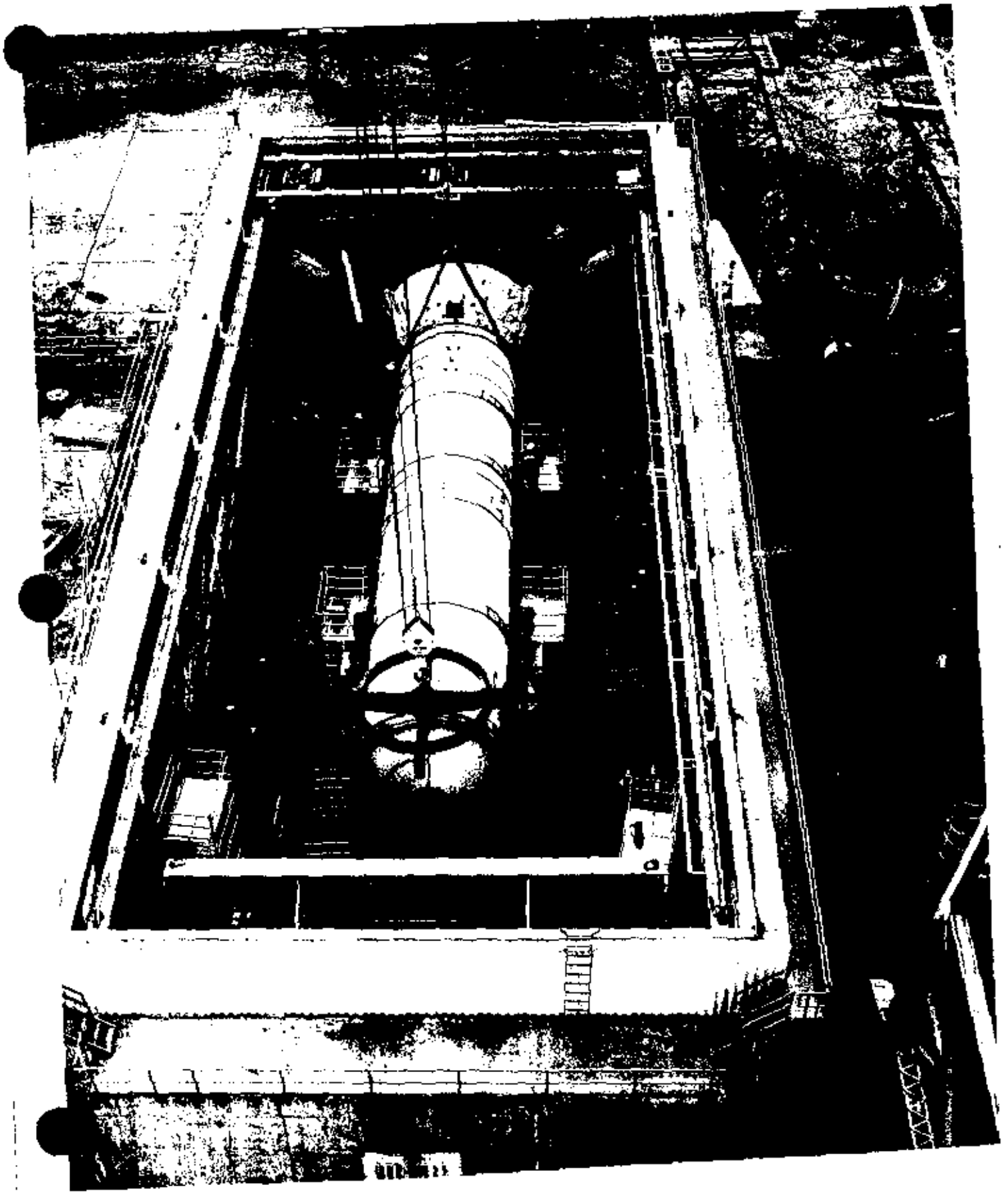
1. Propulsion and Structural Test Facility
2. Huntsville, Alabama
3. NASA
4. 1971
5. NASA, Marshall Space Flight Center Facilities Office
6. Exterior View



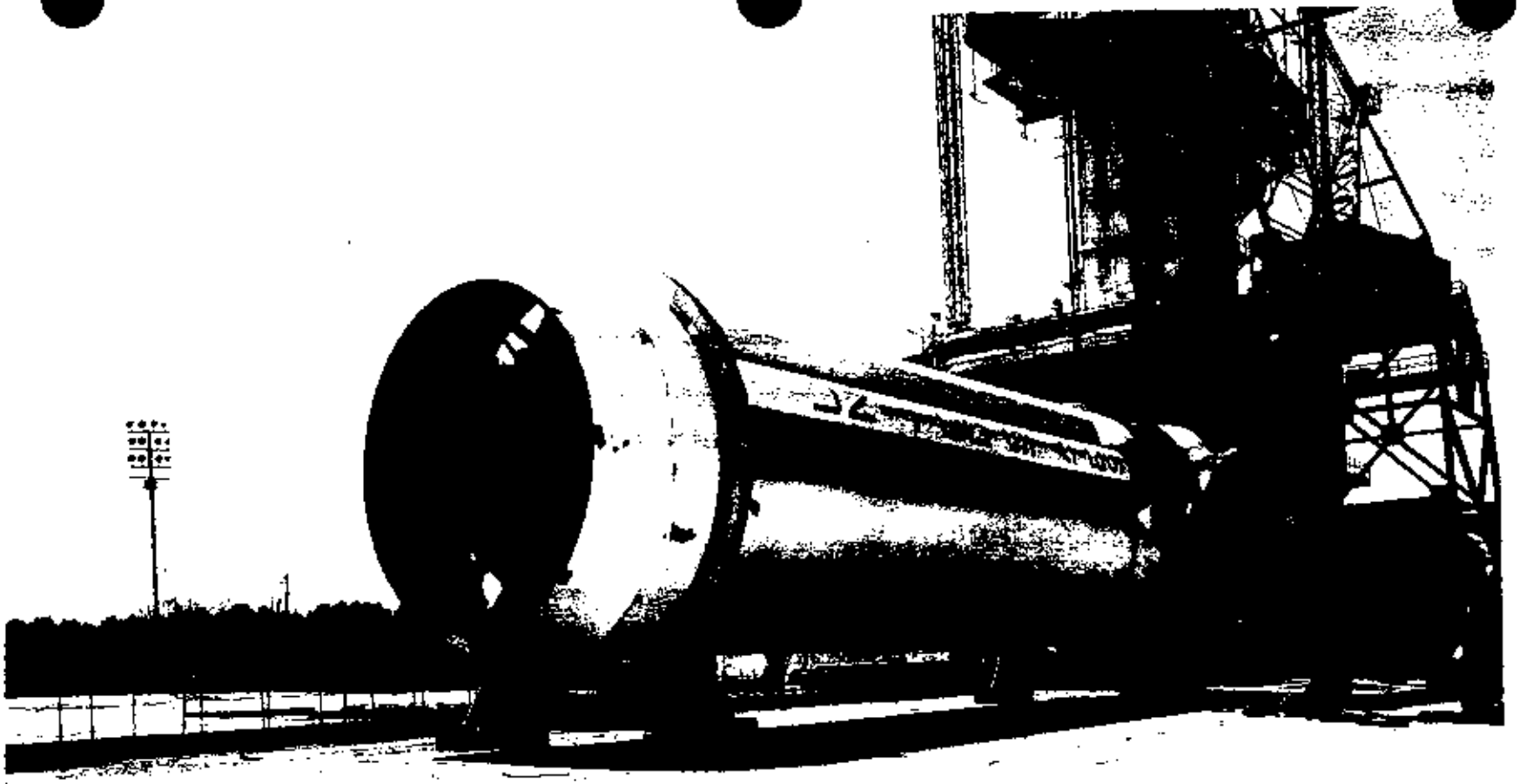
1. Propulsion and Structural Test Facility
2. Hunstville, Alabama
3. NASA
4. 1984
5. NASA, Marshall Space Flight Center Facilities Office
6. Exterior View of West Side of Facility used for Solid Rocket Booster Testing



1. Propulsion and Structural Test Facility
2. Huntsville, Alabama
3. NASA
4. 1984
5. NASA, Marshall Space Flight Center Facilities Office
6. Interior View of Solid Rocket Booster Structural Testing



1. Propulsion and Structural Test Faciltity
2. Huntsville, Alabama
3. NASA
4. 1984
5. NASA, Marshall Space Flight Center Facilities Office
6. Exterior view of East Test position with Saturn Stage in foreground



Man in Space Theme Study
Federal Agency Nomination

NPS Form 10-900
(7-81)

**United States Department of the Interior**
**National Park Service**

# National Register of Historic Places Inventory—Nomination Form

For NPS use only

received

date entered

See instructions in *How to Complete National Register Forms*
Type all entries—complete applicable sections

## 1. Name

historic Rocket Propulsion Test Complex A-1/A-2, B-1/B-2

and/or common A-1/A-2, B-1/B-2 Test Stands

## 2. Location

street & number National Space Technology Laboratories (NSTL) ___ not for publication

city, town Bay St. Louis ___ vicinity of congressional district

state Mississippi code 28 county Hancock code 045

## 3. Classification

| Category | Ownership | Status | Present Use | |
|---|---|---|---|---|
| X district | X public | ___ occupied | ___ agriculture | ___ museum |
| ___ building(s) | ___ private | ___ unoccupied | ___ commercial | ___ park |
| X structure | ___ both | ___ work in progress | ___ educational | ___ private residence |
| ___ site | **Public Acquisition** | **Accessible** | ___ entertainment | ___ religious |
| ___ object | ___ in process | X yes: restricted | X government | ___ scientific |
| | ___ being considered | ___ yes: unrestricted | ___ industrial | X transportation |
| | | ___ no | ___ military | X other: Space Exploration |

## 4. Owner of Property

name National Aeronautics and Space Administration (NASA)

street & number

city, town Washington ___ vicinity of state D.C. 20546

## 5. Location of Legal Description

courthouse, registry of deeds, etc. National Aeronautics and Space Administration (NASA)

street & number Real Property Management Office Code NXG

city, town Washington state D.C. 20546

## 6. Representation in Existing Surveys

title None has this property been determined eligible? ___ yes ___ no

date ___ federal ___ state ___ county ___ local

depository for survey records

city, town state

# 7. Description

| Condition | | Check one | Check one |
|---|---|---|---|
| X excellent | ___ deteriorated | ___ unaltered | X original site |
| ___ good | ___ ruins | X altered | ___ moved date _____ |
| ___ fair | ___ unexposed | | |

**Describe the present and original (if known) physical appearance**

"B" Test Complex

The Rocket Propulsion Test Complex ("B" Test Complex) was constructed in 1965 to support static testing of the S-1C stage of the Saturn V rocket. The test stand is a dual position stand 407 feet tall and is constructed from steel and concrete. The test stand rests on 1600 steel pilings each 98 feet long. During test firings the S-1C stage was secured by four huge hold-down arms anchored to a slab of concrete 39 feet thick. The restraining arms clamped onto the rocket tail by means of a drive mechanism geared to move only 3 inches per minute.

In addition to the test stand, the B Test Complex consists of a Test Control Center, and the required technical facilities (water, electrical, high pressure gas, propellant systems, etc.) as well as the associated ground support equipment necessary to control and fire the captive stage.

The test stand is nominally rated for static testing stages with up to 7,500,000 pounds of thrust. One side of the test stand has been modified to accommodate the testing of the space shuttle main propulsion system elements (the engines, the External Tank, and a simulated Orbiter with flight propulsion systems).

A well-equipped machine shop is in the west test pier. The shop has a limited manufacturing capability used in the support of various engine or stage testing and ground support equipment.

The Test Control Center (TCC) houses the equipment and people required to control, observe, supervise, and monitor the operation of the test complex. The TCC is also a position from which technical observers can view test firings and which provides a blastproof location for test stand personnel who have vacated the stand during test firings. The TCC is capable of supporting additional stage and/or engine test stands.

The High-Pressure Gas System includes a gas battery of air, nitrogen, and helium. The propellant system includes a 300,000-gallon ready storage tank and docking and transfer facilities for the liquid propellant barges.[1]

"A" Test Complex

The "A" Test Complex consists of two single-position test stands, designated A-1 and A-2, a Test Control Center (TCC), observation bunkers, technical systems (such as high-pressure gas systems, water, electrical, etc.), as well as all associated ground service equipment necessary to control and fire engines or stages involved.

Each stand is capable of static firing a stage up to 33 feet in diameter and 82 feet long. Stages of greater or smaller diameter and length can be tested by using an adapter system of modifying the stand. These stands were designed for 1,000,000 pounds of thrust although they have a capability to 1,200,000 pounds. The stand propellant systems include liquid oxygen and liquid hydrogen.

The TCC performs the same functions as the "B" TCC. It is also capable of supporting additional test stands without modifying the physical facilities.

The high-pressure gas battery contains air, helium, and nitrogen. There is a separate gas battery for the hydrogen system.[2]

The "A" Test Complex now supports engine testing for the Space Shuttle program.

# 8. Significance

| Period | Areas of Significance—Check and justify below | | | |
|---|---|---|---|---|
| ___ prehistoric | ___ archeology-prehistoric | ___ community planning | ___ landscape architecture | ___ religion |
| ___ 1400–1499 | ___ archeology-historic | ___ conservation | ___ law | ___ science |
| ___ 1500–1599 | ___ agriculture | ___ economics | ___ literature | ___ sculpture |
| ___ 1600–1699 | ___ architecture | ___ education | ___ military | ___ social/humanitarian |
| ___ 1700–1799 | ___ art | X engineering | ___ music | ___ theater |
| ___ 1800–1899 | ___ commerce | ___ exploration/settlement | ___ philosophy | X transportation |
| X 1900– | ___ communications | ___ industry | ___ politics/government | X other (specify) Space Exploration |
| | | ___ invention | | |

**Specific dates** 1965-Present **Builder Architect** NASA

**Statement of Significance (in one paragraph)**

The National Space Technology Laboratories was established in the early 1960s as the national rocket test range for flight certifying large rocket propulsion systems. The Rocket Propulsion Test Complex ("B" Test Complex and the "A" Test Complex) were both built in 1965 to support this goal. The "B" Test Complex supported all ground testing for the S-1C stage of the Saturn V rocket and the "A" Test Complex performed all ground testing for the S-II stage of the Saturn V rocket.

The Saturn V rocket was one of the most reliable rockets ever built for the space program and was crucial to the effort to land a man on the moon. The success of the Saturn V was dependent upon extensive ground testing of the vehicle. Once the Saturn V lifted off the pad there was no turning back for repairs. Its powered flight was brief but critical. The economics of rocketry and the physical safety of the astronauts demanded that the rocket work perfectly. This was the purpose of the Rocket Propulsion Test Facility.

This facility was the primary site for conducting research, development and certification testing on non-flight engines to improve and upgrade basic engine design, and acceptance testing of flight engines. No Saturn V was shipped to the Kennedy Space Center until its engines were fully tested and certified. Any problem capable of causing a failure in the vehicle was discovered and corrected before the actual launch. The Rocket Propulsion Test Complex was the critical final step in certifying the first stage of the Saturn V rocket for flight.

Footnotes

1. Roger E. Bilstein, Stages to Saturn: A Technological History of the Apollo/Saturn Launch Vehicles (Washington, D.C.: National Aeronautics and Space Administration, 1980), p. 207.

   NSTL Facilities Master Plan (Washington, D.C.: National Aeronautics and Space Administration, 1979), p. 56.

2. NSTL Facilities Master Plan, p. 56.

Bibliography

Bilstein, Roger E. Stages to Saturn: A Technological History of the Apollo/Saturn Launch Vehicles. Washington, D.C.: National Aeronautics and Space Administration, 1980.

Brooks, Courtney G., Grimwood, James M., and Swenson, Loyd S. Chariots for Apollo: A History of Manned Lunar Spacecraft. Washington, D.C.: National Aeronautics and Space Administration, 1979.

Discovering...Space-Oceans-Earth. NSTL, Mississippi: National Space Technology Laboratories. No Date.

Master Plan NSTL Facilities. Washington, D.C.: National Aeronautics and Space Administration, 1980.

Technical Facilities Catalog Vol. III. Washington, D.C.: National Aeronautics and Space Administration, 1974.

## 9. Major Bibliographical References

See continuation sheets

## 10. Geographical Data

Acreage of nominated property: Less than 1 acre

Quadrangle name: Logtown

Quadrangle scale: 1:24,000

UMT References

| | Zone | Easting | Northing |
|---|---|---|---|
| A | 16 | 252070 | 3362810 |
| B | 16 | 251330 | 3361790 |
| C | 16 | 252670 | 3361640 |
| D | | | |
| E | | | |
| F | | | |
| G | | | |
| H | | | |

**Verbal boundary description and justification**

The boundary of the Rocket Propulsion Test Complex is defined by the outside perimeters of Building 4220, 4122, and 4120 at the National Space Technology Laboratory.

**List all states and counties for properties overlapping state or county boundaries**

state _____ code _____ county _____ code _____

state _____ code _____ county _____ code _____

## 11. Form Prepared By

name/title: Barry A. Butowsky

organization: National Park Service — date: May 15, 1984

street & number: Division of History — telephone: (202) 343-8168

city or town: Washington, D.C. 20240 — state: _____

## 12. State Historic Preservation Officer Certification

The evaluated significance of this property within the state is:

___ national ___ state ___ local

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89-665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service.

State Historic Preservation Officer signature _____

title _____ date _____

For NPS use only

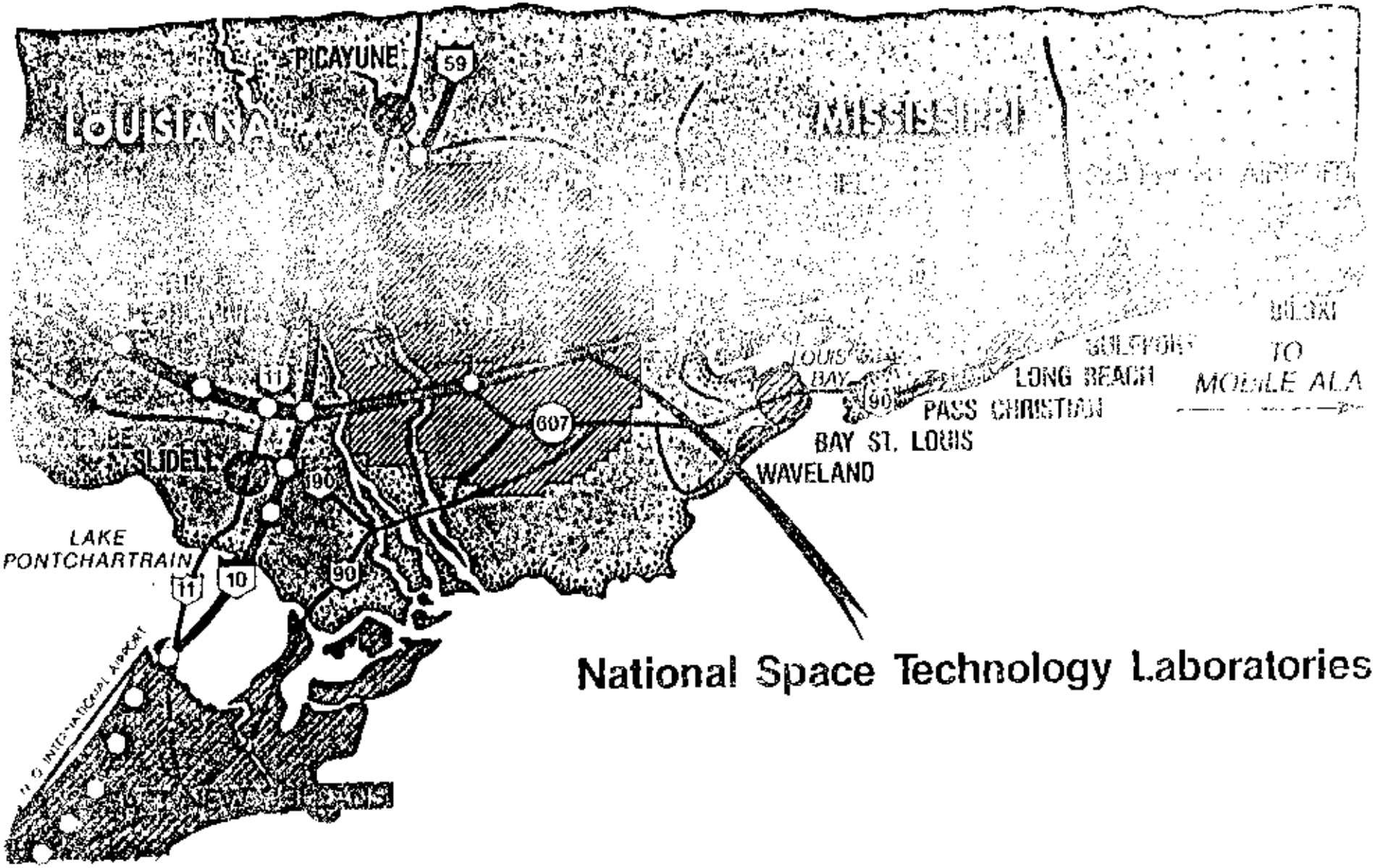
I hereby certify that this property is included in the National Register

_____ date _____

Keeper of the National Register

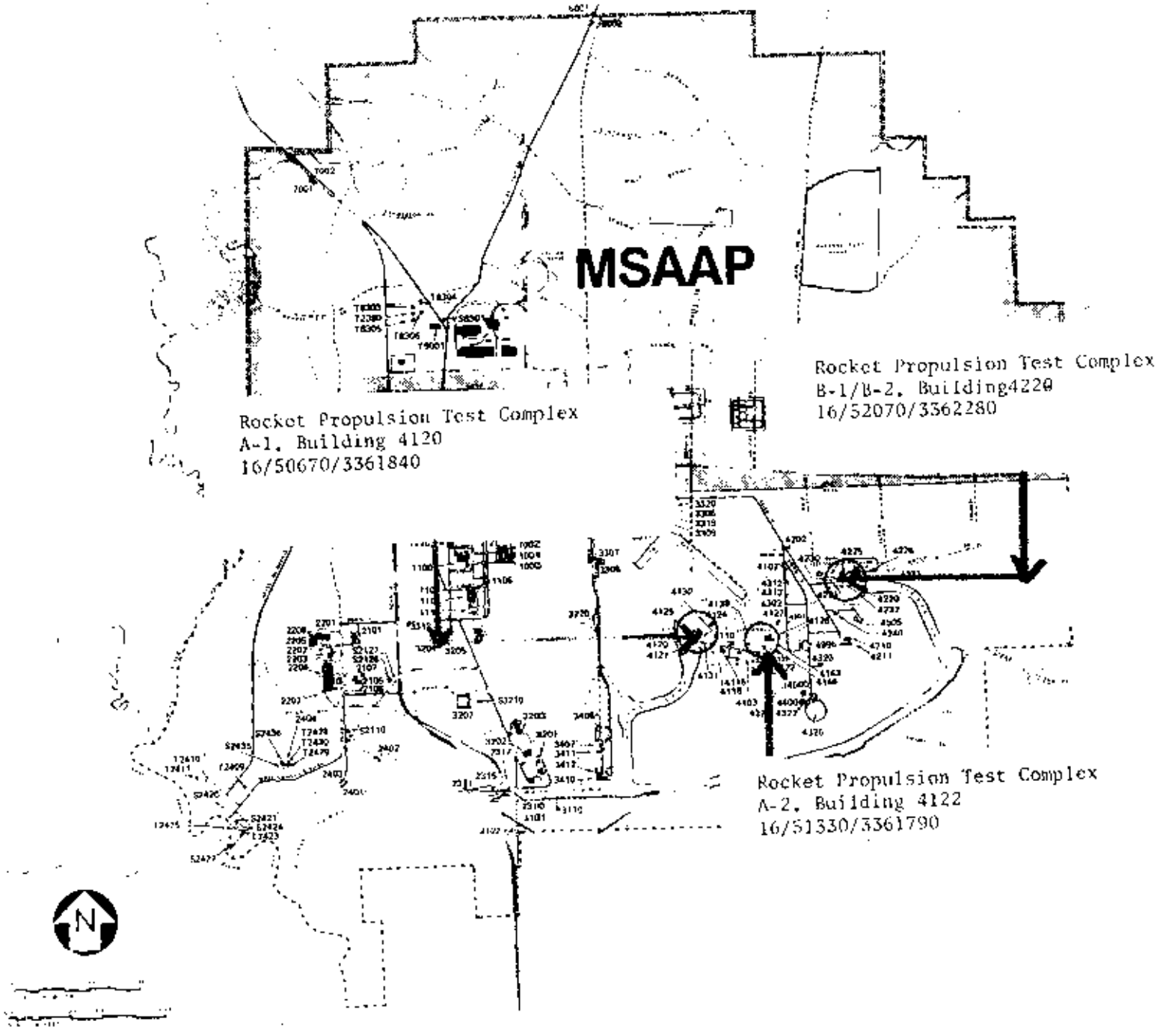
Attest: _____ date _____

Chief of Registration




National Space Technology Laboratories

# National Space Technology Laboratories



UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Rocket Propulsion Test Complex
B-1/B-2
UTM References:
16/252070/3362280

Rocket Propulsion Test Complex
A-1
UTM References:
16/250670/3361840

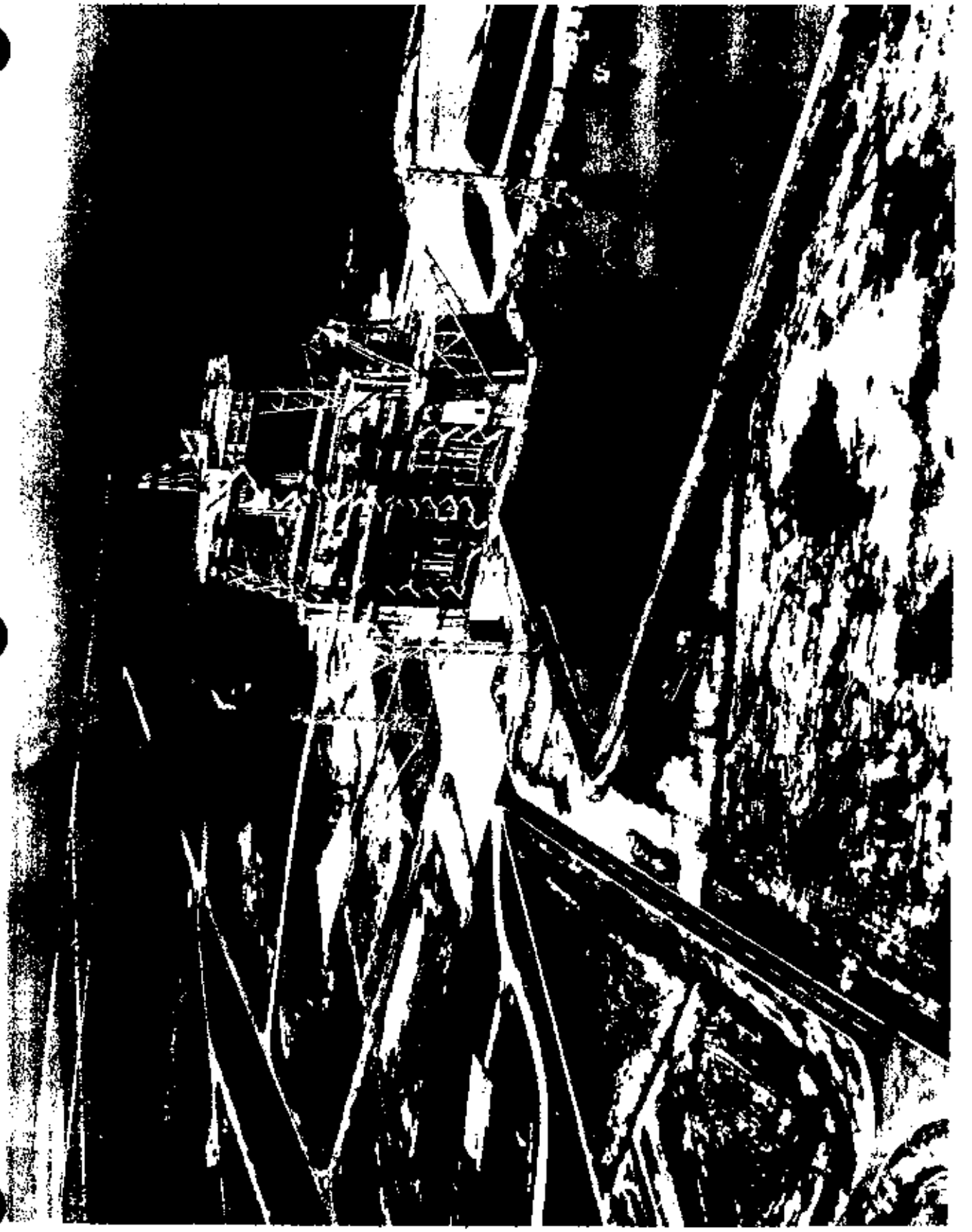
FACILITY

NASA

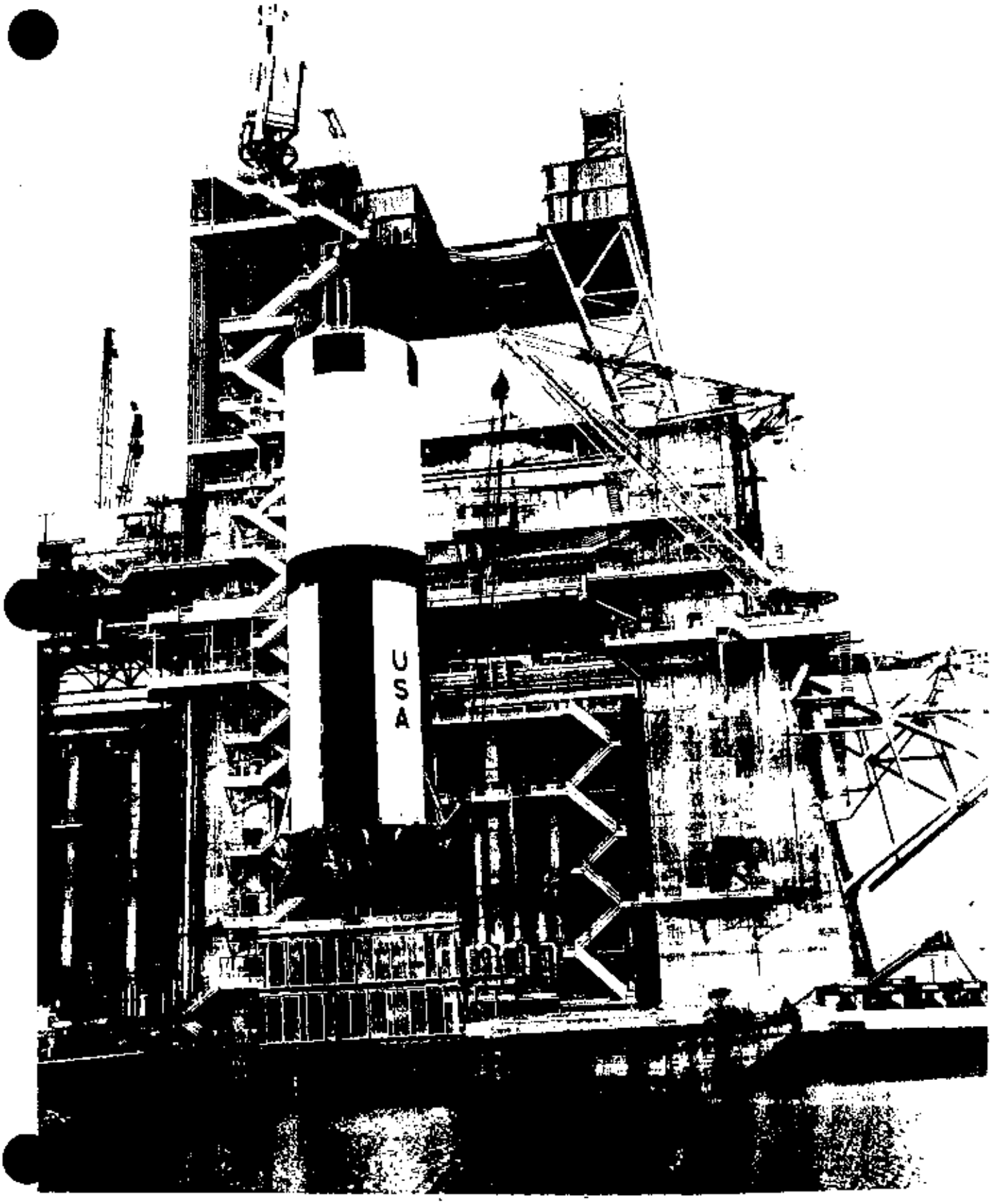
Rocket Propulsion Test Complex
A-2
UTM References:
16/251330/3361790

Flowing Well

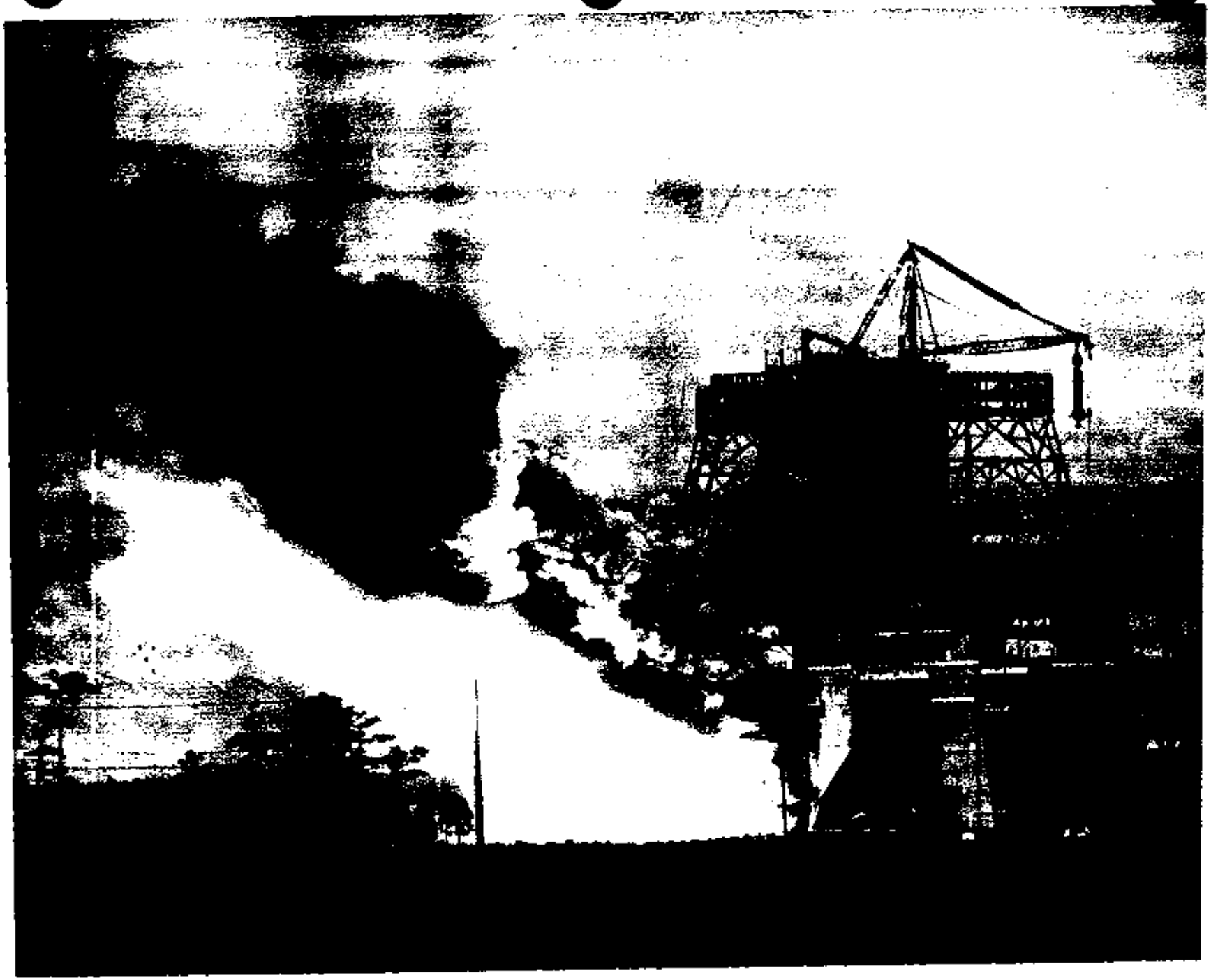
1. Rocket Propulsion Test Complex B-1/B-2
2. Bay St. Louis, Mississippi
3. NASA
4. 1973
5. Marshall Space Flight Center Facilities Office
6. Aerial View of B-1/B-2 Test Stand



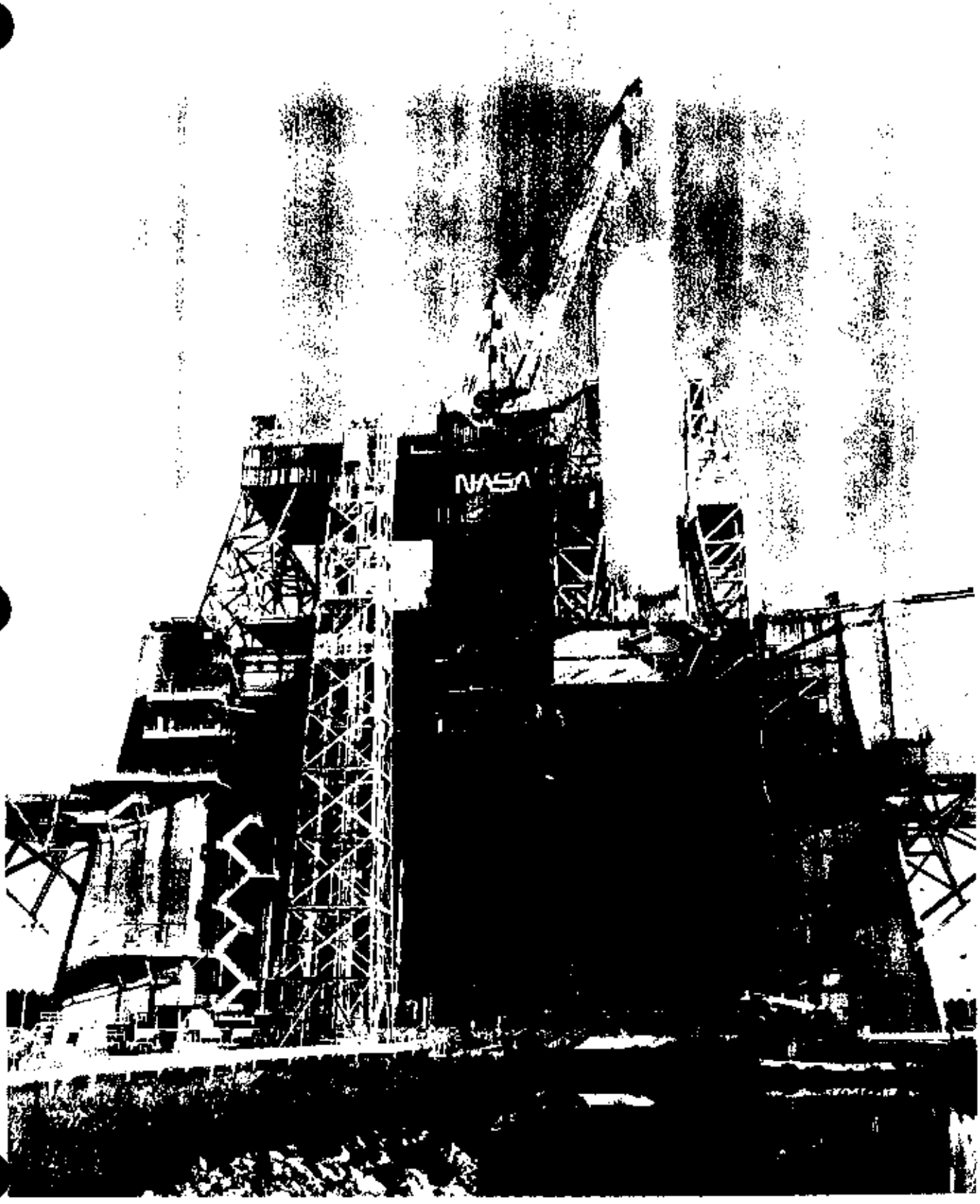
1. Rocket Propulsion Test Complex B-1/B-2
2. Bay St. Louis, Mississippi
3. NASA
4. 1966
5. NSTL Facilities Office
6. First Stage of Saturn V being hoisted into test stand


USA

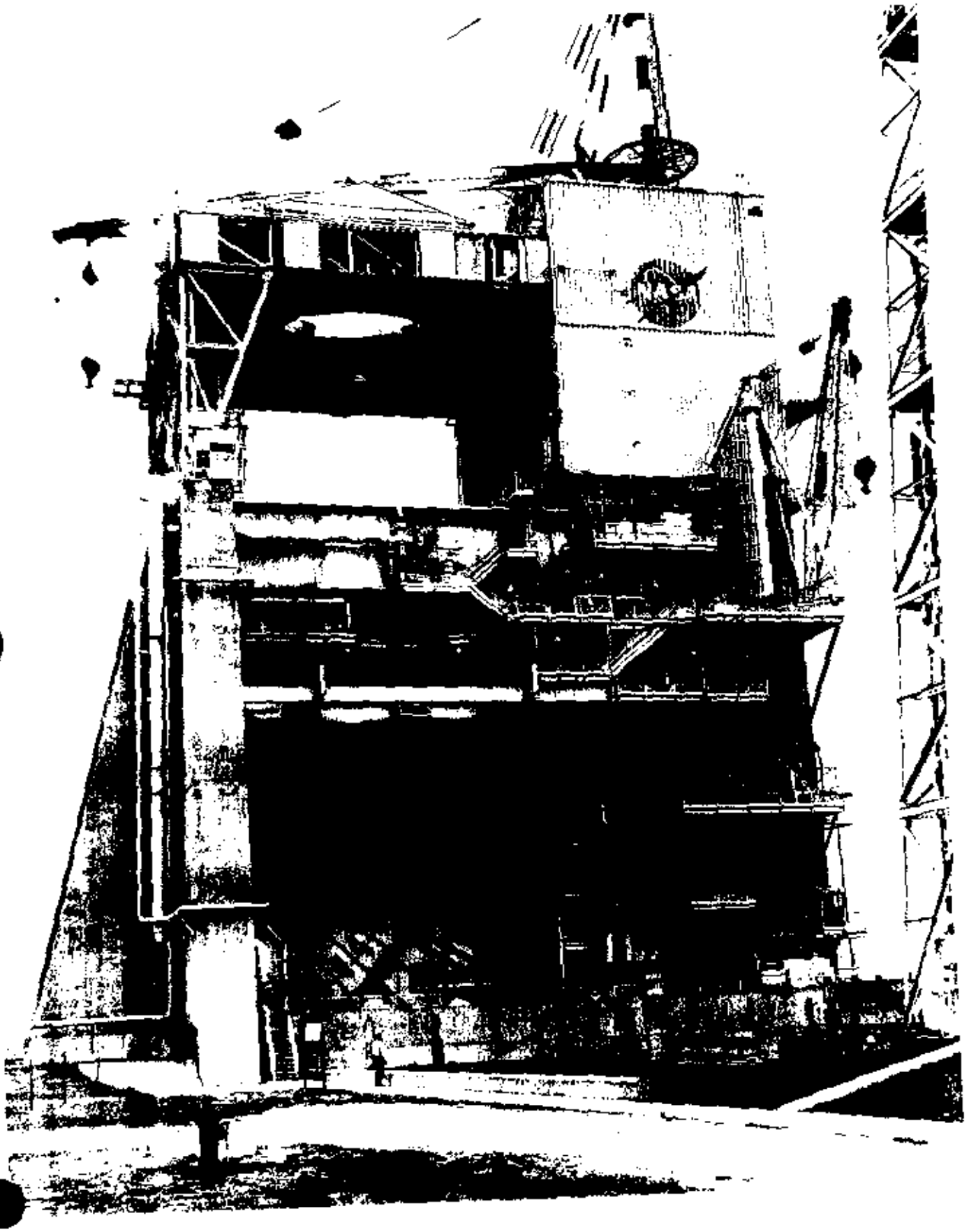
1. Rocket Propulsion Test Complex B-1/B-2
2. Bay St. Louis, Mississippi
3. NASA
4. 1967
5. NSTL Facilities Office
6. Test of Saturn V 1st stage booster



1. Rocket Propulsion Test Complex B-1/B-2
2. Bay St. Louis, Mississippi
3. NASA
4. 1977
5. NSTL Facilities Office
6. External Tank of Space Shuttle being hoisted into test stand

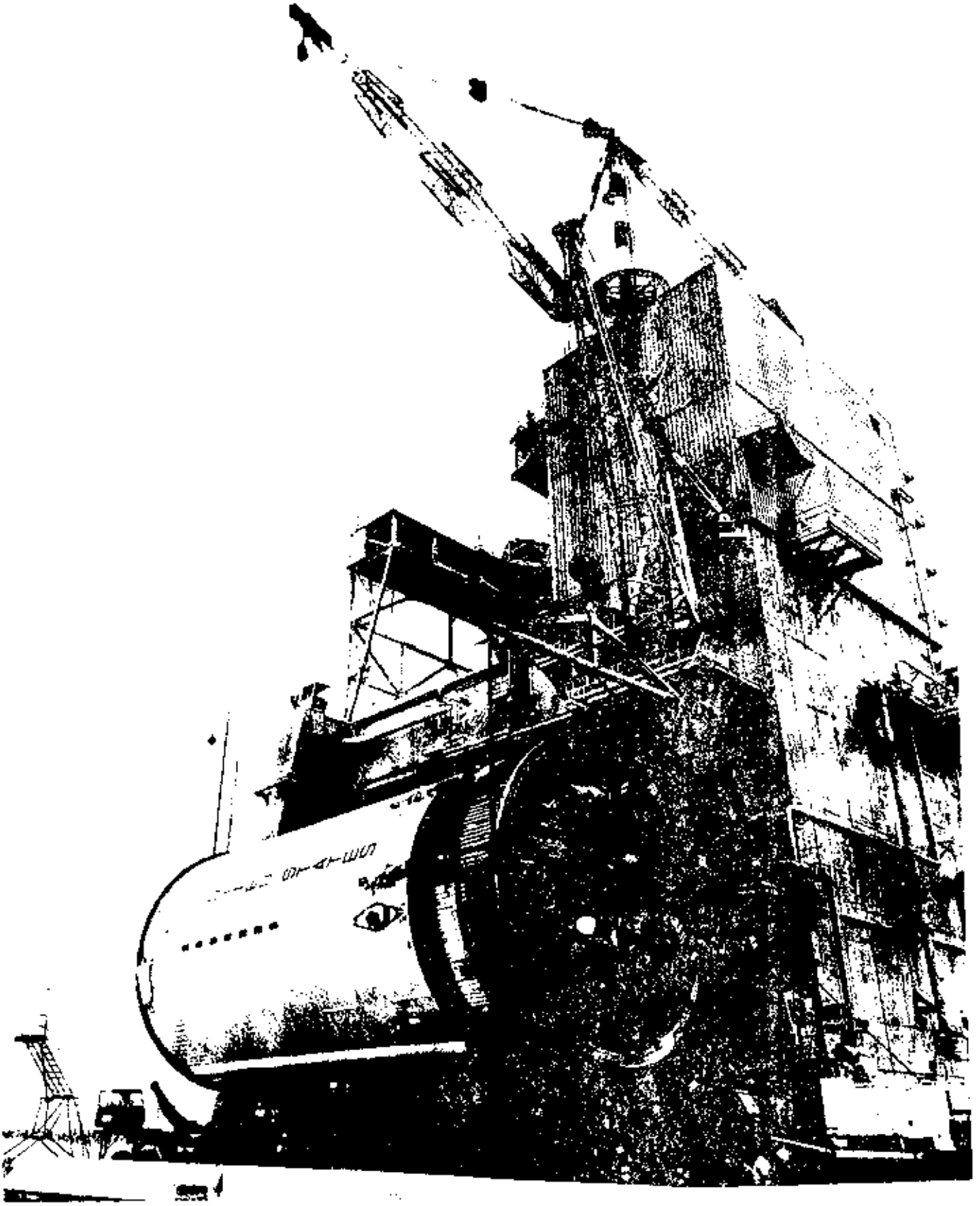

NASA

1. Rocket Propulsion Test Complex A-1
2. Bay St. Louis, Mississippi
3. NASA
4. 1971
5. NSTL Facilities Office
6. Exterior View of A-1 Test Stand



1. Rocket Propulsion Test Complex A-1
2. Bay St. Louis, Mississippi
3. NASA
4. 1967
5. NASA, Marshall Space Flight Center Facilities Office
6. A-1 Test Stand with Saturn V S-11 stage in place ready for firing.

1. Rocket Propulsion Test Complec A-2
2. Bay St. Louis, Mississippi
3. NASA
4. 1966
5. NSTL Facilities Office
6. Installation of S-11 stage of Saturn V Rocket in A-2 Test Stand



1. Rocket Propulsion Test Complec
2. Bay St. Louis, Mississippi
3. NASA
4. 1973
5. NASA, Marshall Space Flight Center Facilities Office
6. Aerial View of A-2 Test Stand

ROCKET TEST FACILITIES

11. Saturn V Dynamic Test Stand (Marshall)

NPS Form 10-900
(7-81)

**United States Department of the Interior**
**National Park Service**

# National Register of Historic Places Inventory—Nomination Form

For NPS use only
received
date entered

See instructions in *How to Complete National Register Forms*
Type all entries—complete applicable sections

## 1. Name

historic Saturn V Dynamic Test Stand

and/or common Dynamic Structural Test Facility

## 2. Location

street & number George C. Marshall Space Flight Center ___ not for publication

city, town Huntsville ___ vicinity of congressional district

state Alabama code 01 county Madison code 089

## 3. Classification

| Category | Ownership | Status | Present Use | |
|---|---|---|---|---|
| ___ district | X public | ___ occupied | ___ agriculture | ___ museum |
| ___ building(s) | ___ private | ___ unoccupied | ___ commercial | ___ park |
| X structure | ___ both | ___ work in progress | ___ educational | ___ private residence |
| ___ site | **Public Acquisition** | **Accessible** | ___ entertainment | ___ religious |
| ___ object | ___ in process | X yes: restricted | ___ government | ___ scientific |
| | ___ being considered | ___ yes: unrestricted | ___ industrial | ___ transportation |
| | | ___ no | ___ military | X other: Inactive |

## 4. Owner of Property

name National Aeronautics and Space Administration (NASA)

street & number

city, town Washington ___ vicinity of state D.C. 20546

## 5. Location of Legal Description

courthouse, registry of deeds, etc. National Aeronautics and Space Administration (NASA)

street & number Real Property Management Office Code NXG

city, town Washington state D.C. 20546

## 6. Representation in Existing Surveys

title Historic Properties Report (Draft) has this property been determined eligible? ___ yes ___ no

date July 1983 X federal ___ state ___ county ___ local

depository for survey records U.S. Army Redstone Arsenal

city, town Huntsville state Alabama

# 7. Description

| Condition | | Check one | Check one |
|---|---|---|---|
| X excellent | ___ deteriorated | ___ unaltered | X original site |
| ___ good | ___ ruins | X altered | ___ moved date _____ |
| ___ fair | ___ unexposed | | |

**Describe the present and original (if known) physical appearance**

The Dynamic Structural Test Facility was built in 1964 to conduct mechanical and vibrational tests on the fully assembled Saturn V rocket. The facility is 360 feet high and 122 feet by 98 feet at the base. It has a maximum center bay size of 74 feet by 74 feet, has a main derrick at the top of the structure capable of handling 200 tons at a 70 foot radius. The facility is connected by a cable tunnel to the East Test Area which provides instrumentation for testing. An elevator provides access to 15 of the 16 levels.

When in use the test vehicle rests on hydrodynamic supports which provide a maximum of 6 degrees of freedom of movement which is required when large space vehicles are dynamically tested. Vibration loads can be induced in the pitch, yaw, or longitudinal axis to obtain resonance frequencies and bending modes. Vertical mating procedures between stages can also be investigated and checked out.

After completion of testing for the Saturn V program the Dynamic Structural Test Facility was modified for testing the Space Shuttle. At the present time this facility is on a standby basis, but because of its unique capabilities to dynamically test large space vehicles, it will be retained for use in future NASA programs.

# 8. Significance

| Period | Areas of Significance—Check and justify below | | | |
|---|---|---|---|---|
| ___ prehistoric | ___ archeology-prehistoric | ___ community planning | ___ landscape architecture | ___ religion |
| ___ 1400–1499 | ___ archeology-historic | ___ conservation | ___ law | ___ science |
| ___ 1500–1599 | ___ agriculture | ___ economics | ___ literature | ___ sculpture |
| ___ 1600–1699 | ___ architecture | ___ education | ___ military | ___ social/ humanitarian |
| ___ 1700–1799 | ___ art | X engineering | ___ music | ___ theater |
| ___ 1800–1899 | ___ commerce | ___ exploration/settlement | ___ philosophy | X transportation |
| X 1900– | ___ communications | ___ industry | ___ politics/government | X other (specify) Space Exploration |
| | | ___ invention | | |

**Specific dates** 1964-Present **Builder/Architect** NASA

**Statement of Significance (in one paragraph)**

The Dynamic Structural Test Facility is significant because of its connection with the testing and development of the Saturn V rocket.

The Saturn V rocket was one of the most reliable rockets ever built. Upon its success depended the fate of the Apollo program and the Skylab program. The success of the Saturn V was because of two factors: (1) the stringent reliability and quality assurance programs developed to oversee the manufacture of the Saturn V, and (2) exhaustive ground testing.

The ground testing program was crucial to the success of the Saturn V. Once launched a Saturn V could never be recovered for testing. Any flaw in the vehicle could result in the loss of the vehicle and the loss of the lives of the astronauts riding the Apollo Command Module.

The Saturn V had to work and perform its job successfully every time. There was no margin for error. Due to this fact as much as 50 percent of the total effort and money in the Saturn V program was devoted to ground testing the vehicle. Every component of the vehicle was tested again and again separately and in partial and full assembly.

The Dynamic Structural Test Facility at Marshall represented the last step in this testing process before a Saturn V was accepted for full flight status. Once all of the components were accepted and tested the Saturn V was assembled and brought to the Dynamic Structural Test Facility to test the entire vehicle under dynamic load conditions. Mechanical and vibrational tests on the flight vehicle and on separate flight configurations were conducted until the data indicated that the Saturn V was clean and ready for flight status. Testing conducted in this facility permitted NASA and industry engineers their last chance to detect and correct any problems or flaws in the fully assembled flight vehicle. The success of the Saturn V program and the fact that no Saturn V ever failed in flight is indicative of the contribution of this facility. Major problems capable of causing a failure of the vehicle were discovered and corrected before the Saturn V ever reached Launch Complex 39 at the Kennedy Space Center. When the Apollo 11 moon flight lifted off the pad in July 1969 the astonauts and NASA were confident that the Saturn V would complete its job and launch the Command and Lunar Landing Module into a safe moon-bound trajectory.

Bibliography

Bilstein, Roger E. Stages to Saturn: A Technological History of the Apollo/Saturn Launch Vehicles. Washington, D.C.: National Aeronautics and Space Administration, 1980.

Brooks, Courtney G., Grimwood, James M. and Swenson, Loyd S. Chariots for Apollo: A History of Manned Lunar Spacecraft. Washington, D.C.: National Aeronautics and Space Administration, 1979.

Draft Historic Properties Report: Redstone Arsenal, Alabama with the George C. Marshall Space Flight Center. Silver Spring, Maryland: Building Technology Incorporated, 1983.

Master Plan George C. Marshall Space Flight Center. Washington, D.C.: National Aeronautics and Space Administration, 1980.

Technical Facilities Catalog Vol. III. Washington, D.C.: National Aeronautics and Space Administration, 1974.

## 9. Major Bibliographical References

See continuation sheets

## 10. Geographical Data

Acreage of nominated property Less than 1 acre

Quadrangle name Madison

Quadrangle scale 1:24,000

UMT References

| | Zone | Easting | Northing |
|---|---|---|---|
| A | 16 | 530600 | 3831960 |
| B | | | |
| C | | | |
| D | | | |
| E | | | |
| F | | | |
| G | | | |
| H | | | |

**Verbal boundary description and justification**

The boundary of the Saturn V Dynamic Test Stand is defined by the outside perimeter of Building 4550 at the Marshall Space Flight Center.

**List all states and counties for properties overlapping state or county boundaries**

| state | code | county | code |
|---|---|---|---|
| state | code | county | code |

## 11. Form Prepared By

name/title Barry A. Balowsky

organization National Park Service date May 15, 1984

street & number Division of History telephone (202) 343-8168

city or town Washington, D.C. 20240 state

## 12. State Historic Preservation Officer Certification

The evaluated significance of this property within the state is:

___ national ___ state ___ local

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89-665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service.

State Historic Preservation Officer signature

title date

For NPS use only

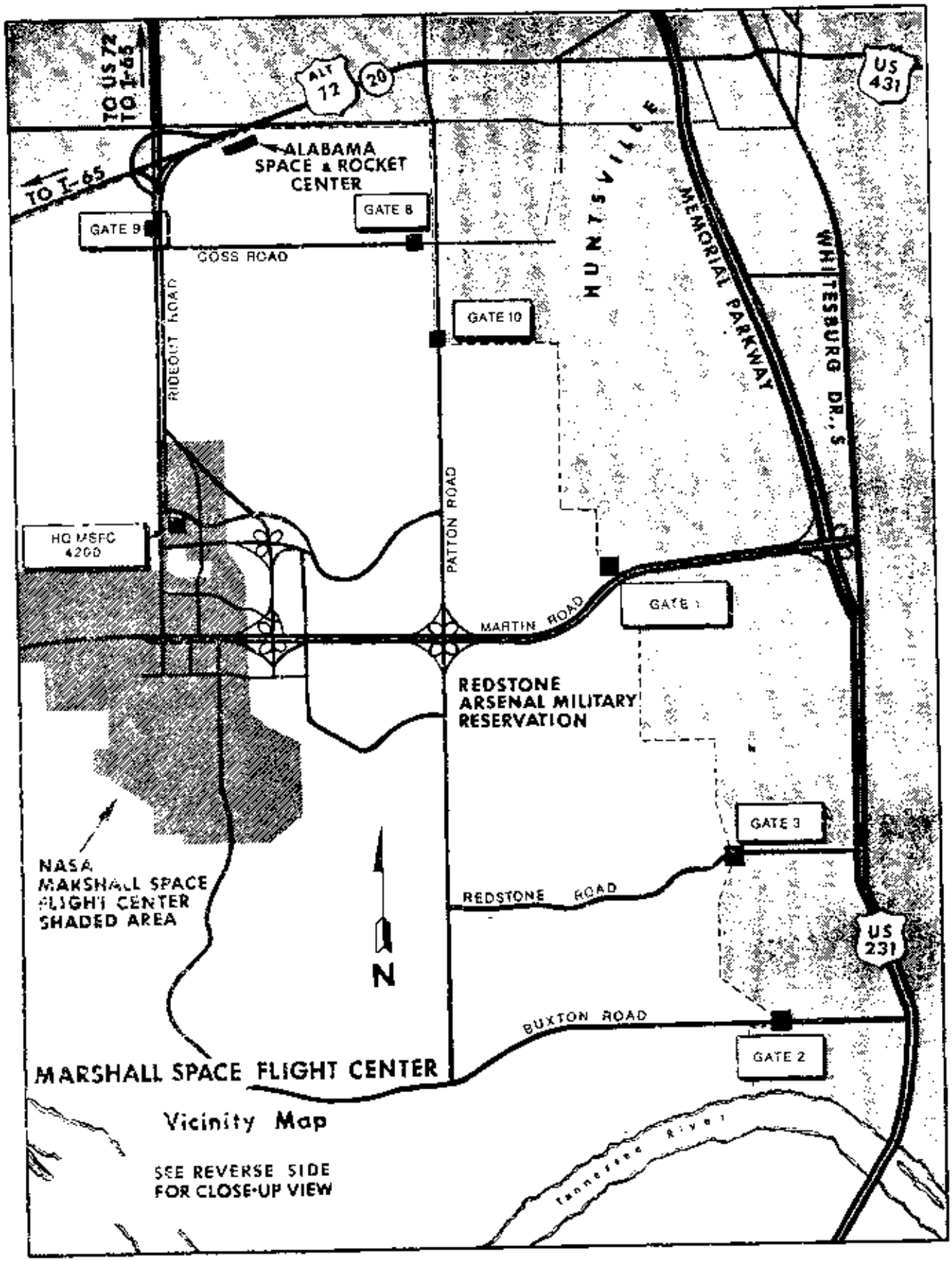
I hereby certify that this property is included in the National Register

date

Keeper of the National Register

Attest: date

Chief of Registration


TO US 72
TO I-65
ALT 72
20
US 431
TO I-65
ALABAMA SPACE & ROCKET CENTER
GATE 8
GATE 9
COSS ROAD
RIDEOUT ROAD
GATE 10
HUNTSVILLE
MEMORIAL PARKWAY
WHITESBURG DR., S
PATTON ROAD
HQ MSFC 4200
MARTIN ROAD
GATE 1
REDSTONE ARSENAL MILITARY RESERVATION
GATE 3
NASA MARSHALL SPACE FLIGHT CENTER SHADED AREA
REDSTONE ROAD
N
US 231
BUXTON ROAD
GATE 2
MARSHALL SPACE FLIGHT CENTER
Vicinity Map
SEE REVERSE SIDE FOR CLOSE-UP VIEW
Tennessee River

# MARSHALL SPACE FLIGHT CENTER, ALABAMA

## FACILITIES SITE MAP

4700 AREA

4702 Shop Building
4703 Storage Building
4704 Hydraulic Press Fac.
4705 Machine Shop & Neutral Buoyancy Simulator
4707 Shop & Assembly Building
4708 Engr & Development Lab
4711 Developmental Processes Lab
4712 Office Building
4714 Mech. Group Building
4715 Storage Building
4716 Test Control Building
4721 Training Fac.
4722 Shop & Office Building
4723 Shop & Storage Building
4731 Storage Building
4732 Bioprocessing Fac.
4733 Impulse Base Flow Fac
4734 Vacuum Pump House
4738 Fabrication Dev. Building
4740 Water Pollution Contr. Fac.
4744 Compressed Air Fac.
4746 Office Bldg.
4747 Air Compressor Bldg
4752 Multipurpose High Bay Fac.
4755 High Bay Assembly Fac.
4759 Model Shop Building
4760 Surface Treatment Facility
4764 Chemical Storage Shed
4767 Heat Treatment Fac.
4774 Storage Building
4775 High Reynolds Fac.
4776 Experimental Acoustic Test Fac.

4200 AREA

4200 Office Building
4201 Office Building
4202 Office Building
4207 Communications Facility
4241 Shop & Storage Bldg.
4244 Storage Building
4249 Office Building
4256 Office & Shop Bldg.
4251 Equipment Shed

4300 AREA

4306 Office Building
4312 MSFC Security HQ
4313 Shop Building
4347 Solar Magnetograph Fac.
4348 Storage Building
4353 Photo Lab.
4373 Laboratory Building (Assigned to Army)

4400 AREA

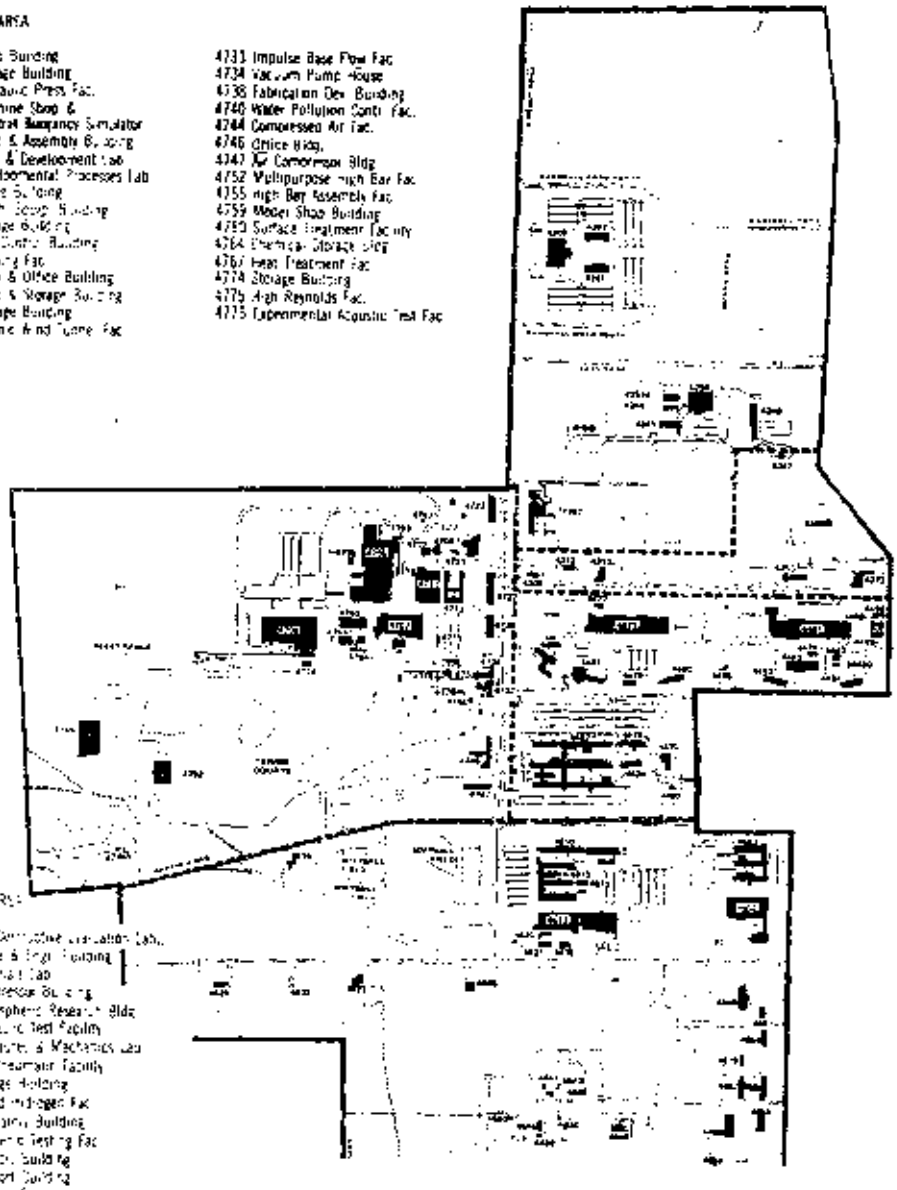
4436 Storage
4467 Celestial & Optical Sensors Fac.
4471 Storage & Office Bldg.
4472 Shop Building
4475 Hazardous Operations Lab.
4476 Environmental Test Fac.
4478 Equipment Shed
4479 Storage Shed
4480 Paint Shop
4481 Space Sciences Lab.
4482 Transportation Support Bldg
4483 Vehicle Maint. Shop
4485 Office Building
4487 Laboratory & Dec. Bldg.
4490 Storage Shed
4491 Documentation Repository
4492 Elec. Sys. Lab Bldg. (On loan to Army)
4493 Shop & Storage Bldg.
4494 Center Activities Bldg.
4495 Shop Bldg.
4498 Storage Building
4499 Storage Building

4500 AREA

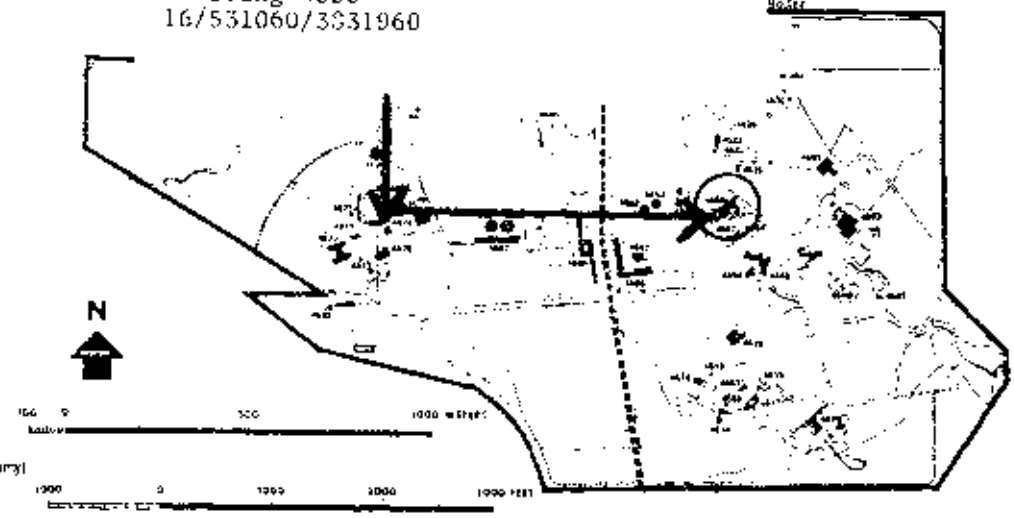
4514 Propulsion Sys. Test Std.
4516 LOX Storage Fac.
4517 $LH_2$ Storage Facility
4518 Hydrogen Transfer Control House
4519 LOX Transfer Control House
4522 Propulsion Sys. Component Test Std.
4523 Test Stand Terminal Bldg.
4525 LOX Transfer Control House
4526 $LH_2$ Transfer Control House
4527 $LH_2$ Storage Tank
4532 Propulsion Sys. Component Test Std.
4540 Model Propulsion Sys. Test (Acoustic)
4541 Test Stand Control Bldg.
4545 Demineralized Water Plant
4550 Structural Test Fac.
4551 Struct. Test Fac. Terminal Bldg.
4552 Water Reservoir
4553 Test Fac. Terminal Bldg.
4554 Test Fac. Support Bldg.
4557 Structural Test Fac.
4558 Structural Test Fac. Terminal Bldg.
4561 Shop & Lab Bldg.
4562 Water Reservoir
4566 Office Building (On loan to Army)
Pump and Boiler House
Blockhouse and Cable Tunnels
Propulsion & Struct. Test Fac.
Test & Data Recording Fac.
Cold Calibration Test Stand
Boiler

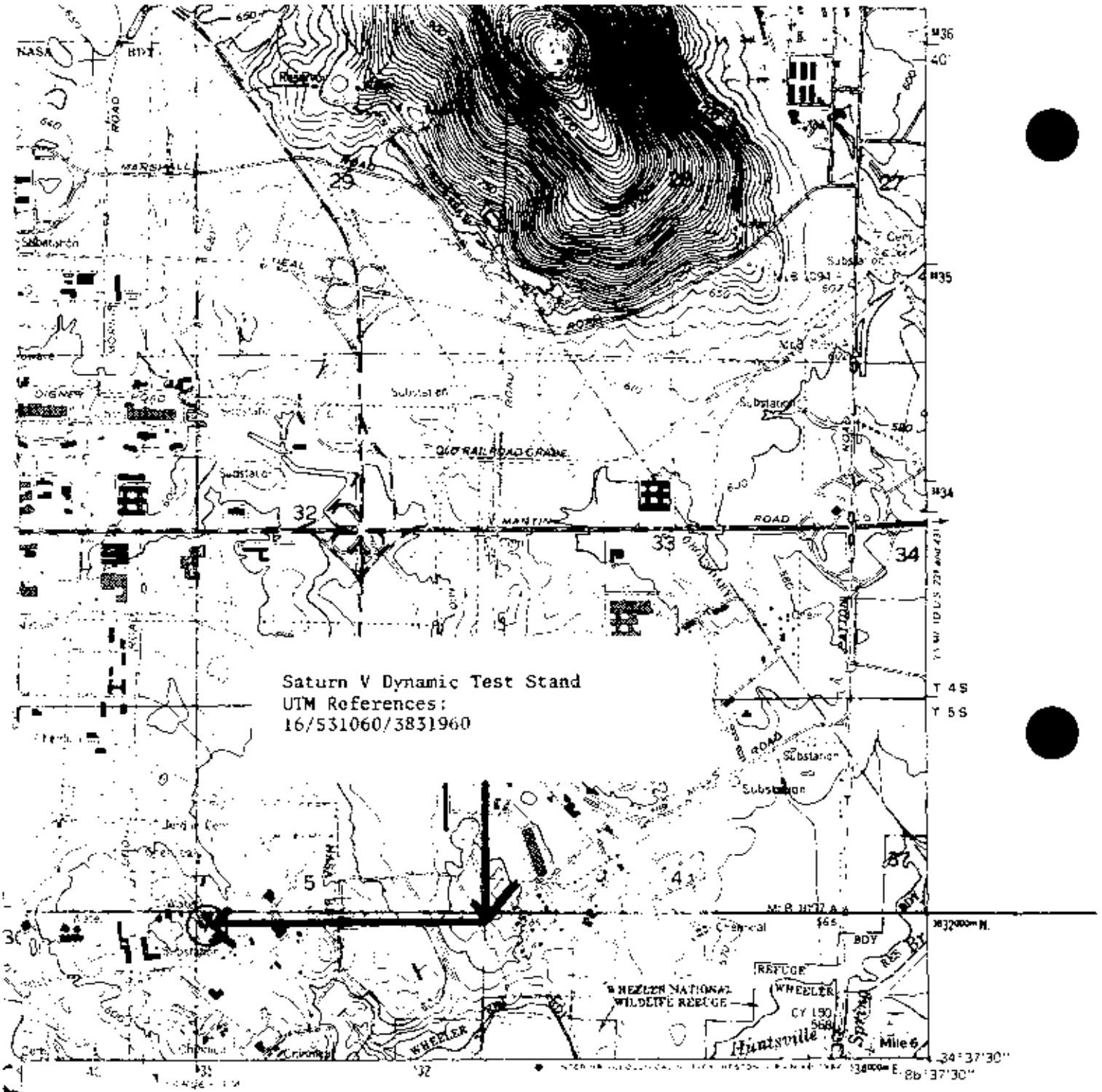
4600 AREA

4609 Sun Simulation Lab.
4610 Office & Engr. Building
4612 Materials Lab
4613 Compressor Building
4614 Atmospheric Research Bldg
4618 Hydraulic Test Facility
4619 Structures & Mechanics Lab
4620 LH Pressurization Facility
4621 Storage Building
4622 Liquid Hydrogen Fac
4623 Laboratory Building
4625 Cryogenic Testing Fac
4630 Support Building
4633 Support Building
4640 Support Building
4641 Support Building
4642 Support Building
4645 Manufacturing Support Bldg
4646 Warehouse
4647 Support Building
4648 Support Building
4649 Support Building
4650 Shop Fac.
4651 Compressed Gas Storage Bldg
4652 Office Building
4653 Multipurpose High Bay Fac.
4654 Hydraulic Support Dev. Fac.
4657 LH2 Fabrication Fac
4659 HP GH2 Storage
4660 Power Plant
4663 Compressor Fac
4665 Electric Propulsion Test Site
4666 Office Building
4667 Pump House
4668 Water Reservoir
4669 Water Reservoir
4670 Propulsion & Struct. Test Fac.
4671 Test Fac. Support Bldg
4672 Cryogenic Storage Fac
4673 Fuel Tank
4674 Blockhouse
4679 Office & Storage Bldg
4692 Data Connect Bldg (Assigned to Army)
4696 Propulsion Test Fac
4697 Observation Bunker
4698 Propulsion Test Fac



Saturn V Dynamic Test Stand
Building 4550
16/531060/3331960






ROAD CLASSIFICATION

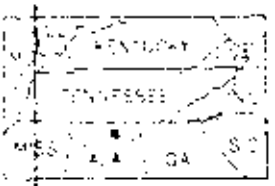
Primary highway, all weather, hard surface

Light duty road, all weather, improved surface

Secondary highway, all weather, hard surface

Unimproved road, fair or dry weather

Interstate Route — U. S. Route — State Route




QUADRANGLE LOCATION

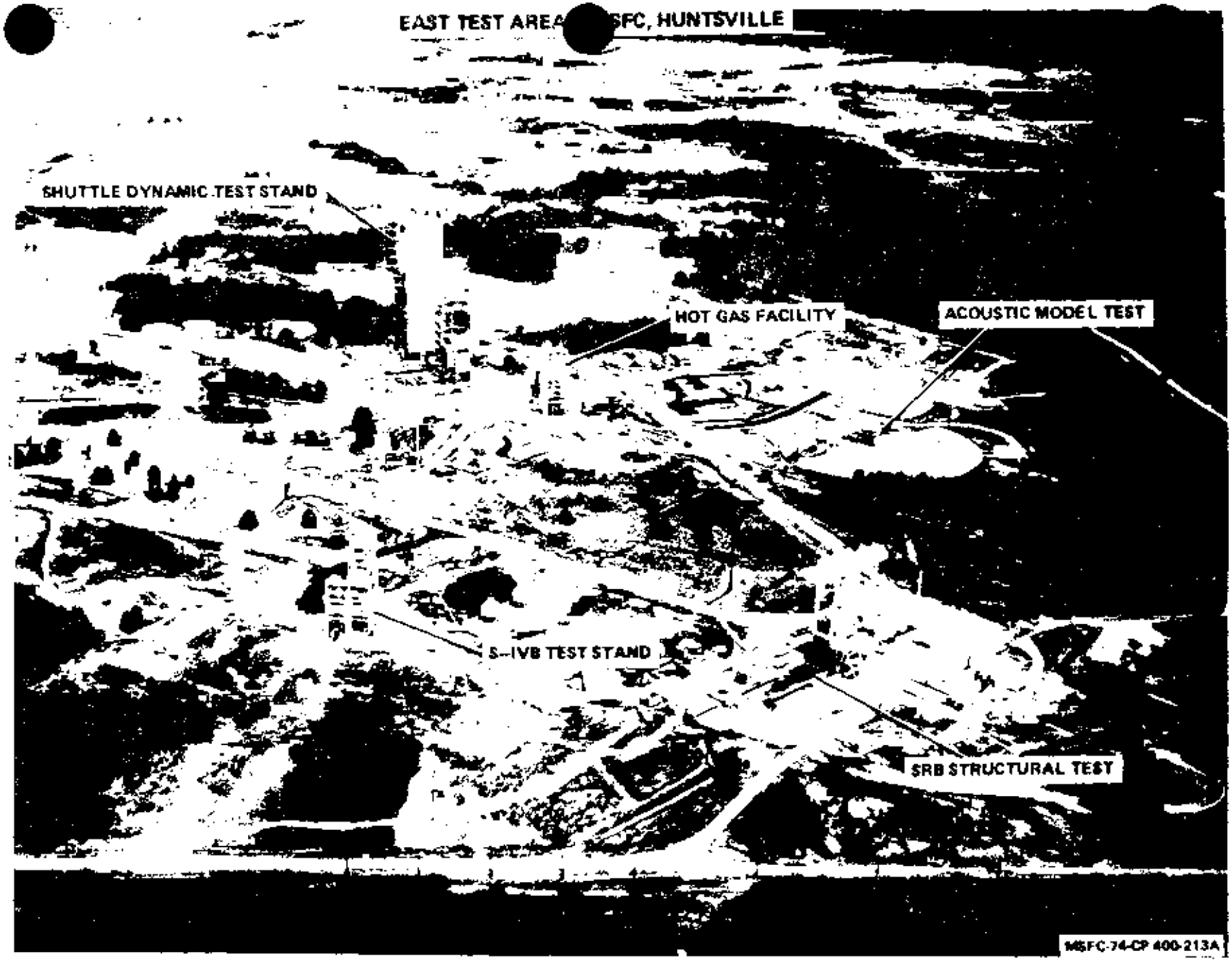
There may be private inholdings within the boundaries of the National or State reservations shown on this map

MADISON, ALA.

N3437.5—W8637.5/7.5

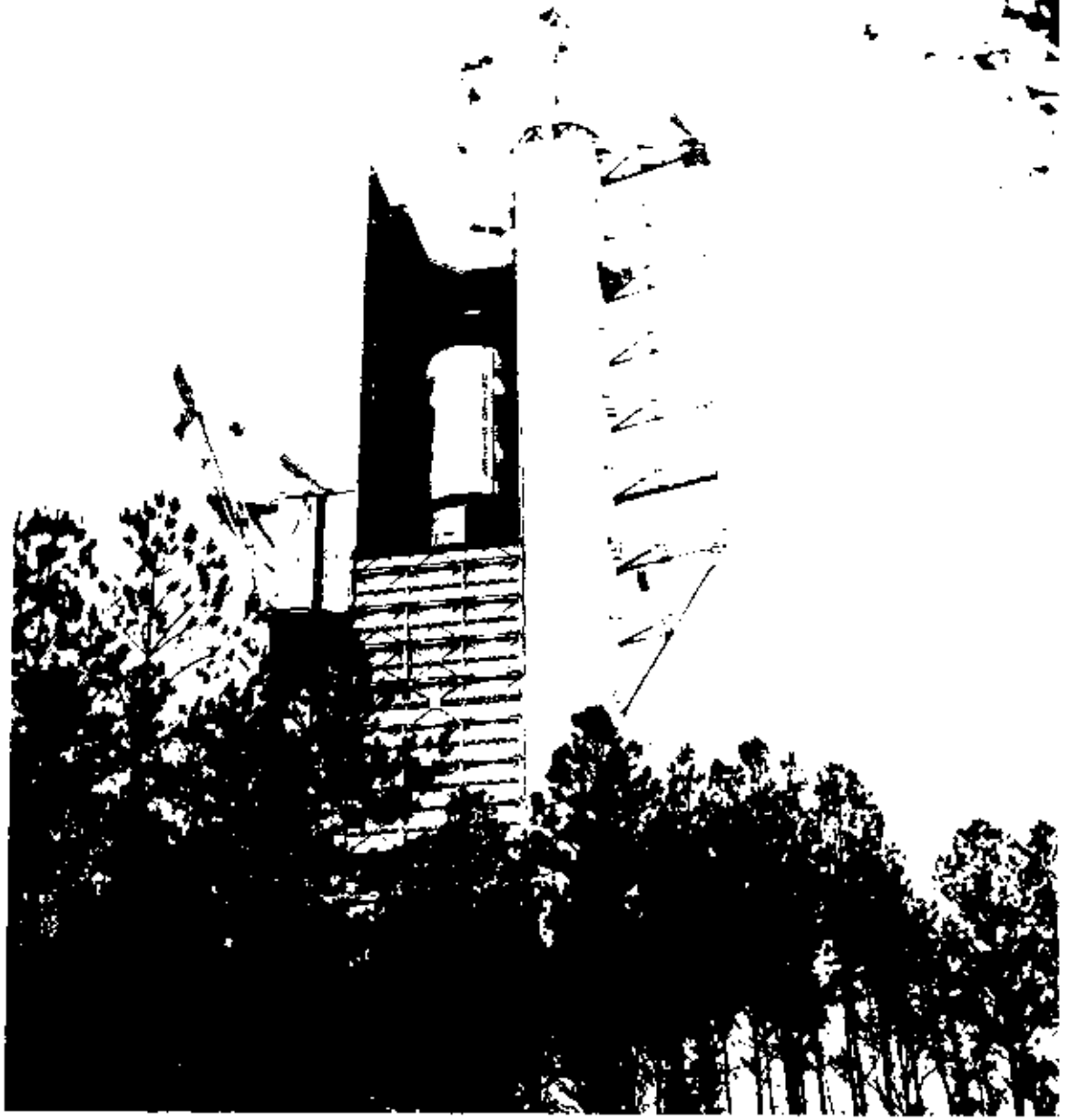
1975
PHOTOREVISED 1982
DMA 3653 II NW-SERIES V844

1. Saturn V Dynamic Test Stand
2. Huntsville, Alabama
3. NASA
4. 1974
5. NASA, Marshall Space Flight Center Facilities Office
6. Aerial View of the East Test Area of the MSFC. Saturn V Dynamic Test Stand (Shuttle Dynamic Test Stand) is in the upper left hand corner.

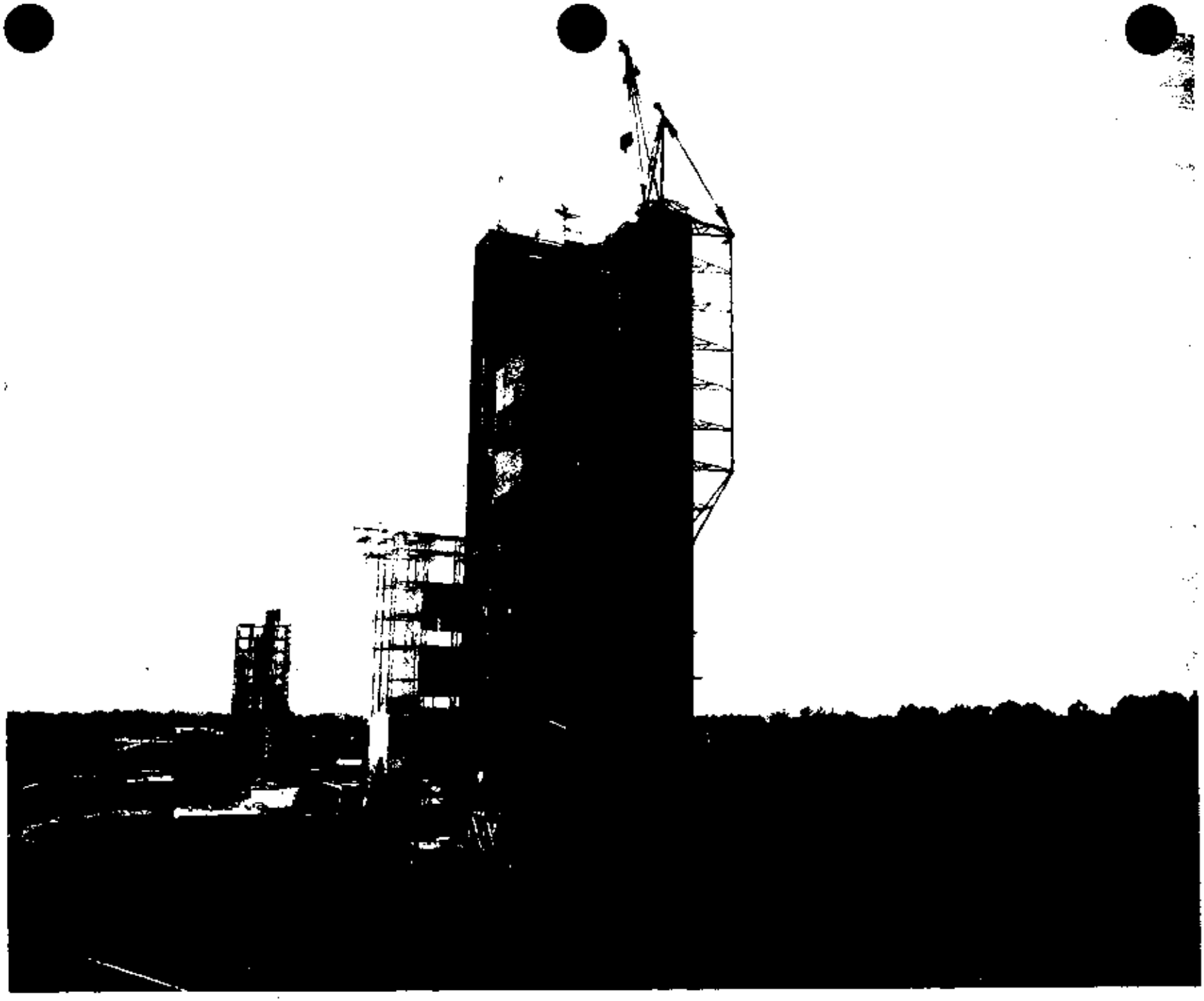

EAST TEST AREA
SFC, HUNTSVILLE
SHUTTLE DYNAMIC TEST STAND
HOT GAS FACILITY
ACOUSTIC MODEL TEST
S-IVB TEST STAND
SRB STRUCTURAL TEST
MSFC-74-CP 400-213A

1. Saturn V Dynamic Test Stand
2. Huntsville, Alabama
3. NASA
4. 1966
5. NASA, Marshall Space Flight Center Facilities Office
6. Exterior view of Saturn V Dynamic Test Stand with S-11 stage in place.

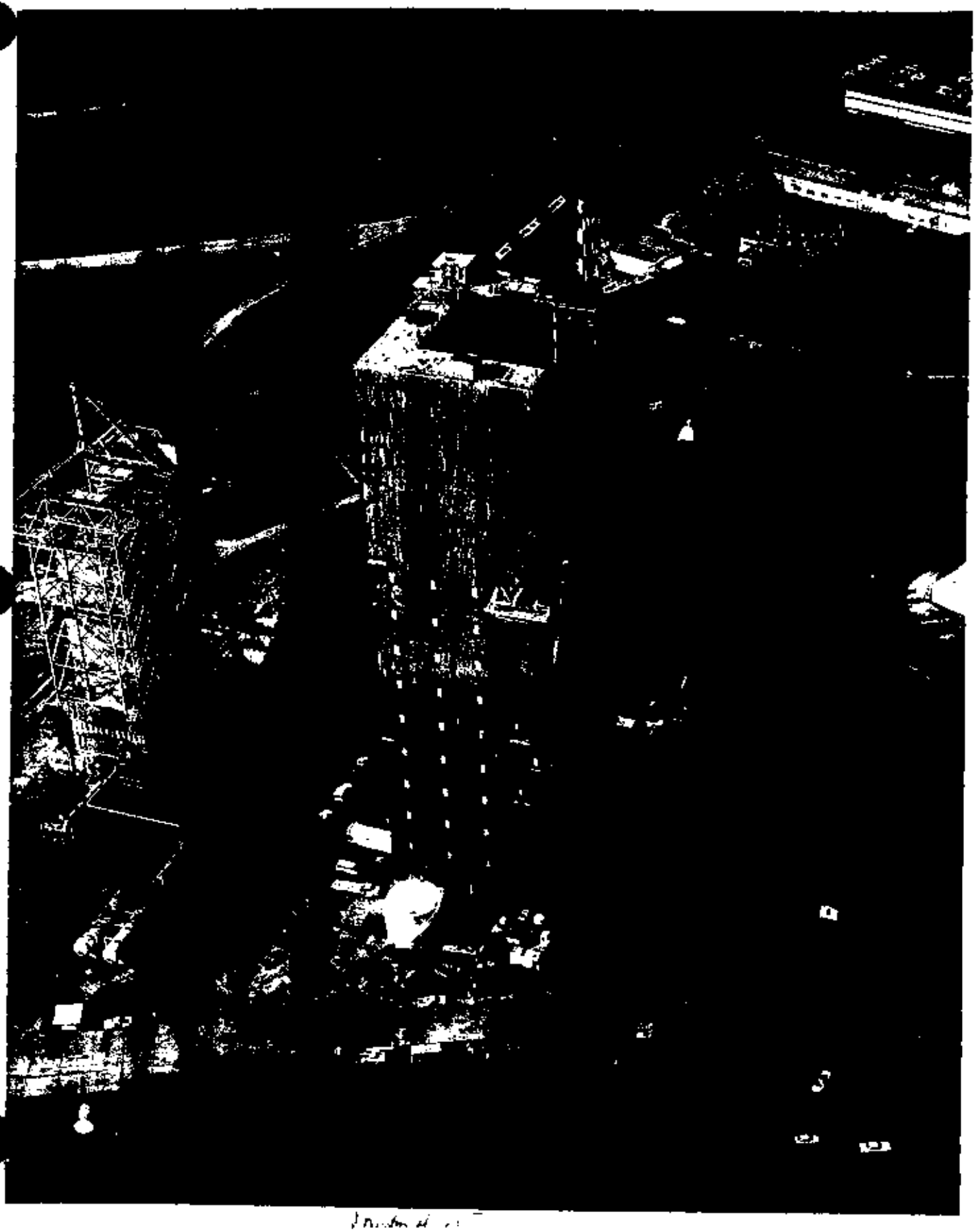
S-II FACILITIES CHECKOUT STAGE IN DYNAMICS TEST STAND—MSFC



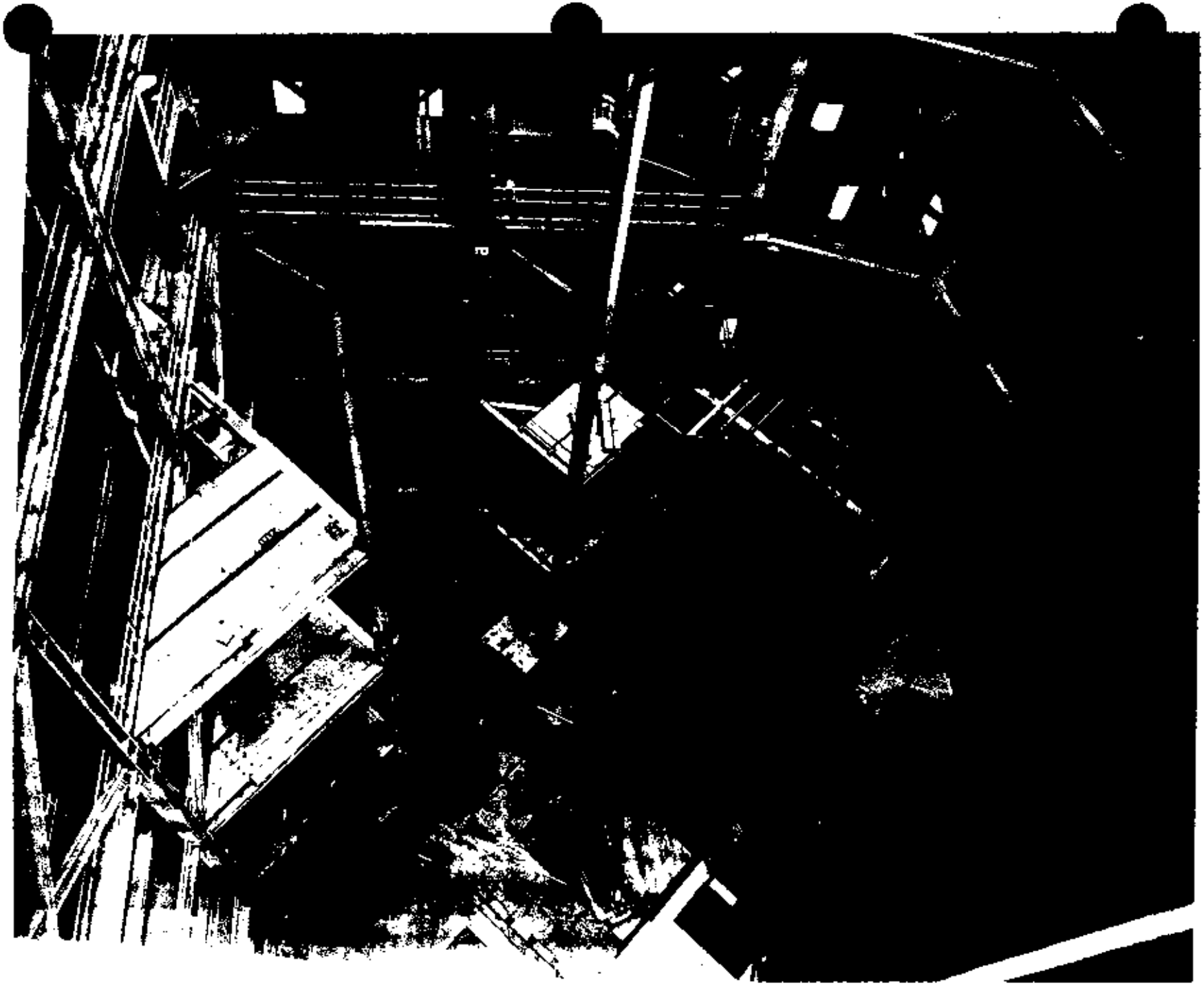
1. Saturn V Dynamic Test Stand
2. Huntsville, Alabama
3. NASA
4. 1976
5. NASA, Marshall Space Flight Center Facilities Office
6. Exterior view of Saturn V Dynamic Test Stand in process of being modified for Shuttle use.



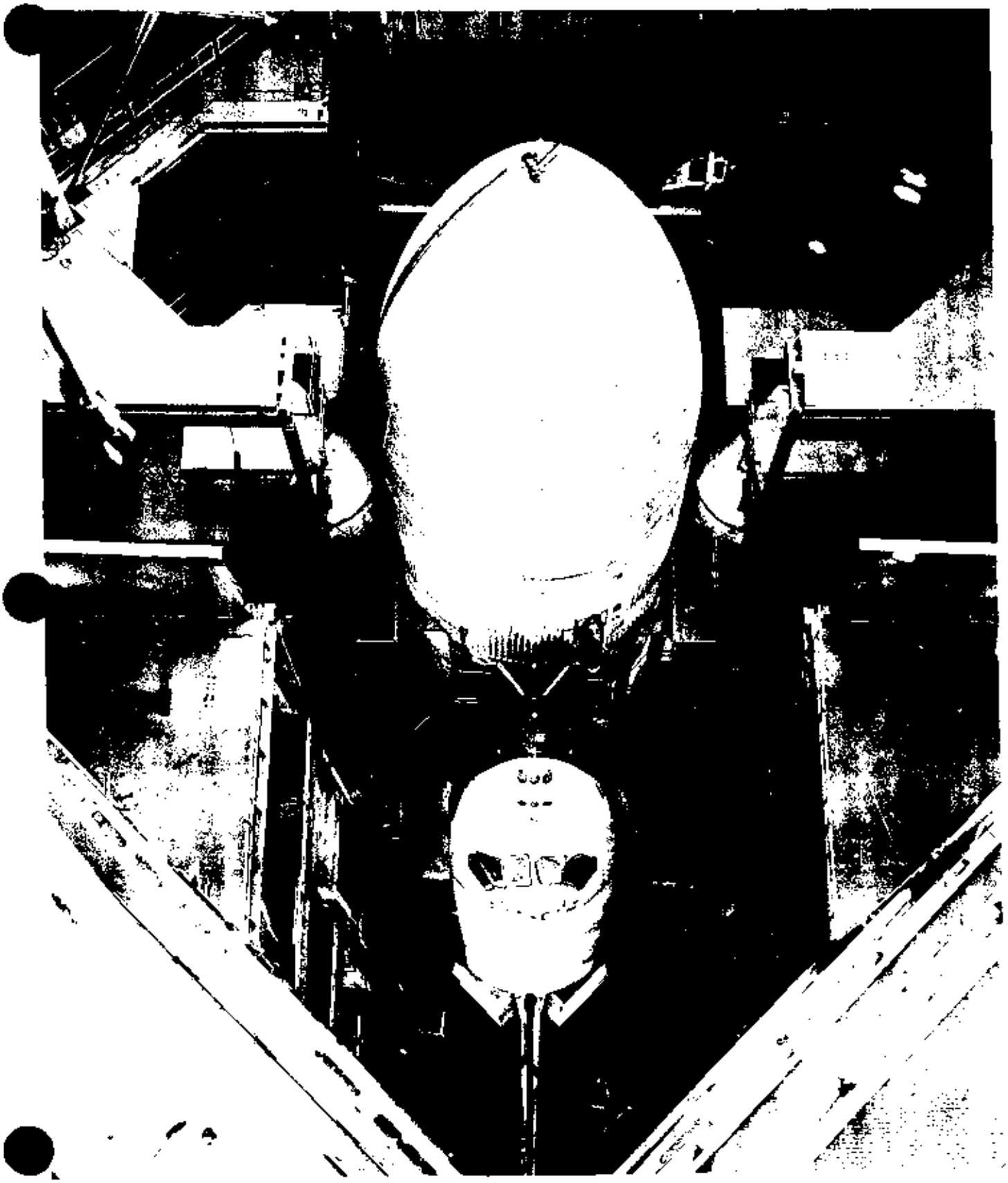
1. Saturn V Dynamic Test Stand
2. Huntsville, Alabama
3. NASA
4. 1980
5. NASA, Marshall Space Flight Facilities Office
6. External View showing Space Shuttle being hoisted into Test Stand.



1. Saturn V Dynamic Test Stand
2. Huntsville, Alabama
3. NASA
4. 1977
5. NASA, Marshall Space Flight Center Facilities Office
6. Interior view of Test Stand



1. Saturn V Dynamic Test Stand
2. Huntsville, Alabama
3. NASA
4. 1978
5. NASA, Marshall Space Flight Center Facilities Office
6. Interior view with Space Shuttle in place



ROCKETS

12. Saturn V Space Vehicle (Alabama Space and Rocket Center)

Man in Space Theme Study
Federal Agency Nomination

NPS Form 10-900
(7-81)

**United States Department of the Interior**
**National Park Service**

# National Register of Historic Places Inventory—Nomination Form

For NPS use only
received
date entered

See instructions in *How to Complete National Register Forms*
Type all entries—complete applicable sections

## 1. Name

historic Saturn V Space Vehicle

and/or common Saturn V Space Vehicle

## 2. Location

street & number Tranquility Base ___ not for publication

city, town Huntsville ___ vicinity of congressional district

state Alabama code 01 county Madison code 089

## 3. Classification

| Category | Ownership | Status | Present Use | |
|---|---|---|---|---|
| ___ district | X public | ___ occupied | ___ agriculture | X museum |
| ___ building(s) | ___ private | X unoccupied | ___ commercial | ___ park |
| X structure | ___ both | ___ work in progress | ___ educational | ___ private residence |
| ___ site | **Public Acquisition** | **Accessible** | ___ entertainment | ___ religious |
| ___ object | ___ in process | X yes: restricted | ___ government | ___ scientific |
| | ___ being considered | ___ yes: unrestricted | ___ industrial | ___ transportation |
| | | ___ no | ___ military | ___ other: |

## 4. Owner of Property

name National Air and Space Museum, Smithsonian Institution (On extended loan to Alabama Space and Rocket Center)

street & number

city, town Washington ___ vicinity of state D.C.

## 5. Location of Legal Description

courthouse, registry of deeds, etc. Office of the Judge Probate

street & number Madison County Courthouse

city, town Huntsville state Alabama

## 6. Representation in Existing Surveys

title National Register Inventory has this property been determined eligible? X yes ___ no

date 1977 ___ federal X state ___ county ___ local

depository for survey records National Park Service, Interagency Resources Division

city, town Washington state D.C.

# 7. Description

| Condition | | Check one | Check one |
|---|---|---|---|
| X excellent | ___ deteriorated | X unaltered | ___ original site |
| ___ good | ___ ruins | ___ altered | ___ moved date _____ |
| ___ fair | ___ unexposed | | |

**Describe the present and original (if known) physical appearance**

The Saturn V Space Vehicle is in the Rocket Park of the Alabama Space and Rocket Center and consists of three tank-type propellant stages and payload. The vehicle is exhibited horizontally, one stage on a trailer, others on cradles.

Primary materials: aluminum alloys, stainless steel and titanium.

Length: 365 feet.

Weight: 6,200,000 pounds.

First Stage: 33 feet diameter by 138 feet; five F-1 engines.
Assembled by Marshall Space Flight Center and Boeing Aircraft Corporation

Second Stage: 33 feet diameter by 81 feet; five J-2 engines.
Assembled by North American Rockwell.

Third Stage: 22 feet diameter by 59 feet; 1 J-2 engine.
Assembled by McDonnell-Douglas.

Pay Load: (1) Apollo Command Module - cone-shaped, 10 feet 7 inches high, 12 feet 10 inches diameter

Habitable volume - 210 cubic feet.
Weight - 13,000 pounds.

(2) Service Module: Cylinder-shaped, 22 feet 7 inches high, 12 feet 10 inches diameter.
Weight - 55,000 pounds.
Assembled by North American Rockwell.

Cost: $15,010,000.00[1]

# 8. Significance

| Period | Areas of Significance—Check and justify below | | | |
|---|---|---|---|---|
| ___ prehistoric | ___ archeology-prehistoric | ___ community planning | ___ landscape architecture | ___ religion |
| ___ 1400–1499 | ___ archeology-historic | ___ conservation | ___ law | ___ science |
| ___ 1500–1599 | ___ agriculture | ___ economics | ___ literature | ___ sculpture |
| ___ 1600–1699 | ___ architecture | ___ education | ___ military | ___ social/ humanitarian |
| ___ 1700–1799 | ___ art | X engineering | ___ music | ___ theater |
| ___ 1800–1899 | ___ commerce | ___ exploration/settlement | ___ philosophy | X transportation |
| X 1900– | ___ communications | ___ industry | ___ politics/government | X other (specify) Space Exploration |
| | | ___ invention | | |

**Specific dates** 1965-1973 **Builder/Architect** Boeing Aircraft, McDonnald Douglas, North American Rockwell

**Statement of Significance (in one paragraph)**

On July 16, 1969, a Saturn V Space Vehicle rose from the launch pad carrying astronauts Neil A. Armstrong, Edwin E. Aldrin, and Michael Collins toward mankind's first expedition to the surface of the moon. Because stages of the Saturn V are not recovered after use, a Saturn which has actually flown a mission will never be available to the public. The test stages located at the Alabama Space and Rocket Center are full operational units of the actual flight stages and provide a realistic view of the vehicle which carried the first men to the moon and placed the first U.S. space station into orbit.

The decision to develop the Saturn V was officially announced on January 10, 1962. It was the first large vehicle in the U.S. space program to be conceived and developed for a specific purpose--the lunar landing. NASA formally assigned the task of developing the Saturn V to the Marshall Space Flight Center on January 25, 1962. Launch responsibility was given to the Kennedy Space Center in Florida.

Marshall Center designers decided that a three-stage vehicle would best serve the immediate needs for a lunar landing mission and also serve as a general purpose space exploration vehicle. The Saturn V provided the U.S. with the capability to put into earth orbit some 280,000 pounds of payload or send 95,000 pounds to the moon. During a seven-year period, a total of 13 Saturn V vehicles were launched, including two unmanned test flights; ten Apollo flights; and one flight which carried the Skylab space station to earth orbit. The Saturn V performed successfully in all missions.[2]

There are three remaining examples of the Saturn V space vehicle in existence. One is found at the Kennedy Space Center, one is at the Johnson Manned Space Flight Center, and the last is found at the Alabama Space and Rocket Museum in Huntsville, Alabama, adjacent ot the Marshall Space Flight Center.

The Saturn V at the Alabama Space and Rocket Museum was chosen to represent the class of Saturn V's as a National Historic Landmark for several reasons.

1. The Saturn V at Huntsville is closely associated with its site. The design, development, and manufacture of the Saturns was the responsibility of the NASA-Marshall Space Flight Center at Huntsville, Alabama, which at the time, was under the leadership of Dr. Werner von Braun. Dr. von Braun headed a nationwide team drawn from industry, government, and the educational community which provided the expertise to produce the Saturn.

2. The Saturn V on display at the Alabama Space and Rocket Museum is the actual test rocket that was used in dynamic testing of the Saturn facilities at Huntsville. The stages of this rocket were used to check out all of the Saturn V facilities at Huntsville. Thus, while the rocket was not intended to be flown, it was a working vehicle that prepared the way for the Saturn V rockets that were flown and eventually destroyed.

3. The Saturn V at the Alabama Space and Rocket Museum is also the best preserved example of this space vehicle. It has been maintained since it went on exhibit in 1969 and is in mint condition. Both the Saturn V's at the Kennedy Space Center and the Houston Manned Space Flight Center exhibit extensive deterioration due to the elements.

4. Finally the Saturn V at the Alabama Space and Rocket Center has the best remaining integrity of the class. Its three principal stages and instrument unit are intact thus representing all the necessary parts to the Saturn V that launched the American exploration of the moon.

In a letter to the National Register of Historic Places in 1978, Michael Collins, Director of the National Air and Space Museum and participant in the Apollo 11 mission that first landed men on the moon, said the following about the Saturn V at the Alabama and Rocket Museum:

> This letter is written in response to the application by the Alabama Space and Rocket Center recommending listing of the Saturn V space launch vehicle on the National Register of Historic Places.
>
> The uniqueness of the Saturn V, the high level of technology that it represents and the successful role that it played in making possible man's landing on the Moon seems to qualify for national recognition by placement on the National Register of Historic Places. In addition, the location is adjacent to the NASA/Marshall Space Flight Center which was responsible for the design and development of this vehicle.
>
> For these reasons we concur in the application for listing made by the Alabama Space and Rocket Center.

The Saturn V Space Vehicle was a unique engineering masterpiece that formed the key link in the chain that enabled Americans to travel to the moon. The success of the Saturn V made possible the success of the American Space Program.

Footnotes

1. Edward O. Buckbee, "National Register of Historic Places Inventory Saturn V Space Vehicle Huntsville" (Alabama, Alabama Space and Rocket Center, 1977), p. 2.

2. Ibid., 3.

Bibiography

Bilstein, Roger E. Stages to Saturn: A Technological History of the Apollo/Saturn Launch Vehicles. Washington, D.C.: National Aeronautics and Space Administration, 1980.

Brooks, Courtney G., Grimwood, James M., and Swenson, Loyd S. Jr. Chariots for Apollo: A History of Manned Lunar Spacecraft. Washington, D.C.: National Aeronautics and Space Administration, 1979.

Buckbee, Edward O. "National Register of Historic Places Inventory Saturn V Space Vehicle Huntsville". Alabama: Alabama Space and Rocket Center, 1977.

## 9. Major Bibliographical References

See continuation sheets

## 10. Geographical Data

Acreage of nominated property Less than 1 acre

Quadrangle name Madison

Quadrangle scale 1:24,000

UMT References

| | Zone | Easting | Northing |
|---|---|---|---|
| A | 16 | 531520 | 3848010 |
| B | | | |
| C | | | |
| D | | | |
| E | | | |
| F | | | |
| G | | | |
| H | | | |

Verbal boundary description and justification

The boundary of the Saturn V Space Vehicle is shown as the green line on the accompanying map entitled "Rocket Park."

List all states and counties for properties overlapping state or county boundaries

state code county code

state code county code

## 11. Form Prepared By

name/title Mary A. Bilowsky

organization National Park Service date May 15, 1984

street & number Division of History telephone (202) 343-8168

city or town Washington, D.C. 20240 state

## 12. State Historic Preservation Officer Certification

The evaluated significance of this property within the state is:

___ national ___ state ___ local

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89-665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service.

State Historic Preservation Officer signature

title date

For NPS use only

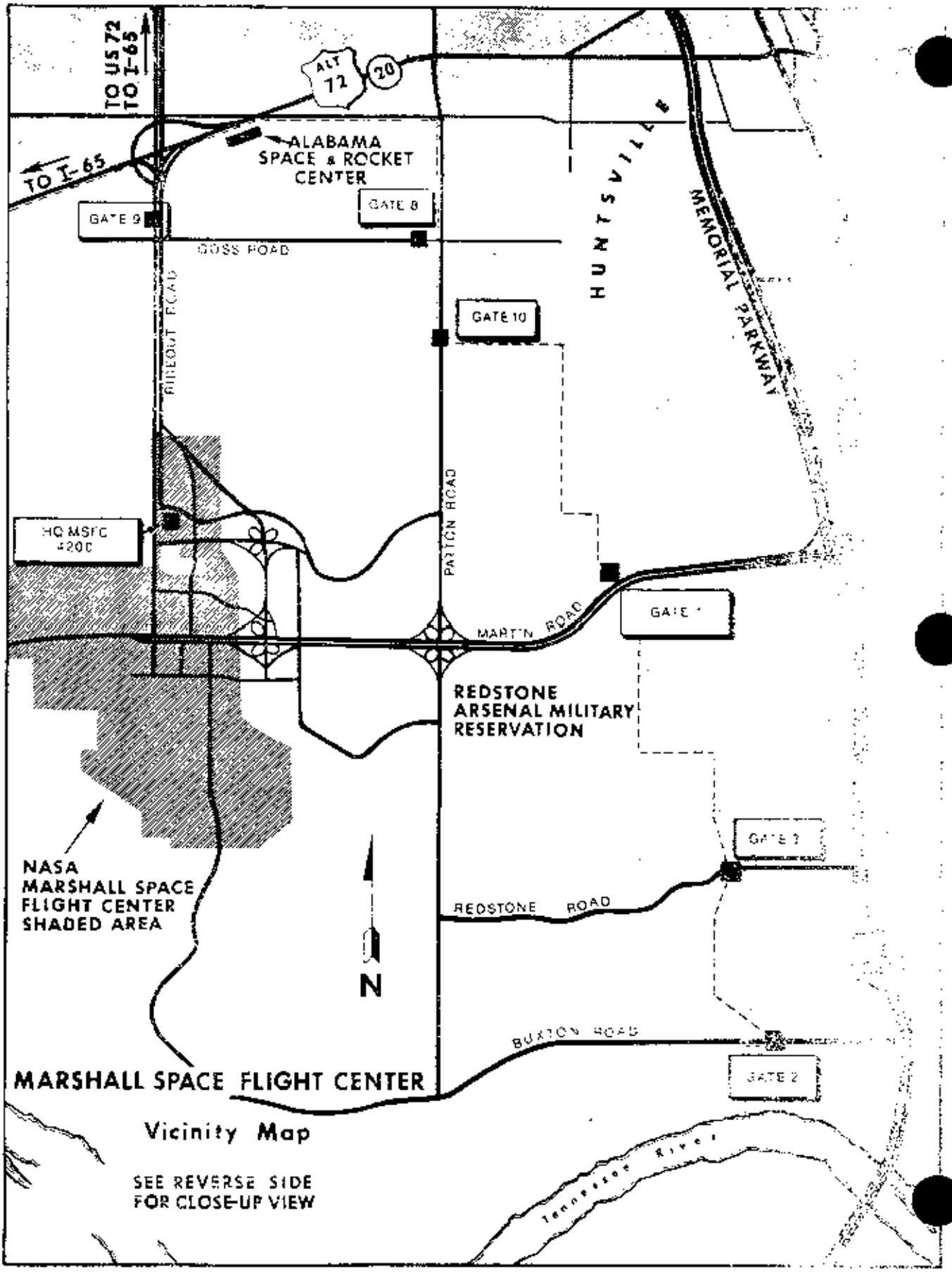
I hereby certify that this property is included in the National Register

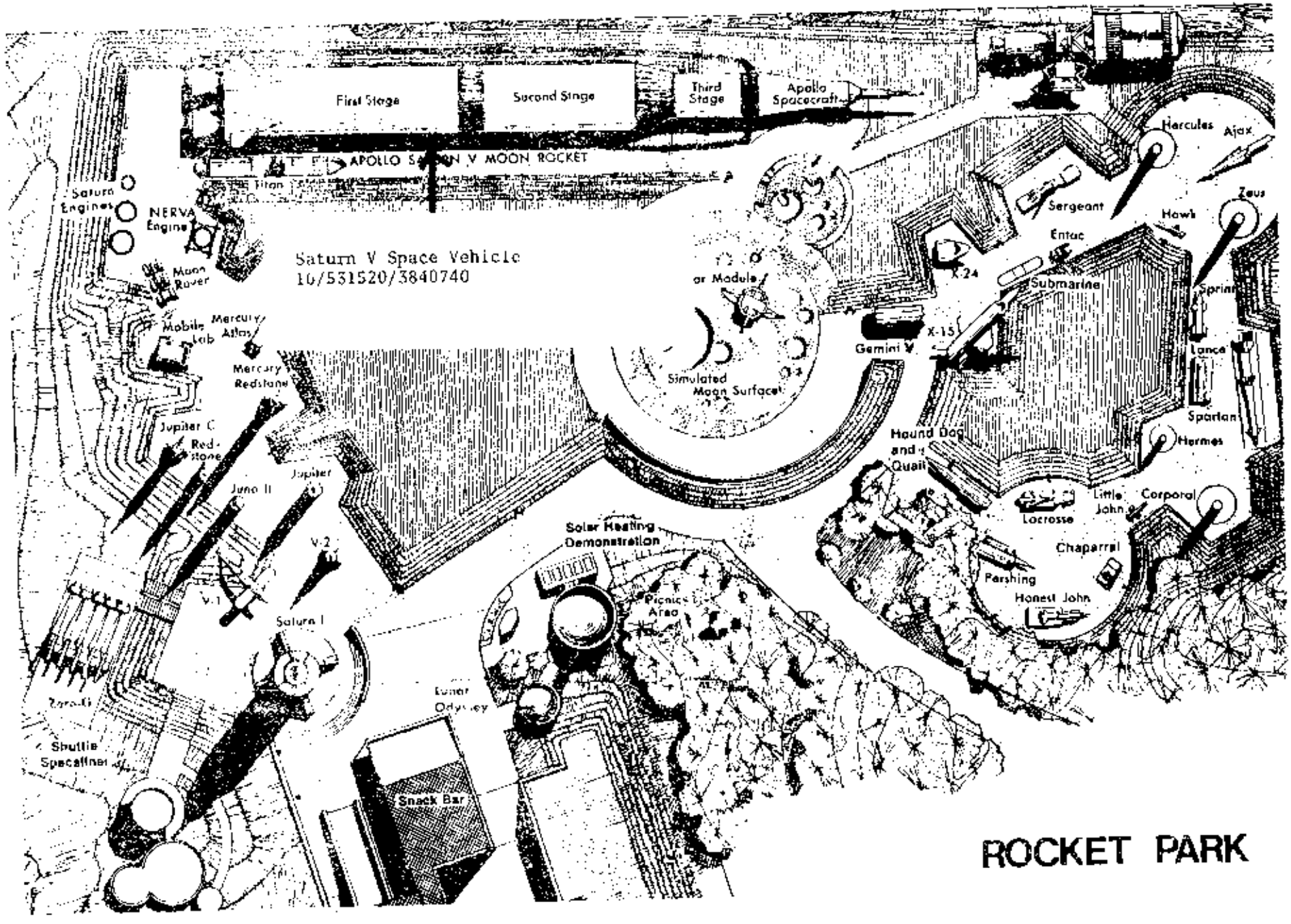
date

Keeper of the National Register

Attest: date

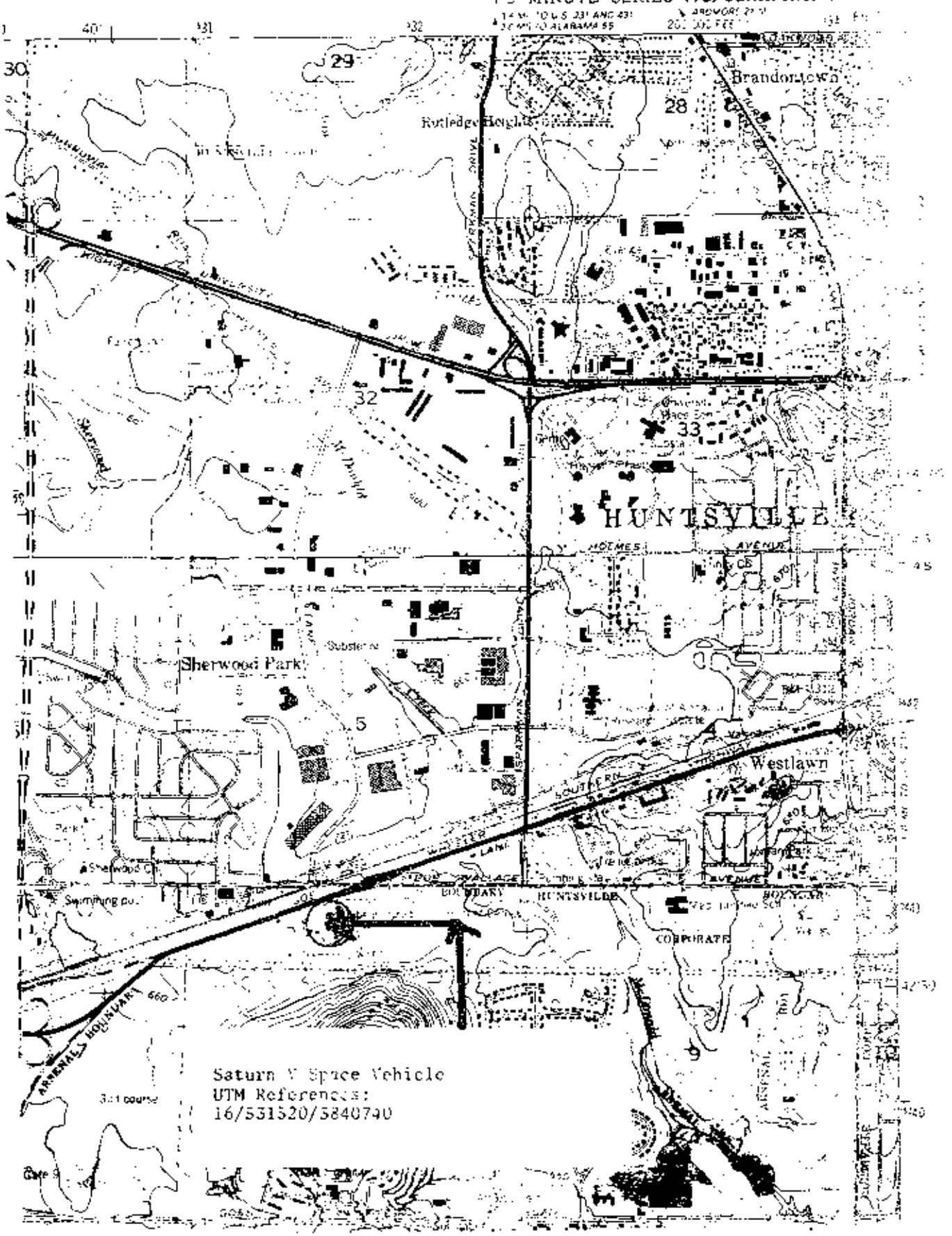
Chief of Registration


TO US 72
TO I-65
ALT 72
20
TO I-65
ALABAMA SPACE & ROCKET CENTER
GATE 9
GATE 8
GOSS ROAD
HUNTSVILLE
MEMORIAL PARKWAY
GATE 10
BIRDOUT ROAD
PATTON ROAD
HQ MSFC 4200
MARTIN ROAD
GATE 1
REDSTONE ARSENAL MILITARY RESERVATION
GATE 3
NASA MARSHALL SPACE FLIGHT CENTER SHADED AREA
REDSTONE ROAD
N
BUXTON ROAD
GATE 2
MARSHALL SPACE FLIGHT CENTER
Vicinity Map
SEE REVERSE SIDE FOR CLOSE-UP VIEW
Tennessee River

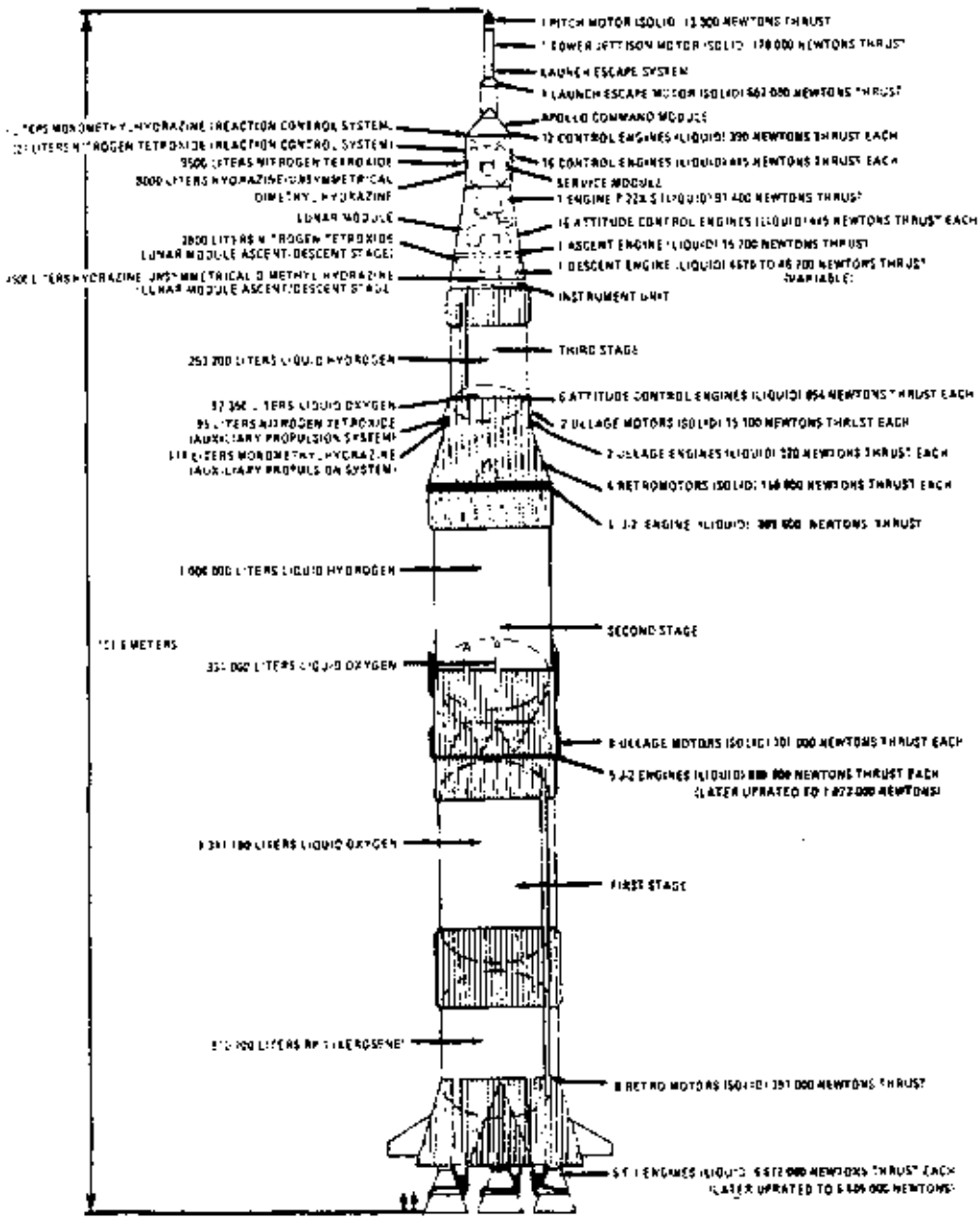

First Stage
Second Stage
Third Stage
Apollo Spacecraft
APOLLO SATURN V MOON ROCKET
Titan
Saturn Engines
NERVA Engine
Moon Rover
Mobile Lab
Mercury Atlas
Mercury Redstone
Jupiter C
Redstone
Juno II
Jupiter
V-2
V-1
Saturn I
Zero-G
Shuttle Spacelinner
Saturn V Space Vehicle
10/531520/3840740
or Module
Simulated Moon Surface
Solar Heating Demonstration
Picnic Area
Lunar Odyssey
Snack Bar
Hercules
Ajax
Zeus
Sergeant
Hawk
Entac
X-24
Submarine
Sprint
Gemini V
X-15
Lance
Spartan
Hound Dog and Quail
Hermes
Little John
Corporal
Lacrosse
Chaparral
Pershing
Honest John

ROCKET PARK

MADISON QUADRANGLE
ALABAMA - MADISON CO.
7.5 MINUTE SERIES (TOPOGRAPHIC) 75-

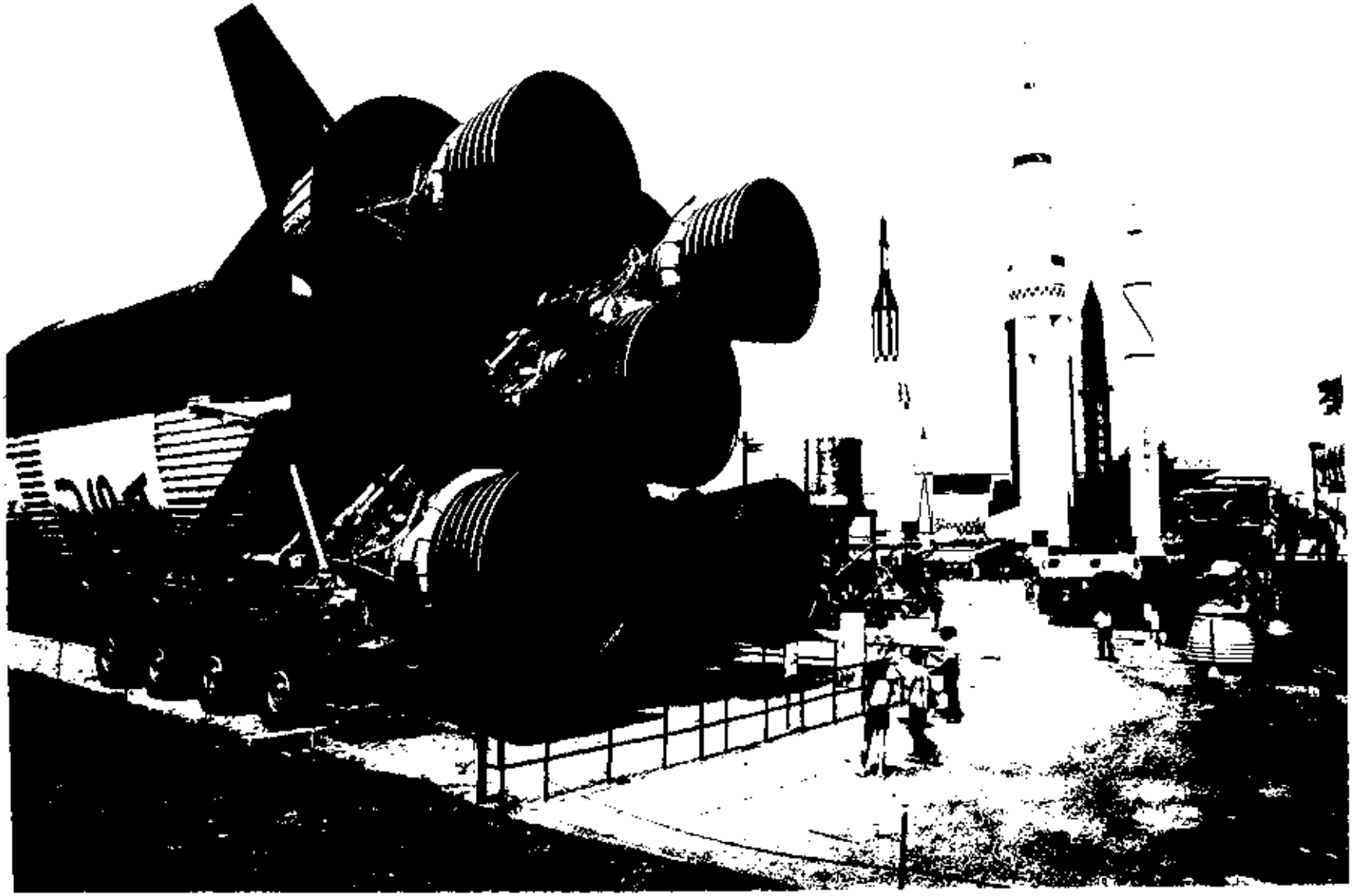


# Schematic of Saturn V




Source: Bilstein, p. 405

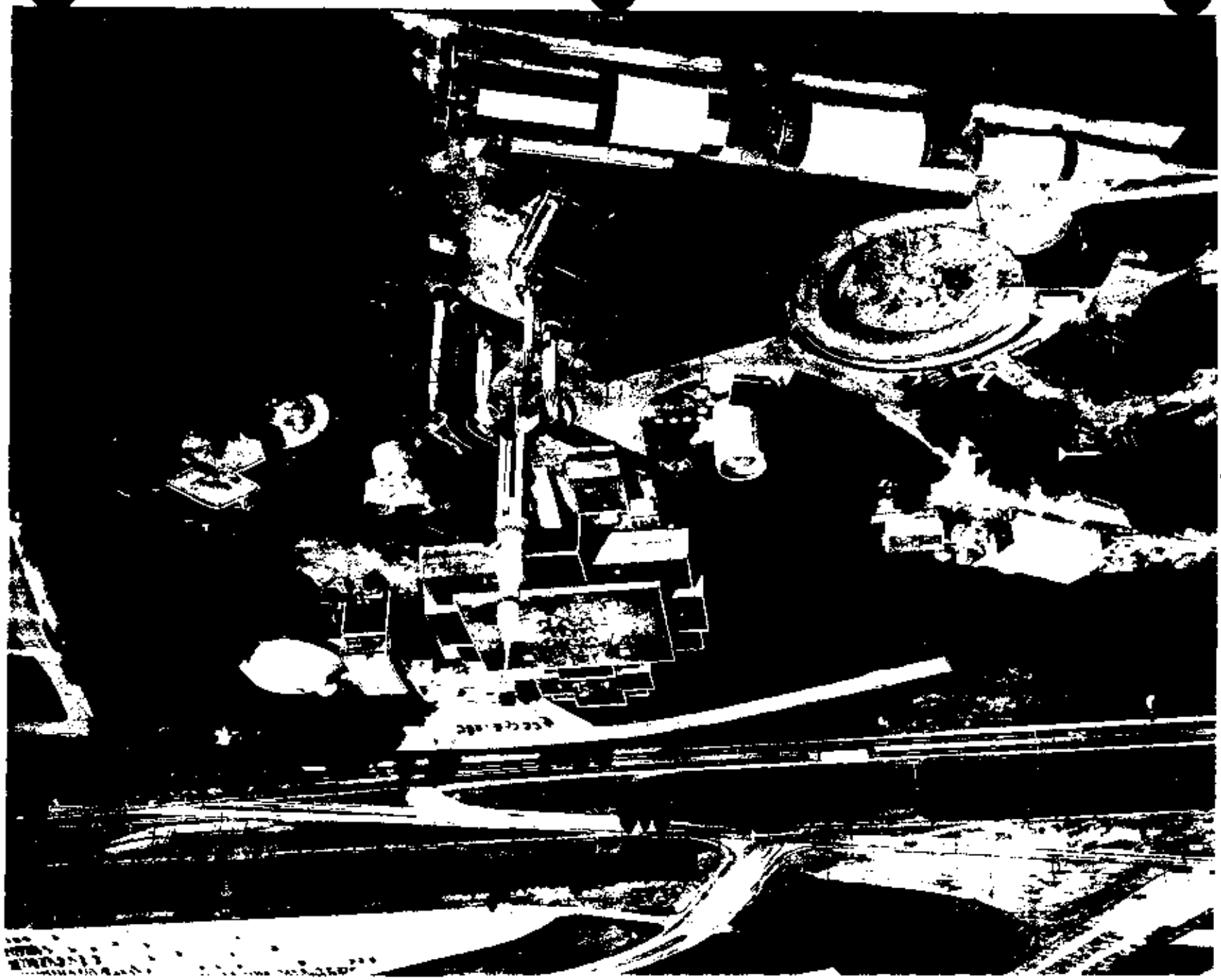
1. Saturn V Space Vehicle
2. Hunstville, Alabama
3. Alabama Space and Rocket Center
4. 1984
5. Alabama Space and Rocket Center
6. Rear View of 1st Stage of Saturn V Space Vehicle



1. Saturn V Space Vehicle
2. Huntsville, Alabama
3. Alabama Space and Rocket Center
4. 1984
5. Alabama Space and Rocket Center
6. Side View of Saturn V Space Vehicle


ASC

1. Saturn V Space Vehicle
2. Huntsville, Alabama
3. NASA, Marshall Space Flight Center Facilities Office
4. 1982
5. NASA, Marshall Space Flight Center Facilities Office
6. Aerial View of "Rocket Park" at the Alabama Space and Rocket Center showing the Saturn V Space Vehicle



## LAUNCH PADS

13. Space Launch Complex 2 (Vandenberg AFB)

Man in Space Theme Study
Federal Agency Nomination

NPS Form 10-900
(7-81)

**United States Department of the Interior**
**National Park Service**

# National Register of Historic Places Inventory—Nomination Form

For NPS use only
received
date entered

See instructions in *How to Complete National Register Forms*
Type all entries—complete applicable sections

## 1. Name

historic Space Launch Complex 2

and/or common Missile Launch Complex 2

## 2. Location

street & number Vandenberg Air Force Base ___ not for publication

city, town Lompoc ___ vicinity of congressional district

state California code 06 county Santa Barbara code 083

## 3. Classification

| Category | Ownership | Status | Present Use | |
|---|---|---|---|---|
| ___ district | X public | ___ occupied | ___ agriculture | ___ museum |
| ___ building(s) | ___ private | ___ unoccupied | ___ commercial | ___ park |
| ___ structure | ___ both | ___ work in progress | ___ educational | ___ private residence |
| ___ site | **Public Acquisition** | **Accessible** | ___ entertainment | ___ religious |
| ___ object | ___ in process | X yes: restricted | X government | X scientific |
| | ___ being considered | ___ yes: unrestricted | ___ industrial | X transportation |
| | | ___ no | X military | X other: Space exploration |

## 4. Owner of Property

name United States Air Force/National Aeronautics and Space Administration

street & number Vandenberg Air Force Base

city, town Lompoc ___ vicinity of state California

## 5. Location of Legal Description

courthouse, registry of deeds, etc. United States Air Force/LEER

street & number Building 516, Bolling Air Force Base

city, town Washington state D.C. 20032

## 6. Representation in Existing Surveys

title None has this property been determined eligible? ___ yes ___ no

___ federal ___ state ___ county ___ local

depository for survey records

city, town state

# 7. Description

| Condition | | Check one | Check one |
|---|---|---|---|
| X excellent | deteriorated | unaltered | X original site |
| good | ruins | X altered | moved date |
| fair | unexposed | | |

**Describe the present and original (if known) physical appearance**

Space Launch Complex 2 (SLC-2) is at Vandenberg Air Force Base and is part of of the Kennedy Space Center Western Test Range Operations Office. This complex is composed of the NASA Launch Operations Building, Blockhouse, and two launch pads (East and West). SLC-2E was decommissioned and stripped in 1975, SLC-2W is active. Its last launch is scheduled for March 1984. Only the blockhouse and pad 2-W with supporting structures retain their integrity and are considered a part of this nomination. The NASA Launch Operations Building served to house NASA and contractor personnel between launches and is not considered integral to the site and is not included in this nomination.

Blockhouse

The Launch Control Blockhouse at SLC-2 was and is used to control launches from both the East and West Pads. The blockhouse is a self-contained reinforced concrete building capable of withstanding the dangers of catastrophic vehicle failure at lift-off. The control room room houses numerous monitor consoles necessary to support the vehicle and spacecraft during testing and final countdown. Television monitors are mounted in the control room wall for viewing the vehicle and critical prelaunch functions from cameras at vantage points around the complex.[1]

Umbilical Tower

The Umbilical Tower supports purge, coolant, and propellant lines as well as electrical cables and environmental ducts required for checkout and launch of the Delta Space vehicle. The Tower is an 8-feet x 8-feet x 124 feet-high free standing steel structure.[2]

Service Structure

The Service Structure is a rail-mounted, steel structure 166 feet high. The enclosed tower, which is moved by a hydraulic drive system, is used for erection, assembly, and checkout of Delta launch vehicles. The structure has a 15-ton overhead bridge crane, a 3-ton interior bridge crane, and one 2500-lb. capacity elevator. Eight working levels are provided, with the top one infinitely adjustable within an 18-feet working range.[3]

Support System

The support system for SLC-2 includes propellant storage and handling equipment, hydraulic power units, high pressure nitrogen and helium storage tanks, and a nitrogen purge system. An air-conditioning unit, hydro-pneumatic controls, and vehicle checkout equipment are housed in the Launch Pad Building and in the electrical equipment building. The launcher has a wet flame bucket that is used during ignition and lift-off of the Delta Space Vehicle.[4]

# 8. Significance

| Period | Areas of Significance—Check and justify below | | | |
|---|---|---|---|---|
| ___ prehistoric | ___ archeology-prehistoric | ___ community planning | ___ landscape architecture | ___ religion |
| ___ 1400–1499 | ___ archeology-historic | ___ conservation | ___ law | ___ science |
| ___ 1500–1599 | ___ agriculture | ___ economics | ___ literature | ___ sculpture |
| ___ 1600–1699 | ___ architecture | ___ education | ___ military | ___ social/humanitarian |
| ___ 1700–1799 | ___ art | X engineering | ___ music | ___ theater |
| ___ 1800–1899 | ___ commerce | ___ exploration/settlement | ___ philosophy | X transportation |
| X 1900– | ___ communications | ___ industry | ___ politics/government | X other (specify) Space Technology |
| | | ___ invention | | |

**Specific dates** 1957–1964 **Builder/Architect** U.S. Air Force

**Statement of Significance (in one paragraph)**

Space Launch Complex 2 was built for the Air Force in 1957 for their Intermediate Range Ballistic Missile (IRBM) Testing Program. The complex fired the Thor IRBM in various USAF testing programs during its early years.

NASA acquired SLC-2E in 1962 and SLC-2W in 1969. Minor modifications were made on both pads so that NASA could launch its Delta rocket. Since the Delta was a direct outgrowth of the Thor rocket, modifications were kept to a minimum. The complex was used by NASA to launch polar orbiting satellites using the reliable Delta rocket. As the need to launch polar orbiting satellites decreased, NASA abandoned SLC-2E in 1975 and concentrated its operations at SLC-2W. SLC-2E reverted to the control of the Air Force which decommissioned and stripped the pad of all of its equipment and salvageable materials in 1975.

SLC-2W is the best surviving example of a launch complex built in the 1950s at the beginning of the American effort to explore space. The blockhouse, with its supporting electrical equipment, is intact. Only the most minimum of modifications were made over the years. The blockhouse with its electronic equipment is today the best surviving example of working electronics used to support a space launch from this era. The only comparable example is the blockhouse at Launch Complex 26 at Cape Canaveral Air Force Station. The equipment at Launch Complex 26 is not operational. It was reconstructed for visitor interpretation when Launch Complex 26 became part of the United States Air Force Museum. The equipment at the blockhouse at SLC-2 is operational, dates from the period of the 1950s, and is integral to the site. It is the best surviving example of this technology.

In a similar manner the Launch Pad at SLC-2W is intact and survives from the 1950s with only minor modifications done to change from the Thor to the Delta Launch Vehicle. While the Redstone gantry at Launch Complex 26 and the Atlas gantry at Launch Complex 13 at Cape Canaveral Air Force Station are comparable, the gantry and supporting structures at SLC-2W are in a better state of preservation. SLC-2W is still a working complex and has been continuously maintained since 1957. The last maintenance performed on Launch Complex 13 was in 1978. The Redstone gantry at Launch Complex 26 is in serious danger of being lost to rust and the elements.

SLC-2W with its blockhouse is a unique resource that represents the best surviving example of a working 1950s-era launch complex that propelled Americans into Space.

Footnotes

1. Western Test Range Operations Handbook (John F. Kennedy Space Center, January 1968), p. V-1.

2. Technical Facilities Catalog Vol. 11 (Washington, D.C.: National Aeronautics and Space Administration, 1974), p. 9-151.

3. Ibid.

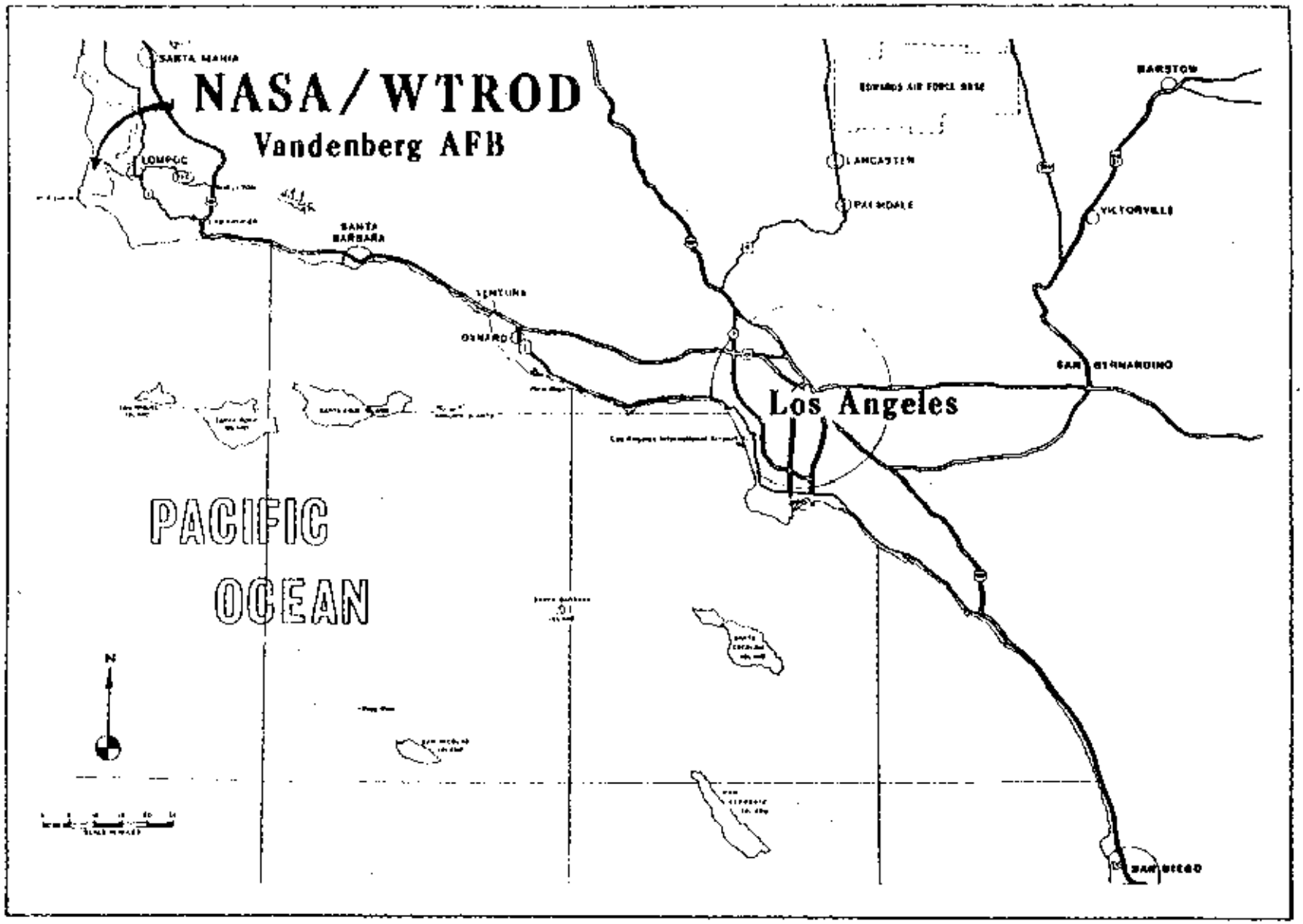
4. Western Test Range Operations Handbook, p. V-7.

Bibliography

1. Technical Facilities Catalog Vol. II. National Aeronautics and Space Administration: Washington, D.C., 1974.

2. Western Test Range Operations Handbook. John F. Kennedy Space Center: Florida, 1968.

SOUTHERN CALIFORNIA COAST




Source: KSC Western Test Range Operations Handbook, Figure 1-2

## 9. Major Bibliographical References

See continuation sheets

## 10. Geographical Data

Acreage of nominated property Less than 1 acre

Quadrangle name Surf

Quadrangle scale 1:24,000

UMT References

| | Zone | Easting | Northing |
|---|---|---|---|
| A | 10 | 710315 | 3848470 |
| B | | | |
| C | | | |
| D | | | |
| E | | | |
| F | | | |
| G | | | |
| H | | | |

**Verbal boundary description and justification**

The boundary of Space Launch Complex 2W is shown as the green line on the accompanying map entitled "Western Test Range Operations Handbook, Appendix-Space Launch Complex 2W."

**List all states and counties for properties overlapping state or county boundaries**

state code county code

state code county code

## 11. Form Prepared By

name/title Harry A. Butowsky

organization National Park Service date May 15, 1984

street & number Division of History telephone (202) 343-8168

city or town Washington, D.C. 20240 state

## 12. State Historic Preservation Officer Certification

The evaluated significance of this property within the state is:

___ national ___ state ___ local

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89-665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service.

State Historic Preservation Officer signature

title date

For NPS use only

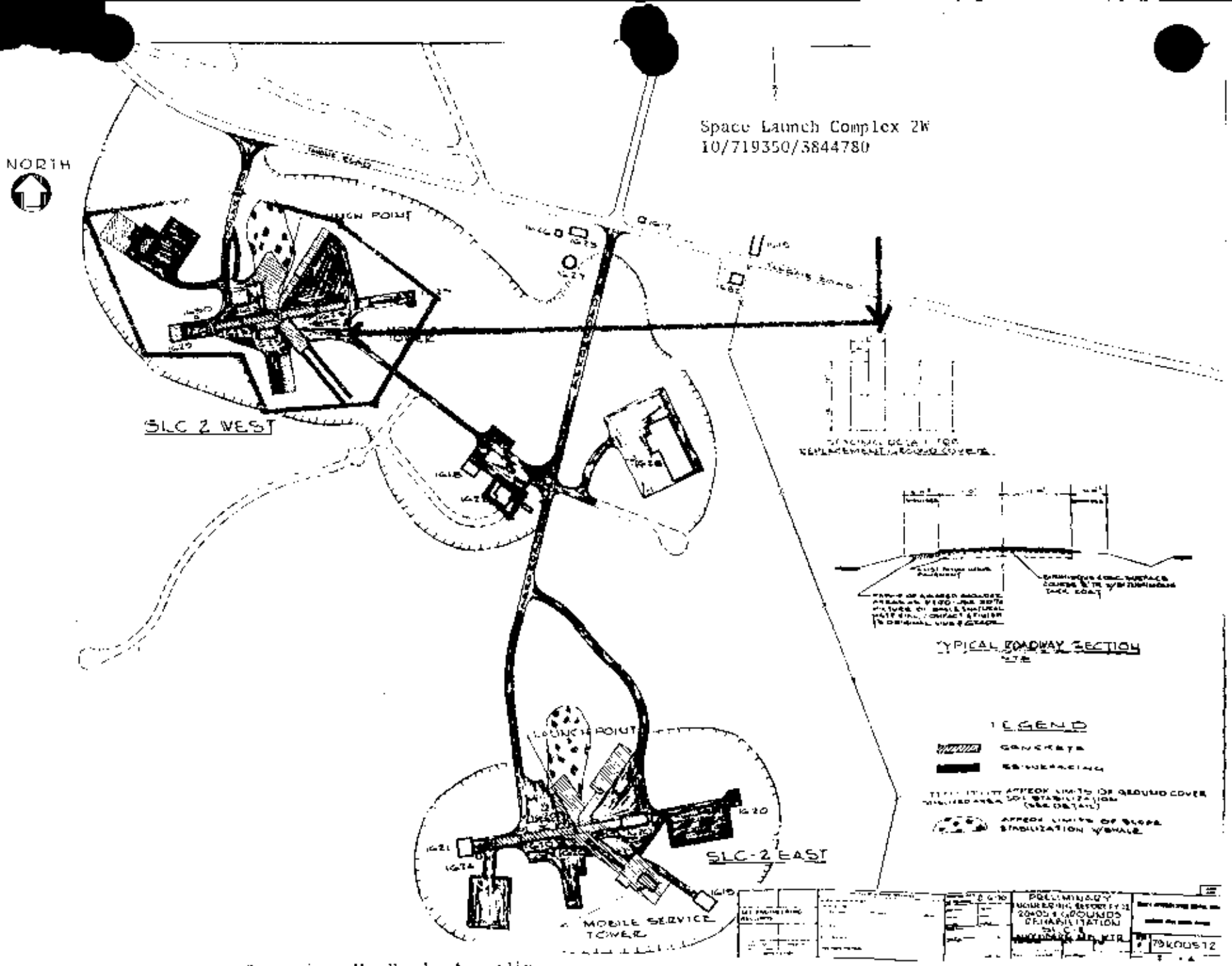
I hereby certify that this property is included in the National Register

date

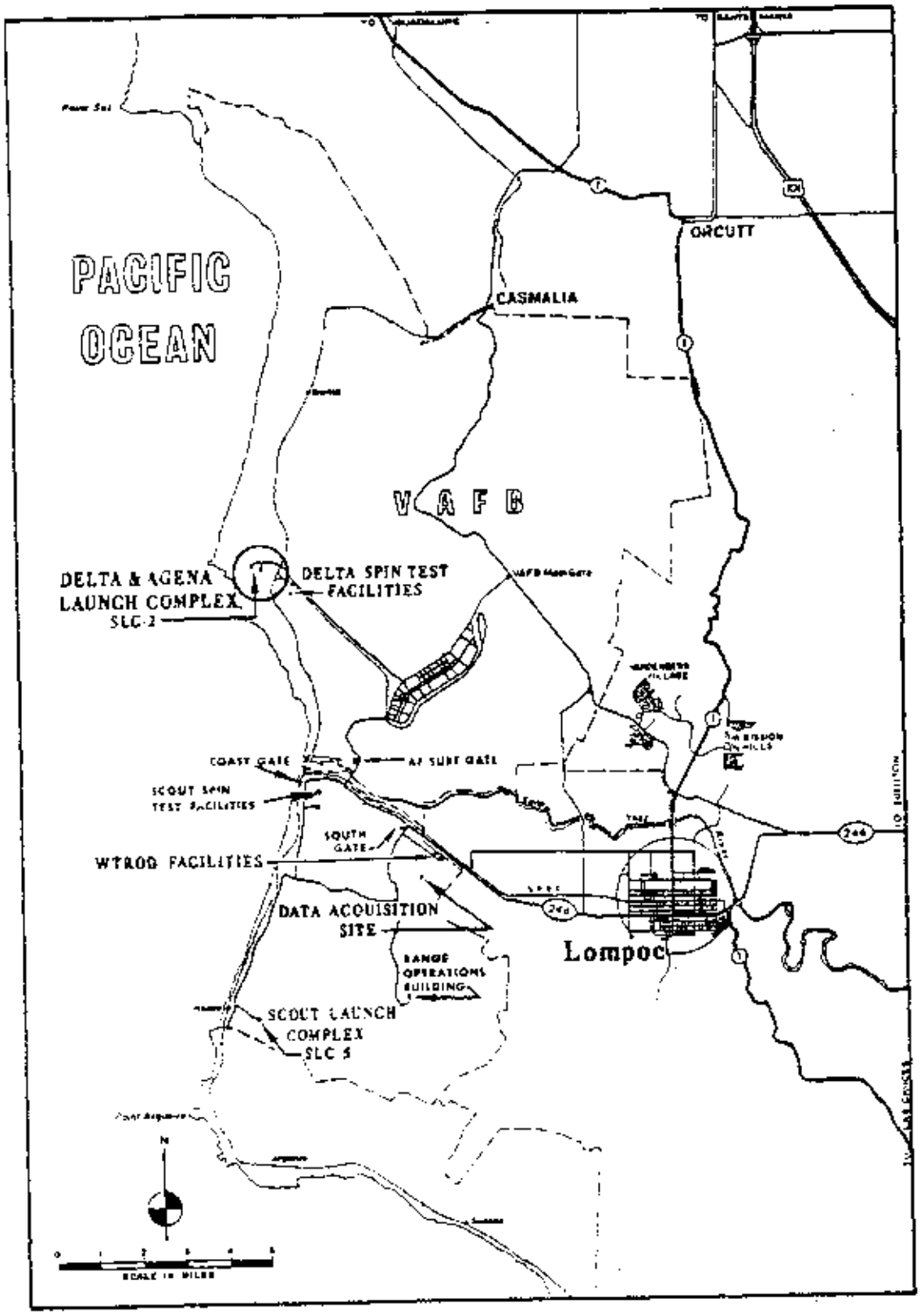
Keeper of the National Register

Attest: date

Chief of Registration

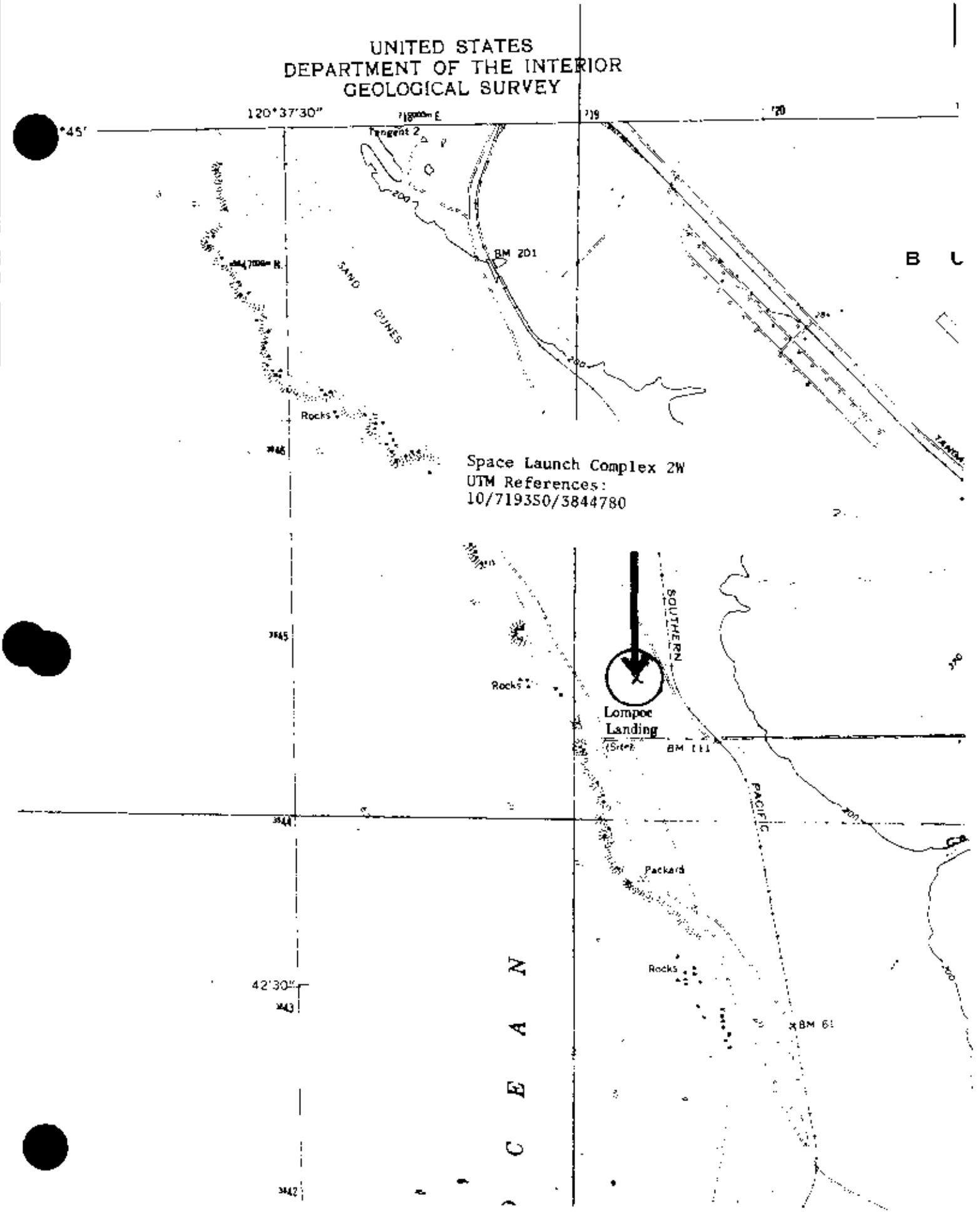



Source: Western Test Range Operations Handbook, Appendix

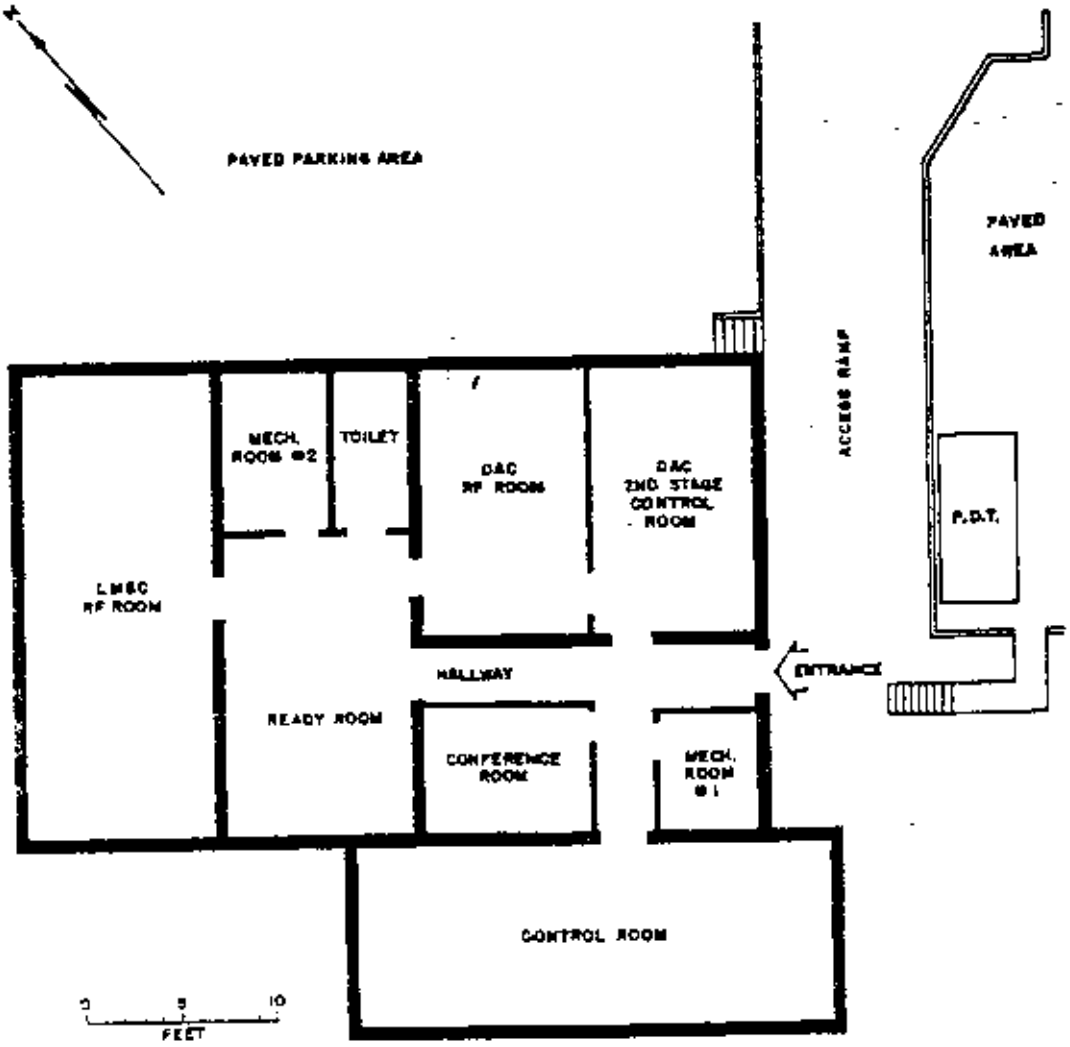



Source: KSC Western Test Range Operations Handbook, Figure 1-3

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

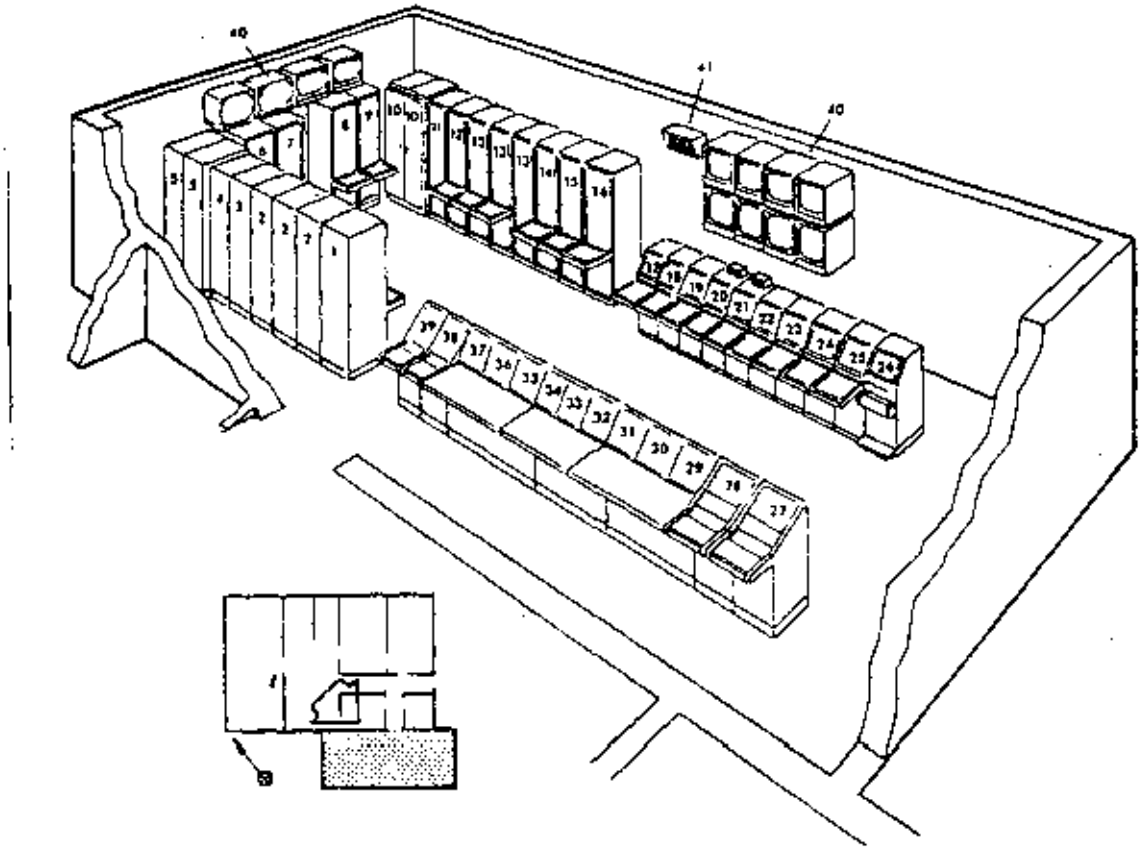


FLOOR PLAN OF BLOCKHOUSE




Source: KSC Western Test Range Operations Handbook, p. V-5

# SLC-2 BLOCKHOUSE CONTROL ROOM

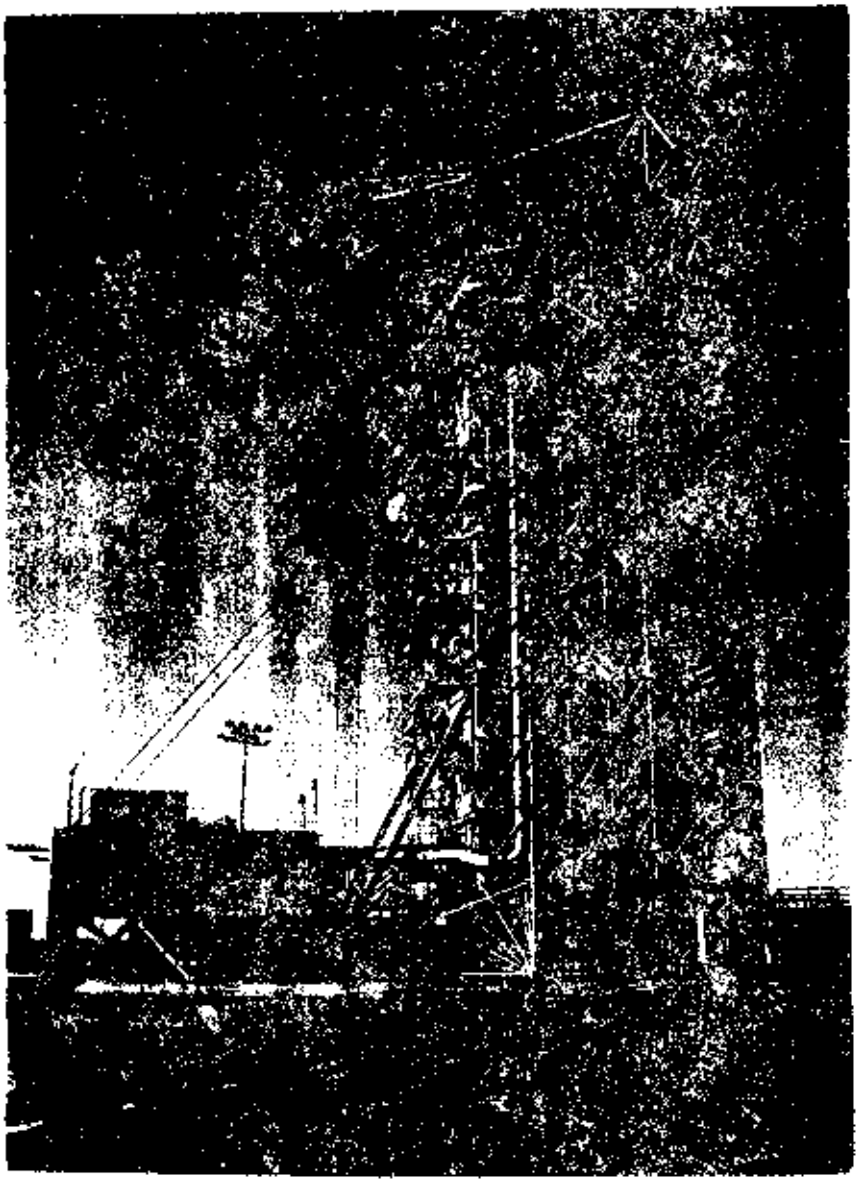


1 LMSC PAD-2 A.E.T. CSL
2 LMSC PAD-2 GUIDANCE CSL
3 LMSC PAD-2 ELEC CSL
4 LMSC PAD-2 PWR SUPPLY
5 LMSC PAD-2 I/C BOX
6 LMSC PAD-2 PNEU CSL
7 LMSC PAD-2 PROP CSL
8 LMSC PAD-1 PROP CSL
9 LMSC PAD-1 PNEU CSL
10 LMSC PAD-1 I/C BOX
11 LMSC PAD-1 PWR SUPPLY
12 LMSC PAD-1 ELEC CSL
13 LMSC PAD-1 GUIDANCE CSL
14 LMSC PAD-1 A.E.T. CSL
15/16 NASA S/C CSL
17 DAC PAD-1 MALFUNCTION & CONT STATUS CSL
18 DAC PAD-1 PROP CONT & MON CSL
19 DAC PAD-1 LAUNCH ADVISOR CSL
20/21 DAC FACILITY CSL
22 DAC PAD-2 LAUNCH ADVISOR
23 DAC PAD-2 PROP CONT & MON
24 DAC PAD-2 MALFUNCTION & CONT STATUS CSL
25 DAC PAD-1 & 2 WECO CONT CSL
26 DAC PAD-1 & 2 SPIN MOTOR MON
27 CAMERA CONTROLLER
28 DAC OPERATIONS & CONTROL
29/30 DAC ASST LAUNCH COND
31 DAC LAUNCH CONDUCTOR
32 NASA TEST CONTROLLER
33 LAUNCH SUPPORT OFFICER
34 NASA OPERATION & LAUNCH DIR
35/36 ASST OPS & LAUNCH DIR
37 DAC TALKER
38 S/C LAUNCH CONDUCTOR
39 AFWTR COMPLEX SAFETY OFFICER
40 TV MONITORS
41 COUNTDOWN CLOCK

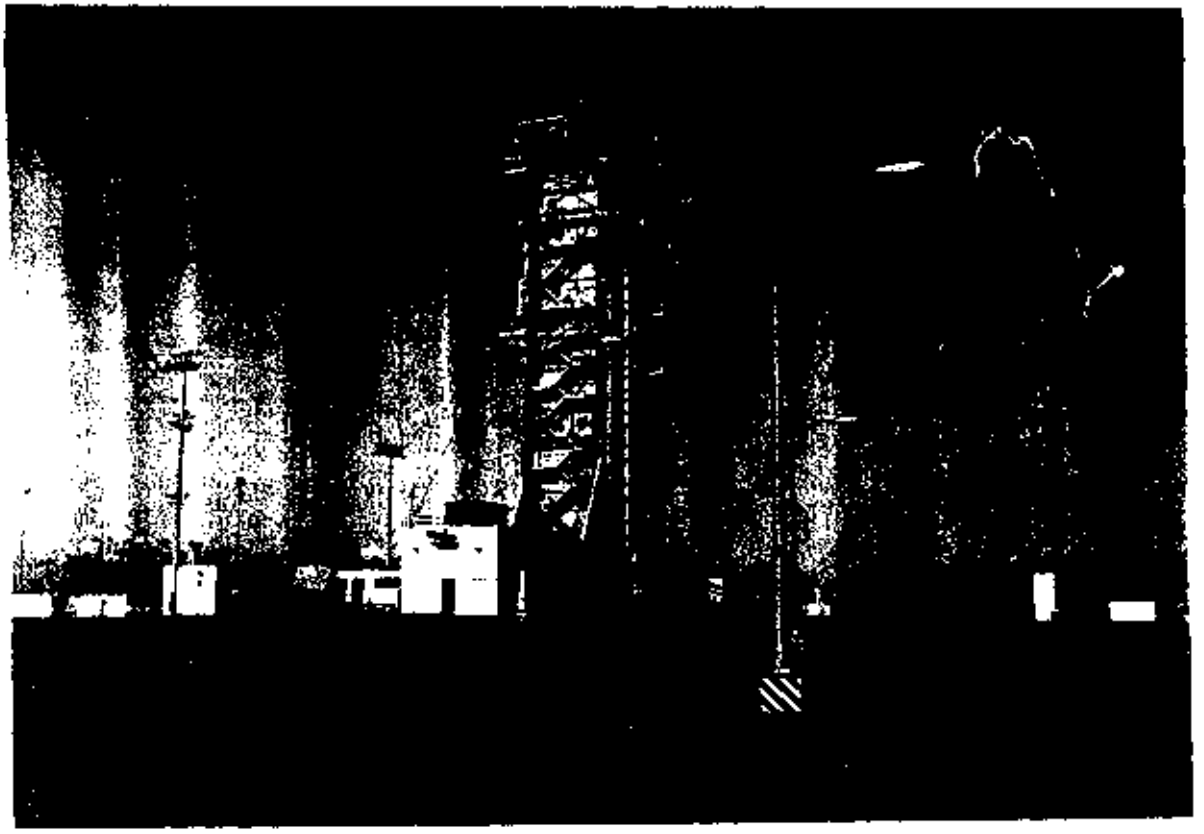
Source: KSC Western Test Range Operations Handbook, p. V-5

1. Space Launch Complex 2W
2. Lompoc, California
3. USAF
4. 1983
5. Vandenberg AFB, California
6. Aerial View of Space Launch Complex 2W

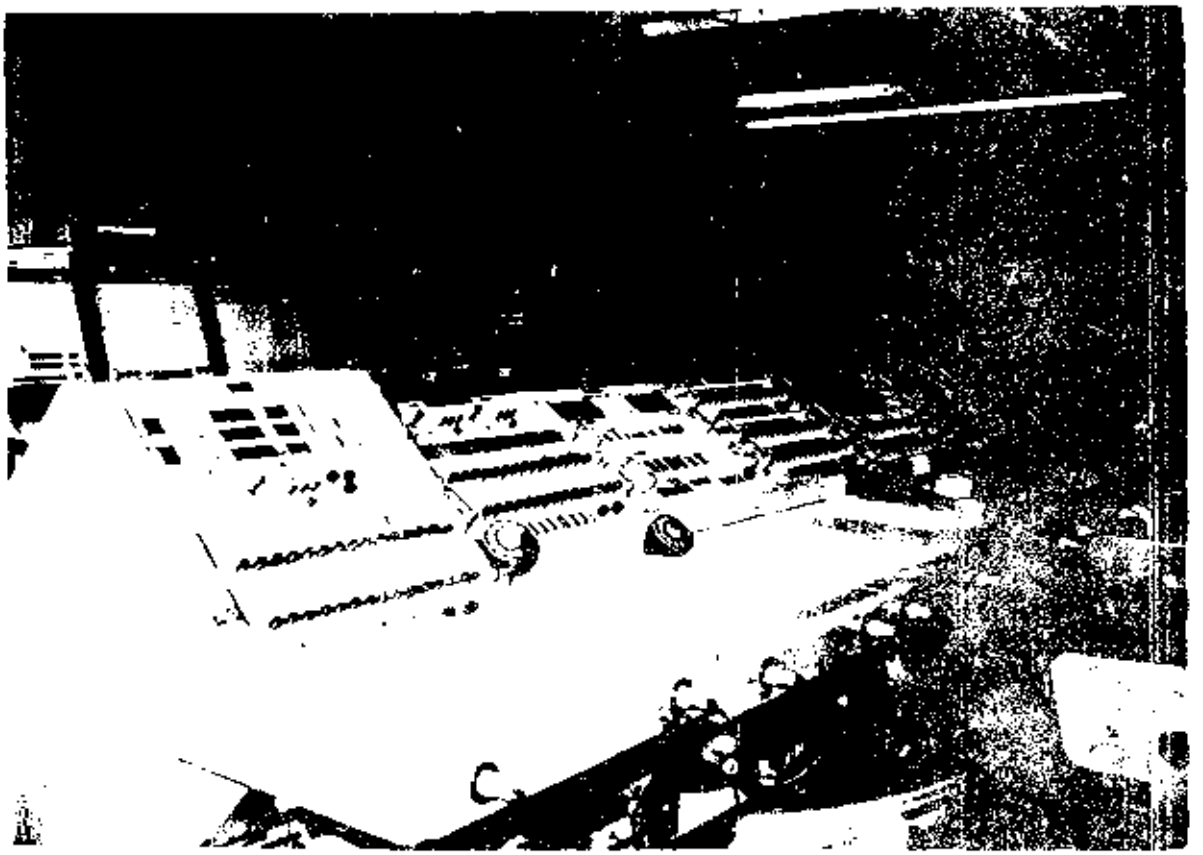
1. Space Launch Complex 2
2. Lompoc, California
3. USAF
4. 1983
5. Vandenberg AFB, California
6. Exterior View



1. Space Launch Complex 2W
2. Lompoc, California
3. USAF
4. 1983
5. Vandenberg AFB, California
6. Exterior View



1. Space Launch Complex 2W
2. Lompoc, California
3. USAF
4. 1983
5. Vandenberg AFB, California
6. Interior View of Blockhouse Firing Room



## APOLLO TRAINING FACILITIES

14. Lunar Landing Research Facility (Langley)

15. Rendezvous Docking Simulator (Langley)

16. Lunar Landing Training Vehicle (Alabama Space and Rocket Center)

17. Neutral Buoyancy Space Simulator (Marshall)

Man in Space Theme Study
Federal Agency Nomination

NPS Form 10-900
(7-81)

**United States Department of the Interior**
**National Park Service**

# National Register of Historic Places Inventory—Nomination Form

For NPS use only
received
date entered

See instructions in *How to Complete National Register Forms*
Type all entries—complete applicable sections

## 1. Name

historic Lunar Landing Research Facility

and/or common Impact Dynamics Research Facility

## 2. Location

street & number Langley Research Center ___ not for publication

city, town Hampton ___ vicinity of congressional district

state Virginia code 51 county Hampton code 650

## 3. Classification

| Category | Ownership | Status | Present Use | |
|---|---|---|---|---|
| ___ district | X public | ___ occupied | ___ agriculture | ___ museum |
| ___ building(s) | ___ private | ___ unoccupied | ___ commercial | ___ park |
| ___ structure | ___ both | ___ work in progress | ___ educational | ___ private residence |
| ___ site | **Public Acquisition** | **Accessible** | ___ entertainment | ___ religious |
| ___ object | ___ in process | X yes: restricted | X government | X scientific |
| | ___ being considered | ___ yes: unrestricted | ___ industrial | X transportation |
| | | ___ no | ___ military | X other: Aeronautical Research |

## 4. Owner of Property

name National Aeronautics and Space Administration (NASA)

street & number

city, town Washington ___ vicinity of state D.C. 20546

## 5. Location of Legal Description

courthouse, registry of deeds, etc. National Aeronautics and Space Administration (NASA)

street & number Real Property Management Office Code NXG

city, town Washington state D.C. 20546

## 6. Representation in Existing Surveys

title None has this property been determined eligible? ___ yes ___ no

date ___ federal ___ state ___ county ___ local

depository for survey records

city, town state

# 7. Description

| Condition | | Check one | Check one |
|---|---|---|---|
| X excellent | ___ deteriorated | ___ unaltered | X original site |
| ___ good | ___ ruins | X altered | ___ moved date _____ |
| ___ fair | ___ unexposed | | |

**Describe the present and original (if known) physical appearance**

The Lunar Landing Research Facility is in the West Area of the Langley Research Center. This facility was constructed in 1965 at a cost of $3.5 million and was used by the Apollo astronauts as a training simulator to study and practice piloting problems in the final phase of the lunar landing mission. A list of the Apollo astronauts that trained on the Lunar Landing Research Facility can be found in Appendix A at the rear of this nomination.

The Lunar Landing Research Facility is an A-frame steel structure 400 feet long and 230 feet high. Associated with this facility is a full-scale Apollo Lunar Excursion Module or LEM. Simulation of lunar gravity is achieved by employing an overhead partial-suspension system which provides a lifting force by means of cables acting through the vehicle's center of gravity so as to effectively cancel all but one-sixth of earth's gravitational force. The lifting force and vertical alignment of the cables are controlled automatically through the action of servo-controlled hydraulic drive systems which power the overhead traveling bridge crane and dolly unit mounted on the large gantry structure. The bridge follows in the down-range motion of the vehicle, and the under-slung dolly follows in the cross-range direction.[1]

The cables are attached to the vehicle by means of a gimbal system which provides freedom of motion in pitch, roll, and yaw. This system consists of a swiveled-truss assembly directly over the cab and two vertical struts attached to the vehicle on its pitch axis. Load cells are carried in the vertical struts to sense cable force for the lift servo system, and cable angle sensors are mounted on the bottom of the dolly to provide error feedback signals for the bridge and dolly servo drive systems. Automatic braking equipment built into the servo drive units provide an extra safety feature. The LEM can fly in a space of about 180 feet high, by 360 feet long, and 42 feet wide.[2]

The LEM was constructed using many pieces of off the shelf equipment such as the H-34 helicopter cabin and landing gear shock struts. Nitrogen gas was used to pressurize the fuel system which provided 90 percent hydrogen peroxide to the main lifting body rocket assembly and to the 20 attitude rocket motors located around the periphery of the vehicle frame. The cab of the LEM can accommodate two persons at the same time. A common instrument panel is mounted between the two pilots. Attitude controls at the right hand seat consist of a set of standard foot pedals for yaw control and a two-axis side-arm controller used for pitch and roll control. The left hand seat is provided with a three-axis side arm controller. Thrust of the main engines is controlled by either pilot with his left hand using the collective pitch levers. Weight of the vehicle is 12,000 pounds, of which 3300 pounds was hydrogen peroxide fuel, giving a flight duration of slightly less than three minutes.[3]

The Lunar Landing Research Facility was also used as a lunar-walking simulator for the Apollo astronauts. This was done by suspending the subject on his side so that he was free to generate walking movements on a plane inclined to about 80.5 degrees relative to the vertical direction of earth's gravity. Suspension for the test subject was supplied by a series of slings and cables attached to a lightweight trolly which traveled freely along an overhead track. By varying the angle of the inclined plane it was possible to simulate other gravitational fields. For example, to simulate the condition of weightlessness, the walkway would be moved directly under the track so that the cables were vertical and the test subject horizontal.[4]

The base of the Lunar Landing Facility was modeled with fill dirt to resemble the surface of the Moon. Pock-marked holes, pits and craters resemble the lunar landscape encountered by Apollo 11 when it landed on the Moon in July 1969.

The Lunar Landing Facility is intact and retains almost all of its design integrity. The facility is now known as the Impact Dynamics Research Facility and is used by NASA Langley for aircraft impact studies. The base of the facility has been modified so that the simulated lunar landscape is gone and has been replaced by an impact runway that can be modified to simulate various types of crash environments. The complex cable system that once carried the LEM now supports various test aircraft in crash studies. The lunar walkway has been removed. The LEM is on the site but the main engine and some of the controls have been removed. The original electronics associated with the site are in the process of being upgraded to meet modern requirements of the crash testing program.

An institutional rehabilitation of the office portion of the facility is now underway and will be completed by October 1, 1984.

# 8. Significance

| Period | Areas of Significance—Check and justify below | | | |
|---|---|---|---|---|
| ___ prehistoric | ___ archeology-prehistoric | ___ community planning | ___ landscape architecture | ___ religion |
| ___ 1400–1499 | ___ archeology-historic | ___ conservation | ___ law | ___ science |
| ___ 1500–1599 | ___ agriculture | ___ economics | ___ literature | ___ sculpture |
| ___ 1600–1699 | ___ architecture | ___ education | ___ military | ___ social/ humanitarian |
| ___ 1700–1799 | ___ art | X engineering | ___ music | ___ theater |
| ___ 1800–1899 | ___ commerce | ___ exploration/settlement | ___ philosophy | X transportation |
| X 1900– | ___ communications | ___ industry | ___ politics/government | X other (specify) Space Exploration |
| | | ___ invention | | |

**Specific dates** 1965–1972 **Builder/Architect** NASA

**Statement of Significance (in one paragraph)**

The Lunar Landing Research Facility permitted NASA to train the Apollo astronauts to fly in a simulated lunar environment that produced LEM vehicle dynamics. This training gave Neil Armstrong and others the opportunity to safely experience the dynamics of lunar flight while in a controlled research environment. Experience gained at the Lunar Landing Research Facility enabled Neil Armstrong and others to train with a greater degree of confidence on the Lunar Research Training vehicle at Houston and Edwards Air Force Base and eventually to journey to the moon in July 1969.

The decision by President John F. Kennedy to land a man on the Moon by 1969 meant that NASA had to quickly determine the method of accomplishing the journey. NASA engineers evaluated three means to do this by 1962: direct ascent, Earth-orbit rendezvous (EOR), or lunar-orbit rendezvous (LOR).

Direct ascent to the moon was ruled out because of the size of the launch vehicle required to accomplish the mission. The EOR concept was ruled out because two launch vehicles were required to meet mission requirements. NASA chose the LOR concept which called for a single rocket to launch two spacecraft into lunar orbit where one would remain in orbit while the other would decend to the Moon. The vehicle on the Moon would then boost itself back into lunar orbit, rendezvous and dock with the mother ship, which would then return to the Earth.

While this was a bold plan that held out the promise of achieving a lunar landing by 1969 it presented many technical difficulties. The LOR plan was based on the premise that NASA trained astronauts could master the techniques of landing the LEM on the lunar surface and returning to orbit and docking with the mother ship. The Lunar Landing Research Facility was designed to solve one part of this problem, that is, how to land men on the surface of the Moon. The need for such a facility arose from the fact that there was no direct parallel between the unique piloting problems of the LEM and normal aircraft operating in Earth's atmosphere. Conditions encountered by the LEM were different due to the Moon's lack of an atmosphere and low gravitational force. For example, a vehicle operating in the vicinity of the Moon requires the use of control rockets which are operated in an on-off manner, thereby producing abrupt changes in control torques rather than the smoothly modulated controlled torques of a helicopter. Furthermore, inasmuch as the LEM hovers with a thrust equal to its weight, the lunar vehicle hovers with only one-sixth of the thrust required to hover the same vehicle in Earth's gravity. As a result, the control system characteristics in translation are markedly different from those of an Earth vehicle, thus precluding the extrapolation of results in Earth conditions to lunar conditions.[5]

Experiences gained by the Apollo astronauts on the Lunar Landing Research Facility indicated that it was possible to successfully master the complicated skills that were required to land the LEM on the Moon. Both Neil Armstrong and Edwin Aldrin trained there for many hours. Only when they successfully mastered skills necessary to fly the LEM would NASA approve plans for their historic first landing on the Moon in July 1969.

Because of this, the Lunar Landing Research Facility was an indispensable tool that enabled NASA to land a man on the Moon by July 1969.

Footnotes

1. Donald E. Hewes, Reduced Gravity Simulator For Studies of Man's Mobility In Space And On The Moon. Report Presented at the Human Factors Meeting, Dayton, Ohio, October 18-21, 1965 (Hampton, Va.: Langley Research Center, 1965), p 3.

2. Ibid.

3. Ibid., 4.

4. Ibid., 1-2.

5. No Author Given, Lunar Landing Research Facility (Hampton, Va.: Langley Research Center, 1969), p. 1-2.

Bibliography

Benson, Charles D., and Faherty, William Barnaby. Moonport: A History of Apollo Launch Facilities and Operations. Washington D.C.: National Aeronautics and Space Administration, 1979.

Brooks, Courtney G.; Grimwood, James.; and Swenson, Jr., Loyd S. Chariots for Apollo: A History of Manned Lunar Spacecraft. Washington, D.C.: National Aeronautics and Space Administration, 1979.

Hewes, Donald E. Reduced Gravity Simulator For Studies of Man's Mobility In Space And On The Moon. Report Presented at the Human Factors Meeting Dayton, Ohio, October 18-21, 1965. Hampton, Va.: Langley Research Center 1965.

Levine, Arnold S. Managing NASA in the Apollo Era. Washington, D.C.: National Aeronautics and Space Administration, 1982.

Lunar Landing Research Facility. No Author Given. Hampton, Va.: Langley Research Center, 1969.

Morse, Mary Louise, and Bays, Jean Kernahan. The Apollo Spacecraft: A Chronology. Washington, D.C.: National Aeronautics and Space Administration, 1973.

Technical Facilities Catalog Vol.1. Washington, D.C.: National Aeronautics and Space Administration, 1974.

U.S. Congress. House, United States Civilian Space Programs A Report prepared for the Subcommittee on Space Science and Applications. Serial D, Vol. 1, January 1981.

## 9. Major Bibliographical References

See continuation sheets

## 10. Geographical Data

Acreage of nominated property Less than 1 acre

Quadrangle name Newport News North

Quadrangle scale 1:24,000

UMT References

| | Zone | Easting | Northing | | Zone | Easting | Northing |
|---|---|---|---|---|---|---|---|
| A | 18 | 376500 | 4106900 | B | | | |
| C | | | | D | | | |
| E | | | | F | | | |
| G | | | | H | | | |

Verbal boundary description and justification

The boundary of the Lunar Landing Research Facility is shown as the black circle on the accompanying map entitled "NASA, Langley Research Center, Figure 1-4, West Area."

List all states and counties for properties overlapping state or county boundaries

| state | code | county | code |
|---|---|---|---|
| | | | |
| state | code | county | code |

## 11. Form Prepared By

name/title Harry A. Butowsky

organization National Park Service date May 15, 1984

street & number Division of History telephone (202) 343-8168

city or town Washington, D.C. 20240 state

## 12. State Historic Preservation Officer Certification

The evaluated significance of this property within the state is:

___ national ___ state ___ local

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89-665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service.

State Historic Preservation Officer signature

title date

For NPS use only

I hereby certify that this property is included in the National Register

date

Keeper of the National Register

Attest: date

Chief of Registration

Appendix A

## ASTRONAUTS TRAINED AT LUNAR LANDING RESEARCH FACILITY

Armstrong, Neil A.

Aldrin, Edwin E., Jr.

Anders, William A.

Bean, Alan L.

Borman, Frank

Carr, Gerald P.

Cernan, Eugene A.

Chaffee, Roger

Cooper, L. Gordon, Jr.

Conrad, Charles

Duke, Charles M.

Engle, Joe N.

Haise, Fred W., Jr.

Irwin, James B.

Lovell, James A., Jr.

McDivitt, James A.

Mitchell, Edgar D.

Schmitt, Harrison H.

Schweickart, Russell L.

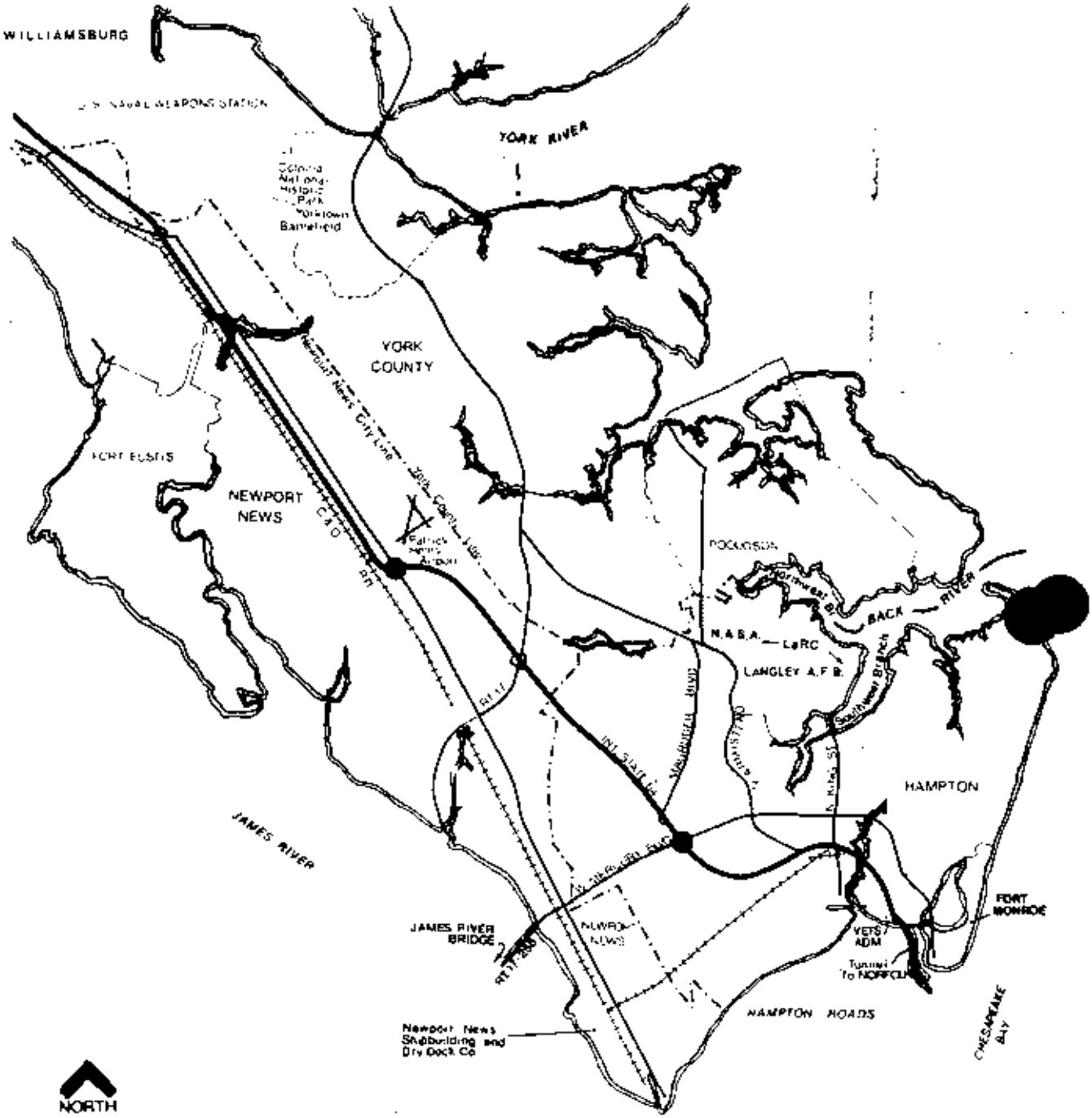
Scott, David R.

Shepard, Allen B., Jr.

Stafford, Thomas P.

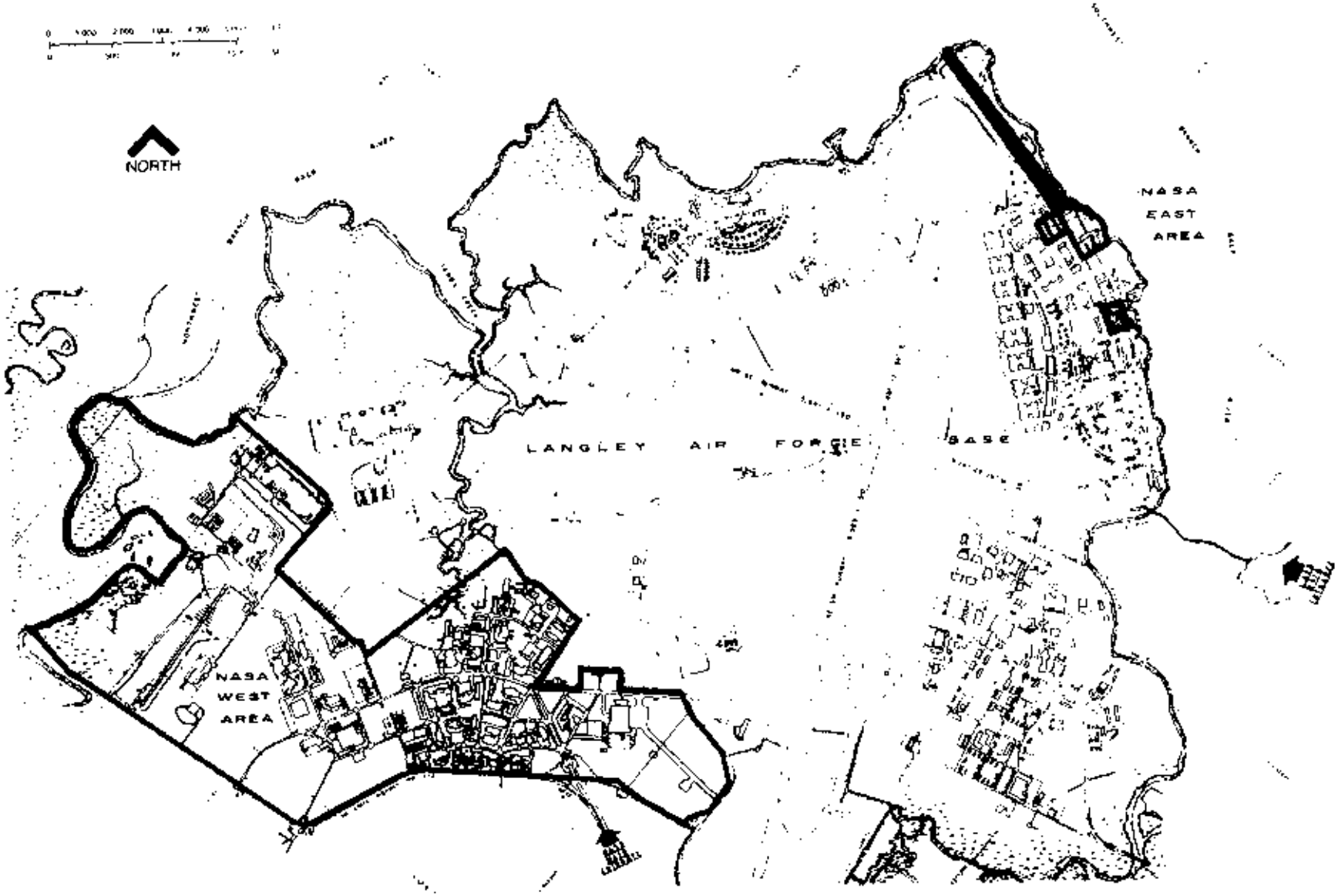
Williams, C. C.

Young, John W.




NASA
National Aeronautics and Space Administration
**Langley Research Center**
Hampton, Virginia
23665

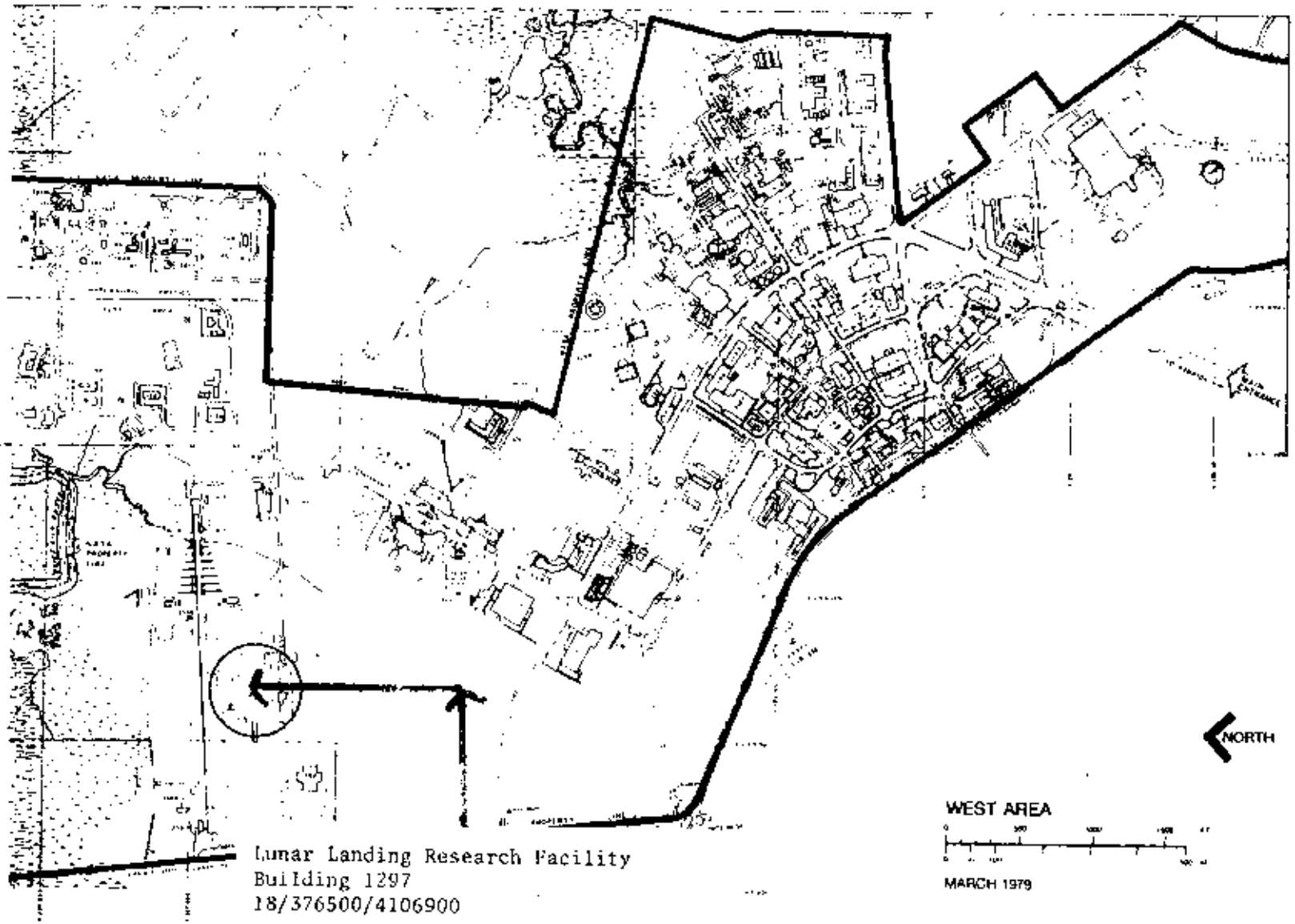
**FIGURE 1-1**
**Regional Map**




NASA
National Aeronautics and
Space Administration

**Langley Research Center**
Hamp[illegible] Virginia
23665

**FIGURE 1-2**
**Combined East & West Area**

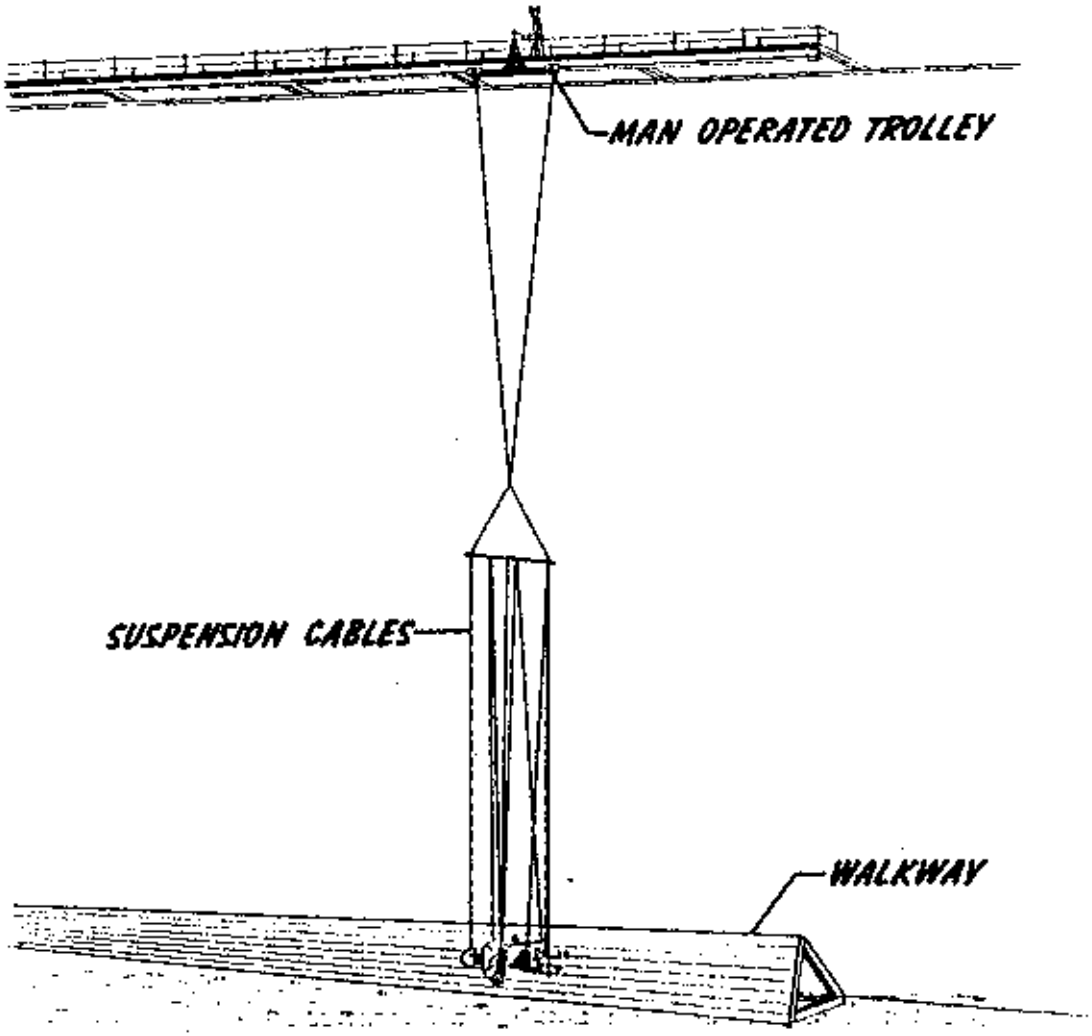



NASA
National Aeronautics and
Space Administration

**Langley Research Center**
Hampton, Virginia
23665

**FIGURE 1-4**
**West Area**

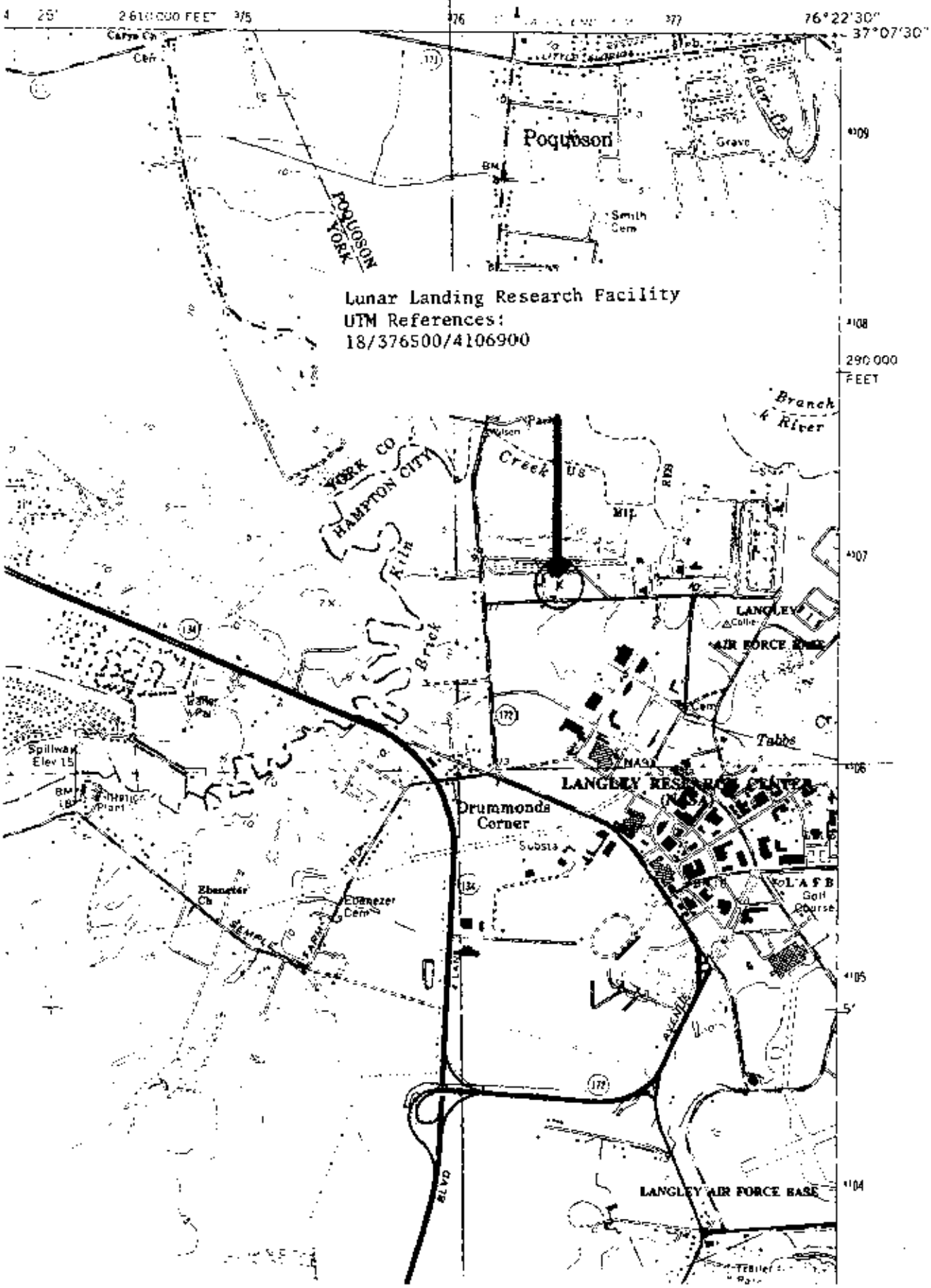
# MAN SELF-LOCOMOTION STUDIES




Sketch illustrating the lunar walking simulator.

Source: Hewes, p. 8.

NEWPORT NEWS NORTH QUADRANGLE
VIRGINIA
7.5 MINUTE SERIES (TOPOGRAPHIC)



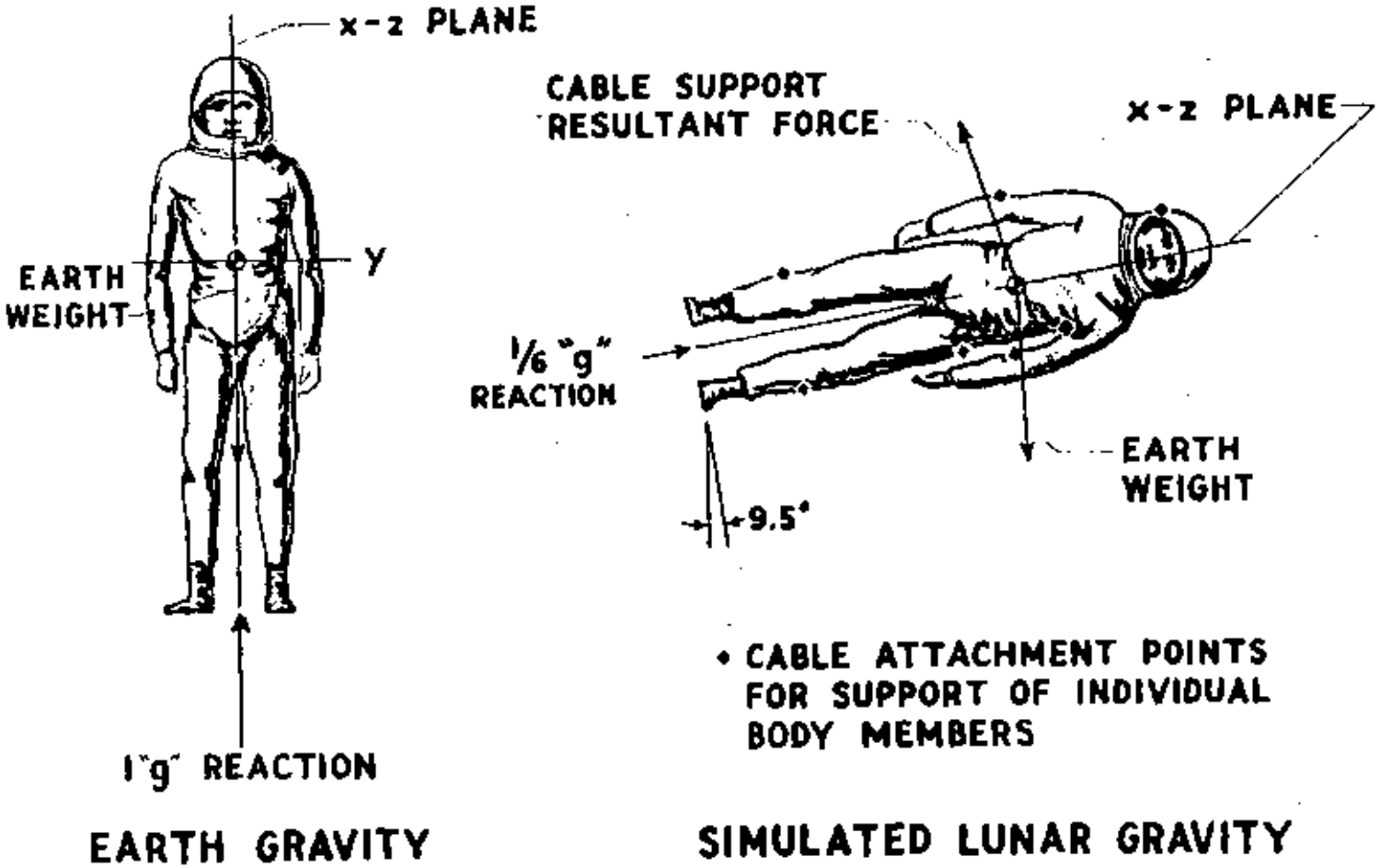
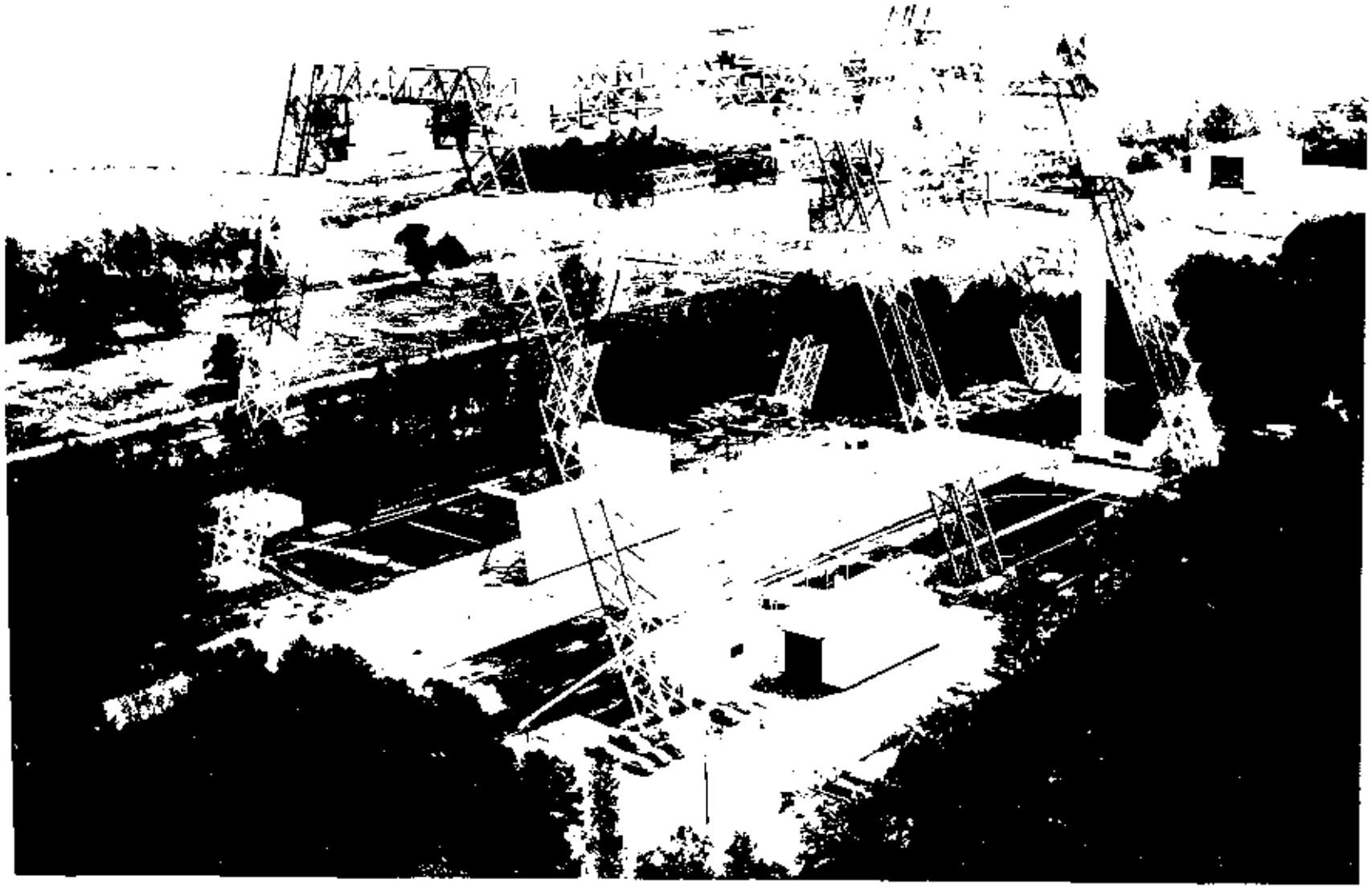



Illustration of lunar gravity simulation technique for self-locomotive studies.

Source: Hewes, p. 7.

1. Lunar Landing Research Facility
2. Hampton, Virginia
3. NASA
4. 1981
5. NASA, Langley Research Center Facilities Office
6. Aerial View of Lunar Landing Research Facility

NASA
L-61-5980

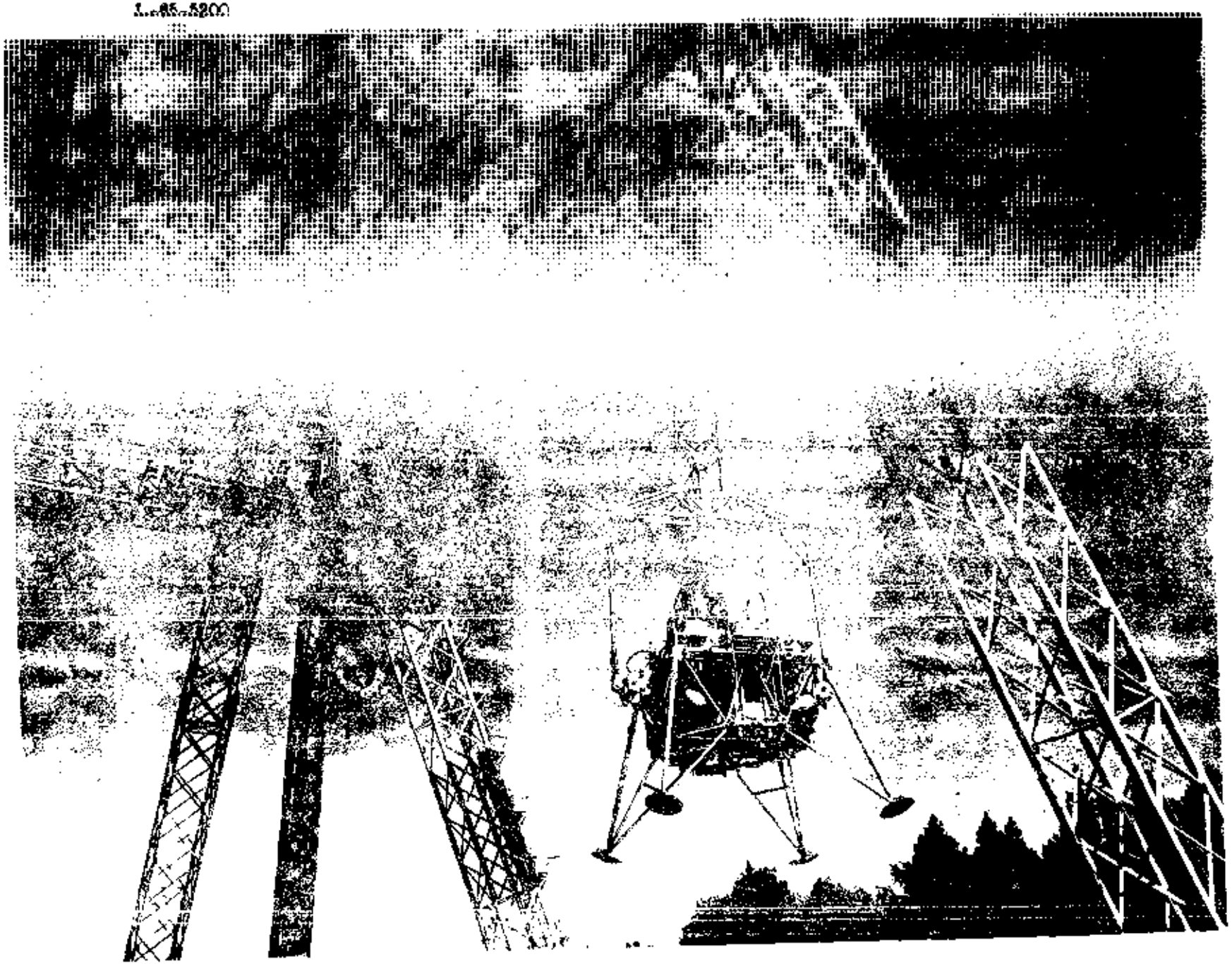


1. Lunar Landing Research Facility
2. Hampton, Virginia
3. NASA
4. 1979
5. NASA, Langley Research Center Facilities Office
6. Ground View of Lunar Landing Research Facility

NASA
L-79-6046

1. Lunar Landing Research Facility
2. Hampton, Virginia
3. NASA
4. 1965
5. NASA, Langley Research Center Facilities Office
6. LEM hanging from overhead partial - suspension system

NASA
L-65-5200



NPS Form 10-900
(7-81)

**United States Department of the Interior**
**National Park Service**

For NPS use only
received
date entered

# National Register of Historic Places Inventory—Nomination Form

See instructions in *How to Complete National Register Forms*
Type all entries—complete applicable sections

## 1. Name

historic Rendezvous Docking Simulator

and/or common Real-Time Dynamic Simulator

## 2. Location

street & number Langley Research Center ___ not for publication

city, town Hampton ___ vicinity of congressional district

state Virginia code 51 county Hampton code 650

## 3. Classification

| Category | Ownership | Status | Present Use | |
|---|---|---|---|---|
| ___ district | X public | ___ occupied | ___ agriculture | ___ museum |
| ___ building(s) | ___ private | ___ unoccupied | ___ commercial | ___ park |
| ___ structure | ___ both | ___ work in progress | ___ educational | ___ private residence |
| ___ site | **Public Acquisition** | **Accessible** | ___ entertainment | ___ religious |
| ___ object | ___ in process | X yes: restricted | ___ government | ___ scientific |
| | ___ being considered | ___ yes: unrestricted | ___ industrial | ___ transportation |
| | | ___ no | ___ military | X other: Inactive |

## 4. Owner of Property

name National Aeronautics and Space Administration (NASA)

street & number

city, town Washington ___ vicinity of state D.C. 20546

## 5. Location of Legal Description

courthouse, registry of deeds, etc. National Aeronautics and Space Administration (NASA)

street & number Real Property Management Office Code NXG

city, town Washington state D.C. 20546

## 6. Representation in Existing Surveys

title None has this property been determined eligible? ___ yes ___ no

date ___ federal ___ state ___ county ___ local

depository for survey records

city, town state

# 7. Description

| Condition | | Check one | Check one |
|---|---|---|---|
| X excellent | ___ deteriorated | ___ unaltered | X original site |
| ___ good | ___ ruins | X altered | ___ moved date _____ |
| ___ fair | ___ unexposed | | |

**Describe the present and original (if known) physical appearance**

The Rendezvous Docking Simulator (RDS) is in Building 1244 in the East Area of the Langley Research Center. The RDS is a full-scale dynamic facility which was used to study pilot-controlled docking of various types of space vehicles. It was built in 1963 and simulated contolled docking procedures for both the Gemini spacecraft with the Agena booster and the Apollo Lunar Excursion Module with the Command Module.

The simulator consists of an overhead carriage and cable-suspended gimbal system. The carriage is electrically driven and provides three degrees of freedom in translation. The gimbal is hydraulically driven and provides three degrees of freedom in rotation. Thus, the pilot flies the vehicle in six-degree-of-freedom motion which is controlled in a closed-loop fashion through a ground-based analog computer. The operating volume of the simulator is 210 feet horizontally by 15 feet laterally and 40 feet vertically. This enabled the test pilots to dock with target Gemini and Apollo spacecraft in a three dimensional mode.[1] Depending upon the test, either a full scale module of the Gemini or Apollo spacecraft, could be hung from the simulator.

After the completion of the Apollo program the Rendezvous Docking Simulator was modified to solve open-and-closed loop pilot control problems, aircraft landing approaches, simulator validation studies, and passenger ride quality studies. The name of the facility was changed and it is now called the Real-Time Dynamic Simulator. Modifications to the facility consisted of removing the Apollo Command Module cockpit and installing an aircraft cockpit. The system was also linked to the Langley real-time digital computer system and Langley landing terrain scene generator.[2] At the present time this facility is no longer in use.

# 8. Significance

| Period | Areas of Significance—Check and justify below | | | |
|---|---|---|---|---|
| ___ prehistoric | ___ archeology-prehistoric | ___ community planning | ___ landscape architecture | ___ religion |
| ___ 1400–1499 | ___ archeology-historic | ___ conservation | ___ law | ___ science |
| ___ 1500–1599 | ___ agriculture | ___ economics | ___ literature | ___ sculpture |
| ___ 1600–1699 | ___ architecture | ___ education | ___ military | ___ social/ humanitarian |
| ___ 1700–1799 | ___ art | X engineering | ___ music | ___ theater |
| ___ 1800–1899 | ___ commerce | ___ exploration/settlement | ___ philosophy | X transportation |
| X 1900– | ___ communications | ___ industry | ___ politics/government | X other (specify) Space Exploration |
| | | ___ invention | | |

**Specific dates** 1963-1972 **Builder/Architect** NASA

**Statement of Significance (in one paragraph)**

The Rendezvous Docking Simulator is significant because it permitted NASA to train Gemini and Apollo astronauts in docking procedures they had to master before attempting to land on the moon. The simulator gave the astronauts the experience of a docking spacecraft in a safe three dimensional mode that closely approximated a space environment. Training received here and in the Lunar Landing Research Facility was indispensable to accomplishing the goal of landing men on the moon by 1969.

The decision by President Kennedy to land a man on the moon by 1969 meant that NASA had to quickly decide the method of accomplishing the journey. NASA engineers decided that the best method of accomplishing the goal of the moon landing was through the concept of the lunar orbit rendezvous (LOR) which called for a single Saturn V launch of two spacecraft into lunar orbit where one would remain in orbit and the other would descend to the moon. Successful completion of this method of traveling to the moon meant that the vehicle on the moon would have to boost itself back into lunar orbit, rendezvous, and dock with the mother ship and then return to the Earth.

The LOR technique was a bold decision to speed up the schedule for landing a man on the moon. To accomplish this mission it was essential that Apollo astronauts be trained in all aspects and problems likely to arise in the attempt to dock the Apollo Command and Lunar Excursion Modules in lunar orbit. Failure to accomplish this docking would result in the failure of the entire mission and the likely loss of the lives of the astronauts. This justified the need for the Rendezvous Docking Simulator. Only when the Apollo astronauts had successfully mastered rendezvous and docking skills, learned on this facility, would NASA give permission for the attempt to land on the moon.

Footnotes

1. Howard G. Hatch, Jr., Jack E. Pennington, and Jere B. Cobb, Dynamic Simulation of Lunar Module Docking with Apollo Module in Lunar Orbit NASA TN D-3972 (Hampton, Va: Langley Research Center, No Date), p. 3.

2. Technical Facilities Catalog Vol. 1. (Washington, D.C.: National Aeronautics and Space Administration, 1974), pp. 3-44, 3-45.

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Benson, Charles D., and Faherty, William Barnaby. Moonport: A History of Apollo Launch Facilities and Operations. Washington D.C.: National Aeronautics and Space Administration, 1979.

Brooks, Courtney G., Grimwood, James, and Swenson, Jr., Loyd S. Chariots for Apollo: A History of Manned Lunar Spacecraft. Washington, D.C.: National Aeronautics and Space Administration, 1979.

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Pennington, Jack E., Hatch, Howard, Jr., G., and Driscoll, Norman R. A Full-Size Pilot-Controlled Docking Simulation of the Apollo Command and Service Module with the Lunar Module. NASA TN D-3688. Hampton, Va.: Langley Research Center, 1966.

Technical Facilities Catalog Vol. 1. National Aeronautics and Space Administration, 1974.

U.S. Congress. House, United States Civilian Space Programs A Report prepared for the Subcommittee on Space Science and Applications. Serial D, Vol. 1, January 1981.

## 9. Major Bibliographical References

See continuation sheets

## 10. Geographical Data

Acreage of nominated property Less than 1 acre

Quadrangle name Newport News North

Quadrangle scale 1:24,000

UMT References

| | Zone | Easting | Northing |
|---|---|---|---|
| A | 18 | 377520 | 4105060 |
| B | | | |
| C | | | |
| D | | | |
| E | | | |
| F | | | |
| G | | | |
| H | | | |

Verbal boundary description and justification

The boundary of the Rendezvous and Docking Simulator is contained within the perimeter of Building 1244 in the East Area of the Langley Research Center.

List all states and counties for properties overlapping state or county boundaries

state code county code

state code county code

## 11. Form Prepared By

name/title Harry A. Butowsky

organization National Park Service date May 15, 1984

street & number Division of History telephone (202) 343-8168

city or town Washington, D.C. 20240 state

## 12. State Historic Preservation Officer Certification

The evaluated significance of this property within the state is:

___ national ___ state ___ local

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89-665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service.

State Historic Preservation Officer signature

title date

For NPS use only

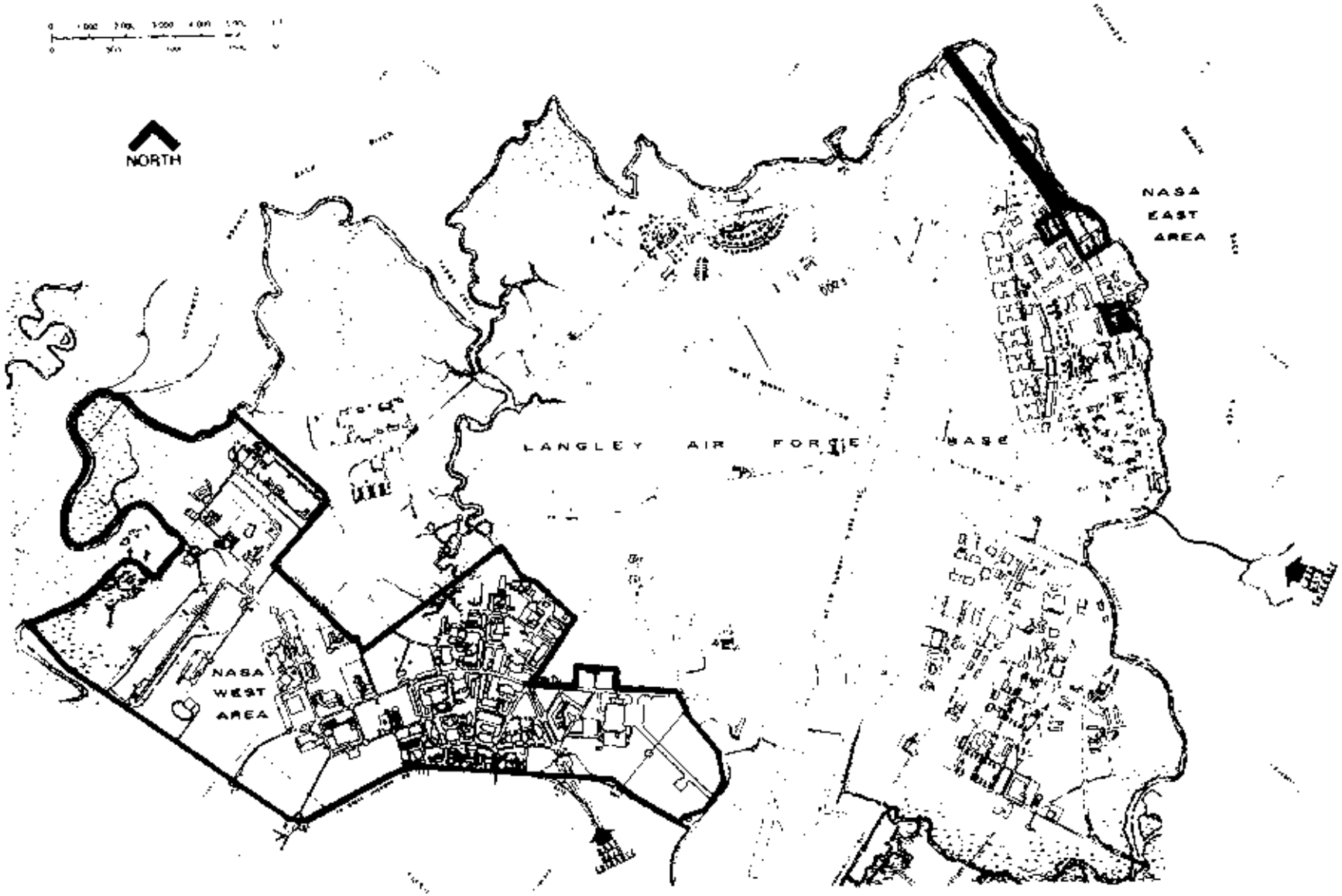
I hereby certify that this property is included in the National Register

date

Keeper of the National Register

Attest: date

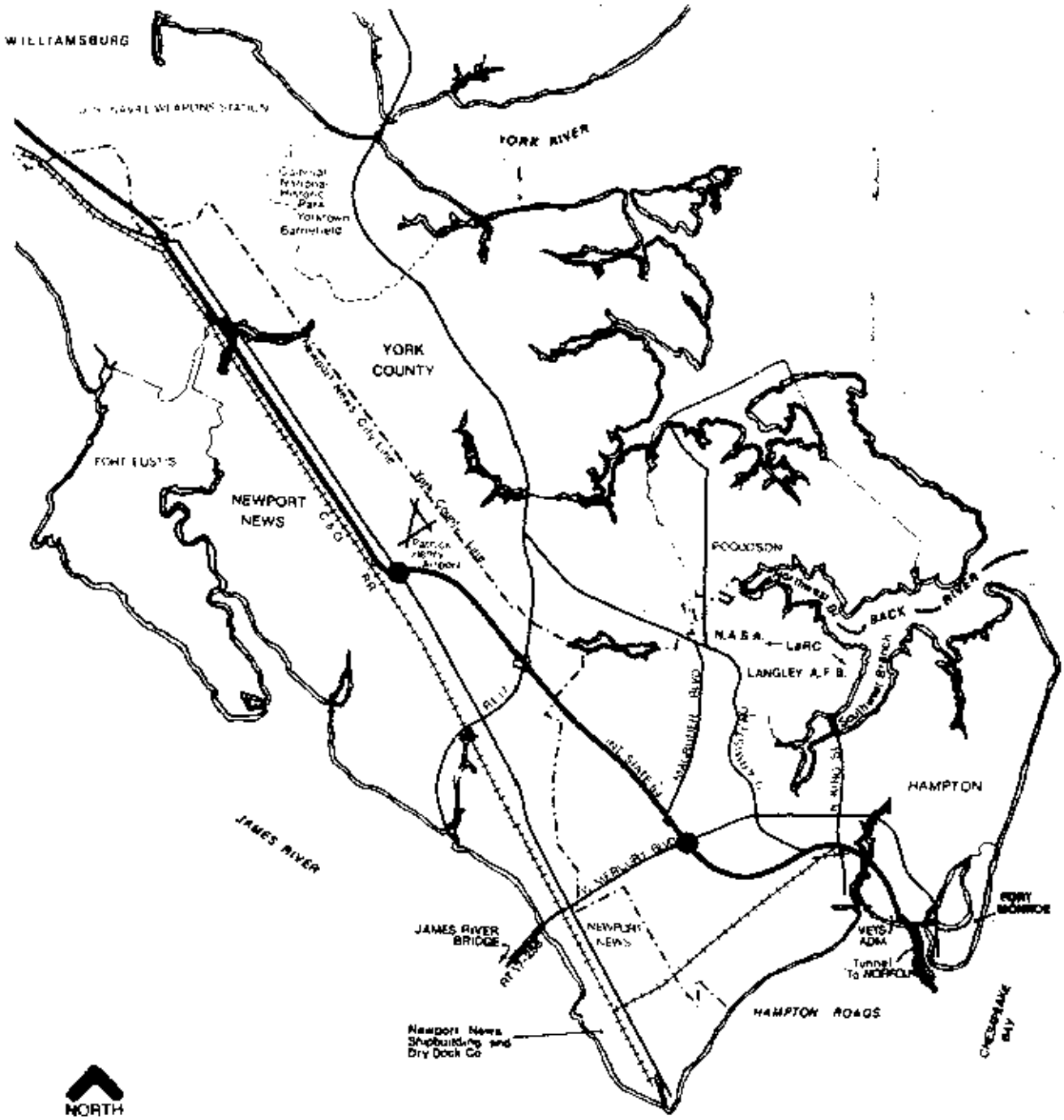
Chief of Registration




NASA
National Aeronautics and
Space Administration

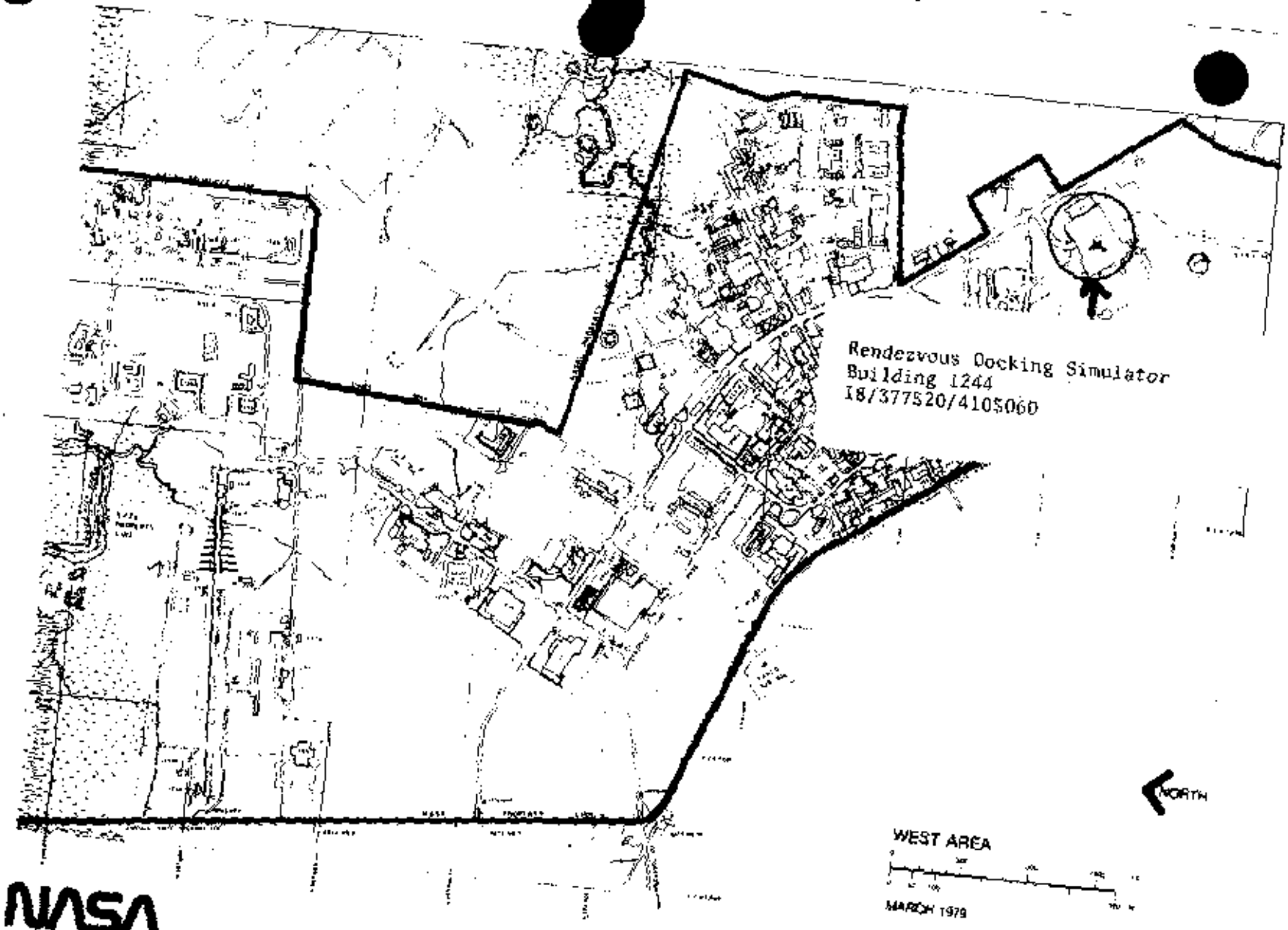
**Langley Research Center**
Hampton, Virginia
23665

**FIGURE 1-2**
**Combined East & West Area**




NASA
National Aeronautics and Space Administration
**Langley Research Center**
Hampton, Virginia
23665

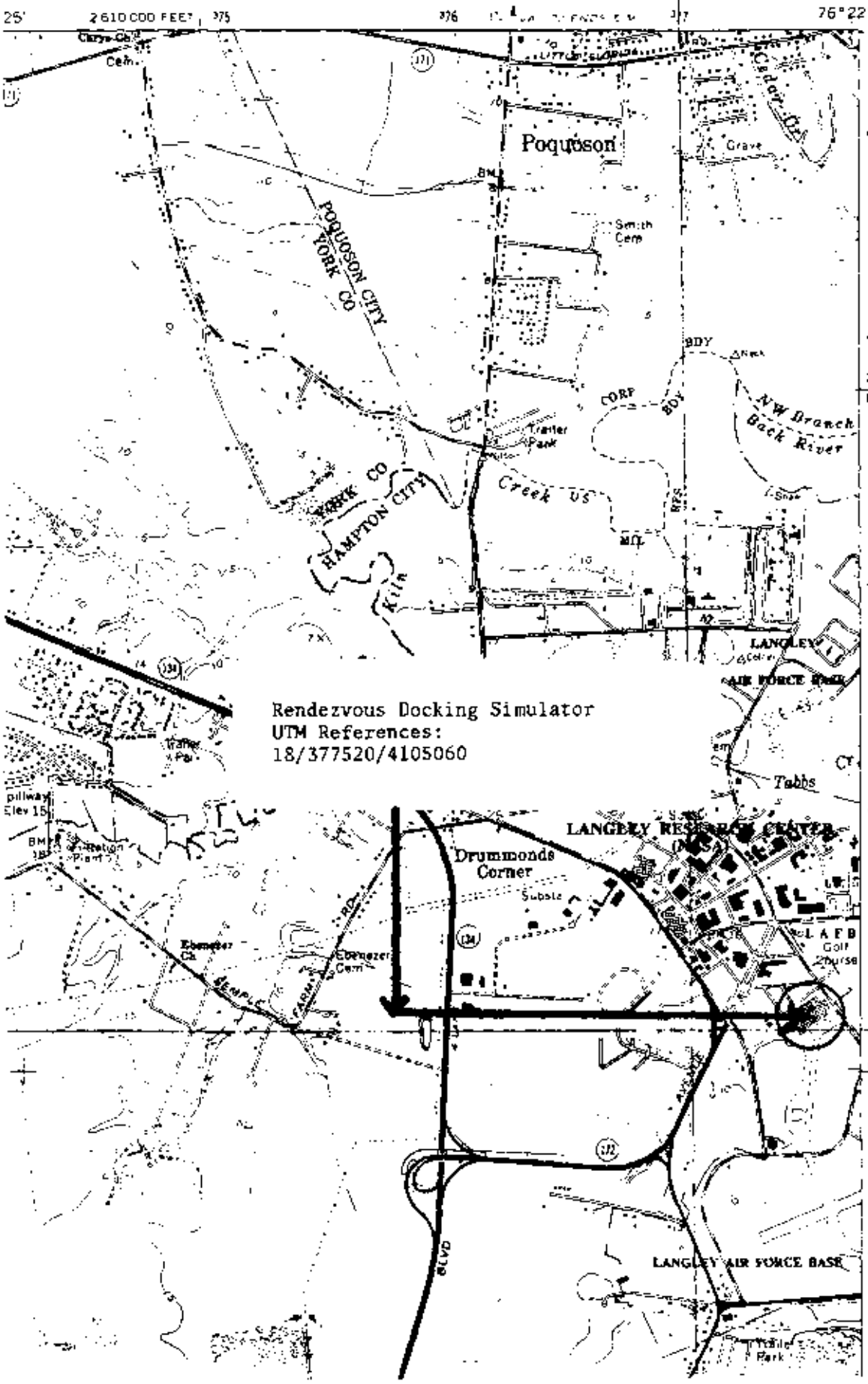
**FIGURE 1-1**
**Regional Map**



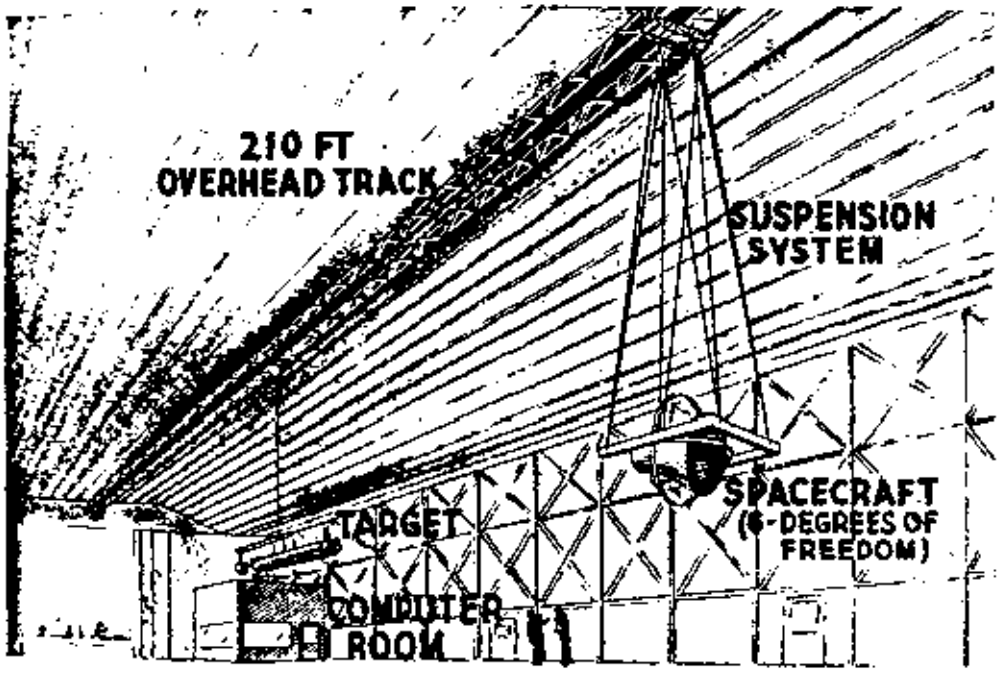

NASA
National Aeronautics and Space Administration
Langley Research Center
Hampton, Virginia
23665

FIGURE 1-4
West Area

# NEWPORT NEWS NORTH QUADRANGLE
VIRGINIA
7.5 MINUTE SERIES (TOPOGRAPHIC)



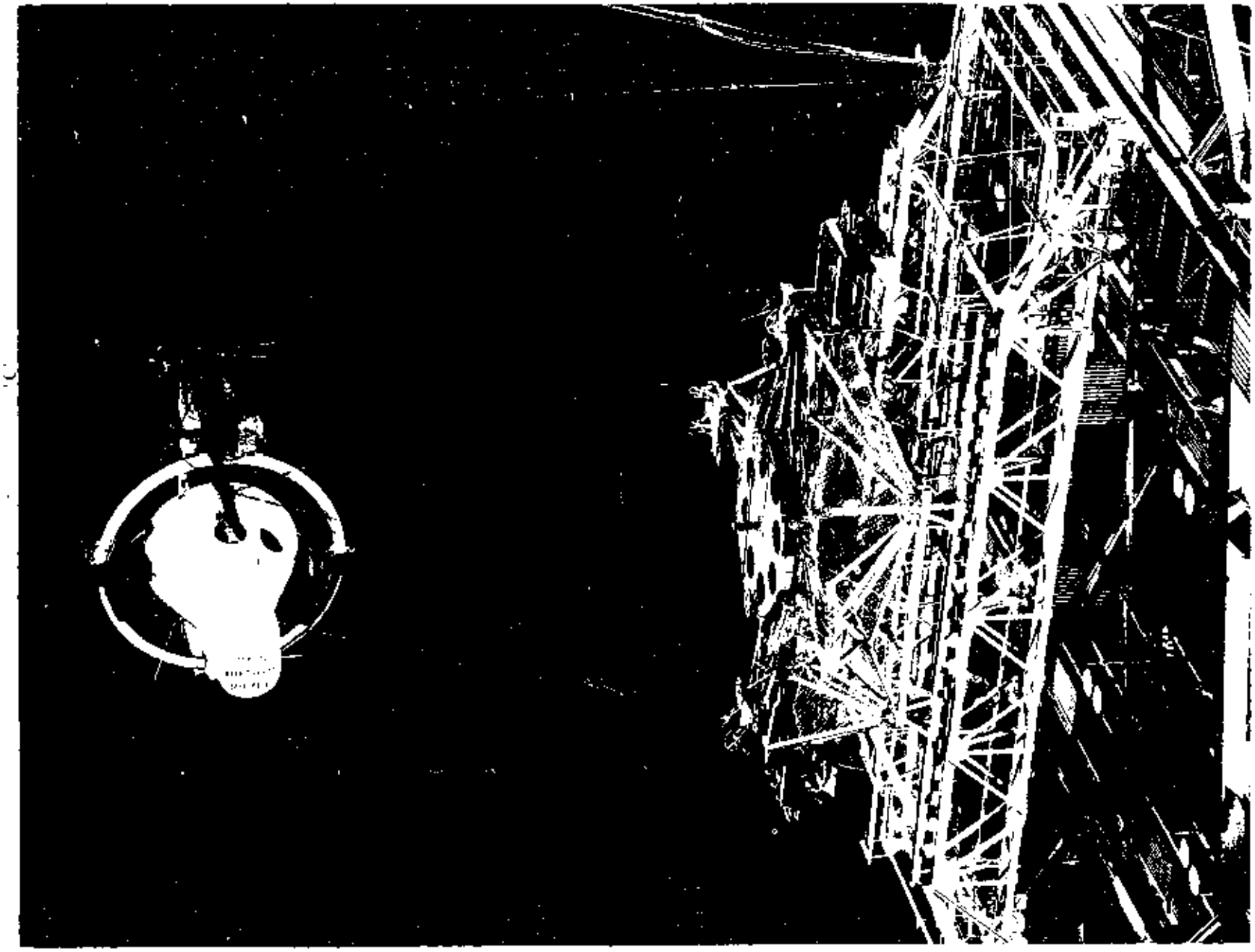
Rendezvous Docking Simulator




Source: Technical Facilities Catalog Vol. 1, 1967, p. 4-35.

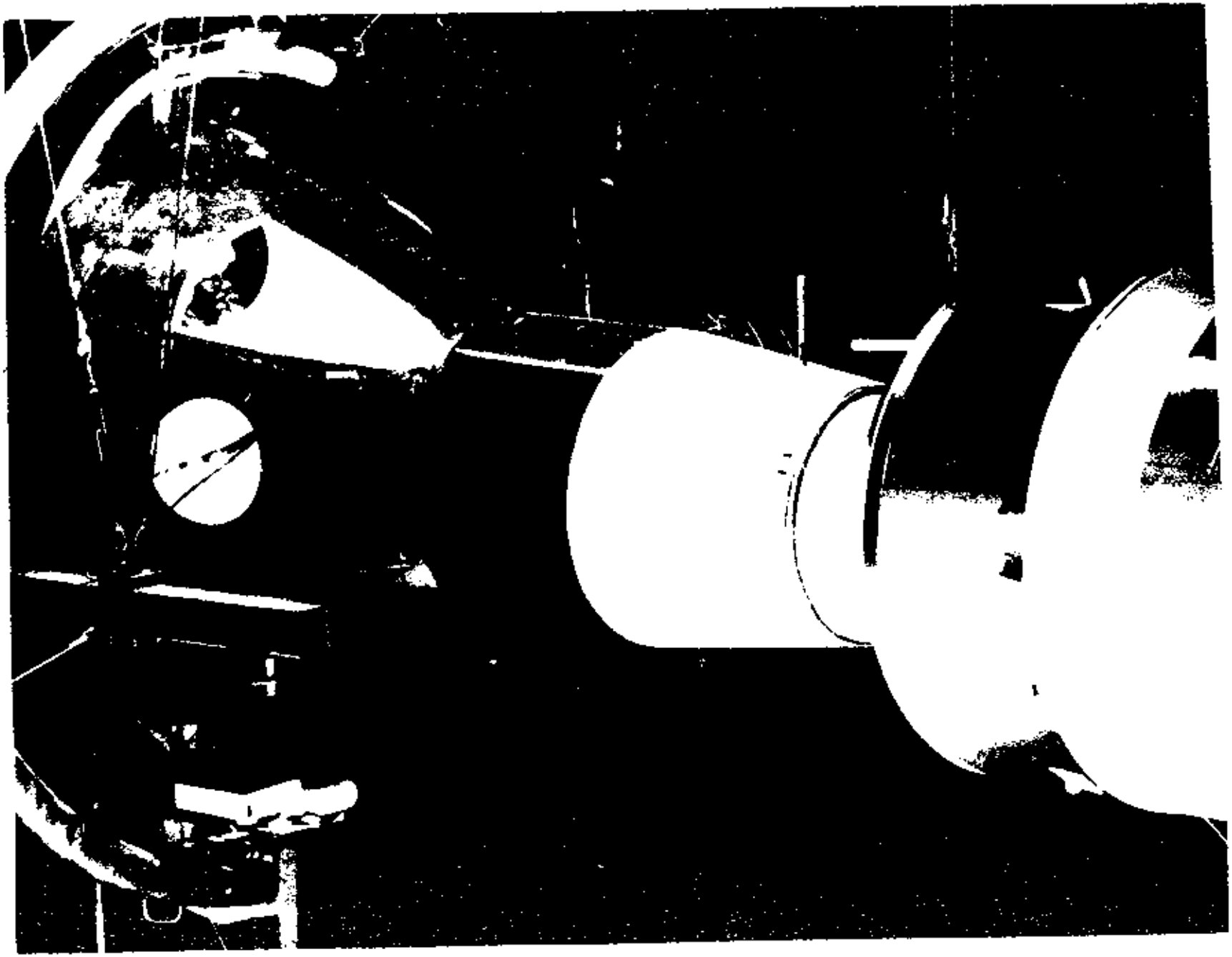
1. Rendezvous Docking Simulator
2. Hampton, Virginia
3. NASA
4. 1964
5. NASA, Langley Archives Office
6. Rendezvous Docking Simulator with Gemini module

NASA
L-64-4307



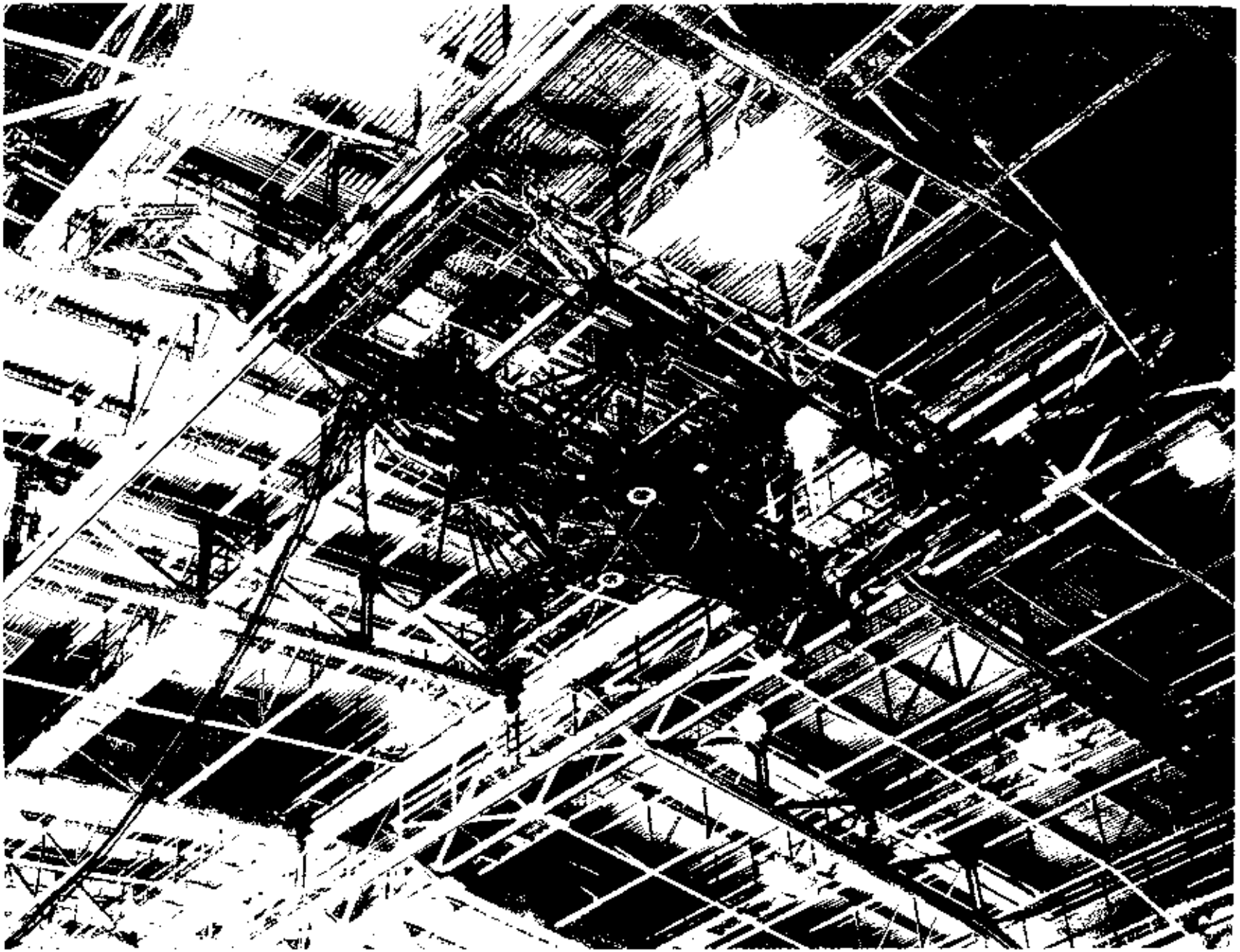
1. Rendezvous Docking Simulator
2. Hampton, Virginia
3. NASA
4. 1964
5. NASA, Langley Archives Office
6. Rendezvous Docking Simulator Gemini module with Agena Target Vehicle

NASA
L-64-3506



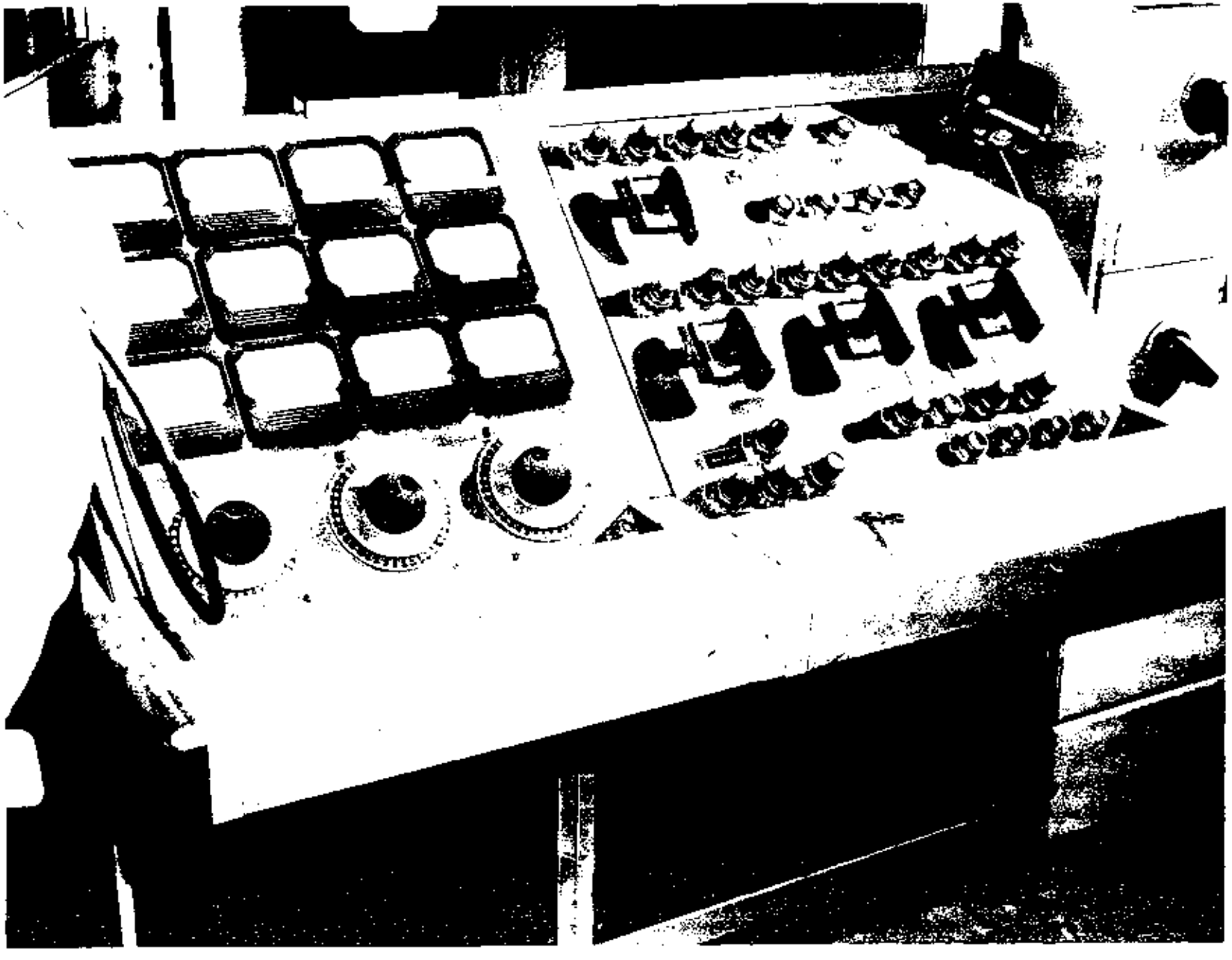
1. Rendezvous Docking Simulator
2. Hampton, Virginia
3. NASA
4. 1984
5. NASA, Langley Research Center Facilities Office
6. Modern view of RDS on top of Building 1244

NASA
L-84-5320



1. Rendezvous Docking Simulator
2. Hampton, Virginia
3. NASA
4. 1984
5. NASA, Langley Research Center Facilities Office
6. Control Panel for the RDS

NASA
L-84-5318



1. Rendezvous Docking Simulator
2. Hampton, Virginia
3. NASA
4. 1984
5. NASA, Langley Research Center Facilities Office
6. Control Panel for the RDS

# 8. Significance

| Period | Areas of Significance—Check and justify below | | | |
|---|---|---|---|---|
| ___ prehistoric | ___ archeology-prehistoric | ___ community planning | ___ landscape architecture | ___ religion |
| ___ 1400–1499 | ___ archeology-historic | ___ conservation | ___ law | ___ science |
| ___ 1500–1599 | ___ agriculture | ___ economics | ___ literature | ___ sculpture |
| ___ 1600–1699 | ___ architecture | ___ education | ___ military | ___ social/ humanitarian |
| ___ 1700–1799 | ___ art | X engineering | ___ music | ___ theater |
| ___ 1800–1899 | ___ commerce | ___ exploration/settlement | ___ philosophy | ___ transportation |
| X 1900– | X communications | ___ industry | ___ politics/government | X other (specify) Space Exploration |
| | | ___ invention | | |

**Specific dates** 1958-1978 **Builder/Architect** U.S. Army

**Statement of Significance (in one paragraph)**

The Pioneer Station antenna was the first antenna to support the National Aeronautics and Space Administration's unmanned exploration of deep space. It was the prototype antenna for the entire Deep Space Network and had many of its design features incorporated into later improved antennas. During the course of its operational life the Pioneer Deep Space Station antenna tracked a variety of NASA missions including projects--Pioneer, Echo, Ranger, Lunar Orbiter, Surveyor, Apollo, Helios, Mariner, Viking and Voyager.

When NASA assigned responsibility to the Jet Propulsion Laboratory (JPL) for the unmanned exploration of the moon and planets in our solar system, the problems implicit in the assignment were awesome. Aside from designing and fabricating the spacecraft itself, JPL had to solve the many problems in extending the arts of telecommunications and tracking. While research in sophisticated techniques of space age telecommunications had been going on since 1954, there was little experience in dealing with the practical problems of tracking a spacecraft traveling far from Earth, maintaining communication contact, and capturing radio waves generated from the far reaches of space. The problem was to design and build a space broadcasting and receiving station here on Earth.[3]

Prior to the Space Act of 1958 construction began on the Pioneer Station antenna as an Army project under JPL. After the creation of NASA the Pioneer Station antenna became the first deep space tracking station in the NASA deep space communications network. In deciding where to build the Pioneer Station two stipulations were that the location had to be far from man-made electrical and commercial radio and television interference and that the terrain be of a natural bowl shape.[4]

A suitable site was found in the heart of the Mojave Desert in California, at Fort Irwin, about 45 miles from the town of Barstow. It was at this site that JPL built the Pioneer Station antenna which eventually grew into the Goldstone Deep Space Communications Complex. At the present time the Goldstone Complex consists of four Deep Space Stations (DSSs)--Pioneer (DSS 11), Echo (DSS 12), Venus (DSS 13) and Mars (DSS 14). These stations are named for the projects in which they first participated.[5]

To provide continous 24-hour coverage for space probes, NASA also established two overseas tracking stations in the Deep Space Network. These stations are in Canberra, Australia, and in Madrid, Spain, and are spaced approximately 120 degrees apart so that spacecraft are always in view of at least one tracking station.

The Pioneer Station antenna represents the first generation of 26-meter antennas that enabled NASA to solve the technical problems of tracking deep space probes. Although it has now been superseded by newer and more efficient antennas it was the first, the prototype for the entire system. Features incorporated into the latest generation of 64-meter antennas that enable NASA to track Pioneer and Voyager Spacecraft to the very edge of the Solar System and beyond were first developed and proven at the Pioneer Station. In recognition of the importance of the Pioneer station to the Deep Space Network, and to the people who worked there, NASA dedicated a plaque to the station in 1978 recognizing its role and contribution to the continuing mission of NASA in the exploration of space.

Footnotes

1. N. A. Renzetti, ed., A History of the Deep Space Network From Inception to January 1, 1969 Technical Report 32-1533 (Pasadena, California: Jet Propulsion Laboratory, 1971), Vol. 1., pp. 10-11.

2. Ibid., 13.

3. Goldstone DSCC (Pasadena, California: Jet Propulsion Laboratory, 1979), p. 6.

4. Ibid.

5. Ibid.

Bibliography

Corliss, William R. A History of the Deep Space Network. Washington, D.C.: National Aeronautics and Space Administration, 1976.

Description of the Deep Space Network Operational Capabilities as of January 1, 1966 Technical Memorandum No. 33-255. Pasadena, California: Jet Propulsion Laboratory, July 1, 1966.

Directory of Goldstone DSCC Buildings and Supporting Facilities. Seventh Edition, August 1979.

Goldstone DSCC. Pasadena, California: Jet Propulsion Laboratory, 1979.

Renzetti, N.A. ed. A History of the Deep Space Network Technical Report 32-1533, Vol. 1. Pasadena, California: Jet Propulsion Laboratory, 1971.

## 9. Major Bibliographical References

## 10. Geographical Data

Acreage of nominated property Less than 1 acre

Quadrangle name Goldstone Lake

Quadrangle scale 1:62,500

UMT References

| | Zone | Easting | Northing | | Zone | Easting | Northing |
|---|---|---|---|---|---|---|---|
| A | 11 | 530600 | 3916025 | B | | | |
| C | | | | D | | | |
| E | | | | F | | | |
| G | | | | H | | | |

**Verbal boundary description and justification**

The boundary of the Pioneer Deep Space Station Antenna includes only the Antenna and the base upon which it is now physically located.

**List all states and counties for properties overlapping state or county boundaries**

state code county code

state code county code

## 11. Form Prepared By

name/title Harry A. Butowsky

organization National Park Service date May 15, 1984

street & number Division of History telephone (202) 343-8168

city or town Washington, D.C. 20240 state

## 12. State Historic Preservation Officer Certification

The evaluated significance of this property within the state is:

___ national ___ state ___ local

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89-665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service.

State Historic Preservation Officer signature

title date

For NPS use only

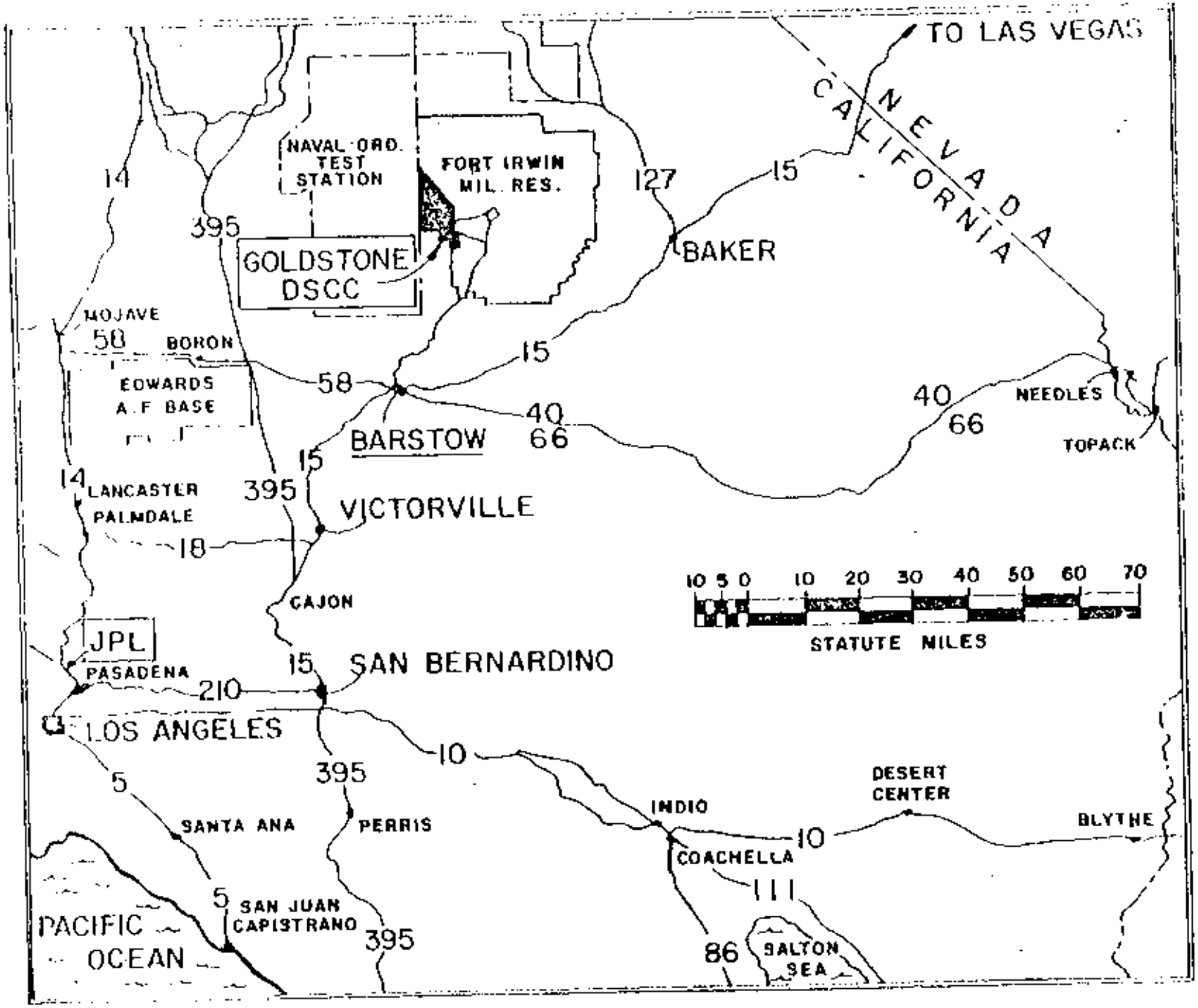
I hereby certify that this property is included in the National Register

date

Keeper of the National Register

Attest: date

Chief of Registration

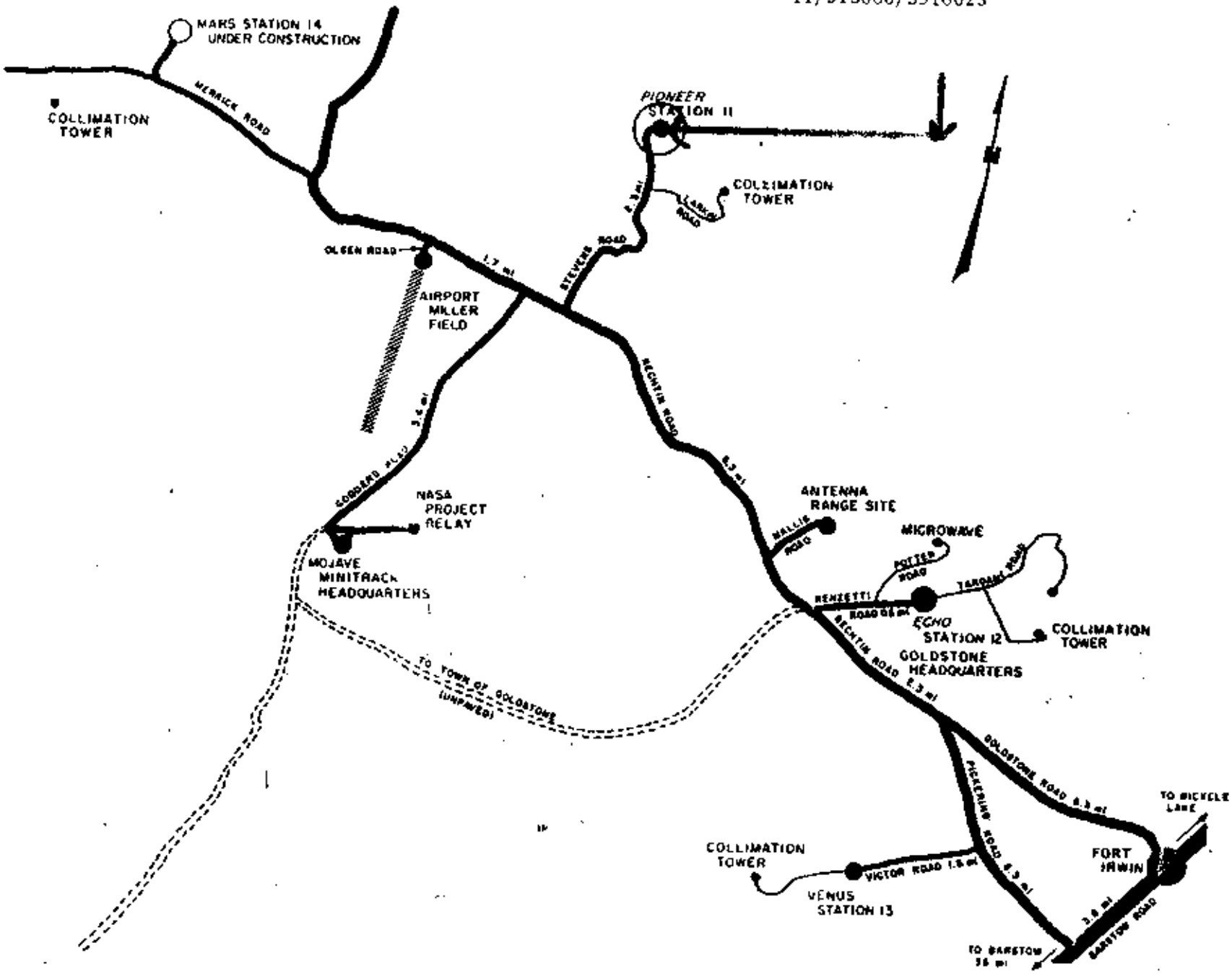



GEOGRAPHIC RELATIONSHIP OF GOLDSTONE TO JPL, PASADENA

Source: Directory of Goldstone DSCC Buildings and Support Facilities, No page number.

Area m[illegible] Goldstone stations

Pioneer Deep Space Station
11/513060/3916025

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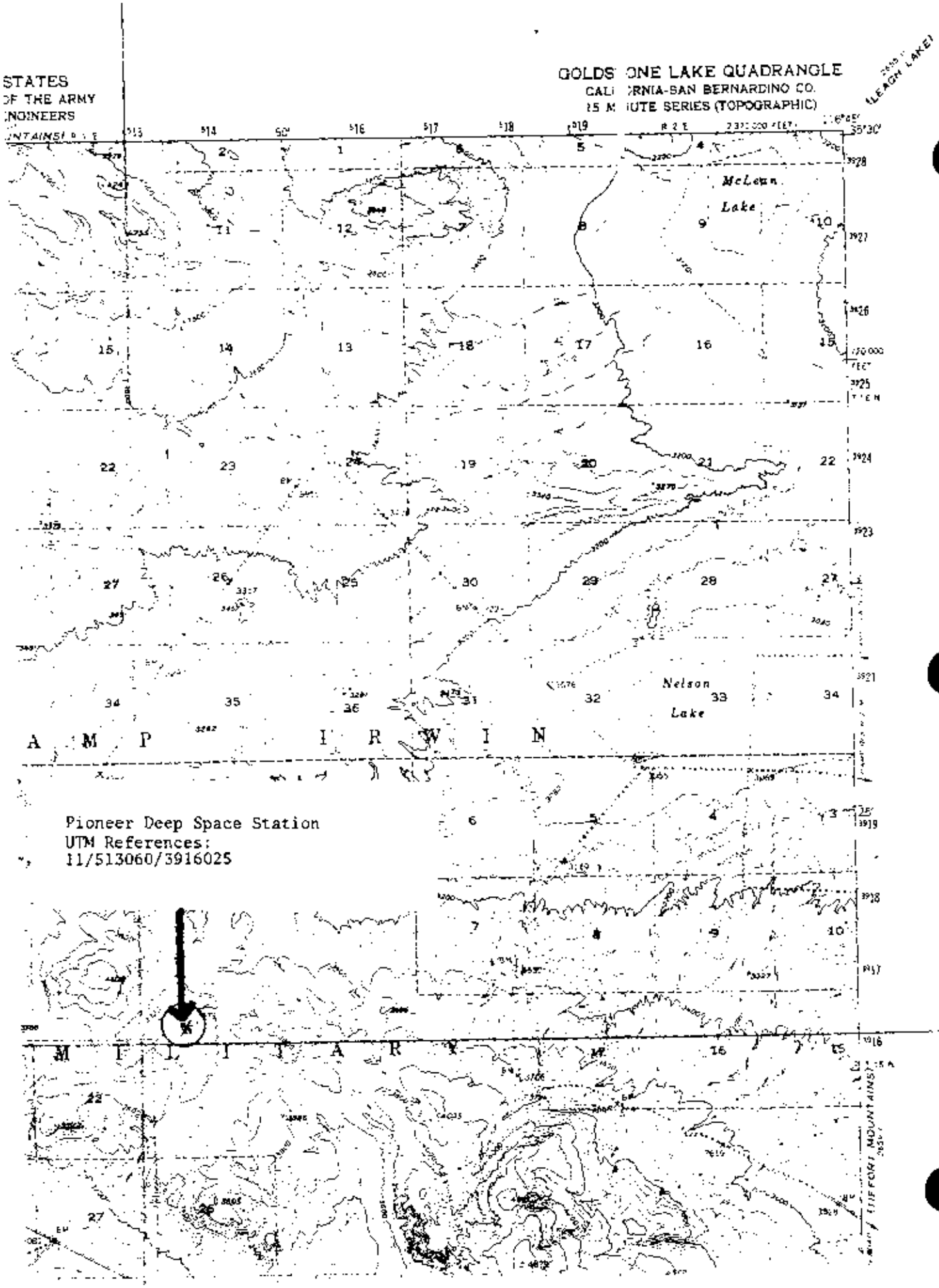
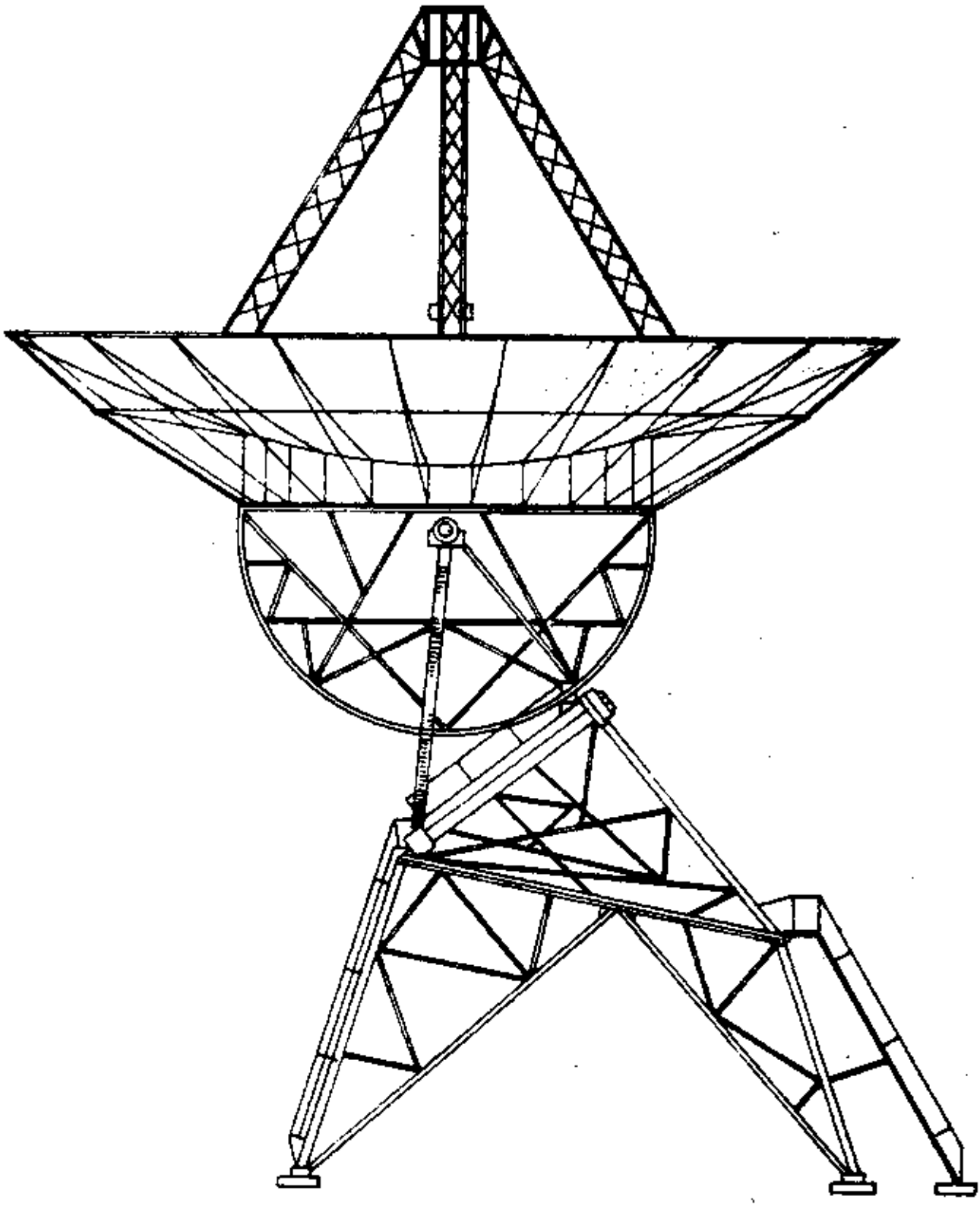

STATES
OF THE ARMY
ENGINEERS
GOLDS ONE LAKE QUADRANGLE
CALI RNIA-SAN BERNARDINO CO.
15 M UTE SERIES (TOPOGRAPHIC)
McLean
Lake
Nelson
Lake
A M P I R W I N
M I L I T A R Y
Pioneer Deep Space Station
UTM References:
11/513060/3916025

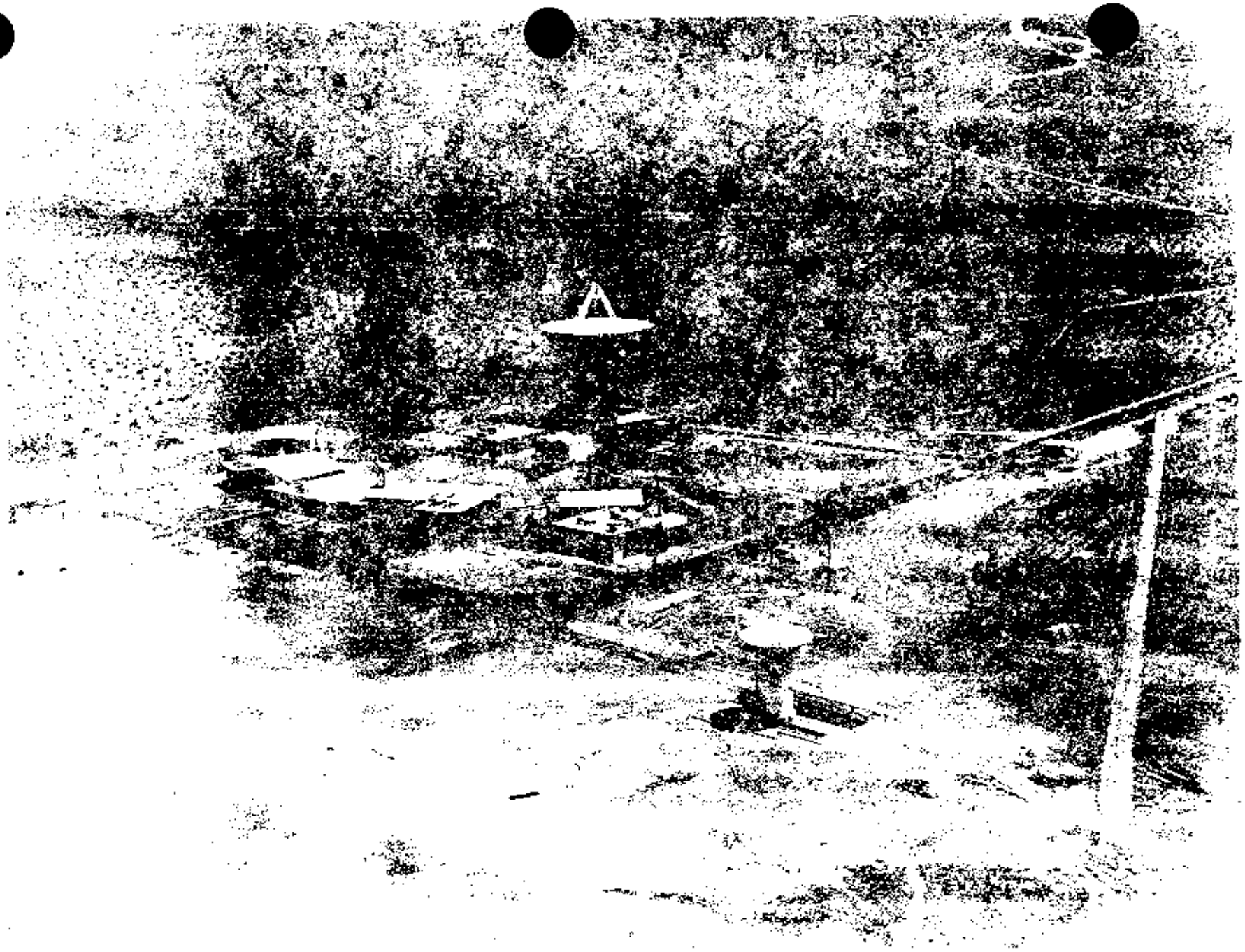
# 26 METER (85')
# ANTENNA, BLDG G-4
# PIONEER STATION

SCALE: NONE



Source: Directory of Goldstone DSCC Buildings and Support Facilities, No page number.

1. Pioneer Deep Space Station
2. Fort Irwin, California
3. NASA-JPL
4. Pre-1969
5. JPL Facilities Office
6. Aerial View of the Pioneer Deep Space Station and support buildings



1. Pioneer Deep Space Station
2. Fort Irwin, California
3. NASA-JPL
4. 1983
5. JPL Facilities Office
6. Exterior View of the Pioneer Deep Space Station

## MISSION CONTROL CENTERS

22. Space Flight Operations Facility (JPL)

23. Apollo Mission Control Center (Johnson)

NPS Form 10-900
(7-81)

**United States Department of the Interior**
**National Park Service**

# National Register of Historic Places Inventory—Nomination Form

For NPS use only
received
date entered

See instructions in *How to Complete National Register Forms*
Type all entries—complete applicable sections

## 1. Name

historic Space Flight Operations Facility

and/or common Space Flight Operations Facility

## 2. Location

street & number Jet Propulsion Laboratory ___ not for publication

city, town Pasadena ___ vicinity of congressional district

state California code 06 county Los Angeles code 037

## 3. Classification

| Category | Ownership | Status | Present Use | |
|---|---|---|---|---|
| ___ district | X public | X occupied | ___ agriculture | ___ museum |
| X building(s) | ___ private | ___ unoccupied | ___ commercial | ___ park |
| ___ structure | ___ both | ___ work in progress | ___ educational | ___ private residence |
| ___ site | **Public Acquisition** | **Accessible** | ___ entertainment | ___ religious |
| ___ object | ___ in process | X yes: restricted | X government | X scientific |
| | ___ being considered | ___ yes: unrestricted | ___ industrial | ___ transportation |
| | | ___ no | ___ military | X other: Space Exploration |

## 4. Owner of Property

name National Aeronautics and Space Administration (NASA)

street & number

city, town Washington ___ vicinity of state D.C. 20546

## 5. Location of Legal Description

courthouse, registry of deeds, etc. National Aeronautics and Space Administration (NASA)

street & number Real Property Management Office Code NXC

city, town Washington state D.C. 20546

## 6. Representation in Existing Surveys

title None has this property been determined eligible? ___ yes ___ no

date ___ federal ___ state ___ county ___ local

depository for survey records

city, town state

# 7. Description

| Condition | | Check one | Check one |
|---|---|---|---|
| X excellent | ___ deteriorated | ___ unaltered | X original site |
| ___ good | ___ ruins | X altered | ___ moved date _____ |
| ___ fair | ___ unexposed | | |

**Describe the present and original (if known) physical appearance**

The Space Flight Operations Facility (SFOF) is at the Jet Propulsion Laboratory (JPL) in Pasadena, California. The SFOF is where spacecraft tracking and scientific data are received and processed from JPL's Deep Space Network.

The SFOF was constructed in 1963 and is composed of three floors and a basement. The SFOF is a square building with a standby powerhouse extending from the basement on the west side. The entire structure encloses 122,074 square feet. All parts of the building, except for parts of the basement and the standby power house, are air-conditioned to precise tolerances. The exterior of the structure has a rock and concrete face.

At the heart of the SFOF is the Network Operations Control Center which provides a centralized control point for NASA's Deep Space Network. The Network Operations Control Center has two separate functional elements: Network Operations Control and Network Data Processing.

The Network Operations Control Center houses control consoles, video displays, projection screens, status and operation displays, closed circuit television communication links and telephones necessary to control and monitor deep space flight operations. The Network Data Processing Center houses the computers and the data storage and processing facilities necessary to support the Network Operations Control Center. Other areas of the building house offices, public viewing areas and additional support facilities for the Network Operations Control Center.

The SFOF is an active NASA facility supporting various ongoing NASA projects including the tracking of the Voyager Spacecraft. It has continually been modified and its equipment upgraded since it was built and put into operation in 1964.

# 8. Significance

| Period | Areas of Significance—Check and justify below | | | |
|---|---|---|---|---|
| ___ prehistoric | ___ archeology-prehistoric | ___ community planning | ___ landscape architecture | ___ religion |
| ___ 1400–1499 | ___ archeology-historic | ___ conservation | ___ law | ___ science |
| ___ 1500–1599 | ___ agriculture | ___ economics | ___ literature | ___ sculpture |
| ___ 1600–1699 | ___ architecture | ___ education | ___ military | ___ social/humanitarian |
| ___ 1700–1799 | ___ art | X engineering | ___ music | ___ theater |
| ___ 1800–1899 | ___ commerce | ___ exploration/settlement | ___ philosophy | ___ transportation |
| X 1900– | X communications | ___ industry | ___ politics/government | X other (specify) Space Exploration |
| | | ___ invention | | |

**Specific dates** 1963-Present **Builder/Architect** NASA

**Statement of Significance (in one paragraph)**

The Jet Propulsion Laboratory from the beginning of its association with NASA in 1958 has served as the primary NASA center for the unmanned exploration of the planets. The first version of the Space Flight Operations Facility was built in 1958 to support the Explorer 1 satellite. This mission control center was in a single room that housed all the communications, recording, and other support equipment necesasary for Explorer 1. By 1961, with the coming of Project Ranger to explore the moon, it was obvious that a more elaborate mission control center was necessary. The Space Flight Operations Facility was constructed to replace the original Explorer 1 mission control center and to provide the depth of technical support needed by newer generations of unmanned spacecraft.

The Space Flight Operations Facility was constructed to be part of the Deep Space Network (DSN). The main elements in the DSN are the Deep Space Instrumentation Facility (DSFI), the Ground Communications System (GCS), and the Space Flight Operations Facility (SFOC).

The DSIF is a network of tracking and communications stations located approximately 120 degrees apart in longitude to insure that a spacecraft is always within the field of at least one of the tracking stations.

The GCS consists of voice, teletype and high speed data circuits that link each tracking station with both Cape Canaveral and the SFOF.

The SFOF at the Jet Propulsion Laboratory is the focal point of the Deep Space Network. The Space Flight Operations Facility is significant because it is the hub of the vast communications network through which NASA controls its unmanned spacecraft flying in deep space. Commands that control spacecraft flying millions of miles from the earth are sent from the Network Control Center in the Space Flight Operations Facility. Scientific and engineering information generated by unmanned spacecraft is transmitted to the Space Flight Operations Facility. Inasmuch as the Jet Propulsion Laboratory is NASA's primary center for the unmanned exploration of the planets, the Space Flight Operations Facility is the heart and mind of the Jet Propulsion Laboratory. The Mariner, Viking, Pioneer, and Voyager projects that have explored the planets and solar environment have all been controlled for at least part of their missions in this facility. The vast harvest of scientific information concerning the planets and the universe gathered by these spacecraft first saw the light of day and were read by technicians working in the Space Flight Operations Facility.

The scale of the achievements of NASA's planetary exploration program over the last twenty years is staggering. Like the great early explorers of human history, Columbus, Magellan, Balboa, Cortes, and Champlain the unmanned spacecraft of NASA, Ranger, Mariner, Pioneer, Viking and Voyager have opened new worlds to human understanding and comprehension. The Space Flight Operations Facility for this period of time has been at the heart of this operation. Through the achievements of modern technology and communications the entire human family was able to travel to the planets and experience the thrill of discovery. The Space Flight Operations Facility is the symbol of this technology and the resource most closely associated with the unmanned planetary exploration program of the Jet Propulsion Laboratory and the National Aeronautics and Space Administration.

Bibliography

Corliss, William R. A History of the Deep Space Network. Washington, D.C.: National Aeronautics and Space Administration, 1976.

Description of the Deep Space Network Operational Capabilities as of January 1, 1966 Technical Memorandum No. 33-255. Pasadena, California: Jet Propulsion Laboratory, July 1, 1966.

Koppes, Clayton R. JPL and the American Space Program: A History of the Jet Propulsion Laboratory. New Haven: Yale University Press, 1982.

Newell, Homer E. Beyond the Atmosphere: Early Years of Space Science. Washington, D.C.: National Aeronautics and Space Administration, 1980.

Renzetti, N.A. (ed.) A History of the Deep Space Network Technical Report 32-1533. Vol. 1. Pasadena, California: Jet Propulsion Laboratory, 1971.

Technical Facilities Catalog Vol. 1. Washington, D.C.: National Aeronautics and Space Administration, 1974.

Washburn, Mark. Distant Encounters: The Exploration of Jupiter and Saturn. New York: Harcourt Brace Jovanovich, 1983.

## 9. Major Bibliographical References

See continuation sheets

## 10. Geographical Data

Acreage of nominated property Less than 1 acre

Quadrangle name Pasadena

Quadrangle scale 1:24,000

UMT References

| | Zone | Easting | Northing |
|---|---|---|---|
| A | 11 | 391870 | 3784880 |
| B | | | |
| C | | | |
| D | | | |
| E | | | |
| F | | | |
| G | | | |
| H | | | |

Verbal boundary description and justification

The boundary of the Space Flight Operations Facility is shown as the green line on the map entitled "Space Flight Operations Facility Location Map."

List all states and counties for properties overlapping state or county boundaries

state code county code

state code county code

## 11. Form Prepared By

name/title Harry A. Butowsky

organization National Park Service date May 15, 1984

street & number Division of History telephone (202) 343-8168

city or town Washington, D.C. 20240 state

## 12. State Historic Preservation Officer Certification

The evaluated significance of this property within the state is:

___ national ___ state ___ local

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89-665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service.

State Historic Preservation Officer signature

title date

For NPS use only

I hereby certify that this property is included in the National Register

date

Keeper of the National Register

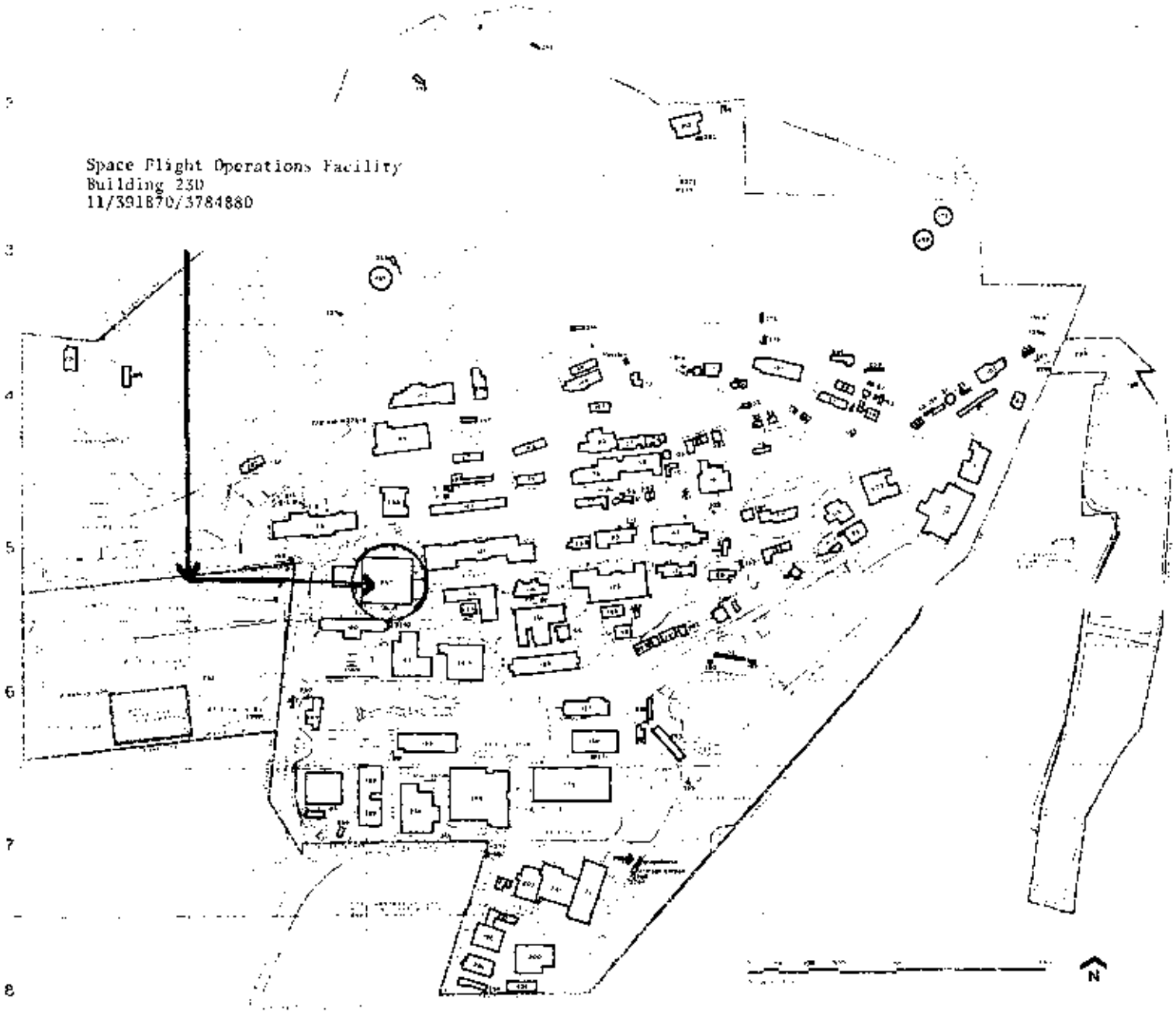
Attest: date

Chief of Registration

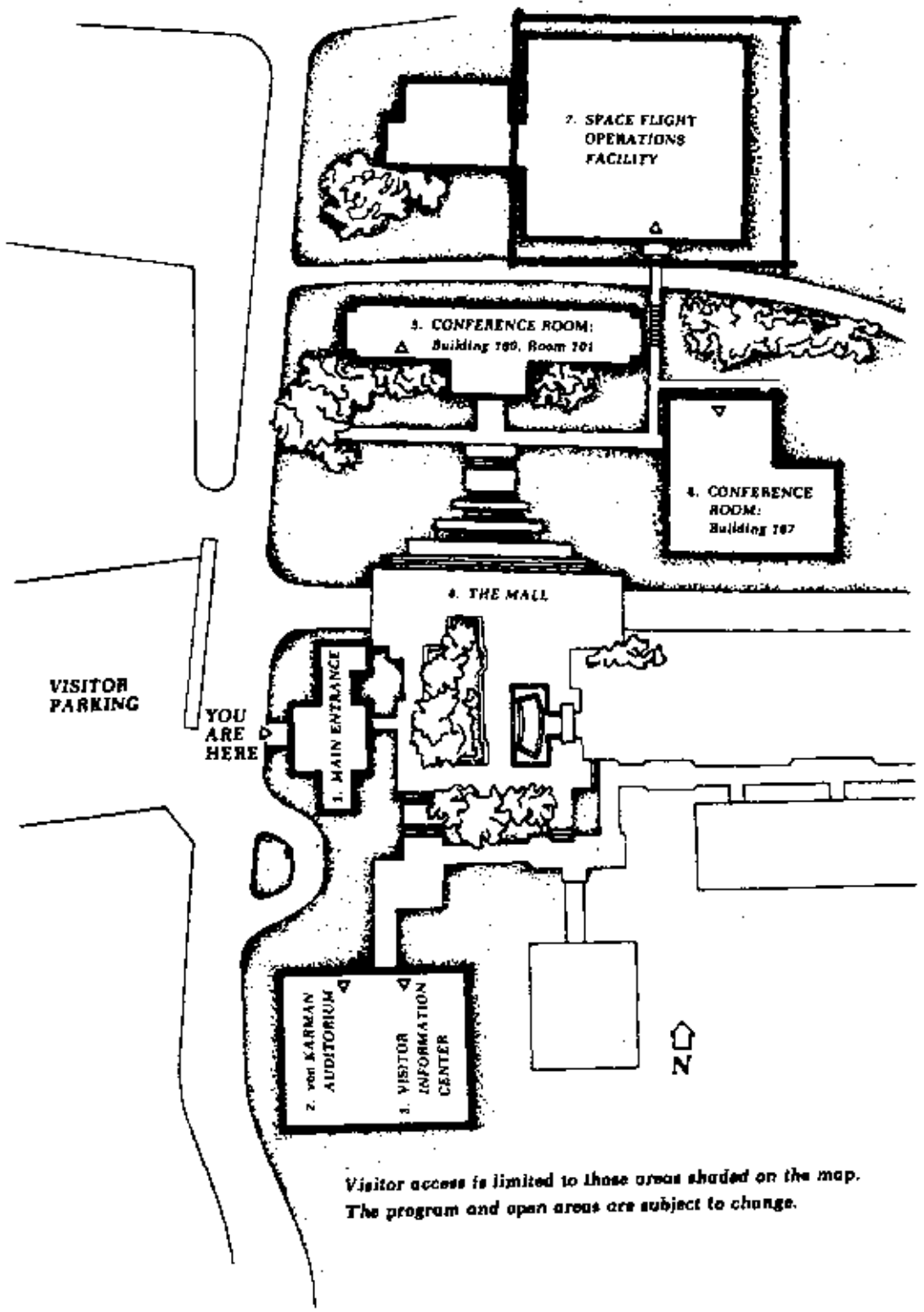
# JET PROPULSION LABORATORY

CALIFORNIA INSTITUTE OF TECHNOLOGY

SITE PLAN · FACILITY LOCATIONS

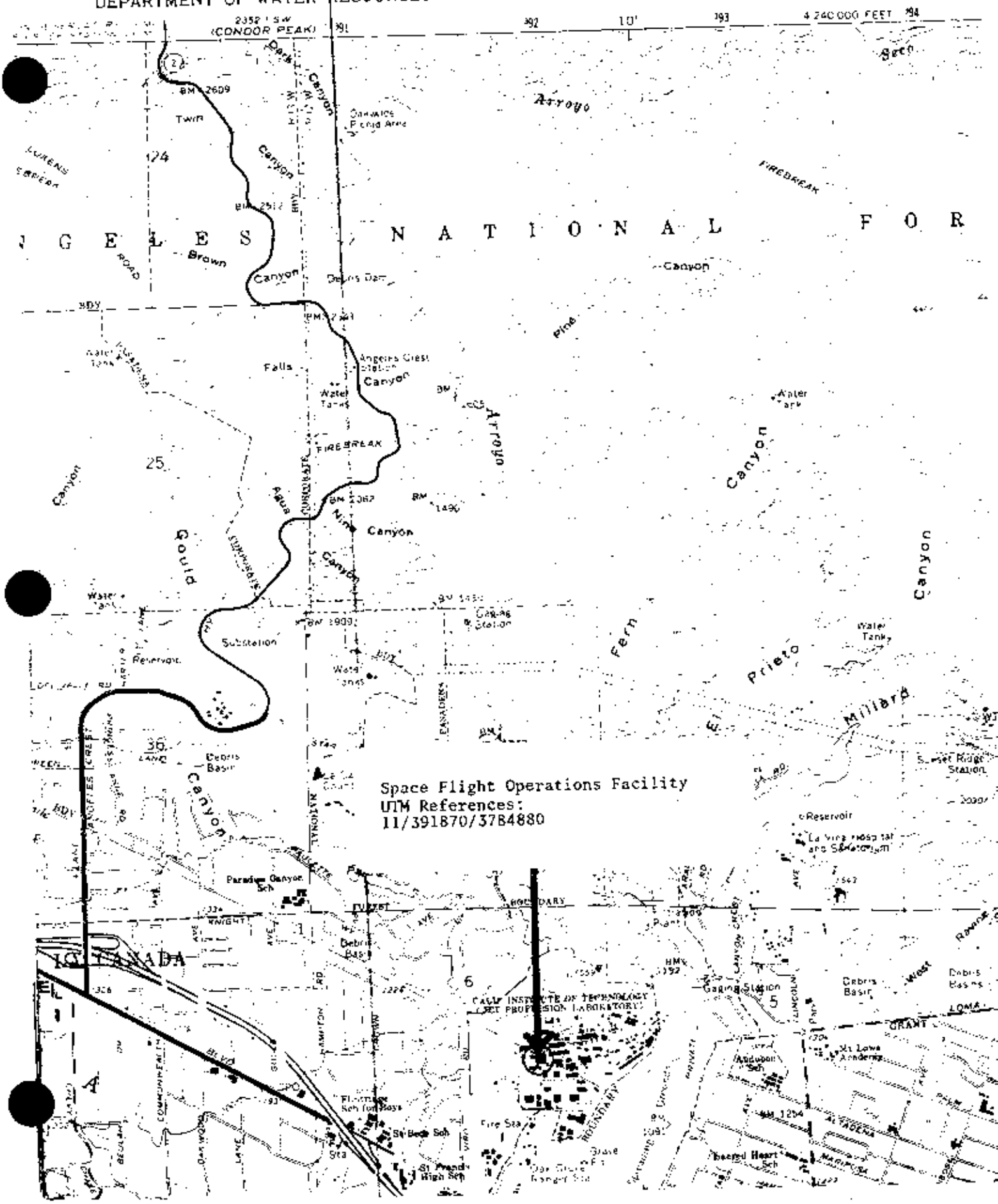


Space Flight Operations Facility Location Map

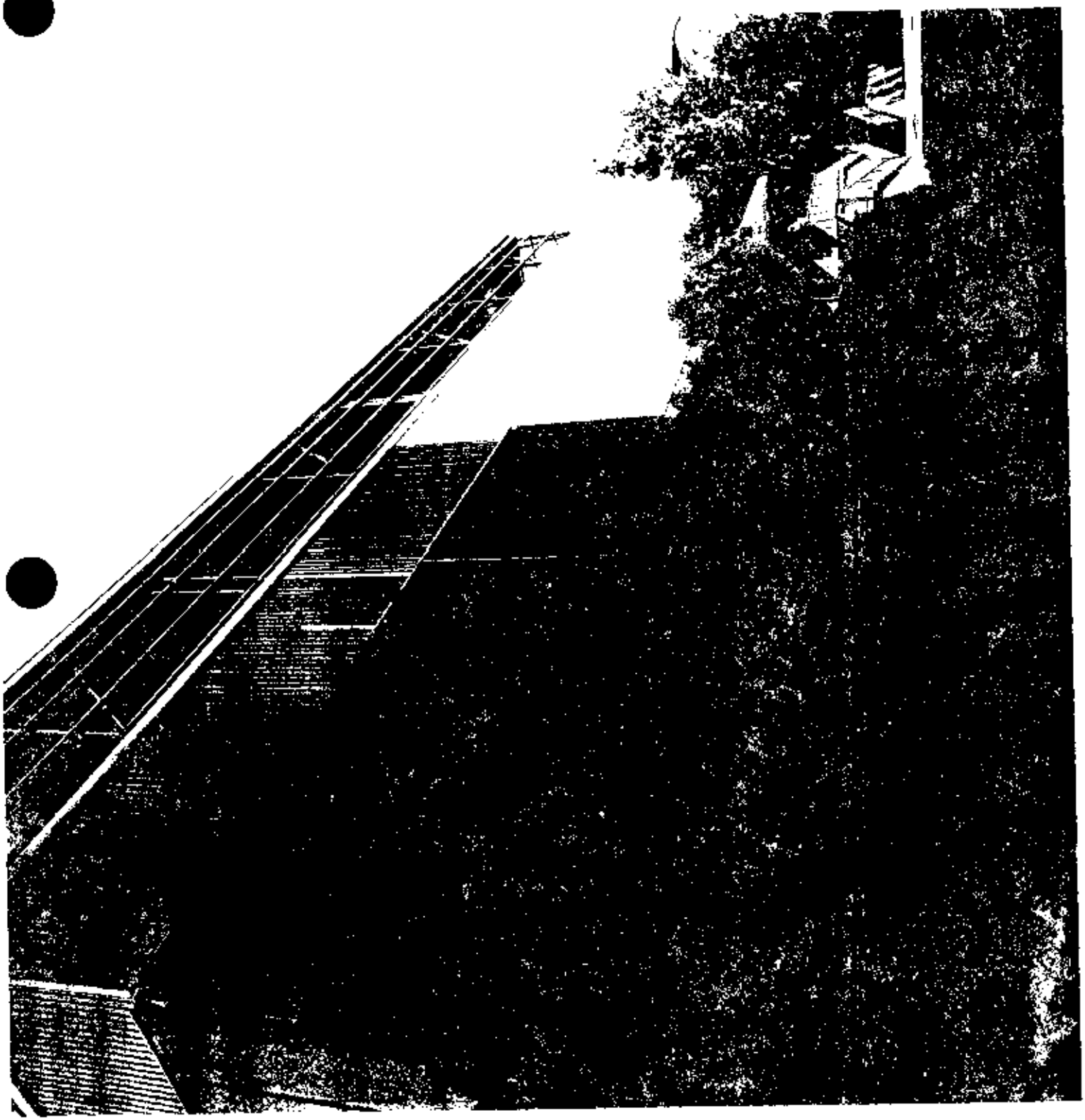



*Visitor access is limited to those areas shaded on the map.*
*The program and open areas are subject to change.*

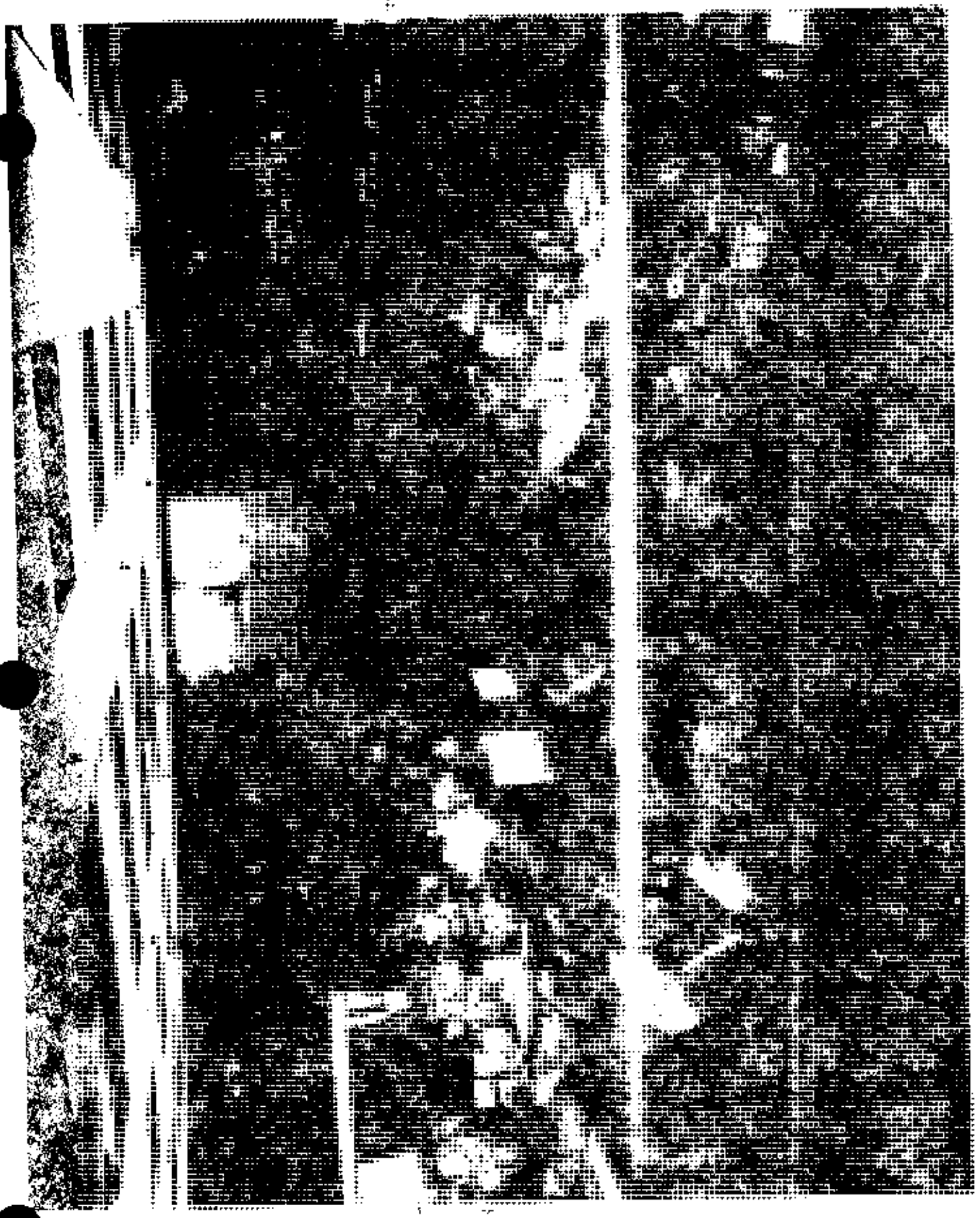
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES



1. Space Flight Operations Facility
2. Pasadena, California
3. NASA-JPL
4. 1983
5. JPL Facilities Office
6. Exterior View of Space Flight Operations Facility Building #230



1. Space Flight Operations Control Facility
2. Pasadena, California
3. NASA-JPL
4. 1976
5. JPL Public Affairs Office
6. Interior View of the Network Operations Control Center



1. Space Flight Operations Facility
2. Pasadena, California
3. NASA-JPL
4. 1981
5. JPL Public Affairs Office
6. Interior View of the Network Operations Control Center

NPS Form 10-900
(7-81)

**United States Department of the Interior**
**National Park Service**

# National Register of Historic Places Inventory—Nomination Form

For NPS use only
received
date entered

See instructions in *How to Complete National Register Forms*
Type all entries—complete applicable sections

## 1. Name

historic: Apollo Mission Control Center

and/or common: Mission Control Center

## 2. Location

street & number: Lyndon B. Johnson Space Flight Center ___ not for publication

city, town: Houston ___ vicinity of congressional district

state: Texas code: 48 county: Harris code: 201

## 3. Classification

| Category | Ownership | Status | Present Use | |
|---|---|---|---|---|
| ___ district | X public | ___ occupied | ___ agriculture | ___ museum |
| X building(s) | ___ private | ___ unoccupied | ___ commercial | ___ park |
| ___ structure | ___ both | ___ work in progress | ___ educational | ___ private residence |
| ___ site | **Public Acquisition** | **Accessible** | ___ entertainment | ___ religious |
| ___ object | ___ in process | X yes: restricted | X government | X scientific |
| | ___ being considered | ___ yes: unrestricted | ___ industrial | X transportation |
| | | ___ no | X military | X other: Space Exploration |

## 4. Owner of Property

name: National Aeronautics and Space Administration (NASA)

street & number:

city, town: Washington ___ vicinity of state: D.C. 20546

## 5. Location of Legal Description

courthouse, registry of deeds, etc.: National Aeronautics and Space Administration (NASA)

street & number: Real Property Management Office Code NXG

city, town: Washington state: D.C. 20546

## 6. Representation in Existing Surveys

title: None has this property been determined eligible? ___ yes ___ no

date ___ federal ___ state ___ county ___ local

depository for survey records

city, town state

# 7. Description

| Condition | | Check one | Check one |
|---|---|---|---|
| X excellent | ___ deteriorated | ___ unaltered | X original site |
| ___ good | ___ ruins | X altered | ___ moved date ___ |
| ___ fair | ___ unexposed | | |

**Describe the present and original (if known) physical appearance**

The Apollo Mission Control Center is in Building 30 at the Lyndon B. Johnson Manned Space Flight Center in Houston, Texas. The three-story structure consists of a mission operations wing (MOW), operations support wing (OSW), and an interconnecting lobby wing. The MOW contains systems and equipment required to support the mission control function. The OSW contains offices, laboratory, and technical support areas for the flight operations directorate. The lobby wing provides additional office space and dormitory facilities utilized by flight controlers during space flights of extended duration. The mission control center is supported by an emergency power building that houses standby electrical power and air-conditioning systems in the event that primary sources fail.

Principal systems on the first floor are the real time computer complex and the communications systems. These systems support the dual mission facilities and systems on the second and third floors. The communications system provides the interface between the mission control center in Houston and the manned space flight network and the launch site.

Principal areas on the second floor are the mission operations control room (MOCR), the staff support rooms (SSR), the simulation facilities, and the master digital command system. The MOCR is the principal command and control center, staffed with key mission operations teams responsible for overall management of the flight.

Principal areas on the third floor are the MOCR, the SSR, the recovery control room, the meteorological area, and the display and timing area. The MOCR and SSR are exact duplications of the areas on the second floor.

The recovery control room, the meteorological area, and the display and timing areas support the dual mission facilities and systems on the second and third floors.

The MOCR on the second floor is the principal command and decision area in the MCC. Critical information related to spacecraft, launch vehicle, and ground systems, as well as aeromedical parameters from the worldwide stations, ships, and aircraft, is processed and displayed within the MOCR. Based on an analysis of this continuous flow of information, personnel in this room must assess the spacecraft flight status and progress, and then, in time-critical periods, determine the continuation, alteration, or termination of the space flight.

This is an ongoing NASA facility and is currently being modified to accommodate flights of the shuttle. The third floor of the facility has been turned over to the Air Force and is in the process of being converted into a secure area from which Air Force shuttle flights will be monitored. The second floor of the facility housing the mission control operations room is being divided into two rooms to accommodate increasing numbers of shuttle flights.[1]

# 8. Significance

| Period | Areas of Significance—Check and justify below | | | |
|---|---|---|---|---|
| ___ prehistoric | ___ archeology-prehistoric | ___ community planning | ___ landscape architecture | ___ religion |
| ___ 1400–1499 | ___ archeology-historic | ___ conservation | ___ law | ___ science |
| ___ 1500–1599 | ___ agriculture | ___ economics | ___ literature | ___ sculpture |
| ___ 1600–1699 | ___ architecture | ___ education | ___ military | ___ social/ humanitarian |
| ___ 1700–1799 | ___ art | X engineering | ___ music | ___ theater |
| ___ 1800–1899 | ___ commerce | ___ exploration/settlement | ___ philosophy | ___ transportation |
| X 1900– | X communications | ___ industry | ___ politics/government | X other (specify) |
| | | ___ invention | | Space Exploration |

**Specific dates** 1965-Present **Builder/Architect** NASA

**Statement of Significance (in one paragraph)**

The Apollo Mission Control Center is significant because of its close association with the manned spacecraft program of the United States. This facility was used to monitor nine Gemini and all Apollo flights including the flight of Apollo 11 that first landed men on the moon. After the end of the Apollo Program this facility was used to monitor manned spaceflights for Skylab, Apollo-Soyuz, and all recent Space Shuttle flights.

The support provided by the Apollo Mission Control Center to the first manned landing on the surface of the moon was critical to the success of the mission. It exercised full mission control of the flight of Apollo 11 from the time of liftoff from Launch Complex 39 at the Kennedy Space Center to the time of splashdown in the Pacific. The technical management of all areas of vehicle systems of Apollo 11 including flight dynamics, life systems, flight crew activities, recovery support, and ground operations were handled here.

Through the use of television and the print news media the scene of activity at the Apollo Mission Control during the first manned landing on the moon was made familiar to millions of Americans. When Neil Armstrong reported his "giant leap for mankind" to Mission Control his words went immediately around the world and into history. The Apollo Mission Control Center and Launch Complex 39 at the Kennedy Space Center are the two resources that symbolize for most Americans achievements of the manned space program leading to the successful first moon landing during the flight of Apollo 11 in July 1969.

Footnotes

Harry Butowsky, et. al., Man in Space Reconnaissance Survey (Denver, National Park Service, 1981), pp. 57-8.

Bibliography

Brooks, Courtney G., Grimwood, James M., Swenson, Loyd S. Chariots for Apollo: A History of Manned Lunar Spacecraft. Washington, D.C.: National Aeronautics and Space Administration, 1979.

Butowsky, Harry, et. al. Man in Reconnaissance Survey. Denver: National Park Service, 1981.

Mission Control Center. Washington, D.C.: National Aeronautics and Space Administration, No Date.

## 9. Major Bibliographical Reference

See continuation sheets

## 10. Geographical Data

Acreage of nominated property Less than 1 acre

Quadrangle name League City

Quadrangle scale 1:24,000

UMT References

| | Zone | Easting | Northing | | Zone | Easting | Northing |
|---|---|---|---|---|---|---|---|
| A | 15 | 297660 | 3271460 | B | | | |
| C | | | | D | | | |
| E | | | | F | | | |
| G | | | | H | | | |

Verbal boundary description and justification

The boundary of the Apollo Mission Control Center is defined by the outside perimeter of Building 30 at the Lyndon B. Johnson Space Center.

List all states and counties for properties overlapping state or county boundaries

| state | code | county | code |
|---|---|---|---|
| | | | |
| state | code | county | code |

## 11. Form Prepared By

name/title Barry A. Butowsky

organization National Park Service date May 15, 1984

street & number Division of History telephone (202) 343-8168

city or town Washington, D.C. 20240 state

## 12. State Historic Preservation Officer Certification

The evaluated significance of this property within the state is:

___ national ___ state ___ local

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89-665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service.

State Historic Preservation Officer signature

title date

For NPS use only

I hereby certify that this property is included in the National Register

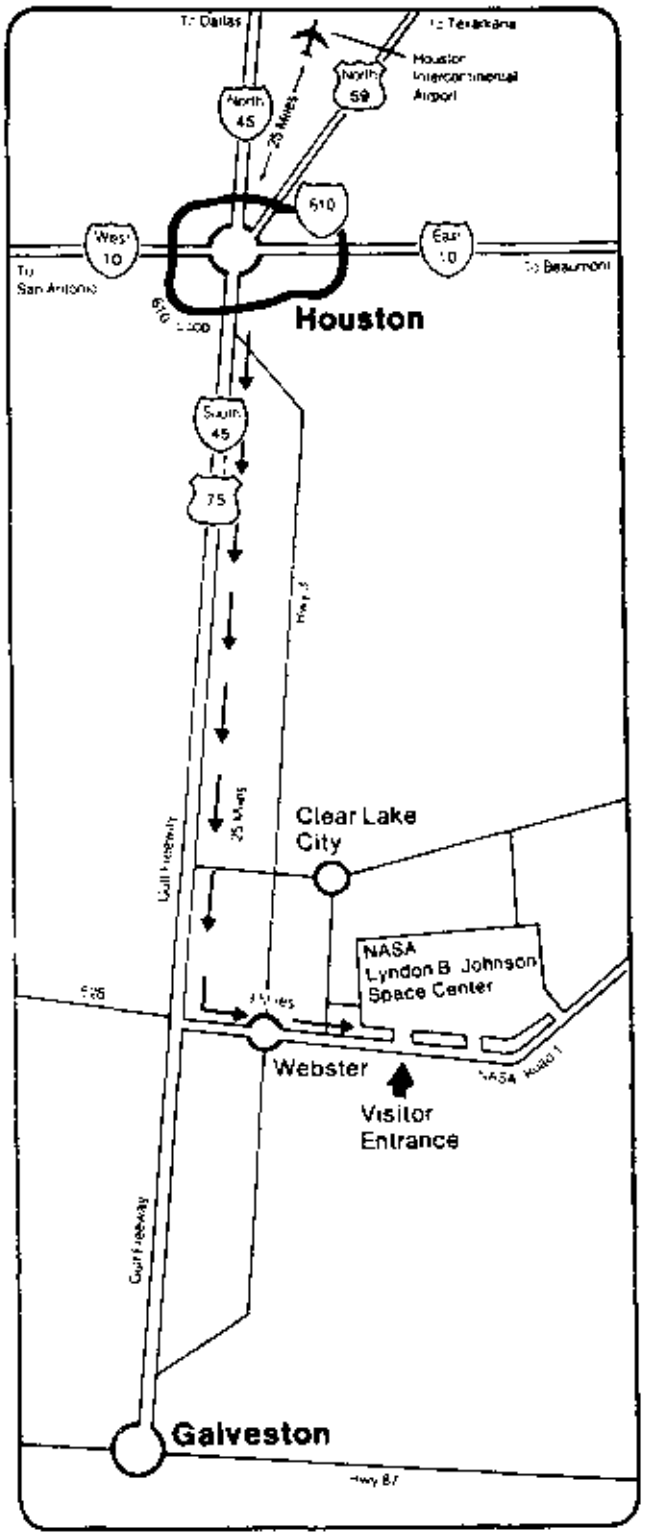
date

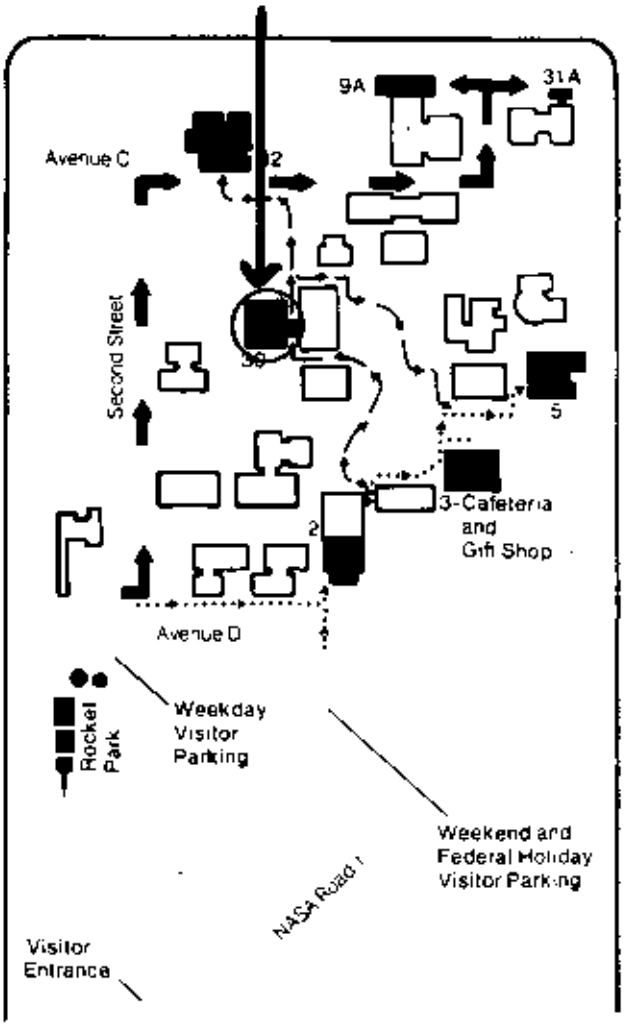
Keeper of the National Register

Attest: date

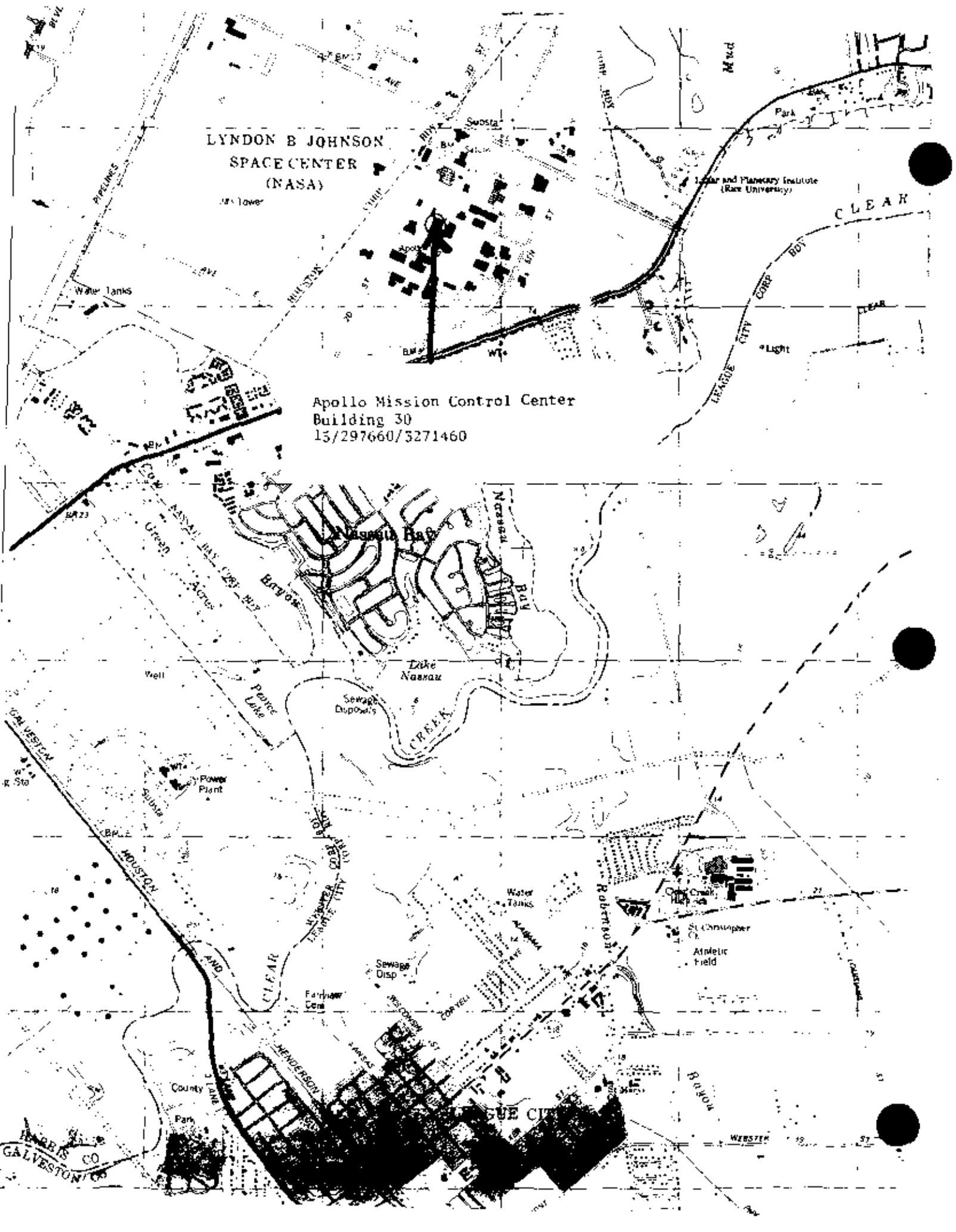
Chief of Registration

Apollo Mission Control Center
UTM References:
15/297660/3271460

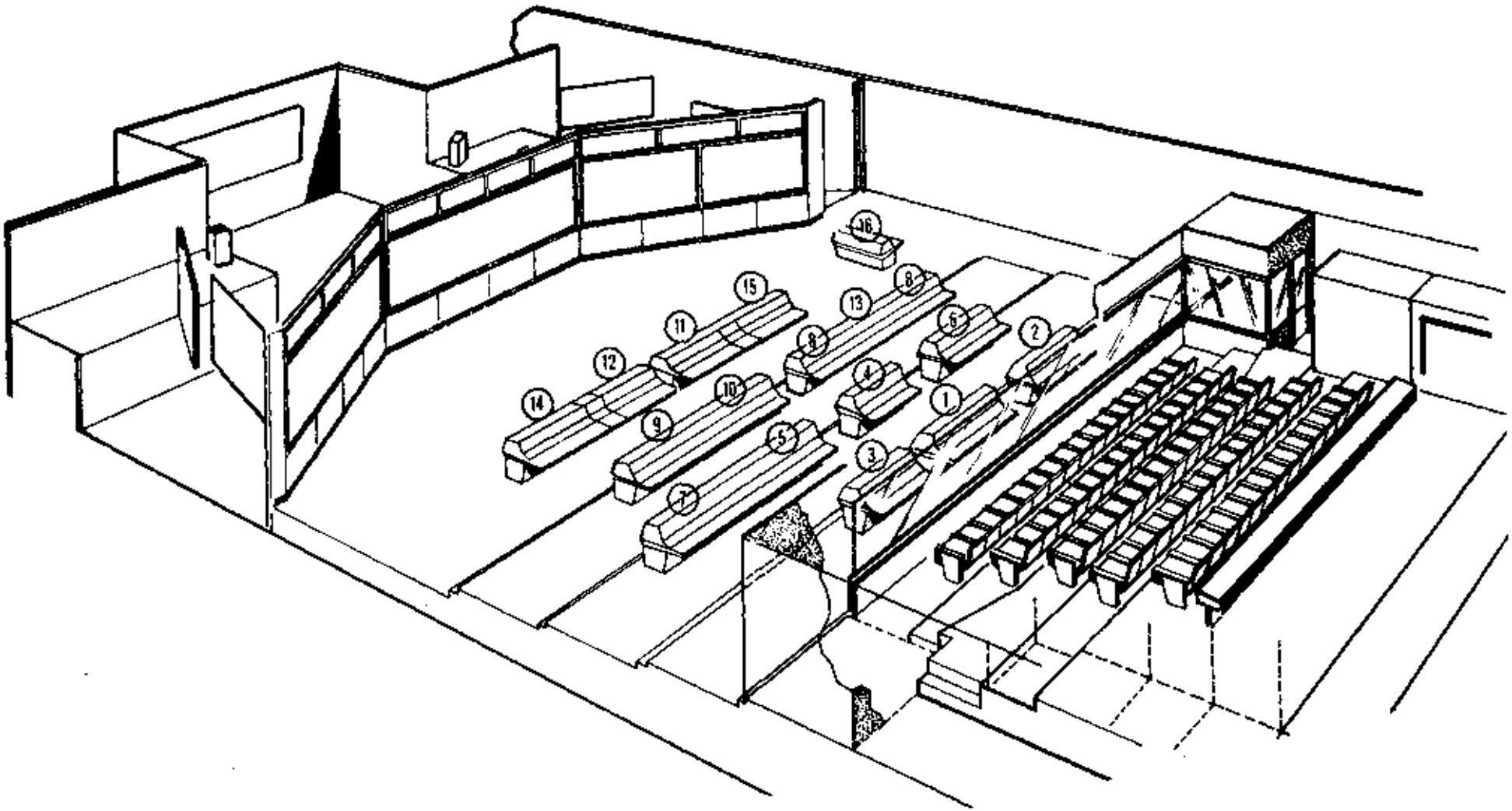



Bldg.
2 - Visitor Center
3 - JSC Cafeteria and Gift Shop
5 - Mission Simulation and Training
9A - Space Shuttle Orbiter Training
30 - Mission Control Center
31A - Lunar Sample Building
32 - Space Environment Simulation Laboratory


LYNDON B JOHNSON
SPACE CENTER
(NASA)
Water Tanks
Apollo Mission Control Center
Building 30
15/297660/3271460
Lunar and Planetary Institute
(Rice University)
CLEAR
Light
Park
Water Tanks
Power Plant
Sewage Disposal
Sewage Disp
Cemetery
County Park
Athletic Field
HOUSTON
GALVESTON
HARRIS CO
GALVESTON CO
WEBSTER
Bayou

Apollo Mission Control Circa 1969




Source: Mission Control Center, No Date, No Page Number.

The 16 positions in the control room and the primary responsibilities are as follows. A graphic illustration shows the location of these consoles.

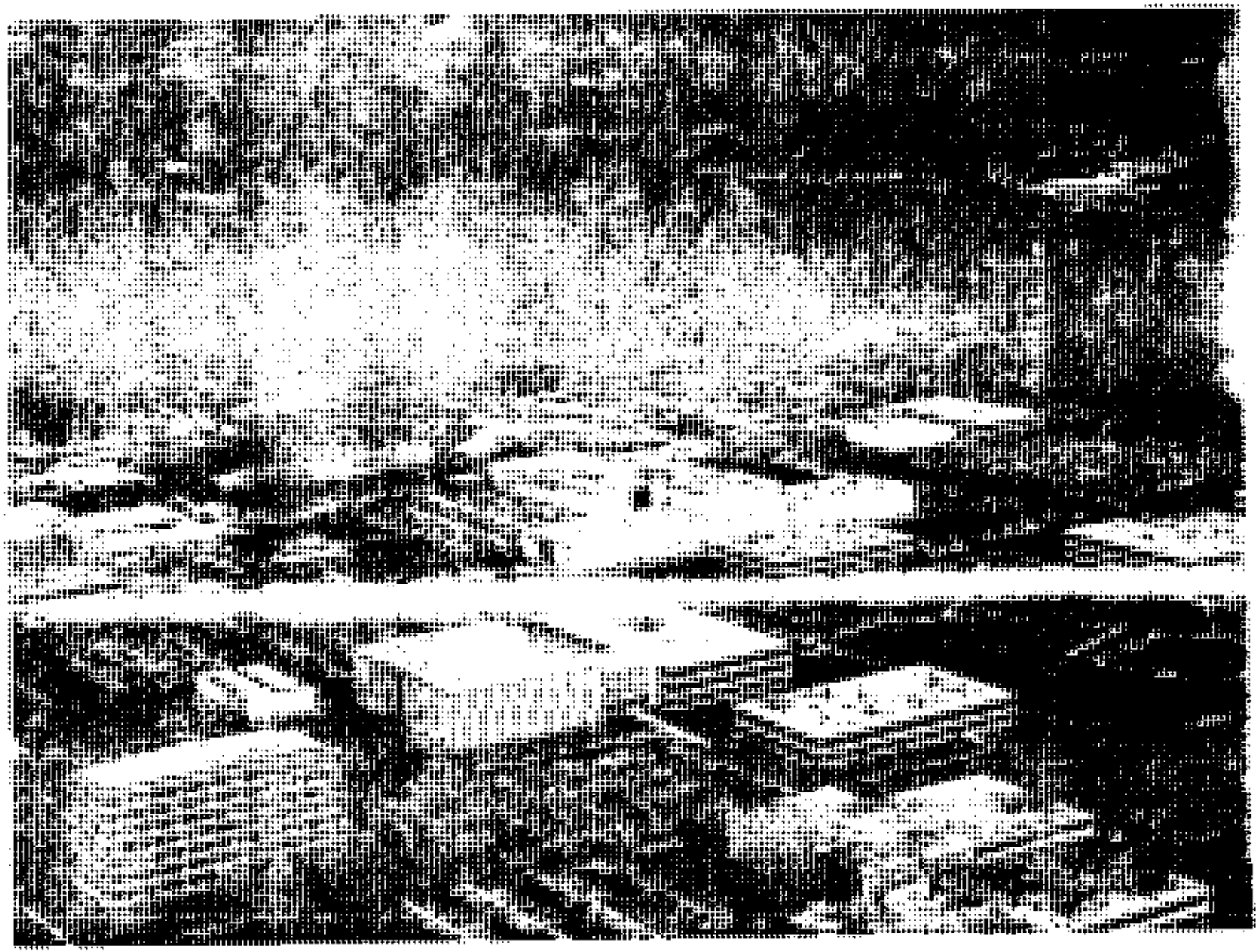
1. Mission Director — overall mission responsibility and control of flight test operations. In Project Mercury there were no alternative mission objectives that could be exercised other than early termination of the mission. The Gemini and Apollo missions, however, offer many possible alternatives which have to be decided in real time.
2. Department of Defense Representative — overall control of Department of Defense forces supporting the mission, including direction of: the deployment of recovery forces, the operation of the recovery communications network, and the search, location and retrieval of the crew and spacecraft.
3. Public Affairs Officer — responsible for providing information on the mission status to the public.
4. Flight Director — responsible to the Operations Director for detailed control of the mission from liftoff until conclusion of the flight; assumes the duties of the Operations Director in his absence.
5. Assistant Flight Director — responsible to the Director for detailed control of the mission from liftoff through conclusion of the flight; assumes the duties of the Flight Director during his absence.
6. Network Controller — has detailed operational control of the Ground Operational Support System network.
7. Operations and Procedures Officer — responsible to the Flight Director for the detailed implementation of the MCC/Ground Operational Support Systems mission control procedures.
8. Vehicle Systems Engineers — monitor and evaluate the performance of all electrical, mechanical and life support equipment aboard the spacecraft (this includes the Agena during rendezvous missions).
9. Flight Surgeon — directs all operational medical activities concerned with the mission, including the status of the flight crew.
10. Spacecraft Communicator — voice communications with the astronauts, exchanging information on the progress of the mission with them.
11. Flight Dynamics Officer — monitors and evaluates the flight parameters required to achieve a successful orbital flight; gives "GO" or "Abort" recommendations to the Flight Director.
12. Retrofire Officer — monitors impact prediction displays and is responsible for determination of retrofire times.
13. Guidance Officer — detects Stage I and Stage II slowrate deviations and other programmed events, verifies proper performance of the Gemini Inertial Guidance System and recommends action to the Flight Director.
14. Booster Systems Engineer — monitors propellant tank pressurization systems and advises the flight crew and/or Flight Director of systems abnormalities.
15. Assistant Flight Dynamics Officer — monitors and evaluates Gemini launch vehicle systems and reports any abnormalities to the Flight Director.
16. Maintenance and Operations Supervisor — responsible for the performance of MCC-H equipment and its ability to support the mission in progress.

Information is displayed on television monitors, indicator lights and digital readout devices on the consoles. Information is also displayed on the large group display projection screens at the front of the control room.

A visitor viewing room, providing seating space for 74 persons, is located at the rear of each MOCR. This is a separate room with a glass front which permits authorized visitors to observe the functioning of the control room during a mission.

1. Apollo Mission Control Center
2. Houston, Texas
3. NASA
4. 1966
5. NASA, Houston Public Affairs Office
6. Aerial View of Apollo Mission Control, Building 30

NASA
S-66-56317



1. Apollo Mission Control Center
2. Houston, Texas
3. NASA
4. 1979
5. NASA, Houston Public Affairs Office
6. Interior View of Mission Operations Control Room

National Aeronautics and
Space Administration

S-79-25792

Lyndon B. Johnson Space Center
Houston, Texas 77058

1. Apollo Mission Control Center
2. Houston, Texas
3. NASA
4. 1982
5. NASA, Houston Public Affairs Office
6. Interior View of Mission Operations Control Room during flight of Space Shuttle Challenger

NASA National Aeronautics and Space Administration

S84-26332

Lyndon B. Johnson Space Center
Houston Texas 77058

## OTHER SUPPORT FACILITIES

24. Rogers Dry Lake (Edwards AFB)

Man in Space Theme Study
Federal Agency Nomination

NPS Form 10-900
(7-81)

**United States Department of the Interior**
**National Park Service**

For NPS use only
received
date entered

# National Register of Historic Places Inventory—Nomination Form

See instructions in *How to Complete National Register Forms*
Type all entries—complete applicable sections

## 1. Name

historic Muroc Dry Lake

and/or common Rogers Dry Lake

## 2. Location

street & number Edwards Air Force Base ___ not for publication

city, town ___ vicinity of congressional district

state California code 06 county Kern, San Bernardino code 029

## 3. Classification

| Category | Ownership | Status | Present Use | |
|---|---|---|---|---|
| ___ district | X public | ___ occupied | ___ agriculture | ___ museum |
| ___ building(s) | ___ private | ___ unoccupied | ___ commercial | ___ park |
| ___ structure | ___ both | ___ work in progress | ___ educational | ___ private residence |
| X site | **Public Acquisition** | **Accessible** | ___ entertainment | ___ religious |
| ___ object | ___ in process | X yes: restricted | X government | ___ scientific |
| | ___ being considered | ___ yes: unrestricted | ___ industrial | ___ transportation |
| | | ___ no | X military | X other: Aeronautical Research, Space Exploration |

## 4. Owner of Property

name United States Air Force

street & number Edwards Air Force Base

city, town ___ vicinity of state

## 5. Location of Legal Description

courthouse, registry of deeds, etc. United States Air Force/LEE\

street & number Building 516, Bolling Air Force Base

city, town Washington state D.C.

## 6. Representation in Existing Surveys

title None has this property been determined eligible? ___ yes ___ no

date ___ federal ___ state ___ county ___ local

depository for survey records

city, town state

# 7. Description

| Condition | | Check one | Check one |
|---|---|---|---|
| X excellent | ___ deteriorated | X unaltered | X original site |
| ___ good | ___ ruins | ___ altered | ___ moved date _____ |
| ___ fair | ___ unexposed | | |

**Describe the present and original (if known) physical appearance**

Rogers Dry Lake is within the boundaries of Edwards Air Force Base in California, approximately 100 miles northeast of Los Angeles. Rogers Dry Lake is part of the Antelope Valley region of the Mojave Desert and is bounded by the Soledad Mountains, the Sierra Pelona ranges of the San Gabriel Mountains, the Long Buttes, and the Tehachapi Mountains. The lake forms the lowpoint of the Antelope Valley which ranges in altitude from 2,300 to 3,000 feet above sea level.

Rogers Dry Lake is sixty-five miles square and shaped roughly like a lopsided figure-8, 12 1/2 miles long and 5 miles wide. It is a pluvial lake that was formed during the late Pleistocene Era about 2.5-million years ago. The lake is naturally flat and its surface is unusally hard and can support up to 250 pounds per square inch of pressure enabling even the heaviest aircraft to land and take off from the lake bed. The lake is dry for most of the year except for brief occasions when rainfall fills the lake bottom to a depth of a few inches.

Rogers Dry Lake has 60 miles of marked and maintained runways which are 300 feet wide. Its broad expanse of hardened clay surface forms the largest natural landing field in the world.

# 8. Significance

| Period | Areas of Significance—Check and justify below | | | |
|---|---|---|---|---|
| ___ prehistoric | ___ archeology-prehistoric | ___ community planning | ___ landscape architecture | ___ religion |
| ___ 1400–1499 | ___ archeology-historic | ___ conservation | ___ law | ___ science |
| ___ 1500–1599 | ___ agriculture | ___ economics | ___ literature | ___ sculpture |
| ___ 1600–1699 | ___ architecture | ___ education | X military | ___ social/ humanitarian |
| ___ 1700–1799 | ___ art | ___ engineering | ___ music | ___ theater |
| ___ 1800–1899 | ___ commerce | ___ exploration/settlement | ___ philosophy | ___ transportation |
| X 1900– | ___ communications | ___ industry | ___ politics/government | X other (specify) Aeronautical Researc Space Exploration |
| | | ___ invention | | |

**Specific dates** 1933–Present **Builder/Architect** N/A

**Statement of Significance (in one paragraph)**

Rogers Dry Lake is the primary resource associated with and responsible for the establishment of Edwards Air Force Base and the Dryden Flight Research Facility. Edwards AFB is the world's premier flight testing and flight research center. Both Edwards and Dryden have had a profound impact on the development of aerospace technology and military security. It is precisely the presence of the natural attributes of clean air, isolated location, ideal weather, variable terrain, and the large expanse of dry lakebeds that first attracted the Army to the Rogers Dry Lake in 1933. These natural assets enabled the military and later the National Advisory Committee for Aeronautics (NACA) and the National Aeronautics and Space Administration (NASA) to flight test aircraft that were on the cutting edge in aviation and aerospace technology. Starting in 1947 with the flight of the Bell X-1, the first plane to break the sound barrier, to the landing of the Space Shuttle Columbia in 1981, Rogers Dry Lake has been the scene of the most important developments in the history of aviation.

General History

Rogers Dry Lake area was little more that a watering stop for the Atchison, Topeka & Santa Fe Railroad until 1910 when the Corum family settled near the lake.[1]

Clifford Corum, his wife Effie, and his brother Ralph were homesteaders and were the earliest known settlers of this region. Seeking to attract others to the area they built a combination store and post office. Effie drove the family buggy across the scorching desert seeking the necessary signatures for a petition that would officially give the Corum name to their post office. When the Postal Department rejected the name because of its similarity to another California town, the Corums presisted in immortalizing their name. They decided to reverse the letters in Corum and the name Muroc was born.

Muroc was first used by the military in 1933 when a small advance party from March Field in Riverside came to design and maintain a bombing range for the Army Air Corps. Four years later, the entire Air Corps was performing bombing and gunnery maneuvers here.

At the outbreak of World War II, the south end of the lake was used for training P-38 Lightning fighter pilots, and B-24 Liberator and B-25 Mitchell bomber crews.

Bombing practice targets included a realistic 650-foot model of a Japanese Navy heavy cruiser, dubbed the "Muroc-Maru." Pilots and bombardiers used the "ship" for strafing, identification, and skip bombing practice. The Muroc-Maru passed from landmark to legend in 1950 when it was "sunk" as a flight hazard by Army engineers, who first had to rid the hull of unexploded bombs.

In February 1942, Col. Benjamin W. Chidlaw and Lt. Col. Ralph P. Swofford of the Materiel Center at Wright Field, Ohio, on an extended tour of the western United States, chose Muroc Dry Lake as the ideal location to test the new "super secret" Bell-built XP-59 jet airplane.

Later, negotiations with the Muroc Bombing and Gunnery Range commanding officer, Maj. Glen L. Arbogast, resulted in assignment of a portion of Muroc Dry Lake north of the Santa Fe Railroad for exclusive use of the Materiel Center personnel who had been directed to proceed to Muroc, California, to take charge of the "Materiel Center Flight Test Site." In September 1942, America's first jet arrived at Muroc by rail. While it was being readied for its first flight, a wooden propeller was attached to the nose of the aircraft to disguise its jet propulsion. The XP-59A made its first flight October 1, 1942.

As tests of the XP-59A progressed, it became apparent that the location was ideal for testing aircraft. In addition to a climate assuring 350 days a year flying weather, the dry lake was a ready-made emergency landing field for experimental aircraft.

From December 1942 the base was called the Materiel Command Flight Test Base. In 1944 it was redesignated the Muroc Flight Test Base. In October 1946 the Muroc Flight Test Base on the north end of Muroc Dry Lake and the Bombing and Gunnery Crew Training Base on the south end of the dry lake at merged into a single flight test facility at Muroc Army Air Field under the jurisdiction of the Air Materiel Command.

Muroc Army Air Field was redesignated Muroc Air Force Base in February 1948 and became Edwards Air Force Base in February 1949 in honor Capt. Glen W. Edwards. A native of Lincoln, California, Captain Edwards had been killed June 5, 1948, during a performance test of a YB-49 "flying wing" experimental jet bomber. Official dedication of the newly named Edwards AFB took place January 27, 1950.

Through the years, Edwards has been the focal point for testing and evaluating aircraft concepts and designs and has contributed directly to the improved combat capability of the Air Force. Many aerospace "firsts" have occurred in the skies above Edwards. Capt. Charles E. Yeager became the first man to break the once-feared sound barrier. He accomplished this feat October 14, 1947, in the Bell X-1 experimental rocket plane. This led directly to the development of the supersonic Century Series of fighter aircraft beginning with the F100 Super Sabre.

The three X-15s, the world's fastest and highest flying winged aircraft, were tested from 1959 until 1968. Knowledge gained from their 199 flights in the research program hastened the day of the United States manned space and moon flights.

The second X-15, now on display at the Air Force Museum, Wright-Patterson AFB, Dayton, Ohio, set an unofficial world speed record of 4,520 mph October 3, 1967. The X-15s reached altitudes of more than 67 miles. Other test projects have included the XB-70A triple-sonic Air Force research aircraft, the F-111A supersonic variable sweep-wing jet fighter, the X-13 vertical take-off and landing airplane, and the C-5A Galaxy cargo aircraft.

After the X-15, the Air Force-National Aeronautic and Space Administration (NASA) research partnership turned to a different kind of experimental rocket craft--a specially contoured, wingless vehicle called the lifting body.

Not designed for speed like the X15s, the lifting bodies were shaped to fly both as a spacecraft and a wingless airplane. They were tested to determine their qualities for an extended near-earth flight and for conventional runway approach and landing. The knowledge gained from the lifting body research has aided in the development of the space shuttle.

The shuttle eliminates costly "throw-away" boosters and ocean splashdowns. Edwards AFB was the prime landing site for all space shuttle tests and development flights. During the entire life of the space shuttle program the desert base, with its uniquely qualified large drylake bed, will continue to be a contingency landing site on any orbital mission.

The natural resource of Rogers Dry Lake has made possible the successful development and testing of generations of American aircraft leading to the Space Shuttle today. Because of this association with the History of American Aviation the Rogers Dry Lake is uniquely qualified for designation as a National Historic Landmark.

Footnotes

1. The descriptive material for the general history of this section has been taken from Antelope Valley Salutes Edwards AFB (Riverside, Ca.: Armed Services Press, 1982), pp. 37-9.

Bibliography

Antelope Valley Salutes Edwards AFB. Riverside, Ca.: Armed Services Press, 1982.

National Aeronautics and Space Administration. Flight Research Center. No place of publication, No publisher listed, no date given.

National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center Enviromental Resources Document, Edwards, Ca.: Hugh L. Dryden Flight Reserach Center, 1980

National Aeronautics and Space Administration. NASA Dryden. Edwards, Ca.: Hugh L. Dryden Flight Research Center, no date.

National Aeronautics and Space Administration. NASA FACTS: Ames Research Center Hugh L. Dryden Flight Research Facility. Edwards, Ca.: Hugh L. Dryden Flight Research Facility, 1982.

Rogers Dry Lake UTM References

Rogers Dry Lake North

A. 11/428690/3868300
B. 11/428958/3864000
C. 11/426060/3859300

Rogers Dry Lake South

D. 11/425600/3854900
E. 11/422870/3850280
F. 11/420000/3853950

Redman

G. 11/416960/3856160
H. 11/417500/3857800
I. 11/420030/3859000

Rogers Dry Lake North

J. 11/421040/3860710
K. 11/420040/3865460

Edwards

L. 11/418850/3864560
M. 11/420150/3870860

Rogers Dry Lake North

N. 11/422950/3872940
O. 11/425860/3871360

## 9. Major Bibliographical References

See continuation sheets

## 10. Geographical Data

Acreage of nominated property Sixty-five square miles

Quadrangle name See continuation sheet

Quadrangle scale 1:24,000

UMT References see continuation sheet

| | Zone | Easting | Northing | | Zone | Easting | Northing |
|---|---|---|---|---|---|---|---|
| A | | | | B | | | |
| C | | | | D | | | |
| E | | | | F | | | |
| G | | | | H | | | |

**Verbal boundary description and justification**

The boundary of the Rogers Dry Lake is shown as the green line on the following U.S.G.S. Maps: Rogers Dry Lake North, Rogers Dry Lake South, Redman and Edwards.

**List all states and counties for properties overlapping state or county boundaries**

state code county code

state code county code

## 11. Form Prepared By

name/title Harry A. Butowsky

organization National Park Service date May 15, 1984

street & number Division of History telephone (202) 343-8168

city or town Washington, D.C. 20240 state

## 12. State Historic Preservation Officer Certification

The evaluated significance of this property within the state is:

___ national ___ state ___ local

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89-665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service.

State Historic Preservation Officer signature

title date

For NPS use only

I hereby certify that this property is included in the National Register

date

Keeper of the National Register

Attest: date

Chief of Registration

ROGERS LAKE NORTH QUADRANGLE
CALIFORNIA-KERN CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)

**Rogers Dry Lake UTM References**

**Rogers Dry Lake North**

A. 11/428690/3868300
B. 11/428958/3864000
C. 11/426060/3859300

**Rogers Dry Lake South**

D. 11/425600/3854900
E. 11/422870/3850280
F. 11/420000/3853950

**Redman**

G. 11/416960/3856160
H. 11/417500/3857800
I. 11/420030/3859000

**Rogers Dry Lake North**

J. 11/421040/3860710
K. 11/420040/3865460

**Edwards**

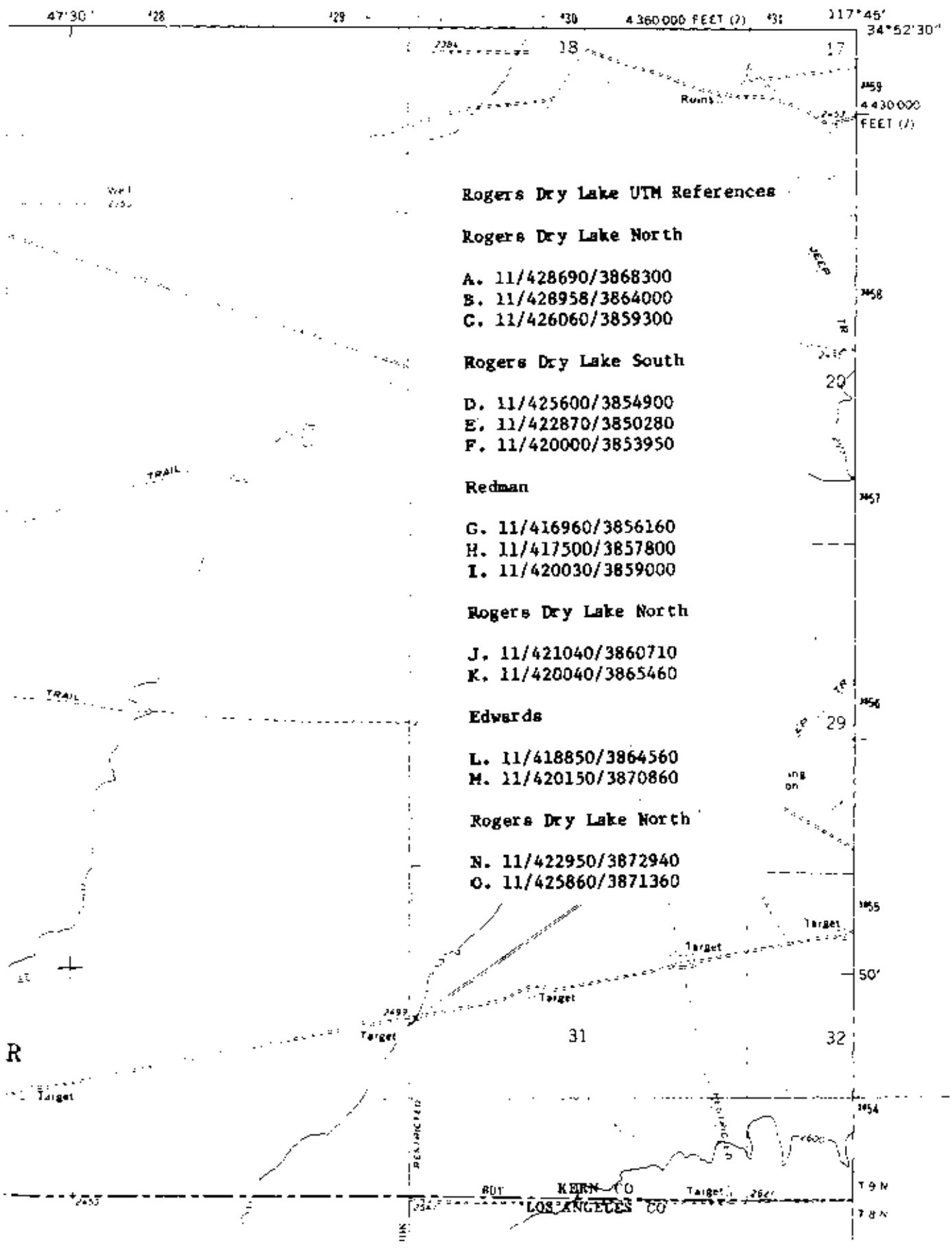
L. 11/418850/3864560
M. 11/420150/3870860

**Rogers Dry Lake North**

N. 11/422950/3872940
O. 11/425860/3871360

E

ROGERS LAKE SOUTH QUADRANGLE
CALIFORNIA
7.5 MINUTE SERIES (TOPOGRAPHIC)
SE/4 ROGERS LAKE 15' QUADRANGLE




**Rogers Dry Lake UTM References**

**Rogers Dry Lake North**

**A. 11/428690/3868300**
**B. 11/428958/3864000**
**C. 11/426060/3859300**

**Rogers Dry Lake South**

**D. 11/425600/3854900**
**E. 11/422870/3850280**
**F. 11/420000/3853950**

**Redman**

**G. 11/416960/3856160**
**H. 11/417500/3857800**
**I. 11/420030/3859000**

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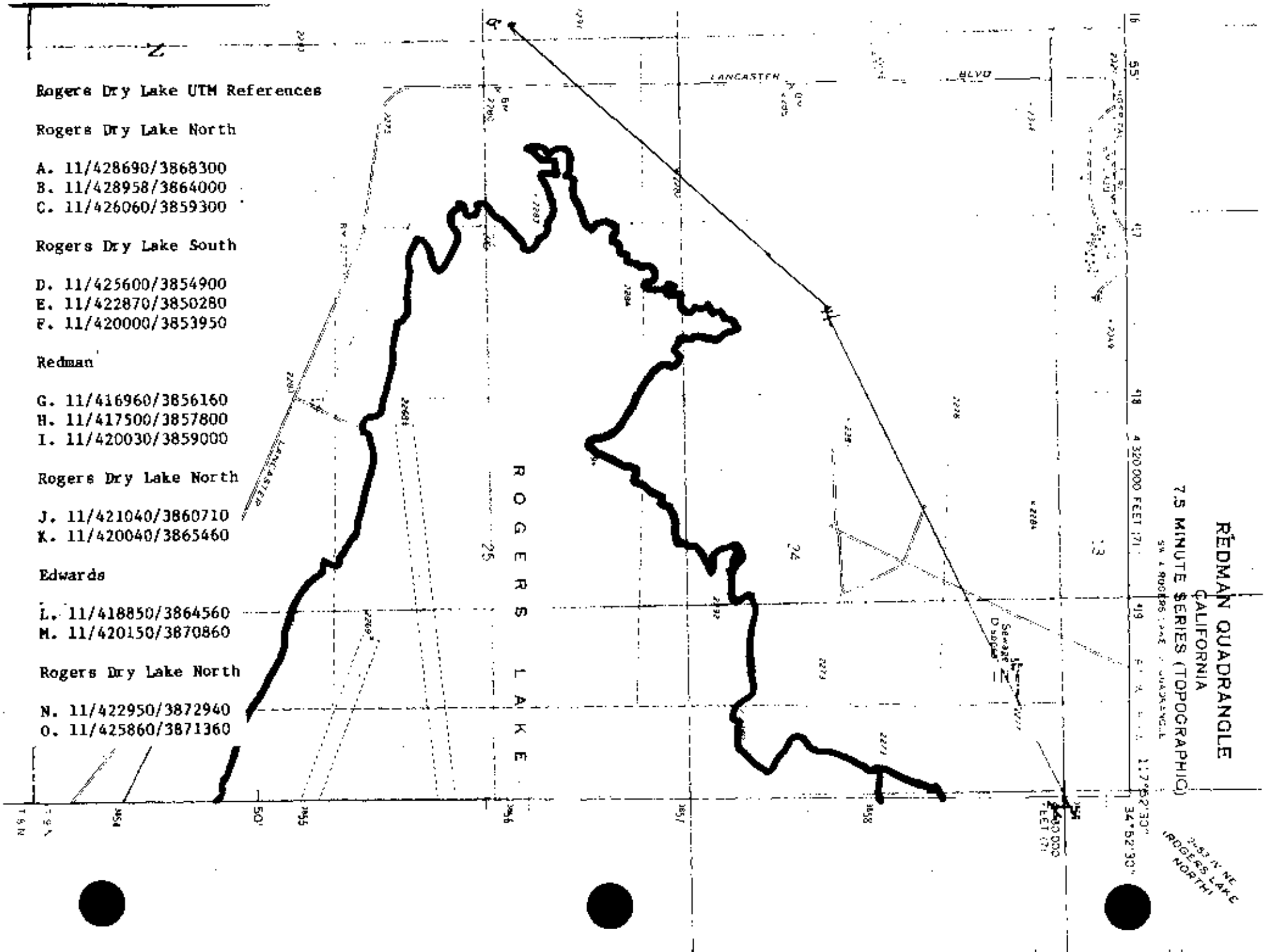

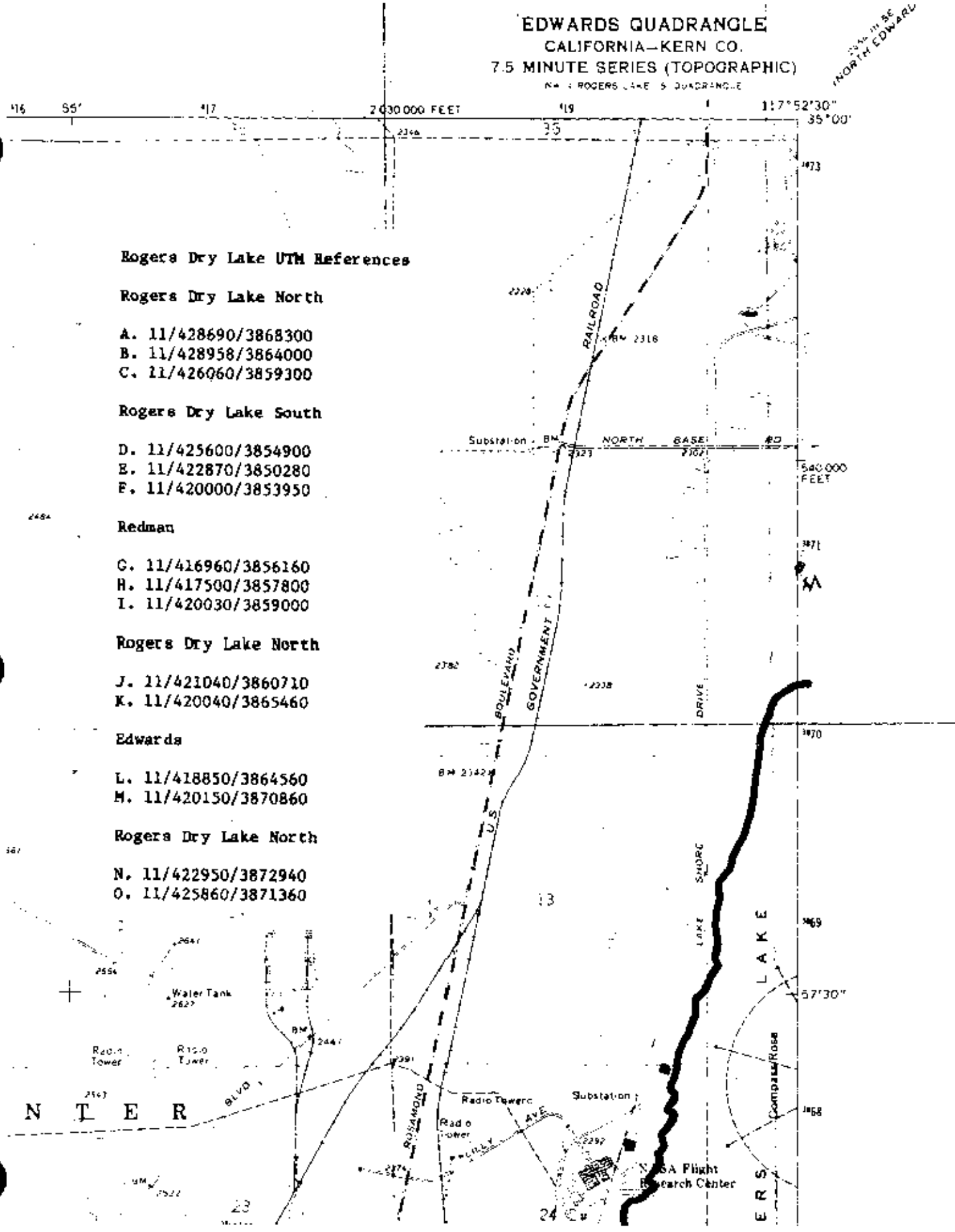


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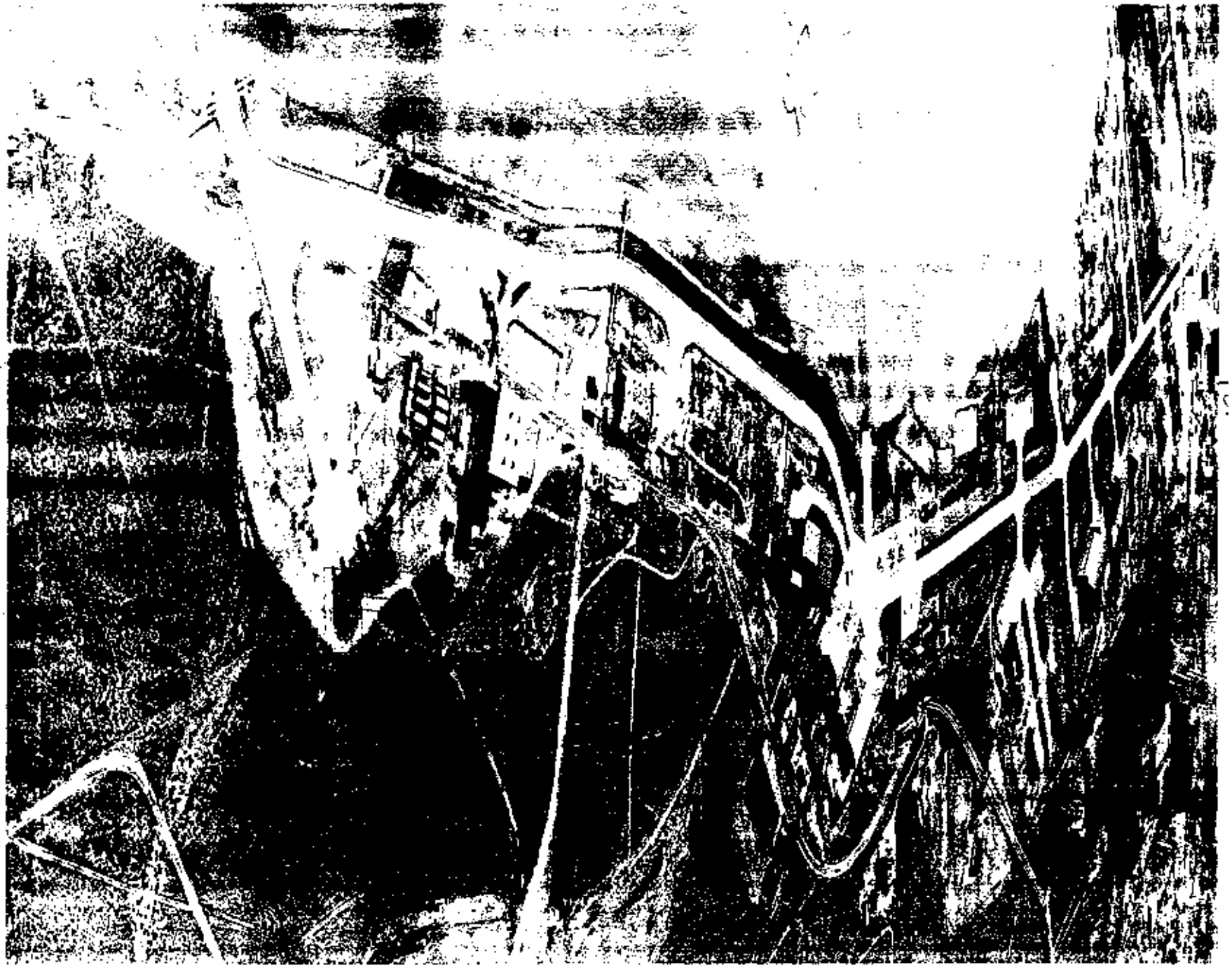
**Rogers Dry Lake North**

N. 11/422950/3872940
O. 11/425860/3871360

1. Rogers Dry Lake
2. Edwards Air Force Base
3. NASA
4. 1983
5. NASA, Dryden Flight Research Center
6. Dryden Flight Research Center and Edwards Air Force Base next to the Rogers Dry Lake



1. Rogers Dry Lake
2. Edwards Air Force Base, California
3. NASA
4. Unknown
5. NASA, Dryden Flight Research Center
6. The Bell X-1E on the Rogers Dry Lake

NASA National Aeronautics and Space Administration

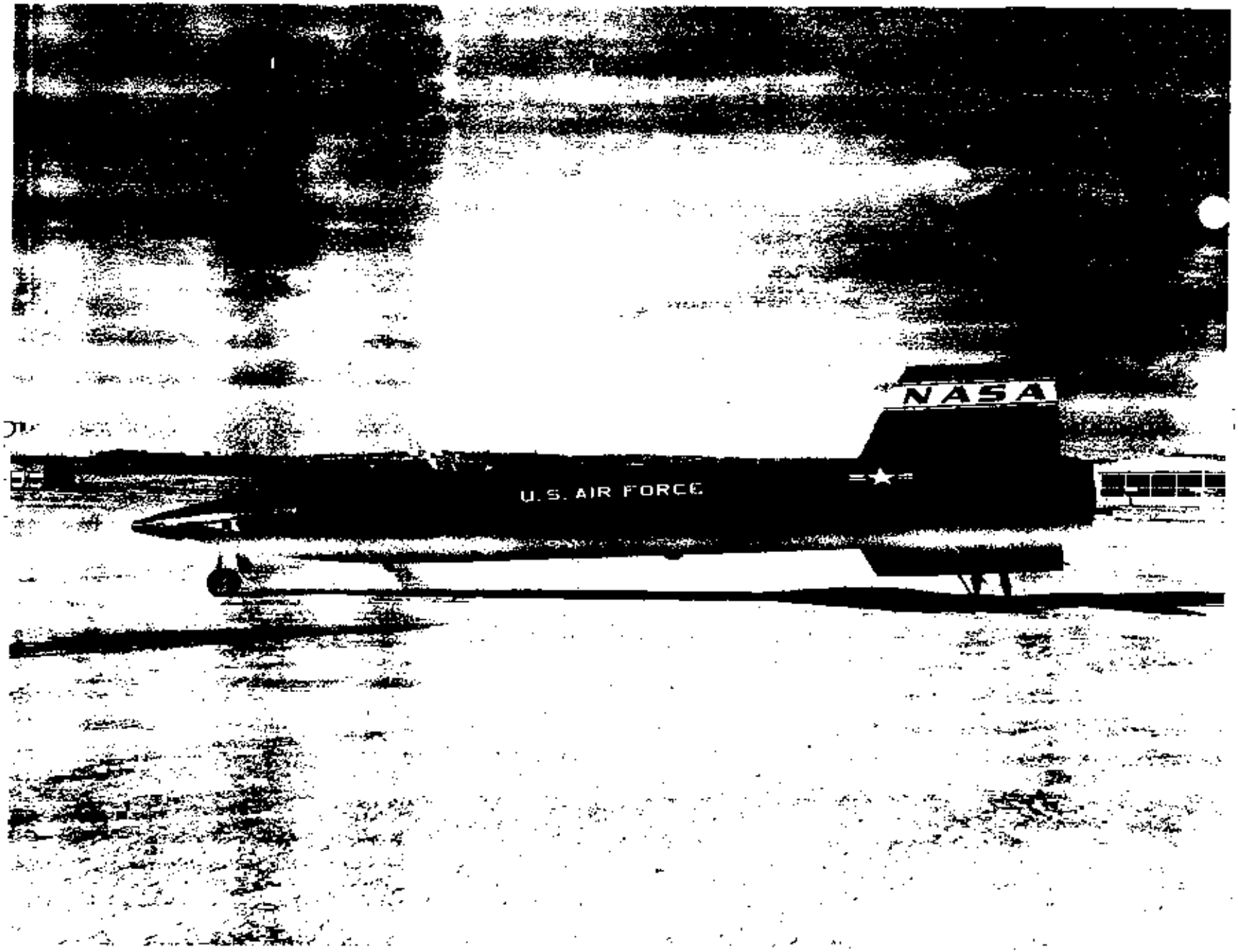
Hugh L. Dryden Flight Research Center
Edwards, California


E-1920

1. Rogers Dry Lake
2. Edwards Air Force Base, California
3. NASA
4. Unknown
5. NASA, Dryden Flight Research Center
6. The X-15 research aircraft on the Rogers Dry Lake

NASA National Aeronautics and Space Administration

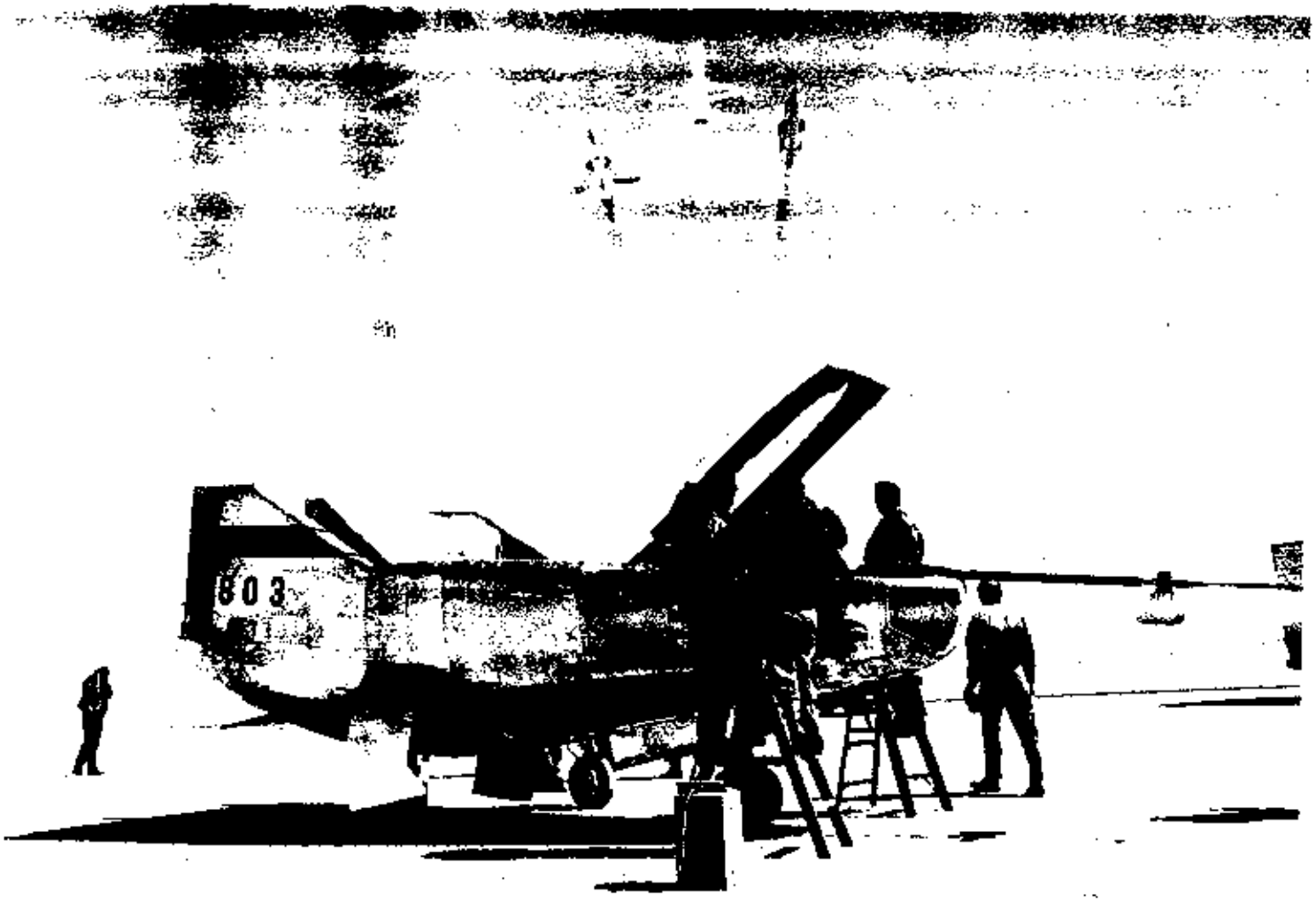
Hugh L. Dryden Flight Research Center
Edwards, California




B-7900

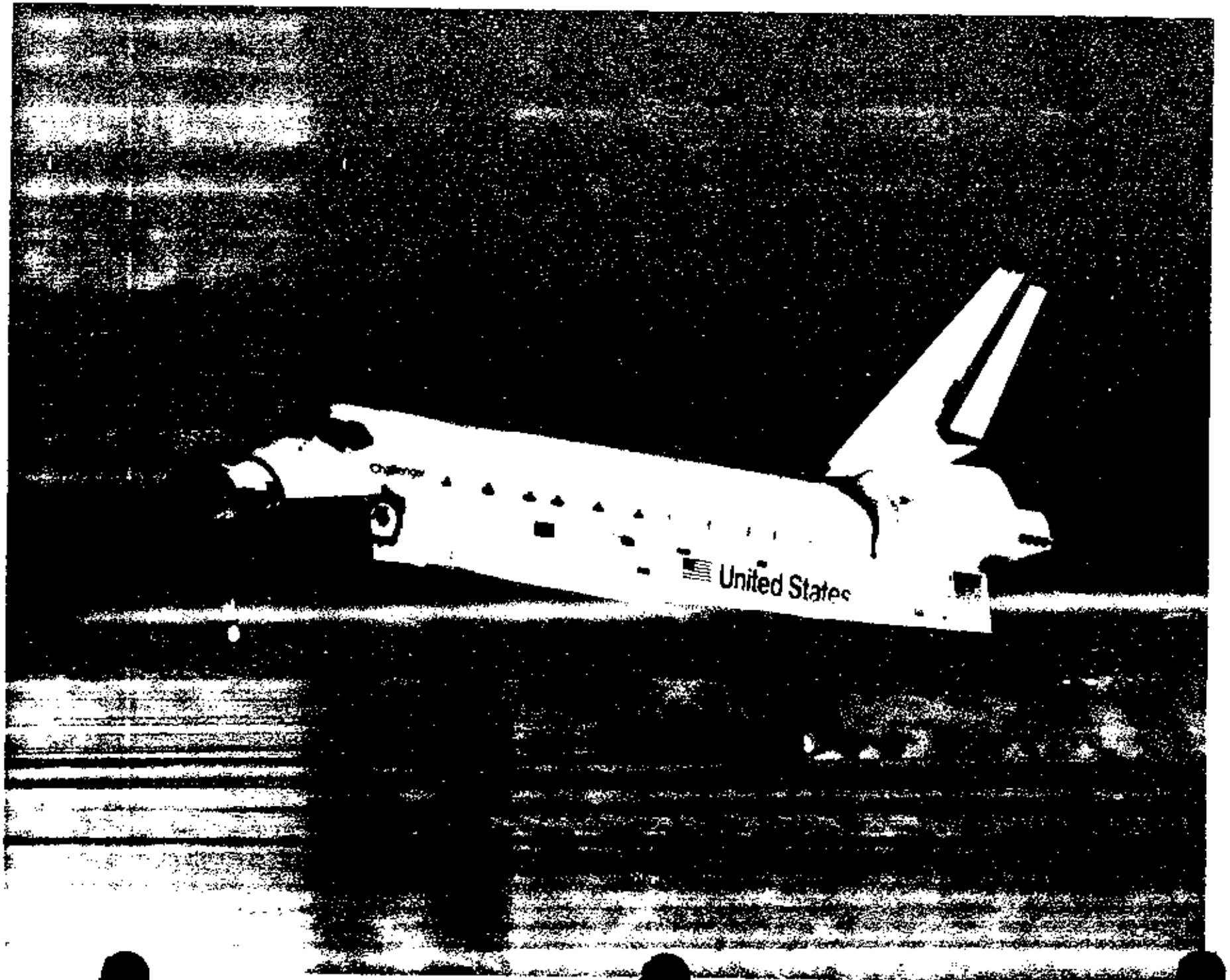
1. Rogers Dry Lake
2. Edwards Air Force Base, California
3. NASA
4. Unknown
5. NASA, Dryden Flight Research Center
6. The M-2 lifting body on the Rogers Dry Lake

NASA
E-22786




Flight Research Center
Edwards, California

1. Rogers Dry Lake
2. Edwards Air Force Base, California
3. NASA
4. Unknown
5. NASA, Dryden Flight Research Center
6. Space Shuttle Challenger landing on the Rogers Dry Lake


United States