HISTORIC AMERICAN ENGINEERING RECORD

LUNAR LANDER RESEARCH FACILITY/IMPACT DYNAMICS RESEARCH FACILITY
BUILDING 1297

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LANGLEY RESEARCH CENTER
HAMPTON, VIRGINIA

Submitted to:
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LANGLEY RESEARCH CENTER

Submitted by:
JAMES RIVER INSTITUTE FOR ARCHAEOLOGY, INC.

Date: September 2006

HISTORIC AMERICAN ENGINEERING RECORD

NASA LANGLEY RESEARCH CENTER
LUNAR LANDER RESEARCH FACILITY/IMPACT DYNAMICS RESEARCH FACILITY

HAER No. VA-118-G

Location: 14 West Bush Road
National Aeronautical and Space Administration's (NASA) Langley Research Center (LaRC), Hampton, Virginia.

UTM Coordinates for facility center point: E376521, N4106819

The Lunar Lander Research Facility (LLRF), Facility No. 1297, is located in a relatively undeveloped and isolated section of NASA Langley Research Center at the end of West Bush Road. A wooded natural area generally surrounds the site. To the north beyond a strip of woods is the Landing Loads Facility (Facility 1257) and to the southwest is a large incinerator with a 250-foot tall stack (Facility No. 1288). As tall as a 24-story building, the A-framed LLRF, commonly referred to as the Gantry, is a conspicuous landmark visible from much of the surrounding area. It is used as an unofficial aid to navigation by boaters in the Back and Poquoson Rivers as well as in the nearby southern portions of Chesapeake Bay. Aircraft warning lights mounted on its top make it visible at night.

Date(s) of Construction: Completed 1965

Engineer: Jackson and Moreland

Present Owner(s): United States Government

Present Use: Impact Dynamics Research Facility

Significance: The Lunar Lander Research Facility is of national significance for its role in, and contribution to, the United States space program. It was designated a National Historic Landmark in 1985.

Project Information: This documentation was prepared in February 2006, for NASA Langley Research Center under contract with Science Applications International Corporation which assists NASA in addressing environmental compliance requirements.

The documentation was prepared with the assistance of a number of individuals including:

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Special thanks are also given to Kristen Poultney and Caroline Diehl of Science Applications International Corporation and Carol Herbert of NASA for their assistance and support in completion of this project.

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Historical Background:

When President John F. Kennedy confidently predicted in 1961 that the United States would land a man on the Moon by the end of the decade, the task of implementing what seemed to be a wildly ambitious goal fell to the engineers of the National Aeronautics and Space Administration (NASA). Three different strategies for a Moon landing appeared possible: direct ascent, Earth-orbit rendezvous (EOR), or lunar-orbit rendezvous (LOR). A direct ascent to the Moon was ruled out due to the projected size of the launch vehicle, while the EOR concept would require two separate launch vehicles. NASA eventually settled on the LOR method, in which a single rocket would launch two spacecraft into lunar orbit. One would circle the Moon while the other descended to the lunar surface. The lander would then boost itself back into orbit, dock with the mother ship, and return to Earth.

The success of the LOR strategy ultimately depended on whether the astronauts could learn to safely land the Lunar Excursion Module (LEM) on the Moon's surface and return into orbit to dock with the mother ship. A major obstacle in designing a training procedure, however, was that the LEM would handle far differently in the Moon's atmosphere, with 1/6th the gravitational pull of Earth's. The problem thus became how to replicate the operation of the LEM in a low gravitational environment. The solution came in the form of the Lunar Landing Research Facility (LLRF), a training simulator that allowed NASA engineers to study the complex lunar landing process, while giving the Apollo astronauts critical hands-on pilot training in the LEM.

The LLRF was completed in 1965 at a cost of $3.5 million. Located in the West Area of Langley Research Center, the most obvious feature of the LLRF was its enormous gantry, which became an unmistakable landmark on the horizon. The A-frame steel structure, measuring 400 feet long by 240 feet high, was composed of truss elements arranged with four sets of inclined legs that provided adequate clearance for any pendulous motion the vehicle might develop. An elevator shaft in the east end provided access to the overhead equipment, while catwalks allowed the inspection of all structural areas.

The LLRF simulated lunar gravity through an overhead partial-suspension system that provided lifting force through cables acting through the LEM's center of gravity, counteracting all but 1/6th of the Earth's gravitational force. Both the lifting force and vertical alignment of the cables was controlled automatically through servo-controlled hydraulic drive systems that powered an overhead traveling bridge crane and dolly unit mounted on the gantry. The cables were attached to the LEM with a gimbal system that allowed complete freedom of motion. Protected by automatic and manual braking equipment, the LEM could fly unobstructed within an area measuring approximately 360 feet long, 180 feet high, and 42 feet wide.

The operation of the facility was directed from a control room on the second floor of the 2-story office and shop building located near the southwest corner of the gantry structure.

From here the movements of the LEM, bridge, and dolly could be viewed by the test director and facility operators through large observation windows. The control room was equipped with controls for the manual and automatic operation of the bridge crane drive system, while numerous instrument displays indicated the status and performance of the drive system and the LEM. Two-way communications throughout the facility allowed the test director to maintain constant voice contact with the pilot and operational crews. Sophisticated data, photographic, and voice recorders rounded out the facility's technologically advanced features, providing a complete analytical framework for the testing process.

In addition to allowing flight testing of the LEM, the LLRF also was used as a lunar-walking simulator for the Apollo astronauts. This was accomplished by suspending the astronaut on his side with a system of slings and cables, allowing him to walk on a plane inclined to approximately 80.5 degrees relative to the vertical direction of Earth's gravity. Other gravitational conditions, even weightlessness, could be created by varying the inclination of the walkway. Initially paved with a 30-foot wide strip of concrete to minimize jet-blast effects and fuel spillage problems, the base of the LLRF later was modeled with fill dirt to resemble the lunar surface, complete with the holes, pits, and craters the astronauts would encounter on the Moon.

From its inception in 1965 until the end of the Apollo program in 1972, the LLRF was used to train 24 astronauts for lunar missions, including Neil A. Armstrong and Edwin E. "Buzz" Aldrin, Jr., of Apollo 11, the first men to walk on the Moon. Armstrong offered what was perhaps the greatest tribute to the importance of the LLRF in the success of the Apollo program. When asked what it was like to land on the Moon, he replied: "Like Langley."

Although the end of manned lunar missions made the LLRF redundant by the early 1970s, NASA quickly contrived a new use for this Langley landmark, converting it into a full-scale crash test facility for General Aviation aircraft. Redesignated the Impact Dynamics Research Facility (IDRF), it was designed to obtain definitive data on the structural response of aircraft, and the forces transmitted to the occupants, during a crash impact. Data from testing could be correlated with analytical predictive models, while full-scale crash tests would help evaluate crashworthy design concepts both for aircraft structure and for seat and restraint systems.

The first full-scale crash test at the new IDRF was conducted in February 1974. These tests took advantage of the large dimensions of the gantry structure, using a "pendulum-swing" technique in which aircraft were placed in harnesses, raised to the desired height and pullback position, and released. One of the most important features of the facility was its ability to conduct full-scale crash tests of light aircraft and rotorcraft under free-flight conditions, allowing the test staff control over the attitude and velocity of test craft on impact. In 1981, a 70-foot Vertical Test Apparatus, or vertical drop tower, was constructed beneath the northwest leg of the gantry, allowing for a different range of testing procedures. Over the course of its lifetime, the IDRF was used to conduct 41 full-scale crash tests of General Aviation aircraft, including landmark studies to establish baseline crash performance data for metal and composite aircraft; 11 full-scale crash tests of civilian helicopters; 48 Wire Strike Protection System (WSPS) qualification tests of Army helicopters, including the AH-1 Cobra; 3 vertical drop tests of Boeing 707 transport aircraft fuselage sections; and 60-70 drop tests of the F-111 Aardvark. In addition, the IDRF aided in numerous component tests in support of the Mars Sample Return Earth Entry Vehicle program, and other unique experiments including a tether-hover test of the XFV-12A, vertical drop tests of CH-47 Chinook helicopter fuselage sections containing artillery projectiles, and drop tests of an energy-absorbing pallet for the deployment of a remote-controlled vehicle.

Maintenance of the large gantry structure was complicated in the early 1980s by the construction nearby of a plant that burned refuse to generate steam used by NASA and Langley Air Force Base. Only 90 feet tall, the smokestack's effluent tended to blow onto the gantry, hastening paint damage and corrosion. As a result, the stack was raised to 250 feet in the mid-1980s. It was at this time that the historical significance of the LLRF and its many contributions to the U.S. space program was formally recognized, with the facility designated a National Historic Landmark in 1985.

Although the resolution of the smokestack issue reduced the pace of the gantry's deterioration, NASA's decision to end research at the IDRF prompted the decision to halt a costly restoration and repainting program. The final Department of Defense-sponsored full-scale crash tests at the IDRF were conducted in 1999. Full-scale crash and drop tests of civilian aircraft continued until 2003 with support from the Accident Mitigation Element of the NASA Aviation Safety Program. The IDRF was reopened in August 2005 and is currently used for testing of landing systems for the Crew Exploration Vehicle (CEV) in support of the space mission; impact dynamics analysis (dropping fuselage, full scale models) in support of aeronautics; and general research on landing systems. Future testing anticipated for the facility includes retrorocket testing, water impact testing, and hazard avoidance (for lunar missions).

Chronology:

1961	President John F. Kennedy predicts that the U.S. will land a man on the moon by the end of the decade.
1965	The Lunar Landing Research Facility is completed.
1969	Apollo 11 astronauts Neil A. Armstrong and Edwin E. "Buzz" Aldrin, Jr., complete training at the facility prior to their successful moon landing mission.
1972	The Apollo program ends.
1974	The redundant Lunar Landing Research Facility is converted to use as the Impact Dynamics Research Facility.
1985	The facility is designated a National Historic Landmark.
2003	Testing is ended at the Impact Dynamics Research Facility.
2005	IDRF reopens and testing is conducted in support of aeronautics and space missions.

Sources Consulted:

Butowsky, Harry A. *Man in Space: National Historic Landmark Theme Study*. National Park Service, Department of the Interior, Washington, D.C., 1984a.

National Register of Historic Places Inventory-Nomination Form, Lunar Landing Research Facility. National Park Service, Department of the Interior, Washington, D.C., 1984b.

Jackson, Karen E., Richard L. Boitnott, Edwin L Fasanella, Lisa E. Jones, and Karen H. Lyle. *A Summary of DOD-Sponsored Research Performed at NASA Langley's Impact Dynamics Research Facility*. Paper presented at the American Helicopter Society 60th Annual Forum, Baltimore, Maryland, 2004.

O'Bryan, Thomas C., and Donald E. Hewes. *Operational Features of the Langley Lunar Landing Research Facility*. NASA Technical Note D-3828, 1967.

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Physical Description:

C. W. Regan, Inc., general contractor, erected the LLRF in 1965 from a design by the engineering firm of Jackson and Moreland. It is a structure of monumental scale and retains most of its original design integrity. An open trussed steel A-frame structure, its overall plan dimensions at the top are 414 feet (east-west) by 214 feet (north-south) and approximately 549 feet (east–west) by 295 feet (north-south) at its base. The top of the structure is 240 feet 6 inches above grade. Four pairs of legs support horizontal trusses. The legs are trusses, 14-foot square in cross section, with web members on each side. Three pairs of the legs are transverse (north-south) and are spaced 200 feet apart center to center. The transverse legs are spaced 75-feet apart at the top and 200 feet apart at the base resulting in an inward incline of approximately 60 degrees. Each pair of transverse legs is connected at the top by a horizontal truss that is also 14-foot square. At the east end two inclined longitudinal trussed legs align with the top corners of the eastern most transverse legs. In addition to supporting vertical loads, they provide longitudinal bracing. At the top of the structure are two longitudinal, horizontal steel trusses that are 16-feet square and 400 feet long; one is on the north side, the other on the south. At an elevation of approximately 168 feet above grade is a second horizontal truss. This lower truss, also 14-feet square, is U-shaped in plan. The west end of this truss is the open end of the U. It engages the middle and easternmost A-frames and its nominal overall dimensions in plan are 105 feet (north-south) by 224 feet (east-west). The corner members of the square trusses are wide flange steel beams and web members are steel angles. All members in the trusses have bolted connections. The trussed legs are supported on square concrete footings that are nominally 20 feet square. The A-Frame and horizontal trusses are painted red and white in alternating bands. A bridge crane travels the length of the LLRF in the plane of the top horizontal trusses. A dolly service dock (platform) projects towards the inside of the gantry near the top of the southeast corner. There is a vehicle launch and service dock (also a platform) mounted on the east end of the U-shaped lower horizontal truss. A steel stair with approximately 25 intermediate landings is attached to the outside face of the southeast leg. At the southeast corner of the gantry an elevator, enclosed in a freestanding shaft, provides access to observation areas, platforms and catwalks at the top and lower horizontal truss levels. The elevator shaft and its adjacent elevator machine room are clad with corrugated metal panels. Numerous conduits travel up the outside face of southeast leg and provide electrical power, control and communications circuits to the top of the structure. At the northeast corner is a drop test facility that was installed in 1967 (Facility No. 1297F). This structure, formed by two steel pipe columns nominally 20 feet apart, supports a platform, a hoist and a lifting frame for the test load.

The base of the gantry is paved with a concrete slab. In the 1960s this area was modeled with fill dirt to replicate the lunar surface. Now removed, the Reduced Gravity Walking Simulator was a concrete wall approximately four feet tall. To support its current role as an impact research facility, a solid billboard like panel has been erected under the gantry on the north side and serves as a measuring device for impact tests. The panel is 12 meters tall and slightly wider than 30 meters. Its face is painted white and a grid of black lines spaced one meter apart subdivides it. "NASA LaRC FULL-SCALE IMPACT DYNAMICS RESEARCH FACILITY" is painted on the panel in black letters that are nearly a meter tall. A storage area covered by an arched fabric-covered structure is north of this panel.

A two-story office, control room and shop building supports the operations of the gantry. It is located at the west end of the gantry on the south side between two of the trussed legs. The building is L shaped with the leg of the L parallel to the longitudinal axis of the gantry and the foot of the L projecting to the south. Its overall plan dimensions are nominally 100 feet (east-west) by 60 feet (north-south). The original 1965 section of the building, located at the east end, is almost square in plan. A rectangular addition was placed on the west end in 1966 soon after the original building was completed. The front (north) section of the 1965 building faces the LLRF and has two stories. Offices are on the first floor and the control room is on the second floor. The addition has two stories; the first floor is office space and the second floor contains a large conference room. The north (front) wall of the offices in the original building and in the addition has continuous windows in steel storefront type frames. The windows are glazed with grey glass and are not operable. Below the sills and above the heads of the glazing are flat metal panels. The front of the control room has an unobstructed view of the gantry. It is enclosed with an aluminum storefront assembly that has glass on three sides and overhead on the slightly inclined roof. Other exterior walls of the office are faced with flush metal panels. The shop area is a high bay pre-engineered building that abuts the office and control room section. The exterior walls of the shop are finished with "Sculptured Steelox" vertical ribbed metal panels. It has coiling steel overhead doors at the east and west ends. The offices have been renovated to provide open space and are subdivided by freestanding cubicles. They feature carpet and vinyl composition tile floors, painted vinyl wall covering on fixed partitions, suspended acoustical tile ceilings with recessed fluorescent lighting, and "McQuay Seasonmaker" fan-coil units below the windows. In the control room the original metal control console extends across the front wall below the windows. The office space on the second floor between the control room and the conference room has an elevated computer floor. The shop floor is a concrete slab on grade; the mezzanine floors are concrete on exposed metal deck supported on an exposed steel frame. The mezzanines have steel pipe rails along their open edges. Shop walls are painted metal panels and the ceiling is exposed plastic faced batt insulation fastened between roof purlins. The steel rigid frames of the pre-engineered building are exposed in the shop.

South of West Bush Road are three pre-engineered steel storage buildings constructed in the 1970s. A 3-foot chain link fence encloses the gantry area. A 10-foot tall safety fence, reinforced by steel fence posts and horizontal steel cables, separates the front of the office from the gantry operation area. Near the east end of the site adjacent to West Bush Road is a sign that displays a plaque attesting to the designation of the LLRF as a National

Historic Landmark in 1985. The facility is still in operation as the Impact Dynamics Research Facility.

HISTORIC AMERICAN ENGINEERING RECORD

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NASA LANGLEY RESEARCH CENTER
LUNAR LANDER RESEARCH FACILITY/
IMPACT DYNAMICS RESEARCH FACILITY
Hampton
Virginia

HAER NO. VA-118-G

Chris Cunningham, photographer, March 2006

VA-118-G-1	VIEW OF LUNAR LANDER RESEARCH FACILITY/IMPACT DYNAMICS RESEARCH FACILITY LOOKING SOUTHWEST.
VA-118-G-2	VIEW OF LUNAR LANDER RESEARCH FACILITY/IMPACT DYNAMICS RESEARCH FACILITY WITH ELEVATOR IN FOREGROUND LOOKING NORTHWEST.
VA-118-G-3	VIEW OF LUNAR LANDER RESEARCH FACILITY/IMPACT DYNAMICS RESEARCH FACILITY LOOKING WEST.
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VA-118-G-6	CLOSE UP VIEW OF LUNAR LANDER RESEARCH FACILITY/IMPACT DYNAMICS RESEARCH FACILITY BRIDGE CRANE LOOKING SOUTHEAST.
VA-118-G-7	VIEW OF LUNAR LANDER RESEARCH FACILITY/IMPACT DYNAMICS RESEARCH FACILITY LOOKING EAST.
VA-118-G-8	Photocopy of photograph (original in Langley Research Center Archives, Hampton, VA [LaRC] (NASA L-54-7836) VIEW OF LUNAR LANDER RESEARCH FACILITY/IMPACT DYNAMICS RESEARCH FACILITY CONTROL ROOM.

VA-118-G-9	Photocopy of photograph (original in Langley Research Center Archives, Hampton, VA [LaRC] (NASA L-69-6324) AERIAL VIEW OF LUNAR LANDER RESEARCH FACILITY/IMPACT DYNAMICS RESEARCH FACILITY LOOKING NORTHWEST.
VA-118-G-10	Photocopy of photograph (original in Langley Research Center Archives, Hampton, VA [LaRC] (NASA L-65-4813) VIEW OF LUNAR LANDER RESEARCH FACILITY/IMPACT DYNAMICS RESEARCH FACILITY IN USE WITH LUNAR LANDING MODULE SUSPENDED FROM ABOVE.
VA-118-G-11	Photocopy of photograph (original in Langley Research Center Archives, Hampton, VA [LaRC] (1965-L-06577) ASTRONAUT TRAINING AT LUNAR LANDER RESEARCH FACILITY/IMPACT DYNAMICS RESEARCH FACILITY.

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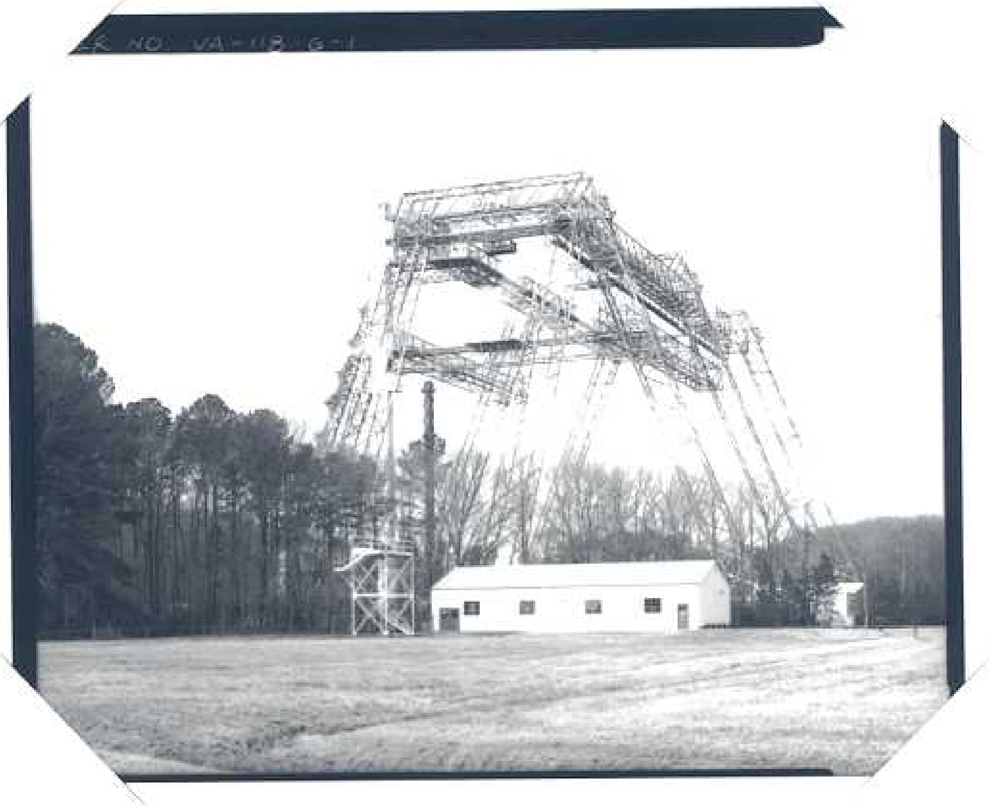

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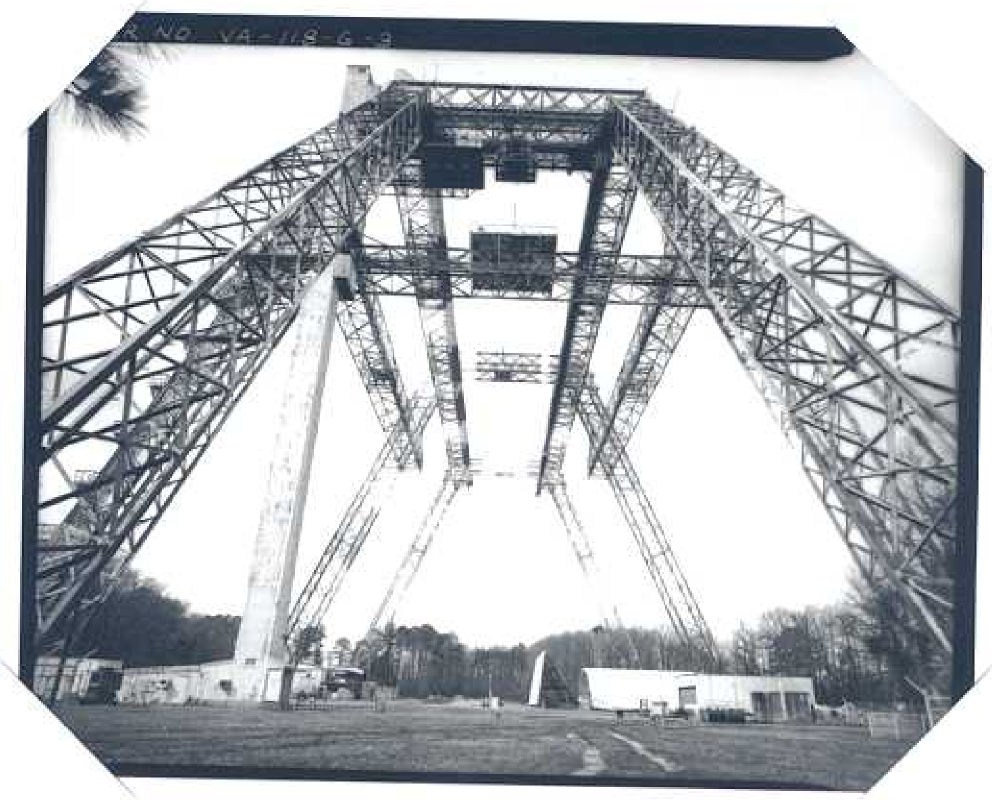

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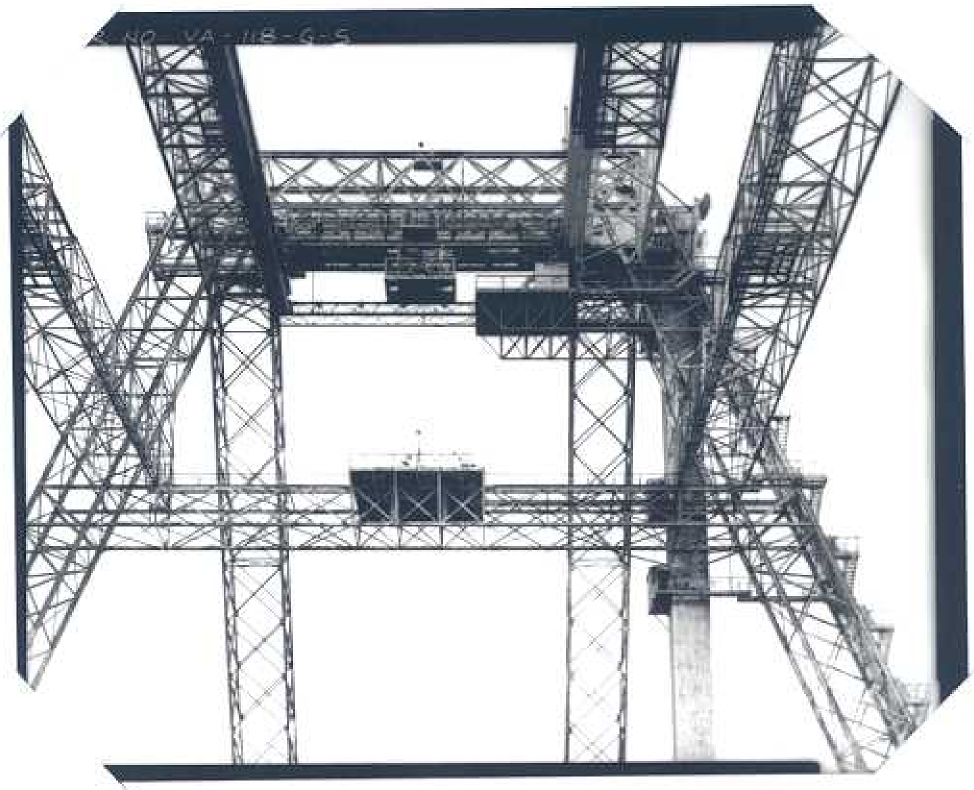

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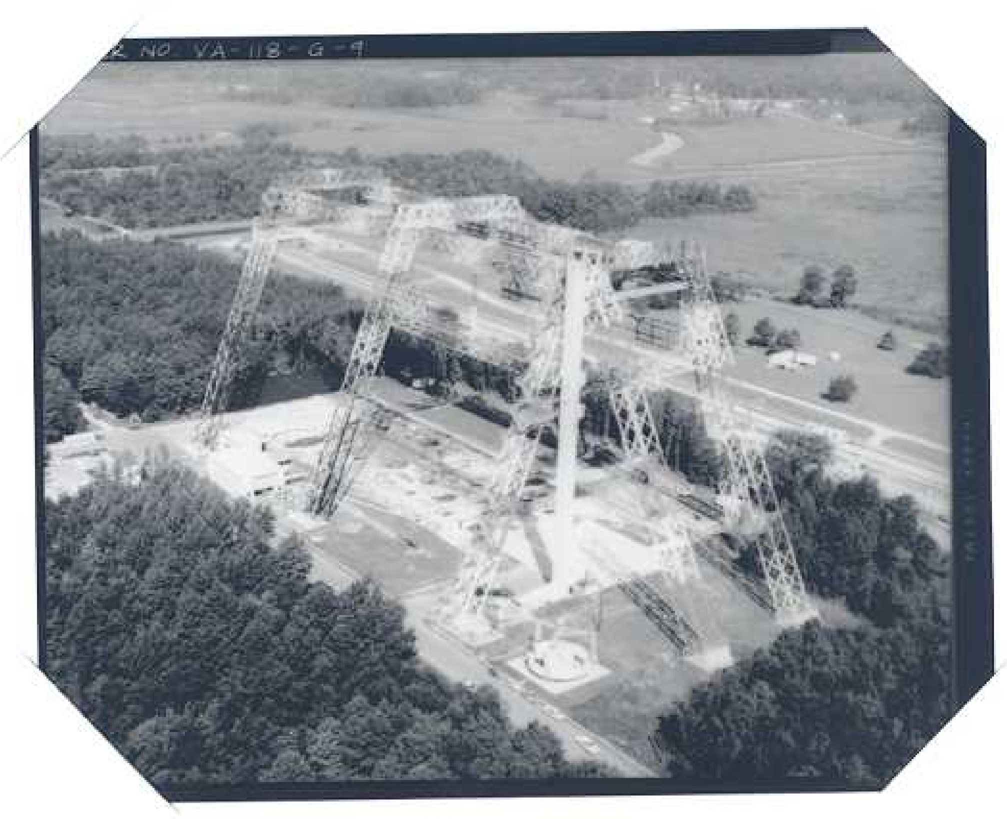

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HAER NO. VA-118-G-11

LUNAR LANDER RESEARCH FACILITY

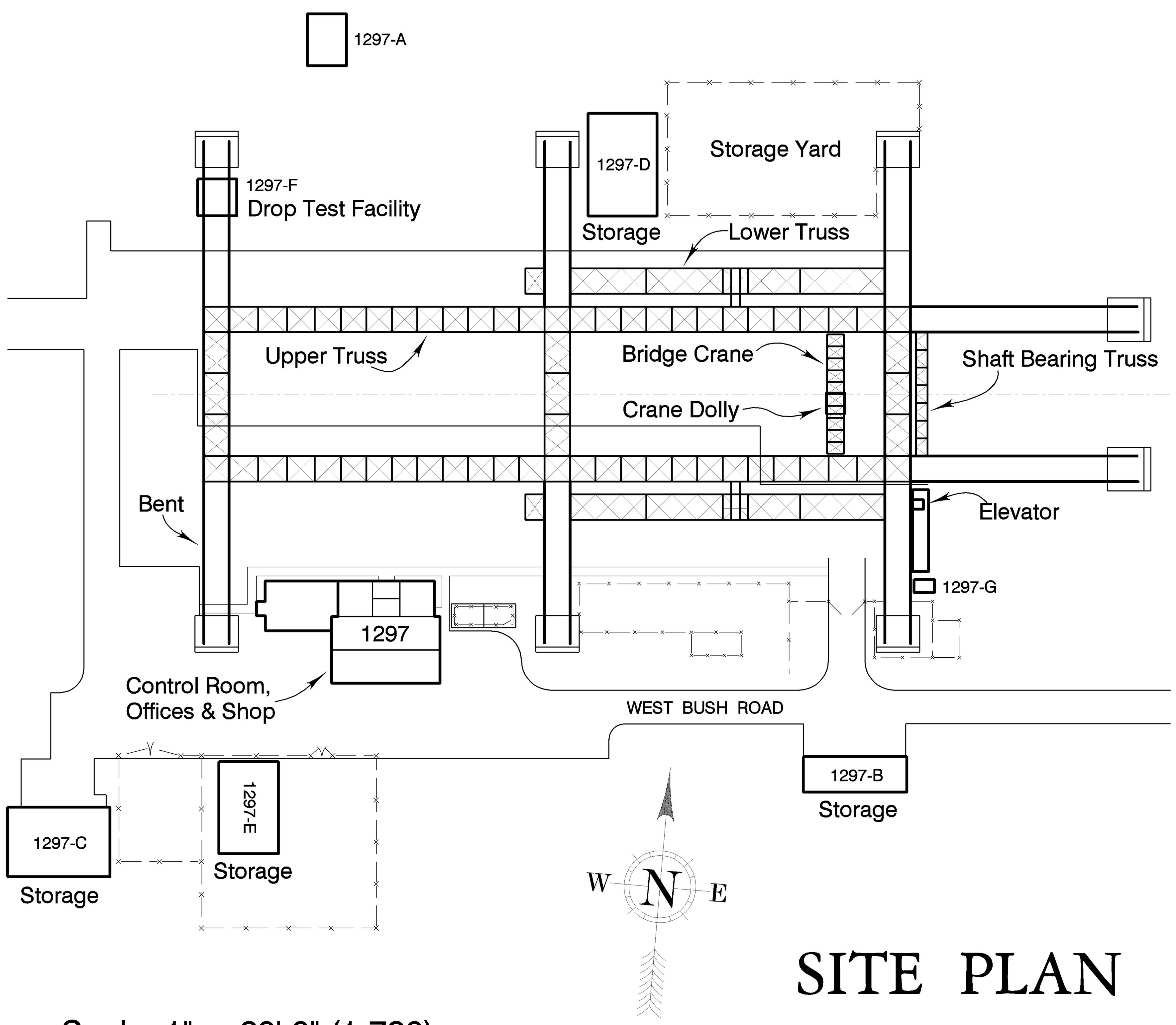
Building 1297
National Aeronautics and Space Administration - Langley Research Center
Hampton, Virginia

With the advent of the Apollo program in 1961, NASA set up numerous sites to train astronauts for Moon landings after the Lunar Orbit Rendevous strategy was selected as the most efficient plan to put men on the Moon and return them safely to Earth. The Lunar Lander Research Facility (LLRF) was conceived to permit astronauts to practice landing a Lunar Excursion Module (LEM) in simulated lunar gravity, 1/6 that of the Earth, while allowing NASA engineers to study the operating characteristics of the LEM in low-gravity conditions. The resulting steel structure was erected in 1965 for $3.5 million. It is 400 feet long and 240 feet high, composed of eight trussed legs and four longitudinal trusses which support a travelling crane and cable suspension system for the LEM simulator, or Lunar Lander Research Vehicle (LLRV). The approximate operating area for the LLRV was 360 feet long, 42 feet wide and 180 feet high. An elevator at the east end transported personnel to observation booths, platforms and catwalks to record tests, service machinery and inspect the gantry structure. An alternate training device, the Lunar Landing Research Vehicle (or "Flying Bedstead"), was a free-flying jet-powered landing trainer used at Edwards Air Force Base in California.

Pilots in the LLRV controlled its motions, monitored and governed by the facility director and operators in the second floor control room at the facility's shop and office building near the gantry's outhwestern leg. The control room was fitted with large windows at the sides and roof to give a complete view of the gantry, its equipment and the LLRV. Two-way communications and controls for the bridge crane were at hand along with status and performance indicators for the LLRV and gantry. The LLRV itself was suspended in a gimbal which permitted free motion on all axes. LLRV pilots had two minutes' hydrogen peroxide fuel with which to land, and they controlled the LLRV's attitude via 20 peroxide-fueled attitude rockets, interlocked with the gantry suspension system to produce the effects anticipated in lunar gravity. Photographic, voice and data recorders provided data for analysis and refinement of operations. The gantry also provided astronauts with training experience walking on the Moon in space suits by suspending them on cables inclined at an 80.5° angle. The facility's success was acknowledged by Neil A. Armstrong when he was asked what it was like to land and walk on the Moon. He replied: "Like Langley."

The LLRF trained 24 astronauts by the end of the Apollo program in 1972. By 1974 NASA had converted the gantry to test general aviation aircraft in full-scale crash tests, redesignating it as the Impact Dynamics Research Facility (IDRF). The dimensions of the gantry were large enough to mount test aircraft in harnesses, lift them to the desired height and pullback position, then release them to swing down like pendulums into the ground. The effects of such crashes on airframe designs were recorded photographically for analysis. In 1981 a 70-foot high Vertical Test Apparatus was erected beneath the northwestern leg of the gantry to conduct drop tests. The IDRF was the site of over 100 tests ranging from metal and composite aircraft frames, helicopters, and sections of Boeing 707 transport fuselages to specialized designs. In 1985 the LLRF was designated a National Historic Landmark.

These drawings were completed by Richard K. Anderson, Jr. of Cultural Resource Documentation Services, Sumter, SC for inclusion in the Historic American Engineering Record (HAER) of the National Park Service, U.S. Department of the Interior. The HAER program documents significant engineering and industrial sites throughout the United States. Project records are maintained in the Prints and Photographs Divison of the Library of Congress. Mr. Anderson prepared these drawings under contract to the James River Institute of Archaeology (JRIA) of Williamsburg, VA (Matthew Laird, Senior Historian) with the assistance of Carol Tyrer. JRIA conducted the HAER documentation project for NASA Langley Research Center under contract to Science Applications International Corporation (SAIC), Hampton VA, which assists NASA in addressing environmental compliance requirements. Caroline Diehl of SAIC and Carol Herbert of Tessada & Associates assisted in identifying and copying numerous references and engineering drawings in support of this project. Matthew Laird composed the HAER data pages with input from David Dutton and Michael Newbill; Chris Cunningham of Richmond, VA prepared the large format photographs.



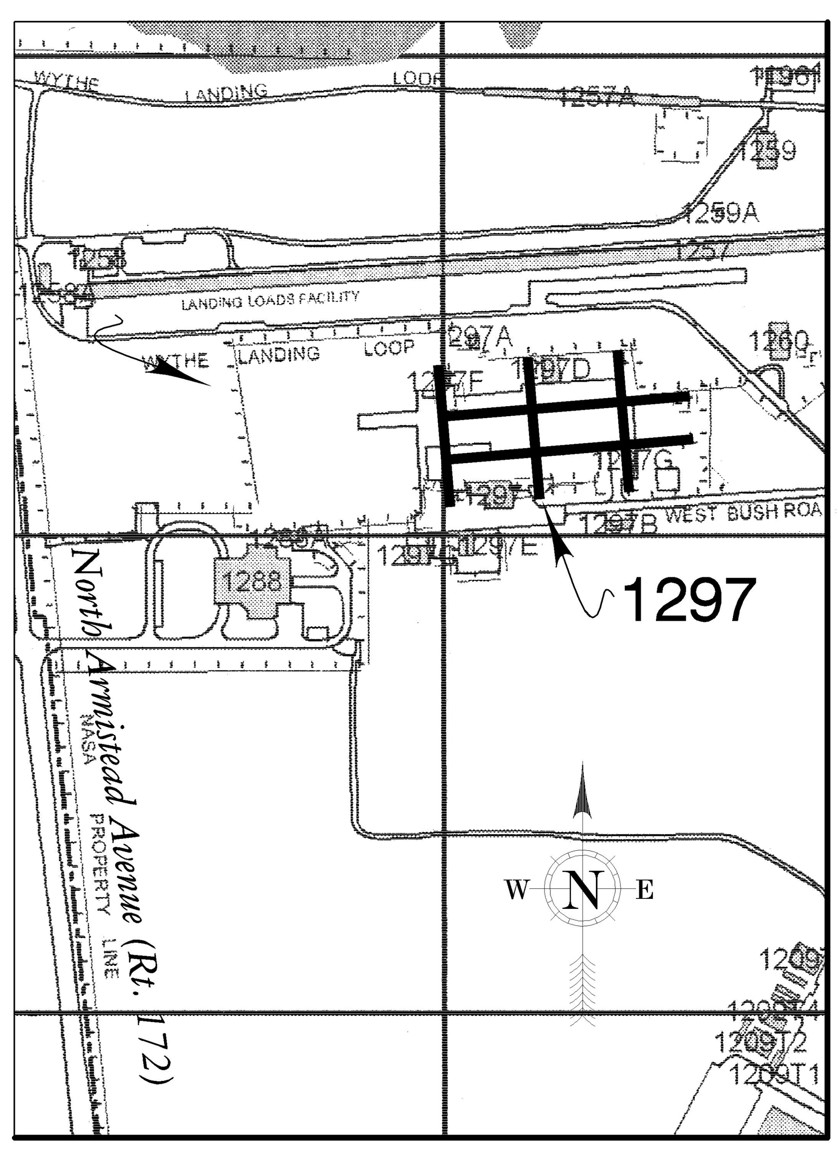
SITE PLAN

Scale: 1" = 60'-0" (1:720)

0 50 100 150 200 250 300 350 400 450 500 550 600 Feet

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 Meters

Based on NASA Langley Research Center "Real Estate Management Office: June 1990 Facility Brochure."



LOCATION MAP

Scale: 1" = 300' (1:3600)

0 500 1000 1500 Feet

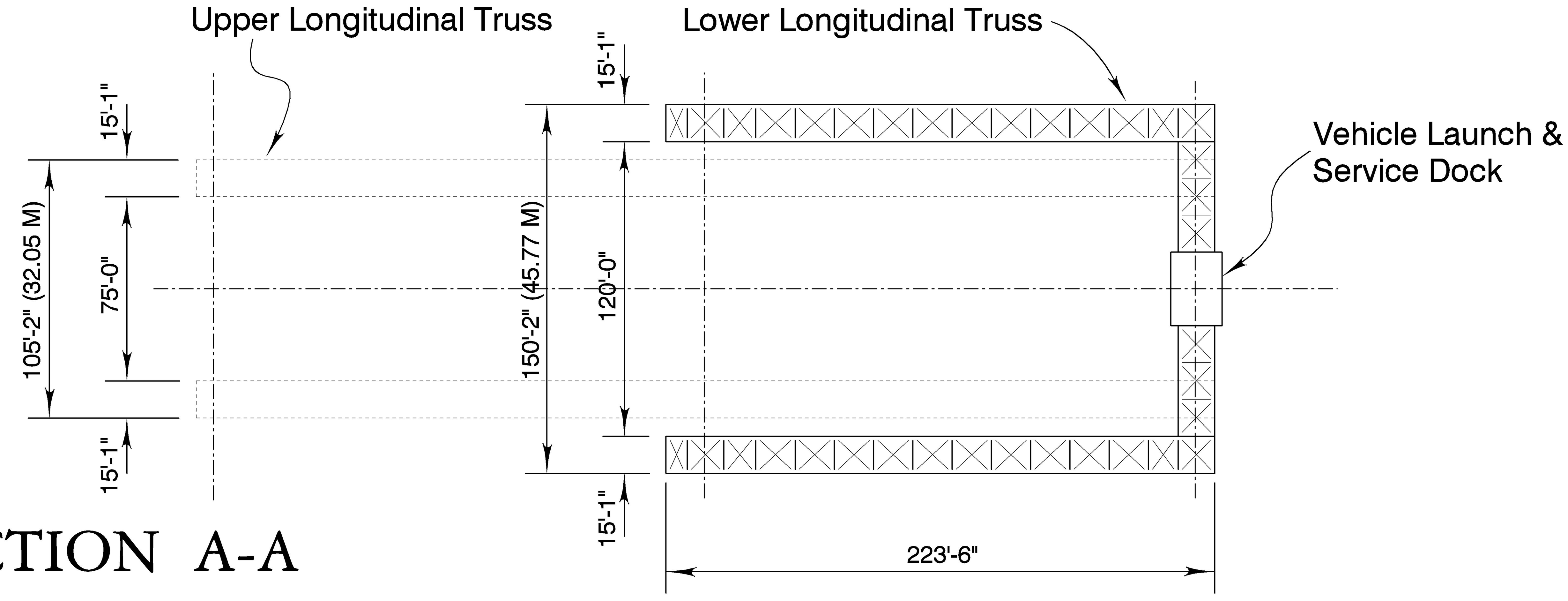
0 100 200 300 400 Meters

Based on NASA Langley Geographic Information System map, October 2001.

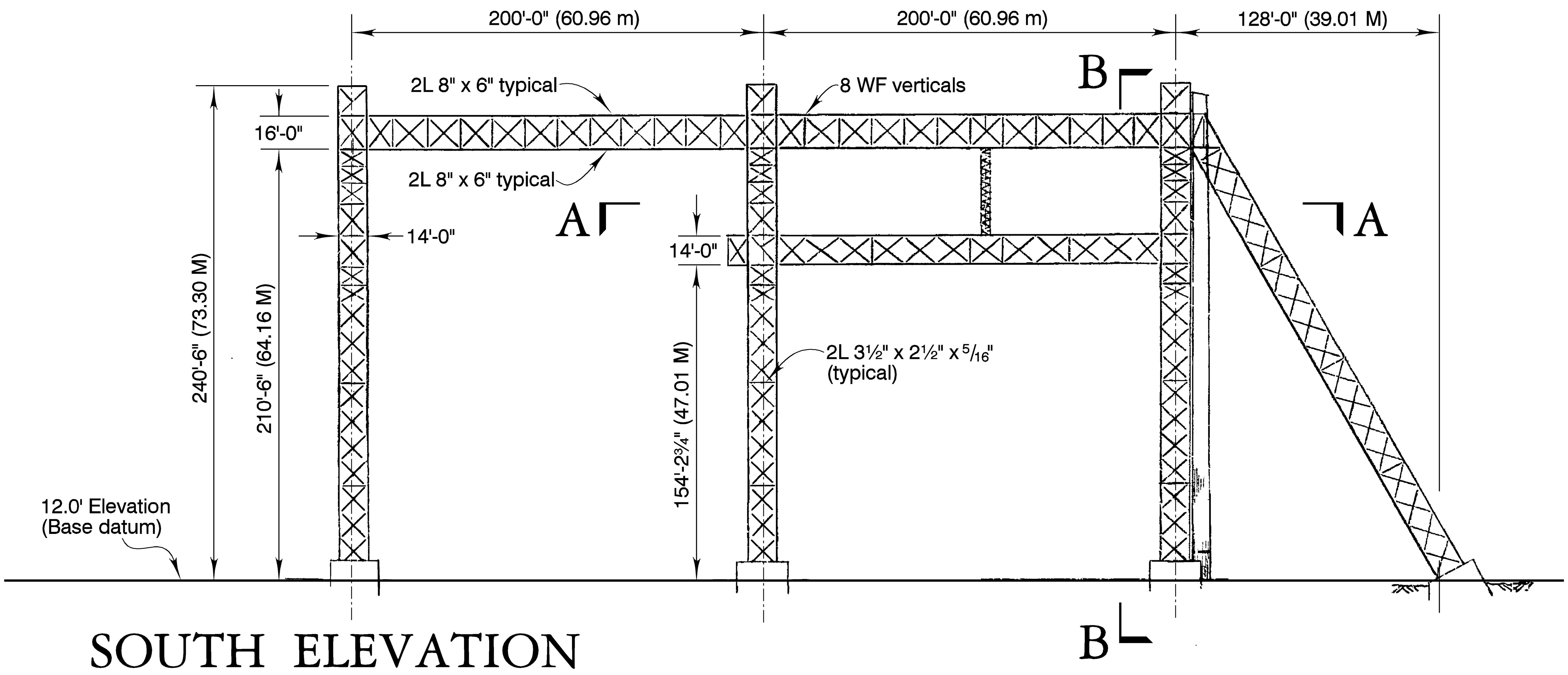
UTM Coordinates: 18.376520.4106820

DELINEATED BY: *Richard K. Anderson, Jr., 2006.*

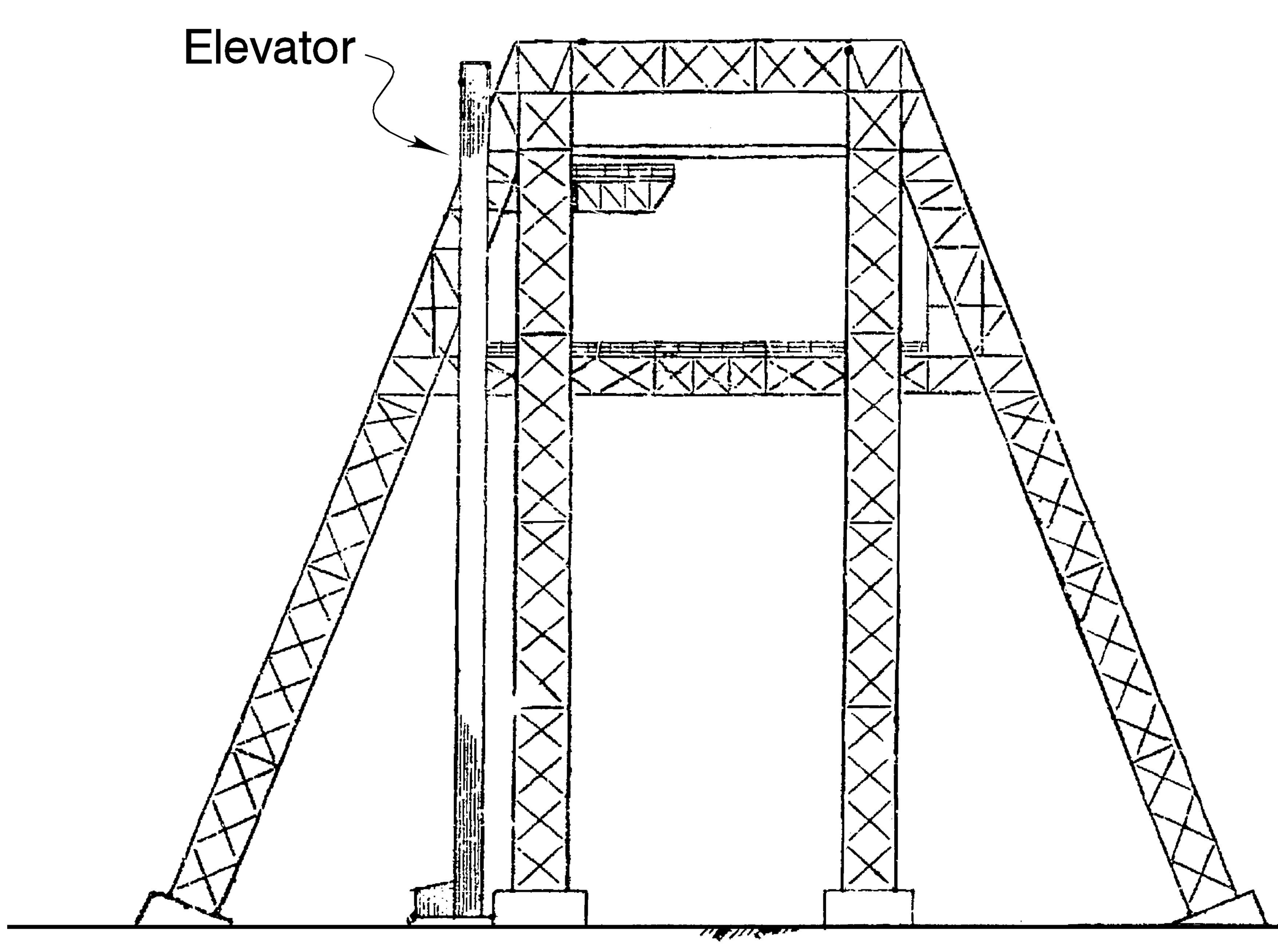
NASA LANGLEY RESEARCH CENTER RECORDING PROJECT NATIONAL PARK SERVICE UNITED STATES DEPARTMENT OF THE INTERIOR	LUNAR LANDER RESEARCH FACILITY (1965) BUILDING 1297, 12 WEST BUSH ROAD HAMPTON HAMPTON VIRGINIA	SHEET 1 of 4	HISTORIC AMERICAN ENGINEERING RECORD VA-118-G	LIBRARY OF CONGRESS INDEX NUMBER

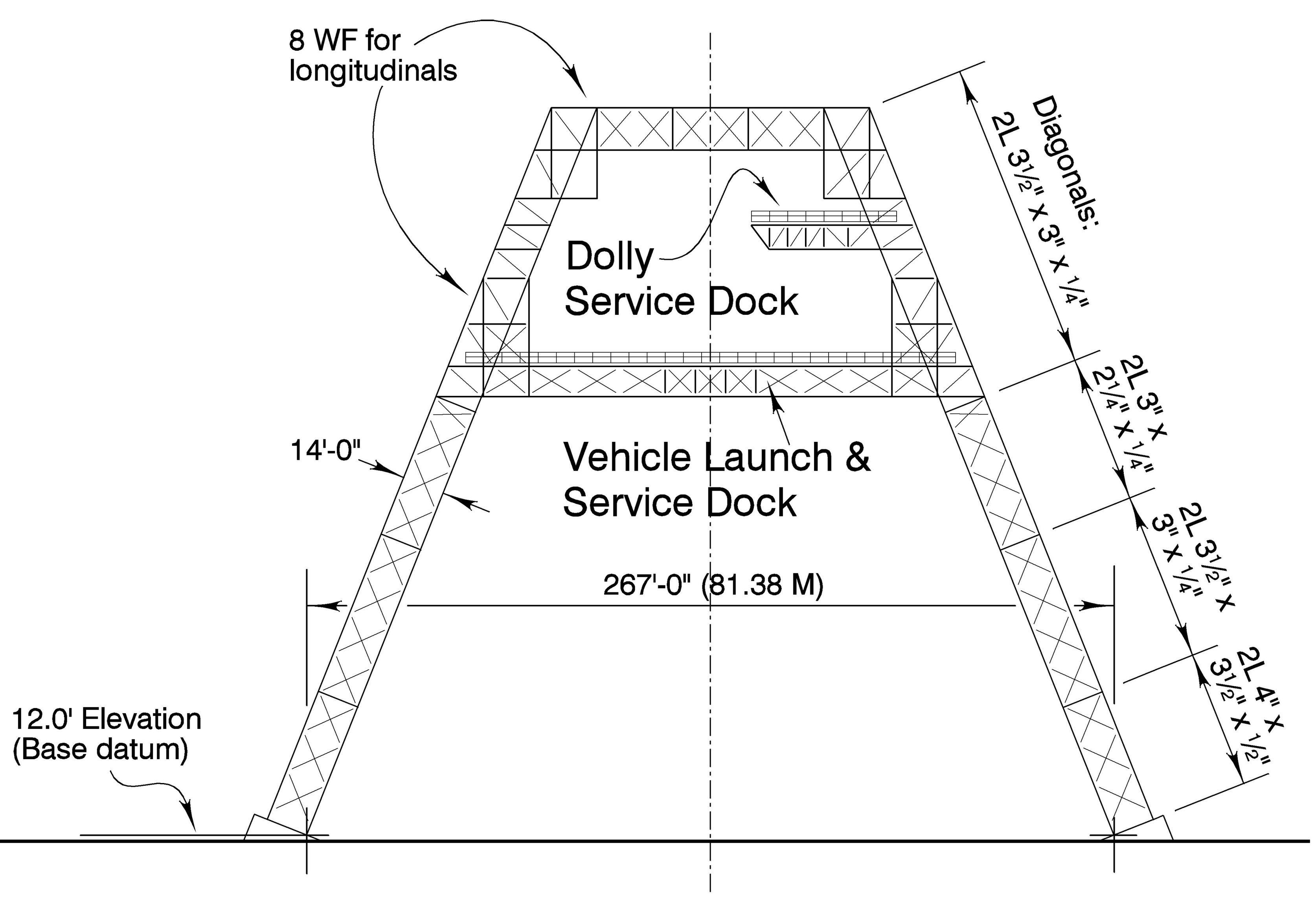


SECTION A-A



SOUTH ELEVATION





EAST ELEVATION

SECTION B-B

Scale: 1" = 40'-0" (1:480)

0 50 100 150 200 250 300 350 400 Feet

0 10 20 30 40 50 60 70 80 90 100 110 120 Meters

Based on NASA Langley Research Center drawing LD-251765 "Gantry Structure - Sht. 1" by Jackson and Moreland, Inc.

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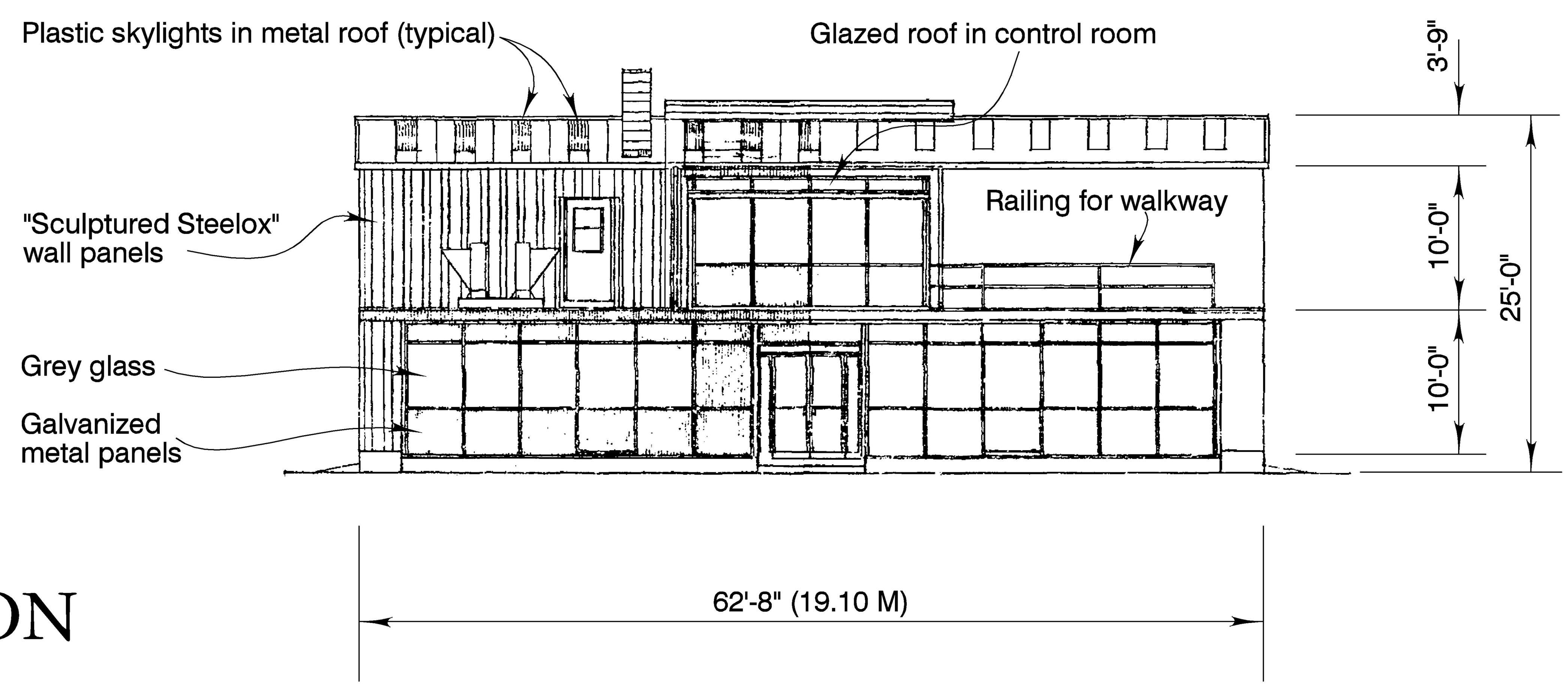
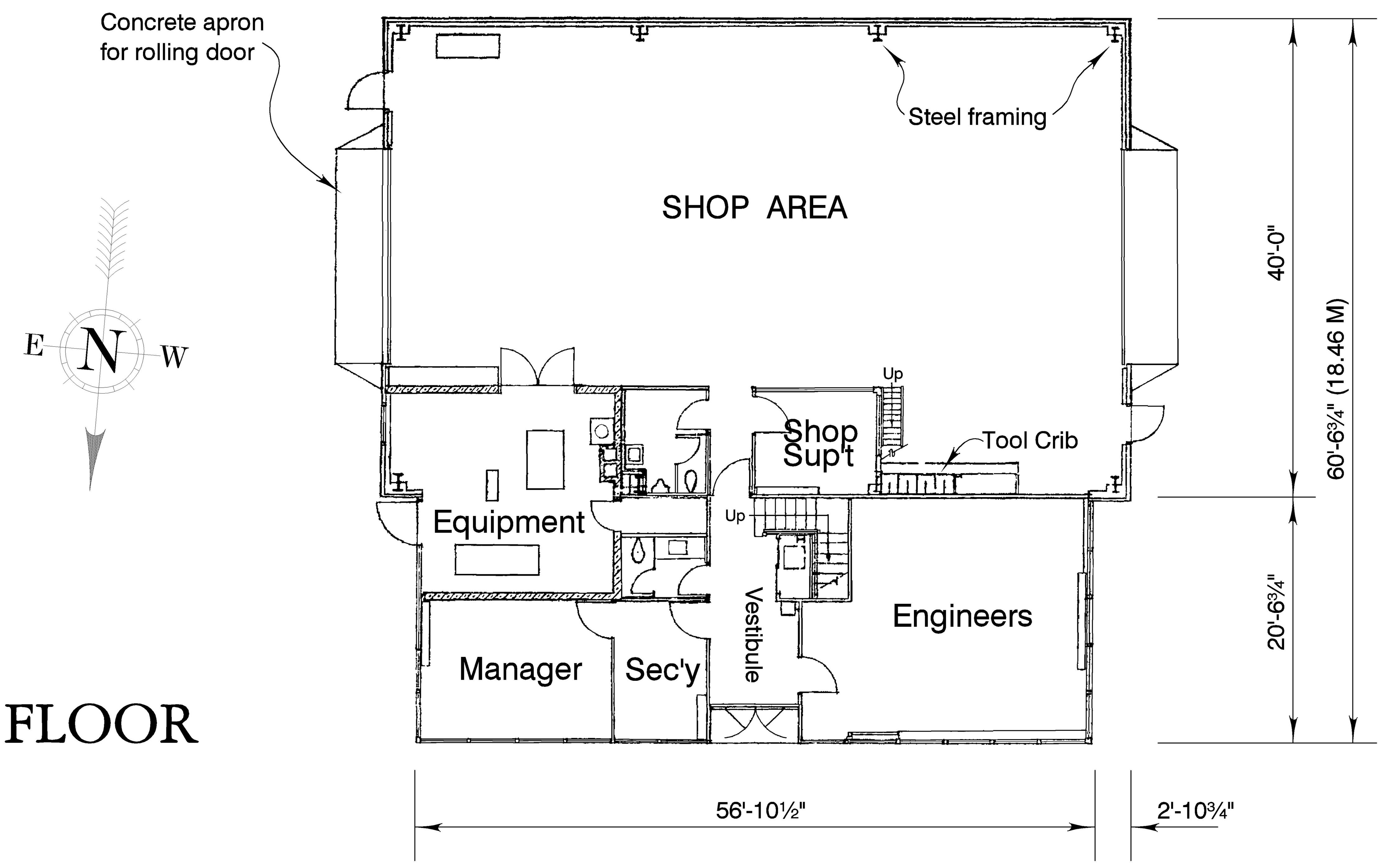
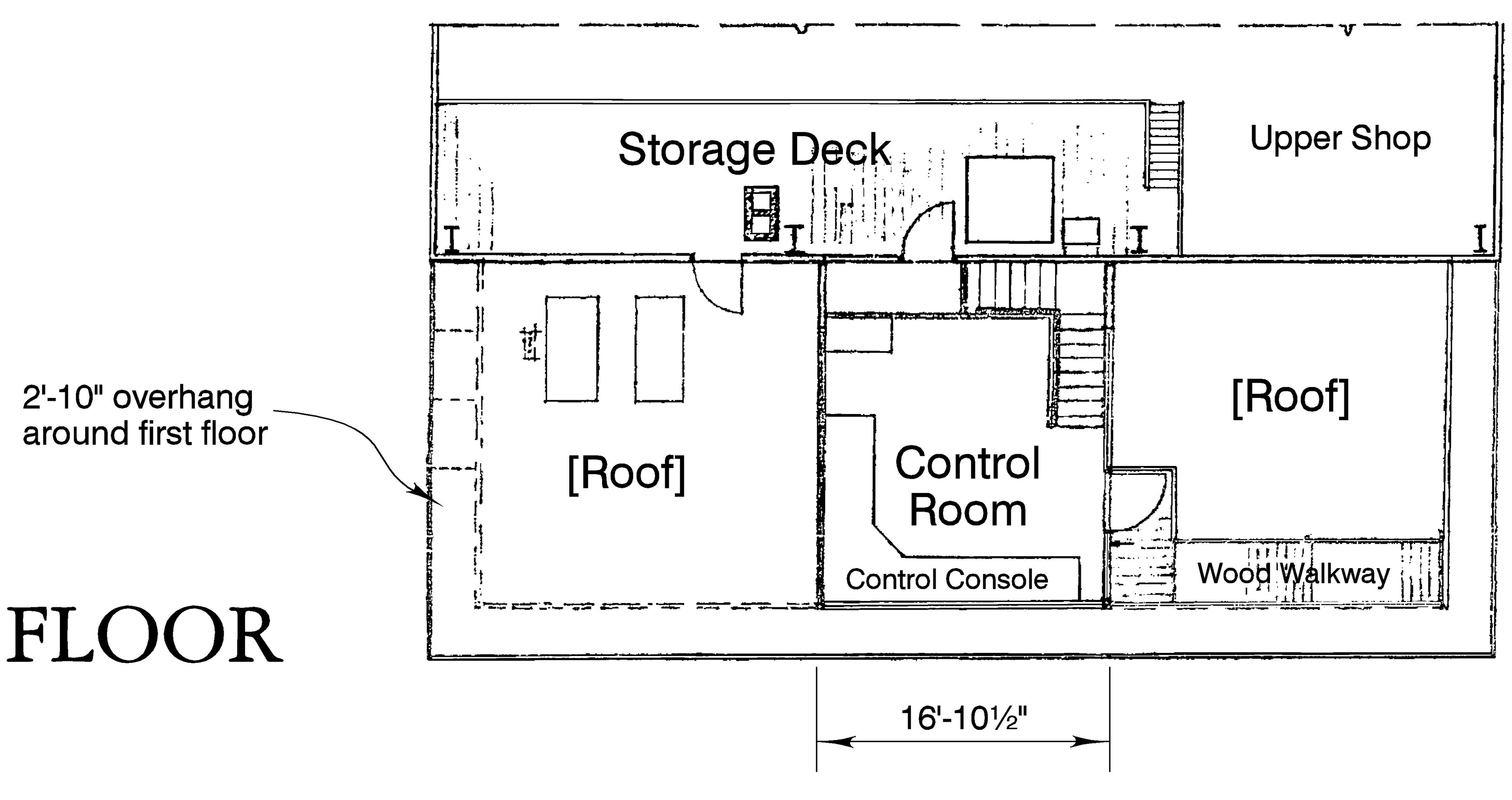
NASA LANGLEY RESEARCH CENTER RECORDING PROJECT NATIONAL PARK SERVICE UNITED STATES DEPARTMENT OF THE INTERIOR	LUNAR LANDER RESEARCH FACILITY (1965) BUILDING 1297, 12 WEST BUSH ROAD HAMPTON HAMPTON VIRGINIA	SHEET 2 OF 4	HISTORIC AMERICAN ENGINEERING RECORD VA-118-G	LIBRARY OF CONGRESS INDEX NUMBER



NORTH ELEVATION

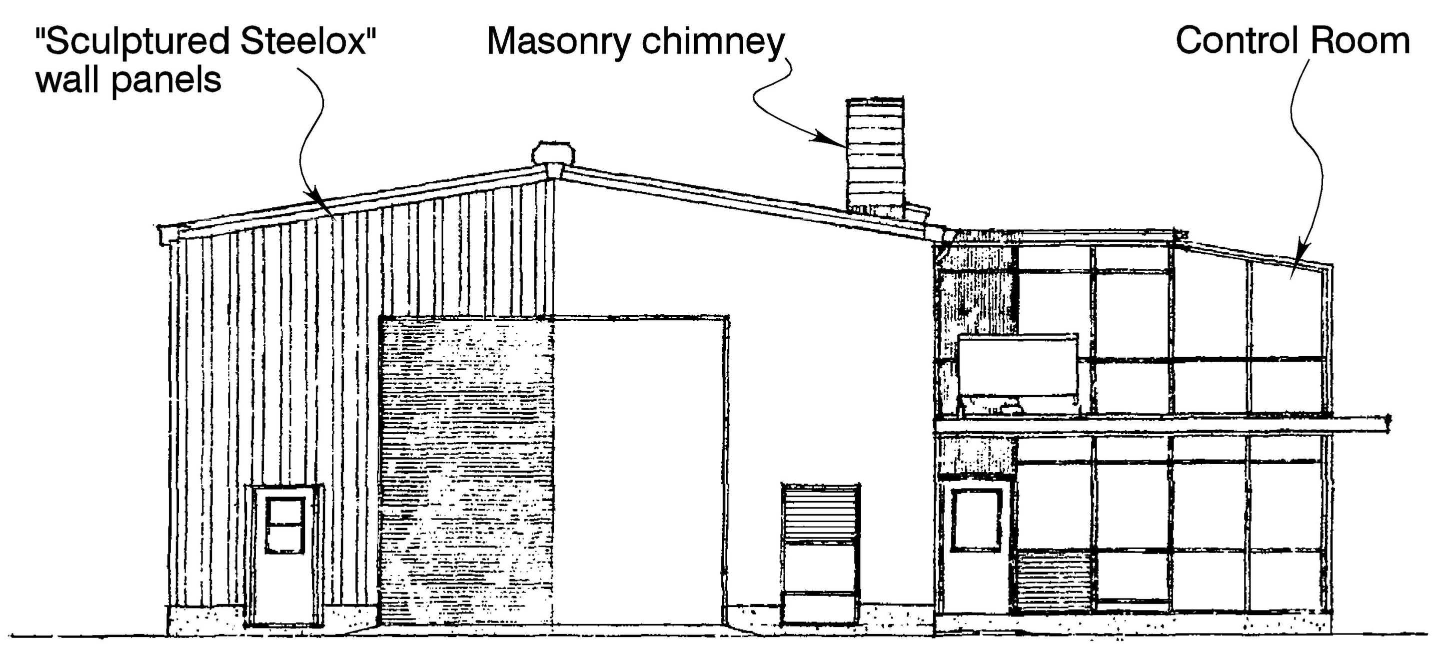


FIRST FLOOR

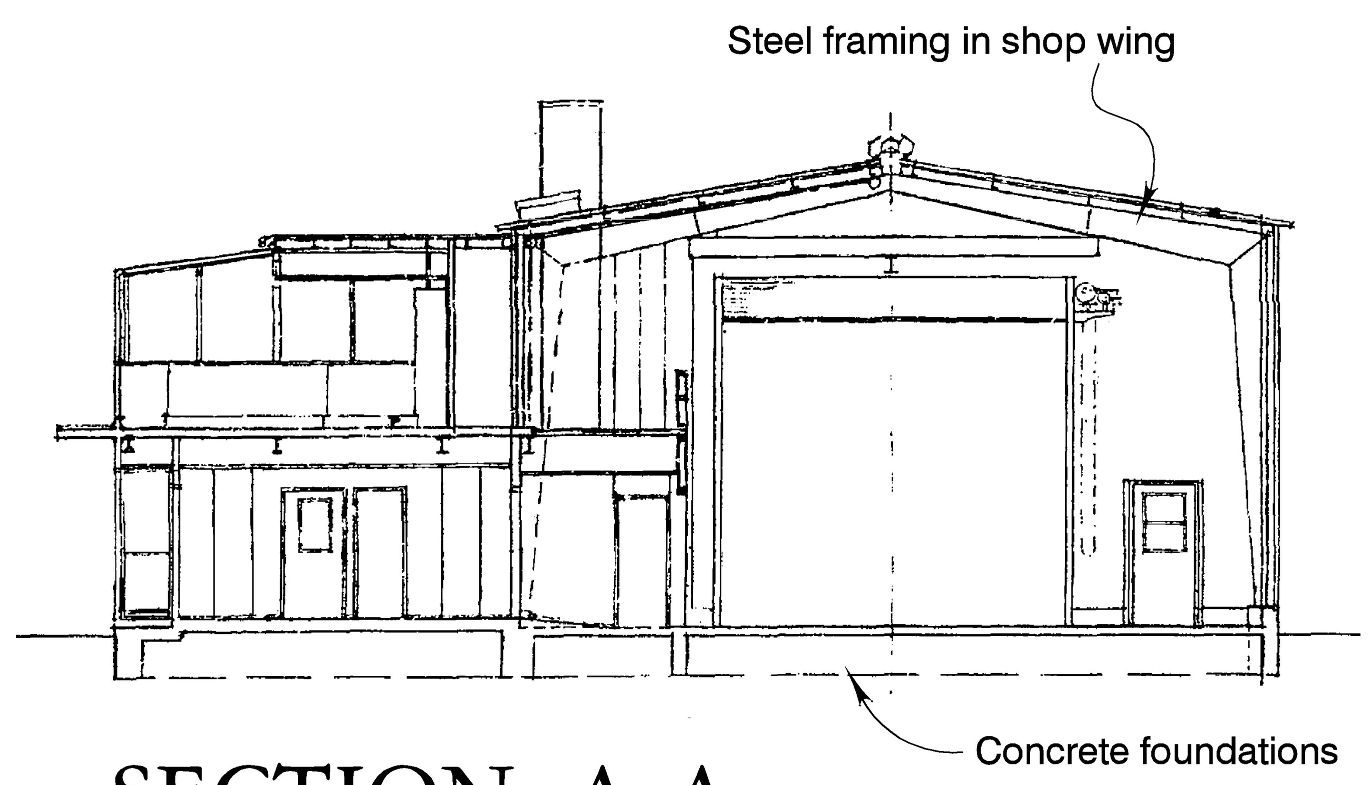


SECOND FLOOR

Building 1297 was built to house the control room, offices and shop which supported gantry operations. It is shown as it appeared during the years astronauts trained for Apollo missions. A small wing (shown in the Site Plan on Sheet 1) was later added to the west end.

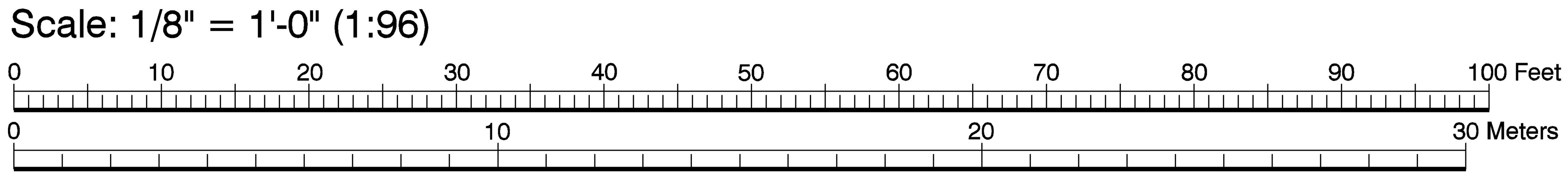


EAST ELEVATION



SECTION A-A

Scale: 1/8" = 1'-0" (1:96)



Plans based on NASA Langley Research Center drawing LD-251,756; elevations and section from LD-251,757, both by Jackson and Moreland, Inc. April 7, 1962.

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NASA LANGLEY RESEARCH CENTER RECORDING PROJECT NATIONAL PARK SERVICE UNITED STATES DEPARTMENT OF THE INTERIOR	LUNAR LANDER RESEARCH FACILITY (1965) BUILDING 1297, 12 WEST BUSH ROAD HAMPTON — HAMPTON — VIRGINIA	SHEET 3 OF 4	HISTORIC AMERICAN ENGINEERING RECORD VA-118-G	LIBRARY OF CONGRESS INDEX NUMBER

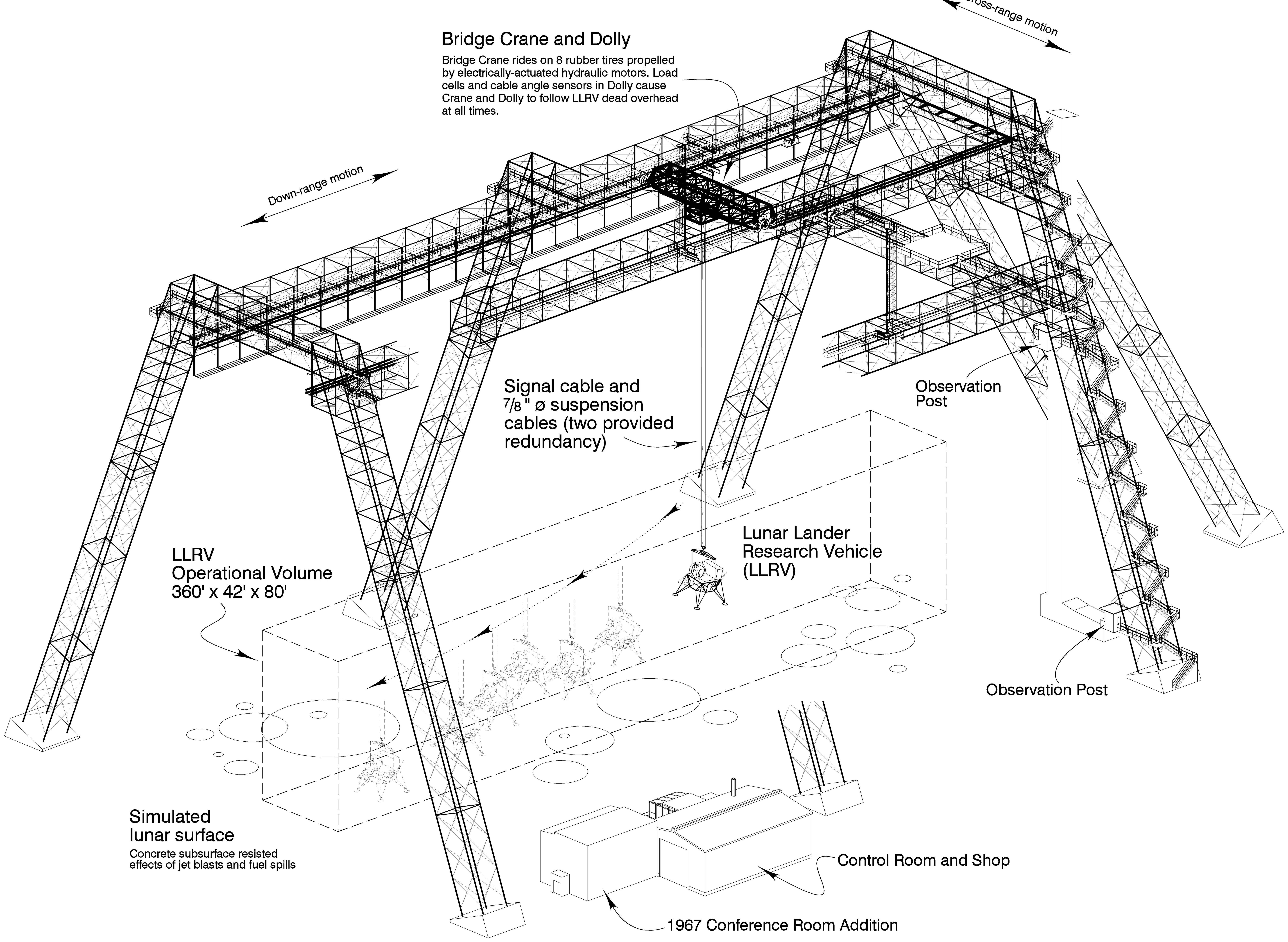
ILLUSTRATIVE VIEW of GANTRY OPERATIONS

The Lunar Lander Research Facility was built to train astronauts to land a rocket-propelled vehicle on the Moon, something no other flight experiences provided. The "gantry" and its control systems were balanced and governed in such a way that the Lunar Lander Research Vehicle (LLRV) behaved as if it were operating in the Moon's 1/6 gravity field. LLRV pilots reported that flights were significantly different from landing a helicopter. Pitch angles six times that necessary in earth's gravity were needed to affect vehicle motion down- or cross-range. Maximum pitch and roll rates of 20°/sec and accelerations of 10°/sec2 were determined to be best. The LLRV is about 2/3 the size of the Apollo Lunar Excursion Module (LEM), but it gave the pilots the sensations of lunar operation. Interference by visual cues from the gantry structure and its surroundings were minimal. The LLRV was designed so that its characteristics could be modified to simulate lander vehicles for other missions.

The gantry structure was designed to support a 64-foot long bridge crane and a 10-foot long dolly capable of suspending 30,000 pounds and moving responsively to signals received from load cells, cable angle sensors and other devices. The bridge crane assembly travelled on eight rubber tires supported by 18-inch wide metal tracks running the length of the 400-foot horizontal trusses. The tires were propelled by hydraulic pumps and motors at each end of the bridge, interconnected so they ran in unison. They derived their energy from an on-board 250 HP electric motor. Three-phase AC electrical power was supplied to the crane via bridge-mounted trolley-collectors in contact with stationary bus bars running the length of the northern upper truss. All hydraulic and electrical systems incorporated fail-safe mechanisms and could be overridden from the ground-based Control Room in emergencies. The suspension cable system provided a vertical lifting force 5/6 of the LLRV's weight acting through the vehicle's center of gravity. The LLRV was suspended in a whiffletree and gimbal mechanism which permitted the vehicle to roll +/- 30°, pitch +/- 30° and yaw +/- 360°. The facility could operate in either of two modes: the first allowed pilots to operate the LLRV without firing the main engine; the gantry suspension system would lift and move the LLRV as if the main engines were operating while hydrogen peroxide fueled attitude control jets and other systems operated normally. This mode saved fuel. The second mode permitted the pilots to fire the main engines.

The LLRV weighed 12,000 pounds including 3,100 pounds of 90% hydrogen peroxide fuel, sufficient for 2 minutes' flight at full power. Non-flammable high-pressure nitrogen gas served to "pump" the fuel to main engines and attitude control jets. Hydrogen peroxide decomposed into oxygen and water when used as a fuel in this manner, though pilots wore water-cooled pressure suits with independent air supply to protect them from any potentially corrosive fumes. Pilots rode in a helicopter "bubble" canopy adapted for the LLRV. The main engine thrust could be varied from 600 to 6,000 pounds; 20 attitude control jets provided 25 to 125 pounds thrust apiece, and operated in an on-off "bang-bang" fashion, similar to contemporary spacecraft. Electrical power for instruments and sensors was provided by an on-board bank of nickel-cadmium batteries. Instruments reported vehicle speed, altitude, attitude and attitude angular rates, fuel usage and remaining quantities, and manifold pressure. A three-axis controller handle, main engine throttle lever and yaw foot-pedals were the main controls. The vehicle landing gear was designed for a maximum landing velocity of 17 feet per second (about 12 mph), though most practice landings were at 1 to 4 ft/sec.

The LLRV provided greater realism of flight than other simulators or helicopters because of the compensatory attitude angles required for rocket-driven control and landing, the main engine sounds, and the LLRV's limited fuel and landing time. It was supposed that this induced pilot stress levels close to those experienced in actual lunar landings.



No Scale. Drawing exported from 3D CAD model based on NASA Langley Research Center drawings LD 251,751 - 251,768 and LD 501,769 - 501,779. Annotations based on material in NASA Technical Note D-3828, "Operational Features of The Langley Lunar Landing Research Facility" by Thomas C. O'Bryan and Donald E. Hewes (February 1967) and "Flight Tests of a Manned Rocket-powered Vehicle Utilizing the Langley Lunar Landing Research Facility" by Thomas C. O'Bryan, August 1966.

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NASA LANGLEY RESEARCH CENTER RECORDING PROJECT
NATIONAL PARK SERVICE
UNITED STATES DEPARTMENT OF THE INTERIOR

LUNAR LANDER RESEARCH FACILITY (1965)
BUILDING 1297, 12 WEST BUSH ROAD
HAMPTON

HAMPTON | VIRGINIA

SHEET 4 OF 4

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