APOLLO LAUNCH COMPLEX 39

FACILITIES HANDBOOK

U. S. ARMY CORPS OF ENGINEERS
South Atlantic Division
Canaveral District

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INTRODUCTION

Since the inception of the National Aeronautics and Space Administration in October 1958, the U.S. Army Corps of Engineers has served as its supervisory design and construction agent in the Cape Kennedy area.

Through its Canaveral District, created on May 1, 1963, and earlier through its Jacksonville District, the Corps has been involved in the engineering and construction of both Apollo Launch Complex 39 and the Industrial Area at the John F. Kennedy Space Center as well as Saturn Launch Complexes 34 and 37 and other launch sites at Cape Kennedy.

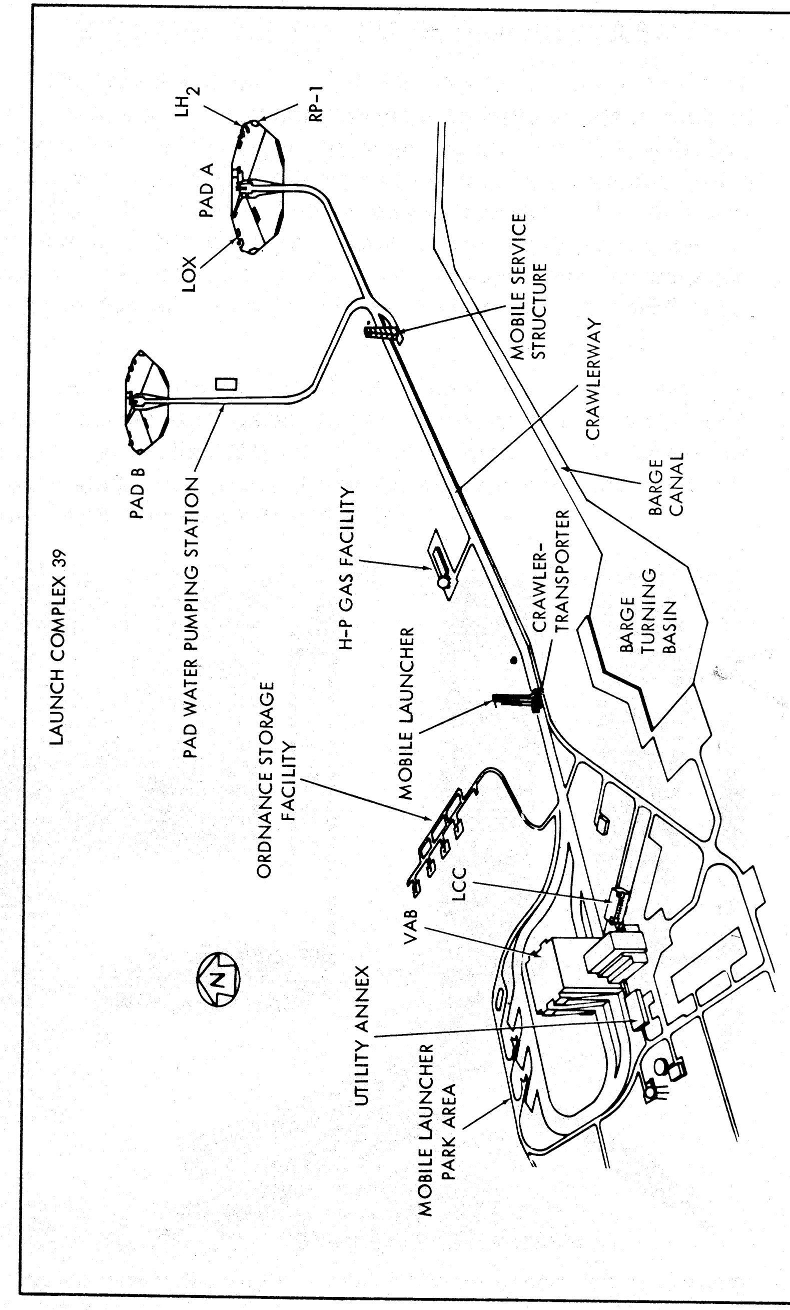
This handbook is concerned with the major facilities at Launch Complex 39, which stretches inland from the Atlantic Ocean across four miles of what, until 1963, was a land of intermittent marshes and sandy scrub growth. In less than four years it was transformed into an operational spaceport embodying a mobile concept—the erection of rockets and spacecraft in one area and their transportation to a separate location for launch.

The facilities detailed in this handbook include not only those supervised for NASA by the Corps of Engineers but also those whose engineering and construction were administered directly by NASA.

They include the Vehicle Assembly Building, a structure large enough to handle the simultaneous erection of four of the 363-foot-tall Apollo-Saturn V launch vehicles; a Launch Control Center for monitoring and controlling all checkout and launch operations; three 46-story-tall Mobile Launchers, weighing 10,500,000 pounds each, on which the vehicles are erected, transported and launched; a 40-story-tall Mobile Service Structure, for working on the vehicles at the launch pads; two Transporters for moving the Mobile Launchers and the Mobile Service Structure; a Crawlerway road on which the Transporters travel; two launch pads, capable of withstanding 7,500,000 pounds of thrust from the Saturn V engines, and the communications and electronics systems which tie the complex together.

Most of the detailed design work and all of the construction which made Launch Complex 39 what it is today were performed by architect-engineer and construction contractors from private industry under contracts awarded and administered by the Corps of Engineers or by NASA directly. Their mutual efforts and success were recognized in 1966 when the American Society of Civil Engineers selected the complex and its facilities as the outstanding civil engineering achievement of the year.

Requests for photographic prints, slides, duplicate negatives or color transparencies of pictures used in this handbook should be directed to the Technical Liaison Office, Canaveral District, U.S. Army Corps of Engineers, P.O. Box 1042, Merritt Island, Florida 32952. (Telephone 305-452-2100)



VEHICLE ASSEMBLY BUILDING (VAB)

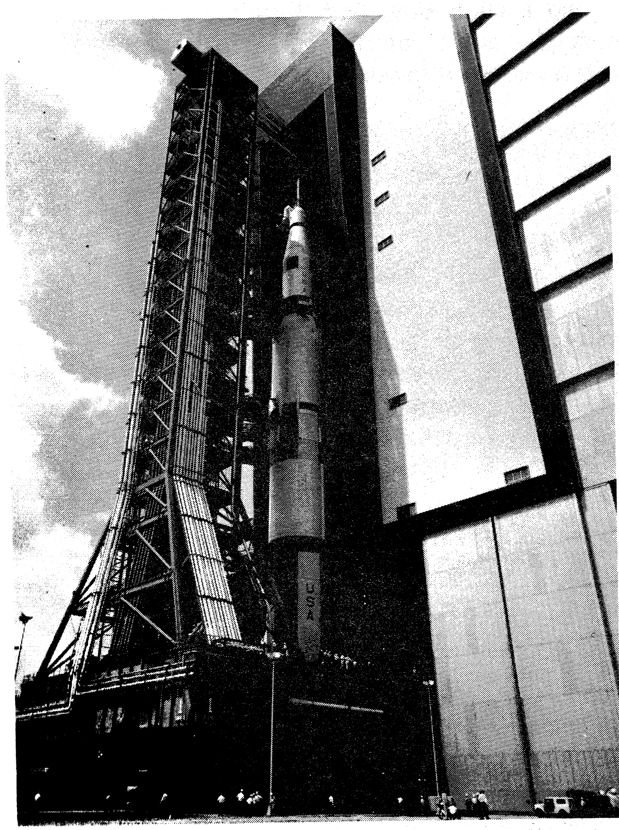
With an inclosed area of 129,482,000 cubic feet, the Vehicle Assembly Building is almost as large as the combined volume of the Pentagon in Washington, with 77,000,000 cubic feet, and the Merchandise Mart in Chicago, with 56,000,000. At the time of its construction, the VAB was the largest building in the world. It has been superseded in size by the assembly building for the supersonic jet transport plane in Everett, Washington, which has 160,000,000 cubic feet.

The VAB has two sections, a Low Bay where individual rocket stages are received and checked out in eight work areas, and a High Bay, with four assembly areas where the rocket stages are erected and mated with the spacecraft and pre-launch checkout takes place.

Vehicle Assembly Building and Launch Control Center (left foreground) in completed form.

Over-all, the building is 525 feet 10 inches in height; 716 feet 6 inches in length, and 518 feet in width.

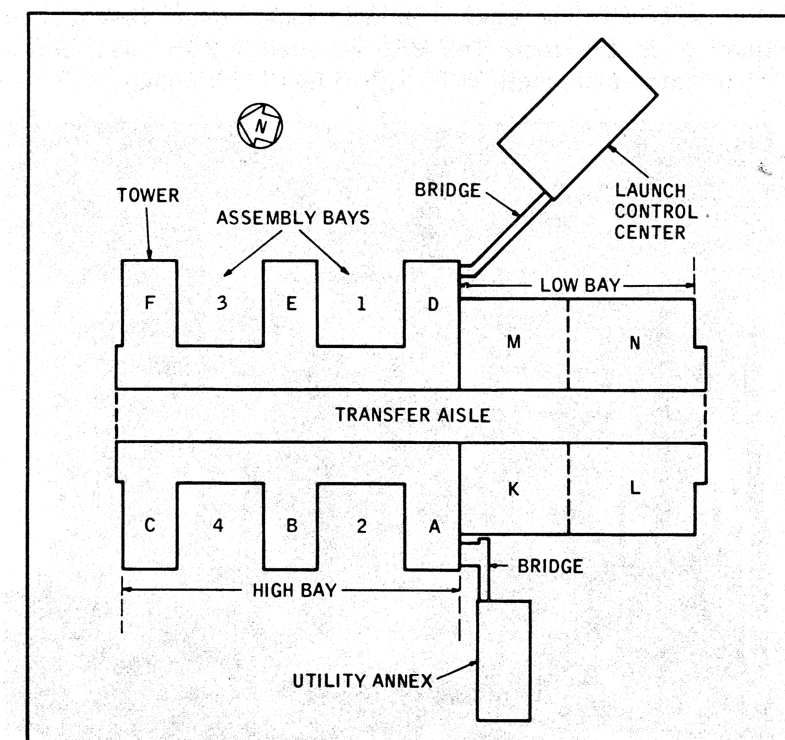
Construction, aside from ground clearing and site preparation, began in July 1963 and the building was substantially completed early in 1966, although complete outfitting of the building is still under way. The first Mobile Launcher was moved into the building on January 27, 1966. The first Apollo-Saturn V, a facilities test model, was rolled out of the building on May 25, 1966. Only two of the four High Bay assembly areas were outfitted as a part of the original construction. Outfitting of a third High Bay area will be completed by the spring of 1968.



Rollout of Apollo-Saturn V Facilities Test Model from Vehicle Assembly Building, May 25, 1966.

DESIGN: The shape of the VAB was developed when handling of rocket components was being planned. An early layout put the checkout bays in a single row and produced a narrow, slablike skyscraper. This plan yielded to a back-to-back arrangement of the bays, with a transfer aisle between rows of checkout bays. The resulting box-type structure is more economical and stiffer and eliminates the need for a separate crane for each bay.

The designers accepted certain penalties for stability purposes. Assembly areas in the High Bay do not provide full-height access to the transfer aisle from ground level. As a result, the rocket stages, including the 287,000-pound first stage of the Saturn V, must be lifted 190 feet over the building's interior framing along the transfer aisle.

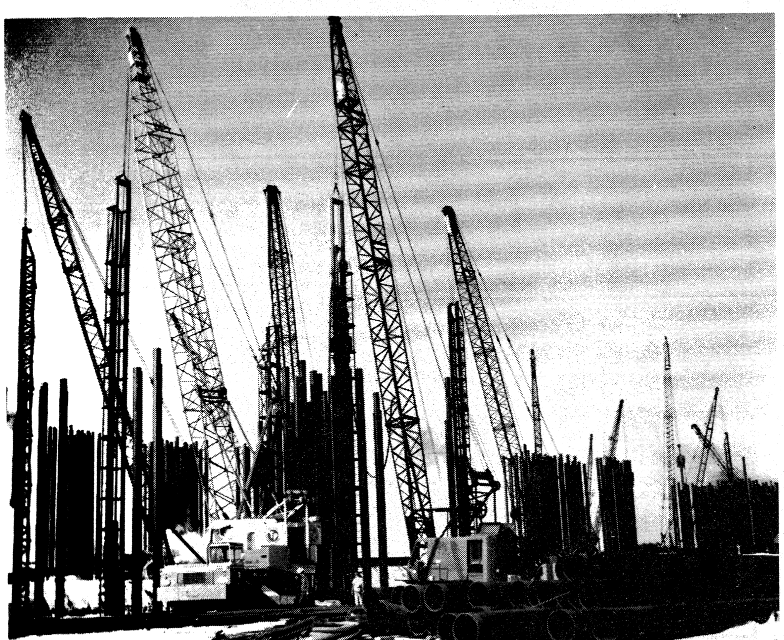


Layout of Vehicle Assembly Building, Launch Control Center, Utility Annex.

FOUNDATION: After the VAB area had been cleared in 1962, more than 1,500,000 cubic yards of soil were deposited on the construction site, raising it to an average height of 7 feet above sea level. The fill came from an access channel dug from the north end of the Banana River to the VAB area and from nearby Banana Creek. This channel is now used to transport the first stage of the Saturn V to an unloading ramp at the VAB.

The VAB site is underlain with sand and compacted shell in the upper 30 to 40 feet. The next 80 feet consists of compressible silts and clays. Usually, at about 120 feet below grade there is a 3-foot-thick limestone shelf. Below that is stiff clay and silt and finally limestone bedrock at 160 feet.

The VAB is supported on open-end steel pipe piles, 16 inches in diameter and 3/8-inch thick, driven 160 feet to bearing on the rock. The VAB required 4,225 piles with a total end-to-end length of 674,000 feet (128 miles).

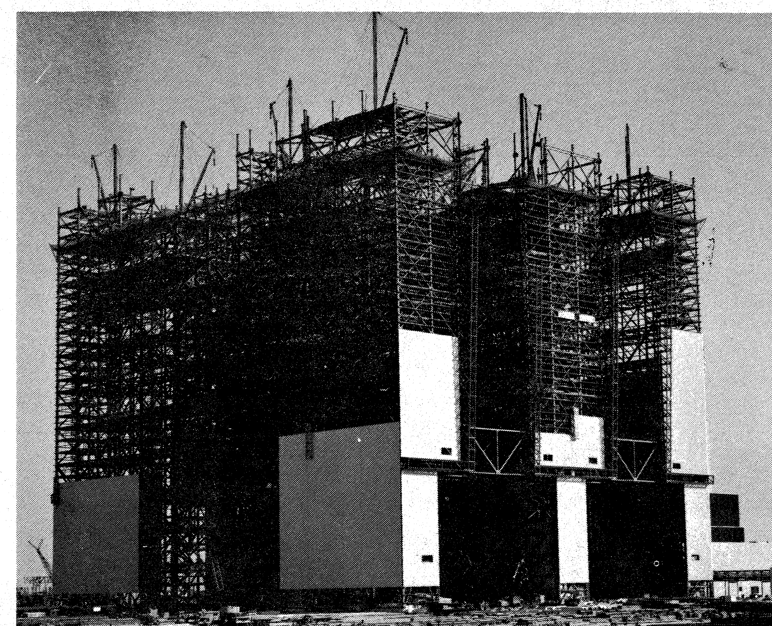


Piledriving for Vehicle Assembly Building.

Each pipe pile has a capacity of 100 tons static downward load and 47 tons uplift, thus serving as an anchor for the building in high winds as well as preventing the structure from sinking into the ground. Fifty thousand cubic yards of concrete were used for pile caps and the ground floor slab.

STRUCTURAL STEEL: The skeleton of the VAB consists of 60,000 tons of structural steel, comprised of 45,000 separate pieces weighing from 150 pounds to 72,000 pounds each. The steel members are fastened with 1,000,000 high-strength bolts.

Basically, the space-truss sytem of the skeletal framework is laid out in multiples of 38 feet horizontally and vertically. The building was designed for five wind conditions, including wind pressures up to 90 pounds per square foot, and suction up to 105 pounds per square foot, as well as dead, live and crane loads. The door mechanism was designed for a maximum operating wind of 63 miles per hour, including gusts.



Steel erection for High Bay, Vehicle Assembly Building.

When higher winds are predicted, work platforms are withdrawn from any launch vehicle erected in the High Bay and the doors are closed.

Erection of the steel framework began in January 1964 and the building was topped out at 525 feet in April 1965.

Some of the base columns have rolled section cores heavier than any previously rolled, weighing up to 734 pounds per foot. With plates welded to the cores, the columns are about 2 feet square and weigh up to 1,305 pounds per foot.

Interior view of transfer aisle, Vehicle Assembly Building, looking from High Bay into Low Bay.

FLOORS: Developed floor area in the VAB totals 1,500,000 square feet. The floors above ground level are four-inch thick, lightweight reinforced concrete slabs.

The Low Bay of the building has three floor levels plus a mezzanine. The High Bay has 26 fully developed floors.

PANELING: Exclusive of doors, the VAB is inclosed with 1,085,500 square feet (23 acres) of insulated aluminum siding and 70,000 square feet of light-emitting plastic panels.

The aluminum siding is designed not only to stabilize thermal effects but also to reduce acoustical pressures created by the launch of a Saturn V.

The translucent panels were designed to provide workers in the VAB with a point of reference to the outdoors without admitting glare or the direct rays of the sun.

Installation of insulated aluminum paneling on exterior of Low Bay, Vehicle Assembly Building.

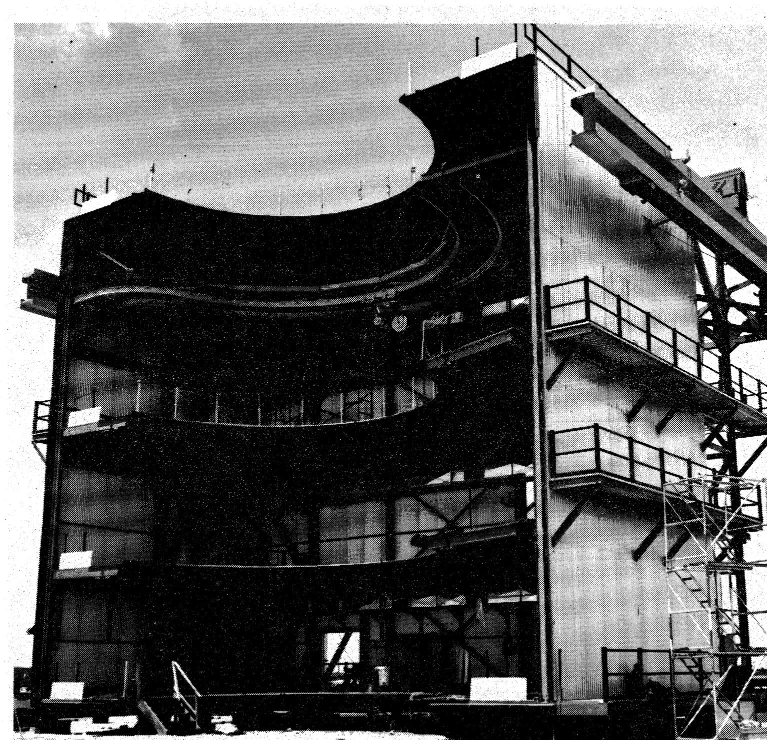
DOORS: The High Bay doors on the VAB are in the shape of an inverted T. The lower portion of the T is 152 feet wide and 114 feet high, closed with four leaves of doors each weighing 73 tons that slide horizontally, similar to the design used on many aircraft hangars. From the 114-foot-level to 456 feet, the doors consist of seven leaves 76 feet wide and 50 feet high each weighing 32 tons, which retract vertically and are stacked at the top of the structure when the door is open.

Vertical lift doors for Vehicle Assembly Building during erection.

ROOF: The roof of the VAB is a specially compounded deck and membrane. It can be used by personnel to service equipment there, such as RF antennas.

WORK PLATFORMS: Each of the completed assembly areas in the High Bay contains five pairs of extensible work platforms which provide air-conditioned areas for technicians to work on the Apollo-Saturn V launch vehicle.

These platforms, 60 by 60 feet and one, two and three stories tall, were assembled outside the VAB and then moved inside for erection and mounting. The platforms are supported by the framework of the VAB and are both vertically and horizontally adjustable to encircle the launch vehicle at various elevations.



Half-section of one of five extensible work platforms placed in each operational High Bay assembly area of Vehicle Assembly Building.

When the platforms surround the vehicle, each side of each platform is cantilevered about 30 feet from the main frame of the building. The area within each platform is air-conditioned and is served by flexible connections to the main utility systems in the building. The platforms are sealed around the vehicle with neoprene seals to prevent damage to the vehicle's skin.

ELEVATORS: The VAB contains 17 elevators, four in the Low Bay; 12 in the High Bay, rising from ground level to Floor 34 (420 feet), and one from Floor 34 to the roof. Provisions have been made for the future installation of four additional elevators in the High Bay area.

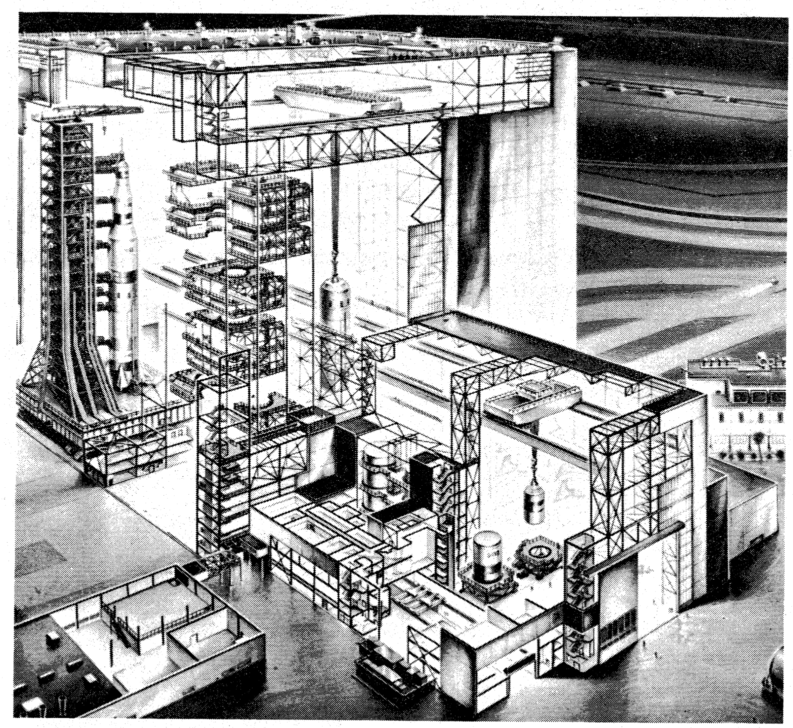
Extensible work platforms in High Bay 1, Vehicle Assembly Building, with upper platform closed, others in retracted positions.

The elevators serve both the fixed floors in the building and the extensible work platforms with their varying elevations. The High Bay elevators operate at a speed of 11 feet per second.

CRANES: The VAB contains more than 70 cranes and other lifting devices. Principal among these are two 250-ton capacity bridge cranes and one 175-ton capacity bridge crane.

Each of the 250-ton cranes serves two assembly areas in the High Bay on opposite sides of the transfer aisle. The cranes weigh 500 tons apiece, have a bridge span of 150 feet and a hook height of 462 feet.

The 175-ton crane runs the length of the transfer aisle through both the Low and High Bays of the building. It has a hook height of 166 feet.



Cutaway sketch of Vehicle Assembly Building.

UTILITIES: Air-conditioning is provided for more than 800,000 square feet of floor area in the VAB, including the extensible work platforms. A Utility Annex located on the west side of the VAB contains four 2,500-ton water chillers with 3,000-horsepower synchronous motors for supplying chilled water to the air-conditioning systems throughout the building.

Fire protection requires three diesel-driven fire pumps and a ground storage reservoir of 1,000,000-gallon capacity. Launch Complex 39, including the VAB, can use a maximum of 2,000,000 gallons of domestic and industrial water a day. The domestic water is supplied by the City of Cocoa. A 250,000-gallon elevated storage tank near the VAB provides a reserve supply.

A public utility supplies electrical power with a total capacity of 50,000 kva. This is supplied through a 115,000-volt substation located near the VAB, which in turn supplies a 13,800-volt underground distribution system throughout the Launch Complex 39 area.

Boiler capacity in the Utility Annex is three units, each with an output of 16,000,000 BTU per hour. Compressed air requirements are for 1,500 cubic feet per minute at 150 pounds per square inch. The electrical standby is a 1,200-kw diesel-driven generator.

REFERENCE DATA
VEHICLE ASSEMBLY BUILDING

CONSTRUCTION PERIOD: July 1963 through present

MAJOR CONTRACTS:

Design—Urbahn-Roberts-Seelye-Moran, New York City, N.Y.

Site preparation—Gahagan Dredging Corp., Tampa, Fla.

Pile driving and foundation work—Blount Brothers Corp., Montgomery, Ala.

General construction, including outfitting Assembly Bays 1 and 3—Joint venture of Morrison-Knudsen Co., Inc.; Perini Corp., and Paul Hardeman, Inc., South Gate, Calif.

Steel fabrication and erection—American Bridge Division of United States Steel Corp., Atlanta, Ga. (Contract awarded separately but administered as a subcontract to the general construction contract)

Outfitting Assembly Bay 2—Akwa-Downey Construction Co., Milwaukee, Wis.

DESIGN AND CONSTRUCTION SUPERVISION: Canaveral District, US Army Corps of Engineers

OVERALL CONSTRUCTION COST: $117,000,000 (including appurtenances except for Launch Control Center)

OVERALL LENGTH: 716 feet 6 inches

OVERALL WIDTH: 518 feet

HEIGHT: 525 feet 10 inches (top of finished roof of High Bay)

VOLUME: 129,482,000 cubic feet

IMPRINT AREA: 343,500 square feet (approximately 7.5 acres)

DEVELOPED FLOOR AREA: 1,500,000 square feet

HIGH BAY:

Volume—117,200,000 cubic feet
Length—442 feet
Width—518 feet
Height—551 feet 10 inches (top of elevator shaft)
526 feet 9 inches (top of parapet)
525 feet 10 inches (top of finished roof)
Imprint area—225,900 square feet
Bays—4 (2 equipped initially)

Floors—26 (fully developed)
Elevators—16 to Floor 34 (Level 420 feet)
1 to Roof from Floor 34
Extensible work platforms—5 pairs in each completed bay

LOW BAY:
Volume—12,282,000 cubic feet
Length—274 feet 6 inches
Width—442 feet
Height—211 feet 3 inches (top of parapet)
210 feet 4 inches (top of finished roof)
Imprint area—117,600 square feet
Checkout cells—8
Floors—3 plus mezzanine
Elevators—4

STEEL: 98,590 tons (60,000 tons - structural steel framework
21,500 tons - steel pipe piles
2,090 tons - reinforcing steel
15,000 tons - general construction steel, including extensible work platforms)

CONCRETE: 65,000 cubic yards (50,000 cubic yards - pile capping and floor slab
15,000 cubic yards - interior floors)

EXTERIOR SURFACE (excluding doors): 1,155,500 square feet
(1,085,500 square feet - insulated aluminum panels
70,000 square feet - plastic panels)

CRANES:
High Bay—2 (250-ton capacity; 462-foot hook height)
Transfer Aisle—1 (175-ton capacity; 166-foot hook height)

HIGH BAY DOORS: 4
Height of each door opening—456 feet (ground to top)
Lower door opening—152 feet wide, 114 feet high (inclosed with 4 leaves sliding horizontally)
Upper door opening—76 feet wide, 342 feet high (inclosed with 7 leaves sliding vertically)

FOUNDATION: 4,225 steel pipe pilings 16-inch diameter, driven an average 160 feet to rock.

COMPARATIVE FIGURES:
Height—VAB 525 feet 10 inches
Empire State, NY, with TV tower—1,472 feet
Terminal Tower, Cleveland—708 feet
City Hall, Los Angeles—454 feet
Dade County Courthouse, Miami—325 feet
Statue of Liberty—305 feet
Washington Monument—555 feet

VOLUME: VAB—129,428,000 cubic feet
Boeing SST Assembly Plant, Everett, Wash.—160,000,000 cubic feet
Great Pyramid of Cheops, Egypt—90,120,000 cubic feet
Pentagon—77,025,000 cubic feet

STEEL QUANTITY: VAB—98,590 tons total
Empire State Building—60,000 tons
VAB equivalent: 30,000 automobiles

PILING: VAB—674,000 feet (128 miles)
VAB equivalent—16-inch steel pipeline from Washington to Philadelphia (123 miles direct distance)

AIR-CONDITIONING: VAB—10,000 tons
VAB equivalent—3,000 homes or 9 hotels similar in size to the Americana in Miami Beach

LAUNCH CONTROL CENTER (LCC)

A four-story concrete structure, the Launch Control Center is located on the east side of the Vehicle Assembly Building and is connected to the VAB by means of an inclosed utilities bridge.

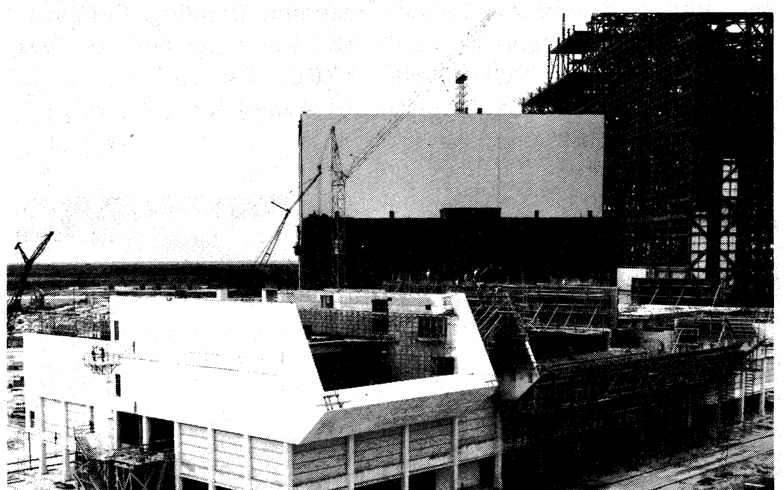
As its name implies, the building is used for controlling pre-launch and launch operations of the Apollo-Saturn V. To do this, the building has four main firing control rooms and various offices, shops, laboratories, supply rooms and personnel facilities.

In both design and construction, the LCC was included in the same work with the Vehicle Assembly Building. Construction of the LCC began in March 1964 and the building was substantially completed in May 1965. The Launch Control Center won the 1965 Architectural Award for the Industrial Design of the Year.

Launch Control Center in completed form showing window louvers.

DESIGN AND CONSTRUCTION: The LCC is a four-story reinforced concrete structure, 378 feet long, 181 feet 6 inches wide, and 77 feet 2 inches high. Its construction made extensive use of precast and prestressed material.

Exterior walls at the first floor are recessed to form an arcade around the building. At this level the walls are sheathed in precast architectural concrete panels surfaced in dark granite chips. The remainder of the building is surfaced predominantly in exposed cast-in-place architectural concrete. The north, east and west exterior walls of the second floor are of uninsulated aluminum V-beam siding to match that on the VAB. The fourth floor south exterior wall is of insulated aluminum V-beam siding and large aluminum air-intake louvers for the mechanical equipment room. Doors and openings in exterior walls are aluminum with hurricane resistant laminated glass windows in aluminum framing.



Launch Control Center during construction.

FIRING ROOMS: Four firing rooms, each 80 by 140 feet and two stories high, are located on the third floor. Each firing room is designed to house 470 monitors and consoles for controlling the assembly and checkout of a launch vehicle in one of the four assembly areas of the VAB. The firing rooms are also used for controlling the launches from the two launch pads.

Two of the four firing rooms are completely outfitted and a third is in the process of being equipped.

Each of the operational firing rooms is equipped with closed circuit television for supervision of launch operations. In addition, four rearview projection screens are located on the fourth floor level, visible to the firing room, to provide data displays.

Interior of Firing Room 1, Launch Control Center, during installation of equipment consoles. TV monitors line walls on either side, with rear-view, data projection screens above.

WINDOWS: To provide launch crews with a view of the launch pads, tinted 3/4-inch thick laminated glass windows are installed in each firing room. The windows measure 80 feet long by 22 feet high in each bay and reduce sound transmission into the firing rooms to normal audible levels during launches. They also allow only 28 percent of the light to penetrate, filtering out rays which cause glare and heat.

The windows are protected by center-pivoted power-operated louvers.

Condensation is controlled by thermostatic elements embedded in the glass. Infrared lamps heat the exterior surface of the glass and prevent the windows from fogging by maintaining the temperature of the glass above the dew point of the outside air.

REFERENCE DATA
LAUNCH CONTROL CENTER

CONSTRUCTION PERIOD: March 1964 to December 1965

MAJOR CONTRACTS:

Design—Urbahn-Roberts-Seelye-Moran, New York City

Construction—Joint venture of Morrison-Knudsen Co., Inc.; Perini Corporation, and Paul Hardeman, Inc., South Gate, Calif.

DESIGN AND CONSTRUCTION SUPERVISION: Canaveral District, US Army Corps of Engineers

CONSTRUCTION COST: $10,000,000

DIMENSIONS:

Length—378 feet
Width—181 feet 6 inches
Height—77 feet 2 inches

ELEVATORS: 4

FLOORS: 4

TOTAL FLOOR AREA: 213,900 square feet

MOBILE LAUNCHERS

Three Mobile Launchers have been constructed for Launch Complex 39. Moved by the Transporter from their parking and refurbishing area just north of the VAB into the building and then out to the launch pad, they serve a dual function as a platform for erection of the Apollo-Saturn V in the VAB and as a stand for launching the vehicle at the pad.

Each Mobile Launcher contains two distinct parts. A two-story-tall launch platform contains computers which are linked to the firing rooms of the Launch Control Center. An umbilical tower provides support for nine swing arms which afford direct access to the launch vehicle; work platforms at 17 tower levels, and distribution lines for propellant, pneumatic, electrical and instrumentation systems.

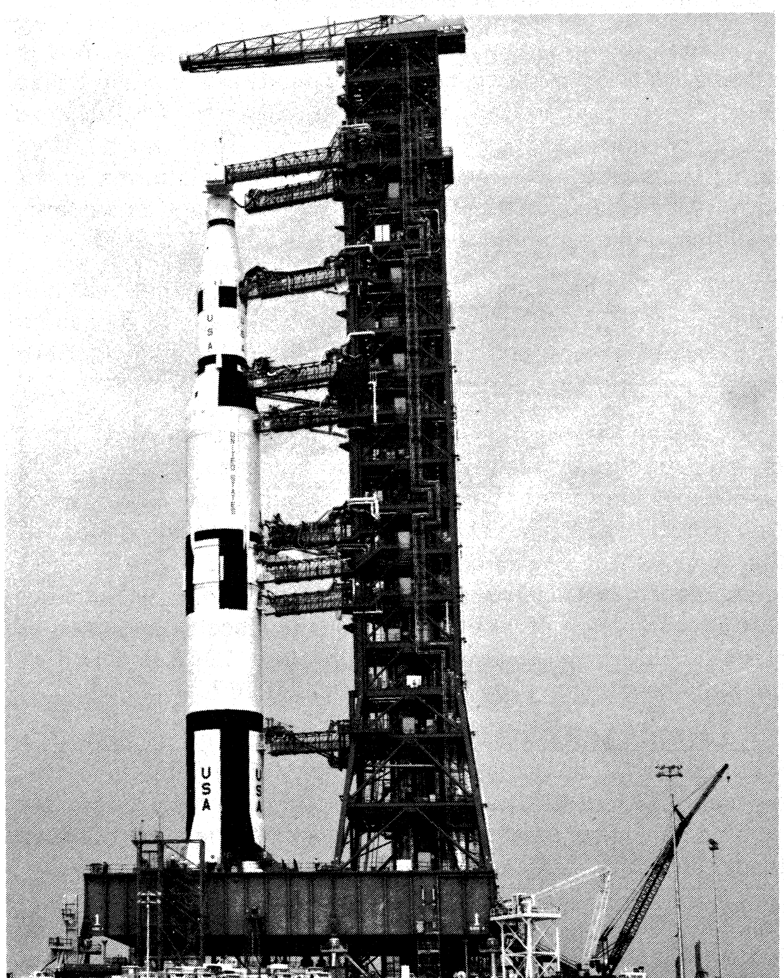
Each Mobile Launcher is 445 feet 9 inches tall and weighs 10,500,000 pounds. The launch platform measures 135 by 160 feet and is 25 feet high. The launchers are the heaviest portable structures known.

Work on the launchers was done in three phases. Erection of the structural steel on the first launcher began in July 1963 and the three were topped out in September 1964, December 1964 and March 1965. The second phase of the work, the installation of mechanical and electrical systems, began in December 1963 and was completed in May 1966. Installation of ground support and miscellaneous equipment including swing arms began in June 1965 and two of the launchers were ready for use early in 1967.

LAUNCH PLATFORM: At their parking site, in the VAB's high bay and at the launch pad, the Mobile Launchers rest on six, 22-foot-tall pedestals. At the pad four extensible columns are also used to stiffen the launcher against rebound loads, should the engines be cut off after ignition.

The launch platform, which is the above-ground base of the Mobile Launcher, has an area of one-half acre. The top deck of the platform is divided into two sections. One section, 60 by 135 feet, is under the umbilical tower and the other section serves as a launch table for the Apollo-Saturn V which is positioned on four hold-down support arms, one on each side of a 45-foot-square exhaust opening through the platform. This opening vents the engine exhaust into the flame trench at the launch pad.

The platform is constructed of welded steel up to six inches thick.



Mobile Launcher with facilities test model of Apollo-Saturn V at Launch Pad A with swing arms affixed to vehicle.

Inside the platform are two levels, with 15 rooms on each level and five compartments which extend through both levels. In these rooms are checkout computers, system test sets, propellant loading equipment, electrical equipment racks and engine hydraulic servicing units.

Certain critical floors within the platform are mounted on springs or shock isolators and the walls are lined with thermal and acoustical fiberglass insulation.

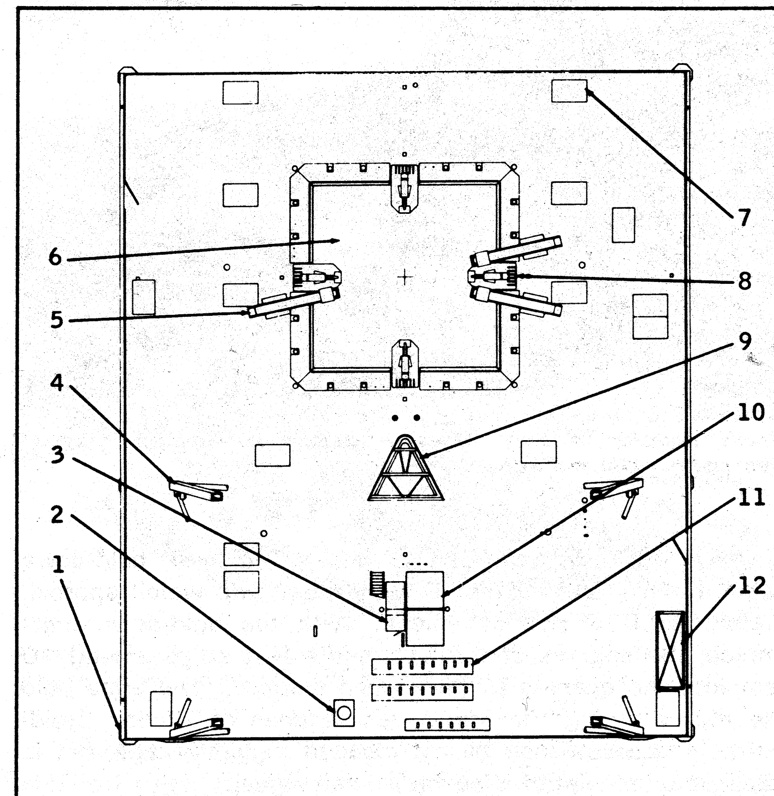
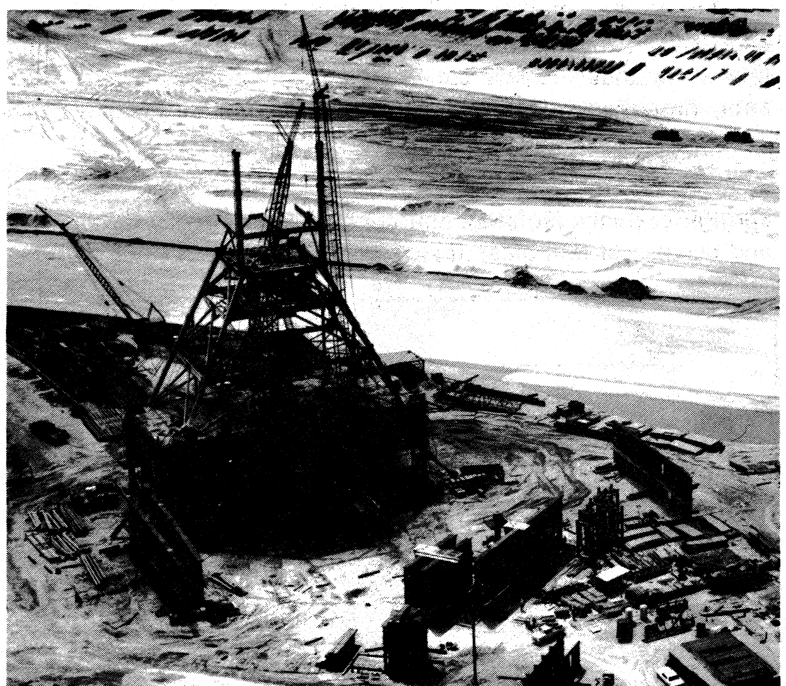


Diagram shows platform deck of Mobile Launcher with (1) dynamic support columns; (2) condenser (AC); (3) stairwell; (4) umbilical tower column; (5) tail service mast; (6) vehicle engine chamber; (7) access hatches; (8) vehicle hold-down and support arms; (9) blast shield; (10) elevators; (11) deck-mounted cable enclosures, and (12) Environmental Control System duct support.



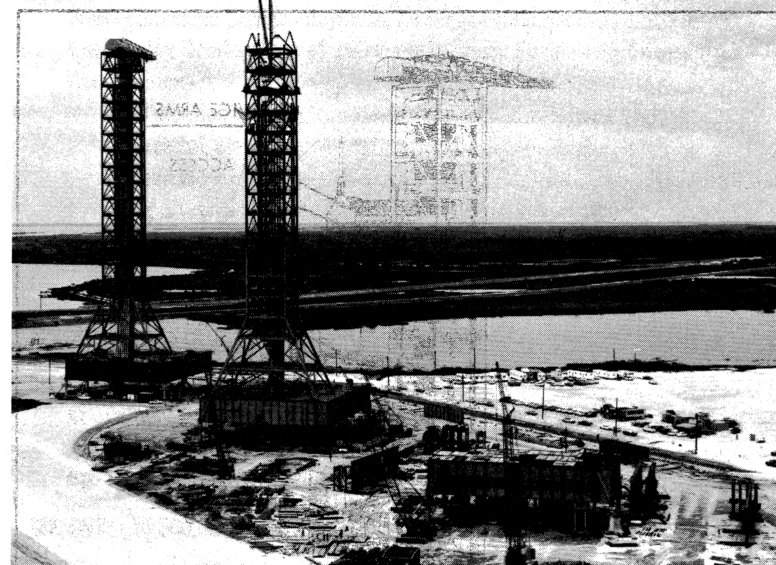
Mobile Launcher in early stages of platform construction and steel erection for umbilical tower.

HOLD-DOWN SUPPORT ARMS: The four hold-down support arms are 10 feet 5 inches tall, and weigh approximately 40,000 pounds apiece. With the hold-down arms affixed, the engines of the Saturn V's first stage extend 10 feet into the opening in the launch platform. The arms hold the rocket during the first seven seconds of ignition. Hold-down is accomplished by a preloaded toggle linkage that is released on receipt of a launch commit signal.

UMBILICAL TOWER: The umbilical tower of each Mobile Launcher, topped by a hammerhead crane, extends 398 feet 9 inches above the launch platform. At its base, the tower is 60 by 111 feet. It tapers for 80 feet to a 40-foot-square tower for the remainder of its height.

Two elevators with a speed of 600 feet per minute and a capacity of 2,500 pounds are located within the framework of the tower to transport technicians and equipment to 17 work platforms and the swing arms.

The hammerhead crane at the top of each tower has a hook height of 376 feet from the deck of the platform, a traverse radius of 85 feet and a 360-degree beam rotation. It has a capacity of 25 tons up to a radius of 50 feet and 10 tons up to a radius of 85 feet.



Aerial photo shows three Mobile Launchers in various stages of construction in area north of Vehicle Assembly Building.

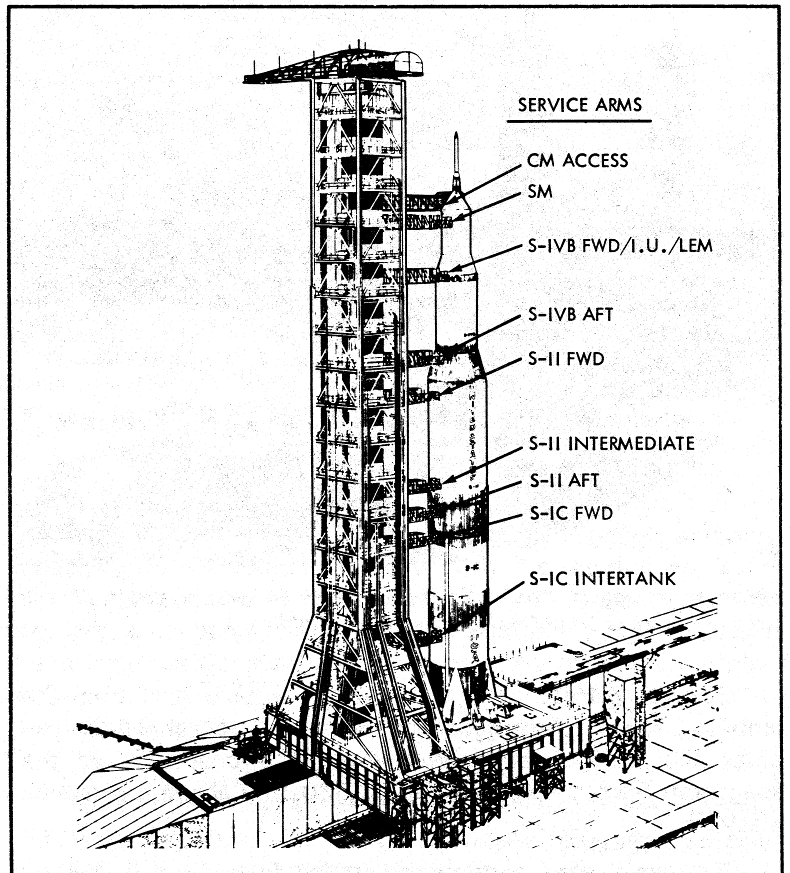
SWING ARMS: The nine swing arms extend from the umbilical tower to the launch vehicle so that technicians can enter the vehicle at various levels. Astronauts board the spacecraft from the topmost arm, 320 feet above the launch platform.

The arms also support propellant lines used in fueling the rocket and carry electrical and pneumatic feeds from the ground into the rocket.

Two of the arms are for the S-1C stage; three for the S-2 stage; two for the S-4B stage including the Instrument Unit and Lunar Module, and two for the Apollo spacecraft's Service Module and Command Module.

Varying in length from 45 to 60 feet depending on the configuration of the vehicle in relation to the umbilical tower, the arms weigh between 35,000 and 52,000 pounds.

When ignition of the rocket occurs, hydraulic systems pull the arms back against the tower in about five seconds.



Sketch of Mobile Launcher at pad showing relationship of swing arms to Apollo-Saturn V.

REFERENCE DATA
MOBILE LAUNCHERS

NUMBER CONSTRUCTED: 3

CONSTRUCTION PERIOD:

Structural steel—July 1963 to March 1965

Mechanical and electrical systems—December 1963 to May 1966

Swing arms, ground support and miscellaneous equipment—June 1965 to present

MAJOR CONTRACTS:

Mobile Launcher Design—Reynolds, Smith and Hills, Jacksonville, Fla.

Engineering development of swing arms—Brown Engineering Co., Huntsville, Ala.

Construction—

Steel erection—Ingalls Iron Works Co., Inc., Birmingham, Ala.

Mechanical, electrical installation—Smith-Ernst, Orlando, Fla.

Ground support equipment—Pacific Crane and Rigging Co., Paramount, Calif.

Swing arms—Hayes International Corp., Birmingham, Ala.

DESIGN AND CONSTRUCTION SUPERVISION: John F. Kennedy Space Center, National Aeronautics and Space Administration

OVERALL CONSTRUCTION COST: $33,963,000

HEIGHT:

At erection area, pad or VAB—445 feet 9 inches (not including 42-foot lightning rod

On Transporter—451 feet maximum (cylinders extended)

WEIGHT: 10,500,000 pounds

LAUNCH PLATFORM:

Height—25 feet

Width—135 feet

Length—160 feet

Mount mechanisms—6 (extending 22 feet above ground)

Exhaust opening—45 feet square

Floor space—Level A (upper): 12,131 feet

Level B (lower): 18,553 square feet

UMBILICAL TOWER:

Height above platform—380 feet (not including crane)

398 feet 9 inches (including crane)

Base dimensions:
- Level 0: 60 feet by 111 feet (tapers to level 80)
- Level 80 to 380: 40 feet square
- Platforms—17
- Elevators—2
  - Capacity: 2,500 pounds
  - Speed: 600 feet per minute maximum
- Crane—1
  - Capacity: 25 tons 50 feet from swivel
    10 tons 85 feet from swivel
  - Beam rotation: 360 degrees

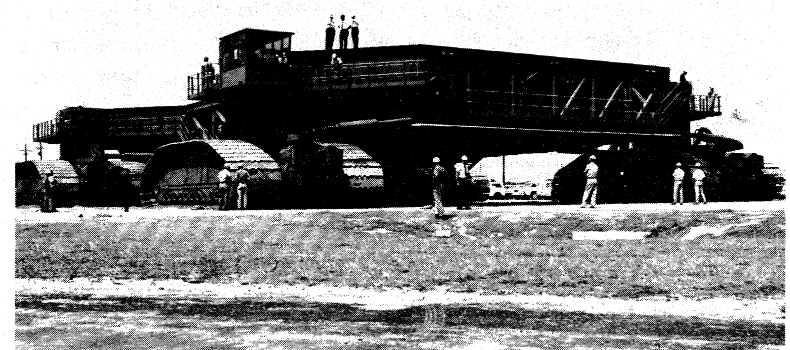
SWING ARMS: 9
- Length—45 to 60 feet
- Weight—35,000 to 52,000 pounds
- Location—S-1C stage: 2
  - S-2 stage: 3
  - S-4B stage (including Instrument Unit and Lunar Module): 2
  - Spacecraft Service and Command Modules: 2

HOLD-DOWN SUPPORT ARMS: 4
- Base dimensions—9 feet 9 inches by 6 feet 4 inches
- Height—10 feet 5 inches
- Weight—40,000 pounds each (approx.)

TRANSPORTERS

Two Transporters were constructed for Launch Complex 39 to move the Mobile Launcher and the assembled Apollo-Saturn V vehicle as well as the Mobile Service Structure.

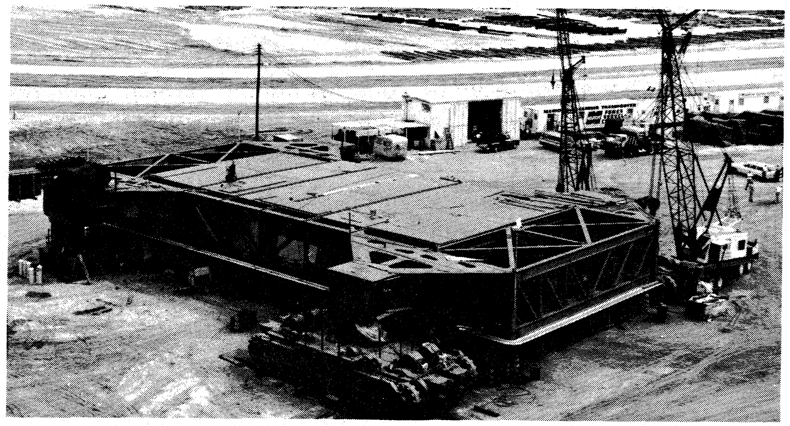
With a platform the size of the infield on a baseball field and a total weight of approximately 6,000,000 pounds, each Transporter can carry a load of up to 12,000,000 pounds at a maximum speed of one mile per hour. It maintains a level platform, holding a launch vehicle within 10 minutes of arc, even while negotiating a 5 percent grade at the approach to the launch pad.



Completed Transporter on maiden run.

In operation, a Transporter moves under a Mobile Launcher or the Mobile Service Structure and its jacking system engages fittings on the underside of its cargo. The Transporter then lifts the structure off its support pedestals, transports it and places it back on support pedestals at the new location.

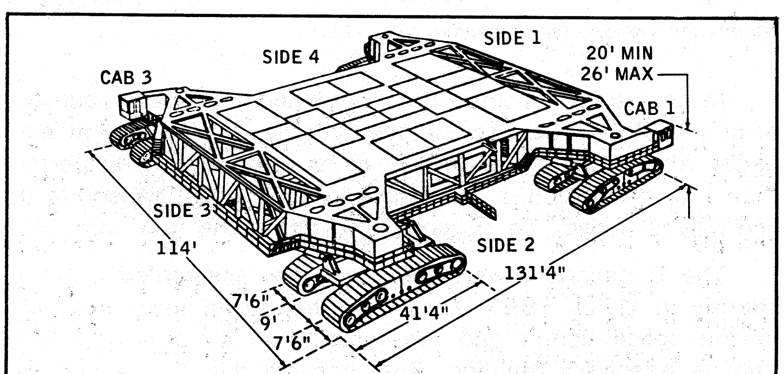
The Transporters were fabricated and assembled in Ohio starting in March 1963. They were then taken apart, shipped to the space center and reassembled in an area near the Vehicle Assembly Building. Both became operational early in 1966.



Assembly of Transporter in area near VAB.

POWER SYSTEM AND TREADS: Each Transporter is 131 feet 4 inches long and 114 feet wide and is powered by two 2,750-horsepower diesel engines. The engines drive four 1,000-kilowatt generators which provide electrical power to 16 traction motors. Through gears the traction motors turn the four double-tracked crawlers spaced 90 feet apart at each corner of the Transporter.

Each of the eight treads is 7 feet 6 inches wide and 41 feet 3 inches long, with approximately 34 feet of each tread bearing on the surface of the Crawlerway at a time. Each link in the tread weighs about one ton.

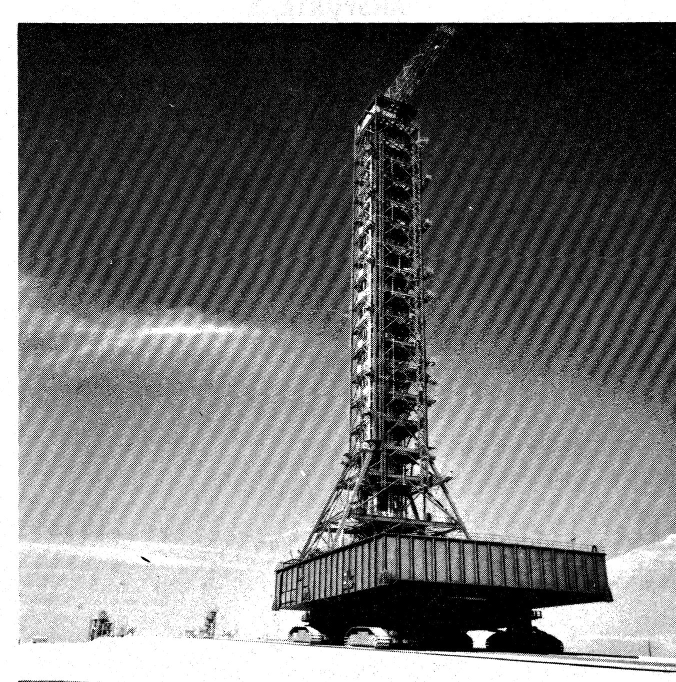


Sketch of Transporter showing basic dimensions and configuration.

A separate power system provides AC power for the load leveling, jacking, steering, ventilating and electronic systems. This AC system has two diesel engines of 1,065 horsepower each and two generators of 750 kilowatts each.

STEERING: Each Transporter has two driver cabs on opposite corners, so that the machine can be driven in either direction. Steering is by means of an electronically controlled hydraulic system. The minimum turning radius is 500 feet.

LOAD LEVELING SYSTEM: The Transporter is capable of positioning a Mobile Launcher and Apollo-Saturn V or the Mobile Service Structure on pedestals within a maximum deviation of two inches. The Transporter's hydraulic jacks, used to lift and lower the crawler's loads, have a 72-inch operating stroke.



Leveling system of Transporter keeps Mobile Launcher's platform level and its umbilical tower within 10 minutes of arc during climb up approach ramp to Pad A. Photo was made during test run of Transporter.

Two identical and independent hydraulic servo systems are provided in each of the Transporters for complete redundancy of the leveling and jacking system. Level sensing and control are initiated by an "X" manometer whose horizontal tubes are 130 feet long. In addition, lateral manometers are installed at each end. They contain transducers which sense errors in leveling and transmit error signals to the servo system. In turn, this system operates two variable control servo pumps, one for each diagonal axis. The pumps support cylinders at each corner of the platform to level the chassis.

The system can be operated manually or automatically.

REFERENCE DATA TRANSPORTERS

NUMBER CONSTRUCTED: 2

CONSTRUCTION PERIOD: March 1963 to early 1966

MAJOR CONTRACTS:
Design—Marion Power Shovel Co., Marion, Ohio
Construction—Marion Power Shovel Co., Marion, Ohio

DESIGN AND CONSTRUCTION SUPERVISION: John F. Kennedy Space Center, National Aeronautics and Space Administration

CONSTRUCTION COST: $13,600,000

HEIGHT:
Minimum (cylinders retracted)—20 feet
Maximum (cylinders extended)—26 feet

LENGTH: 131 feet 4 inches

WIDTH: 114 feet

WEIGHT: 6,000,000 pounds (approx.)

SPEED:
Loaded—1 mile per hour maximum
Unloaded—2 miles per hour maximum

LOAD CAPACITY: 12,000,000 pounds

HYDRAULIC SYSTEM:
Operating pressure—2,780 pounds per square inch
Maximum pressure—5,000 pounds per square inch

POWER SYSTEM (DC):
Diesel engines—2 (2,750 horsepower each)
Generators—4 (1,000 kilowatts each)

POWER SYSTEM (AC):
Diesel engines—2 (1,065 horsepower each)
Generators—2 (750 kilowatts each)

AUXILIARY POWER SYSTEM: (Electrical power for Mobile Launcher during transit)
Generators—2 (150 kilowatts each)

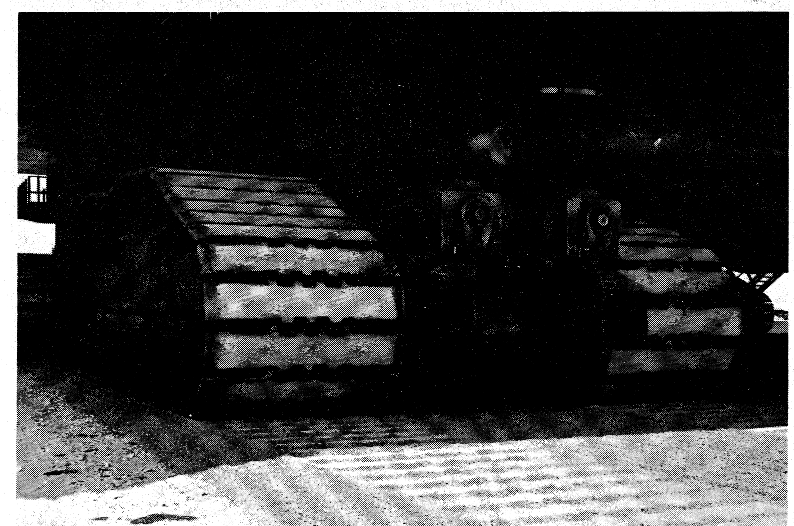
CRAWLERWAY

Consisting of two 40-foot-wide lanes separated by a 50-foot median, the Crawlerway provides a traveling surface for the Transporter between the Vehicle Assembly Building and Launch Pads A and B.

To support the 17,000,000 pound loads of a Transporter carrying a Mobile Launcher and Apollo-Saturn V, the Crawlerway averages 7 feet in thickness.

Initially, the Crawlerway was built between Launch Pad A and the VAB, a distance of 18,159 feet. This work was done under the same contract with which the pad was constructed. Work on this section of the Crawlerway began in November 1963 and was completed in August 1965.

The Crawlerway in the immediate VAB area was built under the general construction contract for the VAB.



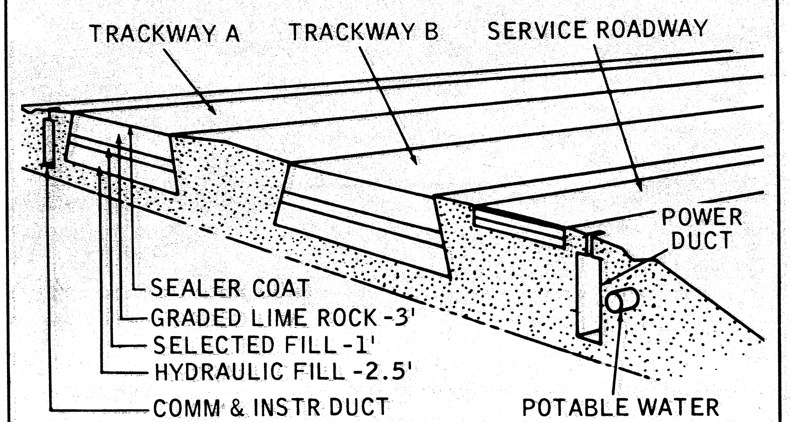
One of four dual tractor units of Transporter. Under maximum load conditions in high winds, each dual unit can exert 5,400,000 pounds of pressure on Crawlerway, or more than 12,000 pounds per square foot.

About two-thirds of the way from the VAB to Pad A, a branch of the Crawlerway extends to Pad B. This section, 11,300 feet in length, was built under the contract for construction of Pad B between December 1964 and February 1966. The over-all distance from the VAB to Pad B is 22,400 feet.

Included in the contract for construction of Pad A and the Crawlerway was the park position for the Mobile Service Structure.

CRAWLERWAY DESIGN AND CONSTRUCTION: Vital to the design of the Crawlerway were considerations of the loads which would be imposed upon it by the Transporter and the condition of the subsurface soil.

Each of the four dual tractor units of the Transporter was calculated to exert 4,400,000 pounds of load on the Crawlerway under nominal operating conditions. When winds produce imbalance on the Transporter and the structures it is carrying, the load per unit was calculated to increase to 5,400,000 pounds. As a result, the Crawlerway was built to withstand loads in excess of 12,000 pounds per square foot.



Profile of typical Crawlerway section (not to scale).

A variety of terrain had to be traversed by the Crawlerway, including dry land, swamp and sloughs. Borings made on dry land showed generally satisfactory subsurface material consisting mostly of fine sands extending to between -40 and -45 feet below sea level. In watery areas, soft silty sands and some soft silts and clays were encountered above the fine sands found in dry land areas.

From an elevation of about -40 to bedrock at -160 feet, the material was more or less compressible, consisting of interbedded clays, silts and silty or clay-type sands.

Placement of sub-base material in early stages of Crawlerway construction.

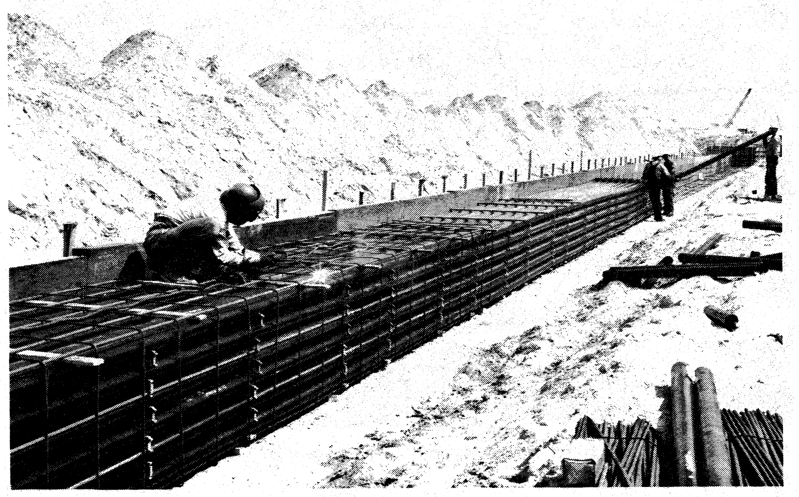
Construction of the Crawlerway was similar to that for a highway causeway. After the softer, unsuitable material was excavated, more than 3,000,000 cubic yards of hydraulic sand fill were placed on the Crawlerway route. This hydraulic fill under the trackways was compacted with vibratory rollers and then proof-rolled with a 100-ton roller.

The roadway consists of three feet of graded crushed aggregate base course and 3-1/2 feet of selected sub-base material. As the top surface on which the Transporter operates, river gravel was placed to a depth of eight inches on curves and four inches on the straightaway sections.

The elevation of the finished Crawlerway is 7-1/2 feet above sea level except for the 5 per cent grade on the approaches to each launch pad.

A 24-foot-wide service roadway borders the Crawlerway on the south side of the Crawlerway to Pad A and the east side of the Crawlerway to Pad B.

UTILITY AND COMMUNICATIONS LINES: Paralleling the Crawlerway on either side are utility and pipe lines linking the control and assembly area of Launch Complex 39 with the launch area.



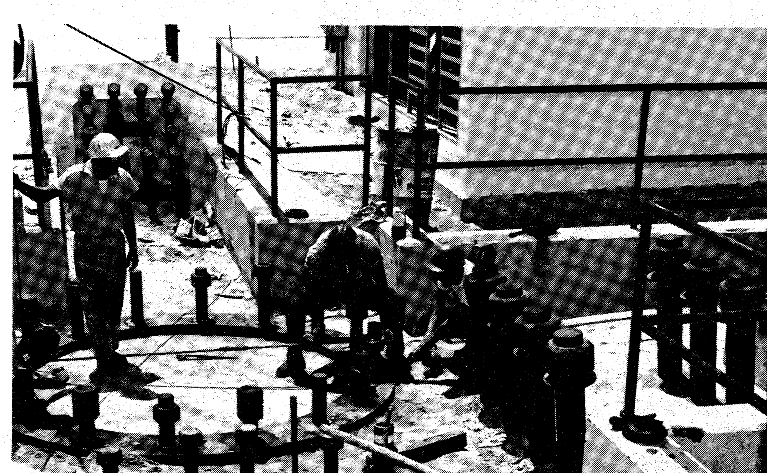
Construction of communication and instrumentation duct-bank paralleling north side of Crawlerway.

Communication and instrumentation lines are placed in ductbanks buried along the north side of the Crawlerway, with as many as 40 ducts per bank. At various intervals these lines pass through repeater buildings.

High pressure gas lines are also located on the north side of the Crawlerway, supported above ground on precast concrete posts and piers. The lines run to the pads from a high pressure gas facility built alongside the Crawlerway. The facility consists of a spherical storage tank and a one-story building for the gas compressors and pumping equipment.

Power duct lines and a line for potable water are on the south side of the roadway. Where any of the lines or piping systems pass beneath the Crawlerway, access tunnels were built to withstand the load conditions of the roadway.

MSS PARK POSITION: Included in the contract for Pad A and the initial segment of the Crawlerway was the park position for the Mobile Service Structure.



Anchor bolts mounted in 14-foot-thick concrete mat now hold support pedestals for Mobile Service Structure in its park position.

The MSS weighs approximately 9,800,000 pounds. When the Transporter which weighs 6,000,000 pounds is moved beneath it, the total load on the park position is 15,800,000 pounds. In addition to this, the MSS standing by itself on its four support legs in the park position, with side struts and hold-down arms for each leg, can exert 13,000,000 pounds downward force and 6,000,000 pounds uplift if wind velocities reach 125 miles per hour.

To support these loading requirements, a 14-foot-thick reinforced concrete mat was constructed, approximately 200 feet square. Support pedestals for the MSS are anchored into this mat.

In structural quantities, the MSS foundation contains 19,000 cubic yards of concrete and 676 tons of reinforcing steel in the largest sizes available.

REFERENCE DATA CRAWLERWAY

CONSTRUCTION PERIOD:
VAB - Pad A—November 1963 to September 1965
Extension to Pad B—April 1965 to February 1966
VAB area—March 1964 to January 1965

MAJOR CONTRACTS:
Design—U.S. Army Corps of Engineers
Construction—
VAB - Pad A—Joint venture of Blount Brothers Corp. and M. M. Sundt Construction Co., Montgomery, Ala.
Extension to Pad B—George A. Fuller Co., Los Angeles, Calif.
VAB area—Joint venture of Morrison-Knudsen Co., Inc.; Perini Corp., and Paul Hardeman, Inc., South Gate, Calif.

DESIGN AND CONSTRUCTION SUPERVISION: Canaveral District, U.S. Army Corps of Engineers

OVER-ALL CONSTRUCTION COST: $7,500,000

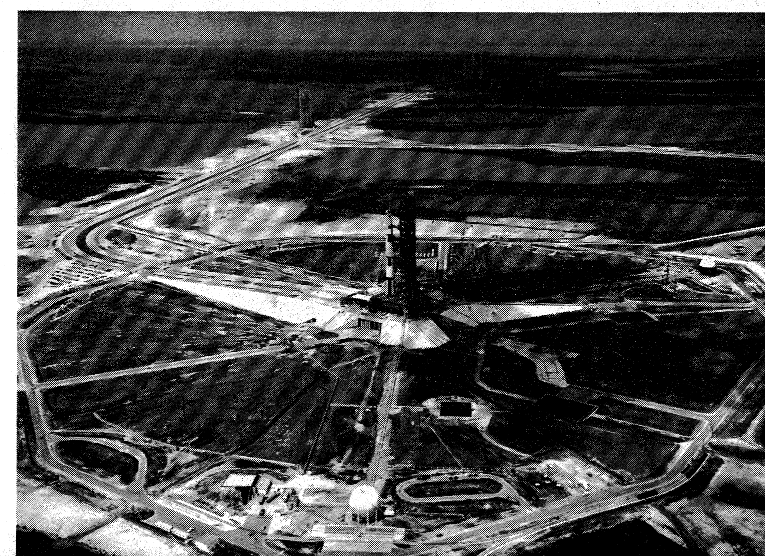
LENGTH:
VAB - Pad A—18,159 feet
Extension to Pad B—11,300 feet
VAB to Pad B—22,400 feet

WIDTH: 130 feet (over-all)
Each lane—40 feet
Median—50 feet
Depth (thickness)—7 feet average

LAUNCH PADS A AND B

Launch Pads A and B for Complex 39 are virtually identical. Each launch pad area covers approximately one-quarter square mile and the pads are 8,716 feet apart. Both pads are connected by the Crawlerway with the Vehicle Assembly Building. Launch Pad A, measured by the Crawlerway, is 18,159 feet from the VAB; Launch Pad B, 22,400 feet. The flame trench of both pads faces due north.

Each launch pad area consists of several major components. The launch pad proper includes the hardstand; the Pad Terminal Connection Room (PTCR), the Environmental Control System (ECS) Room, the High Pressure Gas Storage Facility, the flame trench and apron, and the Emergency Egress System. Perimeter structures in the pad area include the Liquid Oxygen, Liquid Hydrogen and RP-1 fuel storage facilities, holding ponds, camera pads and the flame deflector park position.



Aerial view of Launch Pad A showing Apollo-Saturn V and Mobile Launcher on pad. High Pressure Gas Storage Facility can be seen beneath hardstand, with liquid oxygen and liquid hydrogen storage tanks on far and near side of pad area respectively. RP-1 facility is adjacent to that for liquid hydrogen.

The two pads were built under separate contracts. Construction of Pad A started in November 1963 and the work was substantially completed in October 1965. A facilities test model of an Apollo-Saturn V was moved atop Pad A on May 26, 1966. Construction of Pad B began in December 1964 and the work was substantially completed in April 1967.

SITE PREPARATION: Because of the generally swampy conditions existing in the area of Pads A and B, the construction sites for both were surcharged prior to construction to consolidate the lower soil stratas. An 80-foot-high pyramid of dredged fill from the Banana River and surrounding area was placed on each site. These pyramids settled the pad area approximately four feet before they were removed and construction began. Each of the surcharges required more than 500,000 cubic yards of fill and weighed in excess of 1,500,000,000 pounds. During their existence, the pyramids were termed the "highest mountains in Brevard County"—an accurate statement.

Eighty-foot-high surcharge of dredged fill used to consolidate lower soil stratas at Launch Pad A.

DESIGN AND CONSTRUCTION: Since the top of each pad is 42 feet above the bottom of the flame trench, two cellular structures were developed paralleling the flame trench

to support the various loads of the Transporter with the Mobile Launcher, launch vehicle, and the Mobile Service Structure.

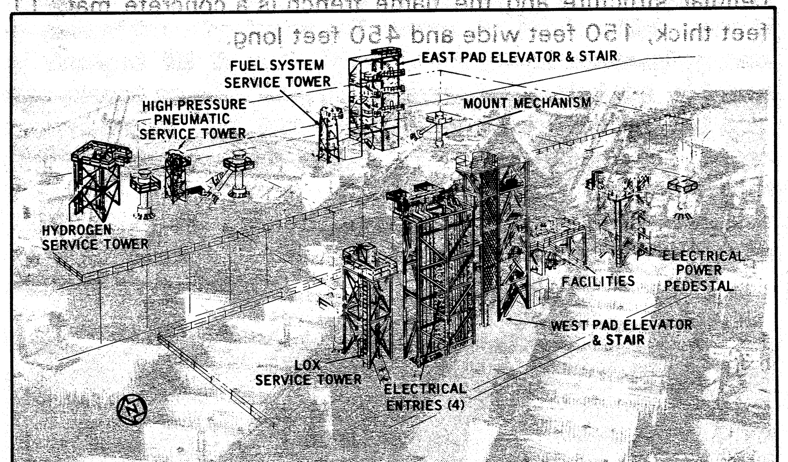
The parallel cellular structures, approximately 400 feet long, 40 feet wide and 42 feet high, are made up of individual cells with concrete diaphragms at 20-foot centers. The longitudinal walls of the cells are approximately three-feet thick and the diaphragms are 33 inches thick. Beneath the cellular structure and the flame trench is a concrete mat, 11 feet thick, 150 feet wide and 450 feet long.

Cellular structures lining flame trench at Launch Pad B.

One of the major engineering problems was the design of the roof slab over the cells to support the Transporter and its loads. The bearing pressures exerted by the tracks of the Transporter are in the range of 10,000 pounds per square foot. A surface 30 feet wide and 520 feet long on each side of the flame trench was designed to be supported by the cell roof slabs. This surface is of 15-inch deep welded grating.

The grating is bolted to imbedded anchor strips and filled with small aggregate concrete. The grating is covered with a resilient operating surface for the Transporter.

Located on the hardstand are service towers which provide interface connections between the pad facilities and the Mobile Launcher for liquid oxygen, hydrogen, RP-1, electrical power and communications, compressed air and environmental control systems.



Also located on the hardstand are the support pedestals for the Mobile Launcher and Mobile Service Structure. The pedestals are designed to support the structures at wind velocities of 80 miles per hour. Some of the service structure reactions on the support pedestals are as high as 8,000,000 pounds. During the firing phase of the vehicle, the Mobile Launcher is supported by six permanent legs and four additional extendable arms that are temporarily fastened to the bottom of the launcher platform and the pad to take the dynamic loads and the rebound that is computed between 7,000,000 and 10,500,000 pounds at liftoff.

The slope from the elevated top of each pad to the general grade level 40 feet below is retained by four-inch thick concrete paving.

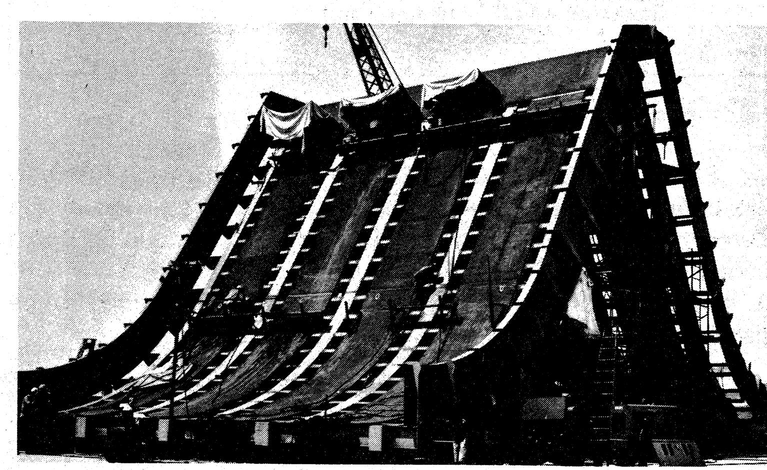
Altogether, each pad contains 68,000 cubic yards of concrete and 5,100 tons of reinforcing steel.

FLAME TRENCH: The flame trench, located in the center of each pad, is 450 feet long excluding the apron at its north end. The trench is 58 feet wide and 42 feet deep.

During launch, the floor and walls of the trench are protected with a refractory brick surface that can withstand temperatures up to 3,000 degrees Fahrenheit, positive and negative pressures of 2-to-10 pounds per square inch and flame velocities in the range of Mach 4. The refractory brick surface has a smoothness tolerance of one-eighth inch in 10 feet.

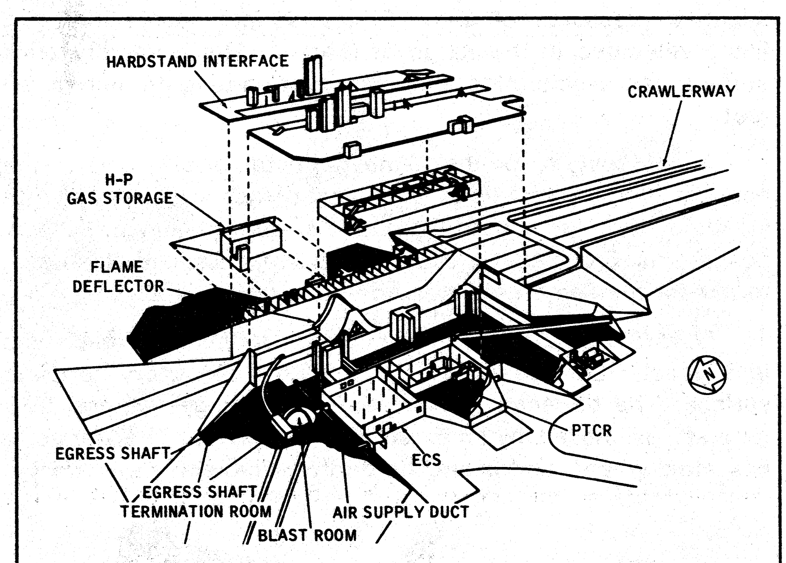
A rail system for the flame deflector is provided in the floor of the trench along with anchorages capable of withstanding the thrust of the vehicle during launch. A park position is provided in the splayed area north of the flame trench for the flame deflector when it is not in use.

FLAME DEFLECTOR: The flame deflector at each pad is a steel, roof-trussed structure with a refractory concrete surface. The deflector is 41 feet 6 inches high, weighs 650 tons and is moved by an external prime mover. The deflector has steel wheels and is anchored into place with thrust locks.



Flame deflector for Launch Pad A during assembly.

PAD TERMINAL CONNECTION ROOM: The Pad Terminal Connection Room (PTCR) contains two stories and is located on the west side of the flame trench beneath the sloping shoulder of the pad. It is covered with as much as 20 feet of earth fill. It houses electronic equipment which provides a connecting link for communication and digital data link transmission lines from the Launch Control Center to the Mobile Launcher. The room is built of reinforced concrete.



Layout sketch of Launch Pads A and B.

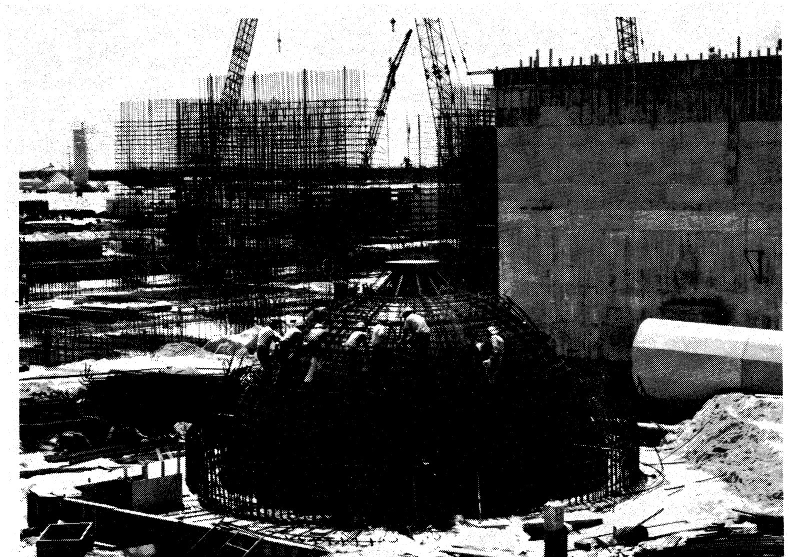
ENVIRONMENTAL CONTROL SYSTEMS ROOM: Also buried beneath the shoulder of the pad on the west side of the flame trench, the Environmental Control Systems (ECS) Room contains one story and is similar in construction to the PTCR. It serves as a distribution point for conditioning and purge gases.

HIGH PRESSURE GAS STORAGE FACILITY: The High Pressure Gas Storage Facility is located beneath the top of the pad on the east side of the flame trench. It is also built of reinforced concrete and is used to store nitrogen and helium used for pressurizing electrical and water systems.

Launch Pad A hardstand area showing pedestals and service towers along with ground level entrances to Pad Terminal Connection Room (PTCR) and Environmental Control System (ECS) Room on near side of pad.

EMERGENCY EGRESS SYSTEM: Both pads contain a personnel escape system for use in a pre-launch emergency. The system contains a stainless steel chute, approximately 200 feet long, in a superelevated curve that starts at the interface with the Mobile Launcher and terminates 40 feet below the pad structure in a rubber-lined termination room.

A blast resistant room adjacent to the termination room contains 20 contour chairs and safety harnesses as well as survival equipment for a period of 24 hours. The blast room is dome-shaped, 40 feet in diameter, with 2-1/2-foot-thick steel and concrete walls and steel doors designed to withstand a blast pressure of 500 pounds per square inch and an acceleration of 75 Gs. A floating concrete floor supports the contour chairs and is built on a spring suspension system which reduces the 75 G force possible on the dome to 4 Gs.



Reinforcing steel for concrete is placed over steel shell of emergency egress dome at Pad A. Earth revetment later covered entire dome to provide additional protection.

WATER SYSTEMS: In addition to a potable water system, provided through pump facilities in the VAB area, an industrial water system serves both launch pad areas. The pumping station for this industrial water system is located near the Crawlerway to Pad B and is capable of furnishing water at a rate of 45,000 gallons per minute.

Industrial water at each pad is distributed through separate industrial water subsystems for Mobile Launcher deck flushing; flame deflector quenching and cooling, umbilical arm cooling, engine chamber deluge, and pad surface and flame trench wall flushing. These subsystems are zone-controlled from the Launch Control Center.

The pad FIREX system provides fire fighting water to the pad propellant storage facilities, high pressure gaseous hydrogen facility, Mobile Service Structure, perimeter fire hydrants, and Mobile Launcher fire hose connections from separate pumps at the industrial water pumping station.

ELECTRICAL SYSTEMS: Both pads have separate electrical distribution systems, one for industrial power, the other for instrumentation purposes. The industrial power system is redundant and provides dual feeders to major load centers. The system incorporates emergency diesel generators for additional reliability under critical loads. Both systems are remotely controlled.

SUPPORT FACILITIES: Major support facilities in the perimeter area of the pad are the storage facilities for liquid oxygen, liquid hydrogen and RP-1.

Liquid oxygen is stored in a 68-foot 9-inch sphere located 1,450 feet from the pad. The double-walled tank has a carbon steel exterior and is lined with stainless steel. Capacity of the tank is 900,000 gallons. Pumps transfer this oxidizer to the vehicle at a maximum rate of 10,000 gallons per minute through a 14-inch transfer line.

The S-1C stage fuel, RP-1, is stored in three 86,000-gallon tanks for a total capacity of 258,000 gallons. The tanks are located 1,350 feet from the center of the pad, on the east side of the pad. The RP-1 is pumped to the vehicle through an 8-inch line at a maximum rate of 2,000 gallons per minute.

An 850,000-gallon liquid hydrogen tank is located near the RP-1 tanks, 1,450 feet from the pad. The hydrogen is transferred to the vehicle through a 10-inch line at a maximum rate of 10,000 gallons per minute.

Propellant loading is remotely controlled from the launch Control Center.

REFERENCE DATA
LAUNCH PADS A AND B

CONSTRUCTION PERIOD:
Pad A—November 1963 to October 1965
Pad B—December 1964 to April 1967

MAJOR CONTRACTS:
Design—Giffels and Rossetti, Detroit, Mich. (both pads)
Construction—
Pad A: Joint venture of Blount Brothers Corp. and M.M. Sundt Construction Co., Montgomery, Ala.
Pad B: George A. Fuller Co., Los Angeles, Calif.

DESIGN AND CONSTRUCTION SUPERVISION: Canaveral District, U.S. Army Corps of Engineers

CONSTRUCTION COST:
Pad A—$21,500,000
Pad B—$20,300,000

SHAPE OF PAD—8-sided polygon

DISTANCE ACROSS PAD—3,000 feet

HARDSTAND AREA—390 by 325 feet

ELEVATION OF PAD SURFACE:
Pad A—48 feet above sea level
Pad B—55 feet above sea level

DISTANCE OF PADS FROM VAB VIA CRAWLERWAY:
Pad A—18,159 feet
Pad B—22,400 feet

DISTANCE BETWEEN PADS: 8,716 feet

QUANTITY OF CONCRETE REQUIRED: 68,000 cubic yards (each pad)

QUANTITY OF REINFORCING STEEL REQUIRED: 5,100 tons (each pad)

FLAME TRENCH:
Length—450 feet
Width—58 feet
Depth—42 feet

FLAME DEFLECTOR:
Height—41 feet 6 inches
Base—48 feet by 77 feet 6 inches
Weight—1,300,000 pounds

ENVIRONMENTAL CONTROL SYSTEM ROOM:
Length—115 feet 2 inches
Width—96 feet
Height—15 feet 7 inches

PAD TERMINAL CONNECTION ROOM:
Length—242 feet 4 inches
Width—68 feet 4 inches
Height—First floor: 15 feet 7 inches
Second floor: 13 feet 6 inches

HIGH PRESSURE GAS STORAGE FACILITY:
Length—109 feet 8 inches
Width—55 feet
Height—33 feet 2 inches

EMERGENCY EGRESS DOME:
Diameter—40 feet
Height—11 feet above suspended floor
Thickness—2 feet 6 inches (steel and concrete)

RP-1 STORAGE:
Number of tanks—3
Capacity—86,000 gallons per tank

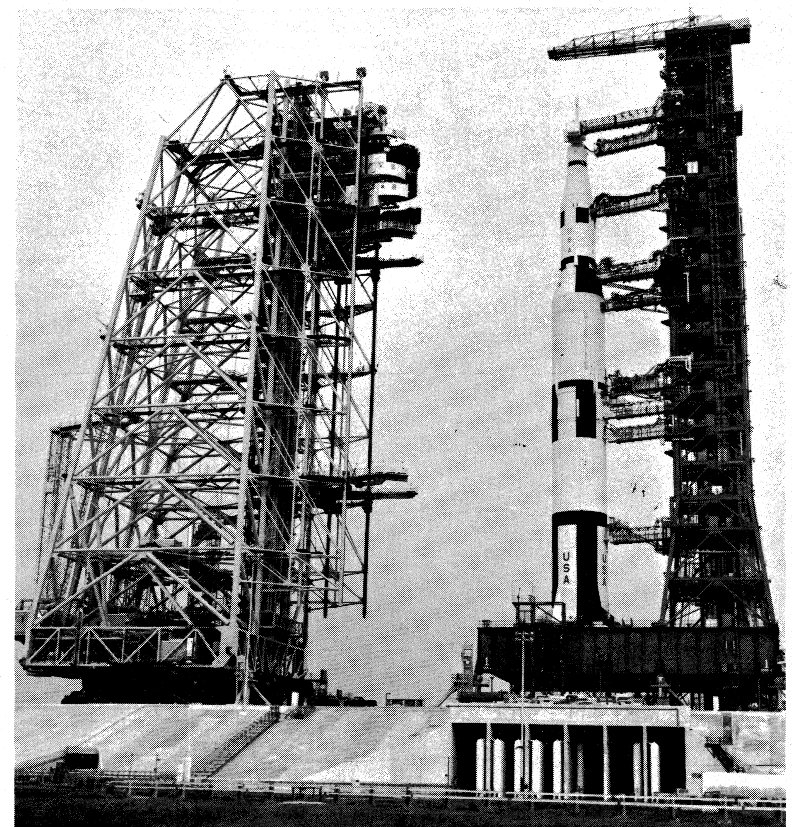
LIQUID OXYGEN STORAGE:
Number of tanks—1
Capacity—900,000 gallons

LIQUID HYDROGEN STORAGE:
Number of tanks—1
Capacity—850,000 gallons

MOBILE SERVICE STRUCTURE (MSS)

The Mobile Service Structure is 402 feet tall and is used to provide personnel access to the Apollo-Saturn V as it stands ready for launching on the Mobile Launcher.

The MSS is required to implement the final inspection of the launch vehicle and to load hypergolic and cryogenic propellants in the spacecraft. By positioning the structure next to the Saturn V on the pad it is possible to maintain the air-conditioned environment required for final servicing of the Apollo spacecraft.

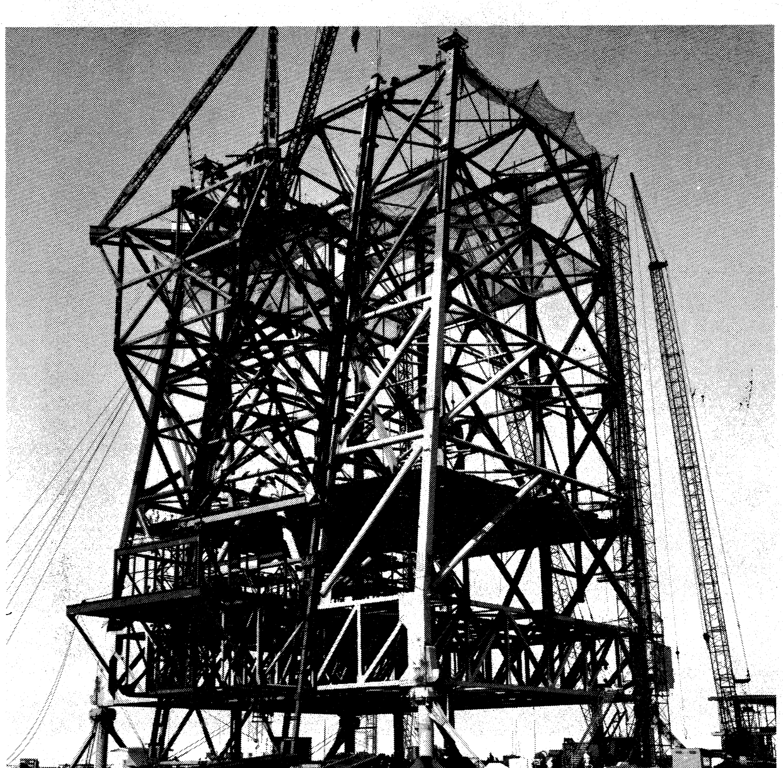


Transporter moves Mobile Service Structure into position for mating with Mobile Launcher and Apollo-Saturn V. Note open position of work platforms to encircle vehicle.

Construction of the MSS was done at its park position along the south side of the Crawlerway, approximately one mile from Launch Pad A. The MSS is moved to and from the pad by the Transporter.

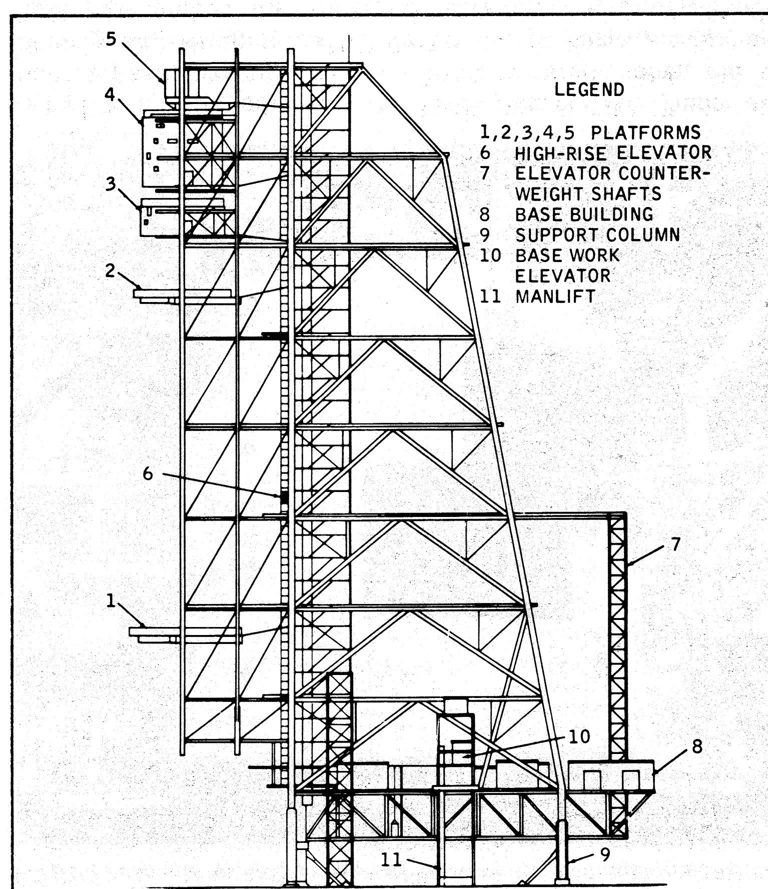
At its base, the MSS is 135 by 132 feet; at its top 113 feet square. It weighs approximately 9,800,000 pounds.

Fabrication of the steel for the MSS started in October 1964. Construction in the field began in February 1965. The structure was topped out on November 19, 1965 and the work was substantially completed in July 1966. The tower was moved atop Pad A for the first time on July 22, 1966 and successfully mated with a Mobile Launcher and a facilities test model of the Apollo-Saturn V.



Steel erection for Mobile Service Structure at mid-point.

STRUCTURAL DESIGN. The general structural configuration of the MSS consists of a set of base trusses approximately 22 feet deep by 130 feet square and a series of eight tower sections, each approximately 44 feet high. In final form, the tower consists of four upright trusses, side-by-side, each approximately 335 feet high, resting on a 22-foot-deep base truss complex 130 feet square. The addition of bracing members across the front and rear planes of the tower form two additional lateral trusses. Altogether the tower and base structure consists of 1,458 pieces of steel, weighing 7,690,933 pounds, connected at 416 joints.

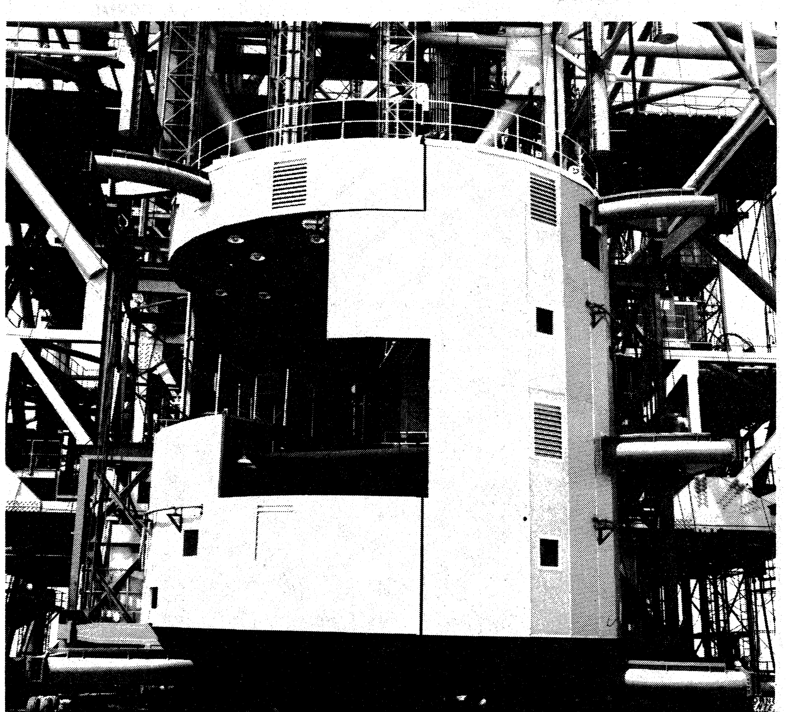


Basic configuration and major components of Mobile Service Structure.

To reduce wind loading and save weight, structural steel tubing was used for most of the tower's framework. The tower was put together in pre-assembled sections. These sections were welded at the fabrication plants, bolted while on the ground and hoisted to position by cranes and derricks.

To minimize weight, flooring on the tower is of aluminum honey-comb panels. This material not only reduced weight but its structural rigidity assured stability of the floors.

WORK PLATFORMS: Since the basic functional requirement of the MSS is to provide personnel access to the Apollo-Saturn V, five work platforms are cantilevered from the forward plane of the tower. These platforms are opened as the tower approaches the pad and then are closed around the launch vehicle and spacecraft after the MSS is in place.



Mobile Service Structure's work Platform No. 4 prior to erection. Platform is only one of five with two levels and is used to provide access to the Apollo spacecraft's Command and Service Modules.

The three upper platforms are in "fixed" positions although they can be repositioned at various levels to serve vehicle configurations which may be developed in the future. In their present positions the upper platforms service the Launch Escape System and the Apollo spacecraft's Lunar, Service and Command Modules.

The two lower platforms service the Saturn V launch vehicle and are vertically self-propelled by the technicians working on them so that the workers have access to the entire surface of the vehicle.

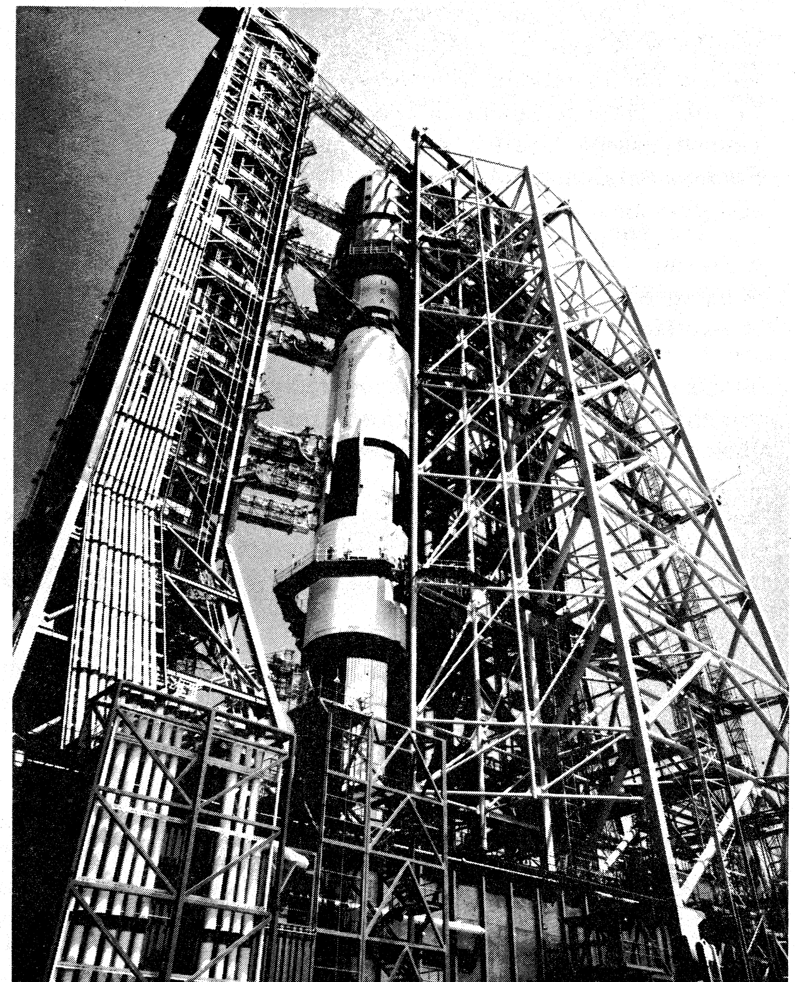
The five platforms are mounted on gear-tooth racks which run the full height of the platform support structure. The two self-propelled platforms are powered by electric motors driving gears which move the platforms up or down the tower at 10 feet per minute. The fixed platforms are locked onto the racks but can be repositioned readily with a system of cables and sheaves using one of the self-propelled platforms as motive power.

ELEVATORS: Two high-rise elevators are provided in the tower structure to carry personnel and equipment to the various working platforms. The elevators have a capacity of 5,000 pounds of equipment or 12 to 16 people.

A separate elevator with the same capacity provides access to the basic working level of the tower, which is 47 feet above ground. This elevator can be raised onto the structure for clearance when the Transporter is moved under the tower. From the basic working deck, personnel can walk to the high-rise elevators. A manlift elevator is also used to provide access from the ground to the base work area.

ANCHORING SYSTEM: Ground-mounted, hold-down clamps restrain the tower from overturning in high winds. One of these clamps is located at each corner of the tower.

Additionally, at the four corners of the tower, shear blocks are provided which fit into cavities in the tops of the support columns. When the tower is set down in position, the open spaces in the column cavities are filled with a spec-



Five work platforms of Mobile Service Structure (right) encircle Apollo-Saturn V at Launch Pad A. Mobile Launcher is to left with swing arms connected to launch vehicle.

ial high-strength, rapid-setting epoxy grout which hardens and withstands the horizontal forces applied to the tower. The grout is divided into segments with eyebolts placed in each for easy removal of the segments when the tower is lifted out of the cavities. The grout segments are an expendable part of the operation.

The MSS can withstand winds of 85 miles per hour in the pad position with holddown clamps; 125 miles per hour in the park position with holddown clamps, and 63 miles per hour when standing free.

BASE BUILDINGS: A variety of buildings are provided on the base working level of the MSS for electrical, mechanical, elevator, communications and television equipment, operations support and toilet facilities.

REFERENCE DATA
MOBILE SERVICE STRUCTURE

CONSTRUCTION PERIOD: February 1965 to July 1966

MAJOR CONTRACTS:

Design—Rust Engineering Co., Pittsburgh, Penna.

Construction—Morrison-Knudsen Co., Inc.; Perini Corp., and Paul Hardeman, Inc., South Gate, Calif.

DESIGN AND CONSTRUCTION SUPERVISION: Canaveral District, U.S. Army Corps of Engineers

CONSTRUCTION COST: $11,600,000

HEIGHT:

Above ground—402 feet

Above base deck—355 feet

WEIGHT: 9,800,000 pounds (7,690,933 pounds of structural steel)

BASE DIMENSIONS: 135 feet by 132 feet

TOP DIMENSIONS: 113 feet square

PLATFORMS: 5

Self-propelled—2 (lower platforms for serving Saturn V rocket and Instrumentation Unit)

Fixed-relocatable—3 (upper platforms for Apollo spacecraft and Launch Escape System)

HIGH-RISE ELEVATORS: 2 (for access to work platforms and tower catwalks)

Load capacity—5,000 pounds (equipment); 12 to 16 passengers

Speed—600 feet per minute (maximum)

BASE WORK ELEVATOR: 1 (access to base work areas and high-rise elevators from ground)
Load capacity—5,000 pounds (equipment); 12 to 16 passengers

MANLIFT ELEVATOR: 1 (access to base work area from ground)

BOOMS AND HOISTS: 2

BASE BUILDINGS:
Mechanical equipment room—1,800 square feet
Operations Support Room—460 square feet
Sanitary facility—180 square feet
Elevator equipment room—1,695 square feet
Communications and television equipment room—430 square feet
Electrical equipment room—1,500 square feet

SUPPORT COLUMNS: 4 each at pad and park position

OPERATIONAL WINDS:
Free standing—63 miles per hour
Pad position with holddown clamps—85 miles per hour
Park position with holddown clamps—125 miles per hour

COMMUNICATIONS AND ELECTRONICS

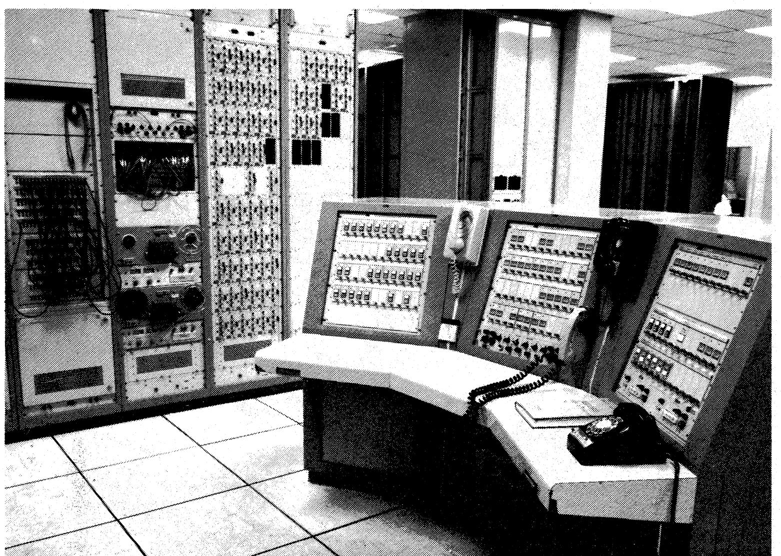
If steel and concrete form the skeleton and muscle of Launch Complex 39, then the communications and electronics systems are the eyes, ears and nerves. These systems allow those responsible for conducting checkout, countdown and launch operations to control these activities, from the Command Module of the spacecraft throughout the pad, to the Launch Control Center and, in fact, everywhere in the complex.

Criss-crossing and running the length and breadth of the complex are every imaginable sort of telephone cable, instrumentation cable, coaxial cable, waveguide, and video cable which form the communications network.

Operational Intercom stations and Operational Television System monitors line equipment racks in Firing Room 1 of the Launch Control Center. The OIS stations shown are part of 2,000 throughout Launch Complex 39. The ones in the foreground are used by test conductors.

Among its many uses, this network is used in two crucial communication and control systems by launch direction personnel. One of these is the Operational Intercom System, which in effect is a large closed circuit radio network. The other is the Operational Television System, which is also a closed circuit system using cable communications rather than radio waves.

The contract for production and installation of the Operational Intercom System was awarded in July 1965 and the installation was substantially completed in May 1967. The work on the Operational Television System was performed between September 1965 and January 1968. Both systems are capable of expansion.



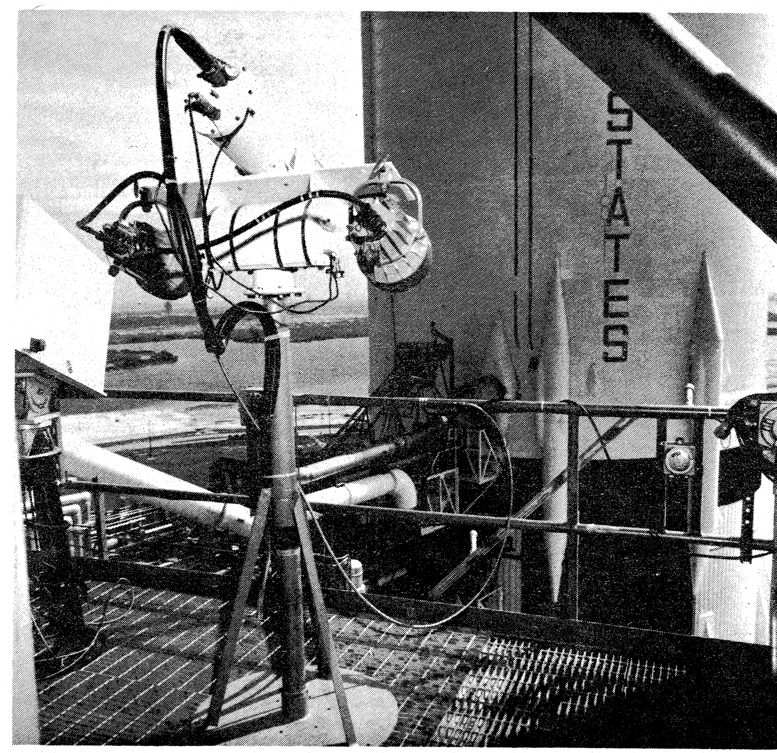
Control center for Operational Intercom System, located in Launch Control Center, links 2,000 dual operator stations throughout Complex 39.

OPERATIONAL INTERCOM SYSTEM: The Operational Intercom System consists of some 2,000 dual operator stations throughout the launch complex. These stations are organized into local communications areas, each of which has between 50 and 200 stations.

Each pad, each Mobile Launcher, each operational firing room of the Launch Control Center and the operational High Bays of the Vehicle Assembly Building form such local communications areas. Ten of these areas have been completed and two more will be finished in the future.

These local communications areas may be organized into from one to four simultaneous missions so that all stations in the various local communications areas forming a mission may communicate. Each station has a capability of operating on two of 112 channels and thus communicating with all other stations on that channel in the same local communications area and in the same mission.

Any station can change channels at will.

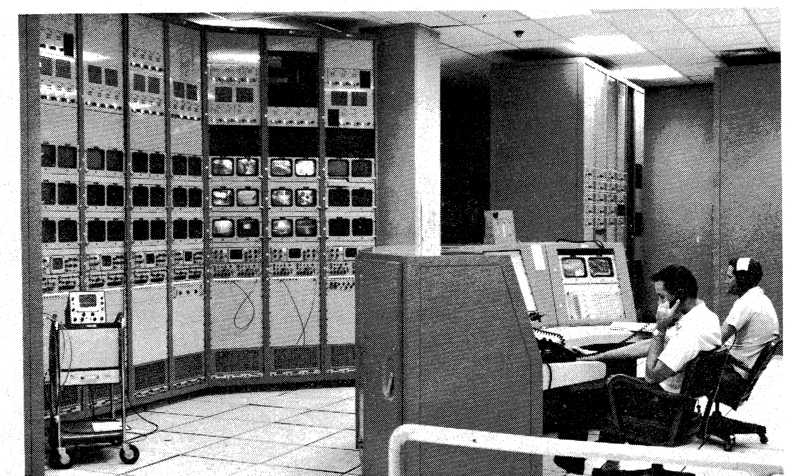


Remotely controlled television camera on Mobile Launcher, focused on Saturn V. Camera is one of 114 in Operational Television System.

OPERATIONAL TELEVISION SYSTEM: The Operational Television System provides remote viewing of launch operations from the Mobile Launcher, the launch pad and the Mobile Service Structure as well as from other selected sites throughout the launch complex.

Pictures are distributed through a switching and distribution center which provides picture identification, camera viewing remote control, picture selection and countdown clock information to the Launch Control Center firing rooms at the direction of controllers in the firing rooms.

During launch operations, 50 cameras in the pad area supply pictures to 80 monitor screens in the firing room in use.



Switching and distribution center for Operational Television System in Launch Control Center.

EXPANSION: When completed, the Operational Television System will have 114 cameras and 255 monitors installed throughout the launch complex, complete with highly complex switching, signal transmission and distribution, and synchronization systems.

Capability of further expansion to accommodate operations in all four firing rooms of the Launch Control Center, all four

High Bays of the Vehicle Assembly Building and a third launch pad have been designed into both the television and intercom systems. Their capability also includes features which allow their integration into communications systems at other NASA control centers, such as the Manned Spacecraft Center in Houston.

ADDITIONAL SYSTEMS: Besides the Operational Television and Operational Intercom systems, other communications and electronics work includes ultra high frequency radio links and walkie-talkies for communication with the Crawler- Transporter and Mobile Launcher during movement; video equipment for transmission of launch data to a dozen locations at Kennedy Space Center and Cape Kennedy Air Force Station, and color television equipment for feeding the networks color pictures of Apollo launches.

REFERENCE DATA
COMMUNICATIONS AND ELECTRONICS

OPERATIONAL INTERCOM SYSTEM

PRODUCTION AND INSTALLATION PERIOD: July 1965 to May 1967

MAJOR CONTRACT: Collins Radio Company, Dallas, Texas

SUPERVISORY AGENT: Canaveral District, US Army Corps of Engineers

COST: $8,000,000

NUMBER OF STATIONS: 2,000

NUMBER OF LOCAL COMMUNICATIONS AREAS: 12 (10 completed)

NUMBER OF STATIONS PER LOCAL AREA: 50 to 200

NUMBER OF CHANNELS: 112

OPERATIONAL TELEVISION SYSTEM

PRODUCTION AND INSTALLATION PERIOD: September 1965 to January 1968

MAJOR CONTRACTS:

System design—Molecular Research, Inc., West Palm Beach, Fla.

Detailed design, production and installation—General Dynamics, Convair Division, San Diego, Calif.

SUPERVISORY AGENT: Canaveral District, US Army Corps of Engineers

COST: $5,000,000

NUMBER OF CAMERAS: 114

NUMBER OF MONITORS: 255

LAUNCH COMPLEX 39 ADDITIONAL FACILITIES

PROPELLANT SYSTEMS COMPONENTS LABORATORY

PURPOSE: Testing, cleaning, refurbishing, storage and dispatch of Apollo-Saturn V propellant systems components; storage and dispensing of high pressure nitrogen; cleaning facilities for propellant transporters

LOCATION: North side of Crawlerway about 3/4 mile east of Vehicle Assembly Building

CONSTRUCTION PERIOD: October 1966 to August 1967

MAJOR CONTRACTS:

Design—Rogers, Lovelock and Fritz, Winter Park, Fla.

Construction—Joint venture of Morrison-Knudsen Co., Inc., and Perini Corp., Titusville, Fla.

DESIGN AND CONSTRUCTION SUPERVISION: Canaveral District, U.S. Army Corps of Engineers

CONSTRUCTION COST: $2,400,000

MAJOR ELEMENTS:

Propellant Components Laboratory Building—175 by 200 feet, one story; clean-room atmosphere in critical cleaning, testing and analysis areas

Propellant Transporter Repair and Maintenance Shed—60 by 84 feet, one story

Petroleum Products Storage Building—30 by 40 feet, one story

Operations Building—40 by 78 feet, one story

Deionized Water Plant—Two skid-mounted 15,000 gallon capacity, 30-inch diameter tanks; three 10,000-gallon deionized water storage tanks; 2 bulk storage tanks of 4,000 gallons capacity each for acid and caustic

Gaseous Nitrogen Loading Station—56 by 95 feet, one story

Gaseous Nitrogen Charging Station—Open area, 47 by 93 feet

Gaseous Nitrogen Bottle Storage Station—34 by 48 feet, one story

Sewage Treatment Plant and Lift Station—Capacity 1,300 gallons per day

BARGE TERMINAL

PURPOSE: Receipt of launch vehicle stages

LOCATION: South of Launch Control Center

CONSTRUCTION PERIOD:
Turning Basin and Unloading Area—November 1962 to January 1964
Terminal Facilities—February 1965 to August 1965

MAJOR CONTRACTS:
Design—Turning basin and barge unloading area: Urbahn-Roberts-Seelye-Moran, New York City, New York
Terminal facilities: Canaveral District, U.S. Army Corps of Engineers
Dredging—Gahagan Dredging Corp., Tampa, Fla.
Barge Unloading Area—R.E. Clarson, Inc., St. Petersburg, Fla.
Terminal Facilities—Arnold M. Diamond, Inc., Great Neck, New York

DESIGN AND CONSTRUCTION SUPERVISION: Canaveral District, U.S. Army Corps of Engineers

OVER-ALL CONSTRUCTION COST: $955,000

DIAMETER OF TURNING BASIN: 1,200 feet

DEPTH OF TURNING BASIN: 10 feet

LAUNCH EQUIPMENT SHOP

PURPOSE: Machine shop facilities for Launch Complex 39

LOCATION: One-half mile south of VAB

CONSTRUCTION PERIOD: November 1964 to October 1965

MAJOR CONTRACTS:
Design—Urbahn-Roberts-Seelye-Moran, New York City, New York
Construction—Smith and Sapp Construction Co., Orlando, Fla.

DESIGN AND CONSTRUCTION SUPERVISION: Canaveral District, U.S. Army Corps of Engineers

CONSTRUCTION COST: $1,500,000

HEIGHT: One story

LENGTH: 180 feet

OVER-ALL WIDTH: 140 feet

BRIDGE CRANE: 1
Capacity—5 tons
Hook height—16 feet

ORDNANCE STORAGE FACILITY

PURPOSE: Storage of explosive devices for Apollo-Saturn V launch vehicle

LOCATION: One-half mile northeast of VAB

CONSTRUCTION PERIOD:
Earth embankment—July 1964 to September 1964
Construction—December 1964 to September 1965

MAJOR CONTRACTS:
Design—Canaveral District, U.S. Army Corps of Engineers
Embankment—C.A. Meyer Paving and Construction Co., Orlando, Fla.
Construction—Akwa-Downey Construction Co., Milwaukee, Wis.

DESIGN AND CONSTRUCTION SUPERVISION: Canaveral District, U.S. Army Corps of Engineers

OVER-ALL COST: $671,000

NUMBER OF STORAGE AREAS: 6

DIMENSIONS:
Storage Areas 1 and 2—50 by 50 feet each (overburdened)
Storage Area 3—40 by 50 feet (overburdened)
Storage Area 4—20 by 12 feet
Storage Areas 5 and 6—10 by 8 feet each

LAB, SHIPPING AND RECEIVING BUILDING: 65 by 40 feet

INSTRUMENTATION BUILDING

PURPOSE: Vehicle testing, tracking, systems checks

LOCATION: One-half mile south of VAB

CONSTRUCTION PERIOD: July 1964 to October 1965

MAJOR CONTRACTS:
Design—Brevard Engineering Co., Cape Canaveral, Fla.
Construction—American Elcon, Inc., Cape Canaveral, Fla.

DESIGN AND CONSTRUCTION SUPERVISION: Canaveral District, U.S. Army Corps of Engineers

CONSTRUCTION COST: $575,000

TOTAL FLOOR AREA: 4,830 square feet
Main Building—3,150 square feet
Instrumented van shed—1,680 square feet

HEIGHT: 17 feet 6 inches
Main Building—12 feet 6 inches
Instrumented van shed—17 feet 6 inches

OVER-ALL LENGTH: 90 feet
Main Building—90 feet
Van Shed—70 feet

OVER-ALL WIDTH: 59 feet
Main Building—35 feet
Van Shed—24 feet

ANTENNA TOWER: 200 feet

PAD WATER PUMPING STATION

PURPOSE: To provide water to launch pads for fire protection and exhaust cooling

LOCATION: On east side of Crawlerway extension to Pad B, about one mile south of Pad B

CONSTRUCTION PERIOD:
Site Preparation—December 1963 to February 1964
Construction—March 1964 to May 1965

MAJOR CONTRACTS:
Engineering for site preparation—Canaveral District, U. S. Army Corps of Engineers
Design—Philpott, Ross and Saarinen, Inc., Fort Lauderdale, Fla.
Site preparation—C. A. Meyer Paving and Construction Co., Orlando, Fla.
Construction—Natkin and Company, Kansas City, Mo.

DESIGN AND CONSTRUCTION SUPERVISION: Canaveral District, U. S. Army Corps of Engineers

OVER-ALL CONSTRUCTION COST: $1,909,000

PUMPING STATION FLOOR AREA: 6,784 square feet

LENGTH: 128 feet

WIDTH: 53 feet

HEIGHT: 30 feet

WELLS: 3 (6-inch casings)
Capacity (from booster pumps) 350 gallons per minute to reservoir

RESERVOIR CAPACITY: 1,000,000 gallons

FIRE PROTECTION SUPPLY:
Pumps—2 (one meets single pad requirements)
Main size—20-inch diameter
Capacity—6,000 gallons per minute (each pump)

INDUSTRIAL SUPPLY FOR EXHAUST COOLING:
Pumps—3 (one used for standby)
Main size—42-inch diameter
Capacity—40,000 gallons per minute (2 pumps)

115,000-VOLT ELECTRICAL SUBSTATION

PURPOSE: Distribution of electrical power to major areas of Launch Complex 39

LOCATION: One-half mile west of VAB

CONSTRUCTION PERIOD:
Original construction—December 1963 to October 1964
Modifications and additions—June 1966 to January 1967

MAJOR CONTRACTS:
Original Design—Urbahn-Roberts-Seelye-Moran, New York City, N.Y.
Design of additions and modifications—Canaveral District, U. S. Army Corps of Engineers
Original construction—Joint venture of W. V. Pangborne Co., Inc., and Lowry Electric Co., Inc., Philadelphia, Pa.
Modifications and Additions—Akwa-Downey Construction Company, Milwaukee, Wis.

DESIGN AND CONSTRUCTION SUPERVISION: Canaveral District, U. S. Army Corps of Engineers

OVER-ALL CONSTRUCTION COST: $818,000

NUMBER OF TRANSFORMERS: 6

CONTROL HOUSE: One story, 22 by 84 feet

CABLE TERMINAL BUILDING

PURPOSE: Communication connections between Kennedy Space Center Industrial Area and Launch Complex 39

LOCATION: One-quarter mile southwest of VAB

CONSTRUCTION PERIOD: April 1964 to March 1965

MAJOR CONTRACTS:

Design—Greening and Sayer, Daytona Beach, Fla.
Construction—Akwa-Downey Construction Co., Milwaukee, Wis.

DESIGN AND CONSTRUCTION SUPERVISION: Canaveral District, U. S. Army Corps of Engineers

COST: $200,000

HEIGHT: One story plus vaults

LENGTH: 92 feet

WIDTH: 71 feet