National Aeronautics and Space Administration

NASAfacts

Building KSC's Launch Complex 39

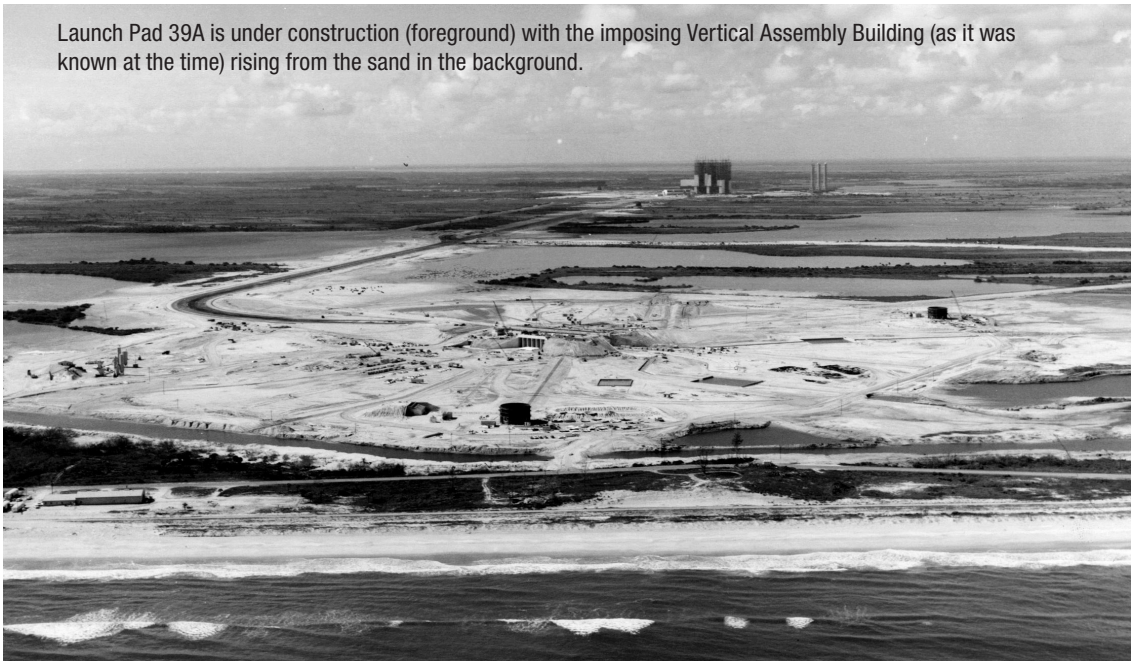
In the beginning, there was sand and palmettos and water. Yet out of this idyllic setting would grow the most unique structures -- engineering milestones -- that would set the stage for the future in space.

The Kennedy Space Center of the 21st century began life in the early 1960s when new facilities were needed to launch the moon-bound Saturn V rockets.

Initial plans called for a launch complex comprising a Vertical Assembly Building (VAB), a launcher-transporter, an arming area and a launch pad. The VAB would consist of assembly bay areas for each of the stages, with a high-bay unit approximately 110 meters in height for final assembly and checkout of the vehicle. Buildings adjacent to the VAB would house the Apollo spacecraft and the Launch Control Center.

The launcher-transporter would incorporate three major facilities: a pedestal for the space vehicle, an umbilical tower to service the upper reaches of the space vehicle, and a rail transporter. An arming tower would stand about midway between the assembly building and the pads.

The Apollo Saturn would carry a number of hazardous explosives: the launch escape system (the tower on top of the vehicle that lifted the spacecraft away from the launch vehicle in case of an emergency), retrorockets to separate the stages, ullage rockets to force fuel to the bottom of tanks, and the launch vehicle's destruct system.



Launch Pad 39A is under construction (foreground) with the imposing Vertical Assembly Building (as it was known at the time) rising from the sand in the background.

These plans would be modified during design and construction stages, such as separating the launcher platform from the transporter and using a roadway instead of rail.

The national goal of accomplishing the manned lunar landing before 1970 drove the building program on Merritt Island. Scheduling was critical, depending upon the concurrent development of the Saturn V launch vehicle, the Apollo spacecraft and launch facilities, and more particularly on the timely delivery of flight hardware to the launch center.

Of more immediate concern was the construction of launch facilities and checking them out many months before the first Saturn V launch. If Dec. 1, 1965, was the date when the launch complexes had to be ready for use, then facilities had to be ready by May 1965 to provide time for checking out and testing the launch complexes.

Dredged sand created the 80-foot-high mound that would become launch pad A.

Construction

Before structures such as the VAB and Launch Pad 39 could emerge on the skyline, the sites had to be prepared and access channels dredged.

In 1962, to clear the land in the VAB area, a palmetto plow was used to pull up trees by their roots, shake off the dirt and pile them for burning. The specialized bulldozers cleared 1.6 square miles (2.5 square kilometers); other equipment removed 978,116 cubic yards (894,400 cubic meters) of soft sand and muck.

To deliver the first and second stages of the Saturn V, water was deemed the best carrier. For delivery close to the launch pad, a barge canal and turn basin near the VAB was needed. The Gahagan Dredging Corp. of Tampa dredged a canal measuring 124.7 feet (38 meters) wide, 9.8 feet (3 meters) deep and 12.4 miles (20 kilometers) long from the original Saturn barge channel in the Banana River to the site of the turn basin. A channel to pad A allowed materials to be delivered directly to the Launch Complex 39 construction site.

During the operations, hydraulic pumps spewed 751,959 cubic yards (6,876,000 cubic meters) of sand and shell, which were used for fill at various sites. Most of it was used for the 187-foot (57-meter) wide, 6.6-foot (2-meter) deep crawlerway stretching 3 miles (4.8 kilometers) from the VAB to pad A (*cover photo*).

The pumps piled up another portion of the dredged sand on the launch pad, creating a flat-topped pyramid of sand and shell 80 feet (24.4 meters) high. During the process, draglines, bulldozers and other earth-moving equipment molded the mound into the approximate shape of the pad. In a short period of time, the pyramid settled 3.9 feet (1.2 meters), compressing the soil beneath. Bulldozers completed the job by removing part of the pile to achieve the proper elevation.

Launch Pad 39A

The shape of launch pad A, approximately 2,297 square feet (0.7 square kilometers), was roughly octagonal. The elevated launch pad, which would rise 39.4 feet (12 meters) above ground level, lay in a north-south direction. This orientation required the crawlerway to make a near right-angle turn before approaching the ramp sloping 5 degrees upward to the top of the pad.

Bisecting the pad would be a flame trench, level with the surrounding area at its base, measuring 59 feet (18 meters) wide and 449.5 feet (137 meters) long. On each side of this flame trench, a cellular structure would support a thick surface, called a hardstand. Eventually, a mobile launcher and the Apollo-Saturn vehicle would be placed on top of this reinforced slab for launch.

The two-story pad terminal connection room and the single-story environmental control systems room would be within the western side of the pad. The former would house the electronic equipment that would connect communication and digital data link transmission lines from a yet-to-be-built launch control center to the mobile launcher when it was on the pad.

The environmental control systems room would serve as the distribution point for air conditioning and water systems.

The high-pressure-gas storage facility, to store and distribute nitrogen and helium gases piped from the converter-compressor facility, would lie beneath the top of the pad on the east side.

The flame trench bisects the launch pad.

An emergency egress system was part of the pad A contract. If a hazardous condition were to arise that allowed safe egress from the spacecraft, the astronauts could cross over to the mobile launcher on a swing arm. They would then ride one of the high-speed elevators to level A, slide down an escape tube to a thickly padded rubber deceleration ramp, and enter -- through steel doors -- a blast room, which could withstand an on-the-pad explosion of the entire space vehicle.

Those inside could stay alive for at least 24 hours to allow rescue crews time to dig them out.

Transportation to the Pad

To lift, hold and move what would be the largest, tallest and heaviest known portable structures on Earth, the crawler-transporter was designed.

Adapted from self-propelled, strip-mining shovels, the massive machines weighed 5.5 million pounds unloaded. This alone required a special roadway to support loads never envisioned for a public road -- in excess of 127,867 pounds (58,000 kilograms) per square meter. The design would comprise dual trackways, separated by a median strip, and would consist of more than three feet (1 meter) of selected sub-base material, topped by 3 feet (1 meter) of graded crushed aggregate, with a blacktop sealer over all.

A service road would border the south side of the crawlerway from the VAB to pad A. Underground ducts for communication and instrumentation lines to link the control and assembly areas with the launch pads would parallel the north side of the crawlerway; power line ducts and a pipeline for drinking water would go along the south side. Where any of the ducts or pipes had to pass beneath the crawlerway, the access tunnels had to be capable of withstanding the load conditions.

The completed crawlerway would be level with the terrain, 7.5 feet (2.3 meters) above sea level.

The converter-compressor facility was built just north of the crawlerway, about one-third of the distance from the VAB to pad A. It consisted of a one-story equipment building and a 1,892,000-liter spherical tank for storing liquid nitrogen, together with an access road and paved parking areas. A railroad spur brought tank-car loads of helium and nitrogen to the facility. Its evaporators, compressors and pumps, in turn, supplied high-pressure gaseous nitrogen and helium to storage and distribution facilities at the VAB and the launch area.

The land clearing, channel dredging and sand fill was completed by September 1963. Six months later, similar efforts began for launch pad B, plus construction of the causeway from Cape Canaveral to Merritt Island east of the industrial area.

Mobile Launcher Platform

Along with the massive rockets to be moved by the crawler-transporter, the mobile launcher was part of the cargo.

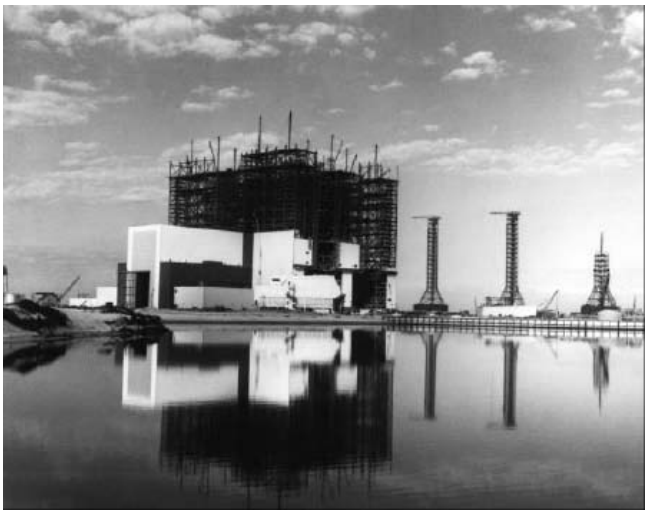
In planning and building the mobile launcher, the most difficult features were the nine swing arms, or service arms, as they were also called, that would provide personnel access and support electrical cables, propellant lines and pneumatic lines to the launch vehicle.

The service arms were to be amazingly complex pieces of equipment. For example, as many as 24 electric cables, each 50 millimeters in diameter, and about 44 fluid service lines, ranging from 12 to 25 millimeters thick, went into a single umbilical carrier. Each arm would be wide enough for a jeep to drive across -- though none ever was to do so. Their length varied with the configuration of the vehicle; they would average more than 22 metric tons in weight.

Prior to the rocket's first motion, five arms would disconnect and begin withdrawal. Arms 4 and 6, providing hydrogen vent ducting and the instrumentation unit, would retract at liftoff.

Since plans called for the construction of the mobile service structure on the parking site, this facility would have to support considerable loads. The service structure would weigh 4,763 metric tons. When the crawler-transporter moved beneath it, the total load on the parking position would be nearly 7,500 metric tons, heavier than the USS Halsey, a guided missile frigate.

In addition to this, calculations showed that, should wind velocities reach 200 kilometers per hour, the service structure, standing by itself on its four support legs in the parked position, with side struts and hold-down arms for each leg, could exert about 6,300 metric tons of force. To withstand these anticipated forces, the parking site had to have a heavily reinforced base.



Mobile launchers are visible to the right of the VAB; at left, the launch control center seems to be part of the VAB.

Driving the pilings for the VAB.

The Vertical Assembly Building

Foremost in the construction timeline was the Vertical Assembly Building, as it was originally named. The $23.5-million contract called for more than 45,000 metric tons of structural steel and the erection of the skeleton framework of the VAB by Dec. 1, 1964.

Construction of the massive building on sandy soil was one of the early design problems. The solution was to drive thousands of piles, steel pipes 41 centimeters in diameter, through the subsoil until they rested on bedrock more than 150 feet below the surface.

These would not only anchor the building but also prevent the structure from sinking into the ground.

That solution, however, created another issue. The building stood only a few feet above sea level and near the ocean. Salt water, saturating the subsoil, reacted with the steel piling to create an electrical current.

To prevent this electrolytic process from gradually eating away the steel pipe, the pilings were grounded by welding thick copper wire to each one and connecting the wires to the steel reinforcing bars in the concrete floor slab. Until this was done, the VAB could be said to be the world's largest wet cell battery.

The pipe for the piling came in 16.8-meter lengths, and welders had to join three and sometimes four lengths of pipe together to make up a single pile. To speed the work, workmen welded at night, then drove the piles, which required better visibility, during the day.

At the peak of activity, 10 pile drivers were in action. Three of them were new, electrically driven, vibratory drivers. When the piles reached the first thin stratum of limestone at about 36 meters, steam- or diesel-driven pile drivers took over and pounded the piles into the bedrock, which ranged from 151 feet to 171 feet (46 to 52 meters) below the sandy surface.

Next, the forms were erected and the reinforcing bars for the concrete pile caps were placed to bond the piles electrically to the reinforcing bars. From the air, the VAB foundation would resemble an underground honeycomb with the concrete pile caps dividing the site into cells or boxes.

As soon as the concrete had set in a series of the pile caps, workmen removed the forms. Then they poured a layer of crushed aggregate into the boxes and poured the asphalt and concrete floor slab on top of the aggregate.

Eventually 41,776 cubic yards (38,200 cubic meters) of concrete were poured for pile caps and floor slab before the foundation was completed in May 1964.

With steel column sections and other structural steel arriving at the job site, erection of the framework began in

The VAB rises in steel to dominate the landscape. On the left is the lower Launch Control Center. In the foreground are the crawlerway and roads.

January 1964 in the low bay area. By this time, the original contract date for completing the structural steel (Dec. 1, 1964) had given way to a completion date of March 7, 1965. The job was a rather straightforward one although, because of the building's unique requirements, it appeared that the structure was being built wrong-side out. Because of the height of the assembly bay door openings - two on each side of the building - the horizontal stiffening structure had to be installed on the interior of the building, parallel to the transfer aisle, rather than along the exterior sides.

Another critical part of the construction was the addition of three cranes. A 175-ton crane with a hook height of about 50 meters would run the length of the building and would traverse both the low bay and high bay areas above the transfer aisle. Two other cranes, with a 250-ton capacity and hook height of approximately 140 meters, would be capable of movement from an assembly bay on the opposite side. Although bridge cranes of this capacity are not unusual in heavy industry, there were unique requirements for precision, smoothness and control of their vertical and horizontal movement. The cranes would cost about $2 million.

Pouring the concrete floor for the VAB.

As the VAB progressed, work began in February 1965 on the high-pressure-gas storage building, the road system in the VAB area, the instrumentation and communication duct banks and tunnels from the launch control center to the crawlerway, and the foundation work for the control center itself.

In March 1965, work started on the water distribution and storage system, on the sewage plant and sewer system, and on the electrical distribution system. In April, construction began on the VAB utility annex, on the paint and chemical storage building, and on the VAB area crawlerways.

Since contractors in widely scattered parts of the country worked on different parts of the total job, construction chiefs on Merritt Island had to test components regularly to see if they fitted and worked together.

These so-called "fit tests" became important procedures in the early stages of construction. The installation of many pieces of vehicle-related ground support equipment -- a necessity for facility checkout -- had to await completion of most of the general construction. [*Moonport*]

Structural parts for the first of the extensible work platforms in the high bays (five pairs of platforms in each high bay) arrived at the VAB site. Workmen assembled these platforms outside the VAB because of their size, approximately 18 meters square and up to three stories tall, and then moved them inside for mounting on the framework. They would be vertically adjustable. Since they were of cantilever design, the platforms could extend horizontally about 9 meters from the main framework of the building to surround the launch vehicle in the high bay.

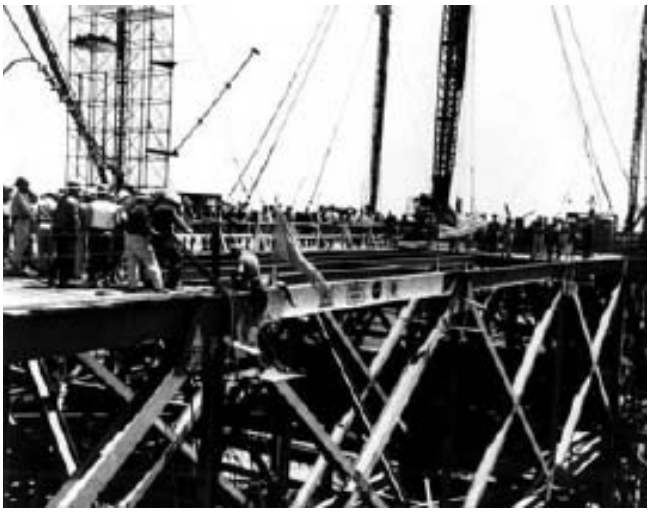
Erection of the VAB's structural steel framework reached the top level of 160 meters at the end of March, and preparations began for the traditional topping-out ceremony. A 3,600-kilogram, 11.6-meter-long, steel I-beam, painted white and bearing the NASA symbol and the insignia of the American Bridge Division of the United States Steel Corporation, stood in front of several of the NASA buildings at KSC during early April to allow NASA and contractor employees to sign their names on it. The signed beam then went under the roof of the VAB over the transfer aisle.

Although workers had topped out the structural steel in the VAB, the work was far from finished. Steven Harris, VAB project manager, noted that one of the biggest tasks was keeping up with evolving equipment as the work went along. He remarked, "The VAB was designed and is being constructed concurrently with the development of the Saturn V vehicle, and any changes made on the vehicle or its support equipment may require changes in the building." At the time he was speaking, designers had already incorporated some 200 changes into the VAB since construction began, the most recent being modification of the extensible platforms as required by the final design of the mobile launcher.

With its completion, the NASA building was so huge that "the Rose Bowl or the Yankee Stadium would fit on the roof."

Launch Control Center

The Launch Control Center (LCC) was part of the VAB contract. The design was a distinctively shaped, four-story building adjoining the VAB on the southeast and



A steel I-beam, signed by NASA and contractor employees who worked on the VAB, was erected over the transfer aisle.

connected with it by an enclosed bridge. The ground floor contained offices, a cafeteria and a dispensary; the second floor housed telemetry and radio equipment. Firing rooms occupied the third floor, and the fourth floor had conference rooms and displays.

The original plan of the launch control center called for four rectangular firing rooms, 28 by 46 meters; one was never to be equipped. When completed, the firing rooms contained similar equipment set up on four levels. The first level took up over two-thirds of the room and would ultimately contain computers and five rows of 30 consoles each. Two rows of consoles (27 in one, 25 in the other) would fill the second level. The third level would contain the consoles of the Kennedy Space Center director and other major officials. To the left of these consoles, two diagonal rows of seats with telephones and listening devices, but no control equipment, would provide a close-up view of operations for technical experts not directly involved in the launch.

On the top level, a glassed-in triangular room would give visiting dignitaries a similar view. They could either watch activities in the firing room or look out the windows at the launch pads. These double-paned windows extended the full width of the rear of the firing room and contained a special heat - and shock-resistant glass. Outside, large vertical louvers, resembling huge venetian blinds, could be closed in a few moments for further protection. [*Moonport*]

In December 1964, the LCC building was nearing completion, although interior mechanical work and the installation of electrical fixtures continued on all four floors. The VAB utility annex was also nearing completion, with boiler stacks and skylights completed and installation of mechanical and electrical equipment continuing. Workers had finished the high-pressure-gas storage building in October. The rest of the area facilities were all nearing the end of brick-and-mortar construction, although much installation and outfitting remained.

Industrial Area

While the Vertical Assembly Building and other facilities moved steadily toward completion at LC-39, the industrial area began to take shape to the south.

The surcharging method was used in preparing the soil by piling sand on the construction site until its weight was approximately equivalent to the weight of the proposed structure. The heavy surcharge compressed the underground layers of clay and coral, squeezing out liquids. The contractors used piling under later parts of the building, as well as for all other buildings on Merritt Island.

The O & C building was to undergo continuous addition, modification and alteration during the succeeding five years. Some contractual changes reflected planned phasing of construction over several fiscal years' funding; some were based on the evolving design of the spacecraft; some were intended to improve the original design of the building.

Designers began drawings for a clean room, or white room, for the Gemini program. This was a dust-free room with high-quality temperature and humidity controls to prevent contamination of the space vehicle. The air intakes would have special filters. Anyone who entered the room would wear clothing resembling surgical uniforms. It would be located in the O & C Building's assembly and test area.

The O & C building was a multi-storied structure of approximately 56,430 square feet (17,200 square meters), containing as much flexibility as the Apollo spacecraft that

Firing room 1 under construction, August 1965. The VIP viewing area is under the glass wall, at left. The windows on the extreme left looked toward the pads. The triangular extension into the room above the VIP area was for the most distinguished guests.

it would test. A high bay, 223.8 feet (68.2 meters) long and 100 feet (30.5 meters) high, and an adjacent 251-foot (76.5-meter) long low bay accommodated the three-man Apollo capsule.

Two altitude chambers were prominent fixtures in the high bay. In these tanks, each 17 meters high and 10 meters in diameter, KSC engineers would check out the command and service modules and the lunar module. After pumps had evacuated the air from the chambers, the Apollo modules were checked out in a near vacuum.

Two airlocks, measuring 8.5 feet (2.6 meters) in height and width, provided access to each chamber. They also housed the rescue teams. If a loss of oxygen were to occur in the spacecraft, the physiological effects on the crewmen would be the same as in space. The rescue teams would have to move fast, after rapidly pressurizing the chamber to a simulated altitude of 24,934 feet (7,600 meters). After testing, the mated spacecraft components -- the command module, the lunar excursion module and the service module -- would be moved from the integrated test area to the VAB in a vertical attitude, ready for stacking on top of the launch vehicle.

The headquarters building, just west of the O & C Building and a much less complicated structure, went up in two phases: first was the central structure, measuring 262 feet by 236 feet (80 by 72 meters); second were the east and west wings. The building stood three stories high, except in the front where a fourth floor contained top administrative offices. The main section of the building extended east and west. The original plan called for four arms stretching to the south. Later, the east and west additions brought with them two other southward extensions. Work on the headquarters building started in February 1964.

On the day the Headquarters Building got under way, construction also began on the two buildings that comprised the central instrumentation facility. The building -- a three-story structure of approximately 12,480 square meters just west of the headquarters building -- would house computers and other electronic equipment for reduction of telemetry data, analysis, and transmission to other NASA centers.

A smaller building, later known as the CIF antenna site, was placed 2.5 kilometers north of the industrial area, to be free of radio-frequency interference and have clear lines of vision to the NASA launch complexes.

The central instrumentation facility centralized the handling of NASA data and provided housing for general instrumentation activities that served more than one complex. The Launch Operations Center coordinated the planning with the other NASA centers and with the Atlantic Missile Range.

Interior of the Operations and Checkout building, August 1965. The two partly visible silos at left are altitude chambers.

It was necessary to ground all metal in the structure and to ground separately the commercial power and the instrumentation power systems. Fluorescent lights were not permitted because they cause electromagnetic interference.

When completed, the central instrumentation facility, with disc-shaped antennas adorning the roof, would be the most distinctive building in the area.

Without doubt, the many amazing structures that were placed on Launch Complex 39 -- the world's largest building, the crawler-transporters, the hold-down arms, the mobile launchers -- constituted one of the most awesome building programs in the world. After the American Society of Civil Engineers considered engineering projects from every part of the country in 1966 -- the Astrodome in Houston, the North California Flood Rehabilitation work, the Trans-Sierra Freeway from Sacramento to the Nevada line, and the hurricane barrier at New Bedford, Mass., among others -- it recognized Launch Complex 39 as the outstanding civil engineering achievement of the year.

Information in this fact sheet was adapted from the NASA history "Moonport: A History of Apollo Launch Facilities and Operations" by Dr. Charles D. Benson and William Barnaby Faherty. For more detailed information about the construction and contracts, see **http://www.nasa.gov/centers/kennedy/news/mediaresources/info_publications.html** for "Moonport" as well as other histories linked there.

Aerial of the VAB site (foreground) and road to pad 39C (later pad A) during dredging of access channel, Jan. 23, 1963.

National Aeronautics and Space Administration

John F. Kennedy Space Center
Kennedy Space Center, FL 32899

www.nasa.gov