CAPE CANAVERAL AIR FORCE STATION,
LAUNCH COMPLEX 39, CRAWLERWAY
(John F. Kennedy Space Center)
Cape Canaveral
Brevard County
Florida

HAER No. FL-8-11-P

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
National Park Service
U.S. Department of the Interior
100 Alabama Street, SW
Atlanta, GA 30303

HISTORIC AMERICAN ENGINEERING RECORD

CAPE CANAVERAL AIR FORCE STATION,
LAUNCH COMPLEX 39, CRAWLERWAY
(John F. Kennedy Space Center)
HAER No. FL-8-11-P

Location: Vehicle Assembly Building/Launch Complex 39 Area
John F. Kennedy Space Center
Cape Canaveral
Brevard County
Florida

The Crawlerway extends from the Vehicle Assembly Building (VAB), located at latitude: 28.585917, longitude: -80.649756 to Launch Complex 39A, located at latitude: 28.604498, longitude: -80.604107. A second branch of the Crawlerway extends from latitude: 28.597163, longitude: -80.617538 to Launch Complex 39B, located at latitude: 28.623123, longitude: -80.620858. The original Mobile Service Structure Park Site is located at latitude: 28.595176, longitude: -80.620545. These coordinates were obtained on January 17, 2012 through Google Earth™. The coordinates datum are North American Datum 1983.

Present Owner/
Occupant: National Aeronautics and Space Administration (NASA)
Kennedy Space Center, FL 32899-0001

Present Use: Transportation facility

Significance: The Crawlerway was listed in the National Register of Historic Places (NRHP) on January 21, 2000. Originally nominated in the context of the Apollo Program, ca. 1961 through 1975, the Crawlerway has since gained importance in the context of the Space Shuttle Program (SSP), ca. 1969 to 2011. It is significant under NRHP Criterion A in the areas of Transportation and Space Exploration, and under Criterion C in the area of Engineering. Because the Crawlerway has achieved significance within the past 50 years, as it was of exceptional importance to the SSP, as well as the Apollo Program, Criteria Consideration G applies. Within the context of the SSP, the period of significance for the Crawlerway is from 1980, when the first flight-ready Space Shuttle vehicle was transported to the launch pad, through 2011, the end of the program. In total, the Crawlerway supported the transport of 135 Space Shuttle missions, as well as sixteen Apollo era flights. Under Criterion C, the Crawlerway is significant as a unique dual-lane surface, specifically designed as a roadway for the transportation of assembled space flight vehicles from the VAB to the launch pad. It was originally engineered to withstand the pressure from the massive weight of the combination of the Saturn rocket, the Mobile Launcher, and the Crawler, at approximately 18.5 million pounds (the combined weight of the Space Shuttle, Mobile Launcher Platform (MLP), and Crawler Transporter was 17 million pounds).

Historian: Patricia Slovinac, Architectural Historian
Archaeological Consultants, Inc. (ACI)
8110 Blaikie Court, Suite A
Sarasota, Florida 34240

September 2012

Project Information: The documentation of the Cape Canaveral Air Force Station (CCAFS), Launch Complex 39, Crawlerway was conducted in 2011-2012 for the John F. Kennedy Space Center (KSC) by Archaeological Consultants, Inc. (ACI), under contract to InoMedic Health Applications (IHA), and in accordance with KSC's Programmatic Agreement (PA) Regarding Management of Historic Properties, dated May 18, 2009. The field team consisted of architectural historian, Patricia Slovinac (ACI), and independent photographer, Penny Rogo Bailes. Assistance in the field was provided by Barbara Naylor, KSC Historic Preservation Officer, and Nancy English, KSC Cultural Resource Specialist. The written narrative was prepared by Ms. Slovinac; it was edited by Joan Deming, ACI Project Manager; Elaine Liston, KSC Archivist; Ms. Naylor and Ms. English of KSC; and Jane Provancha, Environmental Projects-Manager, IHA. The photographs and negatives were processed by Zebra Color, Inc., an independent photography/processing studio.

The Scope of Services for the project, which was written based on the PA, specifies a documentation effort following HAER Level II Standards. Information for the written narrative was primarily gathered through informal interviews with current NASA and contractor personnel and research materials housed at the KSC Archives Department. Selected drawings were provided by KSC's Engineering Documentation Center, which serves as the repository for all facility drawings. For the Crawlerway, this included the original as-built drawings. It should also be noted that KSC does not periodically produce drawings of their facilities to show current existing conditions.

LIST OF ACRONYMS

ACI	Archaeological Consultants, Inc.
ACOE	U.S. Army Corps of Engineers
CCAFS	Cape Canaveral Air Force Station
ET	External Tank
IHA	InoMedic Health Applications
ISS	International Space Station
JSC	Johnson Space Center
KSC	Kennedy Space Center
LC	Launch Complex
MLP	Mobile Launcher Platform
MSFC	Marshall Space Flight Center
MSS	Mobile Service Structure
NASA	National Aeronautics and Space Administration
NRHP	National Register of Historic Places
OV	Orbiter Vehicle
PA	Programmatic Agreement
SRB	Solid Rocket Booster
SSME	Space Shuttle Main Engine
SSP	Space Shuttle Program
STS	Space Transportation System
URSAM	Urbahn, Roberts, Seelye, and Moran
U.S.	United States
VAB	Vehicle Assembly Building

Part I. Historical Information

A. Physical History:

1. **Date of construction:** November 1963 through February 1966.[1]

2. **Architect/Engineer:** Giffels and Rossetti, Inc. of Detroit, Michigan; U.S. Army Corps of Engineers (ACOE), Merritt Island, Florida.[2]

3. **Builder:** Blount Brothers Construction Company of Montgomery, Alabama, and M. M. Sundt Construction Company of Tucson, Arizona (3.44 mile segment between VAB and Launch Complex [LC] 39 Pad A); George A. Fuller Company of Los Angeles, California (2.14 mile segment from main branch of Crawlerway to LC 39 Pad B); Morrison-Knudsen Co., Inc., Perini Corp., and Paul Hardeman, Inc., all of South Gate, California (segment around north side of VAB).[3]

4. **Original plans and construction:** For the most part, the Crawlerway present at the time of documentation resembles the original. The alignment of the Crawlerway has not changed. The only difference is when originally constructed, between November 1963 and August 1965, the main portion of the Crawlerway (from the east elevation of the VAB to LC 39A), had a macadam surface, as did that portion around the north of the VAB (constructed between March 1964 and January 1965).[4]

5. **Alterations and additions:** Between 1965 and 1966, the macadam surface of the main portion of the Crawlerway and the portion around the north of the VAB were removed and replaced with rounded river gravel.[5] From 1993 through 1995, the entire grave surface was replaced, and the limerock base was repaired and restored. In 2010, the gravel surface on the portion of the Crawlerway between the VAB and LC 39, Pad A was replaced.[6]

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[1] ACOE, *Apollo Launch Complex 39* (Cape Canaveral: ACOE South Atlantic Division, no date), 40.
[2] Giffels & Rossetti, Inc., Detroit, "Complex 39, Volume I, Crawlerway and Adjacent Facilities" (architectural drawings, NASA KSC, February 1966), on file, KSC Engineering Documentation Center, Florida.
[3] ACOE, *Complex 39*, 40.
[4] "First Crawlerway Portion Accepted by Space Center," *Spaceport News*, January 21, 1965: 1; ACOE, *Complex 39*, 40.
[5] Charles D. Benson and William B. Faherty, *Moon Launch! A History of the Saturn-Apollo Launch Operations* (Gainesville: University Press of Florida, 2001), 326, 338.
[6] "Crawlerway Undergoes First Full-Scale Refurbishment," *Spaceport News*, May 7, 1993: 3; Justin Junod, personal communication (email) with Nancy English, May 30, 2012.

B. Historical Context:

The VAB/LC 39 Area of the John F. Kennedy Space Center (KSC) was originally designed to accommodate the powerful Saturn V rocket, which was set to launch man to the Moon during the Apollo Program. The tremendously large and complex rocket prompted research into new methods of preparing a vehicle for its voyage into space. Up to this point, all rockets and space modules had been assembled and tested solely at the launch pad from which they would lift off; however, these early vehicles were much simpler in configuration, relying on a single booster to reach orbit as opposed to the planned two or three booster stages for the Apollo vehicles. Additionally, the multi-booster configuration of the Saturn rockets required a longer processing time, which presented a greater potential for delays in processing and checkout due to inclement weather, especially if these activities were completed at the launch pad. Therefore, the decision was made to construct an enclosed facility for vehicle processing, assembly, and checkout (the VAB); and then transport the vehicle atop its launch platform to the launch pad.[7]

The first studies for LC 39 (1961) by Martin Marietta Corporation focused on using either a barge and canal system or a rail line to transport the Apollo vehicles to the launch pads. The initial cost estimates favored the barge system, but further inquiries (late 1961/early 1962) raised substantial questions as to the barge's propulsion and steering capabilities, as well as its ability to keep the vehicle stable. Concurrent with these studies was a comprehensive survey by American Machine and Foundry Company that examined various methods of hauling the vehicle, including a barge and canal system, railway wheels, pneumatic tires, and crawler treads; this study resulted in the suggestion of a combined barge and rail system.[8] In the midst of these studies, Barry Schlenk, a representative of Bucyrus-Erie Company of Milwaukee, Wisconsin, contacted the National Aeronautics and Space Administration (NASA). Schlenk had heard about the vehicle transport conundrum, and with him, brought pictures of a steam-shovel crawler designed and built by his company for use in the coalfields of Kentucky. After a site visit to the coalmine in February 1962, NASA hired Bucyrus-Erie Company to study the use of a crawler-style vehicle to transport the Saturn rocket. The results were successful, and at a conference in June 1962, NASA formally decided to proceed with the use of the Crawler Transporter (Crawler).[9]

On September 8, 1962, NASA issued an updated project document for LC 39, which introduced the requirements for the roadway on which the Crawler would travel; this roadway eventually

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[7] Charles D. Benson and William B. Faherty, *Gateway to the Moon. Building the Kennedy Space Center Launch Complex* (Gainesville, University Press of Florida, 2001), 112-116; Patricia Slovinac, "Cape Canaveral Air Force Station, Launch Complex 39, Crawler Transporters (John F. Kennedy Space Center)," HAER No. FL-8-11-C. Historic American Engineering Record (HAER), National Park Service, U.S. Department of the Interior, September 2009, 11.
[8] Benson and Faherty, *Gateway*, 116-122; Slovinac, "Crawler Transporters," 12.
[9] Benson and Faherty, *Gateway*, 118, 120-122; Slovinac, "Crawler Transporters," 12.

became known as the Crawlerway.[10] As part of the Fiscal Year 1963 construction budget, KSC requested funds for construction of the main branch of the Crawlerway, which extended from the VAB to LC 39A. The funds for the remainder of the Crawlerway were included in the Fiscal Year 1964 budget.[11]

In preparation for construction of the facilities within the VAB/LC 39 Area, ACOE awarded a contract to Gahagan Dredging Corporation of Tampa, Florida, to clear the land, and dredge an access channel (the barge canal).[12] On October 31, 1962, Gahagan began to clear the land in the VAB and LC39 Areas; one week later, the firm started to dredge the barge canal. Approximately 81.2 million cubic feet of the dredged sand were deposited along the site of the Crawlerway, at a width of 187' and depth of 6.5'.[13] Vibratory rollers were used to compact the fill located below the trackways, and a 100-ton vehicle then proof-rolled the fill.[14]

As Gahagan continued to clear and dredge land, on February 1, 1963, NASA signed an $807,220 contract with Giffels & Rossetti, Inc. of Detroit, Michigan, an architecture/engineering firm, for the design of the Crawlerway and the launch pads.[15] On February 21, the first conference regarding the design of the Crawlerway was held at KSC; attendees included four representatives from NASA, four from ACOE's Jacksonville, Florida, office, five from Giffels & Rossetti, and four from URSAM (Urbahn, Roberts, Seelye, and Moran).[16] At this meeting, URSAM suggested that the Crawlerway be comprised of various layers, with a total thickness of roughly 4.5', and topped by a layer of crushed stone and a soft grade of asphalt for economics in maintenance. In addition, it was proposed that the Crawlerway have a 1 percent transverse slope from the center to each outer edge to assist with drainage.[17]

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[10] Benson and Faherty, *Gateway*, 164. The project document provided the basis for KSC's construction budget over the next few fiscal years.
[11] Benson and Faherty, *Gateway*, 164, 166.
[12] The barge canal would be used to transport the first and second stages of the Saturn V vehicle by boat to the VAB area.
[13] "Big Dredges Help Build Cape's Vital Roadways," *Spaceport News*, February 7, 1963: 4. Other portions of the dredged sand were placed at the site of the VAB and LC39 Pad A. Benson and Faherty, *Gateway*, 247, 277.
[14] E. R. Bramlitt, *History of Canaveral District* (Cape Canaveral: ACOE South Atlantic Division, 1971), 57-58; Benson and Faherty, *Gateway*, 247.
[15] "$251 Million Set for Merritt Island," *Spaceport News*, March 12, 1964, 2; Benson and Faherty, *Gateway*, 234.
[16] URSAM was a combination of four New York architecture and engineering firms, organized in 1962. The acronym was created using the first letter in each company's name: Max Urbahn [architectural]; Roberts and Schaefer [structural]; Seelye, Stevenson, Value and Knecht [civil, mechanical and electrical]; and Moran, Proctor, Mueser and Rutledge [foundations]. Patricia Slovinac, "Cape Canaveral Air Force Station, Launch Complex 39, Vehicle Assembly Building (John F. Kennedy Space Center)," HAER No. FL-8-11-B. Historic American Engineering Record (HAER), National Park Service, U.S. Department of the Interior, July 2009, 11.
[17] URSAM, "Minutes of Meeting: Crawlerway Design Conference held at NASA LOC, Cape Canaveral, February 21, 1963," Sweetsir Collection, File No. ARCH00000113, Kennedy Space Center Archives Department, Florida; Benson and Faherty, *Gateway*, 234.

At a second meeting, held on March 27, 1963, Giffels & Rossetti presented their proposed Crawlerway design, which was based on the outcome of the February 21st meeting, to personnel from KSC, URSAM, ACOE, and others. The company's design included a 6" top layer of cutback SA-3 asphalt, and a 1 percent downward slope from the median. Donald Buchanan of KSC, and representatives of the Marion Power Shovel Company (builders of the Crawler) objected to the use of an asphalt surface on the Crawlerway and the sloping surface. They feared that the asphalt would adhere to the vehicle's treads and cause increased friction between the treads and the surface; the surface slope, they argued, would require additional steering correction. The meeting concluded with two definite agreements among the parties. First, two criteria were set for the selection of the surface material: the material was not to adhere to the Crawler's treads and would have a coefficient of friction no greater than 0.3 under expected operating temperature ranges. Second, it was decided that the trackways would be flat, but the median would remain sloped.[18]

After additional meetings and further load capacity studies, NASA issued a request for proposal for the construction of the roughly 18,000' segment of the Crawlerway between the VAB and LC 39A. The roughly $18.5 million contract was issued to the combination of Blount Brothers Construction Company of Montgomery, Alabama, and the M.M. Sundt Construction Company of Tucson, Arizona.[19] Work commenced on November 19, 1963, with preparation of the base sand fill. As the base sand fill was prepared, rollers leveled the fill, and successive layers of consolidated sand and graded crushed aggregate were added. The surface was then sealed with macadam.[20] The work on this segment was completed in August 1965 (Figure Nos. A-3 through A-8).[21] The portion of the Crawlerway around the VAB was constructed by the joint venture of Morrison-Knudsen Co., Inc., Perini Corp., and Paul Hardeman, Inc., all of South Gate, California, as part of the $63.3 million contract for construction of the VAB.[22] This segment was completed between March 1964 and January 1965.[23]

The Crawlerway was used for the first time on January 28, 1965, when the first Crawler was driven for roughly 2,952', and five months later, on June 22, 1965, the Crawler carried its first load, a Mobile Launcher, along the Crawlerway. During this test, the Crawler's treads "chewed

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[18] Morgan F. Jones, KSC, "Memorandum for Record: Crawler-Transporter Crawlerway Meeting; LOC E&L Building, March 27, 1963," April 5, 1963, Sweetsir Collection, File No. ARCH00000113, Kennedy Space Center Archives Department, Florida; Benson and Faherty, *Gateway*, 234.
[19] The contract also included construction of LC 39A. "$251 Million Set," 2; Benson and Faherty, *Gateway*, 277.
[20] URSAM, "Crawlerway Design Conference;" The Ralph M. Parsons Company, Los Angeles, *Preliminary Engineering Report, Space Shuttle Launch and Landing Facilities, Volume V, Crawler/Transporter-Crawlerway*. August 1971, Sweetsir Collection, File No. ARCH00022137, Kennedy Space Center Archives Department, Florida, 7; Benson and Faherty, *Moon Launch!*, 326.
[21] Bramlitt, *Canaveral District*, 57.
[22] ACOE, *Complex 39*, 41; "$251 Million Set," 2.
[23] ACOE, *Complex 39*, 41; "First Crawlerway Portion Accepted by Space Center," *Spaceport News*, January 21, 1965: 1.

up large portions of the [Crawlerway's] macadam surface."[24] As a result, on July 24, 1965NASA tested two stretches of road, approximately one-half of a mile long: one was covered with rounded river gravel, also known as "Alabama River rock," and the other was covered with crushed granite.[25] Based on the results of this test, the decision was made to use rounded river gravel for the Crawlerway surface, 4"-deep on the straight portions and 8"-deep on curves.[26]

On November 30, 1964, NASA signed a contract for approximately $24 million with the George A. Fuller Company of Los Angeles, California, for the construction of Launch Pad 39B and the 7,000' section of the Crawlerway between the main branch and the top of the launch pad.[27] Work on the Crawlerway began in December 1964; the segment was completed in February 1966.[28] This was the only segment of the Crawlerway to be originally constructed with an rounded river gravel surface.

On May 25, 1966, the Crawlerway was used by the Crawler to carry the Apollo 500-F test vehicle to LC 39A for fit checks (Figure No. A-9); the first transfer of a Mobile Service Structure (MSS) to LC 39A along the Crawlerway occurred on July 20, 1966.[29] Subsequently, the Apollo 4 vehicle, which would be the first launch of the Saturn V rocket, was carried to LC 39A on August 26, 1967. During the Apollo era, the Crawlerway supported sixteen flights, which included twelve Apollo flights, four Skylab launches, and the Apollo-Soyuz Test Project (Figure Nos. A-10, A-11). Twelve of the missions launched from LC 39A, and four lifted off from LC 39B.

For the first eleven years of its existence, the only modifications to the Crawlerway were the periodic raking of the rounded river gravel surface using a springtooth harrow (Figure No. A-12).[30] The first substantial refurbishment of the Crawlerway occurred in 1977, when rock from unused areas of the Crawlerway was gathered and spread over active sections of the facility. On December 29, 1980, the Crawlerway supported the SSP for the first time, when the Space Shuttle *Columbia* was carried to LC 39A for STS-1 (Figure No. A-14).

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[24] Benson and Faherty, *Moon Launch!*, 326.
[25] Donald D. Buchanan, KSC, "Memorandum for Record: Surface Coat of Gravel on Crawlerway, Complex 39," June 7, 1965, Sweetsir Collection, File No. ARCH00000113, Kennedy Space Center Archives Department, Florida; Benson and Faherty, *Gateway*, 326.
[26] J. F. Burke, KSC, "LC-39 Crawlerway Surfacing," letter dated August 27, 1965, Sweetsir Collection, File No. ARCH00000113, Kennedy Space Center Archives Department, Florida.
[27] "Past 12 Months 'Busiest Ever' for Facilities," *Spaceport News*, December 31, 1964: 4; Benson and Faherty, *Gateway*, 277.
[28] ACOE, *Complex 39*, 41.
[29] Benson and Faherty, *Moon Launch!*, 338, 342.
[30] A springtooth harrow is a farming machine with curved teeth, typically used for loosening soil. It was commonly used by American farmers to cultivate corn. "Crawlerway Smoothed by Farming Machine," *Spaceport News*, August 17, 1967: 8.

Between 1981 and 1983, additional rounded river gravel was purchased and applied to the main branch of the Crawlerway, between the VAB and LC 39A. Around 1985, the portion of the Crawlerway located west of the VAB was altered with the addition of modular office buildings, trailers, and a parking lot; all were placed on top of the Crawlerway's surface.[31] The same year, the rock over a 600' segment of the Crawlerway near LC 39A was removed and replaced. In 1986, additional rounded river gravel was added to the sloped portion of the Crawlerway within LC 39B.[32]

Beginning in 1993, the Crawlerway underwent its first complete refurbishment. Over a period of two and one-half years, Starbase Development, of Mims, Florida, removed the rounded river gravel surface as well as the 3.5'-thick crushed aggregate base in 1,000' to 1,500' sections. The 3.5' base was repaired and restored using crushed limerock purchased from Goodson Paving, Inc. of Sharpes, Florida; the rounded river gravel was then replaced with materials provided by Conrad Yelvington Distributors, Inc., of Daytona Beach, Florida.[33]

In 2000, as part of the "safe haven" project, the portion of the Crawlerway on the west side of the VAB, between the Crawler Park Site and the southwest High Bay, was restored (Figure No. A-15).[34] Since then, the Crawlerway has not undergone any substantial changes. By the end of the SSP in July 2011, the Crawlerway had supported 135 Space Shuttle missions, eighty-two of which launched from LC 39A and fifty-three of which lifted off from LC 39B. In addition, on October 20, 2009, the Ares I-X vehicle traversed the Crawlerway on its trip to LC 39B for its test flight, and on November 16, 2011, the Crawlerway supported the test of the new Mobile Launcher for the Space Launch System Program (Figure No. A-16).[35]

NASA's John F. Kennedy Space Center (KSC)

NASA KSC is responsible for launch and landing operations, vehicle processing and assembly, and related space exploration programs in support of manned and unmanned missions. It is located on the east coast of Florida, about 150 miles south of Jacksonville and to the north and

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[31] ACI, "Survey and Evaluation of NASA-owned Historic Facilities and Properties in the Context of the U.S. Space Shuttle Program, John F. Kennedy Space Center (KSC), Brevard County, Florida," (Survey report, NASA KSC, 2007), 6-12.
[32] Lockheed Space Operations Company, "Project Plan for LC-39 Crawlerway Refurbishment," May 1990, Railroad Archives, Box 1, Folder 6630-22, Kennedy Space Center Archives Department, Florida, 2-1.
[33] "Crawlerway Undergoes First Full-Scale Refurbishment," *Spaceport News*, May 7, 1993: 3; Lockheed Space Operations Company, "Project Plan," 3-1 through 3-11.
[34] The "safe haven" project modifications, completed by Rush Construction Corporation of Titusville, Florida, allowed KSC to use the southwest High Bay during hurricane season. If sustained winds were 69 miles per hour or greater, a stacked vehicle at the launch pad could be returned to the southwest High Bay in the VAB, leaving the northeast and southeast High Bays open for vehicle stacking operations. See Slovinac, "Vehicle Assembly Building," 14.
[35] Anne Heiney, "Ares I-X: Putting the Pieces Together, *Spaceport News*, October 30, 2001: 4-5.

west of Cape Canaveral, in Brevard and Volusia Counties, and encompasses almost 140,000 acres. The Atlantic Ocean and CCAFS are located to the east, and the Indian River is to the west.

Following the launch of Sputnik I and Sputnik II, which placed Soviet satellites into Earth's orbit in 1957, the attention of the American public turned to space exploration. President Dwight D. Eisenhower initially assigned responsibility for the U.S. Space Program to the Department of Defense. The Development Operations Division of the Army Ballistic Missile Agency, led by Dr. Wernher von Braun, began to focus on the use of missiles to propel payloads, or even a man, into space. The United States successfully entered the space race with the launch of the Army's scientific satellite Explorer I on January 31, 1958, using a modified Jupiter missile named Juno I.[36]

With the realization that the military's involvement in the space program could jeopardize the use of space for peaceful purposes, President Eisenhower formed NASA on October 1, 1958, as a civilian agency with the mission of carrying out scientific aeronautical and space exploration, both manned and unmanned. Initially working with NASA as part of a cooperative agreement, President Eisenhower officially transferred to NASA a large portion of the Army's Development Operations Division, including the group of scientists led by Dr. von Braun, and the Saturn rocket program.[37]

NASA became a resident of Cape Canaveral in 1958 when the Army Missile Firing Laboratory, then working on the Saturn rocket project under the direction of Dr. Kurt Debus, was transferred to the agency. Several Army facilities at CCAFS were given to NASA, including various offices and hangars, as well as LCs 5, 6, and 26; LC 34 at CCAFS was constructed by NASA. The Missile Firing Laboratory was renamed Launch Operations Directorate and became a branch office of Marshall Space Flight Center (MSFC). As the American space program evolved, the responsibilities of the Launch Operations Directorate grew, and NASA Headquarters separated the Directorate from MSFC, officially designating it an independent field installation called the Launch Operations Center.[38]

In May 1961, President John F. Kennedy charged NASA and the associated industries to develop a space program that would surpass the Soviet program by landing a man on the Moon by the end of the decade. With the new, more powerful Saturn V rocket and the accelerated launch schedule, it was apparent that a new launch complex was required, and CCAFS, with twenty-two launch complexes, did not have the space to accommodate new rocket facilities. Merritt Island, an undeveloped area west and north of the Cape, was selected for acquisition, and in 1961, the Merritt Island Launch Area (which, with the Launch Operations Center, would become KSC)

[36] Benson and Faherty, *Gateway*, 1-2.
[37] Benson and Faherty, *Gateway*, 15.
[38] Benson and Faherty, *Gateway*, 136.

was developed. In that year, NASA requested from Congress authority to purchase 80,000 acres of property, which was formally granted in 1962. The U.S. Army Corps of Engineers acted as the agent for purchasing the land, which took place between 1962 and 1964. NASA began gaining title to the land in late 1962, taking over approximately 83,903 acres by outright purchase, which included several small towns, such as Orsino, Wilson, Heath and Audubon, many farms, citrus groves, and several fish camps. Negotiations with the State of Florida provided submerged lands, resulting in the acquisition of property identified on the original Deed of Dedication. Much of the State-provided land was located south of the Old Haulover Canal and north of the Barge Canal.

The American program to put a man in space and land on the Moon proceeded rapidly with widespread support. In November 1963, the Launch Operations Center and Merritt Island Launch Area were renamed John F. Kennedy Space Center to honor the late President.[39] The space program was organized into three phases: Projects Mercury, Gemini, and Apollo. Project Mercury, initiated in 1958, was executed in less than five years. Begun in 1964, Project Gemini was the intermediate step toward achieving a manned lunar landing, bridging the gap between the short-duration Mercury flights and the long-duration missions proposed for the Apollo Program.[40]

Apollo, the largest and most ambitious of the manned space programs, had as its goal the landing of astronauts on the Moon and their safe return to Earth. Providing the muscle to launch the spacecraft was the Saturn family of heavy vehicles. Saturn IB rockets were used to launch the early unmanned Apollo test flights and the first manned flight, Apollo 7, which carried astronauts on a ten-day Earth orbital mission.[41]

Three different launch vehicles were used for Apollo: Saturn I, Saturn IB and Saturn V; and three different launch complexes were involved: LC 34 and LC 37 on CCAFS, and LC 39 on KSC (LC 37B and LC 39 Pads A and B are still active).[42] Altogether, thirty-two Saturn flights occurred (seven from LC 34, eight from LC 37, and seventeen from LC 39 Pad A [twelve] and Pad B [five], including Skylab and the Apollo-Soyuz Test Project) during the Apollo era. Of the total thirty-two, fifteen were manned, and of the seven attempted lunar landing missions, six were successful. No major launch vehicle failures of either Saturn IB or Saturn V occurred. There were two major command/service module failures, one on the ground (Apollo 1) and one on the way to the Moon (Apollo 13).[43]

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[39] Harry A Butowsky, *Reconnaissance Survey: Man in Space* (Washington, DC: National Park Service, 1981), 5; Benson and Faherty, *Gateway*, 146.
[40] Butowsky, *Man in Space*, 5.
[41] Butowsky, *Man in Space*, 5.
[42] LC 39 is comprised of two launch pads, Pad A and Pad B. Unless otherwise noted, the term LC 39 refers to both launch pads.
[43] NASA, *Facts: John F. Kennedy Space Center* (1994), 82.

The unmanned Apollo 4 mission, which lifted off on November 9, 1967, was the first Saturn V launch and the first launch from LC 39 (Pad A) at KSC. The next launch from LC 39 (Pad A) was Apollo 6, on July 14, 1967. Beginning with the launch of Apollo 8 on August 14, 1968, all manned missions have launched from LC 39.[44] On July 20, 1969, the goal of landing a man on the Moon was achieved when Apollo 11 astronauts Neil Armstrong, "Buzz" Aldrin, and Michael Collins successfully executed history's first lunar landing. Armstrong and Aldrin walked on the surface of the Moon for two hours and thirty-one minutes, and collected 21 kilograms of lunar material. Apollo 17 served as the first night launch in December 1972. An estimated 500,000 people viewed the liftoff from LC 39 Pad A, which was the final launch of the Apollo Program.[45]

Skylab, an Earth-orbiting mission that was a follow-on to the Apollo Program, served as an early type of space station. With 12,700 cubic feet of work and living space, it was the largest habitable structure ever placed in orbit, at the time. The station achieved several objectives: scientific investigations in Earth orbit (astronomical, space physics, and biological experiments); applications in Earth orbit (Earth resources surveys); and long-duration spaceflight. Skylab 1 orbital workshop was inhabited in succession by three crews launched in modified Apollo command/service modules (Skylab 2, 3 and 4). Actively used until February 1974, Skylab 1 remained in orbit until July 11, 1979, when it re-entered Earth's atmosphere over the Indian Ocean and Western Australia after completing 34,181 orbits.[46]

The Apollo-Soyuz Test Project of July 1975, the final application of the Apollo Program, marked the first international rendezvous and docking in space, and was the first major cooperation between the only two nations engaged in manned space flight, the U.S. and Russia. As the first meeting of two manned spacecraft of different nations in space, and the first docking and visits by astronauts and cosmonauts into the others' spacecraft, the event was highly significant. The Apollo-Soyuz Test Project established workable joint docking mechanisms, taking the first steps toward mutual rescue capability of both Russian and American manned missions in space.[47]

On January 5, 1972, President Richard M. Nixon delivered a speech in which he outlined the end of the Apollo era and the future of a reusable space flight vehicle, the Space Shuttle, which would provide "routine access to space." By commencing work at this time, Nixon added, "we can have the Shuttle in manned flight by 1978, and operational a short time after that."[48] The Space Task Group, previously established by President Nixon in February 1969, recommended three choices of long-range space plans. All included an Earth–orbiting space station, a space

[44] Apollo 5 launched from CCAFS's LC 37B; Apollo 7 launched from LC 34 at KSC. Benson and Faherty, *Moon Launch!*, 532.
[45] NASA, *Facts*, 86-90.
[46] NASA, *Facts*, 91.
[47] NASA, *Facts*, 96.
[48] Marcus Lindroos, ed., "President Nixon's 1972 Announcement on the Space Shuttle," updated April 14, 2000, http://history.nasa.gov/stsnixon.htm.

shuttle, and a manned Mars expedition.[49] Although none of the original programs presented was eventually selected, NASA implemented a program, shaped by the politics and economic realities of its time that served as a first step toward any future plans for implementing a space station.[50]

During this speech, President Nixon instructed NASA to proceed with the design and building of a partially reusable Space Transportation System (STS; commonly referred to as the Space Shuttle) consisting of a reusable orbiter, three reusable main engines, two reusable solid rocket boosters (SRBs), and one non-reusable external liquid fuel tank (ET). NASA's administrators vowed that the Space Shuttle would fly at least fifty times a year, making space travel economical and safe. NASA gave responsibility for developing the Space Shuttle's orbiter vehicle and overall management of the SSP to the Manned Spacecraft Center (now known as the Johnson Space Center [JSC]) in Houston, Texas, based on the Center's experience. MSFC in Huntsville, Alabama, was responsible for development of the Space Shuttle Main Engine (SSME), the SRBs, the ET, and for all propulsion-related tasks. Engineering design support continued at JSC, MSFC, and NASA's Langley Research Center, in Hampton, Virginia, and engine tests were to be performed at NASA's National Space Technology Laboratories (later named Stennis Space Center) in south Mississippi, and at the Air Force's Rocket Propulsion Laboratory in California, which later became the Santa Susana Field Laboratory.[51] NASA selected KSC as the primary launch and landing site for the SSP. KSC, responsible for designing the launch and recovery facilities, was to develop methods for shuttle assembly, checkout, and launch operations.[52]

On September 17, 1976, the full-scale Orbiter Vehicle (OV) prototype *Enterprise* (OV- 101) was completed. Designed for test purposes only and never intended for space flight, structural assembly of OV-101 had started more than two years earlier in June 1974 at Air Force Plant 42 in Palmdale, California. Although the *Enterprise* was an aluminum shell prototype incapable of space flight, it reflected the overall design of the orbiter. As such, it served successfully in 1977 as the test article during the Approach and Landing Tests aimed at checking out both the mating with the Boeing 747 Shuttle Carrier Aircraft for ferry operations, as well as the orbiter's unpowered landing capabilities.

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[49] NASA, "Report of the Space Task Group, 1969," (Washington, DC: NASA Headquarters, 1969), http://www.hq.nasa.gov/office/pao/History/taskgrp.html.
[50] Dennis R. Jenkins, *Space Shuttle, The History of the National Space Transportation System. The First 100 Missions* (Cape Canaveral, Florida: Specialty Press, 2001), 99.
[51] Jenkins, *Space Shuttle*, 122.
[52] Linda Neuman Ezell, *NASA Historical Databook Volume III Programs and Projects 1969-1978*, The NASA History Series (Washington, DC: NASA History Office, 1988), 121-24, table 2-57; Ray A. Williamson, "Developing the Space Shuttle," in *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program, Volume IV: Accessing Space*, ed. John M. Logsdon (Washington, DC: U.S. Printing Office, 1999), 172-174.

The first orbiter intended for spaceflight, *Columbia* (OV-102*)*, arrived at KSC from Air Force Plant 42 in March 1979. Originally scheduled for liftoff in late 1979, the launch date was delayed by problems with both the SSME components as well as the thermal protection system. *Columbia* spent 610 days in the Orbiter Processing Facility, another thirty-five days in the VAB and 105 days on LC 39A before lifting off on April 12, 1981. STS-1, the first orbital test flight and first SSP mission, ended with a landing on April 14, 1981, at Edwards Air Force Base in California. This launch demonstrated *Columbia's* ability to fly into orbit, conduct on-orbit operations, and return safely.[53] *Columbia* flew three additional test flights in 1981 and 1982, all with a crew of two. The Orbital Test Flight Program ended in July 1982 with 95 percent of its objectives accomplished. After the end of the fourth mission, President Reagan declared that with the next flight the Shuttle would be "fully operational."

During the SSP, a total of 135 missions were launched from KSC. From April 1981 until the *Challenger* accident in January 1986, between two and nine missions were flown yearly, with an average of four to five per year. The milestone year was 1985, when nine flights were successfully completed. The years between 1992 and 1997 were the most productive, with seven or eight yearly missions. Since 1995, in addition to its unique responsibility as the Shuttle launch site, KSC also became the preferred landing site.

Over the past three decades, the SSP has launched a number of planetary and astronomy missions including the Hubble Space Telescope, the Galileo probe to Jupiter, Magellan to Venus, and the Upper Atmospheric Research Satellite. In addition to astronomy and military satellites, a series of Spacelab research missions were flown, which carried dozens of international experiments in disciplines ranging from materials science to plant biology. Spacelab was a manned, reusable, microgravity laboratory flown into space in the Space Shuttle cargo bay. It was developed on a modular basis allowing assembly in a dozen arrangements depending on the specific mission requirements.[54] The first Spacelab mission, carried aboard *Columbia* (STS-9), began on November 28, 1983. Four Spacelab missions were flown between 1983 and 1985. Following a stand-down in the aftermath of the *Challenger* disaster, the next Spacelab mission was not launched until 1990. In total, twenty-four Space Shuttle missions carried Spacelab hardware before the program was decommissioned in 1998.[55]

In 1995, a joint U.S./Russian Shuttle-*Mir* Program was initiated as a precursor to construction of the International Space Station (ISS). *Mir* was launched in February 1986 and remained in orbit

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[53] Jenkins, *Space Shuttle*, 268.
[54] NASA, *NSTS 1988 News Reference Manual* (Florida: Kennedy Space Center, 1988), http://science.ksc.nasa.gov/shuttle/technology/sts-newsref/.
[55] STS-90, which landed on May 3, 1998, was the final Spacelab mission. NASA KSC, "Shuttle Payloads and Related Information," *KSC Factoids* (Florida: Kennedy Space Center, 2002), http://www-pao.ksc.nasa.gov/kscpao/factoids/relinfo2.htm.

until March 2001.[56] The first approach and fly around of *Mir* (STS-63) took place on February 3, 1995, and the first *Mir* docking (STS-71) was in June 1995. During the three-year Shuttle-*Mir* Program (June 27, 1995 to June 2, 1998), the Space Shuttle docked with *Mir* nine times. The Orbiter *Atlantis* flew all but the last two of these docking missions. In 1995, Dr. Norman Thagard was the first American to live aboard the Russian space station. Over the next three years, six more U.S. astronauts served tours on *Mir*. The Shuttle served as a means of transporting supplies, equipment, and water to the space station in addition to performing a variety of other mission tasks, many of which involved Earth science experiments. It returned experiment results and unneeded equipment to Earth. The Shuttle-*Mir* Program served to acclimate the astronauts to living and working in space. Many of the activities carried out were types they would perform on the ISS.[57]

On December 4, 1998, *Endeavour* (STS-88) launched the first U.S. component of the ISS into orbit. This event marked, "at long last the start of the Shuttle's use for which it was primarily designed – transport to and from a permanently inhabited orbital space station."[58] STS-96, *Discovery*, launched on May 27, 1999, marked the first mission to dock with the ISS. Since that time, most Space Shuttle missions supported the assembly of the space station. The last major component of the ISS was delivered in May 2011, during the final flight of *Endeavour* (STS-134).

The SSP suffered two major setbacks with the tragic losses of the *Challenger* and *Columbia* on January 28, 1986, and February 1, 2003, respectively. Following the *Challenger* accident, the program was suspended, and President Ronald Reagan formed a thirteen-member commission to identify the cause of the disaster. The Rogers Commission report, issued on June 6, 1986, which also included a review of the SSP, concluded "that the drive to declare the Shuttle operational had put enormous pressures on the system and stretched its resources to the limit."[59] In addition to mechanical failure, the Commission noted a number of NASA management failures that contributed to the catastrophe. As a result, among the tangible actions taken were extensive redesign of the SRBs; upgrading of the Space Shuttle tires, brakes, and nose wheel steering mechanisms; the addition of a drag chute to help reduce speed upon landing; the addition of a crew escape system; and the requirement for astronauts to wear pressurized flight safety suits during launch and landing operations. Other changes involved reorganization and decentralization of the SSP. NASA moved the management of the program from JSC to NASA Headquarters (Washington, D.C.), with the aim of preventing communication deficiencies.[60]

[56] Tony Reichhardt, ed., *Space Shuttle, The First 20 Years* (Washington, DC: Smithsonian Institution, 2002), 85.
[57] Judy A. Rumerman, with Stephen J. Garber, *Chronology of Space Shuttle Flights 1981-2000* (Washington, DC: NASA History Division, 2000), 3.
[58] Williamson, "Developing," 191.
[59] Columbia Accident Investigation Board (CAIB), *Report, Volume I*, (Washington, DC: U.S. Government Printing Office, 2003), 25, http://history.nasa.gov/columbia/CAIB_reportindex.html.
[60] CAIB, *Report, Volume I*, 101.

Experienced astronauts were placed in key NASA management positions, all documented waivers to existing flight safety criteria were revoked and forbidden, and a policy of open reviews was implemented.[61] In addition, NASA adopted a Space Shuttle flight schedule with a reduced average number of launches and discontinued the long-term practice of launching commercial and military payloads.[62] The launch of *Discovery* (STS-26) from LC 39B on September 29, 1988, marked a Return-to-Flight after a thirty-two-month stand-down in manned spaceflight following the *Challenger* accident.

In the aftermath of the 2003 *Columbia* accident, a seven-month investigation ensued, concluding with the findings of the Columbia Accident Investigation Board, which determined that both technical and management conditions accounted for the loss of the orbiter and crew. According to the Board's Report, the physical cause of the accident was a breach in the thermal protection system on the leading edge of the left wing, caused by a piece of insulating foam, which separated from the ET after launch and struck the wing.[63] NASA spent more than two years researching and implementing safety improvements for the orbiters, SRBs and ET. Following a two-year stand-down, the launch of STS-114 on July 26, 2005, marked the first Return-to-Flight since the loss of *Columbia*.

On January 14, 2004, President George W. Bush outlined a new space exploration initiative in a speech given at NASA Headquarters.

> *Today I announce a new plan to explore space and extend a human presence across our solar system . . . Our first goal is to complete the International Space Station by 2010 . . . The Shuttle's chief purpose over the next several years will be to help finish assembly of the International Space Station. In 2010, the Space Shuttle – after nearly 30 years of duty – will be retired from service. . .*[64]

Following the President's speech, NASA released *The Vision for Space Exploration*, which outlined the Agency's approach to the new direction in space exploration.[65] As part of this initiative, NASA decided that the Space Shuttle would not be upgraded to serve beyond 2010 and, after completing the ISS, the SSP will be retired.

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[61] Cliff Lethbridge, "History of the Space Shuttle Program," 2001, http://spaceline.org/rocketsum/shuttle-program.html.
[62] Lethbridge, "History."
[63] CAIB, *Report, Volume I*, 9.
[64] Weekly Comp. Pres. Docs., Remarks at the National Aeronautics and Space Administration, Vol. 40, Issue 3 (January 19, 2004), http://www.gpo.gov/fdsys/pkg/WCPD-2004-01-19/content-detail.html.
[65] NASA, *The Vision for Space Exploration* (Washington, DC: NASA Headquarters, 2004), http://www.nasa.gov/pdf/55583main_vision_space_exploration2.pdf.

Development of KSC's LC 39 and Vehicle Assembly Building Areas

Today, KSC maintains operational control over 3,800 acres, all located in Brevard County. The major facilities are located within the Industrial Area, the LC 39 Area, the VAB Area, and the Shuttle Landing Facility Area. The LC 39 and VAB Areas were developed primarily to support launch vehicle operations and related launch processing activities. They contain the VAB, the Launch Control Center, the Orbiter Processing Facility (High Bay Nos. 1 and 2), the Orbiter Processing Facility, High Bay No. 3, the two Launch Pads, 39A and 39B, and other support facilities.

Following completion of the Apollo-Soyuz Test Project in 1975, the facilities at KSC were modified to support the SSP. KSC was originally one of three possible launch sites evaluated, along with Vandenberg Air Force Base in California and the White Sands Missile Range in New Mexico. Compared with the other two locations, KSC had the advantage of approximately $1 billion in existing launch facilities. Thus, less time and money would be needed to modify existing facilities at KSC rather than to build new ones at another location. The estimate of $200 to $400 million to modify the existing KSC facilities was roughly half the cost of new construction. In addition, only KSC had abort options for a first revolution return of the low cross-range orbiter.[66]

To help keep costs down, beginning ca. 1976, KSC engineers adapted and modified many of the Apollo launch facilities to serve the needs of the SSP. Among the key facilities undergoing change were the VAB, the Launch Control Center, and LC 39 Pads A and B. New facilities were constructed only when a unique requirement existed. The major new structures included the Shuttle Landing Facility and the Orbiter Processing facilities. Multi-million dollar contracts for design and construction were awarded to both national and local firms, including Reynolds, Smith and Hills of Jacksonville, Florida; the Frank Briscoe Company, Inc. of East Orange, New Jersey; Algernon Blair Industrial Contractors, Inc. of Norcross, Georgia; the Holloway Corporation of Titusville, Florida; and W&J Construction Corporation of Cocoa, Florida.

Alterations to the VAB included modification of two of the four high bays for assembly of the Space Shuttle vehicle, and changes to the other two high bays to accommodate the processing and stacking of the SRBs and ET. The north doors were widened by almost 40' to permit entry

[66] Jenkins, *Space Shuttle,* 112. A first revolution return was type of mission abort that entailed placing the orbiter into a suborbital trajectory, which led to a landing following a single revolution around the Earth. The low cross-range orbiter was an initial design concept where the orbiter had straight wings, as opposed to the delta wing style that was adopted following NASA's evaluation of launch sites. For a first revolution return, the low cross-range orbiter would have a higher angle of approach, a shorter entry-to-touchdown distance, a shorter time-to-touchdown, and a higher landing speed. Bellcomm, Inc., "OSS Study-Space Shuttle Recovery in Southwestern U.S.-Case 900," (memorandum for file, NASA, 1971), 2, http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19790072702_1979072702.pdf.

of the towed orbiter. Work platforms shaped to fit the Shuttle configuration were added to High Bays 1 and 3 where Shuttle assembly occurred, and internal structural changes were also made to High Bays 2 and 4, where the ETs were processed.

Major changes were made to LC 39, Pads A and B. Modifications were completed in mid-1978 at Pad A and in 1985 at Pad B. With the exception of the six fixed pedestals, which support the MLP, all of the structures on the hardstands of each pad were removed or relocated. Fuel, oxidizer, high-pressure gas, electrical, and other service lines were rerouted. New hypergolic fuel and oxidizer support areas were constructed at the southwest and southeast corners, respectively, of the pads. The Saturn fuel support area was removed, a new Fixed Service Structure was erected using an original Apollo-era Launch Umbilical Tower, a Rotating Service Structure was added, the Saturn flame deflectors were replaced, and a Payload Changeout Room and a Payload Ground Handling Mechanism were added. A sound suppression water system was installed on the pads to reduce the acoustical levels within the orbiter's payload bay and thus, to protect it and its payloads from damage. A related system, the Overpressure Suppression System, was installed to reduce the pressure pulse at SRB ignition.[67]

Additional changes were made to Pads A and B in the aftermath of the 1986 *Challenger* accident; other modifications followed the Return-to-Flight in 1988. Among the modifications were the installation of new weather protection structures to supplement the Rotating Service Structure; improvements in temperature and humidity controls for the Payload Changeout Room; upgrades to the emergency exit system, including the addition of two slidewire baskets; installation of new elevators on the Rotating Service Structure; and improvements to the pad communications system. Changes were first made at Pad B, followed by identical changes at Pad A.[68]

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[67] Wallace H. Boggs and Samuel T. Beddingfield, "Moonport to Spaceport. The Changing Face at KSC," *Astronautics & Aeronautics* 20, (July/August 1982): 28-41.
[68] ACI, "Survey and Evaluation of KSC."

Part II. Structural/Design Information

A. General Statement:

1. Character: The Crawlerway (Figure Nos. A-1, A-2; Photo Nos. 1, 2) has an approximate total length of 5 miles. Its main expanse extends from the east side of the VAB towards the two launch pads. Roughly 2 miles from the VAB, the Crawlerway splits into two branches, one of which continues east to LC 39A (Photo No. 3); the other extends north to LC 39B (Photo No. 4). The Crawlerway has a total width of 130' and consists of two trackways separated by a grassed median (Photo No. 5). Originally, the Crawlerway was specially designed to carry the combined load of the Crawler Transporter, the Mobile Launcher, and the Saturn/Apollo Spacecraft; the estimated weight of this combination was 18.5 million pounds.[69] Based on this weight and potential wind loads, ACOE engineers calculated an approximate load of 12,000 pounds per square foot for the Crawlerway. This load rate was sufficient to carry the Space Shuttle, Crawler Transporter, and MLP combination, with an estimated weight of 17 million pounds.

2. Condition of fabric: The Crawlerway is in good condition due to periodic maintenance.

B. Description: The Crawlerway is a 130'-wide roadway, comprised of two 40'-wide trackways separated by a 50'-wide grass median (Photo No. 5). Each trackway consists of five layers of differing materials, with a combined depth of approximately 8'. The top layer consists of rounded river gravel; it is 4" deep on the straight sections and 8" deep on the curves. The second layer contains approximately 3.5' of graded crushed limerock, and the third layer is comprised of 1' of consolidated hydraulic fill sand with a California Bearing Ratio of 25. The fourth layer consists of 2' of sand, compressed to a California Bearing Ratio of 15. Below the sand is a sub-base of hydraulic fill, which ranges in thickness between 1' and 3.5'.[70] Wooden ties form a curb along the length of the outer edge of each trackway; the ties are connected to one another with 1/8"-thick, perforated galvanized steel plates to allow drainage (Photo No. 6).[71]

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[69] Kay Grinter, "Crawlerway Provides 'Firm Foundation' for Saturn V," *Spaceport News*, October 16, 2009: 7. During the Apollo Program, the Crawler was also used to carry the Mobile Service Structure to the launch pad; the combination had an approximate weight of 15.8 million pounds. ACOE, *Complex 39*, 39.

[70] Ralph M. Parsons, *Crawler/Transporter-Crawlerway*, 7. The California Bearing Ratio rating was developed by the California Department of Transportation as a means of measuring the load-bearing capacity of soils used for building roads or airstrips; the harder the surface, the higher the rating. The standard material for this test is crushed California limestone, which was given a value of 100. "California bearing ratio," Wikipedia, 2012, http://en.wikipedia.org/wiki/California_bearing_ratio.

[71] Lockheed Space Operations Company, "LC-39 Crawlerway Refurbishment," 3-5.

In general, the Crawlerway extends from the VAB to both LC 39A (total of 3.4 miles) and LC 39B (total of 4.2 miles); various short branches provide access to the MSS Park Site (Photo Nos. 18, 19), the MLP Refurbishment Area (Photo No. 8), and the Crawler Park Site (Photo No. 17). Within the VAB Area, the layout of the Crawlerway is roughly rectangular. On the west side of the VAB (Photo No. 7), there is one set of trackways, which leads from the southwest High Bay. The trackways extend at an angle of 12 degrees to the south of due west for roughly 126' before curving to the northwest, at a radius of 500', for a length of around 785', and then traveling at an angle of 15 degrees west of due north for approximately 388'. At this point, the Crawlerway curves again toward the northeast for an approximate length of 785' (radius of about 500'), where it then extends straight for roughly 800' at an angle of 12 degrees north of due east (Photo No. 8). The Crawlerway then curves through 80 degrees toward the southeast for a rough length of 672' (radius of around 481') and continues straight for an approximate distance of 350' before it curves towards the southeast over a radius of 481' for a length of 755', where it meets the main branch (Photo No. 9).[72]

The main branch of the Crawlerway begins on the east side of the VAB, where there are two sets of trackways, one from the northeast High Bay and one from the southeast High Bay (Photo Nos. 10, 11). About 550' to the east, the two sets of trackways converge; and about 950' from the VAB, the set of trackways meets with the portion of the Crawlerway that travels north of the VAB. From this junction, the Crawlerway continues to extend towards the launch pads at an angle of 12 degrees north of due east, for about 2,650'. It then curves over a radius of 898' for a length of 163', before it continues straight at an angle of 23 degrees north of due east.[73] After approximately 8,237' (1.56 miles), the Crawlerway divides into two branches, one to LC 39A and the other to LC 39B (Photo No. 12).

The branch to LC 39A continues at an angle of 23 degrees north of due east for approximately 15,900' (3.01 miles). At this point, the Crawlerway curves over a radius of 900' for a length of 1,039', where it then continues due north for about 1,500' (0.28 miles) to the top of the launch pad (Photo No. 13).[74] The second branch, which leads to LC 39B, curves to the northwest over a radius of 500' and a length of 1,080', before extending for roughly 2,200' (0.42 miles) at an angle of around 27 degrees west of due north. This branch then curves through an angle of 27 degrees, with a radius of 1,020', for a length of around 480'. The Crawlerway then travels for approximately 7,750' (1.47 miles) due north to the top of the launch pad.[75]

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[72] ACOE, Merritt Island, "LC-39 VAB Crawlerway Surfacing" (architectural drawings, NASA KSC, May 1968), Sheet 2, on file, KSC Engineering Documentation Center, Florida; Space Gateway Support, *CCAFS/KSC Basic Information Guide* (facilities map, NASA KSC, January 2006), map 7, on file, KSC Master Planning Office, Florida.
[73] Giffels & Rossetti, "Crawlerway and Adjacent Facilities," Sheet 1012.
[74] Giffels & Rossetti, "Crawlerway and Adjacent Facilities," Sheet 1003.
[75] ACOE, Merritt Island, "LC-39 Pad "B," Crawlerway Surfacing; Audio/Video Cables and Miscellaneous Work, Volume 1" (architectural drawings, NASA KSC, December 1966), Sheet 1-3.

D. Site Information: The Crawlerway's spatial arrangement reflects the overall master plan of the LC 39/VAB area. Explosive hazards, the dangers of launching over other complexes or inhabited areas, and maintaining a line of site between the launch vehicle and the Launch Control Center determined the choice of sites for Pads A and B, as well as the distance between them.[76] The need to protect people and facilities from the four common types of launch hazards, blast, acoustic, toxic, and nuclear, determined the choice of location for the VAB, within what was referred to in the master plan as the launch support zone.[77] The Crawlerway, which connected the VAB to the launch pads, had two key design restrictions: a minimum radius of 500' at the curves and a maximum 5 percent grade at the pad approaches.[78] These design restrictions, as well as the idea of keeping the distance between the VAB and launch pads as small as allowed by safety restrictions, determined the final layout of the Crawlerway.

The Crawlerway extends from the VAB area, at its west end, to the two launch pads, 39A at its east end and 39B at its northernmost point. Within the VAB area, the Crawlerway passes the Orbiter Processing Facility (High Bay Nos. 1 and 2), the Thermal Protection System Facility, and the Orbiter Processing Facility, High Bay No. 3. To the north of the Thermal Protection System Facility, on the west side of the Crawlerway, is the Crawler park site. The park site measures approximately 610' x 360', and contains a maintenance/office building and enough space to park both Crawlers. To the north of the Orbiter Processing Facility, High Bay No. 3, on the north side of the Crawlerway is the MLP Refurbishment Area. This site contains two extensions angled 45 degrees from the Crawlerway, each of which measures roughly 430' x 130'; each extension can hold one MLP.

From the VAB, the Crawlerway extends through the flat, marshy terrain of Florida's east coast, parallel to the barge canal. At 7.5' above mean sea level, it crosses dry land, swamps, sloughs, and bogs. All of these soft materials required excavation and replacement with compacted hydraulic sandfill to form a strong foundation.[79] Approximately 4,200' east of the VAB, the Crawlerway passes through the Fluid Servicing Area. Roughly 5,500' further east, just prior to where the Crawlerway splits to head to the different launch pads, is the MSS Park Site. This site consists of an approximate 1,100' length of Crawlerway, which is angled toward the southwest from the main branch. The area contains six support buildings used by technicians who maintained the MSS during the Apollo Program, or if emergency repair work was required on

[76] The mobile launch concept provided for an enclosed building where the launch vehicle could be prepared, protecting the vehicle from corrosion by salt in the air, and protecting the vehicle and technicians from variable Florida weather, such as high winds, rain, and lightning. In addition, the mobile launch concept promised faster launch operations, the vehicle would only require one week at the launch pad, and for cost savings, as the work force would be concentrated in a single facility as opposed to multiple launch pads. Benson and Faherty, *Gateway*, 8-10.
[77] Pan American World Airways, Guided Missiles Range Division, *Analytical Report for NASA Merritt Island Launch Area Master Plan, Volume III* (Cape Canaveral, FL: Pan American World Airways, 1965), Sweetsir Collection, File No. ARCH00017252, Kennedy Space Center Archives Department, Florida.
[78] Pan American World Airways, *Analytical Report*, 28.
[79] Bramlitt, *Canaveral District*, 58.

the Crawler during the Apollo and Space Shuttle Programs. To the south of the MSS Park Site is a KSC Visitor Center tour stop. After passing the MSS Park Site, the Crawlerway again proceeds through marshy terrain to both LC 39 Pad A to the east, and LC 39 Pad B to the north. At the fenced edge of each launch pad, the Crawlerway continues to the top of each pad, at a 5-degree slope.

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Figure A-1. Aerial view of Launch Complex 39 showing the Crawlerway, camera facing northeast, April 16, 1973.
Source: John F. Kennedy Space Center Archives, 108-KSC-373C-546-63.

Figure A-2. Aerial view of Launch Complex 39 showing the Crawlerway, camera facing southwest, November 24, 1975.
Source: John F. Kennedy Space Center Archives, 108-KSC-375C-654.44.

Figure A-3. View of Crawlerway construction, showing hydraulic fill, April 30, 1963.
Source: John F. Kennedy Space Center Archives, LOC-63-4457.

Figure A-4. View of Crawlerway construction, December 26, 1963.
Source: John F. Kennedy Space Center Archives, KSC-64C-7.

Figure A-5. View of Crawlerway construction, near VAB, March 30, 1964.
Source: John F. Kennedy Space Center Archives, KSC-64-2873.

Figure A-6. View of Crawlerway construction, April 7, 1964.
Source: John F. Kennedy Space Center Archives, KSC-64C-994.

Figure A-7. View of Crawlerway construction, April 7, 1964.
Source: John F. Kennedy Space Center, KSC-64C-1008.

Figure A-8. Aerial view of LC 39 construction, showing VAB in foreground and Crawlerway in background and at right, January 28, 1965.
Source: John F. Kennedy Space Center Archives, 100-KSC-65C-980.

Figure A-9. Crawlerway in use as crawler transporter carries the Apollo 500-F test vehicle to LC 39A, May 25, 1966.
Source: John F. Kennedy Space Center Archives, 100-KSC-66C-4696.

Figure A-10. Crawlerway in use as crawler transporter carries Apollo 4 to LC 39A, August 26, 1967.
Note the mobile service structure within its park site at left.
Source: John F. Kennedy Space Center Archives, 107-KSC-67PC-379.

Figure A-11. Rollout of Apollo 11 from the VAB to LC 39A, May 20, 1969.
Source: John F. Kennedy Space Center, KSC-69P-372, accessed via
http://mediaarchive.ksc.nasa.gov/search.cfm.

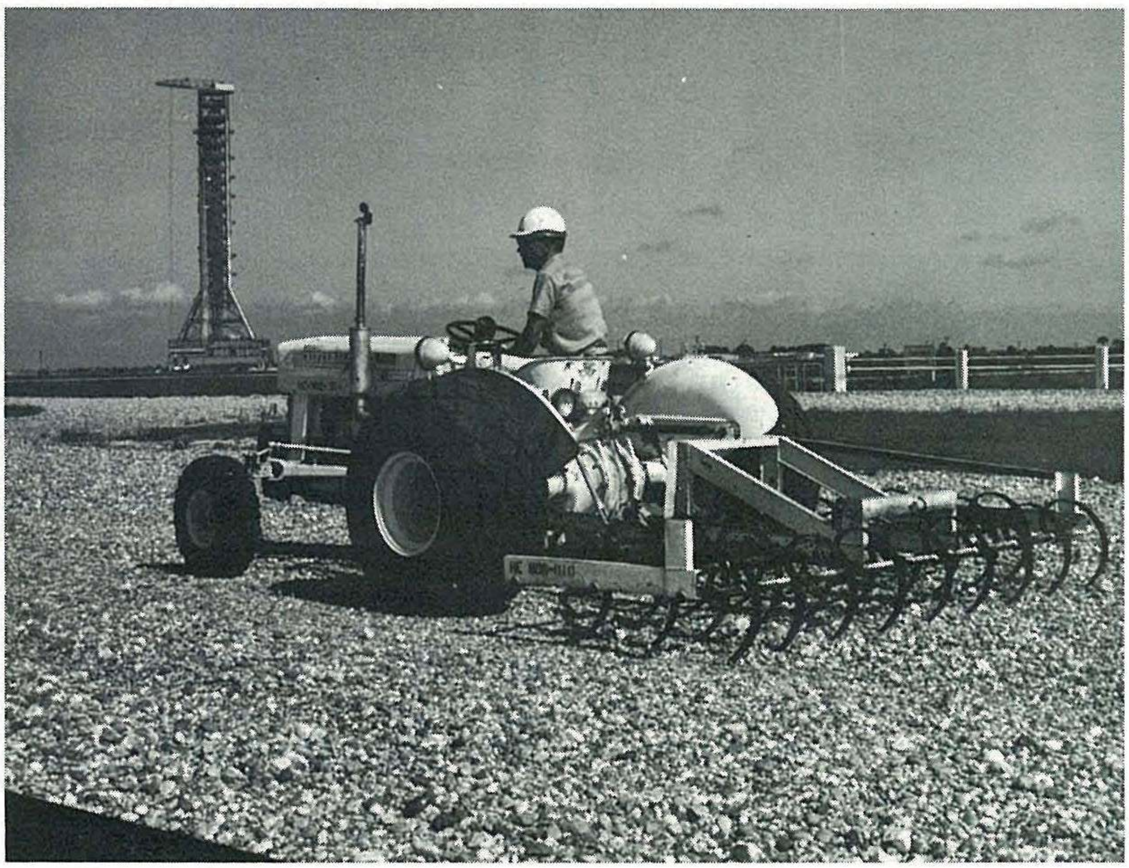

Figure A-12. View of a springtooth harrow being used to smooth the Crawlerway surface.
Source: *Spaceport News*, August 17, 1967, page 8.

Figure A-13. View of a crawler transporter at the base of a launch pad, January 1, 1973.
Note the track imprints within the Crawlerway in the foreground.
Source: John F. Kennedy Space Center Archives, KSC-73PC-772.

Figure A-14. Rollout of Space Shuttle program mission STS-1, December 29, 1980.
Source: John F. Kennedy Space Center Archives, 108-KSC-80PC-724.

Figure A-15. Aerial view of Crawlerway showing the restored portion leading into VAB High Bay No. 2, June 2, 2000.
Source: John F. Kennedy Space Center Archives, KSC-00PP-0728.

Figure A-16. Test rollout of the newly constructed mobile launcher that will be used in the future Space Launch System program, November 16, 2011.
Source: John F. Kennedy Space Center, 2011-7797, accessed via http://mediaarchive.ksc.nasa.gov/search.cfm.

HISTORIC AMERICAN ENGINEERING RECORD

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CAPE CANAVERAL AIR FORCE STATION, HAER No. FL-8-11-P
LAUNCH COMPLEX 39, CRAWLERWAY
(John F. Kennedy Space Center)
Cape Canaveral
Brevard County
Florida

Penny Rogo Bailes, Photographer; November 2011
(FL-8-11-P-1 through FL-8-11-P-30)

FL-8-11-P-1	OVERALL VIEW OF CRAWLERWAY FROM ROOF OF VEHICLE ASSEMBLY BUILDING, FACING NORTHEAST.
FL-8-11-P-2	VIEW OF CRAWLERWAY FROM TOP OF FIXED SERVICE STRUCTURE AT LAUNCH PAD 39A, FACING SOUTH.
FL-8-11-P-3	VIEW OF CRAWLERWAY APPROACH TO LAUNCH PAD 39A, FACING NORTHEAST.
FL-8-11-P-4	VIEW OF CRAWLERWAY APPROACH TO LAUNCH PAD 39B, FACING NORTH.
FL-8-11-P-5	VIEW OF CRAWLERWAY SEGMENT BETWEEN MAIN EXPANSE AND LAUNCH PAD 39B, FACING SOUTH.
FL-8-11-P-6	DETAIL VIEW OF CRAWLERWAY SIDE SUPPORTS, FACING SOUTHEAST.
FL-8-11-P-7	DETAIL VIEW OF THE CRAWLERWAY AT THE WEST SIDE OF THE VEHICLE ASSEMBLY BUILDING, FACING SOUTHEAST.
FL-8-11-P-8	DETAIL VIEW OF THE CRAWLERWAY TO THE NORTH OF THE VEHICLE ASSEMBLY BUILDING INCLUDING THE MOBILE LAUNCHER PLATFORM REFURBISHMENT AREA, FACING NORTH.
FL-8-11-P-9	DETAIL VIEW OF THE INTERSECTION OF THE MAIN EXPANSE OF CRAWLERWAY AND THE SEGMENT LEADING NORTH OF THE VEHICLE ASSEMBLY BUILDING, FACING NORTHEAST.

FL-8-11-P-10 DETAIL VIEW OF THE CRAWLERWAY AT THE EAST SIDE OF THE VEHICLE ASSEMBLY BUILDING, FACING NORTH.

FL-8-11-P-11 DETAIL VIEW OF THE CRAWLERWAY AT THE EAST SIDE OF THE VEHICLE ASSEMBLY BUILDING, FACING WEST.

FL-8-11-P-12 DETAIL VIEW OF THE INTERSECTION OF THE MAIN EXPANSE OF CRAWLERWAY AND THE SEGMENT TO LAUNCH PAD 39B, FACING NORTHEAST.

FL-8-11-P-13 DETAIL VIEW OF THE CRAWLERWAY TERMINUS AT LAUNCH PAD 39A, FACING SOUTHWEST.

FL-8-11-P-14 DETAIL VIEW OF A REFURBISHED ALABAMA RIVER ROCK SURFACE OF THE CRAWLERWAY, FACING NORTHEAST.

FL-8-11-P-15 DETAIL VIEW OF THE ALABAMA RIVER ROCK SURFACE OF THE CRAWLERWAY AFTER USE BY THE CRAWLER TRANSPORTER, NOTE PARTIALLY CRUSHED ROCK TO LEFT, FACING SOUTH.

FL-8-11-P-16 DETAIL VIEW OF CRAWLER TRANSPORTER TREAD IMPRINTS ON THE ALABAMA RIVER ROCK SURFACE OF THE CRAWLERWAY, FACING NORTHWEST.

FL-8-11-P-17 DETAIL VIEW OF THE CRAWLER PARK SITE, FACING SOUTHWEST.

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Photograph Nos. FL-8-11-P-20 through FL-8-11-P-30 are photocopies of engineering drawings, and are 8” x 10” enlargements from 4” x 5” negatives. Original drawings are located at the Engineering Documentation Office, NASA KSC, Florida.

FL-8-11-P-20 Photocopy of drawing
COMPLEX 39, VOLUME I, CRAWLERWAY AND ADJACENT FACILITIES
NASA, John F. Kennedy Space Center, Florida
Drawing 203-102 VOL 01, NASA KSC, February, 1966
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FL-8-11-P-21 Photocopy of drawing
COMPLEX 39, VOLUME I, CRAWLERWAY AND ADJACENT FACILITIES
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FL-8-11-P-22 Photocopy of drawing
COMPLEX 39, VOLUME I, CRAWLERWAY AND ADJACENT FACILITIES
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NASA, John F. Kennedy Space Center, Florida
Drawing 203-102 VOL 01, NASA KSC, February, 1966
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FL-8-11-P-24 Photocopy of drawing
COMPLEX 39, VOLUME I, CRAWLERWAY AND ADJACENT FACILITIES
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Drawing 203-102 VOL 01, NASA KSC, February, 1966
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FL-8-11-P-25 COMPLEX 39, VOLUME I, CRAWLERWAY AND ADJACENT FACILITIES
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FL-8-11-P-26 Photocopy of drawing
COMPLEX 39, VOLUME II, LAUNCH PAD “A” SUPPORT AREA
NASA, John F. Kennedy Space Center, Florida
Drawing 203-102 VOL 02, NASA KSC, February, 1966
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FL-8-11-P-27 Photocopy of drawing
LC-39 PAD “B” CRAWLERWAY SURFACING, AUDIO/VIDEO CABLES AND MISCELLANEOUS WORK, VOLUME I
NASA, John F. Kennedy Space Center, Florida
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FL-8-11-P-28 Photocopy of drawing
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FL-8-11-P-29 Photocopy of drawing
LC-39 PAD "B" CRAWLERWAY SURFACING, AUDIO/VIDEO CABLES AND MISCELLANEOUS WORK, VOLUME I
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LC-39 VAB CRAWLERWAY SURFACING
NASA, John F. Kennedy Space Center, Florida
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