CAPE CANAVERAL AIR FORCE STATION, LAUNCH COMPLEX 39, SHUTTLE LANDING FACILITY HAER No. FL-8-11-J
(John F. Kennedy Space Center)
Near the southwest corner of the Beach Road/
Kennedy Parkway North intersection
Cape Canaveral
Brevard County
Florida

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,
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HAER No. FL-8-11-J

Location: Near the southwest corner of the Beach Road/
Kennedy Parkway North intersection
John F. Kennedy Space Center
Cape Canaveral
Brevard County
Florida

U.S.G.S. 7.5. minute Orsino, Florida, and Wilson, Florida quadrangles, Universal Transverse Mercator coordinates (center of runway): 17.529870.3165372

Date of Construction: 1974-1978

Architect: Greiner Engineering Sciences, Inc., (also known as J.E. Greiner Company, Inc.), of Tampa, Florida (Phases I and II); Connell Associates, Inc., of Coral Gables, Florida (Mate-Demate Device)

Builder: Morrison-Knudsen, Inc., of Darien, Connecticut (Phase I); Reinhold Construction Company of Cocoa, Florida (Phase II); Beckman Construction Company of Fort Worth, Texas (Mate-Demate Device)

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

Present Use: Aerospace Facility-aircraft landing strip

Significance: The Shuttle Landing Facility (SLF) Historic District, which is comprised of the SLF Runway, the Landing Aids Control Building (LACB), and the Mate-Demate Device (MDD), is considered eligible for listing in the National Register of Historic Places (NRHP) in the context of the U.S. Space Shuttle Program (1969-2010) under Criterion A in the area of Space Exploration and under Criterion C in the area of Engineering. Because it has achieved significance within the past 50 years, Criteria Consideration G applies. Under Criterion A, the SLF Historic District is the site where all five orbiters originally arrived at KSC from their assembly plant in Palmdale, California. It serves as the main landing site for the Shuttle vehicle, or as a return from landing site when weather or other issues necessitated the use of Edwards Air Force Base in California, as the landing facility. The LACB functions as the main organizational hub for fire and rescue operations, security officers, safety and medical teams and other KSC support operations during both Shuttle landing and take-off, in the event of an emergency return-to-launch-site (RTLS) maneuver. In addition, the SLF supports astronaut training. Under Criterion C, the SLF Runway and the MDD were specifically engineered for the Space Shuttle orbiter. The 15,000-foot length of the SLF Runway, excluding the 1,000-foot overruns at each end, was necessary due to the speed, 303 mph, with which the orbiter lands, and the thickness of the Runway, 16" at the center and 15" at the sides, is necessary to accommodate the weight of the orbiter. The MDD was specially designed as a large crane, capable of lifting the orbiter, and has two moveable Access/Service Platforms (A/SP), one per orbiter side, to enable the crew to access the locations where the Space Shuttle orbiter attaches to the Shuttle Carrier Aircraft (SCA).

Project Information: The documentation of the Cape Canaveral Air Force Station, Launch Complex 39, Shuttle Landing Facility was conducted in 2010 for the John F. Kennedy Space Center (KSC) by Archaeological Consultants, Inc. (ACI), under contract to Innovative 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), photographer, Penny Rogo Bailes, and assistant photographer, Nigel Rudolph. Assistance in the field was provided by Shannah Trout, IHA's Cultural Resource Specialist. The written narrative was prepared by Ms. Slovinac; it was edited by Joan Deming, ACI Project Manager; Elaine Liston, KSC Archivist; Barbara Naylor, KSC Historic Preservation Officer; and Ms. Trout. The photographs and negatives were processed by Bob Baggett Photography, Inc.

The Scope of Services for the project, which was compiled 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. The available drawings for the SLF included the "as-built" drawings, as well as those depicting major modification to the facility, or any small modifications that required a set of drawings (such as changes to the electrical or mechanical systems). KSC does not periodically produce drawings of their facilities to show current existing conditions.

Report Prepared by: Patricia Slovinac, Architectural Historian
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Date: April 2011

LIST OF ACRONYMS

A/SP	Access/Service Platform
CCAFS	Cape Canaveral Air Force Station
EAFB	Edwards Air Force Base
ET	External Tank
FAA	Federal Aviation Administration
FOD	Foreign Object Debris
ISS	International Space Station
JSC	Johnson Space Center
KSC	Kennedy Space Center
LACB	Landing Aids Control Building
LC	Launch Complex
MDD	Mate-Demate Device
MSBLS	Microwave Scanning Beam Landing System
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
NRHP	National Register of Historic Places
OPF	Orbiter Processing Facility
OV	Orbiter Vehicle
PAPI	Precision Approach Path Indicator
SCA	Shuttle Carrier Aircraft
SLF	Shuttle Landing Facility
SRB	Solid Rocket Booster
SSME	Space Shuttle Main Engine
STS	Space Transportation System
TACAN	Tactical Air Navigation
U.S.	United States
VAB	Vehicle Assembly Building

HISTORICAL INFORMATION

NASA's John F. Kennedy Space Center

The John F. Kennedy Space Center (KSC) is the National Aeronautics and Space Administration's (NASA) primary Center for launch and landing operations, vehicle processing and assembly, and related programs in support of manned space missions. It is located on the east coast of Florida, about 150 miles south of Jacksonville, and to the north and west of Cape Canaveral, in Brevard and Volusia Counties, and encompasses almost 140,000 acres. The Atlantic Ocean and Cape Canaveral Air Force Station (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.[1]

With the realization that the military's involvement in the space program could jeopardize the use of space for peaceful purposes, President Eisenhower established 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 von Braun, and the Saturn rocket program.[2]

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 Kurt Debus, was transferred to the agency. Several Army facilities at CCAFS were given to NASA, including various offices and hangars, as well as Launch Complexes (LC) 5, 6, 26, and 34. 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

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[1] Charles D. Benson and William B. Faherty. *Gateway to the Moon. Building the Kennedy Space Center Launch Complex* (Gainesville, University Press of Florida, 2001), 1-2.
[2] Benson and Faherty, *Gateway*, 15.

MSFC, officially designating it an independent field installation called the Launch Operations Center.[3]

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 for 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) was born. 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 agent for purchasing the land, which took place between 1962 and 1964. NASA began gaining title to the land in late 1962, taking over 83,903.9 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.[4] 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.[5]

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.[6]

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

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[3] Benson and Faherty, *Gateway*, 136.
[4] Harry A Butowsky. *Reconnaissance Survey: Man in Space* (Washington, D.C.: National Park Service, 1981), 5; Benson and Faherty, *Gateway*, 146.
[5] Butowsky, 5.
[6] Butowsky, 5.

KSC (only LC 39 is still active). Altogether, thirty-two Saturn flights occurred (seven from LC 34, eight from LC 37, and seventeen from LC 39, 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).[7]

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 at KSC. On July 20, 1969, the goal of landing a man on the Moon was achieved when Apollo 11 astronauts Armstrong, Aldrin, and 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, which was the final launch of the Apollo Program.[8]

Skylab, an application of 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.[9]

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. As the first meeting of two manned spacecraft of different nations in space, first docking, and first 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.[10]

On January 5, 1972, President 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

[7] NASA. *Facts: John F. Kennedy Space Center* (1994), 82.
[8] NASA. *Facts*, 86-90.
[9] NASA. *Facts*, 91.
[10] NASA. *Facts*, 96.

the Shuttle in manned flight by 1978, and operational a short time after that."[11] The Space Task Group, previously established by President Nixon in February 1969 to recommend a future course for the U.S. Space Program, presented three choices of long-range space plans. All included an Earth–orbiting space station, a space shuttle, and a manned Mars expedition.[12] 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.[13]

During this speech, President Nixon instructed NASA to proceed with the design and building of a partially reusable 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 shuttle would fly at least fifty times a year, making space travel economical and safe. NASA gave responsibility for developing the shuttle orbiter vehicle and overall management of the Space Shuttle program 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.[14] NASA selected KSC as the primary launch and landing site for the Space Shuttle program. KSC, responsible for designing the launch and recovery facilities, was to develop methods for shuttle assembly, checkout, and launch operations.[15]

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 this orbiter 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

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[11] Marcus Lindroos. "President Nixon's 1972 Announcement on the Space Shuttle." (NASA Office of Policy and Plans, NASA History Office, updated 14 April 2000).
[12] NASA, History Office, NASA Headquarters. "Report of the Space Task Group, 1969."
[13] Dennis R. Jenkins. *Space Shuttle, The History of the National Space Transportation System. The First 100 Missions* (Cape Canaveral, Florida: Specialty Press, 2001), 99.
[14] Jenkins, 122.
[15] Linda Neuman Ezell. *NASA Historical Databook Volume III Programs and Projects 1969-1978*. The NASA History Series, NASA SP-4012 (Washington, D.C.: NASA History Office, 1988), Table 2-57; Ray A. Williamson. "Developing the Space Shuttle." *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program, Volume IV: Accessing Space* (Edited by John M. Logsdon. Washington, D.C.: U.S. Printing Office, 1999), 172-174.

mating with the Boeing 747 Shuttle Carrier Aircraft (SCA) for ferry operations, as well as the orbiter's unpowered landing capabilities.

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 (TPS). *Columbia* spent 610 days in the Orbiter Processing Facility (OPF), another thirty-five days in the Vehicle Assembly Building (VAB) and 105 days on Launch Pad 39A before finally lifting off on April 12, 1981. Flight No. STS-1, the first orbital test flight and first Space Shuttle program mission, ended with a landing on April 14 at Edwards Air Force Base (EAFB) in California. This launch demonstrated *Columbia's* ability to fly into orbit, conduct on-orbit operations, and return safely.[16] *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."

By the end of the Space Shuttle program, a total of 135 missions will have been 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 two decades, the Space Shuttle program 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 rear of the space shuttle cargo bay. It was developed on a modular basis allowing assembly in a dozen arrangements depending on the specific mission requirements.[17] The first Spacelab mission, carried aboard *Columbia* (Flight No. 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.[18] In addition to astronomical, atmospheric, microgravity, and life sciences missions,

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[16] Jenkins, 268.
[17] NASA. *NASA Shuttle Reference Manual* (1988).
[18] STS-90, which landed on 3 May 1998, was the final Spacelab mission. NASA KSC. "Shuttle Payloads and Related Information." KSC Factoids. Revised 18 November 2002.

Spacelab was also used as a supply carrier to the Hubble Space Telescope and the Soviet space station *Mir*.

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 until March 2001.[19] The first approach and flyaround of *Mir* took place on February 3, 1995 (STS-63); the first *Mir* docking was in June 1995 (STS-71). During the three-year Shuttle-*Mir* Program (June 27, 1995 to June 2, 1998) the space shuttle docked with *Mir* nine times. All but the last two of these docking missions used the Orbiter *Atlantis*. 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 to Earth experiment results and unneeded equipment. 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.[20]

On December 4, 1999, *Endeavour* (STS-88) launched the first 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.”[21] STS-96, launched on May 27, 1999, marked the first mission to dock with the ISS. Since that time, most space shuttle missions have supported the continued assembly of the space station. As currently planned, ISS assembly missions will continue through the life of the Space Shuttle program.

The Space Shuttle program 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 Space Shuttle program, concluded “that the drive to declare the Shuttle operational had put enormous pressures on the system and stretched its resources to the limit”.[22] 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

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[19] Tony Reichhardt (editor). *Space Shuttle, The First 20 Year*. (Washington, D.C.: Smithsonian Institution, 2002), 85.
[20] Judy A. Rumerman, with Stephen J. Garber. *Chronology of Space Shuttle Flights 1981-2000*. HHR-70 (Washington, D.C.: NASA History Division, Office of Policy and Plans, October 2000), 3.
[21] Williamson, 191.
[22] Columbia Accident Investigation Board. *Report Volume I* (August 2003), 25.

pressurized flight safety suits during launch and landing operations. Other changes involved reorganization and decentralization of the Space Shuttle program. NASA moved the management of the program from JSC to NASA Headquarters, with the aim of preventing communication deficiencies.[23] 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.[24] 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.[25] The launch of *Discovery* (STS-26) from KSC Pad 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 TPS 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.[26] 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. . .*[27]

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.[28] As part of this initiative, NASA will continue to use the space shuttle to complete assembly of the ISS. The Shuttle will not be upgraded to serve beyond 2010 and, after completing the ISS, the Space Shuttle program will be retired.

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[23] CAIB, 101.
[24] Cliff Lethbridge. "History of the Space Shuttle program." (2001), 4.
[25] Lethbridge, 5.
[26] CAIB, 9.
[27] The White House. "A Renewed Spirit of Discovery – The President's Vision for Space Exploration." (January 2004).
[28] NASA Headquarters. "The Vision for Space Exploration." (February 2004).

Development of the Shuttle Landing Facility

Today, KSC maintains operational control over 3,800 acres, all located in Brevard County. The major facilities are situated within the LC 39 Area, the VAB Area, the Industrial Area, and the Shuttle Landing Facility (SLF) Area. The LC 39 and VAB Areas were developed primarily to support launch vehicle operations and related launch processing activities. They contain two Launch Pads, A and B, the VAB, the Launch Control Center, the OPFs, and other support facilities. The Industrial Area was developed to support administrative and technical functions, spacecraft and payload processing, and also to provide areas in which hazardous operations could be performed on spacecraft components. The SLF Area was established at the outset of the Space Shuttle program to provide runway facilities capable of handling the speed and weight of the orbiter.[29] It is comprised of a landing strip and numerous ancillary features needed for the successful operation of the facility, including a Landing Aids Control Building (LACB); a Mate-Demate Device (MDD); approach and runway lighting; navigational aids; a control tower; weather monitors; and a canal that encircles the Runway.

The SLF was designed and constructed in multiple phases, over a period of roughly six years. Design work for the Phase I activities was completed by the consulting engineering firm of J.E. Greiner Company, Inc. of Tampa, Florida, in December 1973. This first phase included the Runway, the orbiter towway, a parking apron, airfield lighting, and associated utilities.[30] On March 14, 1974, NASA awarded a $21,812,737 contract to Morrison-Knudsen, Inc., of Darien, Connecticut, for the construction of Phase I (see Figure Nos. A-1, A-2). A ground-breaking ceremony was held at the site on April 1, 1974; work commenced immediately afterwards.[31] The initial work included clearing the land of trees, brush, and roots, all of which was either burned or shredded and used as topsoil. Afterwards, a base of cement-stabilized sand was laid to bring the surface of the Runway to 9'-6" above mean sea level. At the same time, electrical ducts and water lines were installed, and settlement basins were formed to deter erosion.[32] On May 22, 1975, the first batch of concrete for the Runway was poured; altogether, more than 9,860 slabs of concrete were installed to finish the landing strip, orbiter towway and parking apron (see Figure Nos. A-3, A-4).[33] Afterwards, roughly 5,000 miles of lateral cross-grooves were cut along the entire Runway using diamond-bladed saws (see Figure No. A-6). The idea of including these

[29] Archaeological Consultants, Inc. (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.* On file, NASA KSC, 2007, 1-4.
[30] J.E. Greiner Company, Inc., Tampa. "Space Shuttle Landing Facility-Phase I." December 10, 1973. On file, Engineering Documentation Center, Kennedy Space Center; "KSC Prepares For New Shuttle Role; LC-39 Construction Will Begin In '74." *Marshall Star* (14, 5), October 10, 1973: 2.
[31] "Work On Shuttle Runway Begins." *Spaceport News* (13, 7), April 4, 1974: 5.
[32] "Phase II Runway Bid Opening Set March 26." *Spaceport News* (14, 5), March 6, 1975: 1 and 2.
[33] "Shuttle Preps Move Ahead." *Spaceport News* (14, 11), May 30, 1975: 1; "Shuttle Landing Facility receives concrete award." *Spaceport News* (45, 2), January 20, 2006: 2.

1/4"-wide x 1/4"-deep grooves, spaced 2" apart, was developed by an engineering team at Langley Research Center, as a way to permit water drainage, and thus, prevent hydroplaning.[34] Phase I construction was officially completed on July 14, 1976, although, the first official landing at the SLF had occurred on May 21, 1976, by then-KSC Center Director, Lee R. Scherer, flying a twin-engine Beechcraft. Scherer "made two touch-and-go approaches before setting the craft down and taxiing it to the apron."[35]

With construction of Phase I underway, design work for Phase II of the SLF was completed by Greiner Engineering Sciences, Inc. (formerly J. E. Greiner Company, Inc.) between late-1974 and 1975.[36] This second phase of development included the LACB (see Figure Nos. A-8, A-9); the MDD foundation and utilities; the Orbiter Landing Instrumentation Facilities, which consisted of four Microwave Scanning Beam Landing System (MSBLS) structures, one Tactical Air Navigation (TACAN) structure, two television towers, and one meteorological site; an electrical power distribution system; a water distribution system; a sewage treatment plant for the LACB; and communications cabling.[37] On March 26, 1975, the bids for the construction of Phase II were opened; the contract, in the amount of $2,376,400, was awarded to Reinhold Construction Company of Cocoa, Florida.[38] Phase II construction work was initiated in April 1975 and was completed on August 26, 1976.[39]

Throughout 1976, the architectural/engineering firm of Connell Associates, Inc., of Coral Gables, Florida, completed the design of the MDD, based on their 1975 plans for a similar structure at NASA's Dryden Flight Research Center, at EAFB, in California.[40] On April 19, 1977, Beckman Construction Company of Fort Worth, Texas, was awarded a $1,733,000 contract to build the MDD at KSC; the contract called for the construction of a concrete foundation and erection of the steel superstructure (see Figure Nos. A-10, A-11).[41] At the top of the MDD, NASA placed a temporary Air Traffic Control Tower, which consisted of a "small cab

[34] "Shuttle Runway To Be Grooviest." *Spaceport News* (13, 7), April 4, 1974: 5 and 7.
[35] Frank E. Jarrett. "Chronology of KSC and KSC Related Events for 1976." KHR-2, November 1, 1977, 36; "Scherer Makes First Runway Landing." *Spaceport News* (15, 11), May 27, 1976: 1. The second official landing was made moments later by KSC Deputy Center Director, Miles Ross, who was flying a Cessna Cardinal aircraft; Jarrett, "Chronology for 1976," 25.
[36] Greiner Engineering Services, Inc., Tampa. "Space Shuttle Landing Facility-Phase II." February 3, 1975. On file, Engineering Documentation Center, Kennedy Space Center.
[37] "Phase II Runway Bid Opening Set March 26." *Spaceport News* (14, 5), March 6, 1975: 1.
[38] "Phase II Runway Bid Opening Set March 26." *Spaceport News* (14, 5), March 6, 1975: 1; "Contract Awarded For Space Shuttle Landing Facility." *Marshall Star* (15, 34), May 7, 1975: 2.
[39] Jarrett, "Chronology for 1976," 36.
[40] ACI. *Survey and Evaluation of NASA-owned Historic Facilities and Properties in the Context of the U.S. Space Shuttle Program, Hugh L. Dryden Flight Research Center (KSC), Edwards, California.* On file, ACI, 2007, pages 6-1, 6-2.
[41] Frank E. Jarrett. "Chronology of KSC and KSC Related Events for 1977." KHR-3, November 1, 1978, 27.

where controllers could stick their heads up and pan around looking for traffic."[42] Construction of the MDD was completed in June 1978. On February 26, 1979, the SLF was officially declared completely operational following a readiness inspection. Less than a month later, on March 24, 1979, the Orbiter *Columbia*, became the first orbiter to land at the SLF, as it was delivered to KSC atop the SCA. This event also marked the first use of the MDD to detach the orbiter from the SCA.[43]

Early in the Space Shuttle program, KSC was declared as the primary landing site for the orbiter upon its return to Earth.[44] However, due to "more stable and predictable weather conditions and a diverse choice of concrete and spacious dry lake bed runways," the earliest missions were scheduled to end with a landing at EAFB.[45] The first mission scheduled to land at KSC was STS-7, in June 1983, but inclement weather in the vicinity forced the orbiter to land at EAFB. The next two missions, the first night landings of the program, also landed at EAFB. Finally, at 7:15:54 am on February 11, 1984, STS-11 landed at the SLF, becoming "the first spacecraft in history to land at the same site from which it was launched."[46] It was around this time, that a more permanent Air Traffic Control Tower was constructed along the east side of the SLF Runway, near the midpoint.

Four of the next six missions ended at the SLF; however, at the conclusion of mission STS-23, on April 19, 1985, the Orbiter *Discovery* experienced extensive brake damage and a blown tire upon its landing roll-out. As a result, landings at the SLF were temporarily suspended.[47] Mission STS-24 in January 1986, was set to be the next orbiter to return to KSC, but inclement weather moved its landing to EAFB. Ten days later, the *Challenger* accident occurred, which not only suspended the Space Shuttle program, but also renewed concerns about SLF Runway conditions following the accident investigation.[48]

In response to the safety concerns, an eighteen month study on the orbiter's tires and landing gear, as well as the Runway surface, was conducted by the Langley Research Center. As a result of this research, a $635,529 contract was awarded to Jensen Construction Company of Des

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[42] Elaine Liston, and Dawn Elliott. *History of the Shuttle Landing Facility at Kennedy Space Center*. Proceedings of the 2003 Space Congress, 2003, 5.
[43] "Final Inspection Made on Three Shuttle Facilities." *Spaceport News* (18, 5), March 2, 1979: 1; Frank E. Jarrett. "Chronology of KSC and KSC Related Events for 1979." KHR-4, September 22, 1980, 26-27.
[44] Aaron Cohen. "Contract NAS9-14000, Space Shuttle Orbital Landing Support Airfields." Memo to George W. Jeffs, October 16, 1973. On file, KSC Archives; Robert F. Thompson. "Terminology for Space Shuttle Landing Airfields." Memo to various staff, May 29, 1974. On file, KSC Archives.
[45] NASA. *NASA Facts: Landing the Space Shuttle Orbiter*. FS-2005-08-026-KSC. August 2005, revised 2006, 1. Due to inclement weather at EAFB, STS-3 landed at the White Sands Space Harbor in New Mexico; Jenkins, 266.
[46] "41-B Rolls into history." *Spaceport News*. (23, 4), February 17, 1984: 2; Jim Ball. "KSC Release: 37-84, Landing the Space Shuttle at Kennedy Space Center." February, 1984. On file, KSC Archives, 1 and 5.
[47] Liston and Elliott, 2-3.
[48] NASA, *Landing the Space Shuttle Orbiter*, 2; Jenkins, 266-267.

Moines, Iowa, in January 1988, for modifications to the SLF. The work included resurfacing a 3,500'-long section at both ends of the landing strip. To resurface these sections, self-propelled grinding machines with diamond blades were used to grind the concrete to a smooth surface, and then cut longitudinal "corduroy" grooves, which were smaller than the original grooves. Other Runway work included in the contract consisted of alterations to the lighting fixtures and repainting the Runway markings.[49] In conjunction with the Runway modifications, safety improvements were made to the orbiters, such as the installation of a drag chute and carbon brakes; an upgrade to the main landing gear and tires; and increased nose wheel steering capabilities.[50] Landings at the SLF resumed on November 20, 1990, with the touchdown of *Atlantis* at the end of STS-38.[51]

In August 1991, Goodson Paving, Inc. of Sharpes, Florida, was awarded a $300,000 contract to resurface the overruns at the SLF. The overruns, which provide an additional safety margin for the orbiter during landing, were originally constructed of a mix of soil, concrete, and limestone. NASA engineers were concerned that the weight of the orbiter could loosen this material and produce foreign object debris (FOD) that could potentially damage the vehicle. The contractors were given seventy-two days to complete the work, which would start with the north overrun. This section was to be repaved with a Federal Aviation Administration (FAA)-approved asphalt/concrete mix before the scheduled landing of STS-48 on September 18, 1991. Afterwards, work on the south overrun would be completed. Additional work undertaken at this time included rebuilding the Runway shoulders and replacing the Runway edge lights and lighting distance markers.[52]

In 1994, a group of engineers from JSC and the Langley Research Center, began a study on runway surfaces. The goal of the study was to increase the acceptable crosswind limits for shuttle landings from fifteen knots to around twenty knots. As part of the research, an Instrumented Tire Test Vehicle was used to evaluate tire friction and wear caused by the different runway surfaces studied.[53] By June 1994, the choices were narrowed down to two, and by September 1994, the entire Runway surface was again being resurfaced.[54] The work entailed abrading the entire

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[49] Barbara Selby and Diane Boles. "Release: 88-10, Contract Awarded for Space Shuttle Landing Facility Modifications." January 22, 1988. On file, KSC Archives; "Runway mods a groovy job." *Spaceport News.* (27, 3), January 29, 1988: 1; Jenkins, 282.
[50] NASA, *Landing the Space Shuttle Orbiter*, 2.
[51] Jenkins, 294.
[52] Karl Kristofferson. "KSC Release: 97-91, Florida Firm to Resurface Shuttle Runway Overruns at KSC." August 12, 1991. On file, KSC Archives; Lisa Malone. "Runway enhancements underway at KSC." *Spaceport News.* (30, 15), August 2, 1991: 1 and 6; NASA, *Landing the Space Shuttle Orbiter*, 2.
[53] Alan Aldinger. "New runway surfaces being studied." *Spaceport News.* (33, 10), May 20, 1994: 1 and 8.
[54] Ken Nail, Jr.. "Chronology of KSC and KSC Related Events for 1994." Technical Memorandum 110447, January 1995. On file, KSC Archives, 102-103; "Runway treatments narrowed down to 2." *Spaceport News.* (33, 12), June 17, 1994: 1; "Resurfacing in progress." *Spaceport News.* (33, 19), September 23, 1994: 1.

Runway using a Skidabrader machine, which propelled "tiny steel shot onto the Runway to pulverize the rough surface and create a much smoother finish."[55]

Since then, a few other enhancements have been made to the SLF. In 1996, the electrical substations for the outer Precision Area Path Indicator (PAPI) lights were replaced, and in 1997, new FAA-approved centerline lights, which had been requested by the astronauts for aid in night landings, were installed within the Runway.[56] In 2000, a reusable launch vehicle hangar was constructed along the orbiter towway, followed by a Convoy Vehicle Enclosure in 2001, and a new flight vehicle support building in 2002. Finally, from 2003 to 2004, the SLF received a new, state-of-the-art, Air Traffic Control Tower.[57]

SLF Functions

The SLF, whose official name is "Kennedy Space Center Shuttle Landing Facility," is considered a fully functioning airport, with its own FAA locator designation of "X-68."[58] Its primary function is to serve as a landing facility for the orbiter upon its return to Earth; of the 132 missions that have flown to date, seventy-five have landed at KSC.[59] The SLF Runway is also activated during shuttle launch procedures in the event of an emergency return-to-launch-site landing. In between Space Shuttle launches and landings, the SLF is used for astronaut training, in both the Gulfstream II Shuttle Training Aircraft and the smaller T-38 trainers. Historically, the SLF was also used by the SCA, when it delivered the orbiters to KSC from Palmdale for their maiden flights; when it carried the orbiters back to KSC from a landing at EAFB; or when it transported the orbiters between KSC and Air Force Plant 42 for Orbiter Maintenance Down Periods or Orbiter Major Modifications. In addition, the SLF is used to support military and civilian cargo aircraft; NASA and U.S. Government passenger flights; NASA and Air Force search-and-rescue helicopters; and, more recently, commercial spaceflight training, and research by NASCAR and Formula 1 racing teams.[60]

All of the daily activities that occur at the SLF are controlled by a dedicated group of personnel housed within the LACB Operations Suite, which consists of an Operations Center and a Flight Planning Room. The Flight Planning Room provides an area where SLF personnel can work

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[55] Nail, "Chronology for 1994," 102.
[56] "New SLF centerline lights help guide Discovery home." *Spaceport News* (36, 4), February 28, 1997: 1.
[57] Space Gateway Support. *CCAFS/KSC Basic Information Guide*. KSC-CCAFS-6747, Revision B, January 2006. On file, Kennedy Space Center, 3-9 through 3-11; "Bigger is better at Shuttle Landing Facility." *Spaceport News.* (43, 3), January 30, 2004: 6.
[58] Liston and Elliott, 1 and 4.
[59] Fifty-four missions have landed at EAFB and one landed at White Sands Space Harbor; two missions ended with the loss of the vehicle.
[60] Liston and Elliott, 4; Steven Siceloff. "Shuttle Landing Facility team ready for anything." *Spaceport News* (49, 24), November 27, 2009, 5.

with astronauts, pilots, and ground crews to coordinate and schedule the use of the SLF Runway, not only for orbiter landings, but also for astronaut training flights, orbiter transport flights, commercial flights, and cargo flights. In addition, the Flight Planning Room can be used by astronauts, pilots and other flight crews, as a rest area in between their flights. During Space Shuttle launch and landing procedures, the LACB serves as the main organizational hub for astronauts flying T-38s on weather reconnaissance missions, KSC and Air Force fire and rescue teams, security officers, safety and medical groups, and other KSC support operations. In support of this work, the Operations Center contains various computer consoles, visual displays, and communications equipment that allow SLF technicians to monitor all activities, and relay pertinent information to the appropriate parties. Also included in this room is a replica of the equipment within the Air Traffic Control Tower, in the event of problems within the tower.[61]

All of the personnel who are stationed at the LACB are also Air Traffic Controllers, and as such, work shifts at both the Operations Center and the Air Traffic Control tower. Twelve controllers are included in the SLF staff, with four or five working per shift. They, and other SLF personnel, also take turns performing routine inspections of the Runway and its various components, and coordinate all maintenance activities as necessary. The SLF personnel are also responsible for monitoring wildlife activity within the SLF Area, and deploying the air cannons and other wildlife control as necessary during landing operations to clear the vicinity of animals and birds. In addition, they control all access into and out of the SLF Area, as well as access to all SLF components.[62]

Typical Shuttle Landing Procedures

Throughout an entire mission, weather conditions at KSC are monitored by the Spaceflight Meteorology Group at JSC. Considered part of the National Weather Service, they work with the Range Weather Operations at CCAFS to prepare landing forecasts, using data gathered by instrumentation within the SLF Area, throughout the remainder of KSC, and at CCAFS. About five hours before touchdown, when the shuttle's crew begins to prepare the orbiter for its return to Earth, other NASA astronauts begin to fly reconnaissance planes along the planned landing approach to assist in the evaluation of weather conditions.[63] Based on the Spaceflight Meteorology Group's evaluation of the weather data, Flight Controllers at the Mission Control Center at JSC decide if the orbiter will land at the SLF, and which of the two runway approaches (Runway 15 from the northwest or Runway 33 from the southeast) will be used. Weather that

[61] Larry Parker. Personal communication with Patricia Slovinac, April 12, 2010; NASA, *Landing the Space Shuttle Orbiter*, 5; R.M. Gramling. "Space Shuttle Landing Facility, Phase II Construction Plans, 30% Design Review." Memo to B.R. McCullar, August 2, 1974. On file, KSC Archives.
[62] Parker.
[63] NASA, *Landing the Space Shuttle Orbiter*, 1; Anna Heiney. "Landing 101: How the Space Shuttle makes its safe return to Earth." *Spaceport News* (44, 18), August 19, 2005, 3; NASA KSC. *Landing the Space Shuttle Orbiter at KSC*. KSC Release No. 1-92, Revised October 1995, On file, KSC Archives, 7.

dictates if a landing at the SLF is possible includes the amount of observed cloud cover below 8,000', the range of visibility, crosswind speeds, and if there are thunderstorms in the vicinity.[64] The Flight Controllers use the wind direction and the angle of the sun to determine which runway approach will be used. In ideal conditions, the orbiter will land into the wind, and the sun will be outside of the pilot's field of view.[65] A final "go/no go" or location decision occurs ninety minutes prior to the landing, or approximately thirty minutes prior to the deorbit burn.[66]

Roughly two hours before touchdown, the Orbiter Recovery Convoy begins their preparations at the SLF. The Convoy consists of approximately twenty-five specially designed vehicles and units, and 150 trained personnel, who will perform safing operations, assist the crew in leaving the vehicle, and prepare the orbiter for transfer to the OPF. Typically, the initial preparations include assembling all personnel and vehicles at the Recovery Convoy Staging Area to the east and near the midpoint of the Runway, and making sure everyone is properly attired (see Figure No. A-21).[67] Also around this time, SLF personnel begin to periodically fire the air cannons and circle the runway perimeter to clear the area of wildlife; other technicians walk along the Runway to check for FOD that could potentially damage the orbiter. The walking activities continue until roughly fifteen minutes before landing, while the air cannons will be regularly fired until touchdown.[68]

Approximately one hour before touchdown, the orbiter performs the deorbit burn. About twenty-five minutes before landing, the vehicle begins to pass through the reentry blackout period, from which it emerges roughly twelve minutes before touchdown. At this point, the orbiter is roughly 550 miles from the SLF, at an altitude of about 34 miles (179,520'). When the vehicle is over the Gulf of Mexico (within 300 miles of the Runway and at an altitude of no more than 145,000'), the SLF's TACAN system begins to communicate with the vehicle, providing azimuth and distance measurements to the on-board computers. About two minutes prior to touchdown, when the orbiter is approximately 10 miles from the designated Runway approach and at an altitude of roughly 15,500', the MSBLS system takes over for the TACAN system, to provide more precise guidance signals on slant range, azimuth, and elevation to the orbiter.[69]

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[64] Jim Ball. "KSC Release: 37-84, Landing the Space Shuttle at Kennedy Space Center." February, 1984. On file, KSC Archives, 5. Depending upon the weather conditions and how many days the orbiter has been in space, Flight Controllers can decide to attempt a landing at the SLF later in the day or over the next day or two, or just have the orbiter land at EAFB.

[65] Ball, 7; NASA KSC. *Landing the Space Shuttle*, 7.

[66] Since the orbiter reenters the atmosphere and lands in an unpowered, high-speed glide, once the deorbit burn is performed, the orbiter must land; where the deorbit burn occurs is dictated by the landing site chosen.

[67] NASA KSC. "Shuttle Landing Facility (SLF)." Revised October 6, 1993; NASA, *Landing the Space Shuttle Orbiter*, 7; Ball, 9.

[68] NASA, *Landing the Space Shuttle Orbiter*, 5; Ron Feile. Personal communication with Patricia Slovinac, April 12, 2010.

[69] The MSBLS can also "electronically acquire and guide the orbiter to a completely 'hands off' landing," if necessary. NASA, *Landing the Space Shuttle Orbiter*, 6; Ball, 7.

As the orbiter approaches, the commander and pilot use two different visual aids to ensure that the vehicle is at the proper angle. The first of these are the two sets of PAPI lights that are located roughly 6,500' and 7,500' from the Runway's threshold. The PAPI lights help the crew visually confirm if they are on the correct outer glide slope[70] for the orbiter, which is between 18 and 20 degrees, by the color of the light. If all of the lights are white, the vehicle is above the glide slope, and if they are all red, it is below the glide slope. Both red and white lights are seen when the vehicle is on the correct outer glide slope. Similarly, each approach has a Ball-Bar system that is used by the commander as a visual reference to determine if the orbiter has the proper inner glide slope (1.5 degrees).[71] This system is comprised of a line of twenty-four red lights (the "bar") placed roughly 1,700' from a group of three white lights ("ball"). When the white ball is below the red bar, the vehicle is above the glide slope, and likewise, when the ball is above the red bar, the orbiter is below the glide slope. When it is on the correct glide slope, the ball is superimposed on the bar.[72]

The orbiter touches down at roughly the 2,500' mark on the Runway with its main landing gear, traveling at a speed of roughly 213 to 216 miles per hour. Roughly one-and-a-half seconds later, the pilot chute is deployed, followed by the main drag chute about two-and-a-half seconds after touchdown. About six seconds after the initial landing, after the orbiter has slowed down to about 184 miles per hour, the pilot brings the nose landing gear to the runway. As the vehicle continues to slow down, the nose wheel is the primary control system for keeping it in the proper alignment. Once the orbiter has slowed to about thirty miles per hour, the drag chute disconnects from the vehicle, and the vehicle is brought to a stop using its brakes.[73]

Once the orbiter has come to a complete stop, the Orbiter Recovery Convoy (see Figure No. A-22) begins their work. First, a safety assessment team, fitted with special suits and breathing attire, checks vapor readings and tests for explosive and toxic gases, at a distance of about 1,250' from the orbiter. Once they have declared the area clear, the special Purge and Coolant Umbilical Access Vehicles are brought in behind the orbiter, where they check for hydrogen vapors. If hydrogen is detected (which has never happened), the crew is immediately evacuated and the convoy personnel are cleared from the area. If there is no hydrogen, the umbilicals are connected and the vehicle is purged with air to remove any residual explosive or toxic fumes. All of this occurs within forty-five to sixty minutes following full stop.[74]

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[70] A glide slope is defined as the proper path of descent for an aircraft. The outer glide slope is the orbiter's angle of descent until its final preflare around seventeen seconds before touchdown.
[71] The inner glide slope is the orbiter's angle of descent following the final preflare.
[72] NASA KSC. *Landing the Space Shuttle*, 6; Ball, 7-8; NASA, *Landing the Space Shuttle Orbiter*, 6.
[73] NASA KSC. *Landing the Space Shuttle*, 6.
[74] NASA KSC. *Landing the Space Shuttle*, 7.

When it has been determined that the area in and around the orbiter is clear, the crew egresses from the crew compartment into a crew transport vehicle.[75] Afterwards, a crew of support personnel enters the vehicle to prepare it for towing operations, which includes installing switch guards and removing experiments. Outside of the vehicle, other personnel install landing gear lock pins, disconnect the nose landing gear drag link, and position the towing vehicle in front of the orbiter, to which it is then connected with a tow bar. Approximately four hours after landing, the orbiter is towed from the Runway, along the orbiter towway, and to the OPF.[76]

Orbiter/Shuttle Carrier Aircraft Mate-Demate Operations

The SCA was used to deliver all five operational orbiters (*Columbia, Challenger, Discovery, Atlantis,* and *Endeavour*) from their manufacturing facility in Palmdale, California, to KSC. In addition, it carried the orbiter prototype *Enterprise* to KSC for various fit checks and facility tests. It was also used to return the different orbiters to KSC when they landed at EAFB, at the beginning of the program, and then periodically when weather or other issues necessitated the use of the Edwards facility for landing. It also carried the orbiters to and from Palmdale, until 2001, when the manufacturing facility was still used for routine maintenance or significant modifications on the orbiters. The MDD at the SLF was specially designed and built to provide structural support for the mate (attachment) and demate (detachment) of the orbiter and the SCA.[77]

The mate and demate processes are relatively straightforward, and are essentially opposite of one another.[78] In the case of a demate operation, the first step is for the SCA to taxi from the Runway to the parking apron, where it aligns itself with the center of the MDD (see Figure No. A-23). A tug is then attached to the front of the SCA, and pulls the vehicle into position within the MDD, where technicians secure the aircraft to in-grade tie-down posts. Once this is complete, a set of telescoping posts are attached to the orbiter slingback, to provide additional stability for lifting and lowering operations. Then, the x-y motors, located at the 80’-0” Level of the structure, are used to fine-tune the position of the slingback with respect to the orbiter. Afterwards, small winches are used to pull the four slings outward from the vehicle, so that as the slingback is then lowered, it can envelope the orbiter without damaging it (see Figure No. A-24).

Once the slingback is in position, the appropriate access platforms are moved into place. This includes positioning the Access/Service Platforms (A/SPs) at the 40’-0” Level of the MDD, as well as rotating the nose access platforms at this level into their use position. While the slings are still pulled away from the orbiter, the position of the slingback is fine-tuned a second time,

[75] It is at this point when responsibility for the vehicle passes from JSC to KSC. NASA KSC. *Landing the Space Shuttle,* 8.
[76] NASA KSC. *Landing the Space Shuttle*, 8.
[77] ACI, *Kennedy Space Center*, 6-25, -26; NASA, *Landing the Space Shuttle Orbiter*, 5.
[78] Ray Zinc. Personal communication with Patricia Slovinac, April 14, 2010.

through the x-y motors. The slings are then brought tight and attached to the orbiter. When this action is complete, the orbiter is detached from the SCA, and is lifted to the “40 knot position” (approximately 60’ above grade), where it is held while the SCA is rolled back from the MDD.

Once the SCA has cleared the vicinity, the A/SPs are raised to the 60’-0” Level of the MDD, so the technicians can use them to access a hydraulic plug that releases the orbiter’s landing gear. After the landing gears are locked into place, the hoists and slingback lower the orbiter to the ground (Figure No. A-25). Then, the A/SPs are lowered to the 20’-0” Level of the MDD, so that the slingback can be detached from the orbiter. Afterwards, the slingback is raised, and the tug is brought in and attached to the vehicle, which it then moves across the parking apron (see Figure No. A-26) to the orbiter towway, from which it is then taken to the OPF.[79]

[79] Zinc.

Physical Description

Shuttle Landing Facility

The SLF (Photo No. 1) Historic District is a roughly 1,200-acre complex, located approximately three miles to the northwest of the VAB. The three features that provide the historic significance for the District are the SLF Runway, the LACB, and the MDD. Additional noncontributing elements within the SLF Historic District include a water canal that encircles the entire Runway; a parking apron located to the east of the south end of the Runway, to which it is connected by a "L"-shaped taxiway; an equipment shed off of the south side of the parking apron (ca. 1993), and a media operations building (ca. 2004) and air traffic control tower (ca. 2003) to the east of the SLF Runway's midpoint. There is also an orbiter towway, which extends southeasterly from the bend in the taxiway and is located outside of the SLF boundaries.

SLF Runway

The SLF Runway (Photo Nos. 2 through 12) measures 15,000' in length, 300' in width, and has a thickness that ranges from 16" along the centerline to 15" at the edges. The entirety is constructed of poured concrete; the surface slopes at 0.76 degrees downward from the center line to each edge for run-off purposes. The Runway extends along a northwest to southeast axis that is aligned at a 60-degree angle to the polar east-west axis (Photo No. 92). Like typical commercial airport runways, it is essentially one landing strip that serves as two runways, each of which is given its own number based on the direction of approach. The landing strip is designated as Runway "15" when the orbiter is traveling towards the southeast; but it is called Runway "33" if the vehicle is approaching towards the northwest.

To both the east and west sides of the SLF Runway, there is a 50'-wide concrete shoulder, with a thickness of 12". The west shoulder extends for the entire length of the Runway, while the east shoulder ends roughly 340' from the south end of the Runway, to compensate for the taxiway. At both the north and south ends of the SLF Runway is a poured concrete/asphalt overrun (Photo Nos. 17, 18), each of which measures 1000' in length, 300' in width, and has a thickness of 14". Beginning at the center of the outer edge of each overrun is a roughly 2,040'-long, 8'-wide, asphalt access road (Photo No. 18). Surrounding the Runway, overruns, and half of each access road, is a man-made canal (Photo No. 9), which has an approximate width of 50' for the south, east, and north sections; the west section varies in width from roughly 50' to 315'.

The SLF Runway is fitted with numerous landing aids, including pavement markings, lighting systems, weather monitors, and navigational aids. Most are typical of commercial airports, but a few are Space Shuttle program-specific, as noted below. These features are used to not only assist the astronauts in landing the orbiter, but also pilots who are flying cargo planes or other such aircraft. All of the landing aids systems are capable of supporting both runway approaches.

The SLF Runway features a variety of standard runway markings, all of which use industry standard paint containing reflective beads. The first of these markings is a continuous band along the centerline of the Runway (Photo No. 10). The end points of this line are located roughly 315' into the Runway from the north and south thresholds (Photo No. 11). Each end begins with a roughly 120'-long white line; the color of the line then alternates between 75'-long black segments and 120'-long white segments. Other markings that extend along the entire Runway include a white painted band with black edges that denotes the centerline of each half (east and west) of the Runway (Photo No. 10); a wider, white painted band with black edges, which marks the central 150' of each threshold (Photo No. 6); and two white painted strips (roughly 25' apart) within each shoulder that indicate ground vehicle driving lanes. The remainder of the painted markings are grouped within the initial 3,100' at each end of the Runway and within each overrun.

The overruns are distinguished from the main landing strip not only by the lack of shoulders, but also by alternating yellow and black painted chevrons (Photo No. 17). The yellow chevrons are contained within the central 150' of each overrun surface; the black chevrons extend to the edges. Aside from the painted band noted above, each of the SLF Runway's thresholds are marked on either side of the centerline by a group of six, 7'-wide x 150'-long, painted white lines with black edges (Photo No. 11); an unpainted, roughly 3'-wide band separates each line. Approximately 210' into the Runway from the threshold, the runway designations of "33" at the southeast end (Photo No. 14) and "15" at the northwest end (Photo No. 13) are painted on the concrete. The numbers are roughly 60' in length; the "33" is about 55' in width and the "15" is approximately 40' in width. Each number is white with black edges.

Beginning 500' into the Runway from each threshold and extending to the 3,100' mark, are a series of touchdown zone markings, spaced at 500' intervals. The first touchdown zone is marked by three painted lines on each side of the Runway; each line is 75' in length and 7' in width. The second touchdown zone is designated by a large rectangle (30'-wide and 150'-long) on either side of the centerline. The third and fourth touchdown points are marked by two painted lines on each side of the Runway; each line is the same length and width as those of the first touchdown point. The fifth and sixth touchdown zones are marked with a single line, 75' in length and 7' in width, on either side of the Runway. All of these markings are typical of commercial airports, and are used by pilots who are flying cargo planes, passenger planes, or helicopters. At the fifth touchdown zones, which are roughly 2,500' from each threshold, is one of the Space Shuttle-specific attributes of the SLF Runway: a pair of large, 40'-wide x 200'-long, black rectangles that indicate the orbiter's touchdown point (Photo No. 15). The inner edge of each rectangle is approximately 55' from the painted centerline.

The SLF Runway is fitted with two different navigational aids for assisting the Space Shuttle's landing, a Tactical Air Navigation (TACAN) system, which is also used by the military, and a Microwave Scanning Beam Landing System (MSBLS), which is specific to the Space Shuttle.

Due to the different natures of the systems, only one TACAN site is needed to cover the entire landing strip, but each runway approach contains its own MSBLS complex. The TACAN equipment is located off of F Avenue NW, roughly 1,700’ from the centerline, and approximately 3,700’ from the north end of the Runway. It is typically accessed from Kennedy Parkway North. This small complex consists of a signal tower and a 20’ x 10’ equipment building (Photo No. 31). The MSBLS equipment for each of the runway approaches is located to the west side of the Runway, and is comprised of two stations. The first station, which consists of an azimuth/distance monitor and its associated equipment building (Photo No. 32), is located along the access road, approximately 300’ outward from the end of the overrun. The second part of each MSBLS station is situated roughly 3,400’ into the Runway from each threshold and 85’ from the outer edge of the shoulder, and includes an elevation monitor and its associated equipment building.

Another key feature of the SLF Runway is the lighting system, which like the painted markings, typically follows FAA standards. Each runway approach has an identical lighting system, which begins roughly 7,500’ from the Runway’s threshold. At this location, there is a set of four PAPI lights (Photo No. 29) that are oriented to face the approaching vehicle. A small electrical substation, situated at the east end of this line, powers both these lights and a second set of four PAPI lights, which are located 6,500’ from the end of the Runway (Photo No. 28). Each of the individual lights has three lamps, arranged in a horizontal line (Photo No. 30). Additionally, each runway approach has a third set of four PAPI lights, which are located roughly 2,000’ into the Runway from the threshold; those for the southeastern approach are situated off of the west shoulder of the Runway, while those for the northwestern approach are on the east side of the Runway (Photo No. 21).

Approximately 3,000’ out from each threshold, the runway’s main approach lighting system begins; it ends about 1,000’ into the Runway (Photo Nos. 24, 25). For the 2,000’ prior to the overrun, the system consists of groups of five, constantly lit, above-grade fixtures with one sequential flasher in the middle (Photo No. 26). The groups of lights are spaced roughly 100’ apart, providing for a total of twenty groups, or 100 lights and twenty flashers. The beginning of each overrun is marked by a line of twenty-one, partially in-grade light fixtures, arranged so that there is a group of five in the center, with a group of six to either side. A second such line of lights is positioned at the midpoint. Across the remainder of each overrun, there are eight lines of lights, spaced 100’ feet apart, which consist of a center group of five lights, with a group of three lights to either side (Photo No. 22). The five center lights give off white light, while the side lights produce red light. For roughly 1,000’ in from each runway threshold, the approach lighting system continues, comprised of fully in-grade lighting fixtures, spaced 100’ apart, and arranged in two groups of three lights, one group on either side of the centerline.

In conjunction with the PAPI lights and the approach lighting system, the SLF Runway has additional lighting features to assist the pilots in landing their aircraft. One such feature is the in-grade lights that extend along the centerline (from threshold to threshold), and are spaced roughly 50’ apart (see center bottom of Photo No. 10). In addition, each runway threshold is marked by a line of seventy-nine, partially in-grade light fixtures, that extends for 45’ into the shoulders (Photo No. 16). Near the orbiter touchdown point and the threshold, along the west side of the landing strip for Runway “33” and the east side for Runway “15”, are the bar-on-ball lights (see left side of Photo No. 16). The “bar” lights are comprised of twenty-four red lights near the touchdown point; the ball lights are a group of three white lights near the threshold. The last Runway lighting feature is the set of eight xenon search lights at each approach, which are only used during night landings (Photo No. 23). These lights, each of which produces roughly one billion candlepower, are located roughly 300’ from the end of each overrun, and are split into two groups of four, one group to either side of the access road. A large flatbed trailer holds each group of lights. The lights are oriented so that the light is shining in the same direction in which the orbiter is approaching the Runway.

The SLF Runway has additional features to assist in its function of safely landing the Space Shuttle orbiter. Along both sides of the landing strip are lighting number signs, from “1” to “15”, which shows the pilot how many thousands of feet of runway are remaining (Photo No. 19). Spaced around the Runway are numerous solar-powered air cannons (Photo No. 20) that are set-off periodically before the landing of an aircraft to scare birds out of the vicinity. Finally, various meteorological devices are scattered around the Runway and its vicinity to monitor the weather conditions.

Landing Aids Control Building

Exterior

The LACB is a one-story, rectangular structure located at the southeast corner of the SLF parking apron. It has approximate overall dimensions of 80’ in length (north-south), 58’ in width (east-west), and 17’ in height. The walls of the facility are composed of concrete block, with poured concrete columns. The entirety has a poured concrete slab foundation and a flat, built-up roof, which contains six, 7’-long antenna poles and five weatherheads.

The north elevation (Photo Nos. 41, 47) is considered to be the principal façade of the facility. The main entrance, which consists of a pair of one-light metal swing doors, is situated at the center of the elevation. It is accessed by a concrete stoop that features three concrete steps on its west side, and an inclined ramp on its east side; its north end serves as a loading dock. To the west of the entrance, there are two, 4’ x 7’ fixed windows that correspond to the Operations Center. Each window is fitted with a metal frame and a projecting concrete sill. Below the windows is an expanse of electrical conduit with two junction boxes. The east half of the elevation contains two, 4’ x 3’ windows, also with metal frames and projecting concrete sills. In between these windows is an access ladder to the roof.

The west elevation of the LACB (Photo Nos. 42, 43) also features two, 4’ x 7’ fixed windows that correspond to the Operations Center. Like those on the north elevation, these two windows have metal frames and projecting concrete sills. Towards the south end of the façade, there is a 4’ x 4’ fixed window and a 4’ x 6’ fixed window; each is fitted with a metal frame and a projecting concrete sill. At the south end of the wall, just below the roof line, there is a 5’ x 6’ ventilation louver, which corresponds to an equipment room. In the center of the west elevation hangs a plywood representation of the SLF’s emblem. Other features of this facade include utility pipes and electrical outlets and conduit.

The south elevation of the LACB (Photo Nos. 43-45) contains two entranceways, one located in the center and the other at the east end. The central opening is comprised of a pair of one-light metal swing doors that is accessed via an inset porch with three concrete steps. The entry at the east end is a single, one-light metal swing door with a small concrete threshold. Other features of this elevation include lines of electrical conduit, numerous electrical panels, and utility pipes. The east elevation of the building (Photo Nos. 45-47) features a pair of one-light metal swing doors towards the north end, which is accessed by an inset porch with three concrete steps. Additionally, there are two downspouts, various utility pipes, and electrical conduit and panels, located along the wall.

Interior

The internal layout of the LACB is based on a double-loaded corridor plan. Its primary corridor extends across the entire length of the building, from the main entrance on the north elevation to the pair of metal swing doors on the south elevation (Photo No. 99). Roughly 20’ from the north end of this corridor, a second hallway branches off, ending at the pair of doors on the east elevation. These two corridors divide the fifteen rooms within the LACB into three clusters. To the west of the main corridor is a line of five rooms, and to the east of this corridor, there is a group of four rooms to the north of the side hallway and a cluster of six rooms to the south of the side hallway.

The group of four rooms at the northeast corner of the facility includes the men’s restroom and a janitor’s closet that are both accessed from the main corridor, and a women’s restroom and a work control center that are reached from the side hallway. Across from the latter two rooms are a conference room to the east (previously the meteorological equipment room), and a communications storage room to the west. To the south of these two rooms is the communications equipment room, which can be accessed from either the main corridor or the communications storage room. At the south end is a cable terminal room at the east and a timing and countdown room and administrative telephone room to the west. The cable terminal room is solely entered from an exterior doorway on the south elevation. The line of five rooms to the west of the main corridor are, from south to north, an airfield lighting control and power room, a television and wideband maintenance and storage room, the television equipment room, and the operations suite.

The operations suite is the area of the LACB that gives the building its historic significance. Situated at the northwest corner of the facility, the suite contains two rooms, the Operations Center to the north, and the Flight Planning Room to the south. The Operations Center (Photo Nos. 48-50), which measures approximately 23’ in length and 20’ in width, has painted masonry drywalls, a raised floor, and an acoustical tile ceiling. It is entered from the main corridor through a pair of one-light metal swing doors, located on its east wall. There are two windows on both the north and west walls, which are positioned to enable the staff to monitor the SLF Runway, as well as the MDD. Below the windows on the west wall are two monitoring consoles; a counter with computer stations extends along the north wall below the windows. There are also computer and radar screens located along these walls. In the center of the room are clusters of work stations, with another work station and a white board along the south wall.

The Operations Center and the Flight Planning Room are separated by a partial, full-height wall to the west, and a counter to the east; the latter allows SLF technicians (within the Operations Center) to directly interact with astronauts or pilots in the Flight Planning Room. The Flight Planning Room (Photo No. 50) has approximate overall dimensions of 23’ in length and 16’ in width, and has gypsum board walls, a carpeted floor, and an acoustical tile ceiling. The room is entered through a single, one-light metal swing door on its east wall that opens off of the main corridor. Internally, this room features sofa-style seating along the east, north, and south walls.

Mate-Demate Device

The MDD (Photo Nos. 51-59), which is essentially a large, stationary crane, is located at the northeast corner of the SLF parking apron. It is an open-truss structure with approximate overall dimensions of 105’-6” in the east-west direction, or x-axis, 93’ in the north-south direction, or y-axis, and 107’ in height, or z-axis. The entirety rests on a poured concrete foundation and is composed of a steel I-beam skeleton, with open-grate steel flooring. The structural base of the MDD is comprised of two towers and a horizontal support frame. The towers are aligned with one another along the facility’s y-axis; the east end of the horizontal support frame is mounted between them from the 80’-0” to 100’-0” Levels. This layout creates a “T-shaped” plan when viewed from above (see Photo No. 109), an upside-down “U” for the east and west elevations (see Photo Nos. 51, 55), and a rotated “L” for the north and south elevations (see Photos 53, 57).

The horizontal support structure (see Photo Nos. 52, 58), which is fitted with diagonal bracing, has approximate dimensions of 98’-6” along the x-axis, 34’ along the y-axis, and 27’ in height. This structural component has two access levels, at 80’ and 100’ above grade (Photo Nos. 84 and 85, respectively), that are fitted with a series of catwalks. These 2’-6”-wide catwalks are strategically placed to allow technicians access to the MDD equipment components at these levels. Each of the two cross-braced towers (see Photo Nos. 54, 56) measures 30' in both length and width. They maintain these dimensions up to the 80'-0" Level, where a brace extends from the outer edge of the tower, diagonally to the 100' mark on the inner face of the tower (see Photo Nos. 55, 108).[80] Each tower has a set of U-shaped metal stairs on its east side that provides access to all levels of the MDD. The towers each contain five access levels, at 4'-0", 20'-0", 40'-0", 60'-0", and 80'-0" above grade. The 4'-0", 20'-0", and 40'-0" Levels (Photo Nos. 71, 73, 77) of the two towers extend for the full 30' x 30'; the 60'-0" and 80'-0" Levels of each tower are comprised of a series of catwalks (Photo Nos. 82, 84).

The key feature of the MDD is the orbiter slingback and its associated hoists, which are used to lift and lower the orbiter. The orbiter slingback (Photo No. 60) is a steel box-frame structure that has approximate dimensions of 61' in length (x-axis), 22' in width (y-axis), and 20' in height. At each corner, it has a vertical sling that corresponds to an orbiter attachment point: the two at the east end are for the forward part of the orbiter, while those at the west end correspond to the aft portion. The slings are supported at the top by a rectangular, cross-braced frame, with a stabilizing truss on the east end. This truss helps support the forward crane attachment point, which is located at the top center of the east beam. There are two aft crane attachment points, one on top of each aft sling. Each of these is fitted with one 55-ton crane hook (see Photo No. 64), whose cables extend vertical to a sheave mounted to the underside of the 100'-0" Level (Photo Nos. 68, 69). There, each sheave reorients the cables so that they travel horizontally to a second sheave (Photo No. 70) at the east end of the horizontal support frame. Here, each set of cables is then redirected down to one of three main hoist motors at the 4'-0" Levels of the towers (Photo No. 71). The motor for the forward hook and the left aft hook are situated within the north tower; the motor for the right aft hook is within the south tower. The crane motors are controlled from a small shack that sits at the northwest corner of the north tower (Photo No. 72).

Another prominent feature of the MDD is the two Access/Service Platforms (A/SP), one for each side of the orbiter (Photo No. 86). Each A/SP measures approximately 78' in length, 9' in width, and 12' in height, and is suspended from the horizontal support frame with two telescoping support tubes. These tubes allow the platform to be raised and lowered between the 20'-0" Level (Photo No. 105), known as the "jack position," i.e., when the orbiter is on the ground, and the 60' Level, referred to as "40 knot position," i.e., when the orbiter is suspended above the SCA.[81] Each of the four telescoping legs is raised and lowered by its own hoist; all four of the hoists are located on the 100'-0" Level of the MDD (Photo No. 88). The control boxes for these hoists are located at the 40'-0" Level of the two towers (Photo No. 89). At the east end of each A/SP is an adjustable ramp, which provides access between the platform and the 20'-0", 40'-0", and 60'-0"

[80] For reference, the inner face refers to the side of the tower that abuts the orbiter, i.e., the north side for the south tower and the south side for the north tower.
[81] When the orbiter is attached to the SCA, the A/SP platforms are situated at the 40' Level of the MDD, see Photo No. 106.

Levels of the MDD. Each A/SP also contains eleven hinged platforms, six at the forward end, and five at the aft end, all of which are shaped around the orbiter (Photo No. 87).

Other features of the MDD include various access platforms at the different tower levels. The first set of platforms is a pair of nose access platforms that is suspended below the 20’-0” Level, at roughly 15’-7” above grade (Photo No. 74). The south platform measures roughly 30’ in length and 15’ in width, and the north platform is roughly 18’ in length and 15’ in width; both are formed with steel beams and open-grate metal flooring. The outer edge of each is attached to one of the towers through a rotating hinge; its inner edge is shaped around the orbiter. Each platform is raised and lowered using two hand-powered winches at the 20’-0” Level of the tower, to which it is attached (Photo No. 75). To the west of the north nose access platform is another small access platform made of solid metal sheeting. This platform has approximate measurements of 12’ in length and 7’ in width, and is attached to the tower with a rotating hinge. A third hand winch within the north tower allows this platform to be raised and lowered (Photo No. 76).

At the 40’-0” Level, there are a variety of access platforms. The first of these is a pair of nose access platforms (Photo No. 78), which are an exact replica of those suspended from the 20’-0” Level. There is also a solid metal platform to the west of the north nose access platform, similar to that on the 20’-0” Level. Also at this level, within each tower, is a 8’ x 4’ raised platform, accessed by a set of metal steps. This platform is used to access the A/SP ramp when the orbiter is attached atop the SCA. Suspended from the underside of the 40’-0” Level of the south tower is an “H”-shaped orbiter/747 mating access platform (Photo No. 81). It measures approximately 24’ in length and 11’ in width, and is moved between its use and storage positions by a roller/track mechanism.

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Figure A-1. View of SLF site prior to construction, camera facing north, March 22, 1974.
Source: John F. Kennedy Space Center Archives, 108-KSC-74C-10009.

Figure A-2. View of SLF site, showing construction progress, camera facing north, October 9, 1974.
Source: John F. Kennedy Space Center Archives, 108-KSC-374C-10014.

Figure A-3. View of SLF, showing construction progress, camera facing southeast, April 28, 1975.
Source: John F. Kennedy Space Center Archives, 108-KSC-375C-10031_10.

Figure A-4. Detail view of SLF showing concrete being poured, camera facing north, May 28, 1975.
Source: John F. Kennedy Space Center Archives, 108-KSC-375C-10036_32.

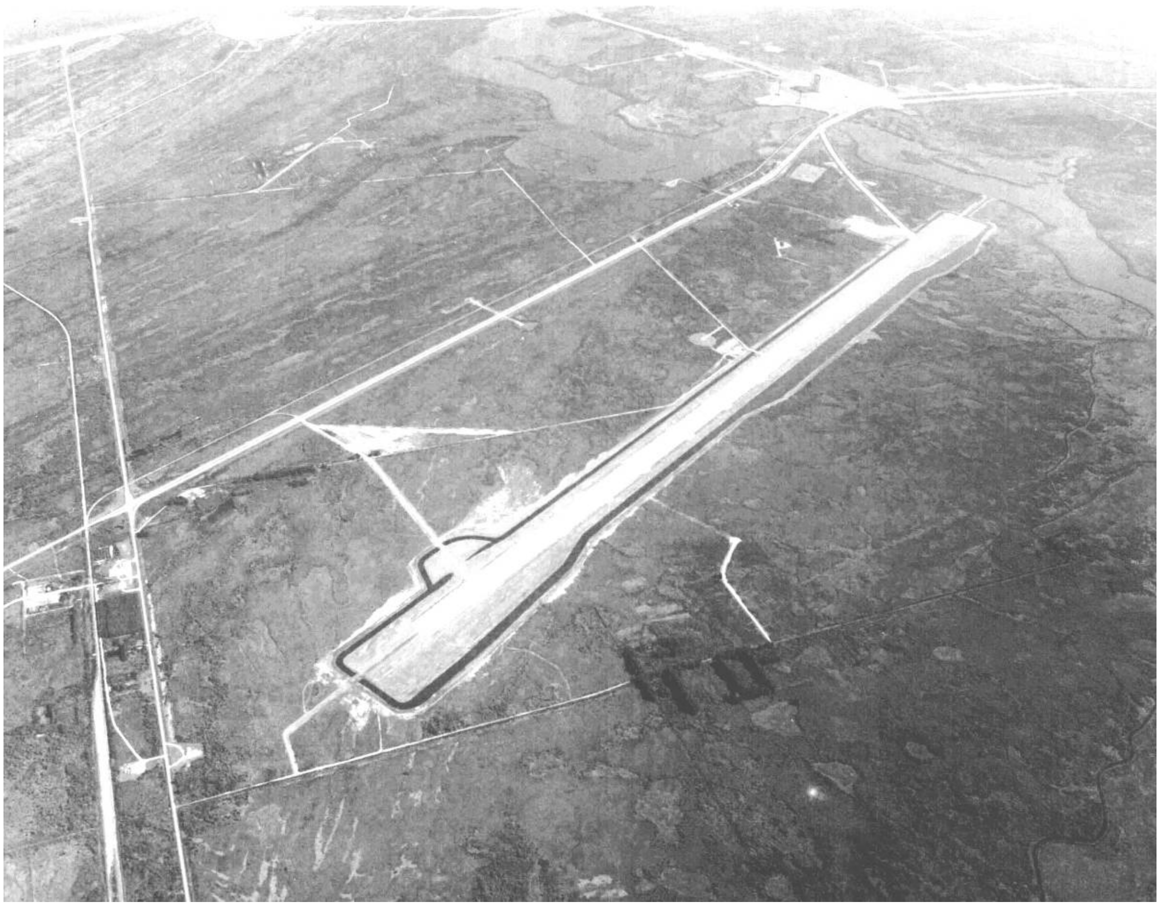

Figure A-5. Aerial view of SLF, camera facing southeast, November 24, 1975.
Source: John F. Kennedy Space Center Archives, 108-KSC-375C-654_60.

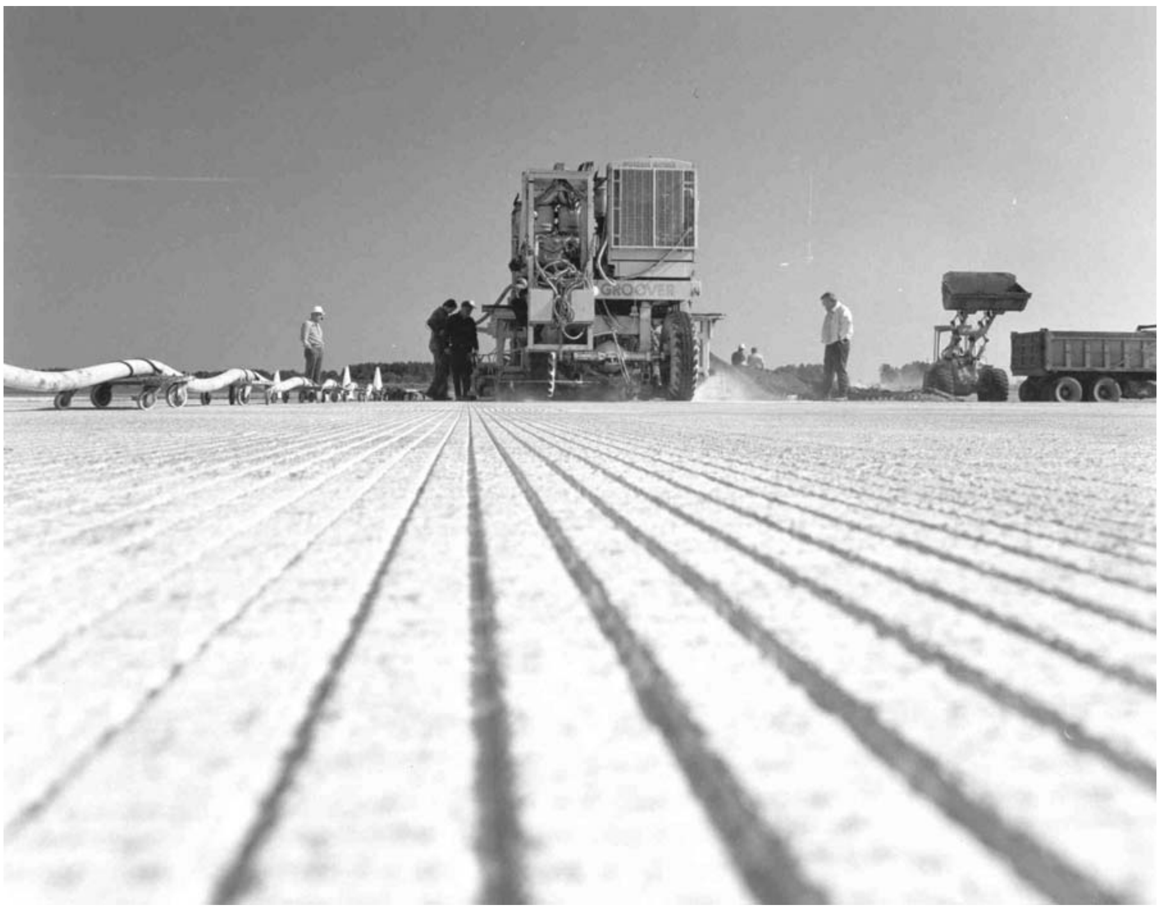

Figure A-6. View of lateral cross-grooves being cut into SLF Runway, direction unknown, November 24, 1975.
Source: John F. Kennedy Space Center Archives, 108-KSC-75P-523.

Figure A-7. SLF Runway lighting test, camera facing northwest, Feburary 25, 1976.
Source: John F. Kennedy Space Center Archives, 108-KSC-376C-42_20.

Figure A-8. Construction progress on LACB, camera facing southwest, January 16, 1976.
Source: John F. Kennedy Space Center Archives, 108-KSC-76C-10006.

Figure A-9. Construction progress on LACB, camera facing northeast, January 16, 1976.
Source: John F. Kennedy Space Center Archives, 108-KSC-76C-10005.

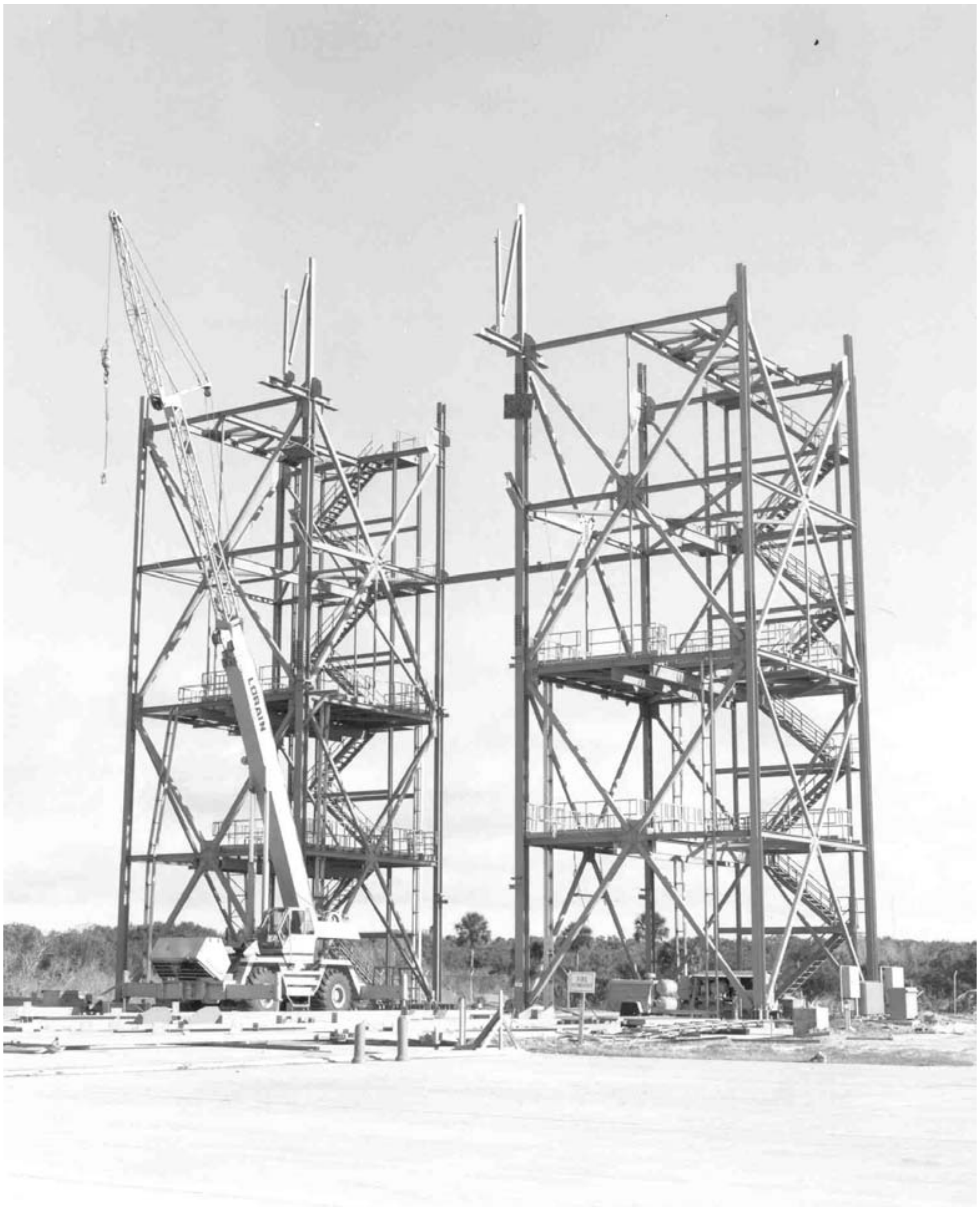

Figure A-10. Construction progress on MDD, camera facing northeast, January 9, 1978.
Source: John F. Kennedy Space Center Archives, 108-KSC-378-28_04.

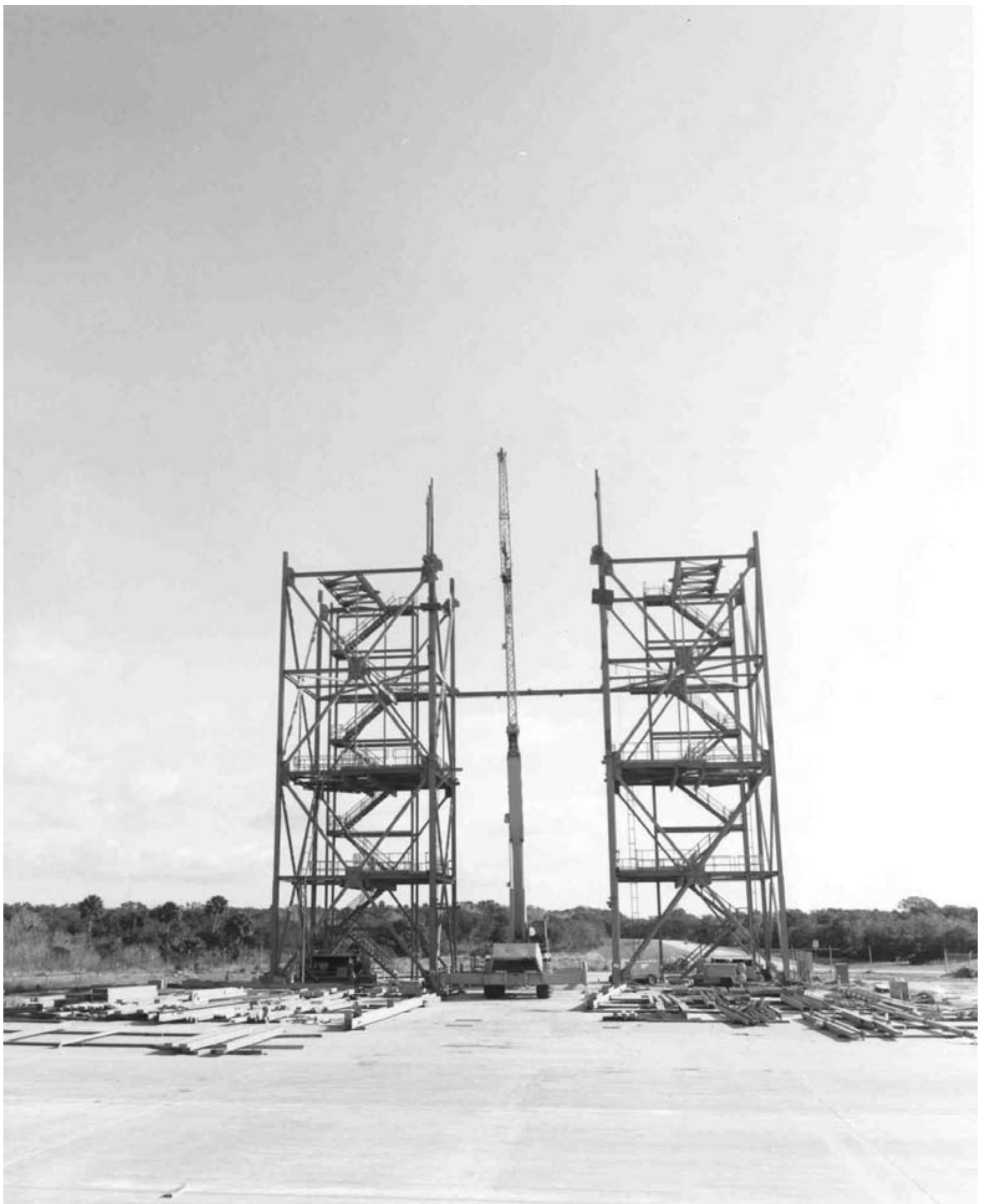

Figure A-11. Construction progress on MDD, camera facing east, January 9, 1978.
Source: John F. Kennedy Space Center Archives, 108-KSC-378-28_06.

Figure A-12. The Orbiter *Columbia* arriving at KSC atop the SCA for its maiden flight, camera facing west, March 24, 1979.
Source: John F. Kennedy Space Center Archives, 108-KSC-79PC-52.

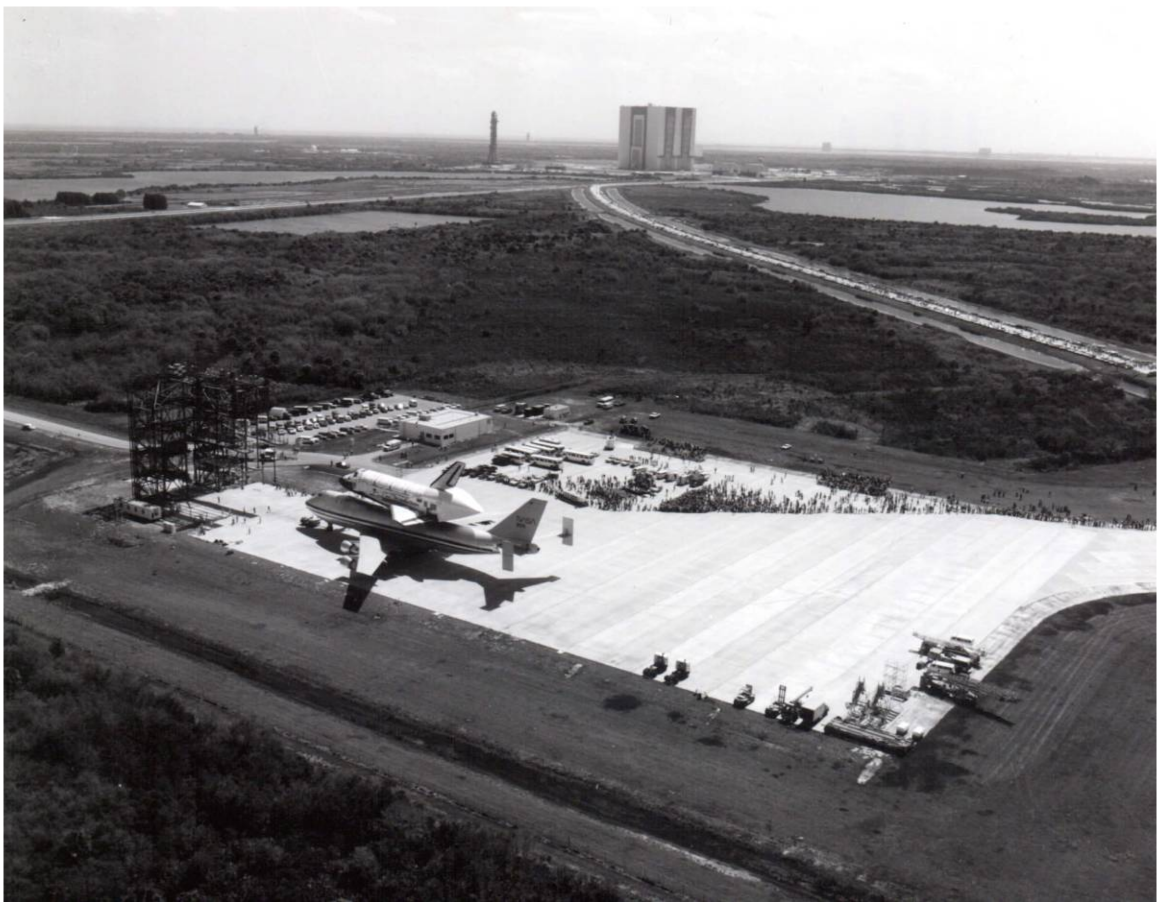

Figure A-13. The Orbiter *Columbia* and SCA ready to enter the MDD for demating operations, camera facing southeast, March 24, 1979.
Source: John F. Kennedy Space Center Archives, 108-KSC-79PC-45.

Figure A-14. The SCA being cleared from the MDD area as *Columbia* is held in place by the slingback, camera facing northwest, March 25, 1979.
Source: John F. Kennedy Space Center Archives, 108-KSC-79PC-60.

Figure A-15. Astronauts John Young (left) and Joe Engle (right) on parking apron with one of the STA's following practice approaches on SLF, camera facing northwest, November 11, 1981. Source: John F. Kennedy Space Center Archives, 108-KSC-81P-531.

Figure A-16. The Orbiter *Challenger* making its second landing at the SLF, camera facing southeast, October 13, 1984.
Source: John F. Kennedy Space Center Archives, 108-KSC-84PC-650.

Figure A-17. The Orbiter *Discovery* landing at night, camera facing southeast, September 22, 1993.
Source: John F. Kennedy Space Center Online Multimedia Gallery, KSC-93PC-1381.

Figure A-18. The Orbiter *Discovery* preparing to touchdown on the SLF Runway, camera facing northwest, November 7, 1998.
Source: John F. Kennedy Space Center Online Multimedia Gallery, KSC-98DC-1580.

Figure A-19. The Orbiter *Discovery* landing on the SLF Runway at dusk, camera facing northwest, December 22, 2006.
Source: John F. Kennedy Space Center Online Multimedia Gallery, KSC-06PP-2896.

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Source: John F. Kennedy Space Center Online Multimedia Gallery, KSC-2010-2800.

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Source: John F. Kennedy Space Center Online Multimedia Gallery, KSC-2010-2834.

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Source: John F. Kennedy Space Center Online Multimedia Gallery, KSC-2010-2832.

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Source: John F. Kennedy Space Center Online Multimedia Gallery, KSC-05PD-1915.

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Source: John F. Kennedy Space Center Online Multimedia Gallery, KSC-05PD-1912.

Figure A-25. *Discovery* being lowered to the ground following demating operations, camera facing northeast, August 22, 2005.
Source: John F. Kennedy Space Center Online Multimedia Gallery, KSC-05PD-1924.

Figure A-26. *Discovery* being pushed onto the SLF parking apron by a tug following demating operations (the SCA is in the background), camera facing west, August 22, 2005.
Source: John F. Kennedy Space Center Online Multimedia Gallery, KSC-05PD-1940.

HISTORIC AMERICAN ENGINEERING RECORD

INDEX TO PHOTOGRAPHS

CAPE CANAVERAL AIR FORCE STATION, LAUNCH COMPLEX 39 HAER No. FL-8-11-J
SHUTTLE LANDING FACILITY (John F. Kennedy Space Center)
Near the southwest corner of the Beach Road/
Kennedy Parkway North intersection
Cape Canaveral
Brevard County
Florida

Penny Rogo Bailes, Photographer; April 2010
(FL-8-11-J-1 through FL-8-11-J-113)

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Photograph Nos. FL-8-11-J-91 through FL-8-11-J-113 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-J-91 Photocopy of drawing
LAUNCH COMPLEX 39-SPACE SHUTTLE LANDING FACILITIES
NASA, John F. Kennedy Space Center, Florida
Drawing 79K04186, NASA-KSC, April, 1973
MASTER SITE PLAN
Sheet 2

FL-8-11-J-92 Photocopy of drawing
SPACE SHUTTLE LANDING FACILITY-PHASE I
NASA, John F. Kennedy Space Center, Florida
Drawing 79K04486, J.E. Greiner Company, Inc., December, 1973
COVER SHEET
Sheet C-1

FL-8-11-J-93 Photocopy of drawing
SPACE SHUTTLE LANDING FACILITY-PHASE I
NASA, John F. Kennedy Space Center, Florida
Drawing 79K04486, J.E. Greiner Company, Inc., December, 1973
LOCATION PLAN
Sheet C-2

FL-8-11-J-94 Photocopy of drawing
SPACE SHUTTLE LANDING FACILITY-PHASE I
NASA, John F. Kennedy Space Center, Florida
Drawing 79K04486, J.E. Greiner Company, Inc., December, 1973
TYPICAL SECTIONS - AIRFIELD
Sheet C-20

FL-8-11-J-95 Photocopy of drawing
SPACE SHUTTLE LANDING FACILITY-PHASE I
NASA, John F. Kennedy Space Center, Florida
Drawing 79K04486, J.E. Greiner Company, Inc., December, 1973
PAVEMENT MARKING PLANS-RUNWAY
Sheet C-60

FL-8-11-J-96 Photocopy of drawing
SPACE SHUTTLE LANDING FACILITY-PHASE I
NASA, John F. Kennedy Space Center, Florida
Drawing 79K04486, J.E. Greiner Company, Inc., December, 1973
PAVEMENT MARKING PLANS-RUNWAY
Sheet C-61

FL-8-11-J-97 Photocopy of drawing
SPACE SHUTTLE LANDING FACILITY-PHASE II
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Drawing 79K05181, J.E. Greiner Company, Inc., February, 1975
COVER SHEET
Sheet C-1

FL-8-11-J-98 Photocopy of drawing
SPACE SHUTTLE LANDING FACILITY-PHASE II
NASA, John F. Kennedy Space Center, Florida
Drawing 79K05181, J.E. Greiner Company, Inc., February, 1975
LACB FLOOR PLAN/SCHEDULES
Sheet A-2

FL-8-11-J-99 Photocopy of drawing
SPACE SHUTTLE LANDING FACILITY-PHASE II
NASA, John F. Kennedy Space Center, Florida
Drawing 79K05181, J.E. Greiner Company, Inc., February, 1975
LACB ELEVATIONS
Sheet A-3

FL-8-11-J-100 Photocopy of drawing
SPACE SHUTTLE LANDING FACILITY-PHASE IIA
NASA, John F. Kennedy Space Center, Florida
Drawing 79K07757, NASA-KSC, November, 1976
OVERALL SITE PLAN
Sheet C-1

FL-8-11-J-101 Photocopy of drawing
SPACE SHUTTLE LANDING FACILITY-PHASE IIA
NASA, John F. Kennedy Space Center, Florida
Drawing 79K07757, Briel Rhame Poynter & Houser, November, 1976
MATING/DEMATING DEVICE, SITE PLAN & LEGEND
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FL-8-11-J-102 Photocopy of drawing
SPACE SHUTTLE LANDING FACILITY-PHASE IIA
NASA, John F. Kennedy Space Center, Florida
Drawing 79K07757, Briel Rhame Poynter & Houser, November, 1976
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NASA, John F. Kennedy Space Center, Florida
Drawing 81K01198, Space Gateway Support, February, 2007
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NASA, John F. Kennedy Space Center, Florida
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NASA, John F. Kennedy Space Center, Florida
Drawing 79K08112, Connell Associates, Inc., December, 1976
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FL-8-11-J-107 Photocopy of drawing
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Drawing 79K08112, Connell Associates, Inc., December, 1976
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FL-8-11-J-108 Photocopy of drawing
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NASA, John F. Kennedy Space Center, Florida
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NASA, John F. Kennedy Space Center, Florida
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FL-8-11-J-110 Photocopy of drawing
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FL-8-11-J-111 Photocopy of drawing
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NASA, John F. Kennedy Space Center, Florida
Drawing 79K08112, Connell Associates, Inc., December, 1976
ELEVATION-ACCESS/SERVICE PLATFORM
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FL-8-11-J-112 Photocopy of drawing
ORBITER MATE/DEMATE DEVICE
NASA, John F. Kennedy Space Center, Florida
Drawing 79K08112, Connell Associates, Inc., December, 1976
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FL-8-11-J-113 Photocopy of drawing
ORBITER MATE/DEMATE DEVICE
NASA, John F. Kennedy Space Center, Florida
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