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

HAER FL-8-11-Q

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
Department of the Interior
100 Alabama St. SW
Atlanta, GA 30303

HISTORIC AMERICAN ENGINEERING RECORD

CAPE CANAVERAL AIR FORCE STATION, LAUNCH COMPLEX 39, PARACHUTE REFURBISHMENT FACILITY

HAER No. FL-8-11-Q

Location: John F. Kennedy Space Center (KSC), Southwest Corner of 3rd Street and Avenue E, Brevard County, Florida.

USGS Orsino, Florida, Quadrangle, Universal Transverse Mercator Coordinates: E 534807.2 N 3154824.07 Zone 17, NAD 1983.

Present Owner: National Aeronautics and Space Administration (NASA)

Present Use: Parachute Refurbishment

Significance: The Parachute Refurbishment Facility (PRF) was built in 1964 to process parachutes for Project Gemini. In 1968, the building was modified into the NASA News Center to house journalists and public relations activities. The building was modified and expanded in 1978 for the U.S. Space Shuttle Program (SSP) to receive, clean, inspect, store, and refurbish the pilot, drogue, and main parachutes used on the Solid Rocket Boosters (SRBs) and shuttle orbiter drag parachute. The PRF also refurbished thermal blankets and tested the materials used to repair the parachutes. The PRF is a one-of-a-kind facility that is considered eligible for listing in the National Register of Historic Places (NRHP) in the context of the SSP (1969-2011) under Criterion A in the area of Space Exploration and Transportation. Because it achieved significance within the past 50 years, Criterion Consideration G also applies. The PRF played an essential role in the re-usability of the Space Shuttle orbiter and SRBs as a Parachute Manufacturing Facility.

Report Prepared by: New South Associates, Stone Mountain, Georgia.

Date: October 10, 2012.

Part I. HISTORICAL INFORMATION

A. INTRODUCTION

The PRF was built in 1964 to process parachutes for NASA’s Project Gemini (1965-66). In 1968, the building was modified for use as the NASA News Center to house journalists and public relations activities. The building was again modified and expanded in 1978 for the SSP to receive, clean, inspect, store, and refurbish the SRB’s pilot, drogue, and main parachutes, and the shuttle orbiter drag parachute. It also refurbished thermal blankets used on the shuttle, tested the nylon and Kevlar materials used to repair the parachutes, and manufactured new parachutes when necessary.[1]

The PRF is historically significant for its association with the history of the Space Transportation System (STS), commonly known as the “Space Shuttle.” The Space Shuttle was a unique breakthrough in the history of the U.S. Space Program with a design that made most of its major components re-usable, a model that decreased program costs and helped make orbital space flight a routine endeavor. The Space Shuttle’s primary re-usable elements were the orbiter spacecraft and the SRBs, while the external tank that housed the main engines’ liquid hydrogen fuel and

[1] National Aeronautics and Space Administration (NASA), “Technical Facilities Catalog,” NHB 8800.5 (II) (John F. Kennedy Space Center [KSC], Florida: March 1967 Edition), 10-61; NASA, “NASA News Center (Mods to Parachute Bldg.)” (KSC, Florida: 1968), no page number; NASA, “Kennedy Space Center: Resource Encyclopedia” (KSC, Florida: 2010), 293.

liquid oxygen oxidizer was not re-used. Essential to the SRBs' re-usability was the use of a series of specially designed parachutes to decelerate the SRBs descent into the ocean after in-flight separation from the ET. Parachutes were also used to slow the orbiter at landing.

List of Acronyms:

ACHP - Advisory Council on Historic Preservation

ACTS – Advanced Communications Technology Satellite

ARF - SRB Assembly and Refurbishment Facility

BSM - Booster Separation Motors

BTA - Booster Trowelable Ablative

CCAFS - Cape Canaveral Air Force Station

DoD – Department of Defense

EDOP - Enhanced Diver Operated Plug

ET – External Tank

ETA - External Tank Attachment

HAER – Historic American Building Record

IHA - InoMedic Health Applications

ISS – International Space Station

KSC – John F. Kennedy Space Center

NASA – National Aeronautics and Space Administration

NRHP – National Register of Historic Places

MCC-1 - Marshall Convergent Coating

PA - Programmatic Agreement

PRF – Parachute Refurbishment Facility

SSP – United States Space Shuttle Program

SRB – Solid Rocket Boosters

SSME – Space Shuttle Main Engine

SRM - solid rocket motors

STS – Space Transportation System

TVC - Thrust Vector Control

TPS - Thermal Protection System

USGS – United States Geological Survey

USBI - United Space Boosters

USA - United Space Alliance

B. HISTORIC CONTEXT

1. NASA and the Space Shuttle Program

NASA was created in 1958 in response to the Soviet launch of the *Sputnik* satellite a year earlier. NASA's first series of missions were to send man into space, followed by manned orbits around the Earth, mastery of rendezvous and docking procedures, and finally, landing man on the moon and returning him safely to Earth. These goals defined the three main programs of the late 1950s and 1960s: Mercury, Gemini, and Apollo. This effort culminated in the first moon landing, which occurred on July 20, 1969. Moon landings continued until 1972 when the Apollo program ended. Programs after Apollo included the Skylab space station that orbited Earth from 1973 to 1979, and the

Apollo-Soyuz Test Project, the first space mission undertaken as a joint effort between the United States and the Soviet Union in 1975. By the mid-1970s, it was clear that NASA's next major program would be based on a reusable Space Shuttle, designed to serve orbiting space stations and related missions.[2]

President Richard Nixon established the Space Task Group in 1969 to recommend the future course of the U.S. Space Program. This led to the creation of the SSP, which was announced in a speech by President Nixon in 1972. In the speech, Nixon outlined the future of the SSP based on the idea that a series of reusable space flight vehicles would provide "routine access to space."[3] Following this announcement, new SSP contracts were awarded, new space vehicles were designed, old Apollo-era facilities were retro-fitted, and new facilities were built. After a decade of preparation, the first shuttle flight occurred in 1981. After almost three decades of operations, the SSP was retired in 2011.[4]

During those thirty years of operation, there were approximately 135 different flights, using a total of five Space Shuttle orbiters: *Columbia*, *Challenger*, *Discovery*, *Atlantis*, and *Endeavour* (the prototype, *Enterprise*, never went into space). The SSP achieved a number of significant goals. In addition to supporting diverse space facilities such as Spacelab, the Hubble Space Telescope, the *Mir* Space Station, and the International Space Station (ISS), the

[2] Joan Deming and Patricia Slovinac, *NASA-Wide Survey and Evaluation of Historic Facilities in the Context of the U.S. Space Shuttle Program: Roll-Up Report,* (Sarasota, FL: Archaeological Consultants, Inc., 2008), 2.1.
[3] Joan Deming and Patricia Slovinac, *NASA-Wide Survey and Evaluation of Historic Facilities in the Context of the U.S. Space Shuttle Program: Roll-Up Report,* (Sarasota, FL: Archaeological Consultants, Inc., 2008), 2.1.
[4] Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 2.1.

shuttles contributed to many other space programs. Among these were various satellite systems (from COMSAT to the Advanced Communications Technology Satellite, or ACTS), and the unmanned probes that were sent to Jupiter (*Galileo*), Venus (*Magellan*), and the Sun (*Ulysses*).[5] Additionally, the shuttle has deployed a number of Department of Defense (DoD) payloads that remain classified.

Two significant accidents have been associated with the SSP. The *Challenger* (January 28, 1986) and *Columbia* (February 1, 2003) disasters resulted in the loss of all crew members on board. Both incidents caused lengthy flight down time for the program, while exhaustive investigations led to extensive physical and procedural improvements.[6]

Most of the STS was in place by the time of the first shuttle launch. The basic STS components have not changed since reusable Space Shuttles were first designed in the 1970s; however, as with any endeavor that occurs over a thirty-year period, changes were made to the STS, its support structures, and its operational procedures based on mission shifts, the two accidents, and improvements in technology.

The final design for the Space Shuttle was chosen from twenty-nine different possibilities in 1972. After years of testing and preparation, the first shuttle vehicle, *Columbia*, arrived at KSC in 1979. *Columbia, STS-1,* lifted off on April 12, 1981, as the first launch of the SSP. Most of the work required to prepare the vehicle for launch was done in the Orbiter Processing Facility (OPF). After a series of test flights each with a crew of two (STS-2

[5] Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 2.22-24.
[6] Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 2.15.

through STS-4), the first operational flight, STS-5, occurred the following year, November 11, 1982.[7]

These launches were conducted from Launch Complex 39, Pad A, on KSC. By the mid-1980s, Launch Complex 39, Pad B, was also available for launch services. Since the beginning, there were on average around five shuttle launches per year, with no launches for many months following each of the two major accidents.[8]

2. Space Shuttle Components

The Space Shuttle, a vehicle designed to be launched vertically, orbit the Earth, and then land horizontally, was comprised of three main components that were clearly visible at the time of launch. These were: 1) the reusable orbiter, as the main shuttle vehicle is called; 2) an external tank (ET), the large orange tank in the middle of the shuttle assembly; and 3) the two reusable SRBs that flanked either side of the ET. Of these three parts, only the ET was expendable and was not recovered after each flight.[9]

The orbiter was the central component of any shuttle flight. The orbiter carried the shuttle astronauts and the payload. Equipped with its own Space Shuttle Main Engines (SSMEs), it was versatile in space and capable of re-entry into Earth’s atmosphere, after which it landed like a glider. It was not, however, capable of leaving the Earth’s gravitational pull upon launch. For this, it required the ET and the two SRBs.

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[7] Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 2.13-15.
[8] Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 6.4; Christy, Howard, RPSF Manager, Personal Communication, February 24, 2010.
[9] Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 3.1.

The ET was 154'-0" tall and 27'-0" in diameter. It served as the structural backbone for the whole shuttle assembly; both the orbiter and the two SRBs were attached to it. Designed in the 1970s by Martin Marietta Corporation, the ET contained liquid hydrogen and liquid oxygen, which served as a fuel and oxidizer for the orbiter's three main engines. The fuel in the ET provided the shuttle with approximately 29 percent of the thrust needed to escape the Earth's gravitational pull and enter orbit. When expended, the ET was jettisoned over the Indian Ocean and not recovered.[10] Most of it burned up upon re-entry.

3. The Solid Rocket Boosters

The SRBs were the workhorses of the shuttle, providing approximately 71 percent of the thrust up to an altitude of about 150,000' before it achieved orbit. The two SRBs were attached to either side of the ET and supported the full weight of the ET and orbiter on the launch pad. Each booster was its own rocket, about 150' tall, with an average diameter of 12'.[11]

The SRBs structure included nine components that housed the boosters' flight hardware, propellant, and parachutes: the nose cap, frustum, forward skirt, aft skirt, nozzle extension, and four solid rocket motors (SRMs). These nine components were grouped into four main segments, each with

[10] Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 3.15, 2.4-5; Presidential Commission, *Report of the Presidential Commission on the Space Shuttle Challenger Accident, June 6, 1986* (Washington, D.C., Steven J. Dick, National Aeronautics and Space Administration (NASA) Chief Historian, Steve Garber, NASA History Web Curator. National Aeronautics and Space Administration, NASA History Office, http://history.nasa.gov/rogersrep/51lcover.htm), Chapter IV.
[11] Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 3.15, 2.4-5.

its own name. The uppermost segment was called the forward assembly. It was composed of the nose cap (6.25′-0″ tall) containing the pilot and drogue parachutes, the frustum (10′-0″ tall) containing three booster separation motors that separated the SRBs from the ET and the three main parachutes used to slow the SRBs descent to the ocean, and the forward skirt (10.75′ tall) containing the boosters' guidance gyroscopes and other flight hardware. The two middle segments (each 26.67′ tall) were referred to as the forward mid (or center) segment and aft mid (or center) segment. The forward mid and aft mid segments were each composed of two SRMs, which are discussed in more detail below. The lowest segment was called the aft segment and included the exit cone, also called the nozzle extension, and when mated to the aft skirt (7.54′ tall) was referred to as the aft booster segment. The aft segment also contained four additional Booster Separation Motors (BSMs), as well as the Thrust Vector Control (TVC) system that steered the STS while in flight.[12]

4. SRB Thermal Protection System (TPS)

Prior to assembly, the SRB frustums, forward skirts, nose caps, aft skirts, and portions of the systems tunnel covers were coated with a multi-layer Thermal Protection System (TPS). The TPS protected the segments from the heat generated during liftoff and atmosphere re-entry. Each segment was first coated with alodine, an anti-corrosion and surface preparation agent, followed by primer, and then a coat of hypalon paint. The first layer of the TPS was applied with a substance known as the Marshall Convergent Coating (MCC-1), a low-density, three-part mixture composed of glass, cork, and a two-part resin. The MCC-1 was applied to booster elements via an automated robot located in the

[12] NASA, *NASA Facts: Solid Rocket Boosters and Post-Launch Processing* (John F. Kennedy Space Center [KSC], Florida), FS-2004-07-012-KSC (Revised 2006), 1-2.

SRB Assembly and Refurbishment Facility (ARF) Manufacturing Building. It was applied in thicknesses ranging from 0.090″ to 0.500″ and then cured for up to 13 hours at temperatures ranging from 112-200 degrees Fahrenheit.[13]

Areas of the booster that needed additional thermal protection received a layer of cork, including the aft and forward skirts, External Tank Attachment (ETA) ring segments, system tunnel covers, and several small parts. Cork acts as an ablative material by absorbing heat through a phase change where a char layer is formed. The layer of cork char acts as an insulator, slowing thermal degradation while maintaining structural geometry. The cork was hand cut to size and bonded to the SRB with epoxy adhesive. The next TPS component was a hand-applied substance called Booster Trowelable Ablative (BTA). BTA was used for insulating protuberances, transition areas, hard to reach areas, and complex surfaces on the boosters' exteriors. BTA was hand applied or molded and then cured at room temperature. The booster elements then received a top coat of Hypalon paint applied manually with brushes and rollers to all TPS surfaces. Finally, a material called Froth Pak, a two-part isocyanate mixture, was applied to the interior surfaces of the aft skirt assembly around the TVC system. The Froth Pak prevented or minimized damage caused by water impact at splash down in the ocean.[14]

5. SRB Design and Function

The initial design for the SRBs was conceived in the 1970s by Marshall Space Flight Center in Huntsville, Alabama, except for the BSMs, which were designed by the Chemical Systems Division of United Technology Corporation in 1975.

[13] United Space Alliance, "Materials and Processes Revision J" (KSC, no date), no page number.
[14] United Space Alliance, "Structures Assembly Buildup Operations, Revision J" (KSC, no date), no page number.

The SRMs were designed, developed, and tested by the Thiokol Chemical Company in Brigham City, Utah. The primary contractor used to build the SRBs was McDonnell Douglas, which was also chosen in 1975 to provide most of the aluminum booster elements like the aft skirts, frustums, nose caps, and other parts. United Space Boosters (USBI) was chosen in 1976 as the booster assembly contractor, and Martin Marietta was selected the same year to produce the SRB parachute system, with Pioneer Parachute Company as a subcontractor. USBI became part of United Space Alliance (USA) in 1999.[15]

The majority of the SRBs' structure was composed of the four SRM segments loaded with solid propellant. When fully loaded each booster assembly weighed around 160 tons, with the majority of that weight in the propellant, which was mostly made of the oxidizer ammonium perchlorate (about 70 percent) and aluminum powder fuel (16 percent).[16] The four SRM segments were stacked together and ignited from the top of the uppermost segment. They burned down the length of the booster like a gigantic Roman candle, beginning at the inner edge of the tube and working outward to the edge of the aluminum rocket casing, until the fuel was spent. After a little over two minutes into the flight, the two SRBs propelled the shuttle assembly more than twenty-six miles above the Earth's surface and exhausted their fuel. The spent booster rockets were then jettisoned from the ET by the BSMs, but momentum continued to propel them upward for about 70 seconds, to about 38.6 nautical miles up,

[15] Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 3.14.
[16] Presidential Commission, *Report on Challenger Accident*, Chapter IV; Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 2.4-5, 3.14; "SRB Complex Work Begins on Site North of VAB," *Spaceport News*, Volume 21, No. 17, August 19, 1982, p. 7; NASA, *NASA Facts: Solid Rocket Boosters and Post-Launch Processing*, 1.

before they reached their apogee and tumbled back toward the ocean.[17]

6. The SRB Parachutes

The SRB parachutes were essential to the re-usability of the boosters and key to the overall success of the SSP. The safe descent of the SRBs into the ocean required the precise deployment of a series of parachutes, including a pilot, drogue, and main canopy parachutes. Each SRB had three main parachutes, although only two were necessary for a safe descent, the third was redundant in case one of them failed. The main canopies were manufactured by Pioneer Aerospace and Irvin Industries, while the pilot and drogue parachutes were manufactured at the PRF. [18]

The original SRB main canopies were 115′ in diameter, but tests soon determined that this was not large enough and they were enlarged to 136′. The pilot parachute measures 12′ in diameter, and the drogue 54′ in diameter. Over the course of the SSP, there have been approximately 58 main SRB canopy parachutes and 15 drogue parachutes, all of which were rotated through the different Space Shuttle launches. The drogues were originally rated for approximately 10 uses before replacement, but testing after their tenth flight determined they were actually good for 15 uses. The main canopies were each rated for 20 uses.[19]

A series of parachutes was deployed from the SRB nose cap and frustum to slow the SRBs’ descent from 230 miles per hour to 50 miles per hour at ocean splashdown. When the

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[17] NASA, *NASA Facts: Solid Rocket Boosters*. (KSC, Florida: no date), IS-2004-09-014-KSC, Revised 2006, no page number; NASA, *NASA Facts: Solid Rocket Boosters and Post-Launch Processing*, 2.

[18] Scott Brady, KSC Senior Parachute Technician, interview with author, November 2011.

[19] Scott Brady, KSC Senior Parachute Technician, interview with author, November 2011.

SRBs fell to an altitude of 2.5 nautical miles, the nose cap separated and released a pilot parachute. The pilot parachute pulled out a drogue parachute that properly oriented the booster into a vertical position and provided initial deceleration of the booster. The drogue and main parachutes were designed to open in a staged, or "reefed," deployment that gradually slowed the SRBs' descent without the parachutes opening all at once. This gradual deceleration prevented the tremendous weight of the SRBs from tearing the parachutes. For example, the drogue parachute began with initial deployment, followed by the first reefed condition of 60 percent parachute inflation, followed by the second reefed condition at 80 percent inflation.[20] At an altitude of 6,000 feet, the drogue parachute fully opened.

With the full deployment of the drogue parachute, the frustum separated from the SRB by firing an ordnance separation ring between the frustum and forward skirt. This deployed the three main parachutes that, like the drogue, opened in reefed stages. The first reefed condition was 15 percent inflation, followed by the second reefed condition of 31 percent inflation, followed by full inflation at an altitude of 2,170 feet. At 2,020 feet, the SRB aft skirt nozzle extension was jettisoned and the boosters landed in the Atlantic Ocean at a speed of 50 miles per hour.[21] After a total descent time of about five minutes, the SRBs hit the ocean nozzle end down, trapping air in the burned out interior of the boosters. This air gave the boosters buoyancy and caused them to float with the forward end about 30 feet out of the water.[22]

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[20] United Technologies/United Space Boosters (USBI), "SRB Recovery Subsystem Reference Trajectory Sequence" (no publication information, no date), no page number. On file at the KSC Archives.
[21] USBI, "SRB Recovery Subsystem Reference Trajectory Sequence."
[22] NASA, *NASA Facts: Solid Rocket Boosters*, no page number; NASA, *NASA Facts: Solid Rocket Boosters and Post-Launch Processing,* 1-2.

7. SRB Recovery, Disassembly, and Refurbishment

After splashdown in the Atlantic, the SRBs and parachutes were recovered by the *Liberty Star* and *Freedom Star*, two ships designed for this purpose, and returned to the Hangar AF Complex on Cape Canaveral Air Force Station (CCAFS). Once the ships reach the splashdown area, a retrieval operation crew of divers used a smaller dive boat to get within working range of the boosters. Divers then entered the water and attached floats to the parachute lines before cutting them loose from the boosters. The three main parachutes were then reeled onboard using large powered reels, followed by the drogue parachute. The drogue parachute at this point was still attached to the frustum, which was hoisted aboard the ship with a 10-ton crane.[23]

With the parachutes and frustums reeled in, the dive crew then repositioned the boosters into a horizontal position for tow back to Hangar AF. The dive crew deployed a special device called the Enhanced Diver Operated Plug (EDOP), a 1,300-pound device that was inserted into the nozzle end of the booster. Once secure, the EDOP pumped air from the ship through a 2,000′ air hose into the booster. The pumped air forced all of the water in the booster out through a one-way valve in the EDOP, which caused the booster to rise up and out of the water until it toppled over into a horizontal position. The boosters were then attached to the ship and towed in "log mode" behind the ships back to Hangar AF for disassembly and refurbishment. Once they reached port, the boosters were repositioned alongside the ships in what was called "hip mode" for easier navigation through the narrow Banana River channel.[24]

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[23] United Space Alliance, "Marine Operations, Revision J" (KSC: no date), MO-1; NASA, *NASA Facts: Solid Rocket Boosters and Post-Launch Processing*, 2.
[24] NASA, *NASA Facts: Solid Rocket Boosters and Post-Launch Processing*, 2.

When the ships arrived at their Hangar AF docking area, the parachutes and frustums were unloaded onto shore and the SRBs were maneuvered one at a time into the slip. While the parachutes were delivered to the PRF for processing, the SRBs were prepared for the initial disassembly and refurbishment process at Hangar AF. They were first hoisted out of the water by a mobile gantry crane. The crane delivered the SRBs to the facility's specially designed railcars for initial visual assessment and transport to the First Wash Building for hydrolase washing, a high-pressure water wash that removed approximately 90 percent of the boosters' TPS.

The remaining TPS material was removed after disassembly with a hydrolase wash, or high-pressure water blast, in the High Pressure Wash and Robot Wash Buildings.[25] After the hydrolase wash, the boosters were then moved into Hangar AF for further assessment and disassembly. Once disassembled, the four empty and cleaned SRMs were loaded onto trucks that transported them to the KSC railway and then shipped back to the Thiokol Chemical Company in Utah for refurbishment. All of the other booster segments were disassembled, cleaned, and processed at Hangar AF, including the frustums, forward skirts, and aft skirts.

8. The PRF

From the receiving dock of Hangar AF, the SRB drogue and pilot parachutes were transferred to the PRF to be cleaned, inspected, and refurbished. The 1964 portion of the building built for the Gemini program contained 8,200 square feet, including the areas now known as Aisle 4 and the central office bay. A historic 1966 photograph shows

[25] Art Morales, George C. Marshall Space Flight Center Office of the Director Shuttle - ARES Transition Office, interview with author, September 27, 2011.

the building's original configuration (Appendix).[26] It was equipped with a 189-foot long parachute packing table, two 30-ton hydraulic presses, one 12-ton hydraulic press, and a vacuum system used for packing parachutes. It had specially designed air-conditioning and humidity control systems required for the special handling and care of the parachutes. The building also housed a fabric repair shop for repairing or fabricating items like storage bags, astronaut harnesses, and extravehicular activity (EVA) umbilical cords.[27]

In 1968, the parachute building was renovated into the NASA News Center and was used for press photographic development. It also housed journalists and public relations activities. This was done as a companion facility to the Press Site at Launch Complex 39, which opened in time for the Apollo 4 launch in 1967.[28] A NASA memorandum from that year stated that the renovation of the parachute building included "expansion of the sanitary, communication, and parking facilities," and the installation of 120 telephone circuits. This work enabled the close association of KSC public relations personnel and the news media, who were previously housed 27 miles away at a news center in Cocoa Beach.[29]

The building continued to function as the NASA News Center for the next decade. The advent of the SSP required new

[26] KSC photograph negative number 105-KSC-66C-5579, dated June 16, 1966. On file at KSC Archives.
[27] NASA, "Technical Facilities Catalog," NHB 8800.5 (II) (KSC, Florida: March 1967 Edition), 10-61; NASA, "NASA News Center (Mods to Parachute Bldg.)" (KSC, Florida: 1968), no page number; NASA, "Kennedy Space Center: Resource Encyclopedia" (KSC, Florida: 2010), 293; KSC photograph negative number 105-KSC-66C-5579, dated June 16, 1966. On file at KSC Archives.
[28] NASA, *NASA Facts: The Press Site at KSC* (KSC: no date), 4. Available at http://www-pao.ksc.nasa.gov/kscpao/nasafact/pdf/PressSite06.pdf; accessed February 24, 2012.
[29] NASA, "NASA News Center (Mods to Parachute Bldg.)" (KSC: 1968). On file at the KSC Archives.

and improved homes for both the press and parachute refurbishment.[30] In 1978, the PRF was renovated and expanded to 35,758 square feet for the SSP to receive, clean, inspect, store, and refurbish the shuttle's pilot, drogue, and main parachutes.

After the parachutes were returned to the PRF, they were unfurled and inspected for damage, then transported on a hanging monorail system into a 30,000-gallon washing machine and then into a dryer heated to 180 degrees with an air flow of 13,000 cubic feet per minute. From there, the parachutes were transported on the monorail into one of the building's processing aisles for further inspections and repairs.

Each SRB canopy parachute typically required hundreds of repairs after each use. Repairs were made on long work tables using industrial sewing machines that could stitch through several inches of material. After the parachutes were cleaned and repaired, they were carefully packed into bags to deploy correctly for the next shuttle launch. It took approximately one week to pack a SRB canopy parachute. More on the operations and processes of the PRF is included in Part III of this document.

9. Conclusion – The Space Shuttle Mission

While the SRB parachute refurbishment process proceeded at the PRF, the shuttle crew arrived to their orbit position. While in orbit on a typical mission, the shuttle crew completed their specific mission objectives, including deploying payload, conducting experiments, and performing extravehicular activities. Space Shuttle payloads were diverse, including: Spacelab; scientific observatories,

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[30] NASA, "Technical Facilities Catalog, Volume II," NHB 8800.5 A(II)(KSC:1974), 9-102.

such has the Hubble Space Telescope or the Chandra X-Ray Observatory; classified DoD payloads; communications satellites; and all the components necessary to construct the ISS.

At the end of the mission, the shuttle landed at KSC as the preferred landing site, although alternate landing locations included Edwards Air Force Base, California, and White Sands Test Facility, New Mexico, for emergency landings. NASA also identified designated airports around the world with runways of sufficient lengths and personnel for either an abort during launch or an alternate emergency-landing site.

The end of the SSP came in July of 2011, when the crew of *Atlantis* landed at KSC to complete the program's 135th mission (STS-135). Since the SSP's first launch in 1981, the program launched 355 astronauts from 16 countries. The five shuttles traveled more than 542 million miles and conducted over 2,000 experiments in the fields of Earth, astronomy, biological, and materials sciences. The shuttles docked with two space stations, including the Russian *Mir* and the International Space Station, and deployed 180 payloads such as satellites and spacecraft. With the return of the final mission, NASA Administrator Charles Bolden said, "the brave astronauts of STS-135 are emblematic of the shuttle program – skilled professionals from diverse backgrounds who propelled America to continued leadership in space with the shuttle's many successes."[31]

C. Physical History of the PRF

1. Date of Construction

[31] Michael Curie, Kyle Herring, and Candrea Thomas, "NASA's Proud Space Shuttle Program Ends With Atlantis Landing," NASA press release, http://www.nasa.gov/home/hqnews/2011/jul/HQ_11-240_Atlantis_Lands.html, accessed on March 8, 2012.

The original portion of the PRF was built in 1964 to process parachutes for NASA's Project Gemini (1965-66). This included the areas known today as Aisle 4 and the central office bay.[32]

2. Architect/Engineer

The original 1964 portion of the PRF was designed by Wellman-Lord Engineering, Inc., of Lakeland, Florida.

The 1978 additions were designed by Sanders & Thomas, Inc., a unit of STV Inc. Sanders & Thomas was a Pennsylvania partnership formed in 1945 by Whitney Sanders and Ralph Thomas. It merged in 1968 with Voss Engineering, an equipment manufacturer no longer associated with the firm, to form STV Inc., which evolved into STV Group, the company's parent firm. STV was also involved in the structural engineering services for KSC's Vehicle Assembly Building (VAB).[33]

The 1985 additions were designed by Burns and Roe Industrial Services Corporation of Cocoa Beach, Florida. Burns and Roe was founded in 1932 by Ralph Roe and Allen E. Burns. The company built much of its early reputation in the 1930s and 1940s on the design and engineering of electric power plants. By the 1950s, the company expanded into national defense projects, including radar and missile installations. In 1963, Ralph Roe handed over control of the company to his son, Kenneth, who continued to broaden its work into nuclear power plants, desalination plants, and aerospace projects. The company was a major participant in the planning of NASA's Mercury and Apollo

[32] Wellman-Lord Engineering, Inc., "MSC Parachute and Paraglider Building, Phase I" (KSC: Florida, 1965), construction drawings.
[33] STV, Inc., "History," http://www.stvinc.com/history.aspx, accessed March 7, 2012.

programs, including Mercury's Ground Support System and Apollo's Lunar Module Test Facility and Site Activation Program in Texas and the White Sands Missile Range in New Mexico. Burns and Roe's connections to NASA led to continued design and engineering work in the 1980s, including construction drawings for the SRB Paint Facility and the TVC Deservicing Building.[34]

3. Builder/Contractor/Supplier

The builder of the original 1964 building was Wellman-Lord Engineering of Lakeland, Florida.

The 1978 additions and modifications were completed by Holloway Corporation of Titusville, Florida, at a cost of $1,608,750.[35]

The builder of the 1985 additions is not known.

4. Original Plans and Construction

An examination of historic photos and original construction drawings shows that the original 1964 portion of the building included the parachute refurbishment area, known today as Aisle 4, and an adjacent block of rooms known as the central office bay.[36] The building had concrete block construction and a flat built-up roof. The original floor plan of the office bay included a locker room, men's toilet, mechanical room, office, parachute holding, paraglider holding, laboratory, and shop. The roof of the

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[34] Burns and Roe, "History and Legacy," http://www.roe.com/about_legacy.htm, accessed December 20, 2011.
[35] Dick Young, "Florida Firm Awarded Contract for Shuttle Parachute Facility," NASA News (October 26, 1977), KSC Release No. 163-77.
[36] KSC photograph number 105-KSC-66C-5579, dated June 16, 1966; Wellman-Lord Engineering, Inc., "MSC Parachute and Paraglider Building, Phase I" (KSC: Florida, 1965), construction drawings.

parachute packing area was approximately 2′-0″ higher than that of the offices. Site staff entered the building via five pedestrian doors on the east side, and parachutes were brought in through double pedestrian doors on the north and south ends of the parachute packing area.

The PRF was accessed from a single entrance drive on Avenue E, which led to the parking area on the east side of the building.

5. Alterations and Additions

In 1968, the building was modified into the NASA News Center to serve as a site for press photograph development, as well as house journalists and public relations activities. This renovation included "expansion of the sanitary, communication, and parking facilities," as well as the installation of 120 telephone circuits.[37]

The building was again modified and expanded in 1978 for the SSP to receive, clean, inspect, store, and refurbish the shuttle's pilot, drogue, and main parachutes. The 1978 additions were designed by Sanders & Thomas, Inc., and built by Holloway Corporation. This work included the following tasks: the removal of interior partitions; upgraded electrical and plumbing systems; new HVAC systems; and the construction of the high bay, the parachute packing aisles on the east end of the building, and the covered "defoul deck" on the north end of the building.[38] Two 1978 aerial photographs show the layout of the new additions after construction (See Appendix).[39]

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[37] NASA, "NASA News Center (Mods to Parachute Bldg.)" (KSC: 1968). On file at the KSC Archives.

[38] Sanders and Thomas, Inc., "Shuttle Parachute Facility Modifications" (KSC: Florida, 1979), construction drawings.

[39] KSC photograph number 108-KSC-378C-202-1, March 29, 1978. On file at the KSC Library Archives.

The last major alterations to the building occurred in 1985 with the construction of a small addition in the center of the east elevation, a new men's restroom, and the construction of a new wing on the southwest corner of the building for storage and what is now called the materials testing area. A 1996 aerial photograph shows the layout of the PRF after these final additions and the construction of the PRF Warehouse.[40]

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[40] Burns and Roe Industrial Services Corporation, "Parachute Refurbishment Facility Modifications" (KSC: Florida, 1985), construction drawings; KSC photograph number KSC-396C-0958-35, February 21, 1996. On file at the KSC Library Archives.

Part II. Structural/Design/Equipment Information

A. General Statement

1. Character

The PRF was built in stages to receive, wash, inspect, repair, and pack the parachutes used on the Space Shuttle SRBs. It is located at the southwest corner of 3rd Street and Avenue E in the KSC Industrial Area. The building is bordered on the north and east by road shoulders and drainage ditches, and on the south and west by undeveloped wetlands. There is a 5,100-square foot GSE storage building on the west side of the PRF.

The PRF is a one-story, concrete-block manufacturing building with an irregular footprint and painted white exterior. It contains 35,758 square feet of work space, including a 2,100 square-foot high bay and 2,025 square foot central office bay. There is an overhead monorail system throughout the building that transported the parachutes from one area to another.

The building has six main sections, including: the central office bay; the high bay; the east parachute refurbishment area (Aisles 1-3); west refurbishment area (Aisle 4); the materials testing area; and the defoul deck. The entire building, except the defoul deck, has a concrete block construction with flat, built-up roofs. The defoul deck is a rectangular, covered, outdoor space that stretches across the north end of the building and beyond its west side to create an L-shaped footprint. It has a reinforced cast concrete structure and built-up roof.

Transportation to the building is accomplished via a pair of entrance drives off of Avenue E. There are parking areas on the east, south, and west sides of the building. There are security gates that restrict access from the parking areas to the defoul deck loading area and the west (rear) side of the building.

2. Condition of Fabric

The PRF remains in excellent condition and does not show any signs of neglect or deterioration.

B. Description of Exterior

1. Overall Dimensions

2. Foundation

The building has continuous reinforced concrete footers under each of its load-bearing walls. The footers vary in thickness from 1′-0″ to 2′-0″, with a depth of 2′-1″.

3. Walls

The PRF has reinforced 8″ concrete block walls divided into 12′-0″ bays. The walls are painted white. The bays are divided by 1′-4″ wide concrete pilasters that are flush with the wall surface. The pilasters join a continuous concrete tie beam at the roofline of the building, which is topped by metal flashing.

4. Structural System

The building has a structural system of load-bearing, reinforced, concrete-block walls. The floor system is a 0′-5″ reinforced concrete slab. It has a steel joist roof structure with built-up roof, and a suspended acoustic tile ceiling. Interior walls of the central office bay are wood frame with drywall.

5. Porches, stoops, balconies, bulkheads

None.

6. Chimneys/stacks

None.

7. Openings

The PRF has no windows except for those that are part of its several half-light doors (see below).

The main entrance to the PRF is a double, half-light pedestrian door on the south side of the building. It is flanked on the east by the high bay’s metal roll-up door, which measures 15′-0″ high x 16′-0″ wide, and on the west by an additional double pedestrian door with no lights.

There are two single, half-light pedestrian doors on the east elevation, one at the north end and one at the south end.

The covered defoul deck on the north end of the building contains five double-door entrances that lead into the main parachute processing area. One of these entrances is a standard double-door pedestrian entrance. The other four are associated with parachute processing Aisles 1-4, and they are labeled with these aisle numbers. The defoul deck’s overhead monorail system, used to move the parachutes, is directed through each of these aisle doors, which open to receive the parachutes into the aisles. West of these parachute processing area doors is a single, half-light pedestrian door that leads from the defoul deck to the rear courtyard area of the PRF.

The west side of the building has a single half-light pedestrian entrance, a single solid pedestrian entrance, and two double solid pedestrian entrances that lead into various interior work areas.

8. Roof

The PRF has a flat, built-up roof. There are metal flashing and gutter systems around the perimeter of the roof line.

C. Description of Interior

1. Floor Plan

The PRF floor plan is arranged so that the central office bay, logistics area, and high bay are flanked on the east and west by parachute refurbishing areas. The materials testing area extends from the southwest corner of the building. The defoul deck extends across the north side of the building and beyond its west side to make an L-shaped footprint.

The east refurbishing area contains Aisles 1-3, which were used for inspection, refurbishment, and packing. Each aisle features 64′-0″ long x 6′-0″ wide work tables, sewing machines, and other equipment.[41] The west work area contains Aisle 4, which was used for parachute manufacturing and refurbishment. It is 200′-0″ long x 20′-0″ wide with a 13′-6″ ceiling height. It contains a specially-designed 185′-0″ steel and wood work table with a composite top that extends the length of the room.[42]

Along the north side of the building is the defoul deck, which contains open inspection areas and the parachute washer and dryer.

The central office bay is 140′-0″ long x 30′-0″ wide with a 10′-0″ ceiling height. From north to south, this area includes the restrooms, mechanical room, machine shop, lunch room/break area, office area, and the equipment transfer aisle. The office area contains cubicle work areas.

The high bay is on the south end of the building and opens to the main parking area. This is where the refurbished main, drogue, and pilot parachutes were integrated into the Main Parachute Support Structure (MPSS). The north end of the high bay is occupied by the logistics area, a one-story, fenced cage-type room that contains the PRFs tools and equipment. The top of the logistics cage was used as a storage area, which is reached by a metal ladder on its east corner. Stored parachutes and other equipment in the high bay were moved with a 5-ton bridge crane with a 17′-0″ hook height.

[41] NASA, "National Space Transportation System Reference: Volume 1, Systems and Facilities" (KSC: 1988), on file at the KSC Library Archives.
[42] Wellman-Lord Engineering, Inc., "MSC Parachute and Paraglider Building, Phase I" (KSC: Florida, 1965), construction drawings.

2. Work Flow

Work in the PRF generally flowed from north to south through the parachute processing areas. Parachutes were delivered to the defoul deck on the north end of the building where they were unpacked, inspected, washed, and dried. They were then moved on the overhead monorail system into the building for further inspection, refurbishment, and packing. After packing, the parachutes were stored in the warehouse building on the west side of the PRF until they were picked up and transported to the SRB ARF Manufacturing Building for installation.

3. Stairways

There is a single metal staircase that leads from the ground floor to the top of the logistics area.

4. Flooring

The PRF has polished concrete floors in the east processing area, defoul deck, and high bay, and tile floors in the west processing area and materials testing area.

5. Wall and Ceiling Finish

The concrete block walls of the east processing area, high bay, and materials testing area are finished in white paint. The west processing area and central office bay have drywall interiors finished in white paint. The ceiling throughout the building is finished with suspended acoustic tile paneling.

6. Openings

The interior work areas in the PRF are connected with open passageways; this enabled the movement of large parachutes. The building's few interior pedestrian doors are on the restrooms, machine shop, and lunch room.

7. Mechanical Equipment

a. Heating, air conditioning ventilation

Due to the humidity and temperature sensitive nature of parachute materials, the PRF required an extensive HVAC system. The most recent system maintained a temperature range of 70 to 80 degrees Fahrenheit.

b. Lighting

The PRF is illuminated by fluorescent lights in the suspended acoustic tile ceiling.

c. Plumbing

The PRF's major plumbing systems served the parachute washing machine, the interior restrooms, and the lunch room/break area. In the 1990s, the original parachute wash system was refined to capture, filter, and re-use water using ozone and particulate filters. Filtered water was stored in a 30,000 gallon storage tank attached to the south side of the defoul deck, adjacent to the washer. Water use was reduced from more than 400,000 gallons per shuttle flight to just 35,000 gallons, a nearly 90 percent reduction.[43]

8. Machines

The PRF is equipped with a number of specialized machines used in the refurbishment process. The first machine used was the overhead monorail that runs throughout the building. Parachutes were first unpacked on the defoul deck and hung on suspension racks that are attached to the monorail. From there they were manually transported through the washer and dryer, and then into the refurbishment and packing aisles in the building.

The defoul deck contains the large parachute wash tank and drying room. The washer was filled about two-thirds of the way up with 25,000 gallons of fresh water to wash each parachute. No detergent was used. The washer recirculated the water anywhere from one hour to eight hours for an overnight soak.

The washer was then drained and the parachute moved into the 4,100-square foot drying room, which used a forced-air system to circulate 140-degree air for 10-12 hours, depending on humidity.[44]

Other machines that were used in the PRF were a variety of hoists, including one 5-ton hoist with a 17-foot hook height in the high bay. There are three 500-pound hoists and three 0.5-ton hoists that were used to lift parachutes in the packing area.

[43] Gene Harm, "Reducing Water Usage in Parachute Refurbishment," Spaceport News (April 24, 1998), 4.
[44] United Space Alliance, "Parachute Operations" Revision J (KSC: no date), 16.

There are also three 1.5-ton floor-mounted hoists along the north end of the Aisles 1-3. These were used to supply tension to the parachute lines during preparation for packing.

At the south end of Aisles 1-3 are three 2-ton capacity in-floor lift tables that were used to properly position the parachute packing canisters during operations.

The materials testing area contains two Tinius Olsen Tensile Strength Machines, one with a 60,000-pound capacity and one with a 12,000-pound capacity. These machines were used to conduct confidence testing on all new parachute materials.

The PRF contains approximately 60 sewing machines of various sizes, some as old as 1985. They were used to repair different types of damage, including radial tears, friction burns, broken stitches, etc. Some machines did single-stitch while others did double stitch, zigzag, and bar tack patterns. The machines' large single needles could penetrate several inches of material. Sewing machines were transferred back and forth from Aisles 1-3 to Aisle 4 through the sewing machine transfer aisle in the PRF's central office bay.

Part III. Operations and Process

A. Operations

KSC maintained nine different flight sets of SRB parachutes, plus additional pilot and drag parachutes for the shuttle orbiter. Each SRB flight set included two pilot parachutes, two drogue parachutes, and six main canopy parachutes, for a total of 72 parachutes. Each main canopy parachute had a 136′-0″ diameter with 204′-long series of risers, bridles, and lines that deployed from its bag in 1.5 seconds. The parachutes deployed so quickly that their fabric, taping, and lines suffered from tears, broken stitches, friction burns, hot debris burns from the jettison of the SRB nozzle extension, and damage at sea after splashdown. A team of 25 trained PRF technicians, plus another 20 engineers and designers, made hundreds of repairs to each parachute to refurbish, store, and deploy them for the next flight.[45]

After ocean retrieval, the parachute reels were unloaded with a crane from the *Liberty Star* and *Freedom Star* ships at the Hangar AF docking area adjacent to the SRB slip. The reels were loaded onto a flatbed truck trailer and transported to the PRF, usually within two days after the launch. The reels were then removed by a forklift and transferred to the PRF defoul deck.

The parachutes were kept wet at all times to prevent them from drying out, which would result in fabric lacerations from salt crystals. A soaker hose system was attached to the parachute reels while aboard the retrieval ships. Once at the defoul deck an overhead sprinkler system was used to keep them moist until processing occurred.

A parachute reel was moved on a pallet mover to the east end of the defoul deck where the protective cover was removed and the parachute lines were connected to an eye-bolt embedded in the concrete floor. The pallet mover was reversed to unreel the parachute so the lines could be untangled and separated from the canopies. PRF employees

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[45] KSC, "Inside the Parachute Refurbishment Facility," Spaceport News (March 2, 2001), 4.

then performed a quick damage assessment and preliminary damage mapping of each retrieved parachute.

The parachutes and its separated lines were then manually hung from the defoul deck’s overhead monorail suspension racks, a labor-intensive task with no mechanical lift assistance. Once attached, the monorail allowed for easy transport of the parachutes throughout the refurbishment areas of the PRF.

Next, the parachutes were manually moved along the monorail into the 25,000-gallon wash tank, which used recirculated water with no detergents or agitation. The wash water was supplied from a 30,000-gallon storage tank on the south side of the defoul deck, which housed all the necessary pumps and filtration units. The parachutes were washed for a minimum of one hour, while a typical wash cycle lasted from four to six hours, or even overnight.

A pallet mover was used to transfer the wet parachute from the wash tank into the drying room. The dryer used a forced-air system at a temperature of about 140 degrees Fahrenheit for a typical 10 to 12 hour drying process.

Following the wash and dry processes, the parachutes were transferred on the monorail into the PRF refurbishing areas. They were removed from the suspension racks and placed on one of the areas’ work tables for preliminary damage inspection. Damaged areas were recorded using color-coded flags affixed directly to the parachutes, which indicated the type and location of damage, and also noted on illustrated diagrams of the parachute canopies. All damages received engineering review to differentiate between repairable damage, such as small rips or tears in stitching, versus those which required full replacement of structural elements like the risers and hardware. All damages were then repaired in Aisles 3 or 4 of the PRF, while Aisles 1 and 2 were reserved for parachute packing.

During packing operations, parachutes received multiple quality inspections at critical steps. It was also during this phase that the Salt Water Activated Releases (SWAR), which detached the parachute lines from the SRBs at splashdown, and the ordnance-fired reefing line cutters were installed by PRF technicians.

The parachute lines were connected to three 1.5-ton hoists mounted in the floor at the north end of the refurbishment areas to hold tension in the lines during preparation for packing. They were stretched out along the work tables as each individual parachute panel was systematically folded into place, creating a long tubular shape. At the other end of the work area, three two-ton capacity in-floor lift tables properly positioned the packing canisters. The parachutes were folded and compressed into the canister according to a precise folding pattern that ensured it would deploy properly during the next flight. Depending on its condition, a single main canopy parachute could be refurbished and ready for another flight in just over a week.[46]

After packing, the parachutes were either boxed for storage in the PRF Warehouse, or transferred to the high bay for integration with the pilot and drogue parachutes, called “clustering,” in the MPSS. Using the 5-ton bridge crane, the pilot and drogue parachutes were integrated into the main parachute clusters. Once all of the parachutes were integrated, the final cluster was covered for delivery to the ARF for build-up and assembly into the SRB frustum.[47]

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[46] KSC, “Parachute Facility Ready for Shuttle,” *Spaceport News* (November 10, 1978), 3.
[47] United Space Alliance, “Parachute Operations” (KSC: no date), 1-28.

WORKER HISTORY

The PRF was staffed with approximately 45 employees during the SSP. Of those, about 20 of them were technicians who worked on parachute refurbishment, repairs, and packing operation. The remaining 25 people were engineers and quality-inspection staff. The PRF was managed by three different contractors, first by USBI, then by Martin Marietta, and finally USA. While the contracting company changed through the years, the PRF technicians and other staff tended to remain constant.[48]

Scott Brady, KSC Senior Parachute Technician, worked at the PRF from 1984 until the end of the SSP in 2011. He came to work at the PRF after his certification as a FAA Master Parachute Rigger in Colorado, where he was an active skydiver with a business selling and repairing parachutes to other skydivers and pilots. He began work at the PRF as a Parachute Technician and recalled that many of the other technicians at the facility had backgrounds as parachute riggers in the Navy. Still others came to the PRF with backgrounds in sewing or without any relevant experience at all and they learned the necessary skills on the job.[49]

In the early years of the SSP, Brady recalls that the SRB parachutes underwent a good deal of testing and changes before they reached their final design. The parachutes were originally 115 feet in diameter, which turned out to be too small and allowed the SRBs to fall too quickly into the ocean. This led to damage on the SRB aft skirts and TVC systems. After testing, the parachute size was increased to 136 feet in diameter. Another significant change in the design involved the closing of the vent at the top of the parachute that allowed it to open faster.

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[48] Scott Brady, interview with author, November 2011; NASA, "NASA Awards More Shuttle Work to USA," *Spaceport News* (August 14, 1998), 4.
[49] Scott Brady, interview with author, November 2011.

The research and testing involved in these and other changes to the parachutes were conducted by PRF engineers such as Bruce Rutledge, who worked in tandem with the Pioneer Parachute Company, which actually manufactured the main SRB parachutes.[50]

During Brady's tenure as a parachute technician, the PRF was "constantly busy," often with a night shift of workers to keep up with the hectic schedule of about eight shuttle flights a year. The intensity of the work tended to be cyclical depending on the flight schedules, with more time spent on repairs and refurbishment during down times in the cycle. During hectic times there were as many as five people packing parachutes on each of the two packing aisles, with another five technicians doing refurbishment work, three technicians doing research and design changes, and others doing materials testing.[51]

Part IV. Sources of Information

A. Engineering Drawings and Plans

Burns and Roe Industrial Services Corporation. "Parachute Refurbishment Facility Modifications." Kennedy Space Center, Florida. Construction drawings, 1985.

Sanders and Thomas, Inc. "Shuttle Parachute Facility Modifications." Kennedy Space Center: Florida. Construction drawings, 1979.

[50] Scott Brady, interview with author, November 2011.
[51] Scott Brady, interview with author, November 2011.

Wellman-Lord Engineering, Inc. "MSC Parachute and Paraglider Building, Phase I." Kennedy Space Center, Florida. Construction drawings, 1965.

B. Early Views

Kennedy Space Center. Photograph negative number 105-KSC-66C-5579, dated June 16, 1966. On file at Kennedy Space Center Library Archives.

Kennedy Space Center. Photograph number 108-KSC-378C-202-1, dated March 29, 1978. On file at the Kennedy Space Center Library Archives.

Kennedy Space Center. Photograph number KSC-396C-0958-35, dated February 21, 1996. On file at the Kennedy Space Center Library Archives.

C. Interviews

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NASA

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"SRB Complex Work Begins on Site North of VAB," *Spaceport News*, Volume 21, No. 17, August 19, 1982.

"Inside the Parachute Refurbishment Facility," *Spaceport News* (March 2, 2001), 4.

"Parachute Facility Ready for Shuttle," *Spaceport News* (November 10, 1978), 3.

Presidential Commission. *Report of the Presidential Commission on the Space Shuttle Challenger Accident, June 6, 1986*. Washington, D.C. Steven J. Dick, NASA Chief Historian,
Steve Garber, NASA History Web Curator. National Aeronautics and Space Administration, NASA History Office. Accessed on August 1, 2010 at http://history.nasa.gov/rogersrep/51lcover.htm.

United Space Alliance. "Materials and Processes Revision J." Kennedy Space Center, no date.

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Dick Young. "Florida Firm Awarded Contract for Shuttle Parachute Facility," *NASA News* (October 26, 1977), KSC Release No. 163-77.

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United Space Alliance, "Parachute Operations" Revision J (KSC: no date).

United Space Alliance, "Parachute Operations" (KSC: no date).

F. Likely Sources Not Yet Investigated

Research was conducted at KSC using primary and secondary sources. Sources that were not investigated that may contain secondary information include NASA Headquarters and at the offices of the various architects and contractors that constructed the PRF.

Additional oral history interviews with other engineers and technicians could also prove useful.

V. Project Information

NASA determined that the PRF was eligible to the National Register of Historic Places under Criterion A in the area of Space Exploration and Transportation. This determination was made by NASA's "Shuttle Transition Historic Preservation Working Group" or HPWG, which looked at 335 facilities at thirteen NASA Centers.[52] As a result of this work, seventy properties were identified as either listed, determined eligible, or were potentially eligible to the National Register. Out of twelve property types identified for NASA's SSP, the PRF was identified as falling within Type 9, which includes Resources Associated with Manufacturing and Assembly Facilities.[53] NASA completed this evaluation before the SSP was terminated in 2011.

A Programmatic Agreement (PA) was developed to document the identified eligible resources and streamline the Section 106 consultation process. Per Section V.A of the PA between NASA, the Advisory Council on Historic Preservation (ACHP), and the Florida State Historic Preservation Officer, dated May 2009, and the Statement of Work provided to New South Associates by KSC/InoMedic Health Applications (IHA) as part of the Task Order Contract dated February 2010, the documentation package for the PRF includes the following items: a written narrative; a series of photographs showing both exterior and interior views using large format negatives; and a selection of existing drawings, which were photographed with large format negatives. This HAER documentation fulfills the recordation requirements of the PA for the facility.

New South Associates, under contract with IHA, a subcontractor to NASA KSC, conducted the HAER documentation and historic research for this project in September and

[52] Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 5.11.
[53] Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 5.11.

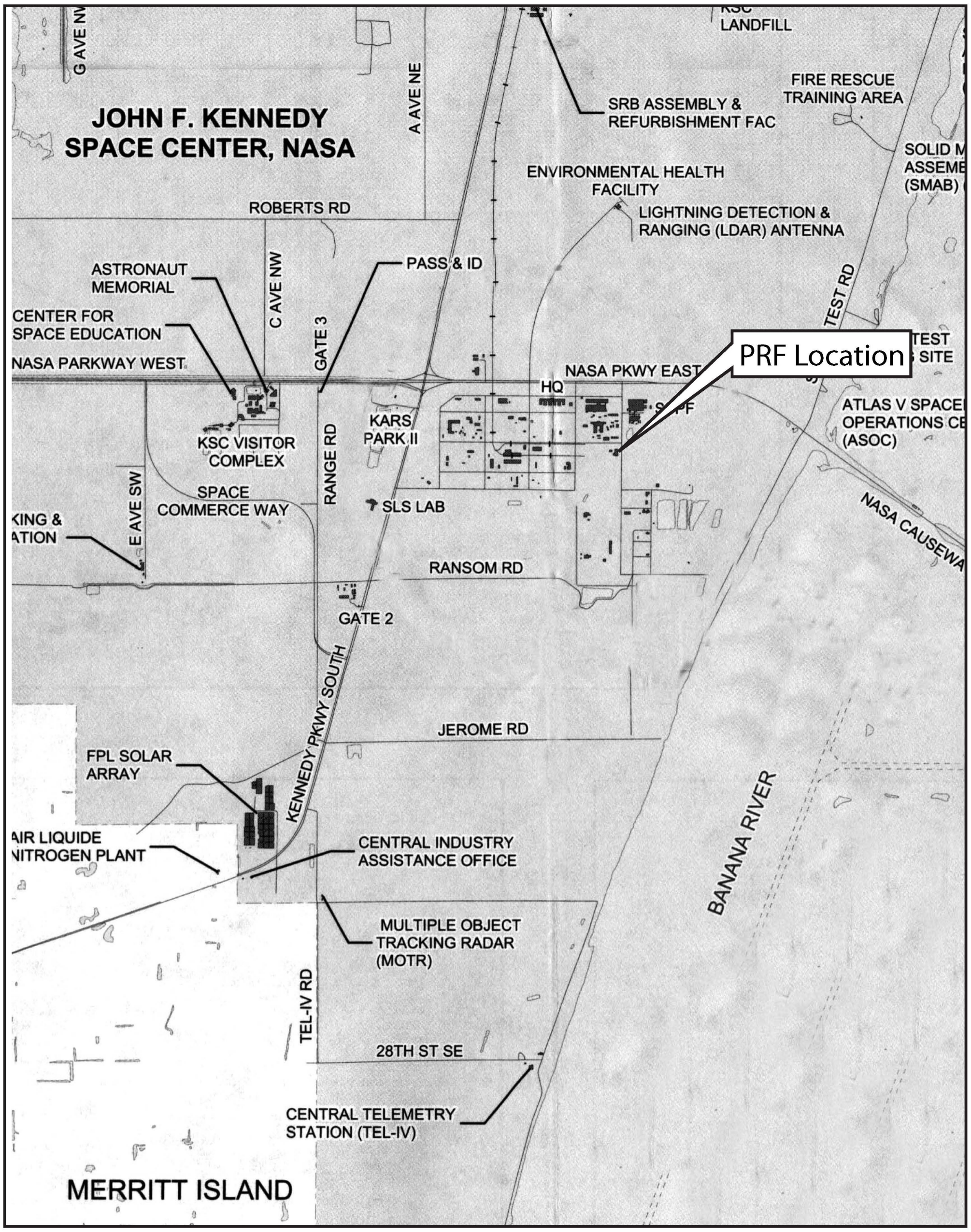
October 2011. With the end of the SSP, the PRF may be altered and modified for future space missions after consultation with the FL SHPO. Therefore, NASA is completing HAER documentation of this facility and other KSC properties to record these as they appear and as they existed during the SSP. David Diener served as the project photographer. Julie Coco served as Principal Investigator, while David L. Price served as Project Historian.

In order to complete the project, New South Associates personnel were allowed full access to the facility, under the supervision of Barbara Naylor, KSC Historic Preservation Officer, and Nancy English, KSC Environmental Specialist. Photographs were taken of the building's interior rooms, exterior, and context. David Price conducted a limited number of oral interviews and otherwise compiled the historic documentation required for the project. The main source interviewed for this project was Scott Brady, KSC Senior Parachute Technician. Elaine Liston, KSC Archivist, provided a wealth of information from her office in the KSC Headquarters Building Archives Office.

Appendix – Historic Views

Source: ESRI Resource Data

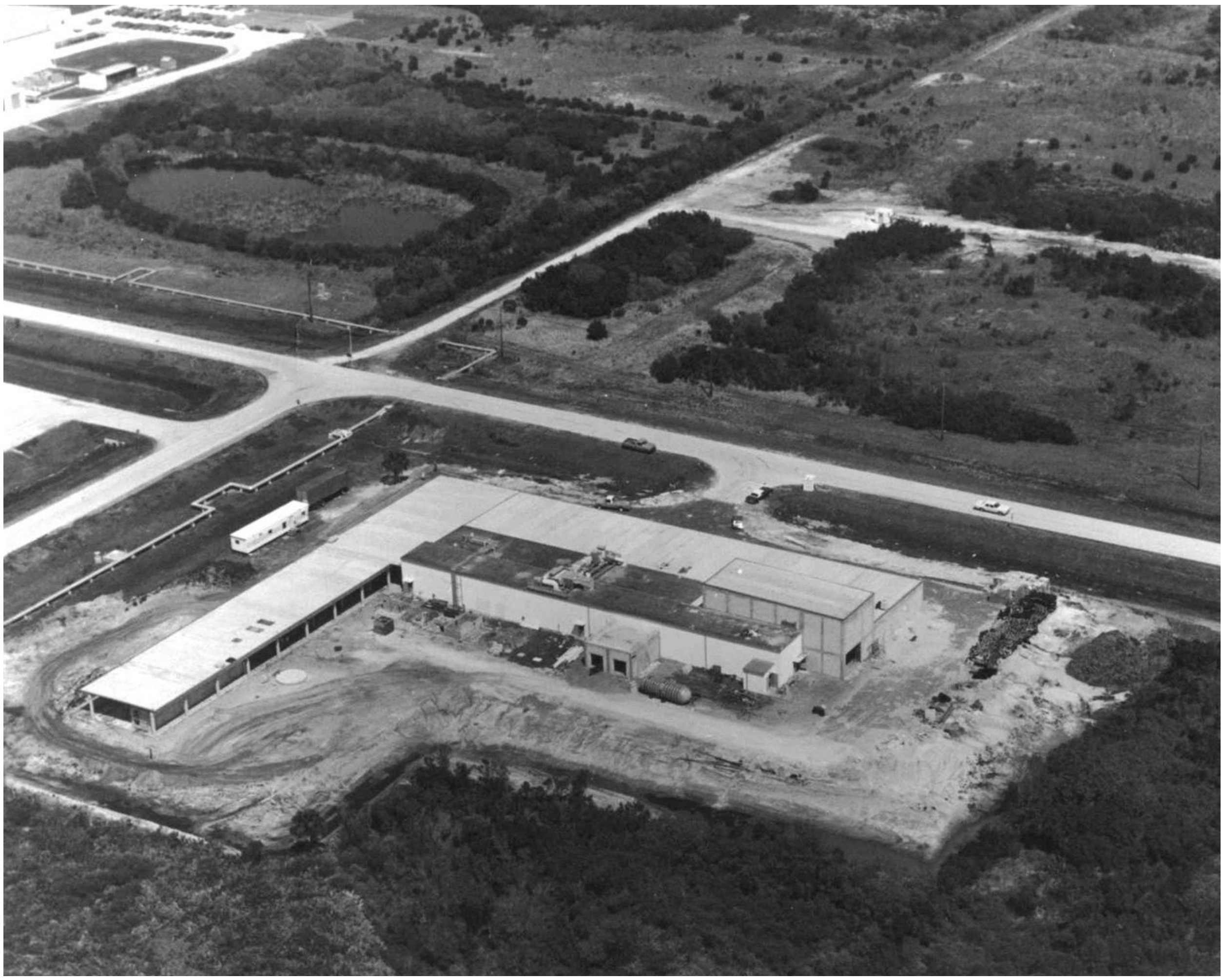
Aerial Photograph Showing the location of the PRF, Kennedy Space Center.



Map Showing the Location of the PRF within Kennedy Space Center. (Courtesy KSC)

Photograph of the Original Parachute Refurbishment Facility Before Additions, View Southwest. (Source: KSC, Image 105-KSC-66C-5579).

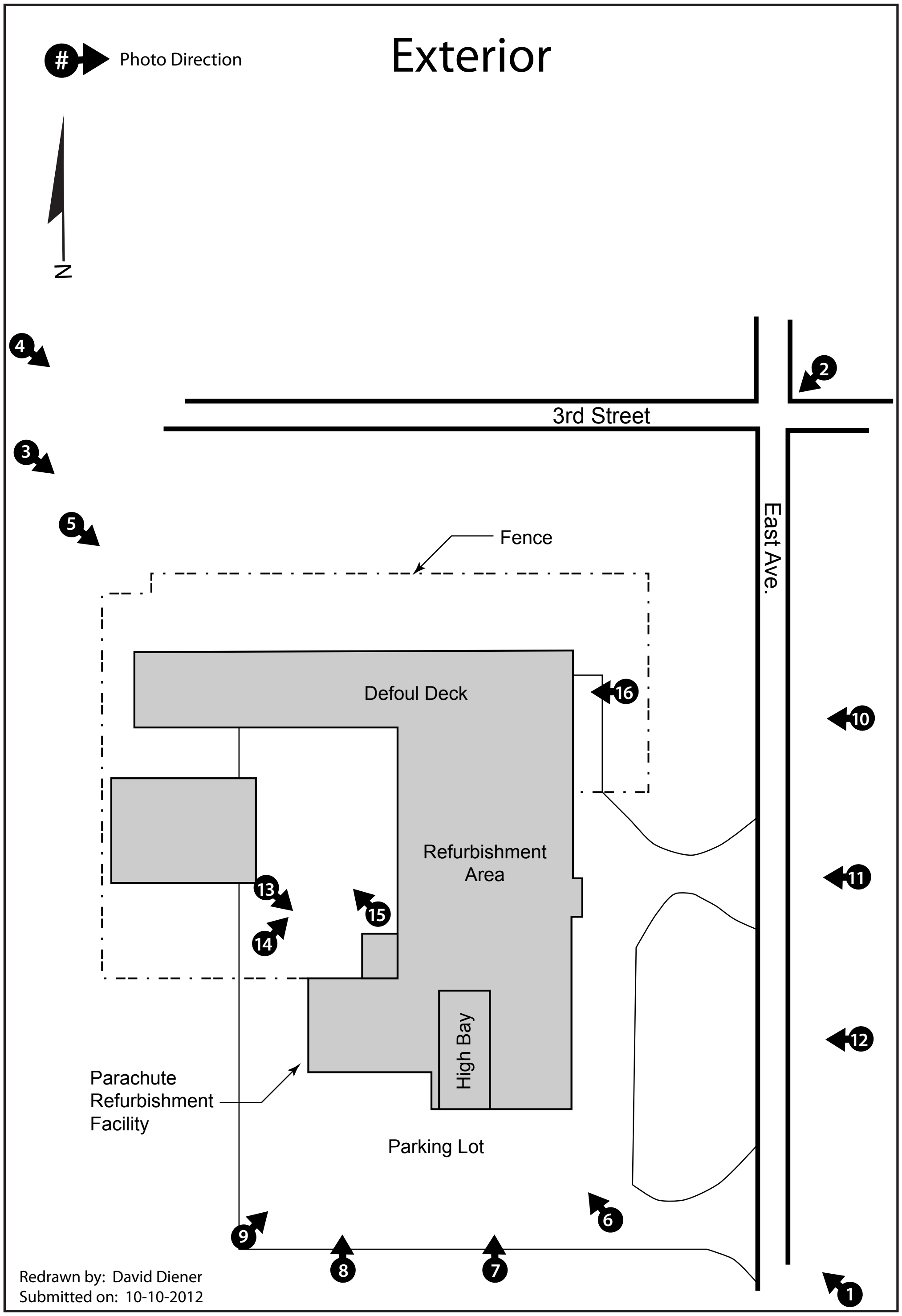
Aerial View of the Parachute Refurbishment Facility After Additions, View Southwest, 1978. (Source: KSC, Image 108-KSC-378C-201-1).



Aerial View of the Parachute Refurbishment Facility After Additions, View Northeast, 1978. (Source: KSC, Image 108-KSC-378C-202-6B).

Aerial View Showing the Parachute Refurbishment Facility After Addition of Materials Testing Area and Warehouse, View Southwest, 1996. (Source: KSC Image KSC-396C-0958-35)

Keys to Views


Exterior
Photo Direction
N
3rd Street
East Ave.
Fence
Defoul Deck
Refurbishment Area
High Bay
Parachute Refurbishment Facility
Parking Lot
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Redrawn by: David Diener
Submitted on: 10-10-2012

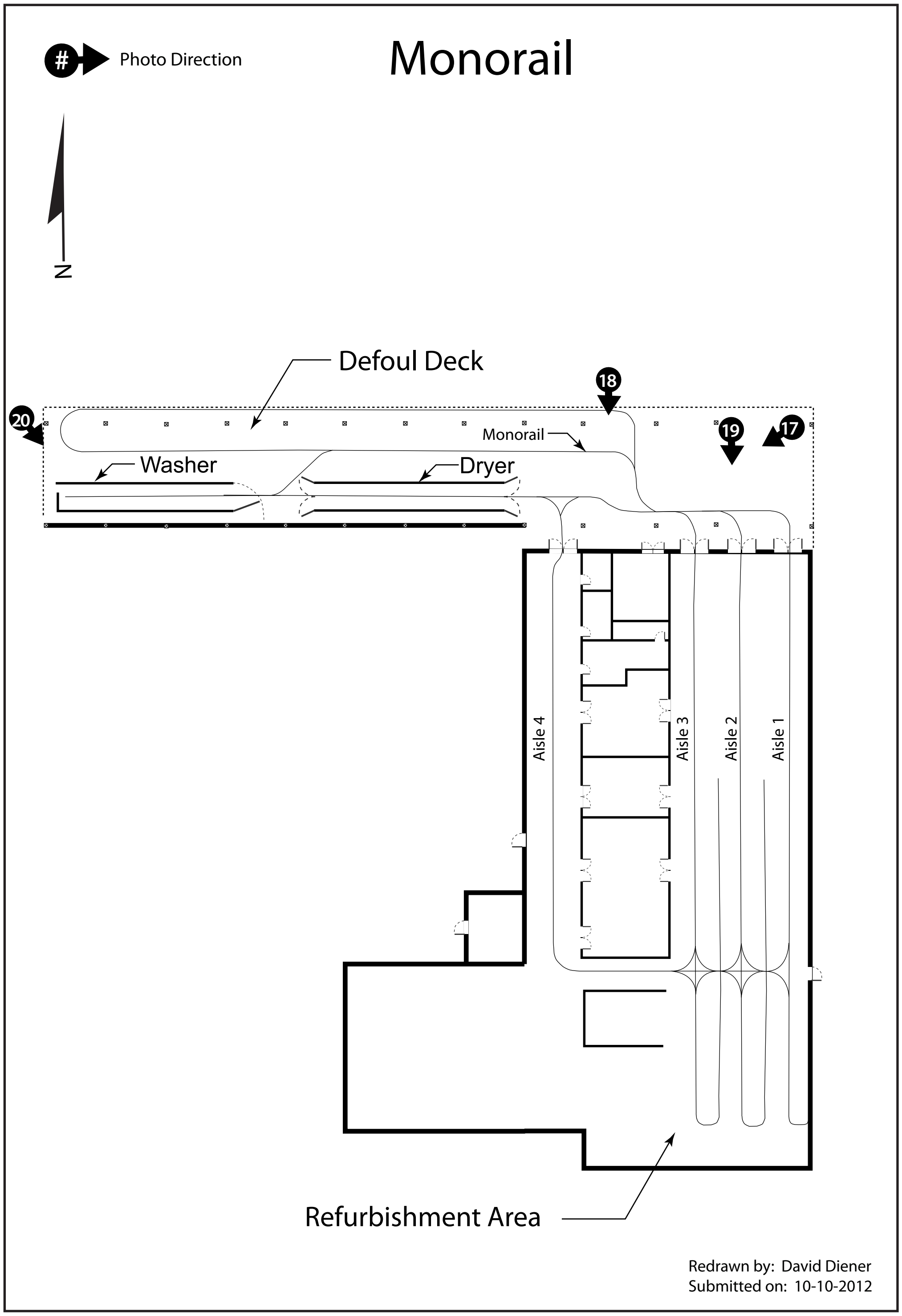


Photo Direction
Monorail
N
Defoul Deck
18
20
19
17
Monorail
Washer
Dryer
Aisle 4
Aisle 3
Aisle 2
Aisle 1
Refurbishment Area
Redrawn by: David Diener
Submitted on: 10-10-2012

Defoul Deck

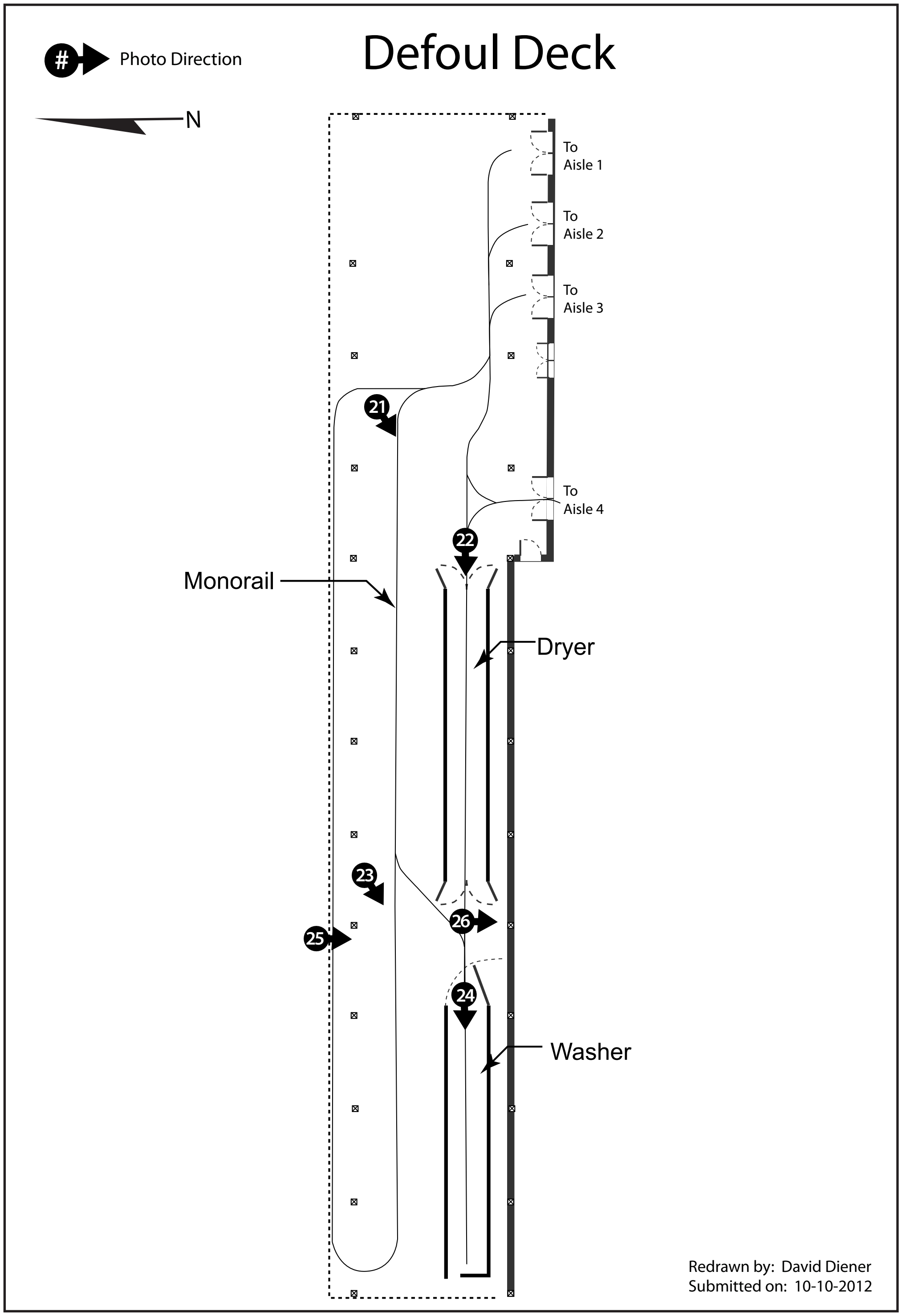


Photo Direction
N
To Aisle 1
To Aisle 2
To Aisle 3
To Aisle 4
21
22
23
24
25
26
Monorail
Dryer
Washer
Redrawn by: David Diener
Submitted on: 10-10-2012

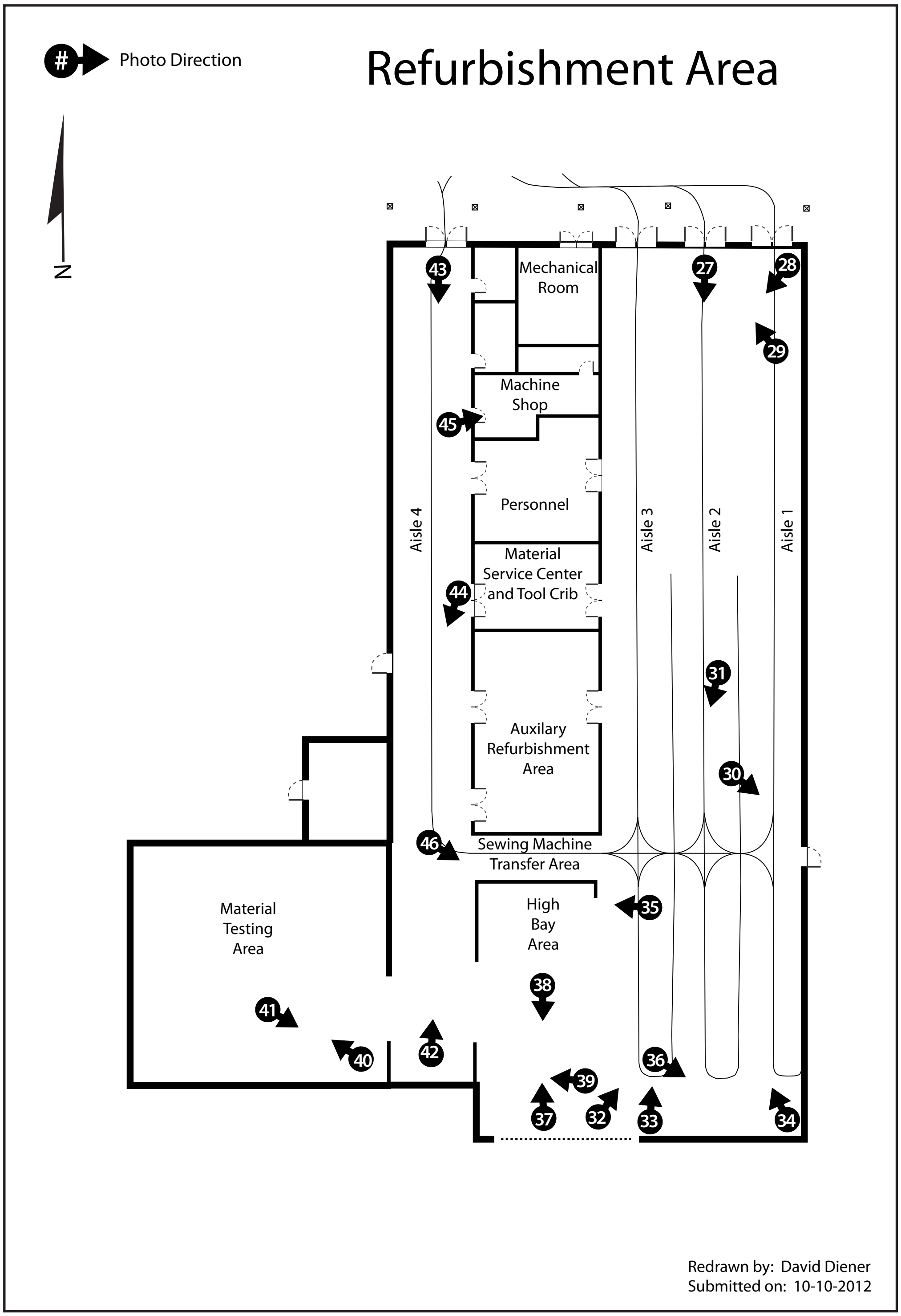


Photo Direction
Refurbishment Area
N
Mechanical Room
Machine Shop
Personnel
Material Service Center and Tool Crib
Auxilary Refurbishment Area
Sewing Machine Transfer Area
High Bay Area
Material Testing Area
Aisle 4
Aisle 3
Aisle 2
Aisle 1
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HISTORIC AMERICAN ENGINEERING RECORD

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HAER No. FL-8-11-Q

CAPE CANAVERAL AIR FORCE STATION
LAUNCH COMPLEX 39
PARACHUTE REFURBISHMENT FACILITY (PRF)
John F. Kennedy Space Center
Cape Canaveral
Brevard County
Florida

David Diener, Photographer September – October 2011

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FL-8-11-Q-57 Photocopy of engineering drawings (8″ x 10″ photo of scanned original; January 22, 1979 by Sanders & Thomas, Inc.; drawings in possession of Kennedy Space Center) "Shuttle Parachute Facility Modifications – Location Maps, Abbreviations & Index."

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FL-8-11-Q-62 Photocopy of engineering drawings (8″ x 10″ photo of scanned original; January 22, 1979 by Sanders

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FL-8-11-Q-64 Photocopy of engineering drawings (8″ x 10″ photo of scanned original; August 13, 1996 by Burns and Roe Industrial Services Corp.; drawings in possession of Kennedy Space Center) "Parachute Refurbishment Facility – Facility Modifications – Site & Grading Plan."

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