CAPE CANAVERAL AIR FORCE STATION, HAER NO. FL-8-11-S
LAUNCH COMPLEX 39,
SOLID ROCKET BOOSTER DISASSEMBLY & REFURBISHMENT COMPLEX
(Hangar AF Complex)
(John F. Kennedy Space Center)
Cape Canaveral
Brevard County
Florida

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

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

HISTORIC AMERICAN ENGINEERING RECORD

CAPE CANAVERAL AIR FORCE STATION, LAUNCH COMPLEX 39, SOLID ROCKET BOOSTER DISASSEMBLY & REFURBISHMENT COMPLEX (Hangar AF Complex)

HAER No. FL-8-11-S

Location: Cape Canaveral Air Force Station, Cape Canaveral, Brevard County, Florida.

USGS Orsino, Florida, Quadrangle, Universal Transverse Mercator Coordinates: E 540465.24 N 3151325.46 Zone 17, NAD 1983.

Date of Construction: 1961-1995

Present Owner: National Aeronautics and Space Administration (NASA)

Present Use: Solid Rocket Booster Disassembly & Refurbishment

Significance: The Solid Rocket Booster (SRB) Disassembly & Refurbishment Complex (Hangar AF Complex) contains Hangar AF and eight other facilities that played an essential role in the re-usability of the SRBs in the Space Shuttle Program (SSP). The complex was originally designed or modified to process SRBs, from pre-launch manufacture and assembly to post-launch recovery, disassembly, cleaning, and refurbishment. The facilities include: Hangar AF, the SRB Recovery Slip, the First Wash Building, the Thrust Vector Control (TVC) Deservicing Building, the High Pressure Wash Building, the Robot Wash Building, the Multi-Media Blast Facility, the High Pressure Gas Building, and the SRB Paint Building. The Hangar AF Complex was determined eligible for the National Register of Historic Places (NRHP) as a historic district in the context of the SSP (1969-2011). All buildings/structures listed above are considered as contributing to the district, but are not considered individually eligible.

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

Date: October 16, 2012

PART I. HISTORICAL INFORMATION

A. INTRODUCTION

The SRB Disassembly and Refurbishment Complex at Hangar AF is located on Hangar Road in the Industrial Area of the Cape Canaveral Air Force Station (CCAFS). The complex contains nine facilities that contribute to the manufacture, refurbishment, or assembly of the SRBs for the Space Shuttle. These facilities include: Hangar AF (8BR2001), the High Pressure Gas Building (8BR2002), the High Pressure Wash Building (8BR2003), the First Wash Building (8BR2004), the SRB Recovery Slip (8BR2005), the SRB Paint Building (8BR2006), the Robot Wash Building (8BR2007), the Thrust Vector Control Deservicing Building (8BR2008), and the Multi-Media Blast Facility (8BR2009).

The complex is a significant historic property for its association with the Space Transportation System (STS), commonly known as the "Space Shuttle." The STS was a unique breakthrough in the history of the U.S. Space Program because it was based on 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. Along with the orbiter spacecraft, the SRBs were two of the shuttle's primary re-usable elements, while the external tank (ET) was not re-used. The SRBs' re-usability was made possible by a number of facilities at Kennedy Space Center (KSC) and CCAFS, including the SRB Disassembly and Refurbishment Complex. The complex is the first place to which the SRBs were brought after their recovery from sea, and where they were disassembled, cleaned and processed before they were moved to other KSC facilities for build-up and assembly.

List of Acronyms:

ACHP – Advisory Council Historic Preservation
AEDC – Arnold Engineering Development Center
ARF – Assembly and Refurbishment Facility
BSM – Booster Separation Motor
BTA – Booster Trowelable Ablative
CCAFS – Cape Canaveral Air Force Station
CDF - Confined Detonating Fuses
CSPE – Chlorosulfonated Polyethylene
DAS – Data Acquisition System
DoD – Department of Defense
EDOP – Enhanced Diver Operated Plug
ET – External Tank
ETA – External Tank Attach
EVA – Extravehicular Activity
GSE – Ground Support Equipment
HAER – Historic American Engineering Record
HPU – Hydraulic Power Units
HPWG – Historic Preservation Working Group
HVAC – Heating Ventilation and Air Conditioning
IEA – Integrated Electronics Assembly
IHA – InoMedic Heath Applications
ISS – International Space Station
KSC – Kennedy Space Center
LRU – Line Replaceable Units
MMBF – Multi-Media Blast Facility
MCC-1 – Marshall Convergent Coating-1
MPSS – Main Parachute Support Structures
NASA – National Aeronautics and Space Administration
NRHP – National Register of Historic Places
PA – Programmatic Agreement
PRF – Parachute Refurbishment Facility
RSS – Range Safety System
S&A – Safe and Arm
SCAPE – Self Contained Atmospheric Protective Ensemble

SHPO – State Historic Preservation Office
SRB – Solid Rocket Booster
SRM – Solid Rocket Motor
SSME – Space Shuttle Main Engines
SSP – Space Shuttle Program
SSVR – Solid State Video Recorder
STS – Space Transportation System
TPS – Thermal Protection System
TVC – Thrust Vector Control
USA – United Space Alliance
USBI – United Space Boosters, Inc.
VAB – Vehicle Assembly Building
WSSH – White Sands Space Harbor

B. HISTORICAL CONTEXT

1. NASA and the Space Shuttle

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. 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. By this time it was clear that the next major program would be based on a reusable space shuttle, designed to serve orbiting space stations and related missions.

President Richard M. 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."[1] 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 on April 12, 1981. After three decades of operations, the SSP was retired in 2011.[2]

During those thirty years of operation, there were 135 different flights, using a total of five Space Shuttles: *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 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*).[3] Additionally, the shuttle has deployed a number of Department of Defense (DoD) payloads that remain classified.

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[1] 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.
[2] Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 2.1.
[3] Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 2.22-24.

Two significant accidents have been associated with the SSP. The *Challenger* exploded shortly after lift-off on January 28, 1986, and the *Columbia* disintegrated on re-entry into the atmosphere, February 1, 2003. In both cases, the accidents killed all crewmembers on board.[4] Both of these accidents resulted in lengthy flight down time for the program, while exhaustive investigations led to extensive physical and procedural improvements. A more in depth discussion of the accident, its causes, and the material and procedural changes it initiated can be found in HAER No. Fl-8-11-G, the Rotational Processing & Surge Facility.

Most of the STS was in place by the time of the first shuttle launch in 1981. 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 Vehicle Assembly Building (VAB). After a series of test flights, each with a crew of two, (STS-1

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[4] 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.[5]

These launches were conducted from KSC's Launch Complex 39, Pad A. By the mid-1980s, Launch Complex 39 Pad B was also available for launch services. Since the beginning, there have been on average around five shuttle launches per year, with few or no launches for many months following each of the two major accidents.[6]

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 are: 1) the reusable orbiter, as the main shuttle vehicle is called; 2) an ET, the large orange tank in the middle of the shuttle assembly; and 3) the two reusable SRBs that flank either side of the ET. Of these three parts, only the ET is expendable and is not recovered after each flight.[7]

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

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

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.

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.[8] 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 feet before it achieved orbit. Each booster is its own rocket, about 150 feet tall, with an average diameter of 12'. 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.[9]

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[8] 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, NASA Chief Historian, Steve Garber, National Aeronautics and Space Administration (NASA) History Web Curator, NASA History Office, http://history.nasa.gov/rogersrep/51lcover.htm), Chapter IV.

[9] Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 3.15, 2.4-5.

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). A drawing illustrating the parts of the SRB can be found in Figure 3, at the back of this document. These nine components were grouped into four main segments, each with its own name. The uppermost segment was called the forward segment. It was composed of the following parts: 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 solid rocket motors (SRMs), which are discussed in more detail below. The lowest segment is called the aft segment and includes the aft skirt (7.54' tall) and the exit cone, also called the nozzle extension. The aft segment also contained four additional BSMs, as well as the Thrust Vector Control (TVC) system that steered the boosters while in flight.[10]

4. SRB Thermal Protection System

Prior to assembly, each individual SRB element was coated with a multi-layer Thermal Protection System (TPS) that protected the booster from the heat generated during

[10] 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.

liftoff and atmosphere re-entry. Each segment was first coated with Alodine, an anti-corrosion and surface preparation agent, followed by primer, and then finished with Hypalon paint. Then the first layer of the TPS was applied with a substance known as the Marshall Convergent Coating (MCC-1), a three-part mixture composed of glass, cork, and a two-part resin. MCC-1 was an ablative insulation material designed to protect the SRBs by absorbing the heat and friction of re-entry instead of the underlying aluminum. MCC-1 replaced the earlier Marshall Sprayable Ablator-2 (MSA-2), which had several drawbacks, including high cost, a brief five-hour life once it was mixed together, inconsistent tensile strength, and a tendency to come off the SRBs during flight and splashdown. MCC-1 was superior to MSA-2 in all respects, with its materials mixed at the point of release from a specialized spray gun by an automated robot located in the SRB Assembly and Refurbishment Facility (ARF).

Areas of the booster that needed additional thermal protection received a layer of cork, including the aft and forward skirts, External Tank Attach (ETA) ring segments, system tunnel covers, and several small parts. 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. 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.[11]

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. 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.[12]

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 most of that weight in the propellant, which was mostly made of the oxidizer ammonium perchlorate (about 70 percent) and aluminum powder fuel (16 percent).[13] The four

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[11] United Space Alliance, "Structures Assembly Buildup Operations, Revision J" (KSC, no date), no page number.
[12] Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 3.14.
[13] 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*,

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 26 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 an approximate altitude of 38.6 nautical miles, before they reached their apogee and tumbled back toward the ocean.[14]

A series of parachutes was deployed to slow the SRBs as they descended back to Earth. When the 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 for the booster. At an altitude of 6,000 feet, the frustum separated from the booster by the firing of an ordnance separation ring between the frustum and forward skirt structure. The separation of the frustum pulled out the three main parachutes that slowed down the speed of the SRBs from 230 miles per hour to 51 miles per hour for a soft landing in the Atlantic Ocean. After about five minutes the SRBs hit the ocean with the nozzle end down, trapping air in the burned out interior of the boosters.

Volume 21, No. 17, August 19, 1982, p. 7; NASA, *NASA Facts: Solid Rocket Boosters and Post-Launch Processing*, 1-2.

[14] NASA, *NASA Facts: Solid Rocket Boosters* (KSC, Florida), IS-2004-09-014-KSC, Revised 2006; NASA, *NASA Facts: Solid Rocket Boosters and Post-Launch Processing*, 2.

This air gave the boosters buoyancy and caused them to float with the forward end about 30 feet out of the water.[15]

6. SRB Recovery, Disassembly, and Refurbishment at Hangar AF

After splashdown in the Atlantic Ocean, the *Liberty Star* and *Freedom Star*, two ships designed for this purpose, recovered the boosters and returned them to the Hangar AF Complex. Once the ships reached 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, followed by the drogue parachute, were then reeled onboard using large powered reels. The drogue parachute at this point was still attached to the frustum, which was hoisted aboard the ship with a 10-ton crane.[16]

With the parachutes and frustums reeled in, the dive crew prepared the boosters 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-foot air hose into the booster. The pumped air forced all water in the booster out through a one-way valve in the EDOP, which caused the booster to rise up 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

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[15] NASA, *NASA Facts: Solid Rocket Boosters*, 1-2; NASA, *NASA Facts: Solid Rocket Boosters and Post-Launch Processing,* 1-2.
[16] United Space Alliance, “Marine Operations, Revision J” (KSC, n.d.), MO-1; NASA, *NASA Facts: Solid Rocket Boosters and Post-Launch Processing*, 2.

the ships back to Hangar AF for disassembly and refurbishment. The ships towed the SRBs via Port Canaveral through the Canaveral Lock, which was built in 1965 to connect the port to the Banana River. The Canaveral Lock is the largest navigation lock in Florida and was designed to allow passage of the Apollo Program's Saturn rockets. Once they reached Port Canaveral and the lock, the boosters were repositioned alongside the ships in what was called "hip mode" for easier navigation through the narrow channel and up the Banana River.[17]

When the ships arrived at their Hangar AF docking area on the Banana River, 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 Parachute Refurbishment Facility (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 manual hydrolase process in the High Pressure Wash Building and Robot Wash Building.[18] After the initial hydrolasing, the boosters were then moved into Hangar AF for further assessment and disassembly. Once disassembled,

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[17] NASA, *NASA Facts: Solid Rocket Boosters and Post-Launch Processing*, 2.
[18] Art Morales, George C. Marshall Space Flight Center
Office of the Director Shuttle - ARES Transition Office, interview with author, September 27, 2011.

the four empty and cleaned SRMs were loaded onto trucks that transported them to the KSC railway and then shipped back to Utah for refurbishment. All of the other booster segments were initially cleaned and processed at Hangar AF, including the frustums, forward skirts, and aft skirts. A detailed discussion of Hangar AF's full disassembly and refurbishment process is included in Part III of this report.

7. Conclusion – The Space Shuttle Mission

While the SRB recovery and refurbishment process began in the Atlantic Ocean and at Hangar AF, the shuttle crew arrived in orbit. During a typical mission, the shuttle crew completed their specific mission objectives, including deploying payloads, conducting experiments, and performing extravehicular activities (EVAs). Space Shuttle payloads were diverse, including: Spacelab; scientific observatories, 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 Space harbor (WSSH), New Mexico, for emergency landings. NASA also 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 ISS, 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."[19]

C. PHYSICAL HISTORY

1. Date(s) of construction:

The Hangar AF Complex was built in three phases from the 1960s through the 1990s. The first phase of construction included construction of Hangar AF and the High Pressure Gas Facility in 1962. The facility was designed by Bail, Horton & Associates of Fort Myers, Florida, and used for staff headquarters and administrative support offices of the Saturn IB and Saturn V rockets during the Apollo Program.[20]

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

[20] Bail, Horton & Associates, "Hangar 'AF'" Construction drawings (KSC, Florida) 1962; KSC, *Technical Facilities Resume: Hangar AF*, Facility No. 10-00-22-00 (KSC, Florida, 1966), 43-44. On file at the KSC Archives.

The hangar site is located on Hangar Road in the CCAFS Industrial Area. This area includes almost two dozen hangars and other buildings, only four of which were used by NASA, with the rest belonging to the Air Force. Another of these NASA buildings is Hangar S, which is adjacent to Hangar AF.[21] Hangar AF was designed to house 66,170 square feet of workspace with a reinforced concrete foundation and a concrete block and aluminum sheeting exterior.

The advent of the SSP in the 1970s initiated the second phase in the construction history of the Hangar AF Complex. Under the SSP, NASA planned to use Hangar AF for the disassembly and refurbishment of the shuttle's re-usable SRBs. The hangar location on the Banana River made it ideal for receiving the boosters from specially-designed ships that towed them in from the sea. The Hangar AF building remained largely unchanged for the Shuttle Program, although its surrounding site received extensive modifications from 1977-1979, including new paving and infrastructure, the construction of the SRB receiving slip, the railways, the First Wash Building, and the High Pressure Wash Building.[22]

Bids for the Hangar AF modifications were accepted in October 1977, with the contract awarded to Holloway Construction at a cost of $3,227,300. The site's new features were scheduled for completion by 1979 and

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[21] KSC, *Technical Facilities Resume: Hangar AF*. Facility No. 10-00-22-00, 43-44; KSC photograph negative number 108-KSC-378C-203/3, dated March 29, 1978. On file at KSC Archives.
[22] Sverdrup & Parcel and Associates, "Solid Rocket Booster Recovery & Disassembly Facility, Hangar AF, CCAFS, Industrial Area" (KSC, Florida). Construction drawings, 1977.

represented the first phase in the SRB disassembly and refurbishment operations at the hangar.[23]

A 1978 aerial photograph of the Hangar AF site shows the condition of Hangar AF and the High Pressure Gas Building at the beginning of the site grading and other preparations.[24] The photograph shows the first construction phase of the SRB Recovery Slip and foundation preparations for the First Wash Building. A subsequent aerial from 1983 shows the condition of the site after the slip and First Wash Building were completed and before the later construction of the SRB Paint Building, the TVC Deservicing Building, the Robot Wash Building (1987), and the Multi-Media Blast Facility (MMBF).[25]

The third and final phase of major construction in the complex occurred from the mid-1980s through 1991, when Hangar AF's capabilities were expanded with the construction of four new buildings: the SRB Paint Building (1984), the TVC Deservicing Building (1985), the Robot Wash Building (1987), and the Multi-Media Blast Facility (1992). Previous to the 1984 completion of the TVC Deservicing Building, the TVC system was tested and assembled in the low bay of the VAB.[26]

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[23] Joseph Andrew Brown, "Bid Cost of Shuttle Facilities, Construction Bidding Cost of KSC's Space Shuttle Facilities," Proceedings from the 23rd Annual American Association of Cost Engineers Meeting, Cincinnati, Ohio, July 15-18, 1979, KSC Facilities Engineering Division, KSC, Florida. On file at KSC Archives.

[24] KSC photograph negative number 108-KSC-378C-203/3, dated March 29, 1978. On file at KSC Archives.

[25] KSC photograph negative number 109-KSC-81PC-459, dated May 4, 1983. On file at KSC Archives.

[26] Kay Grinter, "Assembly and Refurbishment Facility Finishes Shuttle Duties," *Spaceport News* (October 1, 2010): 7.

The SRB Paint Building included a bay for applying Alodine, a corrosion inhibitor, to the bare aluminum surface of SRB components, as well as two booths for applying primer and top coats of paint. The building had a blast bay that used ground walnut shells to strip all the paint from the SRB components without damaging or etching their surfaces. This blast bay was later replaced by the larger and better-equipped MMBF. The TVC Deservicing Building was completed to remove and clean the boosters' TVC systems. The Robot Wash Building was completed with a mechanical robot that was used to spray high-pressure jets of water onto the booster sections to remove the TPS and paint applied to their surfaces. More detailed discussions of the operations and processes of these buildings are included in Part III of this report.

2. Architects/Engineers:

   a. Hangar AF and the High Pressure Gas Building (1962): Bail, Horton & Associates, Architects & Engineers, Fort Myers, Bradenton, Florida.

      Hangar AF and the High Pressure Gas Building were designed in 1961 by Bail, Horton & Associates of Fort Myers, Florida. The principal partner in this firm was George Hamlin Bail, who grew up in Fort Myers and worked in the architectural office of his father, Frank W. Bail. Bail received his A.B. degree from Princeton University in 1943 and then served in the U.S. Army Field Artillery during World War II from 1943 to 1946. After the war, Bail returned to Princeton where he earned a M.F.A degree in Architecture in 1948. Following his graduate work, Bail returned to his father's firm in Fort Myers and worked there for sixteen years. While working for his father, Bail designed projects throughout Florida, including a master plan for Florida State University, projects for the military, the U.S. Army Corps of Engineers, and NASA. He founded Bail, Horton & Associates in 1955 before joining W.R. Frizzell Architects in 1966. Bail became president of this firm after Frizzell died and retired as president in 1987.[27]

b. Hangar AF site modifications, First Wash Building, High Pressure Wash Building, and SRB Recovery Slip (1977): Sverdrup & Parcel and Associates, Inc., Jacksonville, Florida.

The 1977 modifications to the Hangar AF site, including grading and paving, railways, the construction of the SRB Recovery Slip, First Wash Building, and the High Pressure Wash Building were designed by Sverdrup & Parcel and Associates, Inc. Sverdrup & Parcel was the engineering, architectural, and planning services branch of the larger Sverdrup Corporation, a broad-based engineering firm that worked throughout the United States and internationally.[28]

The company was founded as Sverdrup and Parcel in 1928 by Norwegian engineer Leif J. Sverdrup and John Ira Parcel, a professor at the University of Minnesota.

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[27] Thomas J. McQade, Donna A. McQuade, and George Bail AIA, "George H. Bail AIA" (Fort Myers: American Institute of Architects FLASW and The Southwest Florida Museum of History, 2011), 1. http://mcmo-swfl.com/bio/Bail-%20George%20H%20-%20Narrative.pdf. Accessed November 17, 2011.

[28] *Sverdrup Corporation: Company History*, http://www.fundinguniverse.com/company-histories/Sverdrup-Corporation-Company-History.html. Accessed November 17, 2011.

Together, the men specialized in bridge design and construction and became one of the most respected bridge firms in the country by the 1940s. During World War II, the firm broadened its scope of services to include work for the U.S. Corps of Engineers in the Pacific theater, including a chain of airfields in the South Pacific leading to the Philippines.[29]

Domestically, Sverdrup and Parcel continued to concentrate on somewhat routine bridge, railroad, and highway construction. In the late 1940s, however, the firm expanded into the design of military and aviation test facilities for the U.S. Government, including architectural and engineering services at the new Arnold Engineering Development Center (AEDC) in Tullahoma, Tennessee, and the Air Force's Joint Long-Range Proving Ground at Cape Canaveral, Florida. The work at Cape Canaveral opened the door for the firm to work in the 1960s with NASA and the Air Force, first in the development of rocket test stands, and then in 1977 with modifications to Hangar AF.[30]

c. Hangar AF site paving, grading, and drainage work (1991): Reynolds, Smith and Hills, Architects and Engineers, Merritt Island, Florida.

Reynolds, Smith and Hills is a construction and engineering firm based in Jacksonville, Florida, that

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[29] International Directory of Company Histories, *Sverdrup Corporation: Company History* (Farmington Hills, MI: St. James Press, 1996), http://www.fundinguniverse.com/company-histories/Sverdrup-Corporation-Company-History.html. Accessed November 17, 2011.

[30] International Directory of Company Histories, *Sverdrup Corporation: Company History* http://www.fundinguniverse.com/company-histories/Sverdrup-Corporation-Company-History.html. Accessed November 17, 2011.

provides infrastructure services for aerospace, defense, aviation, commercial, and transportation clients. The company was founded in 1941 and has additional offices throughout Florida and the nation.

3. Builder/Contractor/Supplier:

Hangar AF and the High Pressure Gas Building were built in 1962 by Douglass Aircraft Co., Boeing Aircraft Co., and Bendix Corporation, Inc.[31] The 1977 site modifications were completed by Holloway Construction for $3,227,300.[32] The contractors involved in the subsequent construction projects at Hangar AF are not known.

4. Original Plans and Construction:

Hangar AF and the High Pressure Gas Building were originally built in 1962 for NASA's Apollo Program. According to technical reports, they were used for Saturn IB and Saturn V Staff Headquarters and Administrative Support Offices.[33] The buildings' site was a previously undeveloped corner of the CCAFS's Industrial Area immediately southwest of Hangar S. The site was the Industrial Area's closest access point to the Banana River, providing a place for ships to deliver Saturn rocket components. The site's configuration included Hangar AF

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[31] KSC, *Technical Facilities Resume: Hangar AF*, Facility No. 10-00-22-00 (KSC, Florida, 1966), 43-44. On file at the KSC Archives.
[32] Brown, Joseph Andrew, *Bid Cost of Shuttle Facilities, Construction Bidding Cost of KSC's Space Shuttle Facilities*, Proceedings from the 23rd Annual American Association of Cost Engineers Meeting, Cincinnati, Ohio, July 15-18, 1979, 14. On file at the KSC Archives.
[33] KSC, *Technical Facilities Resume: Hangar AF*, 43-44.

(called "Special Assembly Building AF" on the original drawings) and the High Pressure Gas Building, as well as a parking area, access roads, and a wood Sentry House that was later demolished.[34]

Hangar AF was accessed via Hangar Road and a paved parking area to its southeast (where the SRB Paint and High Pressure Wash Buildings are today). The Sentry House was located between the hangar and parking area. Two paved access roads led from the hangar to a concrete loading dock on the Banana River. The first led from the hangar's northwest doors, an area later paved in 1977 in preparation for the SSP. The second road remains in place along the southwest edge of the facility. At the waters' edge was a concrete pad labeled "Saturn Unloading Facility." This pad remains intact and was used to unload SRB frustums and parachute reels from the ships, *Liberty Star* and *Freedom Star*.[35]

An examination of the building's 71-page set of original as-built drawings and historic photographs show that Hangar AF retains its original appearance. The hangar retains its corrugated aluminum roof and siding on the upper levels, and the concrete block exterior of the two-story wings (called "lean-tos" on the plans) on the southwest and northeast elevations. The hangar also retains its original steel high-bay doors.

5. Alterations and Additions:

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[34] Cape Canaveral Air Force Station Master Plan (CCAFSMP) and Building Schedule (Department of the Air Force, Air Force Systems Command, Cape Canaveral, Florida, 1963), 26.
[35] CCAFSMP, 26.

As described in Section 1, Hangar AF's setting was altered considerably in the late 1970s with new infrastructure and buildings as it was modified for use in the SSP. In 1977, the firm of Sverdrup & Parcel and Associates, Inc. was selected to complete the site modifications. The firm's original set of construction drawings includes 71 pages of plans for site work (grading, paving, fencing, utilities, drainage, and railways), the construction of new buildings, and mechanical and electrical upgrades throughout the site. The Hangar AF Complex remained largely unchanged until the mid-1980s, when four new buildings were added: the SRB Paint Building in 1983, the TVC Deservicing Building in 1984, and the Robot Wash Building in 1985. The Multi-Media Blast Facility was added in 1991.

Alterations and additions to individual buildings in the Hangar AF Complex have been minimal over the years. There have been no substantial alterations to the exterior of Hangar AF and a comparison of the building's original 1962 and 1977 as-built drawings show changes to the first floor plans of the north and south "lean-to" sections. The 1962 drawings show an arrangement of rooms separated by wood wall partitions that is slightly different from the 1977 drawings and represents the present floor plan. All of the building's original 1962 masonry wall partitions remain intact.

The SRB Recovery Slip received repairs and improvements in 1995 to stabilize the structure's seawall and bulkhead to improve drainage capabilities. The Hangar AF Complex's remaining buildings are largely in original condition. Alterations to individual buildings in the complex are discussed in Part II, Section B - "Building Descriptions."

PART II. STRUCTURAL/DESIGN/EQUIPMENT INFORMATION

A. GENERAL STATEMENT:

1. Character:

The Hangar AF Complex contains nine contributing industrial buildings that were designed to receive, disassemble, and refurbish the Space Shuttle SRBs. The centerpiece of the complex in terms of size and function is Hangar AF. The complex's boundaries are defined as the edges of the concrete hardscape that surround the Hangar AF area.

Transportation to and through the complex occurs via paved roads and parking areas, including a main entrance driveway at its east end off of Hangar Road. The entrance driveway passes from Hangar Road through a grassy shoulder area into the complex's main visitor parking lot. An additional secondary entrance is provided by Industrial By-Pass Road, on the south side of the complex between the main Hangar AF area and the MMBF. This road leads from Hangar Road directly out to the SRB Recovery Slip area.

Paved roads also lead from the east visitor parking area around the north and south sides of Hangar AF. The north road leads between the hangar and the chain-link fence that separates Hangar AF from the neighboring Hangar S. The south road runs between Hangar AF and the Robot Wash and High Pressure Gas Buildings. Automobiles can drive around Hangar AF on either of these roads to reach the extensive paved SRB recovery/inspection area lying between the SRB Recovery Slip and Hangar AF. An additional access road that is perpendicular to the above roads leads south to the MMBF, which is separated from the main portion of the complex by a ground support equipment (GSE) warehouse.

Another perpendicular road is the driveway to the TVC Deservicing Building on the north side of the complex.

There are three GSE storage areas in the Hangar AF Complex. These areas are used to store various large metal objects like SRB work stands, rail car components, parachute reels, etc. The first GSE storage area is in the eastern corner of the complex on the north side of the visitor parking lot. The second is adjacent to the western corner of Hangar AF. The third is located just west of the First Wash Building, on the south side of the paved SRB recovery/inspection area.

Immediately north of the First Wash Building is the facility's wastewater reclamation storage and settling tank area. All of the water used in the First Wash Building is collected, filtered, and stored for another use in this area.

The complex is bordered on the west by undeveloped green space on the edge of the Banana River. The complex also contains small, irregularly shaped grassy areas that collect surface water runoff, including those around the eastern, southern, and western boundaries.

The building designs and materials used at Hangar AF were conventional and commonly found in twentieth-century industrial and manufacturing sites. The complex's buildings are characterized by utilitarian designs that feature aluminum and/or concrete block exteriors with a variety of built-up roof types (flat, pitched, or shed). The complex contains one structure, the SRB Recovery Slip, which is composed of cast-in-place reinforced concrete.

The complex is historically significant for its association with the SSP and the technical processes that its industrial buildings and structures encompassed, rather than their architectural or engineering merit. Taken individually, these buildings do not communicate architectural or engineering significance. When viewed as a complex, however, they represent one of NASA's essential Space Shuttle manufacturing locations that enabled the re-usability of the SRBs.

The physical arrangement, or site layout, of the complex's resources is a key distinguishing characteristic, as it reveals the workflow of the various steps involved in the disassembly and refurbishment process. The L-shaped complex is long, narrow, and oriented at a northwest-southeast angle. The site workflow generally proceeded from northwest to southeast. The SRBs were delivered via the ships, *Liberty Star* and *Freedom Star,* to the SRB Recovery Slip on the northwestern edge of the complex. From there, they were removed from the water and moved to the southeast for the various steps of inspection, hydrolase wash, disassembly, and preparation for the refurbishment process.

2. Condition of fabric:

   The condition of the Hangar AF Complex's fabric is excellent. The buildings and structures of the complex were regularly maintained throughout their lifespans and do not exhibit any major signs of neglect or deterioration.

B. BUILDING DESCRIPTION:

For full description of the nine buildings and structures that are contributing resources to the Hangar AF Complex Historic District, see the following HAER documents:

1. Hangar AF – HAER NO. FL-8-11-S-1
2. SRB Recovery Slip – HAER NO. FL-8-11-S-2
3. First Wash Building - HAER NO. FL-8-11-S-3
4. Thrust Vector Control Deservicing Building - HAER NO. FL-8-11-S-4
5. High Pressure Wash Building - HAER NO. FL-8-11-S-5
6. Robot Wash Building - HAER NO. FL-8-11-S-6
7. Multi-Media Blast Facility - HAER NO. FL-8-11-S-7
8. High Pressure Gas Building - HAER NO. FL-8-11-S-8
9. SRB Paint Building - HAER NO. FL-8-11-S-9

PART III: OPERATIONS AND PROCESS

A. INTRODUCTION

The primary operations at Hangar AF involved separating all of the SRB segments, removing their electronic and mechanical components, removing their protective TPS finishes, and preparing them for buildup and assembly at the ARF. The buildings and structures at Hangar AF processed the aft skirts, forward skirts, frustums, TVC systems, Main Parachute Support Structures (MPSS), ETA ring, and a variety of small metal parts contained in each of the segments. The boosters’ four SRMs were separated and cleaned at Hangar AF, but then shipped to their manufacturer for full refurbishment. Typically, the number of people working at Hangar AF during the Space Shuttle era was approximately 150 people. It took these workers from two to three weeks to fully process the SRB components from the time of their arrival.

B. CHEMICALS AND MATERIALS

The assembly, refurbishment, and re-use of the SRBs required the use of special-purpose materials and chemicals to address the effects of heat, prevent corrosion, clean metal surfaces, and prepare the SRBs for new missions. The chemicals and materials involved included several trademarked products used in other industries, as well as materials designed in collaboration between NASA and various contractors. These included Alodine, an anodizing coating used on aluminum and other non-ferrous alloys to provide improved corrosion protection and paint adhesion.

Following the application of Alodine, the SRB segments received a full topcoat of Hypalon paint. Originally manufactured by DuPont, Hypalon was a high-performance chlorosulfonated polyethylene (CSPE) synthetic rubber known for its resistance to abrasion, thermal extremes, chemicals, and ultraviolet light. Hypalon CSPE was used as an additive in paint for aerospace and marine uses and in other industrial applications such as in the insulation jacket material for wire and cables.[36]

After the Alodine and Hypalon paint were applied to the SRB segments at Hangar AF, they were transferred to the ARF for the application of the TPS, the MCC-1 ablative (discussed previously) that absorbed the heat of launch and re-entry and protected the underlying aluminum substrates. Once the TPS was applied, the SRB segments were finished off with a topcoat layer of Hypalon paint.

[36] Anixter, Inc., "DuPont is Discontinuing Hypalon," http://corpapps.anixter.com/AXECOM/AXEDocLib.nsf/0/5ZEX7S2R/$file/DuPontDiscontinuingHyphalonJuneJuly09.pdf, accessed July 26, 2013.

C. SRB ARRIVAL, INSPECTION, AND SAFING

The Hangar AF refurbishment process began at the SRB Recovery Slip on the west end of the complex, where the SRBs were towed by the *Freedom Star* and *Liberty Star* ships. The SRBs were then floated, one at a time, into the slip. A mobile 200-ton capacity gantry crane then lifted the SRBs out of the slip and placed them onto specially-designed rail cars, or dollies, which were moved with "Tug" tow tractors along standard gauge (4′-8.5″) tracks embedded in the paved surface of the complex. The dollies resemble flat-bed rail cars, each of which is equipped with a series of eight semi-circle "cradles" that hold the SRBs. The cradles all have belts and rollers along their inside surface that allow workers to rotate the SRBs into correct position using control panels mounted on the sides of the dollies.

The two sets of dolly rail tracks extend all the way from the slip area through wash bays of the First Wash Building and then into Hangar AF where both SRBs were processed at the same time. The SRBs weighed approximately 190,000 pounds at the beginning of the refurbishment process.

After the SRBs were removed from the slip, the booster frustums and parachutes were offloaded from the ships, placed on transport trailers, and taken to Hangar AF for processing.

Once loaded onto the rail cars at the head of the slip area, the pair of SRBs underwent an open assessment to inspect for damage or wear to their structures. After the open assessment, the SRBs were "safed" by removing several components from the forward skirt, including all remaining batteries and ordnance, the Range Safety System (RSS), Safe and Arm (S&A), the Solid State Video Recorders (SSVR), and the Data Acquisition System (DAS).

C. INITIAL HYDROLASING – REMOVAL OF TPS

The SRBs were then moved on the rail cars into the First Wash Building for "hydrolasing," a high-pressure water wash at 20,000 pounds of pressure per square inch. The hydrolase process involved just pressurized water with no other chemical agents. The boosters were hydrolased with both overhead spray bars and by manual hydrolase guns, which removed approximately 90 percent of their TPS. The waste water is collected in a series of drains, sumps, and filters before it is cleaned and stored in an adjacent above-ground tank for future use.

While in the First Wash Building, the boosters' exit cones were removed and inspected. The exit cones were then shipped back to their manufacturer, a defense and aerospace company in Utah, called ATK, for refurbishment.

D. DISASSEMBLY AT HANGAR AF

After hydrolasing in the First Wash Building, the boosters were moved into Hangar AF for disassembly. SRB segment disassembly is accomplished with the use of the hangar's decoupling ring, which was used to separate or "demate" the segments. The decoupling ring was moved into position over the booster with the use of the hangar's two original 1963 cranes manufactured by Manning, Maxwell & Moore. The cranes each have a 40-ton lift capacity, as well as 10-ton auxiliary hoists. Once demated, the cranes were used to lift the segments up and onto mobile transport platforms.

The first segments demated were the aft skirts, which required clearing all non-essential personnel from the facility due to residual hydrazine in the still-intact TVC fuel systems. With the aft skirts removed, personnel then removed the booster nozzles, which were shipped back to ATK for further disassembly and inspection.

The next segments demated were the forward skirts. With the forward skirts removed, the crew could then reach the SRB igniter inside the top SRM segment. The igniter was removed, inspected, and partially disassembled for further inspection. It was then shipped to ATK for further disassembly and inspection.

With the forward and aft skirts removed, the disassembly crew started demating the SRM segments. Crews first inspected the condition of the SRM insulation, casings, and joint conditions. Notes were taken on any propellant that remained unburned and any corrosion found, which was addressed immediately to protect the high-value reusable cases. The four SRM segments were then separated with the decoupling ring. Propellant debris was removed from their interior with a manual high-pressure wash. The end openings of each SRM were covered with "handling rings," large caps that protected their interiors during shipping. The SRM segments were then moved from the rail dollies onto truck trailers via the hangar's overhead crane. The segments were then transferred to the NASA railhead, loaded onto rail cars, covered, and shipped by rail to ATK in Utah for further processing.

Once all of the SRB segments were disassembled, the frustums, aft skirts, and forward skirts underwent the remainder of the refurbishment process in other buildings at the Hangar AF Complex. The frustums were first rinsed and their parachute components were removed. Inside the hangar, the BSMs were inspected and removed for further disassembly and inspection. The frustums were then verified "safe" by inspecting and removing the confined detonating fuses (CDF) used to fire their separation during the booster's descent. All of the remaining frustum components were removed and readied for refurbishment, including their flotation blocks that kept them buoyant at sea, and the MPSS that supports the boosters' main parachutes.

E. FRUSTUM PROCESSING

From Hangar AF, the frustums were transferred to the High Pressure Wash Building or the Robot Wash Building where the TPS was stripped. From there, they were transferred to the MMBF for further blasting of all remaining surface paint down to bare aluminum. The MMBF used glass bead blast media, very small beads that resemble sand. This media has a significant advantage over other blast media, because it does not damage the underlying metal structure. After blasting, the frustums received a complete structural inspection.

From there, the frustums were taken to the SRB Paint Building (also called the Surface Preparation Facility) where they received a coat of Alodine to protect against corrosion, a coat of primer, and a complete top coat of Hypalon paint. At that point, the frustums refurbishment process at Hangar AF was complete and they were transferred to the ARF.

F. AFT SKIRT PROCESSING AND TVC DESERVICING

Once the mechanical components were removed from the aft and forward skirt segments, they received a refurbishment process similar to the frustums. After separation, the aft skirts were moved into the High Pressure Wash Facility where the TVC components were hydrolased to remove the protective interior TPS foam that coated them. Additional interior foam was blasted off in the Robot Wash Building.

The aft skirts were then transferred from the wash facilities to the TVC Deservicing Building on the northern edge of the complex. Once there, the skirts were positioned on either side of the aft skirt deservicing stand, a structure in the middle of the building's main processing bay. There the fuel was removed and the TVC components were disassembled, including the hydraulic reservoirs, APUs, hydraulic power units (HPUs), and related line replaceable units (LRUs).

The TVC fuel was removed using the skirt stand's two deservicing panels on the south side of its upper level. The TVCs are connected to the panels with lines that flush the fuel from the units with alcohol and gaseous nitrogen. The gaseous nitrogen used in this process is stored in large tanks mounted on a truck parked in front of the building. The TVC's APUs are also flushed here with water, alcohol, and gaseous nitrogen. The two panels work in the same way with one used to flush the "rock" side of the TVC and the other to flush the "tilt" side. On the lower level of the stand is another set of instrument panels that are used to give the APUs an additional flush of gaseous nitrogen and water. For their protection, technicians at the TVC Deservicing Building complete this work while wearing a SCAPE outfit: Self Contained Atmospheric Protective Ensemble.

Once removed, the TVC system's fuel service modules, fuel isolation valves, and other fuel components were transferred to the TVC decontamination room in the rear (north) end of the building. There the components were rinsed with water and isopropyl alcohol in large sinks. They were then dried and placed in specially designed plastic bags. After a set amount of time, the bags were checked to verify if the component surfaces had continued to release any fuel vapors. If so, they were washed again. Once fully washed, the components were baked in two vacuum ovens designed to open the pores of the metal to remove any fuel vapors trapped there. The ovens cycled for one-and-a-half hours at 200 degrees Fahrenheit until there were no gas vapors detected. All of the TVC fuel components were baked in the ovens.[37]

After the aft skirts received TPS blasting and the TVC deservicing process, they received an inspection for necessary modifications or structural repairs. Crew members also installed new fasteners and sealed critical joints with sealant. The aft skirts then received coats of Alodine and Hypalon paint to complete the process.

G. FORWARD SKIRT PROCESSING

The forward skirt segments received similar treatment as the frustums and aft skirts. First, the forward integrated electronics assembly (IEA) boxes were removed inside the Hangar AF high bay, along with all related cabling, avionics black boxes, housings, brackets, and panels. They

[37] David Pappalardo, United Space Alliance TVC Technician, interview with author, October 11, 2011.

were then blasted clean at the High Pressure Wash Building and Multi-Media Blast Facility before receiving coats of Alodine and Hypalon paint at the SRB Paint Building.

H. MAIN PARACHUTE SUPPORT STRUCTURES (MPSS) AND EXTERNAL TANK ATTACH (ETA) RINGS PROCESSING

Also processed at Hangar AF were the MPSS and the ETA rings. The MPSS structures were hydrolased to remove sealant followed by media blasting at the MMBF to remove their protective finish. Hardware such as nut plates and shims were removed and reinstalled, followed by a finish touch-up, sealant application, and paint topcoat. The ETA rings were hydrolased and blasted to remove TPS, protective finish, and any corrosion. A protective finish application was performed before moving to Hangar N at CCAFS for further dimensional checks and finish work.

I. SMALL PARTS PROCESSING

Each of the SRB segments contained a number of small but heavy aluminum parts that were individually removed for refurbishment at Hangar AF's Small Parts Processing area after each flight. Examples of these parts included: the IEA box fittings, cable support brackets and lugs, tunnel covers, and ETA ring splice plates. Each of these and other small parts were first disassembled and inspected for repair and modification. They were then transferred to the Small Parts Processing area where residual TPS, protective finish, and corrosion were removed via media blasting in the area's three manual blast booths. Once cleaned and blasted, the parts were inspected for quality control and then coated with an Alodine protective finish, a coat of paint primer, and a top coat of Hypalon paint. Parts also received any necessary mechanical assembly or rework of nut plates, rivets, and other fasteners.

PART IV. SOURCES OF INFORMATION

A. ENGINEERING DRAWINGS AND PLANS

The as-built construction plans for the Hangar AF Complex were provided by KSC. The plans are the only ones available for the complex and were prepared by a variety of engineering and architectural firms. The original 1962 complex plans were prepared by Bail, Horton & Associates of Fort Myers, Florida. Modifications to the complex for the Space Shuttle Program were designed in 1977 by Sverdrup & Parcel and Associates, which included the new First Wash Building, High Pressure Wash Building, and various site alterations. The remaining sets of as-built construction plans were produced for facilities built in the 1980s and 1990s.

AJT & Associates, Inc. "Hangar AF New Multi-Media Blast Facility." Kennedy Space Center, Florida. Construction drawings, 1991.

Bail, Horton & Associates. "Hangar 'AF'." Kennedy Space Center, Florida. Construction drawings, 1962.

Burns and Roe. "Solid Rocket Booster Paint Building - Modification to Existing High Pressure Wash Building." Kennedy Space Center, Florida. Construction drawings, 1983.

Burns and Roe. "Solid Rocket Booster Paint Building." Kennedy Space Center, Florida. Construction drawings, 1983.

Burns and Roe Industrial Services Corporation. "Thrust Vector Control Deservicing Building." Kennedy Space Center, Florida. Construction drawings, 1984.

Sverdrup & Parcel and Associates. "Solid Rocket Booster Recovery & Disassembly Facility, Hangar AF, CCAFS, Industrial Area." Kennedy Space Center, Florida. Construction drawings, 1977.

Wolfberg/Alvarez/Taracido & Associates. "Robot Operated High Pressure Wash Building." Kennedy Space Center, Florida. Construction drawings, 1985.

B. EARLY VIEWS

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Kennedy Space Center. Photograph negative number 109-KSC-81PC-459, dated May 4, 1983. On file at Kennedy Space Center Archives.

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NASA Facts: Solid Rocket Boosters. Kennedy Space Center, Florida. IS-2004-09-014-KSC, Revised 2006.

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Sverdrup Corporation: Company History. http://www.fundinguniverse.com/company-histories/Sverdrup-Corporation-Company-History.html. Accessed November 17, 2011.

United Space Alliance

"Marine Operations, Revision J." (John F. Kennedy Space Center, n.d.), MO-1.

"Structures Assembly Buildup Operations, Revision J" (John F. Kennedy Space Center, n.d.).

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 buildings of the Hangar AF Complex.

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

PART V. PROJECT INFORMATION

NASA determined that the SRB Disassembly & Refurbishment Complex was eligible to the NRHP as a historic district under Criterion A in the area of Space Exploration. This determination was made by NASA's "Shuttle Transition Historic Preservation Working Group" or HPWG, which looked at 335 facilities at thirteen NASA Centers.[38] 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 SRB Disassembly and Refurbishment Complex was identified as Type 2, which includes Resources Associated with Vehicle Processing Facilities.[39] NASA completed this evaluation as the SSP was scheduled for termination 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 (SHPO), 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 August 2011, the documentation package for the SRB Disassembly & Refurbishment Complex 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 District.

New South Associates, under contract with IHA, a subcontractor to NASA, conducted the HAER documentation and historic research for this project in September and October 2011. NASA is completing HAER documentation of the complex

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

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, Cultural Resources Specialist. Photographs were taken of each building's interior, exterior, and context. David Price conducted a limited number of oral interviews and otherwise compiled the historic documentation required for the project. The following people were interviewed for this project: David Price, United Space Alliance, Hangar AF Facility Manager; Art Morales, George C. Marshall Space Flight Center, Office of the Director Shuttle - ARES Transition Office; and Dave Pappalardo, United Space Alliance, TVC Technician. Elaine Liston, KSC Archivist, provided a wealth of information from her office in the KSC Headquarters Building.

Source: USGS 7.5 Minute Topographic Quadrangle Map, Orsino, FL (1976)

Figure 1. USGS Map showing the location of the SRB Disassembly & Refurbishment Complex (Hangar AF Complex).

Source: ESRI Resource Data, Imagery Layer

Figure 2. Aerial Photograph showing the location of the SRB Disassembly & Refurbishment Complex (Hangar AF Complex).

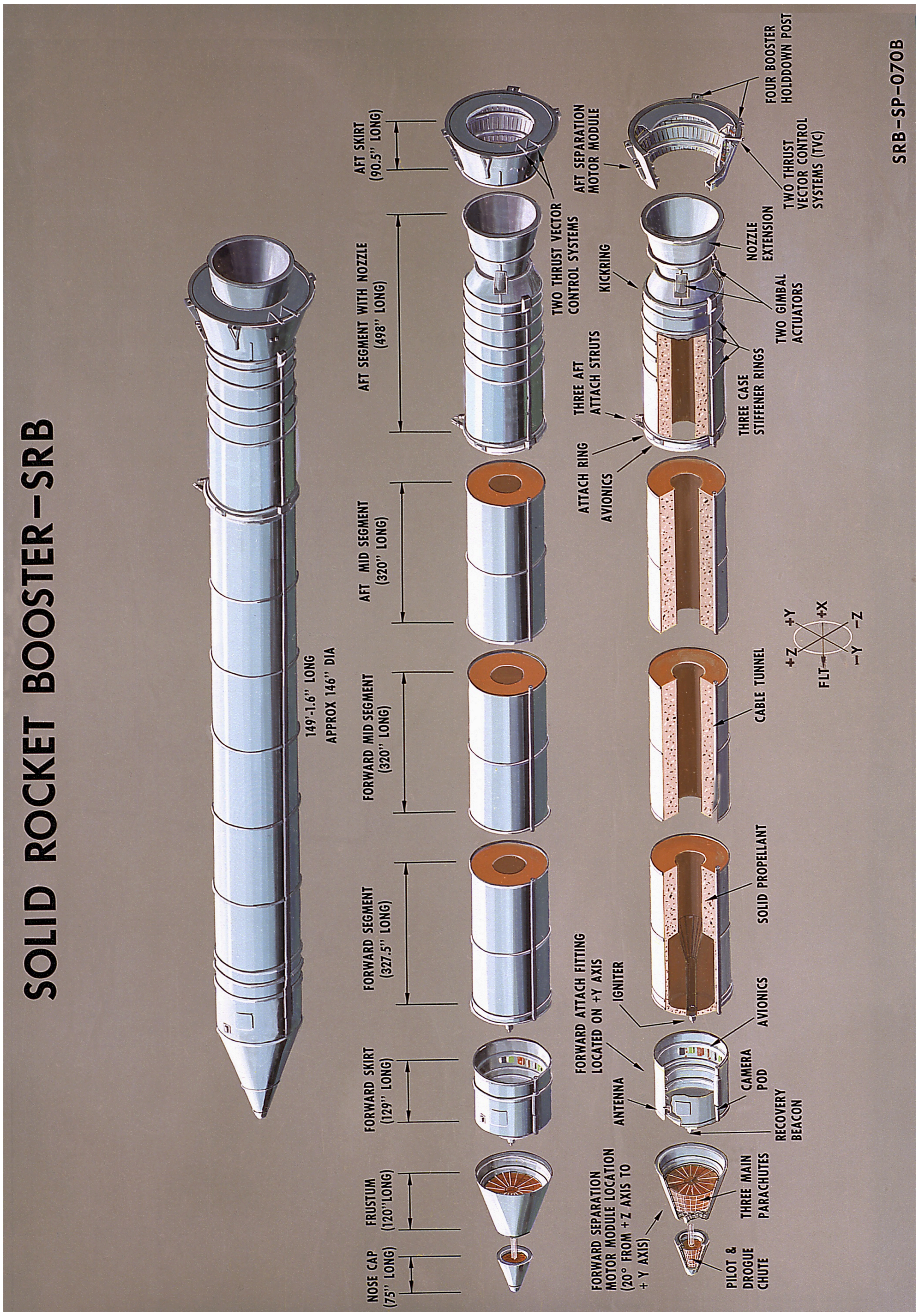

Figure 3. Diagram showing the components of a SRB. (Courtesy of MSFC, MSFC-75-SA-4105-2C)

Figure 4. This 1973 aerial photograph shows the Hangar AF site in its original condition before the 1978-79 modifications and additions for the Space Shuttle Program. Note the ship docked at the original loading dock. (Courtesy KSC, Image 116-KSC-373c-548/16).

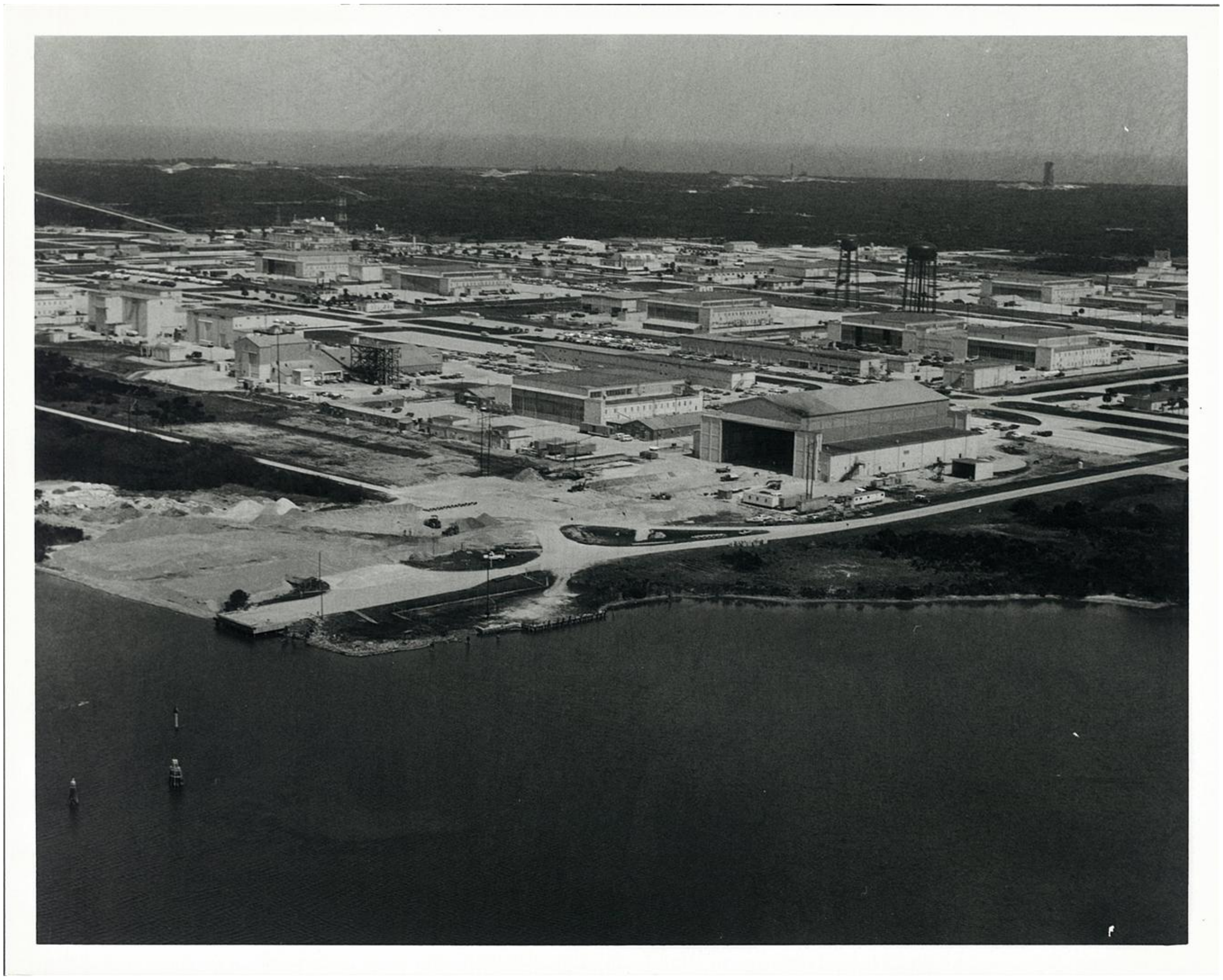

Figure 5. This 1978 aerial photograph of the construction at the Hangar AF site shows the condition of Hangar AF and the High Pressure Gas Building at the beginning of site grading and other preparations for the Space Shuttle Program. (Courtesy of KSC, Image 108-KSC-378C-203/3).

Figure 6. This 1983 aerial photograph shows the condition of the site after the slip and First Wash Building were completed and before the later construction of the SRB Paint Building, the TVC Deservicing Building, the Robot Wash Building (1985), and the Multi-Media Blast Facility (MMBF). (Courtesy of KSC, Image 108-KSC-81PC-459).

Figure 7. This 1983 aerial photograph shows the condition of the complex and its relationship to the CCAFS Industrial Area. (Courtesy of KSC, Image 116-KSC-383C-1256).

Figure 8. Hangar AF during construction of the High Pressure Wash Building, 1978. (Courtesy KSC, Image 108-KSC-378C-364/3).

Figure 9. Construction of the First Wash Building and SRB dolly rails with Hangar AF in the Background, 1978. (Courtesy KSC, Image 108-KSC-378C-759).

Figure 10. First Wash Building with original multi-part doors, 1978. (Courtesy KSC, Image 108-KSC-379C-1060/1).

Figure 11. Interior View of original doors on First Wash Building with center section open, 1978. (Courtesy KSC, image number not shown.)

Figure 12. SRB Recovery Slip with gantry cranes, First Wash Building, and Hangar AF, 1978. (Courtesy KSC, No Image Number).

Figure 13. High Pressure Wash Building, 1978. (Courtesy KSC, Image 108-KSC-3796-1060/3).

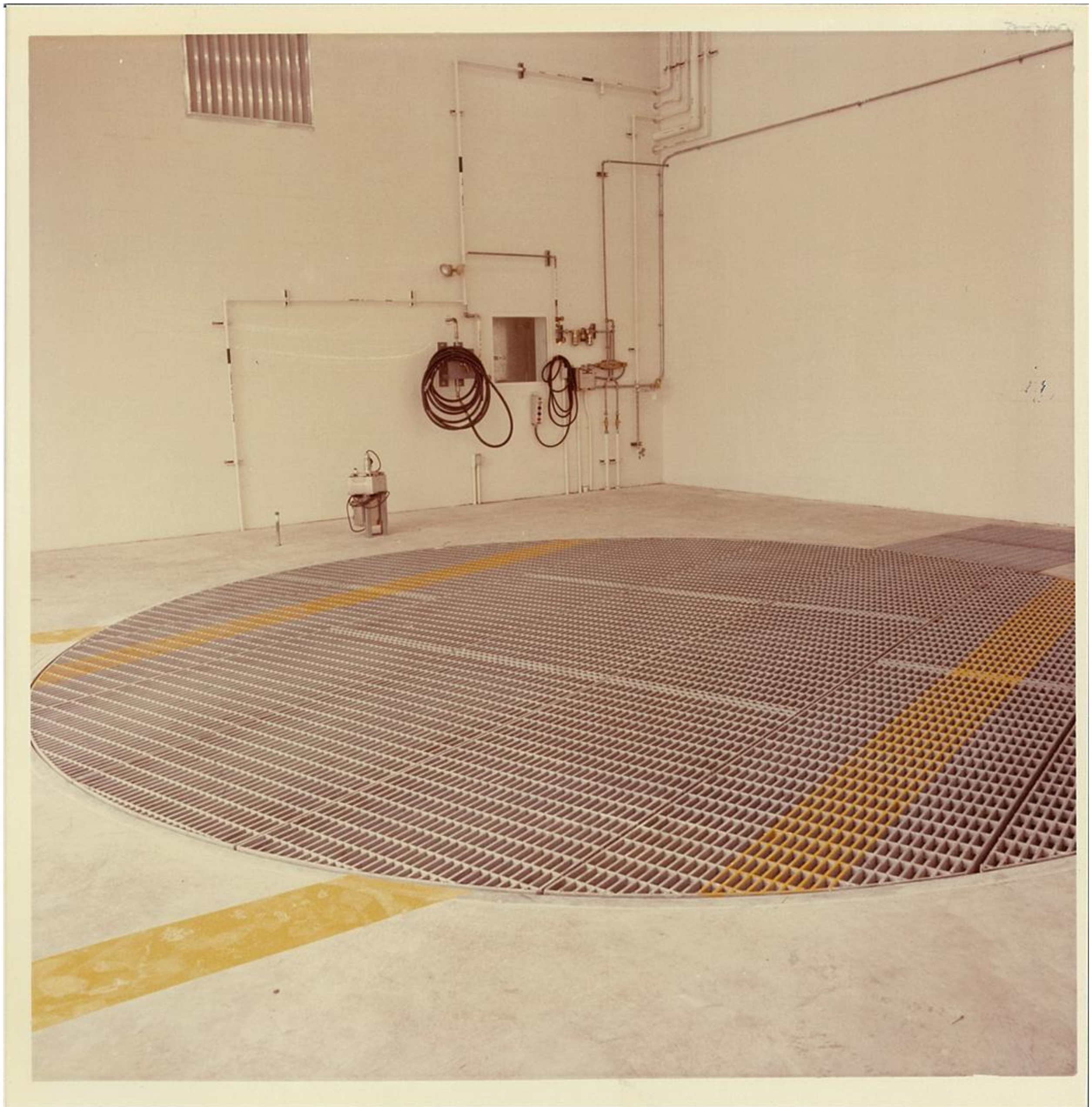

Figure 14. Original turntable in High Pressure Wash Building, 1978. (Courtesy KSC, No Image Number).

Figure 15. SRB Solid Rocket Motor (SRM) segment inside Hangar AF, 1979. (Courtesy: KSC, Image 108-KSC-379C-1061/9).

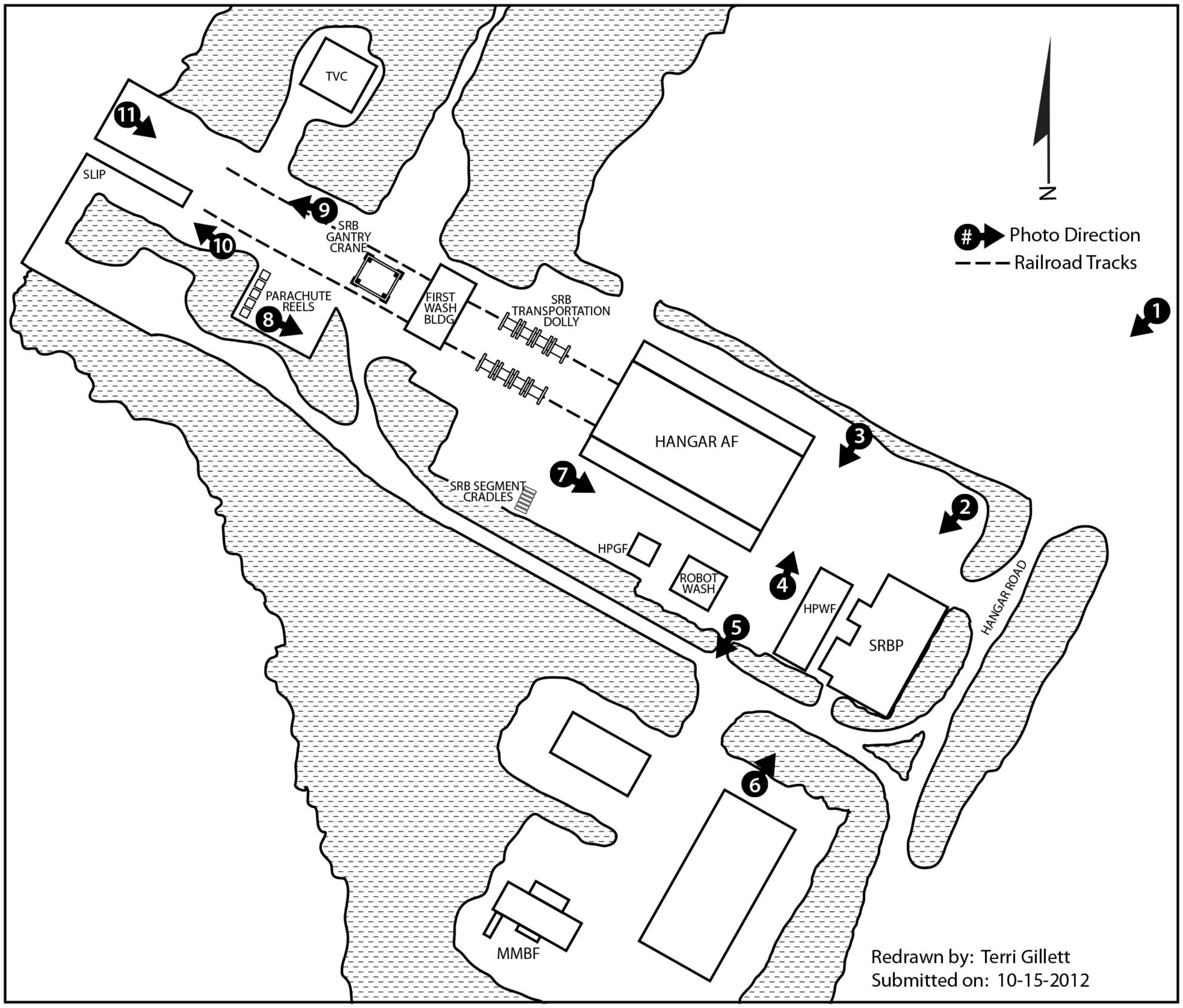

Figure 16. Photograph key for HAER NO. FL-8-11-S.

HISTORIC AMERICAN ENGINEERING RECORD

INDEX TO PHOTOGRAPHS

CAPE CANAVERAL AIR FORCE STATION, HAER No. FL-8-11-S
LAUNCH COMPLEX 39,
SOLID ROCKET BOOSTER DISASSEMBLY & REFURBISHMENT COMPLEX
(HANGAR AF COMPLEX)
(John F. Kennedy Space Center)
Cape Canaveral
Brevard County
Florida

David Diener, Photographer September – October 2011

FL-8-11-S-1	EXTERIOR VIEW OF HANGAR AF HISTORIC DISTRICT FROM HANGAR ROAD, VIEW WEST.
FL-8-11-S-2	EXTERIOR VIEW OF THE SRB PAINT FACILITY, NORTHEAST ELEVATION WITH HIGH PRESSURE WASH BUILDING IN BACKGROUND, VIEW SOUTHWEST.
FL-8-11-S-3	PARKING AREA AND DRIVEWAY ON SOUTHEAST SIDE OF HANGAR AF, SHOWING FIRST WASH BUILDING, VIEW SOUTH.
FL-8-11-S-4	EXTERIOR VIEW OF HANGAR AF, SHOWING SOUTHEAST ELEVATION WITH PARKING AREA IN THE FOREGROUND, VIEW NORTH.
FL-8-11-S-5	VIEW OF ACCESS ROAD THAT LEADS FROM HANGAR AF TO THE MULTI-MEDIA BLAST FACILITY, SHOWING NON-CONTRIBUTING STORAGE BUILDING, VIEW WEST.
FL-8-11-S-6	EXTERIOR VIEW OF THE SRB PAINT FACILITY, SOUTHWEST ELEVATION, WITH HIGH PRESSURE WASH BUILDING AT LEFT, VIEW NORTHEAST.
FL-8-11-S-7	DRIVEWAY BETWEEN HANGAR AF AND THE ROBOT WASH BUILDING AND HIGH PRESSURE GAS BUILDING, VIEW SOUTHEAST.

FL-8-11-S-8 EQUIPMENT STORED ADJACENT TO SRB SLIP, VIEW SOUTHEAST.

FL-8-11-S-9 VIEW TOWARD SRB SLIP AND RECOVERY SHIPS WITH SRB DOLLY RAILS IN FOREGROUND, VIEW NORTHWEST.

FL-8-11-S-10 SRB SLIP WITH SRB RECOVERY SHIP *FREEDOM STAR* IN BACKGROUND AND SRB DOLLY RAILS AT RIGHT, VIEW NORTHWEST.

FL-8-11-S-11 VIEW LOOKING BACK AT FIRST WASH BUILDING AND HANGAR AF FROM SRB SLIP, VIEW SOUTHEAST.

FL-8-11-S-12 Photocopy of engineering drawings (8″ x 10″ photo of scanned original; February 11, 1981 by Sverdrup & Parcel and Associates, Inc.; drawings in possession of Kennedy Space Center) "Solid Rocket Booster Recovery & Disassembly Facility, Hangar AF, CCAFS, Industrial Area, Location Plans - Index of Drawings."

FL-8-11-S-13 Photocopy of engineering drawings (8″ x 10″ photo of scanned original; February 11, 1981 by Sverdrup & Parcel and Associates, Inc.; drawings in possession of Kennedy Space Center) "Solid Rocket Booster Recovery & Disassembly Facility, Hangar AF, CCAFS, Industrial Area, Overall Site Plan."

FL-8-11-S-14 Photocopy of engineering drawings (8″ x 10″ photo of scanned original; February 11, 1981 by Sverdrup & Parcel and Associates, Inc.; drawings in possession of Kennedy Space Center) "Solid Rocket Booster Recovery & Disassembly Facility, Hangar AF, CCAFS, Industrial Area, Site Utility Plan – West."

FL-8-11-S-15 Photocopy of engineering drawings (8″ x 10″ photo of scanned original; February 11, 1981 by Sverdrup & Parcel and Associates, Inc.; drawings in possession of Kennedy Space Center) "Solid Rocket Booster Recovery & Disassembly Facility, Hangar AF, CCAFS, Industrial Area, Site Utility Plan – East."

FL-8-11-S-16 Photocopy of engineering drawings (8″ x 10″ photo of scanned original; February 11, 1981 by Sverdrup & Parcel and Associates, Inc.; drawings in possession of Kennedy Space Center) "Solid Rocket Booster Recovery & Disassembly Facility, Hangar AF, CCAFS, Industrial Area, Railway Plan and Details."

FL-8-11-S-17 Photocopy of engineering drawings (8″ x 10″ photo of scanned original; February 11, 1981 by Sverdrup & Parcel and Associates, Inc.; drawings in possession of Kennedy Space Center) "Solid Rocket Booster Recovery & Disassembly Facility, Hangar AF, CCAFS, Industrial Area, Lighting Fixtures Schedule & Details."