CAPE CANAVERAL AIR FORCE STATION, HAER FL-8-11-R
LAUNCH COMPLEX 39,
SOLID ROCKET BOOSTER ASSEMBLY AND REFURBISHMENT FACILITY
MANUFACTURING BUILDING
(SRB ARF MANUFACTURING BUILDING)
(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 the Interior
100 Alabama St., SW
Atlanta, GA 30303

HISTORIC AMERICAN ENGINEERING RECORD

CAPE CANAVERAL AIR FORCE STATION, LAUNCH COMPLEX 39, SOLID ROCKET BOOSTER ASSEMBLY AND REFURBISHMENT FACILITY MANUFACTURING BUILDING (SRB ARF MANUFACTURING BUILDING)

HAER No. FL-8-11-R

Location: John F. Kennedy Space Center, Southeast Corner of Schwartz Road and Contractors Road, Brevard County, Florida

USGS Orsino, Florida, Quadrangle, Universal Transverse Mercator Coordinates: E 533986.90 N 3159377.19 Zone 17, NAD 1983.

Date of Construction: 1986

Present Owner: National Aeronautics and Space Administration (NASA)

Present Use: Solid Rocket Booster Assembly and Refurbishment

Significance: The Solid Rocket Booster (SRB) Assembly and Refurbishment Facility (ARF) Manufacturing Building played an essential role in the re-usability of the SRBs as it housed the refurbishment and assembly activities for the inert or non-propellant SRB elements, including the forward and aft skirts, frustums, and nose caps. The ARF Manufacturing Building is considered eligible for listing in the NRHP in the context of the U.S. Space Shuttle Program (SSP) (1969-2011) under Criterion A in the area of Space Exploration. Because it has achieved exceptional significance within the past 50 years, Criterion Consideration G also applies.

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

Date: March 6, 2103

Part I. HISTORICAL INFORMATION

A. INTRODUCTION

The Solid Rocket Booster (SRB) Assembly and Refurbishment Facility (ARF) Manufacturing Building was built in 1986 to house the manufacture, assembly, and refurbishment of SRB components. It was designed to expedite SRB refurbishment on-site at the Kennedy Space Center (KSC). The building is located at the southeast corner of Schwartz Road and Contractors Road at KSC, just south of Launch Complex 39 and the Vehicle Assembly Building (VAB).

The ARF Manufacturing Building is a significant historic property for its association with the history of 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 with a design that made most of its major components re-usable, a model that decreased program costs and made orbital spaceflight a routine endeavor. The SRBs were two of the Space Shuttle's primary re-usable elements in addition to the orbiter spacecraft, while the external tank that carried the orbiter's fuel and oxidizer was not re-used. The ARF Manufacturing Building was one of KSC's essential facilities in the refurbishment and assembly of the SRBs.

List of Acronyms:

ABACS - Automated Booster Assembly Checkout Systems

ACHP - Advisory Council on Historic Preservation

ACO - Assembly Check-Out

ACTS – Advanced Communications Technology Satellite

APU - Auxiliary Power Unit

ARF - SRB Assembly and Refurbishment Facility

ASA - Altitude Switch Assembly

BSM - Booster Separation Motors

BTA - Booster Trowelable Ablative

CATS - Component Acceptance Test System

CCAFS - Cape Canaveral Air Force Station

DoD – Department of Defense

EDOP - Enhanced Diver Operated Plug

ET – External Tank

ETA - External Tank Attachment

FOD - Foreign Object Debris

LRU/SRU - Line Replaceable Unit/Shop Replaceable Unit

LSC - Frustum Linear Shaped Charge

GSE - Ground Support Equipment

HAER – Historic American Building Record

IHA - InoMedic Health Applications

IEA - Integrated Electronics Assembly

ISS – International Space Station

KSC – John F. Kennedy Space Center

MSFC - Marshall Space Flight Center

NASA – National Aeronautics and Space Administration

NRHP – National Register of Historic Places

MCC-1 - Marshall Convergent Coating

OPF - Orbiter Processing Facility

PA - Programmatic Agreement

PRF – Parachute Refurbishment Facility

RSS - Range Safety System

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

TSP - Trisodium Phosphate

USGS – United States Geological Survey

USBI - United Space Boosters

USA - United Space Alliance

VAB - Vehicle Assembly Building

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 safely to the 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.[1]

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 Space Shuttle Program (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."[2] Following this announcement, new SSP contracts were awarded, new space vehicles were designed, old Apollo-era facilities were retrofitted, and new facilities were built. After a decade of preparation, the first shuttle flight

[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] 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.

occurred in 1981. In 2011, after almost three decades of operations, the SSP was retired.[3]

During those 30 years of operation, there were over 130 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 unmanned probes that were sent to Jupiter (*Galileo*), Venus (*Magellan*), and the Sun (*Ulysses*).[4] 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* (1/28/86) and *Columbia* (2/1/03) accidents resulted in the loss of all crewmembers on board. Both incidents caused lengthy flight down time for the program, while exhaustive investigations led to extensive physical and procedural improvements.[5]

Most of the Shuttle Transportation System (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 almost a thirty-year period,

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[3] Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 2.1.
[4] Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 2.22-24.
[5] Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 2.15.

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 through STS-4), the first operational flight, STS-5, occurred the following year, November 11, 1982.[6]

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 five shuttle launches per year, with no launches for many months following each of the two major accidents.[7]

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 external tank (ET), the large orange tank in the middle of the shuttle assembly; and 3) the two reusable solid rocket boosters (SRBs) that flank either side of the ET. Of these

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

three parts, only the ET is expendable and is not recovered after each flight.[8]

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.

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 contains 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.[9] 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

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[8] Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 3.1.

[9] 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.

about 150,000′ before achieving 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 is its own rocket, about 150′ tall, with an average diameter of 12′.[10]

The SRBs 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 its own name. The uppermost segment was called the forward segment. 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 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 Booster Separation Motors (BSMs), as well as the Thrust Vector Control system that steered the STS while in flight.[11]

4. SRB Thermal Protection System (TPS)

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[10] Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 3.15, 2.4-5.
[11] 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.

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. After priming and painting, 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 SRB 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.[12]

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 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 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 topcoat of Hypalon paint applied manually with brushes and rollers to all TPS surfaces. Finally, a material called Froth Pak, a two-part isocyanate mixture,

[12] United Space Alliance, "Materials and Processes Revision J" (KSC, no date), no page number.

was applied to the interior surfaces of the aft skirt assembly around the Thrust Vector Control (TVC) system. The Froth Pak prevented or minimized damage caused by water impact at splash down in the ocean.[13]

5. SRB Design and Function

The initial design for the SRBs was conceived in the 1970s by Marshall Space Flight Center (MSFC) 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, Inc. (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.[14]

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).[15] The four

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[13] United Space Alliance, "Structures Assembly Buildup Operations, Revision J" (KSC, no date), no page number.
[14] Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 3.14.
[15] 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 about 38.6 nautical miles up, before they reached their apogee and tumbled back toward the ocean.[16]

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 of 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.

[16] 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.

This air gave the boosters buoyancy and caused them to float with the forward end about 30' out of the water.[17]

6. SRB Recovery, Disassembly, and Refurbishment

After splashdown in the Atlantic, the boosters were recovered by the *Liberty Star* and *Freedom Star*, two ships designed for this purpose, and returned to the Hangar AF Complex on CCAFS. 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 were then reeled onboard the ships 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.[18]

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 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 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

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

ships in what was called “hip mode” for easier navigation through the narrow Banana River channel.[19]

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 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 is removed after disassembly with a manual hydrolase wash, or high-pressure water blast, in the High Pressure Wash and Robot Wash Buildings.[20] After the hydrolase process, 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 where they were 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.

7. The SRB Assembly and Refurbishment Facility (ARF)

From Hangar AF, the inert or non-propellant SRB segments were transferred to the SRB ARF Manufacturing Building at KSC. The ARF was completed in 1986 to house the assembly

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

and refurbishment of the forward and aft skirts, frustums, and nose caps. Other operations in the ARF include the replacement of the boosters' TPS, installation of electronic and guidance systems, integration of the SRB recovery parachutes, and automated checkout of SRB electrical and guidance systems. It was also where the steering elements of the TVC system were tested and assembled, and where the explosive devices (ordnance) for booster separation were installed. A full description of the SRB assembly and refurbishment process at the ARF is included in Part III of this report.

8. Conclusion – The Space Shuttle Mission

While the SRB refurbishment process proceeded at the ARF, up in space 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 as 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, 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 Space Shuttle Atlantis landed at KSC to complete the program's 135th mission (STS-135). Since the SSP's first launch on April 12, 1981, the program included 355 astronauts from 16 countries. The five orbiters 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, 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."[21]

C. Physical History of the ARF

1. Date of Construction

NASA broke ground for the ARF Complex in March, 1985 and completed it in August, 1986. The 45-acre site included five new buildings: the ARF Manufacturing Building, the Engineering and Administration Building, the Chiller Building, the Service Building, and the Aft Skirt Test Facility.[22]

2. Architect/Engineer

The ARF Complex was designed by Reynolds, Smith and Hills, an architecture and engineering firm based in Jacksonville, Florida. The firm was founded in 1941 and has offices located across the country. It specializes in aerospace

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[21] 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.

[22] KSC, *Resource Encyclopedia* KHB-1863, Edition 1 (December 2010): 239. On file at the Kennedy Space Center Archive.

and defense, aviation, corporate, education, health and science, public infrastructure, and transportation.[23]

3. Builder/Contractor/Supplier

Booster Production Co.

4. Original Plans and Construction

Although KSC added new buildings to the ARF Complex after its original 1986 construction, the ARF Manufacturing Building retains its original appearance. Examinations of the building's original construction drawings and a 1987 aerial photograph show that the building has had no major exterior alterations or additions. The interior floor plan and finish materials also remain intact. A full architectural description is found in Part II of this document.

5. Alterations and Additions

The ARF Manufacturing Building has received no major alterations or additions to its interior or exterior. The site has received additional buildings since its original 1986 completion, including the construction of the 1988 Ground Support Equipment (GSE) Building, the 1992 Chemical Reutilization Building, and the 1996 Modular Office Building.

Part II. Structural/Equipment/Design Information

A. General Statement

1. Character

The ARF Manufacturing Building is an industrial processing facility designed to manufacture, assemble,

[23] Reynolds, Smith and Hills, "About RS&H," http://www.rsandh.com/. Accessed December 30, 2011.

and refurbish the non-propellant components of the Space Shuttle SRBs, including the forward and aft skirts, frustums, and nose caps. The steel and concrete block building has a total floor space of 168,014 square feet, which includes a high bay work area flanked on the north and south by three-story wings. The building contains a wide variety of process areas and office space, including:

- a 60′ tall high bay with two 15-ton capacity bridge cranes;
- an Ordnance Build Up room;
- three TVC Build Up rooms;
- a 9,260-square foot TVC conditioned clean area;
- two TPS robotic paint cells with air-powered floor turntables;
- two TPS cure cells;
- an over 10,000-square foot TPS high bay conditioned finish area;
- a 5,800-square foot Electronics and Instrumentation (E&I) conditioned electronics lab area;
- a machine shop for fabricating metal parts;
- and office and conference room space.[24]

The building is also equipped with a variety of mechanical and utility systems, including chilled water, 480 volt/60 hertz electrical service, potable water, compressed air, gaseous nitrogen, gaseous helium, and uninterruptable power supplies.

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[24] KSC, *Resource Encyclopedia*: 239.

2. Setting

The ARF Manufacturing Building is located in the larger complex, a 45-acre site at the southeast corner of Schwartz Road and Contractors Road. The complex contains eight additional buildings, including the Engineering and Administration (E&A) Building and a modular office building that provide a total of 106,500-square feet of office space. There are two GSE service buildings, the Hazardous Waste Storage Facility (also called the Chemical Reutilization Building), the Multi-Purpose Storage Building, and the Chiller Building. Finally, the complex includes the Aft Skirt Test Facility where SRB aft skirts are tested after build up in the ARF.

The complex is located directly south of KSC's Launch Complex 39 and the VAB. From the ARF, refurbished SRB components were transferred to the Rotation Processing and Surge Facility (RPSF) for final build-up and assembly before shuttle launch.

The rectangular site features most of its buildings grouped together in a north-south orientation along its west side. They are surrounded by asphalt parking lots and access roads. The east end of the site is mostly occupied by trees and scrub brush and is bordered by an access road. The exception is the Aft Skirt Test Facility, which is located away from the other buildings at the southeast corner of the site. This facility contains volatile hydrazine fuel used in the aft skirt TVC systems, so the building's separate location ensures safety in the event of an explosion.

The main entrance lies at the north end of the ARF building complex along Schwartz Road. There are entrance drives on either side of a grass lawn with two flag poles at its center. South of the grass lawn is the main parking lot and the two-story E&A Building. Between the E&A Building and the ARF Manufacturing Building is the Chiller Building, which handles the air conditioning and other utilities for the site. Due east of the Chiller Building is a modular office building completed in 1996.

Immediately south of the Chiller Building is the ARF Manufacturing Building, roughly in the center of the north-south oriented complex. South of the ARF Manufacturing Building are the two GSE buildings and the Hazardous Waste Storage Facility, added to the complex in 1988 and 1992, respectively. The GSE buildings and Hazardous Waste Storage Facility feature the same industrial designs and materials shared by the ARF Manufacturing Building, such as metal and concrete.

3. Condition of Fabric

The condition of the ARF Manufacturing Building’s fabric is excellent. The building retains all seven aspects of integrity as defined by the National Register, including its location, setting, design, materials, workmanship, feeling, and association.

B. Description of Exterior

The exterior of the industrial ARF Manufacturing Building is clad in corrugated insulated steel panels made by Butler Manufacturing, except for the first eight feet along the ground floor, which is stucco over concrete block. Each of the building’s three sections has a flat, built-up roof. The building rests on a reinforced concrete slab foundation and has a rectangular footprint.

The exterior is lit by rows of security flood lights positioned approximately two-thirds of the way up on all four elevations. Three enclosed stairwells protrude out from the exterior, including one at either end of the east elevation, and one at the southern end of the west elevation. The stairwells have sloping shed roofs clad in the steel panels and stucco-over-concrete block walls.

The exterior height of the high bay is 60′-6″. All other areas of the building have a height of 44′-0″. The entire building is 253′-0″ wide by 358′-0″ long. The high bay is accessed by two 35′-0″ x 30′-0″ vertical lift doors on the east and west elevations.

The building’s relatively few windows are associated with second-floor interior office areas along the north elevation and wrapping around the southeast corner. Windows throughout the building are a double-light horizontal sliding type with tinted tempered glass and metal frames.

NORTH ELEVATION

The north elevation contains the building’s main double-door pedestrian entrance, accessed via a covered walkway. There is an additional single-door pedestrian entrance near the east corner. The only other exterior feature of the north elevation is a row of twelve metal-sash double-light horizontal sliding windows with tinted tempered glass. These windows are associated with third-floor office space.

SOUTH ELEVATION

The south elevation has second and third-floor office windows on the west end of the elevation. Along the ground floor there are five double-door pedestrian entrances and one single-door pedestrian entrance. There is a row of six flood light fixtures positioned two-thirds of the way up the exterior wall, and an array of utility conduits.

WEST ELEVATION

The west elevation is divided into three sections: the north wing, the high bay, and south wing. These three sections are described here from north to south. The north end of the building begins with a loading area that has a metal roll-up door covered by a metal shed roof supported by two metal poles. Above the awning are three double-light office windows on the third floor. Immediately south of the loading area is one of the building's three enclosed stairwells, described above.

South of the stairwell are two exterior steel-frame utility sheds with open sides, corrugated steel panel shed roofs, and stucco-on-concrete block knee walls. The first shed contains a metal isopropyl alcohol tank and the second contains a metal deionized water tank. Both of these tanks serve the adjacent TVC clean room area on the interior of the building. There is a metal ventilation pipe extending up the side of the building above the first shed.

South of the two utility sheds is a semi-truck trailer containing nine compressed helium tanks, which are also connected to the TVC clean room. This trailer can be disconnected and replaced at any time but is a semi-permanent fixture of the building's exterior.

The high bay section is next with a 35′-0″ tall triple-segmented vertical lift door. The vertical-lift door has a single-door pedestrian entrance embedded in its south end. There is a 25′-0″ tall louvered ventilation panel next to the high bay door.

Beyond the high bay is the south wing, which begins with a set of four office windows on the second and third floors, followed by another exterior stairwell with attached metal lean-to shed. This shed was originally designed to cover external chemical tanks, but the tanks were removed at an unknown date. There is a double-door pedestrian entrance to the south of the shed.

EAST ELEVATION

The north wing of the east elevation contains a single vertical lift door and two single-door pedestrian entrances. The vertical lift door leads into the ordnance room.

The high bay portion is identical to that on the west elevation with a triple segmented vertical lift door and louvered ventilation panel.

The south wing begins with a 15′-0″ tall louvered ventilation panel, followed by a single office window and the building’s third and final exterior stairwell. Between the stairwell and high bay door (below the ventilation panels) is a non-original lean-to shed with picnic tables for employees.

C. Description of Interior

The interior of the ARF Manufacturing Building is divided into three sections: the high bay, the north wing, and the south wing. The following describes the features and work areas of each section.

HIGH BAY

The interior of the high bay work area is approximately 60′ tall x 80′ wide x 250′ long. It is roughly divided into the Aft Assembly Build Up Area on the east end and the Forward Assembly Build Up Area on the west end. The completely refurbished SRB aft skirts, forward skirts, frustums, and nose caps are assembled in these areas.

The high bay has an exposed steel frame structural system and ceiling, concrete block walls, and a concrete slab floor. It has two 15-ton overhead cranes that travel across a steel track system. The bay is lit with flood lights suspended at regular intervals across the exposed steel ceiling structure, as well as other floodlights in the bay's adjacent work areas.

Other work areas that are considered within the footprint of the high bay are the TVC Build Up rooms, the Machine Shop/Aft Skirt Structural Repair Area, and the BSM Cell, where the BSMs were installed in the frustums and aft skirts. Each of these three areas is described below.

TVC Build Up

The three, side-by-side TVC Build Up rooms are accessed via metal roll-up doors on the concrete block north wall of the high bay's west end. The doors have cast concrete lintels and are separated visually by steel columns of the building's structural system.

Each of the identical TVC Build Up rooms measure 35′-2″ square and have a two-story ceiling height. The rooms have concrete block walls, concrete slab floors, and overhead bridge cranes for lifting TVC components. The rooms contain special equipment and instruments used in the assembly of the aft skirt TVC systems, most notably the Portable Service Leak Check Panel, the Gaseous Helium Leak Check Panel, Gaseous Nitrogen Service and Source Panels, and Gaseous Nitrogen Outlet Pressure Gauge. They are lit with ceiling-mounted fluorescent fixtures. Double-door pedestrian entrances are centered in the rear (north) walls of the cells that lead into the TVC Clean Area in the building's north wing.

Machine Shop and Aft Skirt Structural Repair Area

This is a three-story high open bay area separated from the main high bay area by a chain link fence. It has an exposed steel frame structural system, concrete block walls, and a concrete slab floor. The shop is filled with metal fabrication tools and raw materials such as aluminum used to make and replace SRB parts.

Beyond the Machine Shop is a corridor that leads to the building's main pedestrian entrance. The corridor also leads to interior stairwells that go up to the office areas on the second and third floor of the building's north end.

NORTH WING

The ground floor of the ARF Manufacturing Building's north wing contains two areas evaluated for this document: the Ordnance Build Up room and TVC Clean Area. Areas in the north wing not evaluated or described here are the Shipping/Receiving and Logistics Storage area, Employee Break Room, and second floor office areas.

Ordnance Build Up and BSM Cell

The Ordnance Build Up room is a three-story blast resistant concrete room where ordnance was received and staged for installation in the Frustum Linear Shaped Charge (LSC) ordnance rings. The room is located on the exterior east wall of the ARF Manufacturing Building. Ordnance was carried into the room from the exterior via a metal vertical lift door in the east wall.

The room has a rectangular footprint except for the southwest corner, where the wall is set at an angle. The room is accessed from the interior via a vertical lift door and adjacent single pedestrian metal blast door on the west wall. It has concrete interior walls and floor, exposed steel structural system, and a steel panel exterior wall on the east side. The steel exterior wall was designed to explode outward in case of an explosion. Electrical conduits run horizontally along the walls at a height of about 12′ and compressed air stations are positioned along the west wall at regular intervals. Also along the west wall are desks and filing cabinets for administrative purposes.

Overhead there is an oblong monorail track system that carries two one-ton capacity cranes. Other specialized equipment in the room include a number of skirt stands, positioned alongside the aft and forward skirts for work purposes, and a Booster Trowelable Ablative mixing machine against the rear (north) wall.

BSM Cell

At the east end of the high bay’s north wall is the BSM Cell, which measures approximately 35′-0″ square. Designed to store the BSMs, the cell has blast resistant cast concrete walls, doors, and ceiling. There are blast resistant vertical lift doors on the south wall (leading into the high bay) and on the north wall (leading into the Ordnance Build Up room). The room is equipped with an overhead bridge crane.

TVC Clean Area

Immediately north of the TVC Build Up rooms is the TVC Clean Area, where individual TVC components were manufactured and refurbished for installation. The Clean Area includes seven rooms, each with a different function: the Tube/Hose Assembly (Room 110), TVC Sub-Assembly (Room 120), TVC Component Processing Assembly Room (Room 116), TVC Hydraulic Testing (Room 118), TVC Pre-Cleaning (Room 109), TVC Final Cleaning (Room 109A), and the Hydraulic Pump Room (Room 117).

The largest room in the area is the Tube/Hose Assembly (Room 110). This L-shaped room has drywall walls, a suspended acoustic tile ceiling with fluorescent lights, and a tile floor. It contains a number of specialized machines and equipment along the east wall, including three tube-bending machines, three tube-deburring and flaring machines, and a hydrostatic test panel. Another tube bending machine is located on the west wall and there are worktables in the middle of the room. Along the north wall is a gaseous helium leak check panel. In the northwest corner of the room is a recessed area containing an employee desk/work station and the hose cut room containing a chop saw. There are doors on all four sides of the room providing access to other rooms in the area.

To the west of the Tube/Hose Assembly Room is the TVC Sub-Assembly Room, also called the TVC Final Build Up (Room 120). It has drywall walls, a suspended acoustic tile ceiling with fluorescent light fixtures, and a tile floor. Room 120 is where the individual parts of the TVC system were assembled onto upright metal frames before aft skirt installation in the TVC Build Up rooms. The room contains specialized equipment, including mobile steel assembly frames; a gaseous helium gauge on the south wall; Auxiliary Power Unit (APU) fume hood in the southwest corner; a thermal vacuum chamber on the east wall; and a flow bench in the northeast corner. The room also contains several worktables and storage cabinets.

TVC components were cleaned in the adjacent Pre-Cleaning (Room 109) and Final Cleaning (Room 109A). There is a transfer window between the rooms, which was used to move cleaned TVC parts from Room 109 to 109A. Room 109 has concrete block walls, suspended acoustic tile ceiling, and a concrete slab floor. It contains a bank of four trisodium phosphate wash tanks against the north wall and a water sink in the northwest corner. Against the south wall are a blast cabinet, storage cabinets, and the transfer window. TVC parts were brought into this room through a double-door pedestrian entrance on the west wall.

Room 109A contains a number of workbenches and tables, as well as two flow benches and an inspection microscope. It has drywall walls, a drywall ceiling, suspended fluorescent light fixtures, and a concrete slab floor.

The TVC Component Processing Assembly Room (Room 116) is a narrow rectangular room that contains three flow benches and storage shelves on both the east and west walls. It has drywall walls, a suspended acoustic tile ceiling, and tile floor.

The TVC Hydraulic Testing Room (Room 118) has a rectangular footprint, concrete block and drywall walls, and a drywall ceiling with flush-mounted fluorescent light fixtures. At the north end of the room are two hydraulic test benches and flow hoods that were used to test the TVC hydraulic and fuel systems with de-ionized water and hydraulic fluid. Other specialized equipment on the west wall includes a particle-cleaning table, gaseous nitrogen distribution meters, and electrical test equipment. On the east wall is a three-level shelf containing individual TVC component test fixtures.

The Hydraulic Pump Room (Room 117) is on the west side of Room 118 and provided pressure for the equipment in Room 118. It has concrete block walls and a metal roll-up door on the west wall. It contains two pumps, one that handles TVC hydraulic fluid and one that handles de-ionized water.

SOUTH WING

The south wing of the ARF Manufacturing Building’s ground floor includes the Assembly Check-Out (ACO) Test Area, Electronics & Instrumentation (E&I) Area, TPS Operations, and the TPS Finish Area. The second floor contains offices that were not evaluated for this document.

Assembly Check-Out (ACO) Test Area

The ACO Test Area is located adjacent to the southwest end of the high bay. In this location the electrical systems of refurbished forward skirts, aft skirts, and Integrated Electronics Assemblies (IEAs) were tested before assembly. The ACO work area is recessed from the high bay work area to allow the SRB structures to move into it and connect to electronic testing stations housed in the adjacent E&I Area. The ACO test cables and other connectors are attached to the ACO's south wall and lead through the wall into the E&I Area. The high bay's exposed steel structural frame divides the ACO Test Area from the high bay floor. Just in front (north) of the ACO Test Area and attached to the high bay floor is the Forward Skirt Check Gauge Ring, a device that was used to ensure the attachment points on the forward skirt's bottom end are lined up correctly.

Electrical & Instrumentation Area

The E&I Area is composed of four rooms on the west end of the ARF's south wing. From north to south these rooms include the E&I Lab, the LRU/SRU (Line Replaceable Unit/Shop Replaceable Unit) Repair Room, and the Environmental Test Lab. Together these rooms housed the environmental testing processes of all the SRB avionics boxes prior to every shuttle launch, including vibration, thermal, and functional testing. Three programmable thermal chambers in the area provided up to 110 cubic feet of space with a temperature range of up to 350 degrees Fahrenheit. The area also contains several flight hardware testing sets or upright metal cabinets filled with test equipment.

The first room entered from the high bay is the E&I Lab, a rectangular room with concrete block walls, suspended acoustic tile ceiling with fluorescent light fixtures and a specially designed floor that allows access to the modifiable electrical system located beneath it. The room contains several locked, movable metal wire racks that hold avionics equipment for testing. Other specialized equipment in the room includes two Automated Booster Assembly Checkout Systems (ABACS) used to verify the thousands of functions conducted by the avionics in the forward skirt, aft skirt, TVC system, and IEAs. ABACS consisted of two VAX 11/750 computers with four test stations (two aft skirts, two forward assemblies) that were capable of verifying that the vehicle has been properly assembled. There are five individual employee work areas with desks, including four along the south wall, and one on the north wall next to the high bay door. In the southwest corner, there is a fume hood for cleaning units.

The LRU/SRU Repair Room houses repair work of Line Replaceable Units and Shop Replaceable Units, sealed modular components of the SRBs' avionics and electronics systems. It includes an L-shaped main room that contains a thermal chamber and flight hardware testing sets.

Adjacent to the LRU/SRU Repair Room is a controlled environment clean room for IEA internal inspection and repair. The IEA Clean Room has an observation window on its west wall and contains wire equipment racks, workstations, a fume hood, and IEA units strapped to mobile work stands.

The Environmental Test Lab is the southernmost room of the E&I Area. It was designed to subject SRB avionics components to the intense heat and vibration of a Space Shuttle launch. The narrow, rectangular room contains two pieces of specialized test equipment, including a hydraulic vibration table (nicknamed the "Fat Lady") in the center of the room and a thermal chamber on the east wall. The vibration table measures 48″ x 48″ and has programmable controls for both horizontal and vertical vibration. The north and south walls of the room are covered with equipment cables and storage shelves, and there is an employee desk and work area on the west wall.

TPS Operations Area

The TPS Operations Area occupies the majority of the ARF Manufacturing Building's south wing. In this area the TPS coating was applied to the SRB frustums, forward skirts, nose caps, aft skirts, and portions of the systems tunnel covers. From west to east the area includes five process areas that correspond to the TPS work flow: TPS Spray Preparation Area, MCC-1 Mix Room/Spray Cells, TPS Cure Preparation, TPS Cure Ovens and Topcoat Cell, and TPS Finish Area.

TPS Spray Preparation Area

The TPS Spray Preparation Area is a two-story bay with concrete block walls, a concrete slab floor, and ceiling with exposed steel structure and HVAC ducts. The bay is approximately 68′-0″ long by 35′-0″ wide. It is lit with suspended fluorescent fixtures. All SRB structures were moved into this space from the main high bay through a metal roll-up door on the north wall. The SRB structures were staged here before they were moved into the adjacent spray cells.

MCC-1 Mix Room/Spray Cell

After spray preparation, the SRB structures were moved to the MCC-1 Mix Room/Spray Cell area. In this area, the structures received a coat of Marshall Convergent Coating (MCC-1), a lightweight spray-on ablative material containing cork, glass, and epoxy that was developed by MSFC. From north to south, this area includes the two-story north Spray Cell, the MCC-1 Mix Room and TPS Control Room, and the two-story south Spray Cell.

The north and south spray cells are identical in design and construction with concrete block walls, concrete slab floors, ventilation/exhaust systems, floor turntables, fluorescent floodlights, and metal roll-up doors on their west and east walls. There are observation windows looking into both spray cells from the first floor TPS Mix Room and the second floor TPS Control Room. The cells are equipped with ventilation exhaust systems on their outside walls. SRB structures were moved into the cells through the west roll-up door, and then moved into the TPS Cure Preparation Area through the roll-up door on the east.

Both cells used robotic articulated spray guns to apply the MCC-1 at thicknesses ranging from 0.090″ to 0.500″. The north cell contains a pedestal robot manufactured by FANUC Robotics, and the south cell contains a gantry robot manufactured by Niko. The robots were controlled from the second floor control room overlooking the spray cell through observation windows. The FANUC robot is more technologically advanced than the NIKO and was used more often. It consists of a mechanical base or pedestal attached to the southeast corner of the cell with a robotic arm mounted on the top. It has a spray gun and nozzle assembly complete with a retracting pneumatic cylinder used to avoid structure protrusions. It also has collision avoidance sensors and a breakaway safety device. Both cells are also equipped with 16′-0″ diameter mechanical turntables in the floor, which rotated the SRB structure as the robot applied the MCC-1 spray.

Between the two spray cells on the ground floor is the TPS Mix Room. Above it on the second floor is the TPS Control Room. The TPS Mix Room has concrete block walls, a concrete slab floor, and a suspended acoustic panel ceiling with fluorescent light fixtures. The room contains two pairs of dry material hoppers that contained the MCC-1 cork and glass, the "resin pot" and "catalyst pot" that formed the two-part bonding epoxy, and a variety of pumps, flow meters, valves, and electrical equipment used to pump the MCC-1 ablative out to the robotic spray guns.

The TPS Control Room is reached via a metal staircase along the east wall of the TPS Spray Preparation Area. The room serves partly as an office, with employee desks and computerized workstations, along with a bank of electronic control panel boxes on the east wall. The room has concrete block walls, a suspended acoustic tile ceiling with fluorescent light fixtures, and a tile floor. Observation windows on the north and south walls overlook the TPS spray cells. A single-door pedestrian entrance on the east wall of the room leads into the TPS Cure Preparation Area.

TPS Cure Preparation Area

The TPS Cure Preparation Area is similar in design to the TPS Preparation Area described above. This was a staging area for curing the MCC-1 and also where additional cork sheets were applied to SRB parts that required supplementary protection, including the aft skirt, SRB/ET attach ring, BSM, strut fairings, systems tunnel covers, SRB/ET bolt catcher, camera covers, and forward crossover components.

The area is a two-story bay with concrete block walls, a concrete slab floor, and ceiling with exposed steel structure and HVAC ductwork. The bay is approximately 68′ long by 30′ wide. It is lit with suspended fluorescent fixtures.

In the northeast corner of the bay is a staircase that leads up to a small observation room overlooking the adjacent TPS Topcoat Cell. On the east wall of the bay is a pair of side-by-side TPS cure ovens referred to as “cure oven north” and “cure oven south.” The SRB structures were loaded into these ovens and heated for up to 13 hours at temperatures ranging from 112-200 degrees Fahrenheit. This process cured the MCC-1 ablative before the final topcoat of hypalon paint was applied. The ovens feature vertical lift doors on their east and west sides. They have corrugated metal paneled walls, concrete slab floors, and suspended acoustic tile ceiling. They are each lit with four suspended floodlights. Heat was delivered to the oven via metal ducts located in each corner of the oven. A metal ventilation exhaust unit is located on the south walls of the oven.

TPS Finish Area

From the TPS cure ovens, the SRB structures were moved into the TPS Finish Area on the east end of the south wing. This is a two-story bay that measures 90′-0″ long by 50′-0″ wide. It has concrete block walls on the north and west and metal panel walls on the east and south. The ceiling is an exposed steel structure with HVAC ductwork and the floor is concrete slab. It is lit with suspended fluorescent floodlights. The area includes the Topcoat Cell in the northwest corner and the TPS Mix Room in the northeast corner

In the Topcoat Cell, technicians manually applied a topcoat of hypalon paint, with brushes and rollers, to all TPS surfaces on the SRB structures. The cell is a two-story high space that measures 30′-0″ long by 30′-0″ wide. It has concrete block walls, an exposed steel structure ceiling, and a concrete slab floor. It is lit with fluorescent fixtures suspended from the ceiling and mounted on the walls. There is a ventilation exhaust unit on the south wall.

The TPS Mix Room is a one-story wood frame room in the northeast corner of the TPS Finish Area. The room was built to provide a place to mix the hand-applied BTA TPS material. BTA was used to repair and seal gaps between TPS-insulated areas, protect fasteners, and insulate complex structures not covered by the TPS spray robot. The room is a later addition that was not included in the building's original plans. It contains the BTA raw materials and mixing equipment.

Cable Shop

The SRB Cable Shop is an L-shaped room on the second floor of the ARF Manufacturing Building. This shop was used for the refurbishment and pre-installation testing of cables used in the SRB electronics and avionics systems. At the height of production it processed 242 cables per flight set, including 130 refurbished and 112 newly manufactured cables. Equipment used in the room included wire braiding machines, digital microscopes, and cable tester equipment.

The shop has concrete block walls, a suspended acoustic tile ceiling with fluorescent light fixtures, and a tile floor. The long end of the room runs east to west and contains testing stations along the north wall and a cable-manufacturing table running down the center of the room. This table is equipped with side rims to prevent the cables from falling on the floor. The shorter end of the room runs north to south and contains a cable testing area, hardware packaging, and other cable processing areas. These test areas are equipped with workbenches, desks, and computers.

BLOC Room

The Booster Launch Operations Center (BLOC) is a rectangular room with concrete block walls, a suspended acoustic tile ceiling with fluorescent light fixtures, and a carpeted floor. During a shuttle launch it typically contained about 15 people who conducted real-time SRB equipment testing and monitoring of SRB flight data. Computer workstations wrap around the room walls.

Part III. Operations and Process

A. Operations

The ARF Manufacturing Building housed the refurbishment and assembly of the inert or non-propellant SRB structures, including the forward skirts, aft skirts, frustums, and nose caps. The operations in the ARF included critical dimension checks on each SRB structure, the replacement of the TPS, installation of electronic and avionics systems, integration of the SRB recovery parachutes, and automated checkout of SRB electronic and mechanical systems. It also housed the assembly and installation of the steering elements of the TVC system, installation of the explosive devices (ordnance) for frustum separation during SRB descent, and installation of the BSMs.

Once assembled, the SRB structures produced at the ARF Manufacturing Building were referred to as the "aft assembly" and the "forward assembly." The completed aft assembly included the aft skirt, TVC system, TPS, and BSMs. The completed forward assembly included the forward skirt, frustum, nose cap, TPS, BSMs, and avionics and electrical systems. Once assembled, the forward assembly was shipped out of the ARF to the VAB and the aft assembly was shipped to the RPSF, where they awaited final build up and assembly for shuttle flight.

The following describes the general operations that occurred to assemble and refurbish the forward and aft assemblies in the ARF Manufacturing Building. This is followed by more detailed descriptions of the technical operations in each of the ARF's process areas, including the TVC Build Up/Clean Area, Ordnance Build Up, E&I Lab, Cable Shop, and TPS Processing.

1. Aft Skirt Assembly Build Up

Located at the bottom of the SRBs, the aft skirts provided attach points to the Space Shuttle mobile launch platform and provided support to the shuttle on the launch pad prior to liftoff. They provided aerodynamic protection and mounting provisions for the TVC system and aft BSMs. The TVC controlled the direction of flight during the first two minutes of a shuttle mission through incremental movement of the boosters' exhaust nozzles.[25]

The final build up of the aft skirt assemblies occurred primarily in the ARF Manufacturing Building's high bay, after their components were processed in the various process areas. First, the high bay received the recovered

[25] United Technologies USBI, "Fact Sheet: USBI's Role in the Space Shuttle Program," press release, June 1988. On file at the KSC Library Archives.

and disassembled aft skirts from the SRB Disassembly and Refurbishment area at Hangar AF. This often required extensive rearranging of other structures already located in the high bay. The aft skirts then had their critical dimensions checked on the Critical Dimension Gage located just inside the ARF's western high bay door. The structures were lifted with the high bay's overhead crane onto the gage to verify that their dimensions were not altered or damaged by the ocean splashdown. The gage checked their levelness, roundness, and that the connector pins engaged properly. Structural modifications or repairs were then performed as required with materials and parts manufactured in the Aft Skirt Repair Area and Machine Shop located on the north side of the high bay. Once the above steps were completed, the aft skirts underwent their initial mechanical build up, including the installation of zinc anodes, plugs, and TVC brackets.

The aft skirts were then transferred to Mobile Assembly and Refurbishment Stands (MARS) and routed to the TPS processing area for TPS application. TPS was applied, cured, and painted in the processing area before the aft skirts were transferred to the TVC Build Up Area. Technicians there installed the TVC frame modules, actuators, exhaust ducts, and accumulators before performing gaseous helium and gaseous nitrogen leak checks on all installed parts. The TVC cabling systems were then installed and tested.[26]

After TVC installation the aft skirts were transferred to the BSM Cell in the high bay for installation of the BSMs. After BSM installation, the skirts received an Assembly Checkout (ACO) test in the ACO Test Area on the south side of the high bay, then transported to the Aft Skirt Test

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[26] United Space Alliance, "TVC Assembly Buildup Operations – Revision J" (KSC: no date), 1-9.

Facility, east of the ARF Manufacturing Building, for a "hot fire" of the TVC system. The aft skirts were then transferred back to the high bay for a mechanical/TPS/electrical closeout test, a final weight check, and a final inspection and foreign object debris (FOD) check. Once everything was inspected and approved the aft skirt was protected with a special tarp cover and transferred to the RPSF for attachment to the aft rocket motor segment.[27]

2. Forward Assembly Build Up

As with the aft skirts above, the forward skirts and frustum structures were first received at the ARF from the SRB Disassembly and Refurbishment Area at Hangar AF. The forward skirts and frustums were then lifted onto the Critical Dimension Gage in the high bay to verify their levelness, roundness, and pin engagement. The structures, including newly made aluminum nose caps (which are not recovered after each shuttle flight) were then placed on MARS stands and routed to the TPS process area for TPS application.

Once the TPS was applied, the forward skirts and frustums underwent mechanical build up in the high bay. The forward skirt build up began with the installation of the forward dome window, the forward IEA, the forward external tank ring attach fitting (also called the thrust post), Altitude Switch Assembly (ASA), command antenna, Range Safety System (RSS), and the forward skirt aft-looking cameras.

[27] United Space Alliance, "Structures Assembly Buildup Operations – Revision J" (KSC: no date), 1-13.

The frustum build up began with the installation of the BSMs in the BSM Cell. This included an aeroheat shield and a gaseous nitrogen leak check. Following the BSMs was the installation of the forward skirt separation ring, a linear shaped ordnance charge that fired the separation of the frustum from the forward skirt during the SRB descent into the ocean. The main parachute was then mated to the frustum, followed by the pilot and drogue parachutes in the nose cap. All necessary cables and electrical components were also installed at this point.

Once all components were installed, the frustum, forward skirt, and nose cap were joined together in the ARF high bay to create the forward assembly. First the nose cap was lifted up and connected to the frustum. The nose cap/frustum's electrical cables were then mated to the forward skirt and subjected to the ACO procedure in the high bay. The mechanical, TPS, and electrical systems were then checked and closed out. The completed forward assembly was weighed and inspected for foreign object debris (FOD) and then loaded for transport to the VAB, where it was stored until final assembly.

3. TVC Build Up

The TVC system included two auxiliary power units, two hydraulic power units, two precision actuators, 40 flex hoses, and 100 titanium and stainless steel tubes. Components of the TVC were first manufactured and assembled in the TVC Clean Area of the ARF's north wing. This preliminary work was done concurrently with the aft skirt mechanical build up and TPS process. The TVC was then moved out to the TVC Build Up rooms off the high bay where it was attached to the inside of the aft skirt.

Recovered TVC components were first cleaned of residual fuel and other contaminants in the Pre-clean Room (Room 109), which contains a bank of trisodium phosphate (TSP) and deionized water wash tanks. Once cleaned, the washed TVC components were passed through a transfer window into the Clean Room (109A), where technicians removed any remaining contaminants and confirmed cleanliness with microscopic inspection.

The TVC system included a number of tube and hose connectors, which were fabricated in Room 110. Raw tubing materials were cut to length and bent into shape on one of the room's four tube bending tables and machines. Technicians fabricated hoses and connectors at the room's tables and workstations and checked them for leaks with gaseous helium.

The TVC hydraulic system included 19 different parts, which were repaired and refurbished in Room 118 using the Component Acceptance Test System (CATS). The CATS unit on the north side of the room is divided into left and right testing stations, both of which include computerized controls and test hoods into which TVC components were mounted. The station on the left tested the TVC system's hydrazine fuel components, though it used deionized water for testing purposes rather than actual hydrazine. The components were connected to the testing station and brought up to full pressure under simulated flight conditions. The station on the right tested the TVC hydraulic systems in a similar manner. Other equipment in the room tested for particulate matter in the TVC hydraulic fluid. The deionized water and hydraulic fluid for testing was supplied by pumps and reservoirs in the adjacent Room 117.

Once all of the TVC components were cleaned and processed, they were assembled onto mobile metal frames in Room 120. Technicians installed all components into "upper" and "lower" sections (corresponding to their position in the overall TVC system) and then used gaseous helium to check for connection leaks. From there, the TVC frames and aft skirts were routed to the build up room located off the north side of the high bay. Technicians installed the TVC modules, actuators, exhaust ducts, and accumulators, followed by all the hoses and tubes that connected all of the parts together. All connections and components were again checked for leaks with the gaseous helium and gaseous nitrogen leak check panels mounted onto the rooms' walls. Finally, all electrical cables were installed and tested.

Once the TVC was installed in the aft skirt, the entire interior of the skirt was covered with spray-on "froth pak," a two-part isocyanate foam product that prevented or minimized water impact damage to the TVC and skirt structure during splashdown. The froth pak required a supplied air suit during application.

4. Ordnance Build Up/BSM Build Up

The frustum separated from the forward skirt during SRB descent into the ocean in order to release the main parachutes. This separation was accomplished with the frustum linear shaped charge ordnance ring, which was assembled and installed in the Ordnance Build Up room. This room and the attached BSM Cell have blast-resistant concrete walls to minimize damage to the rest of the building in case of accidental explosion. The BSMs, which fired to separate the SRBs from the Space Shuttle's ET, were also installed onto the aft skirt and frustum in the Ordnance Build Up room.

5. Electrical and Instrumentation Area

The SRBs were equipped with a number of E&I systems that were involved with every phase of SRB liftoff and descent. These critical systems included the forward and aft IEAs, RSS, Rate Gyro Assemblies, and many others. The repair and testing of SRB system components was accomplished in the E&I area of the ARF's south wing.

The E&I Area includes four rooms on the west end of the ARF's south wing. From north to south these rooms include the E&I Lab, the LRU/SRU Repair Room, and the Environmental Test Lab. These rooms housed the environmental testing processes of all the SRB avionics components prior to every shuttle launch, including vibration, thermal, and functional testing.

Technicians in the E&I Area used a variety of equipment to test the operation, maintenance, and repair of E&I components:

- Altitude Switch Assembly (ASA) test set;
- Rate Gyro Assembly (RGA) test set;
- Two forward skirt Automated Booster Assembly Checkout Systems (ABACS);
- Two ABACS IEA test stations;
- Uninterruptable power supplies for all test stations;
- Two Consolidated Laser Ranging Data (CRD) test stations;
- C-Band controller test station;
- Auxiliary Power Unit (APU) controller card test set;
- Two Solid State Video Recorder (SSRV) test stations;
- Pressure transducer test bench;
- Vibration table;
- Thermal chambers;
- Controlled environment clean room for IEA inspection and repair.

6. Cable Shop

The SRBs each contained an extensive cabling system that connected its various E&I systems. These cables were manufactured, refurbished, and tested in the cable shop on the second floor of the south wing. The cable shop processed 242 cables per flight set of SRBs, including 130 waterproof reusable cables and 112 new cables. All cables were inspected and bench tested at the shop's workstations prior to installation. This work was conducted on a variety of equipment, including braiding machines, connector machines, flex testers, crimp testers, and digital microscopes.

7. TPS Processing

The TPS Process Area is located in the south wing. All frustums, aft skirts, forward skirts, and nose caps passed through this area to receive TPS, which included MCC-1 spray-on ablative, cork, and BTA. The MCC-1 spray-on ablative was applied in the north and south spray cells by robotic articulated spray guns at thicknesses ranging from 0.090″ to 0.500″. The robotic spray guns worked as the SRB structures were rotated on 16′-0″ diameter mechanical turntables in the floor.

The MCC-1 ablative was manufactured in the TPS Mix Room, between the north and south spray cells. The TPS Mix Room contains two pairs of dry material hoppers that contained the MCC-1 cork and glass, the "resin pot" and "catalyst pot" that formed the two-part bonding epoxy, and a variety of pumps, flow meters, valves, and electrical equipment used to pump the MCC-1 ablative out to the robotic spray guns.

The application of MCC-1 was operated from the TPS Control Room above the TPS Mix Room. The TPS Control Room is an office-type environment with employee desks and computerized workstations, along with a bank of electronic control panel boxes on the east wall. Observation windows on the north and south walls overlook the spray cells.

The TPS was then staged in the TPS Cure Preparation Area before moving into the TPS cure ovens. Additional cork sheets and pieces were applied in this preparation area to protruding SRB parts that required additional protection, including the aft skirt, SRB/ET attach ring, BSM, strut fairings, systems tunnel covers, SRB/ET bolt catcher, camera covers, and forward crossover components.
The TPS was cured in ovens referred to as "cure oven north" and "cure oven south." The SRB structures were loaded into these ovens and heated for up to 13 hours at temperatures ranging from 112-200 degrees Fahrenheit. This process cured the MCC-1 ablative before the final topcoat of hypalon paint was applied.

From the TPS cure ovens the SRB structures were moved into the TPS Finish Area on the east end of the south wing. In the Topcoat Cell, the SRB structures were manually painted, using brushes and rollers, with a topcoat of hypalon paint on all TPS surfaces.

Part IV. Sources of Information

A. Engineering Drawings and Plans

Reynolds, Smith and Hills. "Solid Rocket Booster Assembly and Refurbishment Facility." Kennedy Space Center, Florida. Construction drawings, 1985.

B. Early Views

Kennedy Space Center. Photograph negative number KSC-87PC-769, dated August 20, 1987. Kennedy Space Center Archives.

C. Interviews

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

D. Primary Sources

None.

E. Secondary Sources

Curie, Michael, Kyle Herring, and Candrea Thomas.

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Deming, Joan, and Patricia Slovinac.

2008 *NASA-Wide Survey and Evaluation of Historic Facilities in the Context of the U.S. Space Shuttle Program: Roll-Up Report*. Submitted to the National Aeronautics and Space Administration, Environmental Management Branch. Sarasota, Florida: Archaeological Consultants, Inc. February 2008, revised July 2008.

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Reynolds, Smith and Hills.

2011 "About RS&H," http://www.rsandh.com/. Accessed December 30, 2011.

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1986 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/511cover.htm.

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

2006 *NASA Facts: Solid Rocket Boosters and Post-Launch Processing*. Kennedy Space Center, Florida. FS-2004-07-012-KSC (Rev. 2006).

United Space Alliance

No Date. "Marine Operations, Revision J." Kennedy Space Center, no date. MO-1.

No Date. "Materials and Processes Revision J." Kennedy Space Center, no date.

No Date. "Structures Assembly Buildup Operations, Revision J." Kennedy Space Center, 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 buildings of the SRB Assembly and Refurbishment Facility Manufacturing Building.

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

V. Project Information

NASA determined that the SRB ARF Manufacturing Building 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 13 NASA Centers.[28] As a result of this work, 70 properties were identified as either listed, determined eligible, or were potentially eligible to the National Register. Out of 12 property types identified for NASA's SSP, the SRB Assembly and Refurbishment Facility Manufacturing Building was identified as falling within Property Types 2 and 9, which are Resources Associated with Vehicle Processing Facilities and Resources Associated with Manufacturing and Assembly Facilities, respectively.[29] NASA completed this evaluation as the SSP was terminated in 2011.

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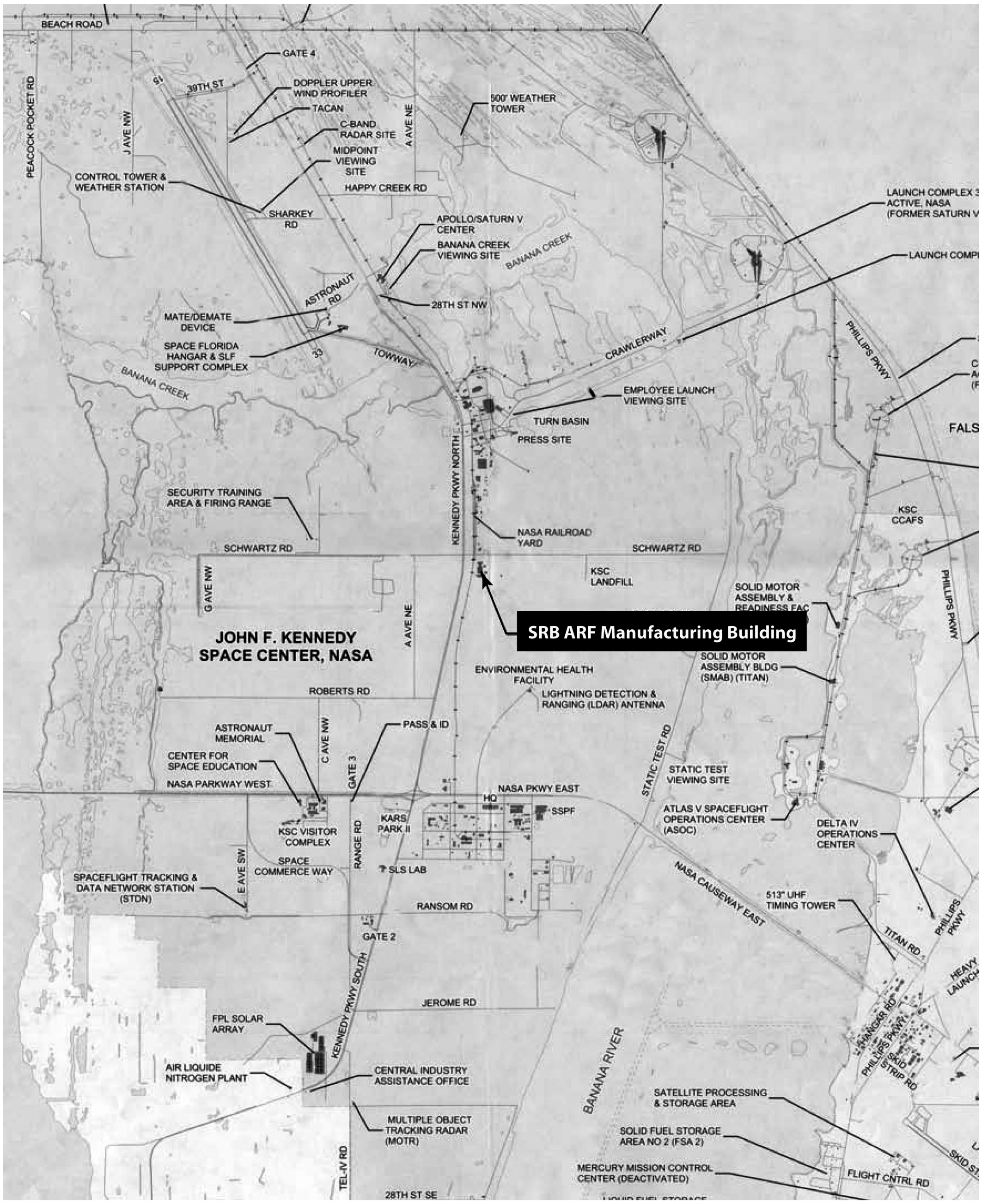
[28] Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 5.11.
[29] Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 5.11.

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, 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 SRB ARF Manufacturing Building 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, conducted the HAER documentation and historic research for this project in September and October 2011. With the end of the SSP, the SRB ARF Manufacturing Building may be altered and modified for future space missions. 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 Cultural Resources 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 Art Morales,

MSFC, Office of the Director Shuttle - ARES Transition Office. Elaine Liston, KSC Archivist, provided a wealth of information from her office in the KSC Headquarters Building.



Map Showing the Location of the SRB ARF Manufacturing Building within Kennedy Space Center. (Courtesy KSC)

Source: USDA Aerial Photograph

Aerial Photograph Showing the location of the SRB ARF Manufacturing Building, Kennedy Space Center.

Aerial photograph of the SRB ARF Manufacturing Building, View Southwest, 1987. (Courtesy KSC, Image KSC-87PC-769).

Aerial Photograph of SRB ARF Manufacturing Building with the VAB in Background, View North, 1992. (Courtesy KSC, Image KSC-392C-2230.14).

Aerial Photograph of the SRB ARF Manufacturing Building, View Northwest, 1996. (Courtesy KSC, Image KSC-96PC-209).

Aerial Photograph of the SRB ARF Manufacturing Building, View Southeast, 1996. (Courtesy KSC, Image KSC-396C-0968.36).

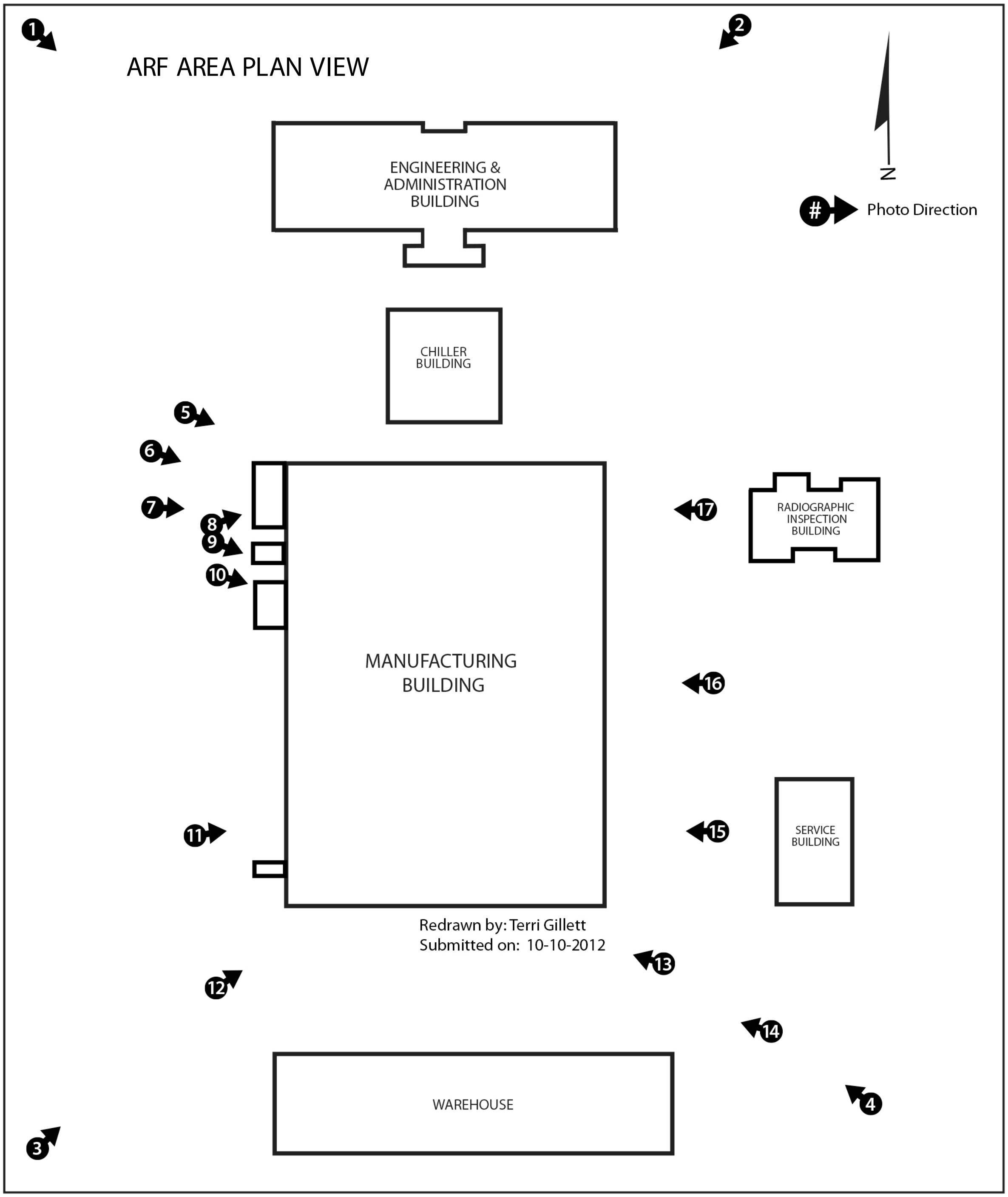

ARF AREA PLAN VIEW
ENGINEERING & ADMINISTRATION BUILDING
CHILLER BUILDING
MANUFACTURING BUILDING
RADIOGRAPHIC INSPECTION BUILDING
SERVICE BUILDING
WAREHOUSE
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Photo Direction
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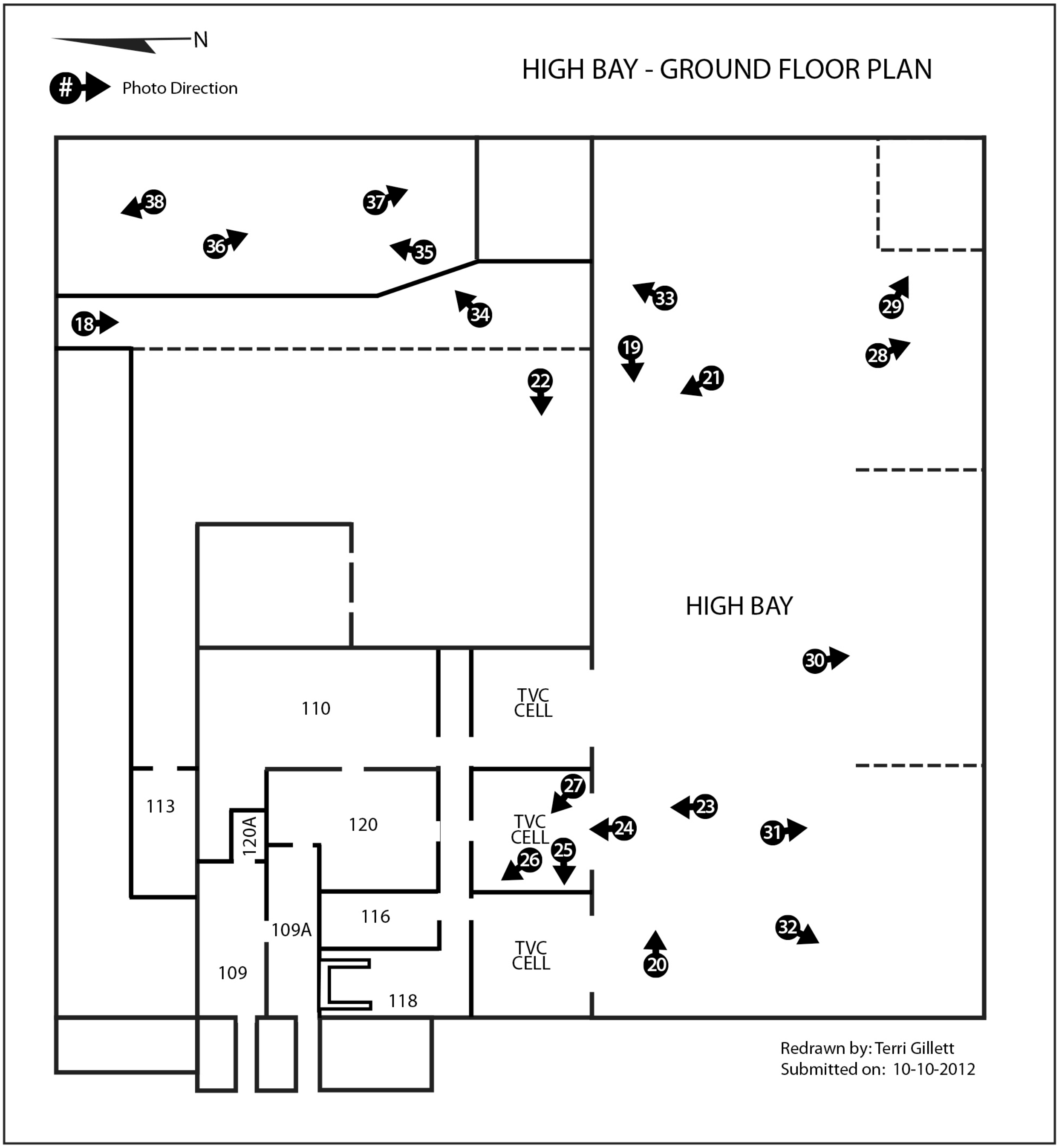
Submitted on: 10-10-2012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HIGH BAY - GROUND FLOOR PLAN
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TVC CELL
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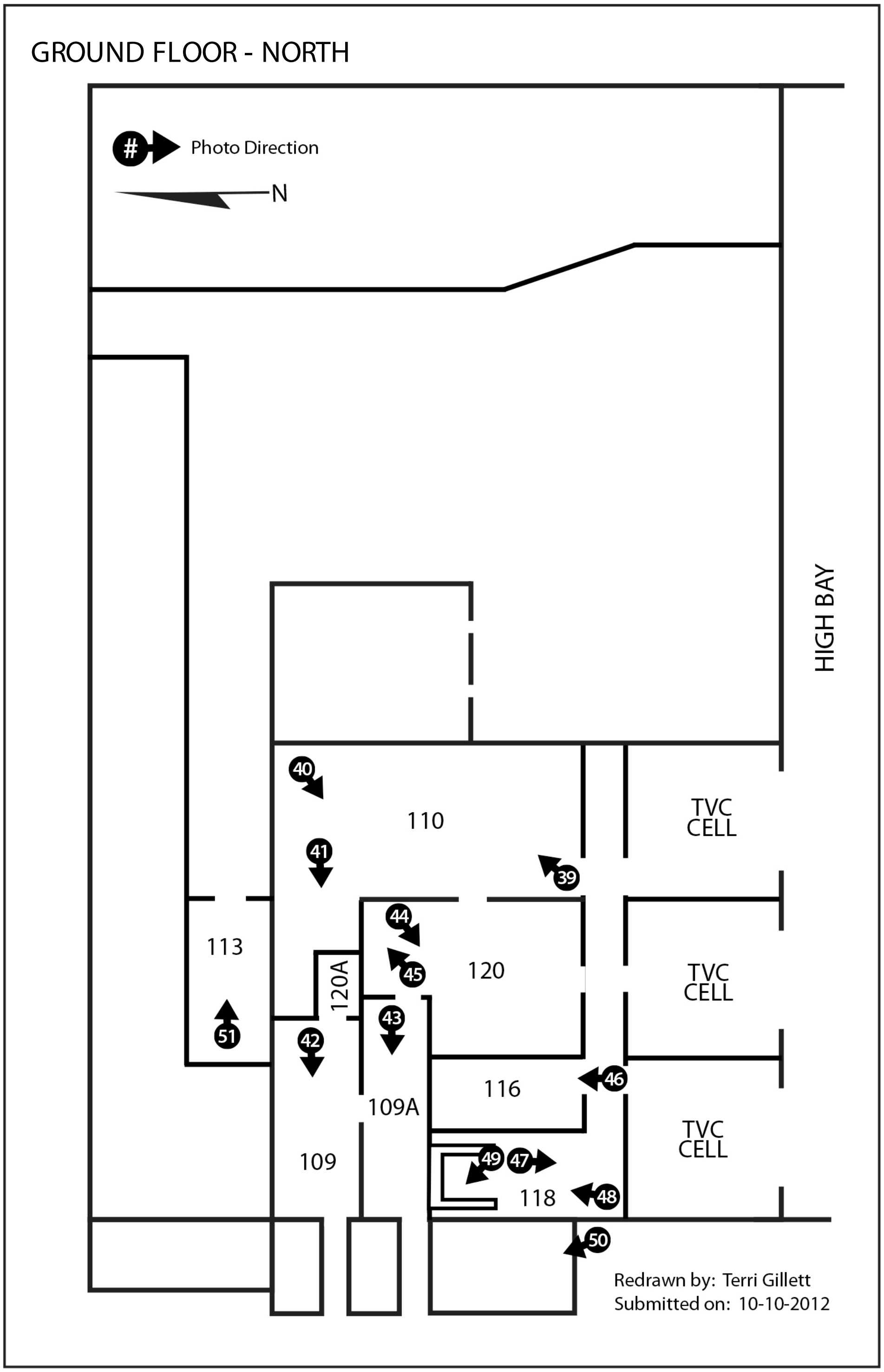
GROUND FLOOR - NORTH
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Redrawn by: Terri Gillett
Submitted on: 10-10-2012

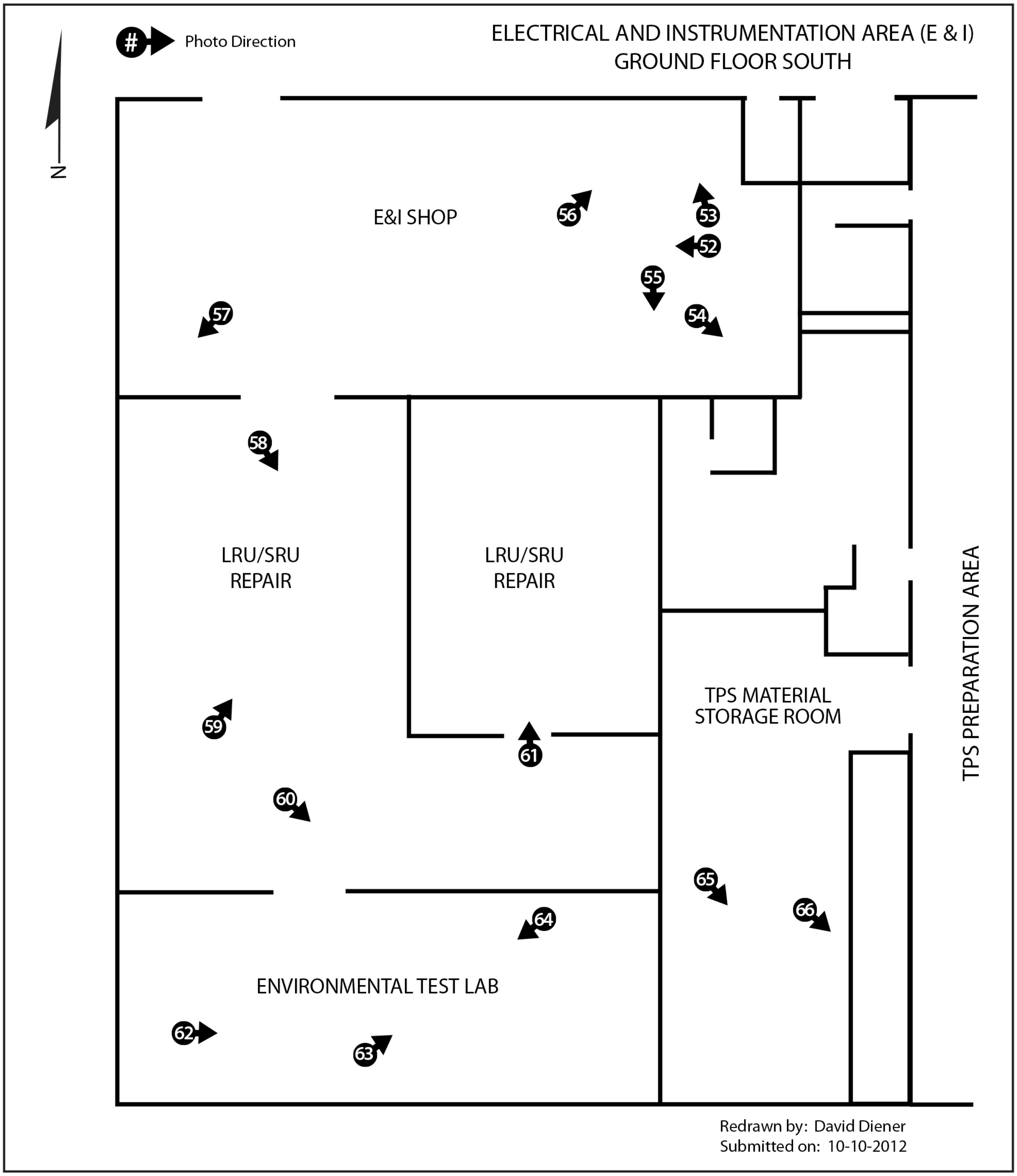
Photo Direction
ELECTRICAL AND INSTRUMENTATION AREA (E & I)
GROUND FLOOR SOUTH
N
E&I SHOP
56
53
52
55
54
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LRU/SRU REPAIR
LRU/SRU REPAIR
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TPS MATERIAL STORAGE ROOM
TPS PREPARATION AREA
65
64
66
ENVIRONMENTAL TEST LAB
62
63
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Submitted on: 10-10-2012

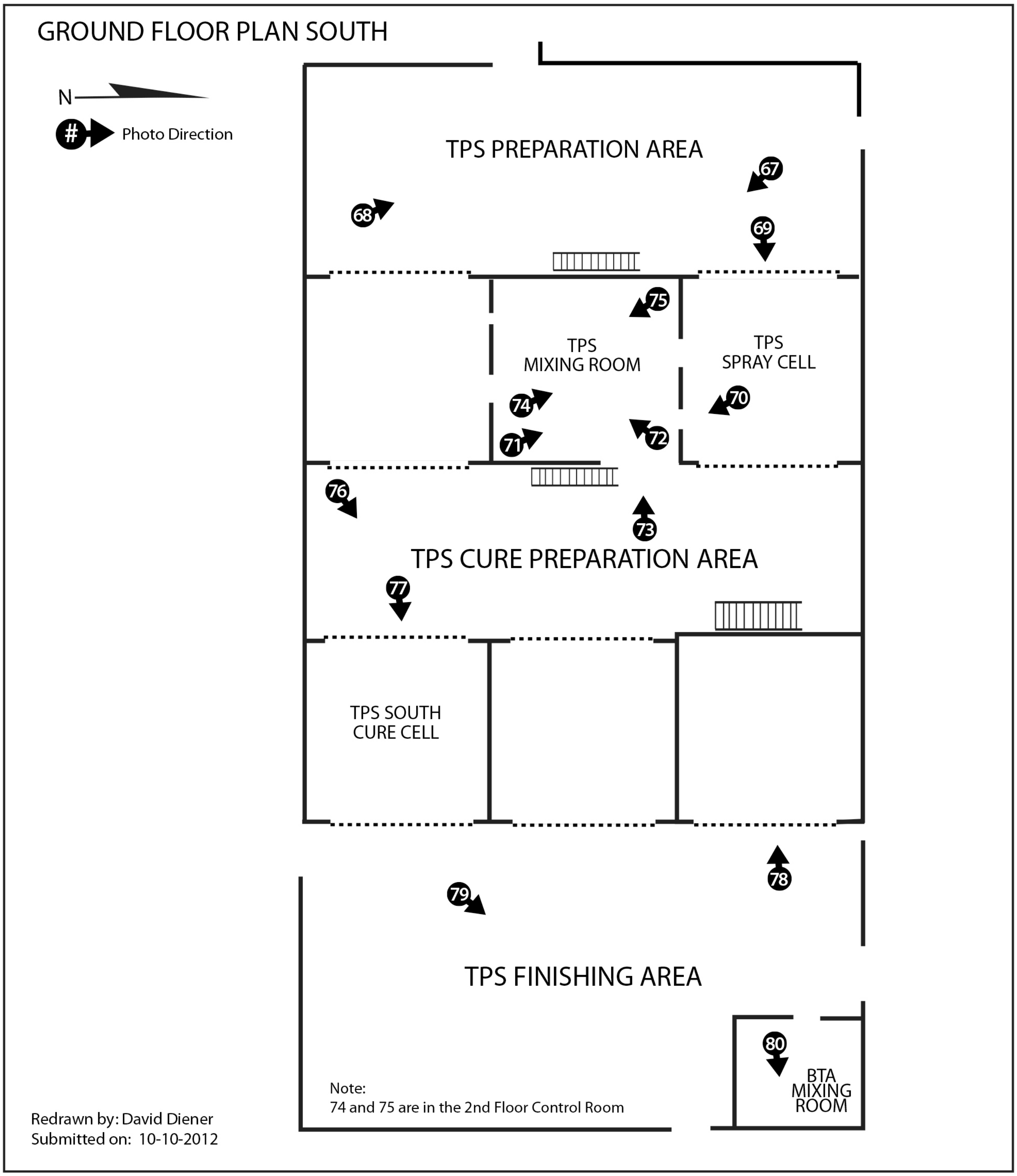
GROUND FLOOR PLAN SOUTH
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Photo Direction
TPS PREPARATION AREA
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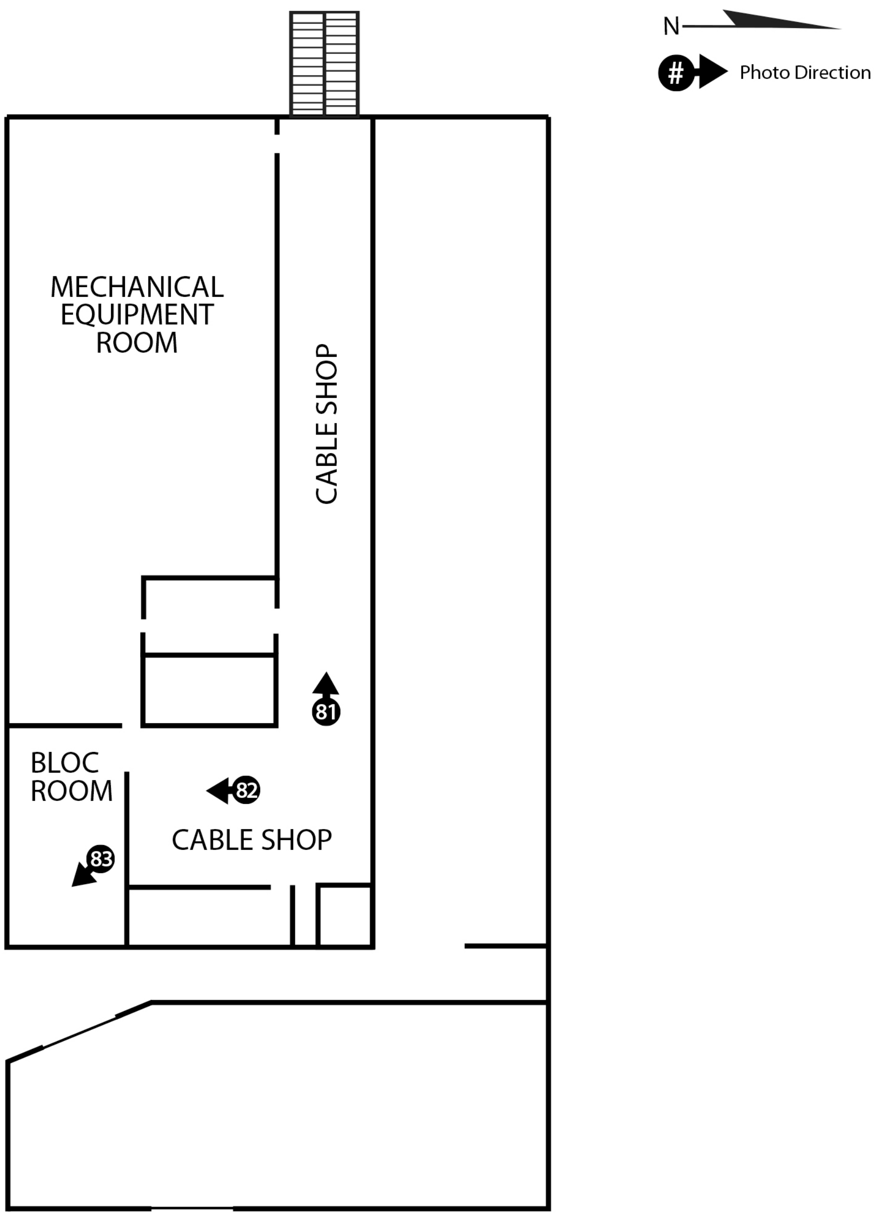
75
TPS
MIXING ROOM
TPS
SPRAY CELL
74
70
71
72
76
73
TPS CURE PREPARATION AREA
77
TPS SOUTH
CURE CELL
78
79
TPS FINISHING AREA
80
BTA
MIXING
ROOM
Note:
74 and 75 are in the 2nd Floor Control Room
Redrawn by: David Diener
Submitted on: 10-10-2012

MEZZANINE FLOOR PLAN - NORTH



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HISTORIC AMERICAN ENGINEERING RECORD

INDEX TO PHOTOGRAPHS

HAER No. FL-8-11-R

CAPE CANAVERAL AIR FORCE STATION, LAUNCH COMPLEX 39
SRB ASSEMBLY & REFURBISHMENT FACILITY MANUFACTURING BUILDING
(SRB ARF MANUFACTURING BUILDING)
John F. Kennedy Space Center
Cape Canaveral
Brevard County
Florida

David Diener, Photographer September – October 2011

FL-8-11-R-1 EXTERIOR OBLIQUE VIEW OF ARF FROM THE WEST ENTRANCE DRIVE, SHOWING NORTHWEST CORNER, VIEW SOUTHEAST.

FL-8-11-R-2 EXTERIOR OBLIQUE VIEW OF ARF FROM THE EAST ENTRANCE DRIVE, SHOWING NORTHEAST CORNER, VIEW SOUTHWEST.

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FL-8-11-R-81 CABLE SHOP, VIEW WEST.

FL-8-11-R-82 CABLE SHOP, VIEW SOUTH.

FL-8-11-R-83 BLOC ROOM SHOWING COMPUTER MONITORS, VIEW SOUTH.

FL-8-11-R-84 Photocopy of engineering drawings (8″ x 10″ photo of scanned original; March 15, 1985 by Reynolds, Smith and Hills; drawings in possession of Kennedy Space Center) "Solid Rocket Booster Assembly and Refurbishment Facility – Cover Sheet."

FL-8-11-R-85 Photocopy of engineering drawings (8″ x 10″ photo of scanned original; May 1, 1985 by Reynolds, Smith and Hills; drawings in possession of Kennedy Space Center) "Solid Rocket Booster

Assembly and Refurbishment Facility – Project Location."

FL-8-11-R-86 Photocopy of engineering drawings (8″ x 10″ photo of scanned original; March 15, 1985 by Reynolds, Smith and Hills; drawings in possession of Kennedy Space Center) "Solid Rocket Booster Assembly and Refurbishment Facility – Index to Drawings – I."

FL-8-11-R-87 Photocopy of engineering drawings (8″ x 10″ photo of scanned original; March 15, 1985 by Reynolds, Smith and Hills; drawings in possession of Kennedy Space Center) "Solid Rocket Booster Assembly and Refurbishment Facility – Index to Drawings – II."

FL-8-11-R-88 Photocopy of engineering drawings (8″ x 10″ photo of scanned original; November 14, 1984 by Reynolds, Smith and Hills; drawings in possession of Kennedy Space Center) "Solid Rocket Booster Assembly and Refurbishment Facility – Site Preparation Plan."

FL-8-11-R-89 Photocopy of engineering drawings (8″ x 10″ photo of scanned original; January 29, 1985 by Reynolds, Smith and Hills; drawings in possession of Kennedy Space Center) "Solid Rocket Booster Assembly and Refurbishment Facility – Pavement Plan."

FL-8-11-R-90 Photocopy of engineering drawings (8″ x 10″ photo of scanned original; January 29, 1985 by Reynolds, Smith and Hills; drawings in possession of Kennedy Space Center) "Solid Rocket Booster Assembly and Refurbishment Facility – Grading Plan."

FL-8-11-R-91 Photocopy of engineering drawings (8″ x 10″ photo of scanned original; October 6, 1986 by Reynolds, Smith and Hills; drawings in possession of Kennedy Space Center) "Solid Rocket Booster Assembly and Refurbishment Facility – Landscape Plan."

FL-8-11-R-92 Photocopy of engineering drawings (8″ x 10″ photo of scanned original; October 6, 1986 by Reynolds, Smith and Hills; drawings in possession of Kennedy Space Center) "Solid Rocket Booster Assembly and Refurbishment Facility – Landscape Plan."

FL-8-11-R-93 Photocopy of engineering drawings (8″ x 10″ photo of scanned original; October 6, 1986 by Reynolds, Smith and Hills; drawings in possession of Kennedy Space Center) "Solid Rocket Booster Assembly and Refurbishment Facility – Manufacturing Building Ground Floor Plan – North."

FL-8-11-R-94 Photocopy of engineering drawings (8″ x 10″ photo of scanned original; October 6, 1986 by Reynolds, Smith and Hills; drawings in possession of Kennedy Space Center) "Solid Rocket Booster Assembly and Refurbishment Facility – Manufacturing Building Ground Floor Plan – Ground Floor Plan – High Bay."

FL-8-11-R-95	Photocopy of engineering drawings (8″ x 10″ photo of scanned original; October 7, 1986 by Reynolds, Smith and Hills; drawings in possession of Kennedy Space Center) "Solid Rocket Booster Assembly and Refurbishment Facility – Manufacturing Building Ground Floor Plan – Ground Floor Plan – South."
FL-8-11-R-96	Photocopy of engineering drawings (8″ x 10″ photo of scanned original; October 7, 1986 by Reynolds, Smith and Hills; drawings in possession of Kennedy Space Center) "Solid Rocket Booster Assembly and Refurbishment Facility – Manufacturing Building Mezzanine Floor Plan – North."
FL-8-11-R-97	Photocopy of engineering drawings (8″ x 10″ photo of scanned original; October 7, 1986 by Reynolds, Smith and Hills; drawings in possession of Kennedy Space Center) "Solid Rocket Booster Assembly and Refurbishment Facility – Manufacturing Building Mezzanine Floor Plan – South."
FL-8-11-R-98	Photocopy of engineering drawings (8″ x 10″ photo of scanned original; October 7, 1986 by Reynolds, Smith and Hills; drawings in possession of Kennedy Space Center) "Solid Rocket Booster Assembly and Refurbishment Facility – Manufacturing Building Second Floor Plan – North."
FL-8-11-R-99	Photocopy of engineering drawings (8″ x 10″ photo of scanned original; October 5, 1986 by Reynolds,

Smith and Hills; drawings in possession of Kennedy Space Center) "Solid Rocket Booster Assembly and Refurbishment Facility – Manufacturing Building Second Floor Plan – High Bay."

FL-8-11-R-100 Photocopy of engineering drawings (8″ x 10″ photo of scanned original; October 7, 1986 by Reynolds, Smith and Hills; drawings in possession of Kennedy Space Center) "Solid Rocket Booster Assembly and Refurbishment Facility – Manufacturing Building Second Floor Plan – South."

FL-8-11-R-101 Photocopy of engineering drawings (8″ x 10″ photo of scanned original; October 7, 1986 by Reynolds, Smith and Hills; drawings in possession of Kennedy Space Center) "Solid Rocket Booster Assembly and Refurbishment Facility – Manufacturing Building Roof Plan."

FL-8-11-R-102 Photocopy of engineering drawings (8″ x 10″ photo of scanned original; October 7, 1986 by Reynolds, Smith and Hills; drawings in possession of Kennedy Space Center) "Solid Rocket Booster Assembly and Refurbishment Facility – Manufacturing Building North Elevation."

FL-8-11-R-103 Photocopy of engineering drawings (8″ x 10″ photo of scanned original; October 7, 1986 by Reynolds, Smith and Hills; drawings in possession of Kennedy Space Center) "Solid Rocket Booster Assembly and Refurbishment Facility – Manufacturing Building South Elevation."

FL-8-11-R-104 Photocopy of engineering drawings (8″ x 10″ photo of scanned original; October 7, 1986 by Reynolds, Smith and Hills; drawings in possession of Kennedy Space Center) "Solid Rocket Booster Assembly and Refurbishment Facility – Manufacturing Building East Elevation."

FL-8-11-R-105 Photocopy of engineering drawings (8″ x 10″ photo of scanned original; October 7, 1986 by Reynolds, Smith and Hills; drawings in possession of Kennedy Space Center) "Solid Rocket Booster Assembly and Refurbishment Facility – Manufacturing Building West Elevation."

FL-8-11-R-106 Photocopy of engineering drawings (8″ x 10″ photo of scanned original; October 7, 1986 by Reynolds, Smith and Hills; drawings in possession of Kennedy Space Center) "Solid Rocket Booster Assembly and Refurbishment Facility – Manufacturing Building, Building Section (1)."

FL-8-11-R-107 Photocopy of engineering drawings (8″ x 10″ photo of scanned original; October 7, 1986 by Reynolds, Smith and Hills; drawings in possession of Kennedy Space Center) "Solid Rocket Booster Assembly and Refurbishment Facility – Manufacturing Building, Building Section (2)."

FL-8-11-R-108 Photocopy of engineering drawings (8″ x 10″ photo of scanned original; October 7, 1986 by Reynolds, Smith and Hills; drawings in possession of Kennedy Space Center) "Solid Rocket Booster

Assembly and Refurbishment Facility – Manufacturing Building, Building Section (3).”

FL-8-11-R-109 Photocopy of engineering drawings (8″ x 10″ photo of scanned original; October 7, 1986 by Reynolds, Smith and Hills; drawings in possession of Kennedy Space Center) “Solid Rocket Booster Assembly and Refurbishment Facility – Manufacturing Building, Building Section (4).”

FL-8-11-R-110 Photocopy of engineering drawings (8″ x 10″ photo of scanned original; October 7, 1986 by Reynolds, Smith and Hills; drawings in possession of Kennedy Space Center) “Solid Rocket Booster Assembly and Refurbishment Facility – Design Criteria, General Notes and Area Plan.”